

**PETITION EXHIBIT 19**



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California Regional Water Quality Control Board  
Central Coast Region  
895 Aero Vista Drive, Suite 101  
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Dear Mr. Hernandez:

**RE: REVIEW OF OLIN CORPORATION DECEMBER 6, 2006 LLAGAS  
SUBBASIN CLEANUP FEASIBILITY STUDY - REVISED**

On behalf of the City of Morgan Hill (the City), WorleyParsons Komex has reviewed the Olin Corporation (Olin) December 6, 2006 Report, "Llagas Subbasin Cleanup Feasibility Study - Revised" (the FS Report) for the Olin property at 425 Tennant Avenue, Morgan Hill, California (the Site), submitted to the Central Coast Regional Water Quality Control Board (RWQCB).

The FS Report is a revision of an earlier feasibility study report, the June 30, 2006 "Llagas Subbasin Cleanup Feasibility Study Report, Olin/Standard Fusee Site, 425 Tennant Avenue, Morgan Hill, California" (MACTEC 2006a; June 30<sup>th</sup> FS Report). Both reports result from a sequence of regulatory directives, particularly the March 10, 2005 RWQCB Cleanup and Abatement Order R3-2005-0014 [2005 CAO] Ordering Paragraph J. RWQCB comments on the June 30<sup>th</sup> FS Report were documented in October 6, 2006 correspondence to Olin (RWQCB 2006a). Previously, RWQCB also provided comments to Olin on their January 31, 2006 Cleanup Level Report (MACTEC 2006b) in a letter dated March 2, 2006 (RWQCB 2006b). Consequently, the current FS report is expected to address the comments and requirements provided in the March 2, 2006 and October 6, 2006 letters from RWQCB to Olin.

## 1. OUTSTANDING DEFICIENCIES

WorleyParsons Komex on behalf of the City of Morgan Hill provided detailed comments on the June 30<sup>th</sup> FS report in a letter to RWQCB dated July 24, 2006 (WorleyParsons Komex 2006a). While the revised FS report addresses some of the deficiencies noted by the City in the July 24, 2006 comment letter, there are many deficiencies that this current FS does not address. However, we will not reiterate our comments at this time, other than to summarize outstanding concerns:

- a) Background perchlorate levels in the Llagas Subbasin still have not been determined by Olin, by either the process for determination of background concentration of contaminants under California Code of Regulations [CCR] Title 23, Division 3, Chapter 15 Sections



2550.4 and 2550.7, or CCR Title 27, Division 2, Subdivision 1, Chapter 3, Subchapter 3, Article 1 Section 20400 as required by the RWQCB in their October 6, 2006 comment letter. The RWQCB has been very explicit in asking that this be accomplished.

- b) State Water Resources Control Board (SWRCB) Resolution Number 92-49 requires that background concentrations be determined in accordance with the above methods if a cleanup level greater than background is proposed. Until a background level is developed in accordance with the above-referenced regulations the RWQCB must continue to hold Olin to a cleanup level of background, that is, 1.4 micrograms per liter (ug/L) as defined by the RWQCB in their October 6, 2006 letter to Olin.
- c) Resolution Number 92-49 specifies the conditions under which a cleanup level other than background can be proposed, as summarized in the RWQCB October 6, 2006 comment letter, and also summarized in the FS Report Section 4 (p. 4-1 and 4-2). A key condition is that the proposed cleanup level be the lowest concentration technically and economically achievable. The FS Report once again does not provide any technical or economic justification for the proposed 6 ug/L cleanup level, since the FS Report shows that cleanup to less than 2 ug/L (Olin's proxy for background) is both technically and economically feasible.

In addition to these outstanding concerns, we note that many of the comments raised in the RWQCB October 6, 2006 letter have also not been addressed in the current FS Report as would have been expected; however, we will defer to the RWQCB for their comments on such deficiencies. The general and specific technical comments from our review of the current FS Report are discussed below.

## **2. DEFICIENCIES OF REVISED FS REPORT**

Overall, the revised FS Report does not meet the requirements of the March 10, 2005 CAO Ordering Paragraph J, or clarifying conditions raised in the October 6, 2006 RWQCB Comment letter. Beyond the above-noted issues of undetermined background perchlorate and inappropriate cleanup level, the overriding deficiency of the FS Report is the incomplete and inconsistent evaluation of the technical feasibility of the groundwater extraction/ex-situ treatment option for Priority Zones B and C, and the sub-Public Health Goal (PHG) zone (< 6 ug/L). We note that a separate feasibility study (FS) prepared by GeoSyntec (Zone A FS Report; GeoSyntec, 2006) was submitted on December 6, 2006 by Olin for Priority Zone A; therefore, our comments below on Zone A cleanup are at present limited, and will be presented in more detail in our review of the Zone A FS Report. Please note that while we have reviewed some aspects of the groundwater flow and solute transport model discussed in Appendix B of the FS Report, detailed review of the model will be deferred until such time as the digital data files are also made available.

Specific comments on the FS Report are:

- (a) The FS Report fails to acknowledge or address the ongoing occurrence of perchlorate in the Deep Aquifer in the area northeast of the Olin Site, which is impacting operating water supply wells of the City of Morgan Hill. Groundwater impacts in this area due to the Olin Site are well documented,



particularly with the most recent data from the Third Quarter 2006 Groundwater Monitoring Report submitted by Olin on October 30, 2006 (MACTEC 2006c). Any cleanup feasibility study by Olin should also address impacted groundwater east, north, and northeast of the Olin Site.

(b) Olin states that perchlorate in the Nordstrom Park well "... is unrelated to operations at the former Olin/Standard Fusee facility." (FS Report p. 5-5), with reference to the Olin Llagas Subbasin Characterization Report of March 29, 2006 (MACTEC 2006d). Although substantial evidence existed at the time of the March 29, 2006 report that the Olin Site was the source of perchlorate, additional data collected by Olin in 2006 has provided irrefutable evidence of northerly groundwater flow in the Middle and Lower Deep Aquifer zones from the Olin site toward the Nordstrom well, and extremely strong evidence that there is a continuous plume of perchlorate that extends from the Site to at least the Nordstrom well. These facts and findings are described in detail in our November 22, 2006 review comments on Olin's Third Quarter 2006 Groundwater Monitoring Report to RWQCB (WorleyParsons Komex 2006b), so they will not be repeated herein.

(c) Olin states and re-states that groundwater extraction and treatment to the proposed cleanup level for Priority Zones B and C, or to background for sub-PHG areas beyond Zone C, is infeasible because "...groundwater extraction would induce adverse effects to the aquifer, such as local dewatering, pumping well interference, and groundwater quality degradation related to over-pumping." (FS Report p. xv (two occurrences); similar statement also on p xii, 4-8, 4-11, 4-12, 7-10, 7-17), and that "Hydraulic containment and treatment of groundwater with perchlorate greater than the MDL cannot be accomplished without disrupting the operation of existing pumping operations." (FS Report p 4-17). Despite the fact that Olin has developed a sophisticated groundwater flow model that could readily document any such effects, no model results or other calculations are provided to substantiate these claims. For example, no maps of projected drawdown due to groundwater extraction alternatives are presented. Similarly, no projections of remediation-induced drawdown at existing wells are presented in the FS Report. Furthermore, this statement avoids mentioning that Olin proposes that all groundwater extracted for Zone B, C and sub-PHG zone remediation would be simultaneously re-injected into the aquifer, minimizing any long-term or large scale effects of pumping. The model and all necessary files should be provided not only to the RWQCB but to other stakeholders as well, including the City. Further, the City believes that to reach any conclusions without having the opportunity to review the model is counter indicated.

(d) Specifically with respect to groundwater extraction and treatment for the Priority B Zone, Olin states that "Any effort to pump an additional 1,000 AF per year would likely create local pumping interferences that could impact existing groundwater users. As such, ...the potential adverse impacts on beneficial uses results in eliminating this alternative for further consideration for this Priority Zone." (FS Report p. 7-10). As noted above, Olin's suggestion of pumping interference due to remediation groundwater extraction is unsubstantiated by information provided in the FS Report, and represents nothing more than conjecture. Moreover, Olin notes that "annual demands by the water systems operated in the cities of Morgan Hill and Gilroy are currently about 15,000 acre-feet per year..." (FS Report p 6-2,3). The relatively small amount of 1,000 acre-feet per year of treated water from groundwater extraction in Priority Zone B could easily be used to replace some of the above-noted municipal pumping, with no little or effect on groundwater resources of existing groundwater users.



In the absence of substantiation of any adverse effects on groundwater resources due to groundwater extraction to background levels, we must conclude that there is *no* technical basis to propose a cleanup level greater than background, as required by Resolution 92-49 and Resolution 68-16 (Anti Degradation Policy). The cleanup goal of 6 ug/L proposed by Olin represents a degradation of groundwater in the Llagas Subbasin and is, therefore, not acceptable to the City nor should it be to the RWQCB as set forth in the October 6, 2006 RWQCB letter, that the proposed 6 ug/L cleanup level is "... clearly inconsistent with the State' Water Board's anti-degradation policy (Resolution no. 68-16)."

(e) As part of their explanation for establishing a cleanup level higher than background under the conditions of Resolution No. 92-49, Olin states that "Concentrations above background in groundwater will rapidly attenuate downgradient from areas of active remedial solutions" (FS Report p. 4-10). However, no technical basis to support this highly optimistic forecast is presented in the FS Report. Clearly, high levels of perchlorate in Zone I groundwater persist downgradient of the active on-Site soil and groundwater remediation that has been ongoing for nearly three years (since February 2004; FS Report p 5-1), contradicting Olin's contention of rapid perchlorate attenuation downgradient of active remediation.

(f) With reference to cleanup levels at the UTC site, Olin states that "Resolution 92-49 requires that Water Boards be consistent in comparable cases and thus the PHG, as approved for the UTC site, ... should also apply in the case of the Olin Site." (FS Report p 4-19, 20). We note that Order No. R2-2004-0032 (included with this letter as Attachment A) for the UTC site from the San Francisco Bay Regional Water Quality Control Board specifies a cleanup level of 6 ug/L (PHG) for on-Site water (both groundwater and surface water), however the same order also specifies the following prohibition:

"Specifically, no detectable concentrations of contaminants shall be allowed in surface waters or underflow at or beyond the property boundary..."

As explained by Keith Roberson, the San Francisco Bay Regional Water Quality Control Board regulator assigned to the UTC case, this prohibition restricts perchlorate in off-site groundwater to non-detect with respect to the analytical method detection limit (personal communication, January 17, 2007). We do not concur with Olin on this point, and conclude that it is unreasonable for RWQCB to apply these same standards to the Olin on-Site clean up level. The UTC site is huge, many times the size of the Olin Site. It is in a relatively remote area that is still largely undeveloped. The Olin site, in contrast, is small and situated in the middle of a populated area and has already degraded water quality in the Llagas Basin that serves thousands of people with drinking water. As for off-Site cleanup level, it is reasonable that the two sites should be treated the same, that is, an off-Site prohibition of perchlorate concentrations in groundwater greater than the MDL of EPA Method 314, (i.e., 1.4 ug/L) as noted by RWQCB (October 6, 2006).

(g) Olin's reliance on dilution and dispersion as dominant mechanisms allowing the feasibility of the Monitored Attenuation (MA) option may be based on optimistic expectations. Olin counts on appreciable dilution from anthropogenic recharge from the Madrone, San Pedro and other recharge ponds operated by the Santa Clara Valley Water District (SCVWD). For example, with respect to



reduction of perchlorate mass flux between Area I and Area II, Olin state that dilution of 40 to 60 % imported water between Area I and II is anticipated, and thus the "...additional source of water from the percolation ponds thus results in a reduction in perchlorate concentration" (FS Report p 3.14). Beyond this, the map of percentage pond recharge water in the Intermediate Aquifer (FS Report Figure 3.9) clearly shows that the calculated percentage of pond water in the vicinity of the plume core in Area I is much closer to 30 % or less.

Moreover, even this magnitude of dilution may be optimistic for three reasons:

(1) the main SCVWD recharge ponds are located well to the east of the Olin site and the Area I plume, and the dominant flow direction in the Shallow and Intermediate aquifers in this area is to the southeast, as shown in FS Report figures 3.2 and 3.3. Consequently, considering the likely dominance of advection as a plume migration mechanism in the Llagas subbasin, and the probable pathlines or "streamtubes" to be followed by the recharge water, it is unlikely that significant transverse lateral mixing of the recharge water and the Area I plume would occur. This could easily be demonstrated through particle tracking and solute transport modeling with Olin's groundwater model, but no such simulations were run.

(2) Evaluation of concentration trends in monitoring wells, discussed in FS Report Appendix C, indicates that over two-thirds of wells do not show a decreasing trend in perchlorate concentrations. Consequently, dilution and dispersion are not actively reducing concentrations.

(3) The development of a thin, 10-mile long plume from the Olin site suggests that advection is the dominant transport mechanism, and dilution and dispersion are not effective mechanisms for long-term reduction of perchlorate concentrations.

(h) Olin suggests that denitrification is occurring in the Deep Aquifer and the corresponding occurrence of biological reduction of perchlorate is an operational mechanism for perchlorate attenuation in the Llagas Subbasin (FS Report p 3-13 and 4-16). Other than the absence of high nitrate concentrations in some portions of the Deep Aquifer, there is *no* evidence to support the contention that denitrification or perchlorate reduction is occurring in the Deep Aquifer. In fact Figure 3-13 shows that nitrate concentrations in the Deep Aquifer downgradient of the Site are nearly everywhere in excess of 20 mg/L; similarly, perchlorate concentrations above the PHG are observed extensively in the Deep Aquifer downgradient of the site, as shown in Figure 3-18. Both of these facts clearly suggest that neither denitrification nor perchlorate reduction are occurring to any appreciable extent in the Deep Aquifer zone downgradient of the Site. This observation contradicts Olin's statement that, in part due to biological reduction of perchlorate, "... perchlorate concentrations above the hypothetical background would not persist in the presence of these attenuation processes." (FS Report p 4-16). Under the groundwater conditions present in the Llagas Subbasin, perchlorate must be considered as a persistent contaminant and, therefore, Olin's supposition is inapposite to the requirements with respect to persistence and permanence of effects for establishing an alternate cleanup level under Resolution No. 92-49.



(i) The groundwater flow and transport model used to evaluate various remediation alternatives including capture zones, groundwater extraction rates and cleanup times, is partially documented in FS Report Appendix B. Numerous deficiencies and errors in the modeling are evident from initial review of Appendix B. The documentation is very incomplete, particularly in terms of calibration (both flow and transport) and sensitivity analysis. As noted above, a thorough review of the Olin groundwater model will be provided at later time, once the model files have been made available.

(j) Olin's analysis of remedial alternatives and scoring of those alternatives in Section 7 of the FS Report contains several inconsistencies which act to bias the ranking of the alternatives. Some of the inconsistencies are within FS Report Table 7.1 itself, whereas other are evident when the scores present in FS Report Table 7.2 are compared against the criteria analysis in FS Report Table 7.1. The issues of concern relate primarily to the analysis and ranking of Alternatives 2 (MA) and 3 (Groundwater extraction/treatment) for Priority Zones B and C. To illustrate these inconsistencies, the relevant portions of FS Report Tables 7.1 and 7.2 are combined and reproduced in the attached Table 1. Although some differences in scoring between Zone B and C should be expected for a given Alternative and Criterion, generally the scoring should be consistent with the analysis provided.

(i) For example, in FS Report Table 7.1, the analysis of the criterion, "Reduction of Toxicity, Mobility, Volume" for Priority Zone B, Alternative 3, is given as "Significant reduction of toxicity, mobility, and volume in treatment area", whereas the analysis for this same criteria for priority Zone C is given as "Limited reduction of toxicity, mobility, and volume - due to well head treatment - tracked." Since private wells in both Priority Zones B and C are subject to wellhead treatment, the reason for this discrepancy in analysis appears unsupportable. The analysis and scoring of this criterion for both Zones B and C should be the same. Note that we have no objection to the score assigned (i.e, value of 3); however, the score value should reflect the same or similar analysis. Note that this type of inconsistency is highlighted in Table 1 with cells that are shaded brown.

(ii) Similarly, FS Report Table 1 has several inconsistencies where the different scores are assigned to criteria with the same analysis. For example, for both Priority Zones B and C, Alternative 2, the "Compliance with Regulatory Requirements" criterion analysis is stated as "Does not actively comply with Resolution No. 92-49", yet this criterion is ranked with a value of 4 for Priority Zone B, and 5 for Priority Zone C. It is hard to understand how an alternative that "Does not actively comply with Resolution No. 92-49" can be assigned a score of 5 out of 5, so presumably the scoring of 4 is more appropriate. As another example of this inconsistency, analysis of the "Overall Protection of Human Health and Environment" criterion is given as "Protects human health and environment by reducing mass of perchlorate, and by IX systems on supply wells. High degree of protection" under Alternative 3 for both Priority Zones B and C, yet the criterion is assigned a value of 5 in Zone B, but only 4 in Zone C. Based on the stated analysis, presumably the ranking for both zones should be more appropriately scored as 5. Yet another, more extreme example of this inconsistency is seen under the "Stakeholder Acceptance" criterion for Alternative 3, where the same analysis, "High Stakeholder Acceptance", is scored as 4 for Priority Zone B, but scored as only 2 for Priority Zone C. Again, based on the common analysis, presumably a value of 4 would apply to both zones. Note that this type of inconsistency is highlighted in Table 1 with cells that are shaded blue.



(iii) A third type of scoring inconsistency in FS Report Tables 7.1 and 7.2 are criteria where appreciably different analysis is assigned the same scoring value. For example, for both Priority Zones B and C, the analysis for criterion "Short Term Effectiveness" is given as "Not effective in short term" for Alternative 2, and "Moderate effectiveness in short term" for Alternative 3, yet both are assigned the same score of 3. Presumably, an alternative that is "not effective" should not be scored the same as one that is moderately effective, so a more appropriate scoring might be a value of 3 for moderately effective and a value of 1 or 2 for not effective. Another example of this type of scoring inconsistency is seen for the criterion "Compliance with Regulatory Requirements" in both Priority Zones B and C, which is described as "Does not actively comply with Resolution No. 92-49" for Alternative 2, and "Complies with regulatory requirements" for Alternative 3, yet both are assigned a score of 4. Again, presumably a lower score, perhaps 2 or 3, should be assigned to the alternative that does not comply with regulatory requirements, whereas an alternative that does comply could be assigned a score of perhaps 5. Note that this type of inconsistency is highlighted in Table 1 with cells that are shaded green.

(iv) WorleyParsons Komex undertook a re-scoring of the criteria and alternatives in Table 1 (from FS Report Table 7.1 and 7.2) to make the scores consistent with analysis for each criterion and alternative. The proposed revised scoring is included in Table 1 below Olin's scoring (from FS Report Table 6.1). Note that other than addressing the types of inconsistencies noted above, the proposed revised scoring preserves the integrity of Olin's original scoring. The proposed re-scoring shows that Alternative 3 (Groundwater Extraction/Treatment) ranks higher than Alternative 2 (MA) for both Priority Zones B and C. Consequently, the preferred remedial alternative for both Priority Zones B and C is groundwater extraction and treatment, not monitored attenuation, as scored by Olin.

(k) Olin's projections of cleanup time for remediation Alternatives 1 (Priority Zone A groundwater extraction/treatment) and 3 (Priority Zones B and C, plus sub-PHG groundwater extraction/treatment) are based on simulated concentrations versus time from the groundwater flow and transport model at a very small number of selected locations, corresponding to existing monitoring wells: 5 in the shallow aquifer, and 4 each in the intermediate and deep aquifer, with only one depth per location (FS Report p 7.4, Figures 7.4, 5, 6 (Zone A); p. 7-9, Figures 7.10, 11, 12 (Zone B); p. 7-16, Figures 7.16, 17, 18 (Zone C); and p 7.20, Figures 7.22, 23, 24 (Sub-PHG zone)). Based on the information provided in the FS Report, there is no way of knowing how representative these few locations are of overall plume remediation. The four to five selected locations generally include one plume core location situated within or near the core of the plume in Priority Zone A (MW-16 or 17), one location downgradient of Priority Zone B (e.g., MW-21), and two further down-gradient locations located on the western fringe of the plume in the sub-PHG zone (MW-26 and 51). None of these locations appear to be located within Priority Zone B or C; however, this is difficult to distinguish accurately since no map of the extent of these Priority Zones is presented in the FS Report. Consequently, the reliability of Olin's projected cleanup times based on the time-concentration plots from this limited number of locations must be questioned. A far better representation would have numerous additional target locations including a range of geographic and depth locations, focusing on the plume centerline, but also including fringe areas and locations directly downgradient of the plume leading-edge at various concentration levels. In addition, a series of plume maps over a range of



snapshot times (e.g. 2, 5, 10, 15, 20 years) would better show the overall progress of each remedial alternative.

(l) There are numerous inconsistencies between the narrative explanation of remedial alternatives presented in the text of Section 7, the listed quantities presented in the associated tables, and estimated costs presented in Appendix D. For example, Section 7.4.3 presents a narrative explanation of the Alternative 3, Ex Situ treatment of groundwater for Priority Zone C, and references numbers of pumping wells and flow rates presented in Table 7.4, and estimated costs presented in Appendix D, Table D.6. The number of pumping wells for this alternative presented in Table 7.4 is 7 wells, the number of pumping wells presented in Table D.6 is 3 wells. The flow rates for the pumping wells presented in Table 7.4 total 2,200 gallons per minute (gpm). The flow rates for the pumping wells presented in Table D.6 total 600 gpm. With Table D.6 itself, the unit cost for conveyance piping is presented as 100 \$/LF under "Assumptions" and the applied at a rate of 200 \$/LF under "Capital Costs".

(m) Costs presented in Appendix D were not estimated in a manner consistent with guidance published by the United States Environmental Protection Agency (EPA 2000). EPA has a published guidance document titled, "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study." The document was published in July 2000 and presents EPA policy on use of a discount rate for NPV calculations. The NPV discount rate recommended by the EPA is 7 percent, which has been adjusted to eliminate the effect of expected inflation. The Report uses an escalation rate of 3 percent and a NPV discount rate of 5 percent. As a result, the costs presented in the Report are significantly higher than the EPA would accept. For example, for Priority Zone B, Alternative 3, Ex Situ, the Report estimates a cost of \$43.7M (however, there appears to be a calculation error in this item; the correct total cost should be \$24.0M). The cost for this alternative using EPA protocol would total \$16.8M, a significant difference in either case.

(n) There are numerous instances where insufficient information is provided in Section 7.0 to support the implementability, effectiveness, and cost of the remedial alternatives, let alone support the detailed analysis using the criteria presented in Table 7.1. For example:

- The extraction wells and reinjection wells presented in the cost estimating tables in Appendix D and Table 7.4 are not identified on the figures presented in the report.
- The route of the conveyance piping between the extraction wells and reinjection wells is not identified on the figures presented in the report.
- The size of the storage tanks are not provided.
- The capacities of the components of the ion exchange based treatment system are not provided.
- The basis for the ion exchange resin usage estimate is not provided.
- The basis for pumping costs is not provided.



This information is necessary to validate the costs and related conclusions presented in the report.

(o) Costs presented in Appendix D apply higher percentages for engineering services than EPA recommends. The Report applies a total percentage to the remedial alternative capital cost of 45% for the design, construction management, and project management services. The EPA recommends a total percentage of 17% for the services. Therefore, the Report presents a capital cost for Priority Zone B, Alternative 3, Ex Situ treatment of \$9.5M, whereas following EPA guidance would lead to an estimate of \$7.9M; a significant difference.

(p) Costs presented in Appendix D use the worst case times projected to achieve cleanup levels, not considering that portions of the aquifers will cleanup sooner than others. For example, Table 7.5 lists times to achieve cleanup goals if Alternative 3, Ex Situ Treatment were implemented in Priority Zone C. The table identifies four well locations each in the shallow, intermediate, and deep aquifers, and the respective times to achieve the cleanup goals at each well location. The times listed in Table 7.5 are from 0 years to 5 years for wells in the shallow aquifer, 0 years to 5 years for wells in the intermediate aquifer, and 1 year to 20 years for wells in the deep aquifer. Only one well location in the deep aquifer is projected to require 20 years to achieve the cleanup goal. The other well locations in the other aquifers are projected to reach the cleanup goal in 5 years or less. However, the cost estimate prepared for the alternative does not take in consideration the fact that portions of the aquifers will cleanup sooner than others. In the case of portions of the aquifer reaching the cleanup goal sooner than others, 7 wells pumping 2,200 gpm from year 5 to year 20 at a cost of \$9.5M may not be required. It may only require 1 well pumping 900 gpm from year 5 to year 20 at a significantly lower cost. However, this analysis has not been performed. Therefore, the cost estimates may be excessive.

WorleyParsons Komex hopes this review is helpful to the RWQCB in your ongoing efforts to cleanup perchlorate released from the Olin Site. We are at your disposal to discuss any of the comments above. If you have any questions or need additional information please call Mark Trudell at 714 379-1157, extension 161.

Sincerely,  
WorleyParsons Komex

Mark Trudell, Ph.D., PG, CHG.

Principal Hydrogeologist

enc.

Steve Winners, PE

Senior Engineer



**WorleyParsons Komex**

resources & energy

cc: Mr. Jim Ashcraft, City of Morgan Hill  
Mr. Steven Hoch, Hatch and Parent



## REFERENCES

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WorleyParsons Komex 2006a. Review of Olin Corporation June 30, 2006 Llagas Subbasin Cleanup Feasibility Report. Letter to Hector Hernandez, RWQCB. July 24, 2006.

WorleyParsons Komex 2006b. Review of Olin Third Quarter 2006 Groundwater Monitoring Report. Letter to Hector Hernandez, RWQCB. November 22, 2006.23 CCR s 2550.4. Concentration Limits.

**TABLE 1**  
**Revised FS Report Table 7.1 (Detailed Analysis of Alternatives), including Olin Scoring and Proposed Revised Scoring**

Alternative	Threatoid Criteria			Balancing Criteria			Modifying Criteria			Total Points
	Overall Protection of Human Health and Environment	Compliance with Regulatory Requirements	Long Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume	Short Term Effectiveness	Implementability	Cost	Stakeholder Acceptance		
<b>Priority B Zone</b>										
Alternative 2- MA (includes wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends)	Protects human health and environment by reducing mass of perchlorate, and by IX systems on supply wells. High degree of protection.	Complies with regulatory requirements with respect to wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends.	Long-term effectiveness due to attenuation, permanent due to source removal.	Limited reduction of toxicity, mobility, and volume - due to wellhead treatment - tracked.	Short term effectiveness.	Easy implementation of attenuation and source removal.	Low to Moderate	With proper planning and education, expected to have high degree of stakeholder acceptance, as this would be implemented in conjunction with remedial activities for Priority A Zone.	3	28
<b>Proposed Revised Score<sup>1</sup></b>	4	4	4	4	3	4	4	3	3	25
<b>Priority C Zone</b>										
Alternative 3- Groundwater Extraction, Treatment, Disposition (includes wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends)	Protects human health and environment by reducing mass of perchlorate, and by IX systems on supply wells. High degree of protection.	Complies with regulatory requirements with respect to wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends.	Long-term effectiveness due to attenuation, permanent due to source removal.	Limited reduction of toxicity, mobility, and volume - due to wellhead treatment - tracked.	Moderate effectiveness in short term.	Easy implementation of attenuation and source removal.	Moderate to High	With proper planning and education, expected to have high degree of stakeholder acceptance, as this would be implemented in conjunction with remedial activities for Priority A Zone.	4	27
<b>Proposed Revised Score</b>	5	5	4	4	3	3	2	4	4	28
<b>Priority D Zone</b>										
Alternative 2- MA (includes wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends)	Protects human health and environment by reducing mass of perchlorate, and by IX systems on supply wells. High degree of protection.	Complies with regulatory requirements with respect to wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends.	Long-term effectiveness due to attenuation, permanent due to source removal.	Limited reduction of toxicity, mobility, and volume - due to wellhead treatment - tracked.	Short term effectiveness due to attenuation, permanent due to source removal.	Easy implementation of attenuation and source removal.	Low to Moderate	With proper planning and education, expected to have high degree of stakeholder acceptance, as this would be implemented in conjunction with remedial activities for Priority A Zone.	3	30
<b>Proposed Revised Score</b>	4	4	4	4	3	4	3	3	3	24
<b>Priority E Zone</b>										
Alternative 3- Groundwater Extraction, Treatment, Disposition (includes wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends)	Protects human health and environment by reducing mass of perchlorate, and by IX systems on supply wells. High degree of protection.	Complies with regulatory requirements with respect to wellhead IX treatment for wells that exceed PHG, and show "increasing" or "probably increasing" trends.	Long-term effectiveness due to attenuation, permanent due to source removal.	Limited reduction of toxicity, mobility, and volume - due to wellhead treatment - tracked.	Moderate effectiveness in short term.	Easy implementation of attenuation and source removal.	High	With proper planning and education, expected to have high degree of stakeholder acceptance, as this would be implemented in conjunction with remedial activities for Priority A Zone.	2	23
<b>Proposed Revised Score</b>	5	5	4	4	3	3	1	2	2	26

**INCONSISTENCIES:**  
- Inconsistent analysis for same alternative and criteria  
- Inconsistent scoring, different score given for same alternative analysis  
- Inconsistent scoring, same score given to different alternative analysis

<sup>1</sup> Note: Proposed Revised Score as suggested by WorleyParsons Komex  
Notes on analysis by WorleyParsons Komex (WPK) are in all caps

**ATTACHMENT A**

**SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD**

**ORDER NO. R2-2004-0032 FOR THE UTC**

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD  
SAN FRANCISCO BAY REGION

**ORDER NO. R2-2004-0032**

**REVISION TO FINAL SITE CLEANUP REQUIREMENTS AND RESCISSION OF ORDERS NOS. 94-064 (AS AMENDED), 98-070, AND 91-006 FOR:**

**UNITED TECHNOLOGIES CORPORATION**

for the property located at  
**600 METCALF ROAD  
SANTA CLARA COUNTY**

The California Regional Water Quality Control Board, San Francisco Bay Region (hereinafter called the Water Board), finds that:

1. **Site Location:** United Technologies Corporation (UTC), hereinafter also referred to as the discharger, owns and operates the San Jose facility in Santa Clara County as shown in Figure 1. The site is located in an unincorporated area of Santa Clara County approximately five miles south of San Jose and four miles east of U.S. Highway 101. The site is located in an area of rolling hills and relatively broad valleys. The two main valleys within the developed portion of the site are Shingle Valley and Mixer Valley. Elevations range from 680 to 1400 feet above mean sea level. Four seasonal creeks flow through the site and converge near the southeastern corner of the site. The combined flow of these creeks discharges into Anderson Reservoir, Santa Clara County's largest drinking water reservoir. Water released from Anderson Reservoir flows to Coyote Creek, which flows northward across the Santa Clara Valley and empties to San Francisco Bay.

Land usage surrounding the UTC site is primarily agricultural. Ranch lands are located to the north, east, and southeast of the site. To the northwest and west are two regional parks and some open public land. The nearest residences are a few ranch houses or other dwellings located within 3,000 feet to the north, northeast, and southeast of the site boundaries.

2. **Site History:** UTC began operations at the 5,113-acre site in 1959. The facility now includes over 200 stations used for laboratories, research, testing, manufacturing, storage, maintenance, and administration. UTC develops, manufactures, and tests space and missile propulsion systems at the site. Solid rocket motors are filled with propellants designed to cause a controlled oxidation reaction that releases large amounts of energy and gas. Solid rocket propellants produced at the UTC facility are typically composed of synthetic rubber with the reactive materials (primarily aluminum and ammonium perchlorate) suspended in the rubber matrix. Aluminum serves as the fuel while ammonium perchlorate is the oxidizer for the reaction. Typical solid rocket propellant consists of approximately 16% aluminum fuel, 12% polymer binder, 2% epoxy curing agent, and about 70% ammonium perchlorate. Large amounts of ammonium perchlorate were used at the site until operations were discontinued in August 2003.

Other materials used in the operations at UTC include epoxies, paints, and insulating materials. Chlorinated and non-chlorinated degreasing agents were also used to dissolve polymers from

hardware. Degreasers included trichloroethene (TCE) and 1,1,1-trichloroethane (TCA). Other volatile organic compounds (VOCs) used at the site included chlorofluorocarbons such as Freon 11 and Freon 113. Historically, spent solvents were collected for evaporation in on-site surface impoundments or shipped off-site for recycling or disposal.

There are three Resource Conservation and Recovery Act (RCRA) Class I surface impoundments at the facility, all of which have been closed. Surface Impoundment 0250 was a 110,540-gallon surface impoundment in Upper Shingle Valley that received metal-finishing wastewater. Surface Impoundment 0635 was a 179,500-gallon surface impoundment in Mixer Valley that received wastewater from a polybutadiene acrylic acid acrylonitrile (PBAN) polymer plant. Surface Impoundment 0706 was a four-cell 42,964-gallon surface impoundment in Mixer Valley that received waste solvents, paint sludges, and ammonium perchlorate washwater. The California Department of Toxic Substances Control (DTSC) certified closure of the three surface impoundments on November 25, 1991. Because the surface impoundments were closed with groundwater contamination left in place, the units will have to be monitored under a post-closure permit. DTSC is in the process of adopting a RCRA Post-Closure Permit for the impoundments.

The former Open Burning Facility (OBF) located in the eastern portion of the facility was a RCRA-regulated treatment facility historically used for open burning of waste propellants and explosives. Wastes were ignited within burn units, which were constructed of earthen berms. Thermal treatment at this facility was discontinued on October 18, 1996. The OBF was certified closed on June 2, 2000. Like the three surface impoundments, the OBF must be monitored under RCRA post-closure permit because of contamination left in place.

3. **Named Discharger:** UTC is named as the sole discharger because it is the current property owner, and because it owned and occupied the property during the time of the activities that resulted in the discharges, has knowledge of the discharges or the activities that caused the discharges, and has the legal ability to prevent future discharges. The results of investigations have confirmed the presence of chemicals used by UTC in soil and groundwater in several areas of the site.

If additional information is submitted indicating that other parties caused or permitted any waste to be discharged on site where it entered or could have entered waters of the State, the Water Board will consider adding that party's name to this order.

4. **Regulatory Status:** The site has been under Water Board oversight since 1965. The site has been regulated under several Water Board orders, including Site Cleanup Requirements (SCR) orders, Waste Discharge Requirements (WDR) orders, and a Water Reclamation Requirements order. To facilitate regulatory oversight, the site was divided in the 1990s into two operable units based on the status of environmental characterization. The fully characterized portion of the site (Mixer Valley and most of Shingle Valley) was designated Operable Unit 1 (OU1); the remainder of the site was designated Operable Unit 2 (OU2). The SCR for OU1, Order No. 94-064, was adopted May 18, 1994, and amended on May 24, 1995, September 13, 1995, and May 21, 1997. The original SCR for OU2, Order No. 95-193, was adopted September 14, 1995 and was later replaced by Order No. 98-070 which was adopted on July 15, 1998. This Order rescinds and supercedes Orders 94-064 (along with its amendments) and 98-070; combines the two operable units into one; and regulates cleanup of soil and groundwater for the entire site.

In 1991, the Water Board issued a Water Reclamation Requirements order, Order No. 91-006, which permitted the facility to reuse treated groundwater for irrigation and dust control. This Order rescinds

Order 91-006; however, on-site reuse of reclaimed water is still permitted as discussed in Finding 15, subject to the requirements specified in Section D of this order (page 25).

The site is also regulated under a Waste Discharge Requirements order, Water Board Order No. 95-190, which was adopted on September 13, 1995. This WDR regulates discharge of treated water from the site's sanitary wastewater treatment plant. This Order does not affect or rescind the WDR. The site also manages storm water runoff under the State General Permit for Storm Water Discharges Associated with Industrial Activities, Permit No. CAS000001.

In addition to the Water Board Orders, the four closed waste management units at the site are regulated under RCRA Post-Closure Permits administered by the DTSC. As discussed in Finding #2, the OBF and three closed surface impoundments (stations 250, 635, and 706) will be regulated under post-closure because the units were not clean-closed due to residual volatile organic compound (VOC) and perchlorate contamination. These units under DTSC oversight are subject to specific RCRA monitoring requirements in addition to the regional groundwater monitoring requirements mandated by the Water Board. The RCRA monitoring requirements are incorporated into the Self-Monitoring Program attached to this Order.

5. **Study Area:** This order pertains to the entire UTC site. The site has been divided into eight geographic/investigative areas as follows:

- Upper Shingle Valley (USV)
- Middle Shingle Valley (MSV)
- Lower Shingle Valley (LSV)
- Motor Test Area (MTA)
- Research and Advanced Technology Area (R&AT)
- Motor Assembly Area and Component Test Area (MAA/CTA)
- Mixer Valley
- Open Burning Facility (OBF).

These areas are identified on the site map (Figure 2). More information on these areas is provided below.

6. **Surface Hydrology:** Three riparian systems, Shingle Creek, Mixer Creek, and Las Animas Creek, exist within the site boundaries. Shingle Creek and Mixer Creek flow in a southeasterly direction through Shingle Valley and Mixer Valley, respectively. Las Animas Creek flows southward through the site, passing between the OBF and the main developed portion of the site. A fourth creek, San Felipe Creek, traverses the eastern side of the site before flowing into Las Animas Creek southeast of the facility boundary. Shingle Creek, Mixer Creek, and San Felipe Creek all flow into Las Animas Creek, and this combined flow empties into Anderson Reservoir. Shingle and Mixer creeks, along with Las Animas Creek above its confluence with San Felipe Creek, are generally small, ephemeral streams with highly variable flows. A characteristic of the creeks is the existence of subsurface stream flow in some reaches. Hydrologic studies have confirmed that some stretches of the streams are gaining, or receive a contribution of their flow from groundwater discharge. The direct communication between groundwater and surface water and the documented discharge of contaminated water into the creeks at the site requires that UTC conduct surface water monitoring at the site. Creeks are currently sampled on a monthly schedule at specified sampling stations both on the site and outside the property boundaries.

The creeks flowing through the site provide a pathway for the potential transport of VOCs and perchlorate to Anderson Reservoir. Preventing or minimizing contaminants in surface waters is a high priority to prevent the spread of contaminants and protect water quality in Anderson Reservoir, which is used as a source of drinking water for several hundred thousand Santa Clara County residents. VOCs and perchlorate are routinely detected in surface waters at the site, particularly during the wetter winter months. Studies have shown this results from the transport of contaminants from surface soils via storm water runoff, as well as from the discharge of contaminated groundwater at creek gaining sections. Perchlorate is occasionally detected, at low concentrations, in Las Animas creek between the site boundary and Anderson Reservoir. Neither VOCs nor perchlorate have been detected to date in the reservoir, which is sampled monthly for perchlorate and quarterly for VOCs by the Santa Clara Valley Water District. It is appropriate to prohibit detectable concentrations of contaminants in surface waters at or beyond the property boundary to assure protection of the existing beneficial use downstream. Tasks 1 and 2 of this Order require the discharger to improve its storm water monitoring program to allow better quantification of the mass of contaminants entering the creeks during and after storms, and to design and implement measures in and downgradient of on-site source areas to eliminate the discharge of contaminants into the creeks.

## 7. Site Hydrogeology

*Hydrogeologic Units:* Developed portions of the site are located either in stream valleys filled with young, unconsolidated alluvium, or on hilly areas underlain by exposed or thinly buried bedrock. Bedrock at the site generally consists of poorly consolidated, non-marine sediments of the Santa Clara Formation, which is of Plio-Pleistocene age. The Santa Clara Formation is a heterogeneous assemblage of discontinuous fluvial deposits ranging from clays to sandy gravels, and dips to the northeast. The alluvium that fills the stream valleys consists of lenses and layers of clay, silt, sand and gravel. Santa Clara Formation underlies the stream valleys.

The Santa Clara Formation's ability to store and transmit water is variable, but it typically has a lower hydraulic conductivity than the alluvium. Hydraulic conductivities measured in the alluvium range from  $3 \times 10^{-2}$  cm/sec to  $2 \times 10^{-4}$  cm/sec, while hydraulic conductivities measured in the Santa Clara Formation range from  $2 \times 10^{-3}$  to  $1 \times 10^{-8}$  cm/sec. In general, the alluvium serves as an aquifer where it is saturated, whereas the Santa Clara Formation is believed to act as a barrier to vertical (and in some places, lateral) groundwater migration. Isolated lenses of groundwater have been identified in the deeper Santa Clara Formation between 50 and 70 feet below the ground surface.

*Hydrogeology of the Valleys:* In Shingle and Mixer valleys, groundwater occurs primarily in the alluvium, but also occurs in limited portions of the Santa Clara Formation in the upper portions of each valley. The alluvium attains a maximum thickness of approximately 50 feet. In Shingle Valley, the water table typically occurs between 15 to 40 feet below the ground surface. In Mixer Valley, groundwater is encountered in the alluvium at shallower depths, typically between 4 and 20 feet. Groundwater in the alluvium appears to be unconfined in some portions of the valleys and semi-confined in others. This situation is characteristic of fluvial deposits containing interbedded, laterally varying materials with contrasting permeability. Saturated alluvium generally overlies tighter Santa Clara deposits described as moist. However, in some areas saturated coarse-grained Santa Clara materials appear to be in contact with saturated alluvium, suggesting there may be localized hydraulic connections between the alluvial and Santa Clara Formation deposits.

*Hydrogeology of the Hills:* The other developed areas of the site are located in hilly areas underlain

primarily by Santa Clara Formation bedrock. These areas include the Motor Assembly Area and Component Test Area (MAA/CTA), the Research and Advanced Technology Area (R&AT) area, the Motor Test Area (MTA), and the Open Burning Facility (OBF).

The MAA/CTA is located in the hills upland of Shingle Valley. Groundwater in the MAA/CTA is generally first encountered in the Santa Clara Formation at depths between 25 and 70 feet. The R&AT and the MTA are located in side valleys adjacent to seasonal creeks that drain into Shingle Valley. The R&AT area and MTA are located either on alluvial soils or directly on Santa Clara Formation. Groundwater at the R&AT and MTA area is encountered at various depths ranging from approximately 14 to 42 feet in alluvium and Santa Clara Formation. Because of the geologic complexity of the Santa Clara Formation, it is difficult to determine groundwater flow pathways in the area. Available data suggest that the groundwater flow direction and orientation of the pollution plumes reflects the orientation of surface drainages in the tributary valleys. These tributary drainages contain surface flow only during the winter months.

The OBF is located on a north-sloping ridge of exposed Santa Clara Formation. Surface drainage is toward both the northwest and east. A thin layer of colluvium varying from 1 to 5 feet thick overlies the Santa Clara Formation. Some alluvium occurs in isolated locations along the two small drainages that trend north and west of the OBF. Groundwater flow at the OBF is extremely variable because of the lateral discontinuity of Santa Clara Formation deposits, and because of surface topography associated with the nearby Calaveras fault.

8. **Remedial Investigation and Remedial Measures:** Remedial investigations at the site began in the 1980s, and continue to be performed as needed to facilitate remedial efforts. Remedial measures to remove VOCs and other chemicals from soil and groundwater began in the late 1980s, and continue to the present. Earlier efforts at the site were focused on remediation of VOCs, while the current focus is on perchlorate remediation. Remedial investigations conducted since 1998 have generally established the extent of perchlorate contamination. Perchlorate has been detected in groundwater in most developed portions of the site, and the distribution generally coincides with the VOC plumes. The highest levels of perchlorate in soil and groundwater occur in the Oxidizer Road area, followed by Mixer Valley and the OBF.

Because of the size and complexity of the site, summaries of the remedial investigations and remedial measures are provided for each main area of the site.

### **Shingle Valley**

*Investigations:* Shingle Valley extends about 14,000 feet (2.5 miles) within the site property boundaries, and includes the most heavily developed areas of the facility. UTC has divided the valley into three investigative areas (Upper, Middle and Lower Shingle Valley). Investigations in Shingle Valley began in 1984, and have included 370 soil borings and installation of 148 monitoring wells.

Shingle Valley contains several VOC plumes and minor fuel hydrocarbon plumes that originated from numerous potential sources including historical drum storage areas, sumps, spills, fuel tanks, and abandoned open burning areas. Ten VOC source areas have been identified in Shingle Valley, including six in Upper Shingle Valley (USV), three in Middle Shingle Valley (MSV), and one in Lower Shingle Valley (LSV). The main VOC plume in USV is approximately 2,600 feet in length and approximately 600 feet wide. The maximum concentration of total VOCs in Shingle Valley groundwater (15,000 µg/L) occurs in the USV plume. The VOC plume in MSV is

approximately 4,200 feet in length and 700 feet in width. VOC concentrations in MSV are lower than those in USV, with a single well containing total VOCs at a concentration exceeding 1,000 ug/L.

The VOC plume in Lower Shingle Valley is approximately 1,300 feet long and up to 500 feet wide. Total VOC concentrations in the LSV plume are generally below 50 ug/L. The VOC plume extends to the property boundary, but extraction wells at the boundary have been effective at preventing offsite migration of VOCs. Since 1998, there has been only one detection of VOCs in one of the five offsite monitoring wells just outside the property boundary, and that detection was at a level well below the drinking water standard.

Shingle Valley also includes one major diesel fuel plume, near Station 0710. The plume extends approximately 400 to 500 feet downgradient of the station and is estimated to be about 250 feet wide. Concentrations of TPH-diesel as high as 700,000 µg/L in groundwater have been detected in the presence of floating product. In August 1996, the Station 0710 air-injection biosparge system was started to remediate groundwater impacted by diesel fuel by stimulating aerobic degradation of diesel by naturally occurring microorganisms. Floating product is removed by periodic manual bailing. The maximum concentration of TPH-diesel in groundwater in 2002 was 85,000 ug/L.

Perchlorate plumes are also present in Shingle Valley, but are smaller and contain lower concentrations than the perchlorate plumes in Mixer Valley and the OBF. The most significant perchlorate plume in USV, near Station 1950, has contained concentrations in groundwater as high as 1,900 µg/L. This plume is no longer than 900 feet. The MSV perchlorate plume is approximately 3500 feet in length and 600 feet in width. The highest perchlorate concentrations in Shingle Valley (9,600 µg/L) occur in the MSV plume.

The perchlorate plume in LSV extends to property boundary, and perchlorate is occasionally detected in two of the five offsite groundwater monitoring wells that lie just outside the boundary. LSV perchlorate concentrations have been measured as high as 227 µg/L. In 2002, the highest perchlorate concentration detected in LSV groundwater was 59 ug/L.

*Remedial Measures:* Soil vapor extraction (SVE) is implemented at source areas with soil VOC concentrations greater than 1 mg/kg total VOCs. Soil cleanup by SVE is currently conducted at 7 areas in Shingle Valley.

The discharger operates 33 extraction wells in Shingle Valley (14 in USV, 9 in MSV, and 10 in LSV) to reduce contaminant concentrations, limit plume migration, and to limit the discharge of contaminated groundwater into Shingle Creek. Groundwater extraction in LSV has the additional goal of preventing off-site migration of contaminants. Groundwater extracted from Upper and Middle Shingle Valley is treated for VOCs and perchlorate at groundwater treatment station (GTS) 2405. Groundwater extracted from Lower Shingle Valley is treated at GTS 2403. Effluent from the treatment systems is routed to holding ponds for on-site reuse.

#### **Research and Advanced Technology Area (R&AT)**

*Investigations:* The R&AT lies in a tributary valley to the west and south of Upper Shingle Valley, and drains into the upper part of USV. Characterization in the R&AT has included 46 soil borings

and installation of 5 monitoring wells. A small groundwater plume containing low levels of VOCs (up to 68 µg/L of TCE) was identified in the vicinity of a basement sump at Station 1710. Perchlorate was detected near the sump at concentrations up to 690 mg/kg in soil and 370 µg/L in groundwater.

*Remedial Measures:* UTC conducts groundwater extraction and treatment for VOCs and perchlorate at Station 1710. Water extracted from this area is treated at GTS 1710, a small-capacity treatment unit used specifically for Station 1710. VOC concentrations have generally remained below MCLs since 1992.

#### **Motor Test Area (MTA)**

*Investigations:* The MTA occupies a relatively large side valley that drains into Shingle Valley from the southwest. Investigations at the MTA have included 69 soil borings and installation of 9 monitoring wells. Solvent handling areas have been identified as a potential source of VOC pollution in the MTA area. Although soil impacts appear to be relatively minor, groundwater has been significantly impacted. Historic maximum groundwater concentrations include 2,300 µg/L TCE, 29,000 Freon 11, and 8,300 µg/L Freon 113. Perchlorate has been detected in groundwater at 130 µg/L. The groundwater pollution plume migrates through saturated alluvium northeastward toward Shingle Valley. Concentrations attenuate rapidly with distance from the source area. Monitoring wells were installed in both alluvium and within the Santa Clara Formation.

*Remedial Measures:* CSD operates one groundwater extraction well near the MTA source area. Extracted water is treated at GTS 2406, a small-capacity treatment unit specifically used for one well in the MTA. The treatment unit was shut down in 1998, when perchlorate was detected at GTS 2406. The unit was restarted again in 2003 after modifying operation of the unit to treat perchlorate. Because groundwater pumping rates in the area are low (less than 0.5 gpm), it is unclear whether groundwater in this area can be successfully remediated through extraction. Task 6 of this Order requires the discharger to evaluate whether alternative remedial technologies (such as in-situ chemical oxidation) might achieve better remedial results than groundwater extraction for VOCs. Despite the intermittent nature of remediation in the area, migration of the MTA plume appears to be minimal due to the slow groundwater flow rates.

#### **Motor Assembly Area/Component Test Area (MAA/CTA)**

*Investigations:* The MAA/CTA is situated in a hilly area underlain by Santa Clara Formation bedrock on the south side of Middle Shingle Valley. Investigations here have included 164 soil borings and installation of 17 monitoring wells. Three source areas were identified. Observed soil impacts were not particularly significant for VOCs other than methylene chloride and acetone, and no perchlorate was detected in soil in the area. However, high VOC concentrations were detected in groundwater within the Santa Clara Formation. TCE has been detected at a maximum concentration of 43,000 µg/L, Freon 11 at a maximum concentration of 330,000 µg/L, and Freon 113 at a maximum concentration of 8,500 µg/L. Perchlorate was detected at a maximum concentration of 102 µg/L in groundwater. Groundwater plumes migrating from each of the three MAA/CTA source areas appear to follow local surface drainage toward Shingle Valley. However, the MAA/CTA plumes do not appear to have migrated extensively, as VOC concentrations attenuate rapidly to less than 10 µg/L before reaching Shingle Valley alluvium.

*Remedial Measures:* Soil vapor extraction is currently performed at one source area to remediate acetone and methylene chloride contamination in soil. Groundwater extraction is performed in the MAA/CTA, however, because groundwater flow rates in the area are generally very low, it is unclear whether groundwater in this area can be remediated through extraction. Task 6 of this Order requires

the discharger to evaluate whether alternative remedial technologies (such as in-situ chemical oxidation) might achieve better remedial results than groundwater extraction for VOCs.

### Mixer Valley

*Investigations:* A series of groundwater investigations in Mixer Valley began in 1981 and ultimately resulted in 420 soil borings and the installation of 122 ground water monitoring wells with depths of up to 100 feet. Contaminant plumes originated from many potential sources including historical locations of drummed storage of various solvents, the Station 0706 Class I surface impoundment, and various inadvertent chemical releases. Six VOC source areas have been identified in Mixer Valley.

The major Mixer Valley groundwater plume currently contains concentrations of total VOCs up to 32,460 µg/L. The high concentrations suggest dense non-aqueous phase liquids (DNAPL) may be present in places, but DNAPL has not been identified. TCA and TCE are the major VOCs present, but vinyl chloride, 1,2-DCE, 1,1-DCE, and 1,1-DCA have also been detected. The Mixer Valley VOC plume is approximately 3,200 feet in length and 600 feet in width.

The Mixer Valley perchlorate plume is approximately 5,500 feet in length and 600 feet in width. Concentrations of perchlorate in Mixer Valley groundwater are highly elevated. The highest concentration of perchlorate in groundwater was measured at 1,282,000 µg/L in the Oxidizer Road area. Several monitoring wells in the Oxidizer Road area contain perchlorate at concentrations that routinely exceed 10,000 ug/L. Surface and shallow soils in the Oxidizer Road area also contain elevated levels of perchlorate, which is picked up by storm water runoff and transported into Mixer Creek. Storm water runoff samples from the Oxidizer Road drainages collected in a 2001 study yielded perchlorate at levels up to 82,000 ug/L. A significant mass of perchlorate is transported into surface water from contaminated soil areas into surface water during storms. In addition to the problem with storm water runoff, hydrologic studies have confirmed that groundwater containing high concentrations of perchlorate discharges into surface water in Mixer Creek. The surface water monitoring program for the site needs to be expanded to allow better monitoring and quantification of perchlorate discharge to streams during and after storm events.

In addition to the VOC and perchlorate plumes, Mixer Valley also contains a station that has been impacted by polychlorinated biphenyls (PCBs) and non-fuel petroleum hydrocarbons (TPH).

*Remedial Measures:* Five of the six VOC source areas in Mixer Valley are being remediated by SVE; remedial alternatives are still being evaluated for the sixth. Groundwater plumes are being remediated through extraction and treatment. The discharger currently operates 14 extraction wells in Mixer Valley. All extracted water is treated for VOCs and perchlorate at GTS 2404, then routed to a holding pond for on-site reuse.

The primary remedial strategy to reduce the discharge of perchlorate-contaminated groundwater to surface water is to lower the groundwater elevations in the dominant pathway areas. Reduction of perchlorate concentrations in soil is another remedial goal in Mixer Valley. A successful pilot test of

anaerobic soil composting conducted in 2001 demonstrated an effective technology for treating perchlorate-impacted soils to less than 1 mg/kg of perchlorate. Task 4 of this Order requires the discharger to evaluate remedial technologies for perchlorate contamination in surface and subsurface soils.

The PCB source area in Mixer Valley has been treated through soil excavation and groundwater extraction and treatment. Approximately 2,400 cubic yards of PCB-contaminated soil was excavated in October 1995. Soil was excavated to a total depth of 25 feet and soil cleanup goals were met. PCB-contaminated groundwater is being remediated by a groundwater treatment system consisting of 3 extraction wells and an aqueous granular activated carbon treatment unit.

### **Open Burn Facility (OBF)**

*Investigations:* Extensive investigations have been conducted in and around the OBF, including 197 soil borings and installation of 60 groundwater monitoring wells. Several sources of soil and groundwater pollution have been identified, including several open burn units (OBUs) and areas designated as the Areas 1, 3, and 7, and the "Debris Area."

The most significantly impacted soils were found in OBU-3 and OBU-5, with levels of up to 1,300 mg/kg total VOCs. Low levels of PCBs were also detected in the OBUs. Areas 1, 3, and 7 contained metals, VOCs, semi-volatile organic compounds (SVOCs), PCBs, and other chemicals. Low levels of VOCs were also detected at the Debris Area. Surface soil sampling to assess the potential for perchlorate runoff impact to surface water yielded a maximum perchlorate concentration of 0.44 mg/kg.

Groundwater impacts at the OBF are significant. TCE was detected in groundwater at a maximum of 260,000 µg/L and TCA at a maximum of 14,000 µg/L. Perchlorate has been detected in most OBF groundwater monitoring wells, with a maximum concentration in groundwater of 52,000 µg/L. PCBs have not been detected in groundwater.

Hydrogeologic investigations suggest that groundwater at the OBF may be physically isolated to some extent. There is little evidence to date of extensive migration of contaminated groundwater away from the OBF area. The OBF is underlain by Santa Clara Formation bedrock of varying lithology and permeability. Three distinct water-bearing zones have been delineated. The water-bearing materials in the top two zones appear to pinch-out or be truncated by unconformities to the north, south, and west and to be truncated by the Calaveras Fault to the east/northeast.

*Remedial Measures:* UTC excavated and removed most contaminated soils in and around the OBF prior to 1995. Areas excavated include OBU-1 and 2, Areas 1, 3, and 7, and the Debris Area. Soils excavated from OBU-1 and OBU-2 were placed in OBU-5 for treatment by SVE. A portion of impacted soil at the OBU-3 containing visible ash was also removed from the site and transported to an offsite permitted hazardous waste facility. The remainder of the impacted soils in OBU-3 and OBU-5 are currently being cleaned up utilizing SVE systems.

Groundwater in the OBF is currently being remediated by the operation of 15 extraction wells. Extracted groundwater is pumped to GTS 2404 in Mixer Valley where it is treated for VOCs and perchlorate. UTC's evaluation of the performance of the groundwater extraction system in 1996, along with subsequent groundwater monitoring, suggests the groundwater extraction system is reducing chemical concentrations and generally preventing migration of the VOC plume. Because of

perchlorate's greater mobility, the ability of the extraction system to control perchlorate migration is less certain. Two monitoring wells (RI-45W and RI-46W) located along the UTC property boundary on the north side of the OBF have shown high concentrations of perchlorate (4,660 ug/L and 1,700 ug/L, respectively) in recent years, suggesting that perchlorate is migrating northward into the offsite area. In 2003, these monitoring wells were converted to extraction wells to provide additional plume migration control at the property boundary. UTC is required to install new monitoring wells in the offsite area north of the property boundary to allow downgradient monitoring of the new extraction wells' effectiveness. These new wells should provide information on the extent to which contaminated groundwater may have migrated into this area.

**Remedial Effectiveness Evaluation:** Between 1998 and 2002, a total of 238 pounds of VOCs were removed from site groundwater by the five GTS systems. Very little perchlorate was removed by the treatment systems prior to 2001 - 2002, when ion exchange resin beds were installed at GTS 2403 and 2404. Perchlorate is currently removed in GTS 2405 by performing more frequent carbon change-outs. The following table shows the amount of chemicals (in pounds) removed from groundwater by each groundwater treatment system in 2002.

**Table 1: Pounds of Chemicals Removed from Groundwater in 2002**

Chemical	GTS 1710	GTS 2403	GTS 2404	GTS 2405	GTS 2406
VOCs	0.003	1.9	25.0	53.8	0
Perchlorate	0	0.3	450	13.1	0

9. **Adjacent sites:** The area surrounding the UTC facility is undeveloped ranch land. No chemical sources have been identified in the areas adjacent to UTC that have impacted the UTC site.

Two offsite areas may potentially be impacted by releases from the UTC site. One of these is the area on the north side of the OBF, as discussed above (Finding 8). Surface drainage patterns limit the extent to which the property north of the OBF has been impacted by contaminated surface runoff or groundwater migration from the OBF. Of greater concern are the potential impacts to Anderson Reservoir, which receives the combined surface flow from all the creeks that pass through the site. As discussed in Finding 6, all of these creeks periodically contain chemicals (especially perchlorate) released from the UTC site. Anderson Reservoir is located approximately 800 to 4000 feet south of the point where Shingle Creek crosses the site boundary, depending on the volume of water stored in the reservoir.

10. **Environmental Risk Assessment:** In 1992, UTC performed a baseline risk assessment and a human health and environmental health evaluation. Primary chemicals of interest and their toxicity were determined, and potential exposure pathways were identified. Risks were identified for carcinogenic and noncarcinogenic chemicals in soil, water, and air, and compared to the acceptable risk range.

In the report entitled *Proposed Final Remedial actions and Cleanup Standards for Operable Unit 2* (December 1997), UTC provided a risk assessment for current industrial cleanup exposures to chemicals of concern, including VOCs and SVOCs. The report also evaluated risk from potential residential exposure to current site conditions, which reflects more health-protective criteria. For industrial receptors, the pathway for exposure to carcinogenic and potentially carcinogenic chemicals is inhalation of vapors and dermal contact with soil. For residential receptors, ingestion of

groundwater is the primary pathway for exposure. A less significant pathway is inhalation of dust. Exposure to TCE represented the greatest cancer risk. Although the current estimated potential increased health risks to industrial receptors did not exceed the EPA guidelines, the current risks to potential residential receptors was found to be excessive. Assuming chemical concentrations proposed for soil and groundwater cleanup standards are achieved before the site would be developed for residential occupancy, the estimated carcinogenic risks would be below acceptable levels.

In December 2003, UTC submitted an addendum to the 1997 risk assessment that evaluated the human health risk posed by two additional chemicals, perchlorate and 1,4-dioxane (1,4-dioxane was used as a stabilizer in some blends of 1,1,1-TCA). On the basis of the perchlorate risk assessment, the addendum proposed cleanup standards for perchlorate of 0.02 mg/kg in soil and 6 ug/L in water. The addendum proposed cleanup standards for 1,4-dioxane of 0.002 mg/kg in soil and 3 ug/L in groundwater. The low soil cleanup standards for these chemicals reflect the ease with which these chemicals are leached from soil, and were driven primarily by the goal of protecting groundwater quality rather than limiting human exposure.

The Water Board considers the following risks to be acceptable at remediation sites: a hazard index of 1.0 or less for non-carcinogens, and an excess cancer risk of  $10^{-4}$  or less for carcinogens.

Due to excessive risk that will be present at the site pending full remediation, the discharger has implemented institutional controls to limit on-site exposure to acceptable levels. Institutional constraints include a deed restriction, and measures to maintain site security and require worker notification of potential health and safety concerns due to the presence of hazardous chemicals in the environment. The deed restriction, approved by the Water Board's Executive Officer and recorded with Santa Clara County in 2002, prohibits the use of shallow groundwater for drinking water at the site. The deed restriction also prohibits residential development at the OBF and restricts use of the OBF for sensitive uses such as hospitals or day care centers.

11. **Feasibility Study:** The 1991 *RCRA Facility Investigation/Corrective Measures Study* included an evaluation of remedial alternatives for groundwater and soil at the UTC site. Also, a list of possible alternatives was developed and evaluated in the discharger's report titled *Proposed Final Remedial Actions and Cleanup Standards for Operable Unit 2* (dated December 1997). Additional alternatives for perchlorate remediation have been considered since 2000.

The objectives for soil remediation are to reduce chemical concentrations in vadose-zone soils to below the cleanup goals and to prevent further impacts to groundwater. The objectives for groundwater remediation are to stop migration of the leading edges of the plumes, minimize migration of the high mass of contamination at source areas, and to reduce chemical concentrations in groundwater within the plumes to below the groundwater cleanup goals.

Remedial actions considered for contaminated soils include no action, soil vapor extraction, soil leaching, biodegradation, excavation and offsite disposal, high temperature incineration, low temperature thermal stripping, and onsite soil washing. Newer technologies were also evaluated, including phytoremediation, in-situ soil flushing, enhanced soil vapor extraction, and anoxic soil composting.

Remedial actions considered for groundwater include no action, subsurface barriers, gradient control, and groundwater extraction and treatment. New groundwater remedial technologies were also evaluated, including in-well air stripping, reactive wells, reactive barriers, oxygen-reducing zones.

The use of ion exchange resin beds has been evaluated as a means of removing perchlorate from extracted groundwater.

12. **Remedial Action Plan:** The discharger's report entitled *RCRA Facility Investigation/ Corrective Measures Study* and its addenda (dated June 1991 and June 1993, respectively) proposed a final cleanup plan for VOCs in Shingle Valley and Mixer Valley. The report entitled *Proposed Final Remedial Actions and Cleanup Standards for Operable Unit 2* (dated December 1997) proposed a final cleanup plan for VOCs in the Research and Advanced Technology area, Motor Test Area, Motor Assembly Area/Component Test Area, and the Open Burning Facility.

The *Five-Year Status Report and Remediation Effectiveness Evaluation* (July 2003) contained an evaluation of the remedial actions that have been implemented at the site between 1998 and 2002 and a summary of new, alternate technologies currently under consideration. This report determined that the remedial actions currently implemented for soil and groundwater cleanup are effective and recommended that these actions be continued.

**Final Remedial Action Plan for VOCs:** The final remedial actions currently implemented to address VOC contamination at the site are as follows:

*Groundwater and surface water:* The discharger plans to continue operation of the existing groundwater extraction and treatment systems to remove chemical mass, reduce concentrations, prevent vertical or lateral migration of contaminants, to prevent seepage of contaminated groundwater into creeks, and to restore groundwater quality. Extracted groundwater is treated at several treatment (GTS) units located throughout the site. These include GTS 2403 and 2405 in Shingle Valley, GTS 1710 in the R&AT area, GTS 2406 in the MTA, and GTS 2404 in Mixer Valley. Water extracted from the OBF area is piped to Mixer Valley for treatment at GTS 2404. Each treatment unit consists of an air stripper and carbon adsorption units with the exception of GTS 1710, 2405, and 2406, which use aqueous-phase carbon only. PCB-contaminated groundwater at Station 0535 in Mixer Valley is treated with aqueous-phase carbon at GTS 0535, then routed to GTS 2404 for further treatment.

*Soil:* Continuation of the existing soil vapor extraction systems to prevent leaching of volatile chemicals from the soil to the underlying groundwater, and to prevent volatilization to the atmosphere. UTC currently operates 15 stationary SVE units, and uses 2 mobile, trailer-mounted SVE units. All identified sources will be treated to achieve soil cleanup standards. A source is defined as soils containing one or more chemicals at concentrations above the cleanup standards established for those chemicals.

*Alternate remedial measures:* The performance of the current soil and groundwater remedial actions will be re-evaluated periodically and if necessary, modifications to the remedial measures will be proposed and implemented.

**Interim Remedial Actions for Perchlorate:** The final cleanup plan summarized above was approved and implemented in the 1990s, prior to the recognition of perchlorate as a significant environmental and human health hazard. For this reason, the final remedial plan was focused on removal of VOCs. Since 2000, UTC has augmented its site cleanup strategies to include measures to reduce perchlorate concentrations in soil and groundwater; to control the migration of groundwater containing perchlorate; and to minimize the discharge of perchlorate into creeks. Anaerobic soil composting is successfully being used to reduce perchlorate concentrations in soil. Measures currently being implemented to address perchlorate contamination in groundwater include:

- operation of extraction wells to collect and treat perchlorate-contaminated water, and to depress the water table and inhibit discharge into creeks;
- addition of ion exchange resin beds to the treatment systems at GTS 2403 and 2404 to remove perchlorate from extracted groundwater;
- increasing the frequency of carbon change-outs at GTS 1710, 2405, and 2406 to prevent perchlorate breakthrough.

13. **Basis for Cleanup Standards:**

- a. **General:** State Board Resolution No. 68-16, "Statement of Policy with Respect to Maintaining High Quality of Waters in California," applies to this discharge and requires attainment of background levels of water quality, or the highest level of water quality which is reasonable if background levels of water quality cannot be restored. Cleanup levels other than background must be consistent with the maximum benefit to the people of the State, not unreasonably affect present and anticipated beneficial uses of such water, and not result in exceedence of applicable water quality objectives. The previously cited remedial action plan confirms the Board's initial conclusion that background levels of water quality cannot be restored. This order and its requirements are consistent with Resolution No. 68-16.

State Board Resolution No. 92-49, "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304," applies to this discharge. This order and its requirements are consistent with the provisions of Resolution No. 92-49, as amended.

- b. **Beneficial Uses:** The Water Board adopted a revised Water Quality Control Plan for the San Francisco Bay Basin (Basin Plan) on June 21, 1995. This updated and consolidated plan represents the Water Board's master water quality control planning document. The revised Basin Plan was approved by the State Water Resources Control Board and the Office of Administrative Law on July 20, 1995, and November 13, 1995, respectively. A summary of regulatory provisions is contained in Title 23, California Code of Regulations, Section 3912. The Basin Plan defines beneficial uses and water quality objectives for waters of the State, including surface waters and groundwaters.

Board Resolution No. 89-39, "Sources of Drinking Water," defines potential sources of drinking water to include all groundwater in the region, with limited exceptions for areas of high TDS, low yield, or naturally high contaminant levels. Groundwater underlying and adjacent to the site qualifies as a potential source of drinking water.

The Basin Plan designates the following potential beneficial uses of groundwater underlying and adjacent to the site:

- Municipal and domestic water supply
- Industrial process water supply
- Industrial service water supply
- Agricultural water supply
- Freshwater replenishment to surface waters

At present, there is no known use of groundwater underlying the site for the above purposes other than replenishment to the creeks that flow through the site.

A drinking water reservoir, Anderson Reservoir, is located 800 to 4000 feet south of the point where Shingle Creek leaves the discharger's property. The existing and potential beneficial uses of Anderson Reservoir include:

- a. Municipal supply
- b. Groundwater recharge
- c. Non - contact water recreation
- d. Warm and cold water habitat
- e. Wildlife habitat
- f. Fish spawning

- c. **Basis for Groundwater and Surface Water Cleanup Standards:** The groundwater cleanup standards for the site are based on applicable water quality objectives and are the more stringent of USEPA and California primary maximum contaminated levels (MCLs) for each chemical of concern. For chemicals that do not have established MCLs, current California provisional action levels or public health goals are used, if such exist. Secondary drinking water standards, based on taste and odor characteristics, were not used in setting cleanup standards at this site.

Because groundwater discharges to creeks that flow through the site, and these creeks discharge into Anderson Reservoir, which is used as a source of drinking water, the same cleanup standards are generally applied to surface water at the site. To protect aquatic life, surface water cleanup standards for some chemicals are lower than drinking water standards. Groundwater and surface water cleanup standards for the site are summarized in Table 2 (page 17). Cleanup to these levels will result in acceptable residual risk to humans.

- d. **Basis for Soil Cleanup Standards:** The soil cleanup standards for the site are summarized in Table 3 (page 18). Cleanup to these levels is intended to minimize leaching of contaminants to groundwater and will result in acceptable residual risk to humans.

14. **Future Cleanup Standards:** The goal of this remedial action is to restore the beneficial uses of groundwater underlying and adjacent to the site. Results from other sites suggest that full restoration of beneficial uses to groundwater as a result of active remediation at this site may not be possible. If full restoration of beneficial uses is not technologically or economically achievable within a reasonable period of time, then the discharger may request modification to the cleanup standards or establishment of a non-attainment area, a limited groundwater pollution zone where water quality objectives are exceeded. Conversely, if new technical information indicates that cleanup standards can be surpassed, the Water Board may decide that further cleanup actions should be taken.
15. **Water Reclamation:** California Water Code Section 13512 declares it is the intention of the Legislature that the State undertake all possible steps to encourage development of water reclamation facilities so that reclaimed water may be made available to help meet the growing water demands of the State. State Water Board Resolution No. 88-160 allows discharges of extracted, treated groundwater from site cleanups to surface waters only if it has been demonstrated that neither reclamation nor discharge to the sanitary sewer is technically and economically feasible.

Consistent with this policy, treated effluent has been used extensively throughout the site, under a Water Reclamation Requirements order issued by the Water Board in 1991 (Order 91-006). UTC reclaims groundwater that is extracted for remediation purposes throughout the site, and reuses it for various purposes such as dust control, landscape irrigation and pasture irrigation. Treated water from GTS 2403, 2404, and 2405 is discharged to Ponds 2140 and 2130 for storage prior to reuse. At times in the past (such as during extended droughts), treated groundwater was also used (as permitted in Order 91-006) for dust control at nearby offsite areas such as the motorcycle park on Metcalf Road, and for dust control and soil compaction during construction of the Silver Creek Country Club.

Prior to 2001, the approved groundwater treatment and reuse systems were designed to treat groundwater containing VOCs, and had a limited capability to remove perchlorate. Because of this limitation, variable concentrations of perchlorate were present in the treated water. Through the practice of using treated effluent for water reclamation purposes, perchlorate was released at the site and to nearby offsite areas at low concentrations. Since the installation of new treatment technologies to remove perchlorate, the treated effluent from the GTS units is now free of detectable perchlorate.

This Order rescinds Order 91-006 and prohibits the use of reclaimed water outside the UTC property. However, on-site reuse of reclaimed water is still permitted, subject to the requirements specified in Section D of this order (page 25).

16. **Basis for 13304 Order:** The discharger has caused or permitted waste to be discharged or deposited where it is or probably will be discharged to waters of the State and creates or threatens to create a condition of pollution or nuisance.
17. **Cost Recovery:** Pursuant to California Water Code Section 13304, the discharger is hereby notified that the Water Board is entitled to, and may seek reimbursement for, all reasonable costs actually incurred by the Water Board to investigate unauthorized discharges of waste and to oversee cleanup of such waste, abatement of the effects thereof, or other remedial action required by this order.
18. **CEQA:** This action is an Order to enforce the laws and regulations administered by the Water Board. This action is categorically exempt from the provisions of the California Environmental Quality Act (CEQA) pursuant to Section 15321 of the Resources Agency Guidelines.
19. **Notification:** The Water Board has notified the discharger and all interested agencies and persons of its intent under California Water Code Section 13304 to prescribe Site Cleanup Requirements for the discharger and has provided them with an opportunity for a public hearing and an opportunity to submit their written views and recommendations.
20. **Public Hearing:** The Water Board, at a public meeting, heard and considered all comments pertaining to this discharge.

**IT IS HEREBY ORDERED**, pursuant to Sections 13304 and 13523 of the California Water Code, that the discharger (or its agents, successors, or assigns) shall cleanup and abate the effects described in the above findings as follows:

**A. PROHIBITIONS**

1. The discharge, storage, or treatment of wastes or materials in a manner that will degrade groundwater or surface water quality or adversely affect beneficial uses of the waters of the State is prohibited.
2. Further significant migration of pollutants through surface or subsurface transport to waters of the State is prohibited.
3. Activities associated with the subsurface investigation and cleanup that will cause significant adverse migration of wastes or hazardous substances are prohibited.
4. The discharge of contaminated groundwater into creeks and surface water is prohibited. Specifically, no detectable concentrations of contaminants shall be allowed in surface waters or underflow at or beyond the property boundary, and no concentrations of contaminants in excess of cleanup standards shall be allowed in on-site surface waters.

**B. CLEANUP PLAN AND STANDARDS**

1. **Implement Cleanup Plan:** The discharger shall implement the remedial action plan described in Finding 12.
2. **Groundwater and Surface Water Cleanup Standards:** The groundwater cleanup standards specified in Table 2 shall be met in all wells. These same standards shall apply to surface waters in drainages and streams because these streams discharge into Anderson Reservoir.

**Table 2: Groundwater / Surface Water Cleanup Standards**

Chemical	Groundwater / Surface Water Cleanup Goal (ug/L) <sup>a</sup>
Acetone	700
Benzene	1
Chlorobenzene	50 (25 for surface water <sup>b</sup> )
Chloroform	100
Carbon tetrachloride	0.5
1,1-Dichloroethene	6
1,1-Dichloroethane	5
<i>cis</i> -1,2-Dichloroethene	6
1,2-Dichloroethane	0.5
1,4-Dioxane	3
Freon 11	150
Freon 113	1,200
Methylene chloride (Dichloromethane)	5

Tetrachloroethene (PCE)	5
Perchlorate	6 <sup>c</sup>
Phenol	4,200 (1,300 for surface water <sup>b</sup> )
Polychlorinated biphenyls (PCBs)	0.5
TPH-diesel	1,000 (200 for surface water <sup>b</sup> )
Trichloroethene (TCE)	5
1,1,1-Trichloroethane (TCA)	200 (60 for surface water <sup>b</sup> )
Toluene	150
Vinyl chloride	0.5
Xylenes	1,750 (13 for surface water <sup>b</sup> )

<sup>a</sup> Groundwater cleanup standards are set at the primary Maximum Contaminant Level (MCL) or drinking water standard for each chemical. For chemicals that do not have an established MCL, the State of California provisional action level or Public Health Goal (PHG) is used as the cleanup standard.

<sup>b</sup> For most chemicals, the surface water cleanup standards are the same as for groundwater. To protect aquatic life, surface water cleanup standards for chlorobenzene, phenol, 1,1,1-TCA, xylenes, and TPH-diesel are set lower than drinking water standards. The surface water standard for these chemicals also applies to groundwater within 75 feet of surface water bodies.

<sup>c</sup> Cal/EPA issued a Public Health Goal of 6 ug/L for perchlorate in March 2004. Cal/EPA will use the PHG to establish an MCL for perchlorate. The groundwater cleanup standard is currently set equal to the PHG. If the MCL differs from the PHG, Water Board staff will consider changing the cleanup standard for perchlorate to the MCL.

3. **Soil Cleanup Standards:** The soil cleanup standards specified in Table 3 shall be met in all source areas.

**Table 3: Soil Cleanup Standards**

Chemical	Cleanup Goal mg/kg
Total VOCs	1
1,4-Dioxane	0.002 <sup>a</sup>
PCBs less than 3 feet deep	3
PCBs greater than 3 feet deep	10

Perchlorate	0.020 <sup>a</sup>
TPH-diesel	500

<sup>a</sup> Based on results of 2003 Risk Assessment addendum. These cleanup standards reflect the tendency of these chemicals to leach from soil into groundwater, and will be protective of groundwater quality.

**C. TASKS**

**1. ENHANCED SURFACE WATER MONITORING PROGRAM**

**1a. WORK PLAN FOR ENHANCED SURFACE WATER MONITORING**

COMPLETION DATE: July 3, 2004

Submit a technical report acceptable to the Executive Officer that provides a detailed plan to expand the surface water monitoring program beyond the current program of monthly creek sampling to a program that includes real-time storm water monitoring and sampling. The plan must include, at a minimum:

- an evaluation of the hydrology of the Shingle Creek, Mixer Creek, and Las Animas Creek watersheds;
- a discussion of techniques to be implemented at the site to provide automated measurement of stream discharge during and after storm events and collection of flow-activated creek samples during peak flows; and
- a schedule for implementation of the new monitoring techniques.

The program must facilitate the quantification of dissolved contaminant mass and mass flux at designated creek sampling stations during and after storm events, especially in Las Animas Creek between the site boundary and Anderson Reservoir. Once the enhanced surface water monitoring plan is approved, UTC shall amend the Environmental Monitoring Program Plan (EMPP) reflecting the changes to the monitoring program.

**1b. IMPLEMENTATION OF ENHANCED SURFACE WATER MONITORING PROGRAM**

COMPLETION DATE: According to Schedule in Task 1a, as approved by Executive Officer

Submit a technical report acceptable to the Executive Officer that documents the completion of the tasks identified in the technical report submitted for Task 1a. Henceforth, surface water and storm water monitoring results are to be reported to the Regional Water Quality Control Board, San Francisco Bay Region. Storm water monitoring results will also be submitted to the State Water Board's storm water monitoring program in Sacramento.

2. **ELIMINATION OF PERCHLORATE DISCHARGE TO CREEKS**

2a. **WORK PLAN FOR ELIMINATION OF PERCHLORATE DISCHARGE TO CREEKS**

COMPLETION DATE: September 1, 2004

Submit a technical report acceptable to the Executive Officer that provides a detailed plan for remedial measures that will be implemented to promptly reduce, and ultimately eliminate, the amount of perchlorate entering creeks and drainages from known source areas of historical perchlorate contamination at the site. The report must:

- list and compare remedial methods that were evaluated for use at the site to reduce perchlorate discharge;
- describe any remedial methods that have been pilot-tested or implemented as interim remedial actions;
- summarize available results of any interim remedial actions implemented to date; and
- provide a detailed plan and schedule of how and when the selected remedial methods will be implemented as final remedial method(s) across the site.

2b. **IMPLEMENTATION OF REMEDIAL MEASURES TO ELIMINATE PERCHLORATE DISCHARGE TO CREEKS**

COMPLETION DATE: According to Schedule in Task 2a, as approved by Executive Officer

Submit a technical report acceptable to the Executive Officer that documents the completion of the tasks identified in the technical report submitted for Task 2a.

3. **ENHANCED LAS ANIMAS AREA GROUNDWATER MONITORING**

3a. **WORK PLAN FOR ENHANCED LAS ANIMAS AREA GROUNDWATER MONITORING**

COMPLETION DATE: September 30, 2004

Submit a technical report acceptable to the Executive Officer that provides a detailed plan to enhance the groundwater monitoring program along Las Animas Creek in the vicinity of the downgradient property boundary. The goal of the enhanced monitoring is to ensure that an adequate array of sentry wells exists in the Las Animas Creek corridor beyond the leading edge of the Lower Shingle Valley contaminant plumes. An additional goal is to ensure that stream baseflow is adequately monitored. Should additional wells be necessary to achieve these goals, the report must:

- propose suitable locations for the new groundwater monitoring wells;

- provide a schedule for installation of the wells; and
- provide a schedule for measuring water levels and collecting representative samples from the wells.

Alternatively, a detailed plan may be provided that enhances control of the LSV contaminant plumes such that existing wells function satisfactorily as sentry wells. Once the plan and schedule are approved by the Water Board, UTC shall submit an addendum to the EMPP reflecting any changes to the monitoring program.

**3b. IMPLEMENTATION OF ENHANCED LAS ANIMAS AREA GROUNDWATER MONITORING PLAN**

COMPLETION DATE: According to Schedule in Task 3a, as approved by Executive Officer

Submit a technical report acceptable to the Executive Officer that documents the completion of the tasks identified in the technical report submitted for Task 3a.

**4. CHARACTERIZATION AND REMEDIATION OF PERCHLORATE CONTAMINATION IN SOIL**

**4a. SUBMIT WORK PLAN FOR PERCHLORATE CHARACTERIZATION IN SOIL**

COMPLETION DATE: June 30, 2004

Submit a technical report acceptable to the Executive Officer that discusses the work plan for characterization of the extent of perchlorate contamination in surface soil at the site.

**4b. SUBMIT PERCHLORATE CHARACTERIZATION REPORT FOR SURFACE SOIL**

COMPLETION DATE: January 31, 2005

Submit a technical report acceptable to the Executive Officer that documents characterization of the extent of perchlorate contamination in surface soil. Soil characterizations should be performed using the best achievable detection limit.

**4c. SUBMIT WORK PLAN FOR PILOT TESTING OF SURFACE SOIL TREATMENT TECHNOLOGIES**

COMPLETION DATE: September 1, 2004

Submit a technical report acceptable to the Executive Officer that discusses the work plan for pilot testing of perchlorate treatment technologies in surface soil at the site.

4d. **COMPLETION OF PILOT TESTING OF SURFACE SOIL TREATMENT TECHNOLOGIES**

COMPLETION DATE: February 28, 2005

Submit a technical report acceptable to the Executive Officer that documents the completion of the tasks identified in Task 4b.

4e. **SUBMIT PERCHLORATE CHARACTERIZATION REPORT FOR SUBSURFACE SOIL**

COMPLETION DATE: March 31, 2005

Submit a technical report acceptable to the Executive Officer that documents characterization of the extent of historical perchlorate contamination at the site in subsurface soil. Soil characterizations should be performed using the best achievable detection limit.

4f. **SUBMIT EVALUATION OF ALTERNATIVE REMEDIAL TECHNOLOGIES AND REMEDIAL ACTION PLAN SUPPLEMENT FOR PERCHLORATE IN SOIL**

COMPLETION DATE: August 30, 2005

Submit a technical report acceptable to the Executive Officer evaluating the feasibility of using remedial alternatives such as anoxic bioremediation, to achieve significant chemical mass reductions in source area soils, and proposes a final action plan for remediation of perchlorate in soil. The report should include:

- A comparison of all alternative remediation methods that were considered, pilot-tested, or implemented as interim remedial actions in the evaluation;
- A detailed summary of the results of the evaluation; and
- Recommendations based on the evaluation results.
- A detailed plan and schedule of how and when the selected remedial methods will be implemented as final remedial method(s) across the site.

4g. **IMPLEMENTATION OF FINAL REMEDIAL MEASURES FOR PERCHLORATE CONTAMINATION IN SOIL**

COMPLETION DATE: According to Schedule in Task 4e, as approved by the Executive Officer

Submit a technical report acceptable to the Executive Officer that documents the completion of the tasks identified in the technical report submitted for Task 4e.

5. **CHARACTERIZATION AND REMEDIATION OF PERCHLORATE CONTAMINATION IN GROUNDWATER**

5a. **SUBMIT WORK PLAN FOR PERCHLORATE CHARACTERIZATION IN GROUNDWATER**

COMPLETION DATE: June 30, 2004

Submit a technical report acceptable to the Executive Officer that discusses the work plan for characterization of the extent of perchlorate contamination in groundwater at the site.

5b. **COMPLETE CHARACTERIZATION OF PERCHLORATE CONTAMINATION IN GROUNDWATER**

COMPLETION DATE: January 31, 2005

Submit a technical report acceptable to the Executive Officer that documents complete characterization of the extent of perchlorate contamination at the site in groundwater. Groundwater characterizations should be performed using the best available method detection limit to define the extent of perchlorate contamination. Characterizations should extend off-site as necessary to define the full, lateral extent of plumes. The report must include concentration contour maps showing the lateral extent of perchlorate plumes.

5c. **SUBMIT EVALUATION OF REMEDIAL TECHNOLOGIES AND REMEDIAL ACTION PLAN SUPPLEMENT FOR PERCHLORATE IN GROUNDWATER**

COMPLETION DATE: April 30, 2005

Submit a technical report acceptable to the Executive Officer evaluating the feasibility of using alternative remedial methods, such as in-situ chemical oxidation or enhanced anoxic bioremediation, to achieve significant chemical mass reductions in source areas, and proposes a final action plan for remediation of perchlorate in groundwater. The report should include:

- A summary of all source areas and other portions of the site where groundwater extraction may fail to achieve target remediation goals;
- A comparison of all remediation methods that were considered, pilot-tested or implemented as interim remedial actions in the evaluation;
- A detailed summary of the results of the evaluation; and
- Recommendations based on the evaluation results.
- A detailed plan and schedule of how and when the selected remedial methods will be implemented as final remedial method(s) across the site.

5d. **IMPLEMENTATION OF FINAL REMEDIAL MEASURES FOR PERCHLORATE IN GROUNDWATER**

COMPLETION DATE: According to Schedule in Task 5b, as approved by the Executive Officer

Submit a technical report acceptable to the Executive Officer that documents the completion of the tasks identified in the technical report submitted for Task 5.

**6. EVALUATION OF ALTERNATIVE REMEDIAL TECHNOLOGIES FOR VOCS**

**6a. SUBMIT EVALUATION OF ALTERNATIVE REMEDIAL TECHNOLOGIES FOR VOCS**

COMPLETION DATE: May 31, 2006

Submit a technical report acceptable to the Executive Officer evaluating the feasibility of using alternative remedial methods, such as in-situ chemical oxidation or enhanced anaerobic bioremediation, to achieve significant VOC mass reductions in source areas where groundwater extraction has been shown to be incapable of fully achieving target remediation goals. Examples of such areas include the area near Station 1710 in the R & AT area, and the MTA. The report should include:

- A summary of all source areas and other portions of the site where groundwater extraction has failed to achieve target remediation goals;
- A comparison of all alternative remediation methods that were considered in the evaluation;
- A detailed summary of the results of the evaluation; and
- Recommendations based on the evaluation results.

**6b. IMPLEMENTATION OF ALTERNATIVE REMEDIAL TECHNOLOGIES FOR VOCS**

COMPLETION DATE: According to Schedule in Task 6a, as approved by the Executive Officer

Submit a technical report acceptable to the Executive Officer that documents the completion of the tasks identified in the technical report submitted for Task 6a.

**7. FIVE-YEAR STATUS REPORT AND EFFECTIVENESS EVALUATION**

COMPLETION DATE: April 30, 2009, and every five years thereafter

Submit a technical report acceptable to the Executive Officer which includes a summary of the results of any additional investigation; an evaluation of the effectiveness of installed final cleanup measures and cleanup costs for the prior 5-year period; additional recommended measures to achieve final cleanup levels, if necessary; and the tasks and time schedule necessary to implement any additional final cleanup measures. This report shall also describe the reuse of extracted groundwater and evaluate and document the cleanup of contaminated groundwater. If cleanup standards in this Order have not been achieved on-site and are not expected to be achieved through continued groundwater extraction and/or soil remediation, this report shall also contain an evaluation addressing whether it is technically practicable to achieve the cleanup standards, and if so, a proposal for procedures to do so. This report shall also include cumulative stream discharge, groundwater level, and analytical data for the five-year period.

**8. SOIL VAPOR EXTRACTION CURTAILMENT**

**8a. SOIL VAPOR EXTRACTION CURTAILMENT PROPOSAL**

**COMPLETION DATE:** 90 Days Prior To Proposed Curtailment of Any Soil Vapor Extraction Well

Submit a technical report and implementation schedule acceptable to the Executive Officer containing a proposal for curtailing operation from any soil vapor extraction wells or piping and the criteria used to justify each curtailment. This report shall include a proposal indicating the locations of borings and sampling intervals to determine concentrations of VOCs remaining in soil. The proposal may include the temporary termination of vapor extraction well operation for an extended period of time to study the effects on chemical migration prior to well destruction.

If the discharger claims that it is not practicable to achieve soil cleanup standards through continued soil vapor extraction in all or any portion of the soil plume area and that significant quantities of chemicals are not being removed through soil vapor extraction, the discharger shall evaluate the reductions in chemical concentrations and the alternative soil cleanup standards that can be practically achieved. The report shall evaluate alternative means of achieving soil cleanup standards and whether conditions for waiving these standards are met (e.g., that meeting the soil cleanup standards is technically impracticable from an engineering perspective) and that the alternative soil cleanup standards proposed will be protective of human health and the environment.

**8b. COMPLETION OF SOIL VAPOR EXTRACTION CURTAILMENT**

**COMPLETION DATE:** According to Schedule in Task 8a as approved by the Executive Officer

Document in a technical report acceptable to the Executive Officer the completion of the necessary tasks identified in Task 8a. This report should include the results of chemical analyses of appropriate verification samples from the source areas, and copies of well destruction completion notices.

**9. SOIL BIOREMEDIATION**

**9a. SOIL BIOREMEDIATION CURTAILMENT PROPOSAL**

**COMPLETION DATE:** 90 Days Prior To Proposed Curtailment of Any Bioremediation System

Submit a technical report and implementation schedule acceptable to the Executive Officer containing a proposal for curtailing bioremediation and the criteria used to justify curtailment. This report shall include a proposal indicating the locations of verification borings and sampling intervals to determine concentrations of contaminants of concern (TPH, VOCs, or

perchlorate) remaining in soil. The proposal may include the temporary termination of bioremediation operation for an extended period of time to study the effects on chemical migration prior to system abandonment.

If the discharger claims that it is not practicable to achieve groundwater and/or soil cleanup standards through continued bioremediation in all or any portion of the plume area and that significant quantities of chemicals are not being removed through bioremediation, the discharger shall evaluate the reductions in chemical concentrations and the alternative cleanup standards that can be practically achieved. The report shall evaluate alternative means of achieving cleanup standards and whether conditions for waiving these standards are met (e.g., that meeting the cleanup standards is technically impracticable from an engineering perspective) and that the alternative cleanup standards proposed will be protective of human health and the environment.

**9b. COMPLETION OF BIOREMEDIATION CURTAILMENT**

**COMPLETION DATE:** According to Schedule in Task 9a Approved by the Executive Officer

Document in a technical report acceptable to the Executive Officer the completion of the necessary tasks identified in Task 8a. This report should include the results of chemical analyses of appropriate verification samples from the source areas, and copies of well destruction completion notices.

**10. GROUNDWATER EXTRACTION CURTAILMENT**

**10a. PROPOSAL TO CURTAIL GROUNDWATER EXTRACTION**

**COMPLETION DATE:** 90 Days Prior To Proposed Extraction Well Pumping Curtailment

Submit a technical report and implementation schedule acceptable to the Executive Officer containing a proposal for curtailing pumping from groundwater extraction well(s) and the criteria used to justify such curtailment. Curtailment of groundwater extraction may include, but is not limited to: final shutdown of the system, phased approach to shutdown, pulsed pumping, or a significant change in pumping rates. The report shall include the rationale for curtailment or modifying the system. This report shall also include data to show that cleanup standards for chemicals of concern have been achieved and have stabilized or are stabilizing, and that the potential for contaminant levels rising above cleanup standards is minimal. This report shall also include an evaluation of the potential for contaminants to migrate into the creeks surface or subsurface flow, and downwards to the Santa Clara Formation aquifers.

All system modifications to the extraction and treatment systems are subject to approval by the Executive Officer. This requirement may be waived by the Executive Officer if deemed appropriate.

If the discharger claims that it is not technically feasible to achieve cleanup standards through groundwater extraction and treatment, the report shall evaluate the alternative standards that

can be achieved, and demonstrate that the alternative cleanup standards proposed will be protective of human health and the environment.

**10b. COMPLETION OF EXTRACTION WELL CURTAILMENT**

**COMPLETION DATE:** According to Schedule in Task 10a Approved by the Executive Officer

Submit a technical report acceptable to the Executive Officer documenting completion of the necessary tasks identified in the technical report submitted for Task 10a.

**11. EVALUATION OF NEW HEALTH CRITERIA**

**COMPLETION DATE:** 90 Days After Request Made by the Executive Officer

Submit a technical report acceptable to the Executive Officer which contains an evaluation of how the final plan and cleanup standards would be affected, if the concentrations as listed in Tables 2 and 3 change as a result of promulgation of revised drinking water standards, maximum contaminant levels or action levels or other health based criteria.

**12. EVALUATION OF NEW TECHNICAL INFORMATION**

**COMPLETION DATE:** 90 Days After Request Made by the Executive Officer

Submit a technical report acceptable to the Executive Officer that contains an evaluation of new technical and economic information that indicates that cleanup standards or cleanup technologies in some areas may be considered for revision. Such technical reports shall not be required unless the Executive Officer determines that such new information indicates a reasonable possibility that the Order may need to be changed.

**13. DELAYED COMPLIANCE**

If the discharger is delayed, interrupted, or prevented from meeting one or more of the completion dates specified for the above tasks, the discharger shall notify the Executive Officer and the Water Board may consider revision to this Order.

**D. WATER RECLAMATION SPECIFICATIONS**

1. **Limits:** Reclaimed water as applied shall meet the following limits:

Constituent	Instantaneous Maximum Limit (µg/L)	Analytical Method
<b>Volatile Organic Compounds</b> Vinyl Chloride Benzene All others, per constituent	0.5 0.5 5.0	U.S. EPA Method 8260, 8021 or equivalent
<b>Semi Volatile Organic</b> PCBs All others, per constituent	0.5 5.0	U.S. EPA Method 8270, 8081, 8082 or equivalent
<b>Total Petroleum Hydrocarbons</b>	50	U.S. EPA Method 8015 or equivalent
<b>Perchlorate</b>	6.0*	U.S. EPA Method 300.0 or equivalent

\* Cal/EPA issued a Public Health Goal of 6 µg/L for perchlorate in March 2004. Cal/EPA will use the PHG to establish an MCL for perchlorate. The groundwater cleanup standard is currently set equal to the PHG. If the MCL differs from the PHG, Water Board staff will consider changing the cleanup standard for perchlorate to the MCL.

2. **Runoff Control:** No reclaimed water shall be allowed to escape from the authorized use areas by airborne spray, nor by surface flow except in minor amounts associated with good irrigation practice, nor from conveyance facilities.
3. **Application Limitations:** No treated groundwater shall be applied to areas of reuse during rainfall, or when soils are saturated to a point where runoff is likely to occur.
4. **Public Contact:** Adequate measures shall be taken to minimize public contact with the reclaimed water, and to inform the public by placing legible conspicuous warning signs with proper wording at adequate intervals around the use and storage areas.
5. **Cross Connection:** There shall be no cross-connection between potable water supply and any piping containing treated groundwater.
6. **Freeboard:** The storage ponds shall be operated to have a minimum of 2 feet of freeboard to prevent overflows.
7. **Violation Notification:** In the event that the discharger is unable to comply with any of the specifications that apply to groundwater reclamation, the discharger shall notify the Water Board by telephone within 24 hours of the incident and confirm it in writing within one week of the telephone notification.
8. **Change in Reclamation:** In accordance with Section 13260 of the California Water Code, the discharger shall file a report with the Water Board of any material change or proposed change in the character, location or volume of the reclaimed water.
9. **No Consumption:** Treated groundwater shall not be used for public consumption.

10. **Vehicle Signs:** Vehicles used for carrying or spraying the reclaimed water shall be identified as such with legible signs.

E. **PROVISIONS**

1. **No Nuisance:** The storage, handling, treatment, or disposal of polluted soil or groundwater, including groundwater reclamation, shall not create a nuisance as defined in California Water Code Section 13050(m).
2. **Good Operation and Maintenance:** The discharger shall operate and maintain in good working order, and operate efficiently as possible, any facility or control system installed to achieve compliance with the requirements of this Order, including groundwater reclamation.
3. **Cost Recovery:** The discharger shall be liable, pursuant to California Water Code Section 13304, to the Water Board for all reasonable costs actually incurred by the Water Board to investigate unauthorized discharges of waste and to oversee cleanup of such waste, abatement of the effects thereof, or other remedial action, required by this order. If the site addressed by this Order is enrolled in a State Board-managed reimbursement program, reimbursement shall be made pursuant to this Order and according to the procedures established in that program. Any disputes raised by the discharger over reimbursement amounts or methods used in that program shall be consistent with the dispute resolution procedures for that program.
4. **Access to Site and Records:** In accordance with California Water Code Section 13267(c), the discharger shall permit the Water Board or its authorized representative:
  - a. Entry upon premises in which any pollution source exists, or may potentially exist, or in which any required record are kept, which are relevant to this Order.
  - b. Access to copy any records that must be kept under the requirements of this Order.
  - c. Inspection of any monitoring or remediation facilities installed in response to this Order.
  - d. Sampling of any groundwater or soil that is accessible, or may become accessible, as part of any investigation or remedial action program undertaken by the discharger.
5. **Self-Monitoring Program:** The discharger shall submit, on an annual basis, an Environmental Monitoring Program Plan (EMPP) that describes in detail the monitoring program that will be conducted the following calendar year. The EMPP shall include, in a separate section, all monitoring required by DTSC for any waste management units under RCRA Post-Closure permit.

The discharger shall also submit an annual environmental monitoring report and three quarterly monitoring reports. The annual monitoring report will provide a summary of data collected during the four quarters of the year. Each monitoring report will provide a

summary of the results of any investigations conducted during the period covered, provide notice of any unusual results from environmental monitoring, and summarize any remedial actions implemented during the period covered.

6. **Contractor/Consultant Qualifications:** All technical documents shall be signed by and stamped with the seal of a registered California geologist, a California certified engineering geologist or a California registered civil engineer.
7. **Lab Qualifications:** All samples shall be analyzed by State certified laboratories or laboratories accepted by the Water Board using approved EPA methods for the type of analysis to be performed or other methods approved by the Water Board. All laboratories shall maintain quality assurance/quality control records for Water Board review. The provision does not apply to analyses that can only reasonably be performed on-site (e.g. temperature).
8. **Document Distribution:** A copy of all correspondence, reports, and documents pertaining to compliance with this Order shall be provided in full, to the following agencies:
  - a. Santa Clara Valley Water District
  - b. Department of Toxic Substances Control, Geological Services Unit (Monitoring Reports only)
  - c. U.S. EPA, Region IX

The discharger shall provide a copy of cover letters, title pages, table of contents and the executive summaries of above compliance reports (except for the annual progress reports and workplans for soil or groundwater remediation, which shall be submitted in full) to the following agencies:

- a. Santa Clara County Department of Environmental Health
- b. California EPA/DTSC Site Mitigation Branch

The Executive Officer may modify this distribution list as needed.

9. **Reporting of Changed Owner or Operator:** The discharger shall file a technical report on any changes in site occupancy and ownership associated with the property described in this Order.
10. **Reporting of Hazardous Substance Release:** If any hazardous substance is discharged in or on any waters of the State, or discharged and deposited where it is, or probably will be discharged in or on any waters of the State, the discharger shall report such discharge to this Board, by calling (510) 622-2300 during regular office hours (Monday through Friday, 8:00 AM to 5:00 PM). A written report shall be filed with the Water Board within five (5) working days. The report shall describe the nature of the quantity involved, duration of incident, cause of release, estimated size of affected area, nature of effect, corrective actions taken or planned, and persons/agencies notified.

This reporting is in addition to the reporting to the Office of Emergency Services required pursuant to the Health and Safety Code.

11. **Rescission of Existing Orders:** This Order rescinds and supercedes all previous Site Cleanup Requirements Orders (94-064, 95-112, 95-194, 97-065, and 98-070). This Order also rescinds Water Reclamation Requirements Order 91-006. This Order does not rescind or supercede the existing Waste Discharge Requirements (Order 95-190) or other applicable permits or orders.
12. **Periodic SCR Review:** The Water Board will review this Order periodically and may revise the requirements when necessary.

I, Bruce H. Wolfe, Executive Officer, do hereby certify that the foregoing is a full, true and correct copy of an Order adopted by the California Regional Water Quality Control Board, San Francisco Bay Region, on May 19, 2004.

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Bruce H. Wolfe  
Executive Officer

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**FAILURE TO COMPLY WITH THE REQUIREMENTS OF THIS ORDER MAY SUBJECT YOU TO ENFORCEMENT ACTION, INCLUDING BUT NOT LIMITED TO: IMPOSITION OF ADMINISTRATIVE CIVIL LIABILITY UNDER WATER CODE SECTIONS 13268 OR 13350, OR REFERRAL TO THE ATTORNEY GENERAL FOR INJUNCTIVE RELIEF OR CIVIL OR CRIMINAL LIABILITY**

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Attachments:   Regional Map  
                  Site Map  
                  Self-Monitoring Program

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD  
SAN FRANCISCO BAY REGION

SELF-MONITORING PROGRAM FOR:

UNITED TECHNOLOGIES CORPORATION

for the property located at  
600 METCALF ROAD  
SANTA CLARA COUNTY

1. **Authority and Purpose:** The Water Board requests the technical reports required in this Self-Monitoring Program pursuant to Water Code Sections 13267 and 13304. This Self-Monitoring Program is intended to document compliance with Board Order No. RB2-2004-0032 (site cleanup requirements).
2. **Monitoring:** The discharger shall measure groundwater elevations in monitoring wells and shall collect and analyze representative samples of groundwater, surface water and reclaimed water according to the Environmental Monitoring Program Plan (EMPP) acceptable to the Executive Officer and submitted annually by October 1.
3. **Annual Monitoring Reports:** The discharger shall submit an annual monitoring report to the Water Board by no later than March 1 following the end of the year. Reports from other Self-Monitoring Programs required Water Reclamation Requirements, and Waste Discharge Requirements may be combined with the annual reports. The report shall include:
  - a. **Transmittal Letter:** The transmittal letter shall discuss any violations during the reporting period and actions taken or planned to correct the problem. The letter shall be signed by the dischargers' principal executive officer or his/her duly authorized representative, and shall include a statement by the official, under penalty of perjury, that the report is true and correct to the best of the official's knowledge.
  - b. **Groundwater Elevations:** Groundwater elevation data shall be presented in tabular form. Groundwater elevation map should be prepared for the wet and dry seasons for each monitored water-bearing zone. Historical groundwater elevations should be included with each annual report.
  - c. **Groundwater Analyses:** All new wells shall be sampled on a quarterly basis for the first year. After the first year, the monitoring schedule shall be set at a frequency appropriate for the purpose of the well. The appropriate EPA methods, pH, and turbidity tests shall be required for all new monitoring and extraction wells. Other tests shall be required for some wells, depending on the well location. Groundwater sampling data shall be presented in tabular form, and an isoconcentration map should be prepared for one or more key contaminants for each monitored water-bearing zone, as appropriate. The annual report shall indicate the analytical method used, detection limits obtained for each reported constituent, and a summary of QA/QC data. Historical groundwater sampling results shall also be included.

Supporting data, such as lab data sheets, need not be included (however, see "Record Keeping" below).

- d. **Groundwater Extraction and Treatment:** The report shall include groundwater extraction results in tabular form, for each groundwater treatment system and for the site as a whole, expressed in gallons per week and total groundwater volume for the year. The report shall also include contaminant removal results, from groundwater extraction and treatment systems expressed in units of chemical mass for the year. Historical mass removal results for groundwater extraction and treatment systems shall be included in the annual report. Contaminant removal results for the SVE systems in units of chemical mass shall be reported annually. Vapor concentrations for startup at each new SVE site visited during the year shall be reported. The report shall also include contaminant concentrations for influent and effluent flows at all the groundwater treatment systems at the site.
  - e. **Status Report:** The annual report shall describe relevant work completed during the reporting period (e.g. site investigation, interim remedial measures) and work planned for the following year.
4. **Quarterly Monitoring Reports:** The dischargers shall submit a quarterly monitoring report to the Water Board by no later than May 1 for the first quarter, August 1 for the second quarter, and November 1 for the third quarter. The quarterly report shall present and discuss (1) any violations during the reporting period and actions taken or planned to correct the problem, (2) problems with monitoring, investigative, or remedial activities conducted during the reporting period, and (3) status of new investigative or remedial actions that have not yet been reported.
  5. **RCRA Post-Closure Compliance Monitoring:** Scheduled monitoring of groundwater at closed Resource Conservation and Recovery Act (RCRA) impoundments 0250, 0635, and 0706 and the former OBF is required under post-closure. This portion of the monitoring program is administered by the Department of Toxic Substances Control (DTSC). The sampling and analysis program proposed for these RCRA units is summarized in Table 1. Point of Compliance (POC) wells for former Surface Impoundments 0250, 0635, and 0706 and the OBF were selected from existing downgradient wells and are also shown in Table 1.

The groundwater monitoring plan for the units under RCRA post-closure permit will include, at a minimum, those analyses and frequency of analyses for those wells listed in Table 1. UTC will report the results of the RCRA sampling on an annual basis in a specific section of the Annual Monitoring Reports. DTSC may request that the RCRA monitoring data be submitted in separate reports or on a more frequent schedule. The RCRA post-closure monitoring program can only be changed with concurrence from DTSC. Other parts of the monitoring program performed under the EMPP can be changed by the RWQCB without concurrence from DTSC.

**Former Surface Impoundment 0250 RCRA Monitoring:** Previous groundwater sampling showed the presence of VOCs, perchlorate and cyanide in former Surface Impoundment 0250 groundwater. Therefore, the proposed RCRA monitoring for former Surface Impoundment 0250 includes VOCs, perchlorate, and total cyanides. Former Surface Impoundment 0250 was used to hold metal finishing wastewater. Therefore, the proposed monitoring will also include the 17 California Assessment Manual (CAM) metals. Because metals and cyanides have not been detected in groundwater above MCLs, sampling for these parameters will only be performed annually.

Former Surface Impoundment 0635 RCRA Monitoring: Previous groundwater sampling showed the presence of VOCs and perchlorate in former Surface Impoundment 0635 groundwater. A pesticide, beta-BHC, was found at a maximum of 0.74 µg/L. Although beta-BHC was not part of the Station 0635 waste stream and may be an artifact (the concentration is too low to confirm using Method 8270), the level is above the California action level of 0.025 µg/L. Therefore, the proposed monitoring for former Surface Impoundment 0635 includes VOCs, perchlorate, and organochlorine pesticides. Due to the recent detection of beta-BHC, pesticides will be measured annually.

Former Surface Impoundment 0706 RCRA Monitoring: Previous groundwater sampling showed the presence of VOCs and perchlorate in former Surface Impoundment 0706 groundwater. Therefore, the proposed RCRA monitoring for former Surface Impoundment 0706 includes VOCs and perchlorate.

Former Open Burning Facility (OBF) RCRA Monitoring: Previous groundwater sampling showed the presence of VOCs, perchlorate, and cyanide in OBF groundwater. Historically, soil contamination with VOCs, semi-volatile organic compounds (SVOCs), perchlorate, metals and polychlorinated biphenyls (PCBs) were removed from the OBF. Therefore, the proposed RCRA monitoring for the OBF includes VOCs, perchlorate, cyanide, SVOCs, 17 CAM metals, and PCBs. Because cyanide, SVOCs, metals, and PCBs have not been detected in groundwater at concentrations exceeding MCLs, sampling for these parameters will only be performed on a 3 to 5-year cycle.

6. **Miscellaneous Requirements:**

- a. Well depths shall be determined on an annual basis and compared to the depth of the well as constructed. If greater than twenty-five percent of the well screen is covered, the discharger shall clear the screen by the next sampling.
- b. Chemical detection limits shall be lower than cleanup standards established in the Order, unless it is technically impractical to achieve detection limits lower than cleanup standards.

7. **Violation Reports:** If the discharger violates requirements in the Site Cleanup Requirements, then the discharger shall notify the Water Board office by telephone as soon as practicable once the discharger has knowledge of the violation. Water Board staff may, depending on violation severity, require the discharger to submit a separate technical report on the violation within five working days of telephone notification.

8. **Other Reports:** The discharger shall notify the Water Board in writing prior to any site activities, such as construction or underground tank removal, which have the potential to cause further migration of contaminants or which would provide new opportunities for site investigation.

9. **Record Keeping:** The discharger or his/her agent shall retain data generated for the above reports, including lab results and QA/QC data, for a minimum of five years after origination and shall make them available to the Water Board upon request.

10. **SMP Revisions:** Revisions to the Self-Monitoring Program or the EMPP may be ordered by the Executive Officer, either on his/her own initiative or at the request of the discharger. Prior to making

SMP or EMPP revisions, the Executive Officer will consider the burden, including costs, of associated self-monitoring reports relative to the benefits to be obtained from these reports.

I, Bruce H. Wolfe, Executive Officer, hereby certify that this Self-Monitoring Program was adopted by the Board on May 19, 2004.

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Bruce H. Wolfe  
Executive Officer

Attachment: Table 1, RCRA Post-Closure Groundwater Monitoring Plan

**Table 1  
RCRA Post-Closure Groundwater Monitoring Plan**

RCRA Unit	RCRA Well ID	COC	Frequency	Next Sampling	USEPA Method
0250	18P-01R*	Perchlorate	6 MO		314.0
	18P-01R*	17 CAM Metals	A		6010
	18P-01R*	VOCs	6 MO		8260
	18P-01R*	Total Cyanides	A		9010
	18P-02	Perchlorate	6 MO		314.0
	18P-02	17 CAM Metals	A		6010
	18P-02	VOCs	6 MO		8260
	18P-02	Total Cyanides	A		9010
	AI-06	Perchlorate	6 MO		314.0
	AI-06	17 CAM Metals	A		6010
	AI-06	VOCs	6 MO		8260
	AI-06	Total Cyanides	A		9010
0635	20C-13	Perchlorate	6 MO		314.0
	20C-13	OC Pesticides	A		8081A
	20C-13	VOCs	6 MO		8260
	20C-14*	Perchlorate	6 MO		314.0
	20C-14*	OC Pesticides	A		8081A
	20C-14*	VOCs	6 MO		8260
	20C-17	Perchlorate	6 MO		314.0
	20C-17	OC Pesticides	A		8081A
	20C-17	VOCs	6 MO		8260
0706	20C-25	Perchlorate	6 MO		314.0
	20C-25	VOCs	6 MO		8260
	20C-35*	Perchlorate	6 MO		314.0
	20C-35*	VOCs	6 MO		8260
	20G-15	Perchlorate	6 MO		314.0
	20G-15	VOCs	6 MO		8260
OBF UPZ	RI-05W*	Perchlorate	6 MO		314.0
	RI-05W*	VOCs	6 MO		8260
	RI-05W*	17 CAM Metals	3 YR	2004	6010
	RI-05W*	PCBs	3 YR	2004	8082
	RI-05W*	SVOCs	3 YR	2004	8270
	RI-05W*	Total Cyanides	3 YR	2004	9010
	RI-12W*	Perchlorate	6 MO		314.0
	RI-12W*	VOCs	6 MO		8260
	RI-12W*	17 CAM Metals	3 YR	2004	6010
	RI-12W*	PCBs	3 YR	2004	8082
	RI-12W*	SVOCs	3 YR	2004	8270
	RI-12W*	Total Cyanides	3 YR	2004	9010
	RI-54W*	Perchlorate	6 MO		314.0
	RI-54W*	VOCs	6 MO		8260
	RI-54W*	17 CAM Metals	3 YR	2004	6010
	RI-54W*	PCBs	3 YR	2004	8082
RI-54W*	SVOCs	3 YR	2004	8270	
RI-54W*	Total Cyanides	3 YR	2004	9010	

**Table 1 (cont.)  
RCRA Post-Closure Groundwater Monitoring Plan**

<b>RCRA Unit</b>	<b>RCRA Well ID</b>	<b>COC</b>	<b>Frequency</b>	<b>Next Sampling</b>	<b>USEPA Method</b>
OBF LUZ	RI-03W	Perchlorate	6 MO		314.0
	RI-03W	VOCs	6 MO		8260
	RI-03W	17 CAM Metals	3 YR	2004	6010
	RI-03W	PCBs	3 YR	2004	8082
	RI-03W	SVOCs	3 YR	2004	8270
	RI-03W	Total Cyanides	3 YR	2004	9010
	RI-25W	Perchlorate	6 MO		314.0
	RI-25W	VOCs	6 MO		8260
	RI-25W	17 CAM Metals	3 YR	2004	6010
	RI-25W	PCBs	3 YR	2004	8082
	RI-25W	SVOCs	3 YR	2004	8270
	RI-25W	Total Cyanides	3 YR	2004	9010
	RI-30W	Perchlorate	6 MO		314.0
	RI-30W	VOCs	6 MO		8260
	RI-30W	17 CAM Metals	3 YR	2004	6010
	RI-30W	PCBs	3 YR	2004	8082
	RI-30W	SVOCs	3 YR	2004	8270
	RI-30W	Total Cyanides	3 YR	2004	9010
	RI-32W	Perchlorate	6 MO		314.0
	RI-32W	VOCs	6 MO		8260
	RI-32W	17 CAM Metals	3 YR	2004	6010
	RI-32W	PCBs	3 YR	2004	8082
	RI-32W	SVOCs	3 YR	2004	8270
	RI-32W	Total Cyanides	3 YR	2004	9010
	RI-45W	Perchlorate	6 MO		314.0
	RI-45W	VOCs	6 MO		8260
	RI-45W	17 CAM Metals	3 YR	2004	6010
	RI-45W	PCBs	3 YR	2004	8082
	RI-45W	SVOCs	3 YR	2004	8270
	RI-45W	Total Cyanides	3 YR	2004	9010
	RI-46W	Perchlorate	6 MO		314.0
	RI-46W	VOCs	6 MO		8260
	RI-46W	17 CAM Metals	3 YR	2004	6010
	RI-46W	PCBs	3 YR	2004	8082
	RI-46W	SVOCs	3 YR	2004	8270
	RI-46W	Total Cyanides	3 YR	2004	9010
	RI-51W	Perchlorate	6 MO		314.0
	RI-51W	VOCs	6 MO		8260
	RI-51W	17 CAM Metals	3 YR	2004	6010
	RI-51W	PCBs	3 YR	2004	8082
	RI-51W	SVOCs	3 YR	2004	8270
	RI-51W	Total Cyanides	3 YR	2004	9010

**Table 1 (cont.)  
RCRA Post-Closure Groundwater Monitoring Plan**

<b>RCRA Unit</b>	<b>RCRA Well ID</b>	<b>COC</b>	<b>Frequency</b>	<b>Next Sampling</b>	<b>USEPA Method</b>
OBF SQsc (LCZ)	BC-03W	Perchlorate	6 MO		314.0
	BC-03W	VOCs	6 MO		8260
	BC-03W	17 CAM Metals	5 YR	2004	6010
	BC-03W	PCBs	5 YR	2004	8082
	BC-03W	SVOCs	5 YR	2004	8270
	BC-03W	Total Cyanides	5 YR	2004	9010
	RI-16W	Perchlorate	6 MO		314.0
	RI-16W	VOCs	6 MO		8260
	RI-16W	17 CAM Metals	5 YR	2004	6010
	RI-16W	PCBs	5 YR	2004	8082
	RI-16W	SVOCs	5 YR	2004	8270
	RI-16W	Total Cyanides	5 YR	2004	9010
	RI-17AW	Perchlorate	6 MO		314.0
	RI-17AW	VOCs	6 MO		8260
	RI-17AW	17 CAM Metals	5 YR	2004	6010
	RI-17AW	PCBs	5 YR	2004	8082
	RI-17AW	SVOCs	5 YR	2004	8270
	RI-17AW	Total Cyanides	5 YR	2004	9010
	RI-19W	Perchlorate	6 MO		314.0
	RI-19W	VOCs	6 MO		8260
	RI-19W	17 CAM Metals	5 YR	2004	6010
	RI-19W	PCBs	5 YR	2004	8082
	RI-19W	SVOCs	5 YR	2004	8270
	RI-19W	Total Cyanides	5 YR	2004	9010

\*Point of Compliance (POC) well  
6 MO: Monitoring parameters sampled every 6 months  
A: Sampled once each year  
3 YR: Sampled every three years  
5 YR: Sampled every five years  
OBF: Open Burning Facility  
UPZ: Upper Perched Zone of the Santa Clara Formation  
LUZ: Lower Unconfined Zone of the Santa Clara Formation  
LCZ: Lower Confined Zone of the Santa Clara Formation  
SQsc: Standard Santa Clara Formation

**PETITION EXHIBIT 20**



**PETITION EXHIBIT 21**

**USE OF MONITORED NATURAL ATTENUATION  
AT SUPERFUND, RCRA CORRECTIVE ACTION,  
AND UNDERGROUND STORAGE TANK SITES**

U.S. Environmental Protection Agency  
Office of Solid Waste and Emergency Response  
Directive 9200.4-17P

April 1999



**USE OF MONITORED NATURAL ATTENUATION  
AT SUPERFUND, RCRA CORRECTIVE ACTION,  
AND UNDERGROUND STORAGE TANK SITES**

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NOTICE: This document provides guidance to EPA and state staff. It also provides guidance to the public and to the regulated community on how EPA intends to exercise its discretion in implementing its regulations. The guidance is designed to implement national policy on these issues. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on EPA, States, or the regulated community, and may not apply to a particular situation based upon the circumstances. EPA may change this guidance in the future, as appropriate.

## PURPOSE AND OVERVIEW

The purpose of this Directive is to clarify EPA's policy regarding the use of monitored natural attenuation (MNA) for the cleanup of contaminated soil and groundwater<sup>1</sup> in the Superfund, RCRA Corrective Action, and Underground Storage Tank programs. These programs are administered by EPA's Office of Solid Waste and Emergency Response (OSWER) which include the Office of Emergency and Remedial Response (OERR), Office of Solid Waste (OSW), Office of Underground Storage Tanks (OUST), and the Federal Facilities Restoration and Reuse Office (FFRRO). Statutory authority for these remediation programs is provided under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA).

**EPA remains fully committed to its goals of protecting human health and the environment by remediating contaminated soils, restoring contaminated groundwaters to their beneficial uses, preventing migration of contaminant plumes<sup>2</sup>, and protecting groundwaters and other environmental resources<sup>3</sup>.** EPA advocates using the most appropriate technology for a given site. EPA does not consider MNA to be a "presumptive" or "default" remedy—it is merely one option that should be evaluated with other applicable remedies. EPA does not view MNA to be a "no action"<sup>4</sup> or "walk-away" approach, but rather

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<sup>1</sup> Although this Directive does not address remediation of contaminated sediments, many of the same principles would be applicable. Fundamental issues such as having source control, developing lines of evidence, monitoring and contingency plans are also appropriate for sediments. However, the Agency is developing the policy and technical aspects for sediments, specifically.

<sup>2</sup> The outer limits of contaminant plumes are typically defined for each contaminant of concern based on chemical concentrations above which the overseeing regulatory authority has determined represent an actual or potential threat to human health or the environment.

<sup>3</sup> Environmental resources to be protected include groundwater, drinking water supplies, surface waters, ecosystems and other media (air, soil and sediments) that could be impacted by site contamination.

<sup>4</sup> For the Superfund program, Section 300.430(e)(6) of the National Contingency Plan (NCP) directs that a "no action alternative" (or no further action) "shall be developed" for all feasibility studies (USEPA, 1990a, p. 8849). The "no action" alternative can include monitoring but generally not other remedial actions, where such actions are defined in Section 300.5 of the NCP. In general, the "no action" alternative is selected when there is no current or potential threat to human health or the environment or when CERCLA exclusions preclude taking an action (USEPA, 1991a). As explained in this Directive, a remedial alternative that relies on monitored natural attenuation to attain site-specific remediation objectives is **not** the same as the "no action" alternative.

considers it to be an alternative means of achieving remediation objectives<sup>5</sup> that may be appropriate for specific, well-documented site circumstances where its use meets the applicable statutory and regulatory requirements. As there is often a variety of methods available for achieving remediation objectives at any given site, MNA may be evaluated and compared to other viable remediation methods (including innovative technologies) during the study phases leading to the selection of a remedy. As with any other remedial alternative, MNA should be selected only where it meets all relevant remedy selection criteria, and where it will meet site remediation objectives within a timeframe that is reasonable compared to that offered by other methods. In the majority of cases where MNA is proposed as a remedy, its use may be appropriate as one component of the total remedy, that is, either in conjunction with active remediation or as a follow-up measure. MNA should be used very cautiously as the sole remedy at contaminated sites. Furthermore, the availability of MNA as a potential remediation tool does not imply any lessening of EPA's longstanding commitment to pollution prevention. Waste minimization, pollution prevention programs, and minimal technical requirements to prevent and detect releases remain fundamental parts of EPA waste management and remediation programs.

Use of MNA does not signify a change in OSWER's remediation objectives. These objectives (discussed in greater detail under the heading "Implementation") include control of source materials<sup>6</sup>, prevention of plume migration, and restoration of contaminated groundwaters, where appropriate. Thus, EPA expects that source control measures (see section on "Remediation of Sources") will be evaluated for all sites under consideration for any proposed remedy. As with other remediation methods, selection of MNA as a remediation method should be supported by detailed site-specific information that demonstrates the efficacy of this remediation approach. In addition, the progress of MNA toward a site's remediation objectives should be carefully monitored and compared with expectations. Where MNA's ability to meet these expectations is uncertain and based predominantly on predictive analyses, decision makers should incorporate contingency measures into the remedy.

The scientific understanding of natural attenuation processes continues to evolve. EPA recognizes that significant advances have been made in recent years, but there is still a great deal to be learned regarding the mechanisms governing natural attenuation processes and their ability to address different types of contamination problems. Therefore, while EPA believes MNA may

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<sup>5</sup> In this Directive, remediation objectives are the overall objectives that remedial actions are intended to accomplish and are not the same as chemical-specific cleanup levels. Remediation objectives could include preventing exposure to contaminants, preventing further migration of contaminants from source areas, preventing further migration of the groundwater contaminant plume, reducing contamination in soil or groundwater to specified cleanup levels appropriate for current or potential future uses, or other objectives. The term "remediation" as used in this Directive is not limited to "remedial actions" defined in CERCLA §101(24), and includes CERCLA "removal actions", for example.

<sup>6</sup> "Source material is defined as material that includes or contains hazardous substances, pollutants or contaminants that act as a reservoir [either stationary or mobile] for migration of contamination to the ground water, to surface water, to air, [or other environmental media,] or acts as a source for direct exposure. Contaminated ground water generally is not considered to be a source material although non-aqueous phase liquids (NAPLS [occurring either as residual- or free-phase]) may be viewed as source materials." (USEPA, 1991b).

be used where circumstances are appropriate, it should be used with caution commensurate with the uncertainties associated with the particular application. Furthermore, largely due to the uncertainty associated with the potential effectiveness of MNA to meet remediation objectives that are protective of human health and the environment, EPA expects that **source control and long-term performance monitoring will be fundamental components of any MNA remedy.**

This Directive is a policy document and as such is not intended to provide detailed technical guidance on evaluating MNA remedies. EPA recognizes that at present there are relatively few EPA guidance documents concerning appropriate implementation of MNA remedies. Chapter IX of OUST's alternative cleanup technologies manual (USEPA, 1995a) addresses the use of natural attenuation at leaking UST sites. The Office of Research and Development (ORD) has recently published a protocol for evaluating MNA at chlorinated solvent sites (USEPA, 1998a). Additional technical resource documents for evaluating MNA in groundwater, soils, and sediments are being developed by ORD. Supporting technical information regarding the evaluation of MNA as a remediation alternative is available from a variety of other sources, including those listed at the end of this Directive. "References Cited" lists those EPA documents that were specifically cited within this Directive. The list of "Additional References" includes documents produced by EPA as well as non-EPA entities. Finally, "Other Sources of Information" lists sites on the World Wide Web (Internet) where additional information can be obtained. Non-EPA documents may provide regional and state site managers, as well as the regulated community, with useful technical information. However, these non-EPA guidances are not officially endorsed by EPA, EPA does not necessarily agree with all their conclusions, and all parties involved should clearly understand that such guidances do not in any way replace current EPA or OSWER guidances or policies addressing the remedy selection process in the Superfund, RCRA, or UST programs.

## BACKGROUND

The term "monitored natural attenuation", as used in this Directive, refers to the reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods. The "natural attenuation processes" that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These *in-situ* processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants. When relying on natural attenuation processes for site remediation, EPA prefers those processes that degrade or destroy contaminants. Also, EPA generally expects that MNA will only be appropriate for sites that have a low potential for contaminant migration. Additional discussion of criteria for "Sites Where Monitored Natural Attenuation May Be Appropriate" may be found later in this Directive. Other terms associated with natural attenuation in the literature include "intrinsic remediation", "intrinsic bioremediation", "passive bioremediation", "natural

recovery”, and “natural assimilation”. While some of these terms are synonymous with “natural attenuation,” others refer strictly to biological processes, excluding chemical and physical processes. Therefore, it is recommended that for clarity and consistency, the term “monitored natural attenuation” be used throughout OSWER remediation programs unless a specific process (*e.g.*, reductive dehalogenation) is being referenced.

Natural attenuation processes are typically occurring at all sites, but to varying degrees of effectiveness depending on the types and concentrations of contaminants present and the physical, chemical, and biological characteristics of the soil and groundwater. Natural attenuation processes may reduce the potential risk posed by site contaminants in three ways:

- (1) Transformation of contaminant(s) to a less toxic form through destructive processes such as biodegradation or abiotic transformations;
- (2) Reduction of contaminant concentrations whereby potential exposure levels may be reduced; and
- (3) Reduction of contaminant mobility and bioavailability through sorption onto the soil or rock matrix.

Where conditions are favorable, natural attenuation processes may reduce contaminant mass or concentration at sufficiently rapid rates to be integrated into a site’s soil or groundwater remedy. Following source control measures, natural attenuation may be sufficiently effective to achieve remediation objectives at some sites without the aid of other (active) remedial measures. Typically, however, MNA will be used in conjunction with active remediation measures. For example, active remedial measures could be applied in areas with high concentrations of contaminants while MNA is used for low concentration areas; or MNA could be used as a follow-up to active remedial measures. EPA also encourages the consideration of innovative technologies for source control or “active” components of the remedy, which may offer greater confidence and reduced remediation time frames at modest additional cost.

While MNA is often dubbed “passive” remediation because natural attenuation processes occur without human intervention, its use at a site does **not** preclude the use of “active” remediation or the application of enhancers of biological activity (*e.g.*, electron acceptors, nutrients, and electron donors). However, by definition, a remedy that includes the introduction of an enhancer of any type is no longer considered to be “natural” attenuation. Use of MNA does not imply that activities (and costs) associated with investigating the site or selecting the remedy (*e.g.*, site characterization, risk assessment, comparison of remedial alternatives, performance monitoring, and contingency measures) have been eliminated. These elements of the

investigation and cleanup must still be addressed as required under the particular OSWER program, regardless of the remedial approach selected.

### Contaminants of Concern

It is common practice in conducting remedial actions to focus on the most obvious contaminants of concern, but other contaminants may also be of significant concern in the context of MNA remedies. In general, since engineering controls are not used to control plume migration in an MNA remedy, decision makers need to ensure that MNA is appropriate to address **all contaminants** that represent an actual or potential threat to human health or the environment. Several examples are provided below to illustrate the need to assess both the obvious as well as the less obvious contaminants of concern when evaluating an MNA remedial option.

- Mixtures of contaminants released into the environment often include some which may be amenable to MNA, and others which are not addressed sufficiently by natural attenuation processes to achieve remediation objectives. For example, Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) associated with gasoline have been shown in many circumstances to be effectively remediated by natural attenuation processes. However, a common additive to gasoline (*i.e.*, methyl tertiary-butyl ether [MTBE]) has been found to migrate large distances and threaten downgradient water supplies at the same sites where the BTEX component of a plume has either stabilized or diminished due to natural attenuation. In general, compounds that tend not to degrade readily in the subsurface (*e.g.*, MTBE and 1,4-dioxane) and that represent an actual or potential threat should be assessed when evaluating the appropriateness of MNA remedies.
- Analyses of contaminated media often report chemicals which are identified with a high degree of certainty, as well other chemicals labeled as "tentatively identified compounds" (TICs). It is often assumed that TICs will be addressed by a remedial action along with the primary contaminants of concern. This may be a reasonable assumption for an active remediation system (*e.g.*, pump and treat) which is capturing all contaminated groundwater, but might not be acceptable for an MNA remedy that is relying on natural processes to prevent contaminant migration. Where MNA is being proposed for sites with TICs, it may be prudent to identify the TICs and evaluate whether they too will be sufficiently mitigated by MNA.
- At some sites the same geochemical conditions and processes that lead to biodegradation of chlorinated solvents and petroleum hydrocarbons can chemically transform naturally occurring minerals (*e.g.*, arsenic and manganese compounds) in the aquifer matrix to forms that are more mobile and/or more toxic than the original materials (USEPA, 1998). A

comprehensive assessment of an MNA remedial option should include evaluation of whether naturally occurring metals will become contaminants of concern.

Addressing the above concerns does not necessarily require sampling and analysis of extensive lists of parameters at every monitoring location in all situations. The location and number of samples collected and analyzed for this purpose should be determined on a site-specific basis to ensure adequate characterization and protection of human health and the environment.

#### Transformation Products

It also should be noted that some natural attenuation processes may result in the creation of transformation products<sup>7</sup> that are more toxic and/or mobile than the parent contaminant (*e.g.*, degradation of trichloroethylene to vinyl chloride). The potential for creation of toxic transformation products is more likely to occur at non-petroleum release sites (*e.g.*, chlorinated solvents or other volatile organic spill sites) and should be evaluated to determine if implementation of a MNA remedy is appropriate and protective in the long term.

#### Cross-Media Transfer

Natural attenuation processes may often result in transfer of some contaminants from one medium to another (*e.g.*, from soil to groundwater, from soil to air or surface water, and from groundwater to surface water). Processes that result in degradation of contaminants are preferable to those which rely predominantly on the transfer of contamination from one medium to another. MNA remedies involving cross-media transfer of contamination should include a site-specific evaluation of the potential risk posed by the contaminant(s) once transferred to a particular medium. Additionally, long-term monitoring should address the media to which contaminants are being transferred.

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<sup>7</sup> The term "transformation products" in the Directive includes intermediate products resulting from biotic or abiotic processes (*e.g.*, TCE, DCE, vinyl chloride), decay chain daughter products from radioactive decay, and inorganic elements that become methylated compounds (*e.g.*, methyl mercury) in soil or sediment. Some transformation products are quickly transformed to other products while others are longer lived.

### Petroleum-Related Contaminants

Natural attenuation processes, particularly biological degradation, are currently best documented at petroleum fuel spill sites. Under appropriate field conditions, the regulated compounds benzene, toluene, ethylbenzene, and xylene (BTEX) may naturally degrade through microbial activity and ultimately produce non-toxic end products (*e.g.*, carbon dioxide and water). Where microbial activity is sufficiently rapid, the dissolved BTEX contaminant plume may stabilize (*i.e.*, stop expanding), and contaminant concentrations in both groundwater and soil may eventually decrease to levels below regulatory standards. Following degradation of a dissolved BTEX plume, a residue consisting of heavier petroleum hydrocarbons of relatively low solubility and volatility will typically be left behind in the original source (spill) area. Although this residual contamination may have relatively low potential for further migration, it still may pose a threat to human health or the environment either from direct contact with soils in the source area or by continuing to slowly leach contaminants to groundwater. For these reasons, MNA alone is generally not sufficient to remediate petroleum release sites. Implementation of source control measures in conjunction with MNA is almost always necessary. Other controls (*e.g.*, institutional controls<sup>8</sup>), in accordance with applicable state and federal requirements, may also be necessary to ensure protection of human health and the environment.

### Chlorinated Solvents

Chlorinated solvents<sup>9</sup>, such as trichloroethylene, represent another class of common contaminants. These compounds are more dense than water and are referred to as DNAPLs (dense non-aqueous phase liquids). Recent research has identified some of the mechanisms potentially responsible for degrading these solvents, furthering the development of methods for estimating biodegradation rates of these chlorinated compounds. However, the hydrologic and geochemical conditions favoring significant biodegradation of chlorinated solvents sufficient to achieve remediation objectives within a reasonable timeframe are anticipated to occur only in limited circumstances. DNAPLs tend to sink through the groundwater column toward the bottom of the aquifer. However, they can also occur as mixtures with other less dense contaminants. Because of the varied nature and distribution of chlorinated compounds, they are typically difficult to locate, delineate, and remediate even with active measures. In the subsurface, chlorinated solvents represent source materials that can continue to contaminate groundwater for decades or longer. Cleanup of solvent spills is also complicated by the fact that a typical spill includes

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<sup>8</sup> The term "institutional controls" refers to non-engineering measures—usually, but not always, legal controls—intended to affect human activities in such a way as to prevent or reduce exposure to hazardous substances. Examples of institutional controls cited in the National Contingency Plan (USEPA, 1990a, p.8706) include land and resource (*e.g.*, water) use and deed restrictions, well-drilling prohibitions, building permits, well use advisories, and deed notices.

<sup>9</sup> Chlorinated solvents are only one type of halogenated compound. Chlorinated solvents are specifically referenced in this Directive because they are commonly found at contaminated sites. The discussion in this Directive regarding chlorinated solvents may also apply to other halogenated compounds to be remediated.

multiple contaminants, including some that tend not to degrade readily in the subsurface.<sup>10</sup> Extremely long dissolved solvent plumes have been documented that may be due to the existence of subsurface conditions that are not conducive to natural attenuation.

### Inorganics

MNA may, under certain conditions (*e.g.*, through sorption or oxidation-reduction reactions), effectively reduce the dissolved concentrations and/or toxic forms of inorganic contaminants in groundwater and soil. Both metals and non-metals (including radionuclides) may be attenuated by sorption<sup>11</sup> reactions such as precipitation, adsorption on the surfaces of soil minerals, absorption into the matrix of soil minerals, or partitioning into organic matter. Oxidation-reduction (redox) reactions can transform the valence states of some inorganic contaminants to less soluble and thus less mobile forms (*e.g.*, hexavalent uranium to tetravalent uranium) and/or to less toxic forms (*e.g.*, hexavalent chromium to trivalent chromium). Sorption and redox reactions are the dominant mechanisms responsible for the reduction of mobility, toxicity, or bioavailability of inorganic contaminants. It is necessary to know what specific mechanism (type of sorption or redox reaction) is responsible for the attenuation of inorganics so that the stability of the mechanism can be evaluated. For example, precipitation reactions and absorption into a soil's solid structure (*e.g.*, cesium into specific clay minerals) are generally stable, whereas surface adsorption (*e.g.*, uranium on iron-oxide minerals) and organic partitioning (complexation reactions) are more reversible. Complexation of metals or radionuclides with carrier (chelating) agents (*e.g.*, trivalent chromium with EDTA) may increase their concentrations in water and thus enhance their mobility. Changes in a contaminant's concentration, pH, redox potential, and chemical speciation may reduce a contaminant's stability at a site and release it into the environment. Determining the existence, and demonstrating the irreversibility, of these mechanisms is important to show that a MNA remedy is sufficiently protective.

In addition to sorption and redox reactions, radionuclides exhibit radioactive decay and, for some, a parent-daughter radioactive decay series. For example, the dominant attenuating mechanism of tritium (a radioactive isotopic form of hydrogen with a short half-life) is radioactive decay rather than sorption. Although tritium does not generate radioactive daughter products, those generated by some radionuclides (*e.g.*, Am-241 and Np-237 from Pu-241) may be more toxic, have longer half-lives, and/or be more mobile than the parent in the decay series. Also, it is

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<sup>10</sup> For example, 1,4-dioxane, which is used as a stabilizer for some chlorinated solvents, is more highly toxic, less likely to sorb to aquifer solids, and less biodegradable than some other solvent constituents under the same environmental conditions.

<sup>11</sup> When a contaminant is associated with a solid phase, it is usually not known if the contaminant is precipitated as a three-dimensional molecular coating on the surface of the solid, adsorbed onto the surface of the solid, absorbed into the structure of the solid, or partitioned into organic matter. "Sorption" will be used in this Directive to describe, in a generic sense (*i.e.*, without regard to the precise mechanism) the partitioning of aqueous phase constituents to a solid phase.

important that the near surface or surface soil pathways be carefully evaluated and eliminated as potential sources of external direct radiation exposure<sup>12</sup>.

Inorganic contaminants persist in the subsurface because, except for radioactive decay, they are not degraded by the other natural attenuation processes. Often, however, they may exist in forms that have low mobility, toxicity, or bioavailability such that they pose a relatively low level of risk. Therefore, natural attenuation of inorganic contaminants is most applicable to sites where immobilization or radioactive decay is demonstrated to be in effect and the process/mechanism is irreversible.

#### Advantages and Disadvantages of Monitored Natural Attenuation

MNA has several potential advantages and disadvantages, and the factors listed below should be carefully considered during site characterization and evaluation of remediation alternatives before selecting MNA as the remedial alternative. **Potential advantages** of MNA include:

- As with any *in situ* process, generation of lesser volume of remediation wastes, reduced potential for cross-media transfer of contaminants commonly associated with *ex situ* treatment, and reduced risk of human exposure to contaminants, contaminated media, and other hazards, and reduced disturbances to ecological receptors;
- Some natural attenuation processes may result in *in-situ* destruction of contaminants;
- Less intrusion as few surface structures are required;
- Potential for application to all or part of a given site, depending on site conditions and remediation objectives;
- Use in conjunction with, or as a follow-up to, other (active) remedial measures; and
- Potentially lower overall remediation costs than those associated with active remediation.

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<sup>12</sup> External direct radiation exposure refers to the penetrating radiation (*i.e.*, primarily gamma radiation and x-rays) that may be an important exposure pathway for certain radionuclides in near surface soils. Unlike chemicals, radionuclides can have deleterious effects on humans without being taken into or brought in contact with the body due to high energy particles emitted from near surface soils. Even though the radionuclides that emit penetrating radiation may be immobilized due to sorption or redox reactions, the resulting contaminated near surface soil may not be a candidate for a MNA remedy as a result of this exposure risk.

The **potential disadvantages** of MNA include:

- Longer time frames may be required to achieve remediation objectives, compared to active remediation measures at a given site;
- Site characterization is expected to be more complex and costly;
- Toxicity and/or mobility of transformation products may exceed that of the parent compound;
- Long-term performance monitoring will generally be more extensive and for a longer time;
- Institutional controls may be necessary to ensure long term protectiveness;
- Potential exists for continued contamination migration, and/or cross-media transfer of contaminants;
- Hydrologic and geochemical conditions amenable to natural attenuation may change over time and could result in renewed mobility of previously stabilized contaminants (or naturally occurring metals), adversely impacting remedial effectiveness; and
- More extensive education and outreach efforts may be required in order to gain public acceptance of MNA.

## **IMPLEMENTATION**

The use of MNA is not new in OSWER programs. For example, in the Superfund program, use of natural attenuation as an element in a site's groundwater remedy is discussed in "Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites" (USEPA, 1988a). Use of MNA in OSWER programs has slowly increased over time with greater program experience and scientific understanding of the processes involved. Recent advances in the scientific understanding of the processes contributing to natural attenuation have resulted in a heightened interest in this approach as a potential means of achieving remediation objectives for soil and groundwater. However, EPA expects that reliance on MNA as the sole remedy will only be appropriate at relatively few contaminated sites. This Directive is intended to clarify OSWER program policies regarding the use of MNA and ensure that MNA remedies are selected and implemented appropriately. Topics addressed include the role of MNA in OSWER remediation programs, site characterization, the types of sites where MNA may be appropriate, reasonable remediation timeframes, source control, performance monitoring, and contingency remedies where MNA will be employed.

Role of Monitored Natural Attenuation in OSWER Remediation Programs

Under OSWER programs, remedies selected for contaminated media (such as contaminated soil and groundwater) must protect human health and the environment. Remedies may achieve this level of protection using a variety of methods, including treatment, containment, engineering controls, and other means identified during the remedy selection process.

The regulatory and policy frameworks for corrective actions under the UST, RCRA, and Superfund programs have been established to implement their respective statutory mandates and to promote the selection of technically defensible, nationally consistent, and cost effective solutions for the cleanup of contaminated media. EPA recognizes that MNA may be an appropriate remediation option for contaminated soil and groundwater under certain circumstances. However, determining the appropriate mix of remediation methods at a given site, including when and how to use MNA, can be a complex process. Therefore, MNA should be carefully evaluated along with other viable remedial approaches or technologies (including innovative technologies) within the applicable remedy selection framework. **MNA should not be considered a default or presumptive remedy at any contaminated site.**

Each OSWER program has developed regulations and policies to address the particular types of contaminants and facilities within its purview<sup>13</sup>. Although there are differences among

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<sup>13</sup> Existing program guidance and policy regarding MNA can be obtained from the following sources: For Superfund, see "Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites," (USEPA, 1988a; pp. 5-7 and 5-8); the Preamble to the 1990 National Contingency Plan (USEPA, 1990a, pp.8733-34); and "Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites, Final Guidance" (USEPA, 1996a; p. 18). For the RCRA program, see the Subpart S Proposed Rule (USEPA, 1990b, pp.30825 and 30829), and the Advance Notice of Proposed Rulemaking (USEPA, 1996b, pp.19451-52). For the UST program, refer to Chapter IX in "How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers;" (USEPA, 1995a).

these programs, they share several key principles that should generally be considered during selection of remedial measures, including:

- Source control measures should use treatment to address “principal threat” wastes (or products) wherever practicable, and engineering controls such as containment for waste (or products) that pose a relatively low long-term threat, or where treatment is impracticable.<sup>14</sup>
- Contaminated groundwaters should be returned to “their beneficial uses<sup>15</sup> wherever practicable, within a timeframe that is reasonable given the particular circumstances of the site.” When restoration of groundwater is not practicable, EPA “expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction.”<sup>16</sup>
- Contaminated soil should be remediated to achieve an acceptable level of risk to human and environmental receptors, and to prevent any transfer of contaminants to other media (e.g., surface or groundwater, air, sediments) that would result in an unacceptable risk or exceed required cleanup levels.
- Remedial actions in general should include opportunity(ies) for public involvement that serve to both educate interested parties and to solicit feedback concerning the decision making process.

Consideration or selection of MNA as a remedy or remedy component does not in any way change or displace these (or other) remedy selection principles. Nor does use of MNA

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<sup>14</sup> Principal threat wastes are those **source materials** that are “highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur. They include liquids and other highly mobile materials (e.g., solvents) or materials having high concentrations of toxic compounds.” (USEPA, 1991b). Low level threat wastes are “source materials that generally can be reliably contained and that would present only a low risk in the event of release.” (USEPA, 1991b). Since contaminated groundwater is not source material, it is neither a principal nor a low-level threat waste.

<sup>15</sup> **Beneficial uses** of groundwater could include uses for which water quality standards have been promulgated, (e.g., drinking water supply, discharge to surface water), or where groundwater serves as a source of recharge to either surface water or adjacent aquifers, or other uses. These or other types of beneficial uses may be identified as part of a Comprehensive State Groundwater Protection Program (CSGWPP). For more information on CSGWPPs, see USEPA, 1992a and USEPA, 1997b, or contact your state implementing agency .

<sup>16</sup> This is a general expectation for remedy selection in the Superfund program, as stated in §300.430 (a)(1)(iii)(F) of the National Contingency Plan (USEPA, 1990a, p.8846). The NCP Preamble also specifies that cleanup levels appropriate for the expected beneficial use (e.g., MCLs for drinking water) “should generally be attained throughout the contaminated plume, or at and beyond the edge of the waste management area when waste is left in place” (USEPA, 1990a, p.8713). The RCRA Corrective Action program has similar expectations (see USEPA, 1996b, pp.19448-19450).

diminish EPA's or the regulated party's responsibility to achieve protectiveness or to satisfy long-term site remediation objectives. EPA expects that **MNA will be an appropriate remediation method only where its use will be protective of human health and the environment and it will be capable of achieving site-specific remediation objectives within a timeframe that is reasonable compared to other alternatives.** The effectiveness of MNA in both near-term and long-term timeframes should be demonstrated to EPA (or other overseeing regulatory authority) through: 1) sound technical analyses which provide confidence in natural attenuation's ability to achieve remediation objectives; 2) performance monitoring; and 3) contingency (or backup) remedies where appropriate. **In summary, use of MNA does not imply that EPA or the responsible parties are "walking away" from the cleanup or financial responsibility at a site.**

It also should be emphasized that the selection of MNA as a remedy does **not** imply that active remediation measures are infeasible, or are "technically impracticable" from an engineering perspective. Technical impracticability (TI) determinations are used to justify a departure from cleanup levels that would otherwise be required at a Superfund site or RCRA facility based on the inability to achieve such cleanup levels using available remedial technologies (USEPA, 1993a). Such a TI determination does not imply that there will be no active remediation at the site, nor that MNA will be used at the site. Rather, such a TI determination simply indicates that the cleanup levels and objectives which would otherwise be required cannot practicably be attained using available remediation technologies. In such cases, an alternative cleanup strategy that is fully protective of human health and the environment must be identified. Such an alternative strategy may still include engineered remediation components, such as recovery of free phase NAPLs and containment of residual contaminants, in addition to approaches intended to restore some portion of the contaminated groundwater to beneficial uses. Several remedial approaches could be appropriate to address the dissolved plume, one of which could be MNA under suitable conditions. However, the evaluation of natural attenuation processes and the decision to rely upon MNA for the dissolved plume should be distinct from the recognition that restoration of a portion of the plume is technically impracticable (*i.e.*, MNA should **not** be viewed as a direct or presumptive outcome of a technical impracticability determination.)

#### Demonstrating the Efficacy of Natural Attenuation Through Site Characterization

**Decisions to employ MNA as a remedy or remedy component should be thoroughly and adequately supported with site-specific characterization data and analysis.** In general, the level of site characterization necessary to support a comprehensive evaluation of MNA is more detailed than that needed to support active remediation. Site characterizations for natural attenuation generally warrant a quantitative understanding of source mass; groundwater flow (including preferential pathways); contaminant phase distribution and partitioning between soil, groundwater, and soil gas; rates of biological and non-biological transformation; and an understanding of how all of these factors are likely to vary with time. This information is generally necessary since contaminant behavior is governed by dynamic processes which must be well understood before MNA can be appropriately applied at a site. Demonstrating the efficacy of

MNA may require analytical or numerical simulation of complex attenuation processes. Such analyses, which are critical to demonstrate natural attenuation's ability to meet remediation objectives, generally require a detailed conceptual site model<sup>17</sup> as a foundation.

EPA recommends the use of conceptual site models to integrate data and guide both investigative and remedial actions. However, program implementors should be cautious and collect sufficient field data to test conceptual hypotheses and not "force-fit" site data into a pre-conceived, and possibly inaccurate, conceptual representation. For example, a common mechanism for transport of contaminants is advection-dispersion, by which contaminants dissolved in groundwater migrate away from a source area. An alternative mechanism of contaminant transport (*i.e.*, NAPL migration) could be associated with a relatively large release of NAPL into the subsurface such that the NAPL itself has the potential to migrate significant distances along preferential pathways. Since NAPL migration pathways are often difficult to locate in the subsurface, one may incorrectly conclude that only the dissolved transport model applies to a site, when a combined NAPL and dissolved phase migration model would be more accurate. Applying a wrong conceptual model, in the context of evaluating an MNA (or any other) remedy, could result in a deficient site characterization (*e.g.*, did not use tools and approaches designed to find NAPLs or NAPL migration pathways), and inappropriate selection of an MNA remedy where long-term sources were not identified nor considered during remedy selection. NAPL present as either free- or residual phase represents a significant mass of contamination that will serve as a long-term source. Sources of contamination are more appropriately addressed by engineered removal, treatment or containment technologies, as discussed later in this Directive. Where the sources of contamination have been controlled, dissolved plumes may be amenable to MNA because of the relatively small mass of contaminants present in the plume.

Site characterization should include collecting data to define (in three spatial dimensions over time) the nature and distribution of contaminants of concern and contaminant sources as well as potential impacts on receptors (see "Background" section for further discussion pertaining to "Contaminants of Concern"). However, where MNA will be considered as a remedial approach, certain aspects of site characterization may require more detail or additional elements. For

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<sup>17</sup> A conceptual site model (CSM) is a three-dimensional representation that conveys what is known or suspected about contamination sources, release mechanisms, and the transport and fate of those contaminants. The conceptual model provides the basis for assessing potential remedial technologies at the site. "Conceptual site model" is not synonymous with "computer model"; however, a computer model may be helpful for understanding and visualizing current site conditions or for predictive simulations of potential future conditions. Computer models, which simulate site processes mathematically, should in turn be based upon sound conceptual site models to provide meaningful information. Computer models typically require a lot of data, and the quality of the output from computer models is directly related to the quality of the input data. Because of the complexity of natural systems, models necessarily rely on simplifying assumptions that may or may not accurately represent the dynamics of the natural system. Calibration and sensitivity analyses are important steps in appropriate use of models. Even so, the results of computer models should be carefully interpreted and continuously verified with adequate field data. Numerous EPA references on models are listed in the "Additional References" section at the end of this Directive.

example, to assess the contributions of sorption, dilution, and dispersion to natural attenuation of contaminated groundwater, a very detailed understanding of aquifer hydraulics, recharge and discharge areas and volumes, and chemical properties is necessary. Where biodegradation will be assessed, characterization also should include evaluation of the nutrients and electron donors and acceptors present in the groundwater, the concentrations of co-metabolites and metabolic by-products, and perhaps specific analyses to identify the microbial populations present. The findings of these, and any other analyses pertinent to characterizing natural attenuation processes, should be incorporated into the conceptual model of contaminant fate and transport developed for the site.

MNA may not be appropriate as a remedial option at many sites for technological or economic reasons. For example, in some complex geologic systems, technological limitations may preclude adequate monitoring of a natural attenuation remedy to ensure with a high degree of confidence that potential receptors will not be impacted. This situation typically occurs in many karstic, structured, and/or fractured rock aquifers where groundwater moves preferentially through discrete pathways (e.g., solution channels, fractures, joints, foliations). The direction of groundwater flow through such heterogeneous (and often anisotropic) materials can not be predicted directly from the hydraulic gradient, and existing techniques may not be capable of identifying the pathway along which contaminated groundwater moves through the subsurface. MNA will not generally be appropriate where site complexities preclude adequate monitoring. In some other situations where it may be technically feasible to monitor the progress of natural attenuation, the cost of site characterization and long-term monitoring required for the implementation of MNA may be higher than the cost of other remedial alternatives. Under such circumstances, MNA may not be less costly than other alternatives.

A related consideration for site characterization is how other remedial activities at the site could affect natural attenuation. For example, the capping of contaminated soil could alter both the type of contaminants leached to groundwater, as well as their rate of transport and degradation. Another example could be where there is co-mingled petroleum and chlorinated solvent contamination. In such cases, degradation of the chlorinated solvents is achieved, in part, through the action of microbes that derive their energy from the carbon in the petroleum. Recovery of the petroleum removes some of the source of food for these microbes and the rate of degradation of the chlorinated solvents is decreased. Therefore, the impacts of any ongoing or proposed remedial actions should be factored into the analysis of the effectiveness of MNA.

Once site characterization data have been collected and a conceptual model developed, the next step is to evaluate the potential efficacy of MNA as a remedial alternative. This involves collection of site-specific data sufficient to estimate with an acceptable level of confidence both the rate of attenuation processes and the anticipated time required to achieve remediation objectives. A three-tiered approach to such an evaluation is becoming more widely practiced and accepted. In this approach, successively more detailed information is collected as necessary to provide a specified level of confidence on the estimates of attenuation rates and remediation timeframe. These three tiers of site-specific information, or "lines of evidence", are:

- (1) Historical groundwater and/or soil chemistry data that demonstrate a clear and meaningful trend<sup>18</sup> of decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points. (In the case of a groundwater plume, decreasing concentrations should not be solely the result of plume migration. In the case of inorganic contaminants, the primary attenuating mechanism should also be understood.)
- (2) Hydrogeologic and geochemical data that can be used to demonstrate **indirectly** the type(s) of natural attenuation processes active at the site, and the rate at which such processes will reduce contaminant concentrations to required levels. For example, characterization data may be used to quantify the rates of contaminant sorption, dilution, or volatilization, or to demonstrate and quantify the rates of biological degradation processes occurring at the site.
- (3) Data from field or microcosm studies (conducted in or with actual contaminated site media) which **directly** demonstrate the occurrence of a particular natural attenuation process at the site and its ability to degrade the contaminants of concern (typically used to demonstrate biological degradation processes only).

**Unless EPA or the overseeing regulatory authority determines that historical data (Number 1 above) are of sufficient quality and duration to support a decision to use MNA, data characterizing the nature and rates of natural attenuation processes at the site (Number 2 above) should be provided. Where the latter are also inadequate or inconclusive, data from microcosm studies (Number 3 above) may also be necessary.** In general, more supporting information may be required to demonstrate the efficacy of MNA at those sites with contaminants which do not readily degrade through biological processes (*e.g.*, most non-petroleum compounds, inorganics), or that transform into more toxic and/or mobile forms than the parent contaminant, or where monitoring has been performed for a relatively short period of time. The amount and type of information needed for such a demonstration will depend upon a number of site-specific factors, such as the size and nature of the contamination problem, the proximity of receptors and the potential risk to those receptors, and other characteristics of the environmental setting (*e.g.*, hydrogeology, ground cover, climatic conditions).

Note that those parties responsible for site characterization and remediation should ensure that all data and analyses needed to demonstrate the efficacy of MNA are collected and evaluated by capable technical specialists with expertise in the relevant sciences. Furthermore, EPA expects that documenting the level of confidence on attenuation rates will provide more technically defensible predictions of remedial timeframes and form the basis for more effective performance monitoring programs.

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<sup>18</sup> For guidance on statistical analysis of environmental data, please see USEPA, 1989, USEPA, 1993b, USEPA, 1993d, and Gilbert, 1987, listed in the "References Cited" section at the end of this Directive.

Sites Where Monitored Natural Attenuation May Be Appropriate

MNA is appropriate as a remedial approach where it can be demonstrated capable of achieving a site's remediation objectives within a timeframe that is reasonable compared to that offered by other methods and where it meets the applicable remedy selection criteria (if any) for the particular OSWER program. **EPA expects that MNA will be most appropriate when used in conjunction with other remediation measures (e.g., source control, groundwater extraction), or as a follow-up to active remediation measures that have already been implemented.**

In determining whether MNA is an appropriate remedy for soil or groundwater at a given site, EPA or other regulatory authorities should consider the following:

- Whether the contaminants present in soil or groundwater can be effectively remediated by natural attenuation processes;
- Whether or not the contaminant plume is stable and the potential for the environmental conditions that influence plume stability to change over time;
- Whether human health, drinking water supplies, other groundwaters, surface waters, ecosystems, sediments, air, or other environmental resources could be adversely impacted as a consequence of selecting MNA as the remediation option;
- Current and projected demand for the affected resource over the time period that the remedy will remain in effect;
- Whether the contamination, either by itself or as an accumulation with other nearby sources (on-site or off-site), will exert a long-term detrimental impact on available water supplies or other environmental resources;
- Whether the estimated timeframe of remediation is reasonable (see section on "Reasonable Timeframe for Remediation") compared to timeframes required for other more active methods (including the anticipated

effectiveness of various remedial approaches on different portions of the contaminated soil and/or groundwater);

- The nature and distribution of sources of contamination and whether these sources have been, or can be, adequately controlled;
- Whether the resulting transformation products present a greater risk, due to increased toxicity and/or mobility, than do the parent contaminants;
- The impact of existing and proposed active remediation measures upon the MNA component of the remedy, or the impact of remediation measures or other operations/activities (e.g., pumping wells) in close proximity to the site; and
- Whether reliable site-specific mechanisms for implementing institutional controls (e.g., zoning ordinances) are available, and if an institution responsible for their monitoring and enforcement can be identified.

Of the above factors, the most important considerations regarding the suitability of MNA as a remedy include: whether the contaminants are likely to be effectively addressed by natural attenuation processes, the stability of the groundwater contaminant plume and its potential for migration, and the potential for unacceptable risks to human health or environmental resources by the contamination. MNA should not be used where such an approach would result in either plume migration<sup>19</sup> or impacts to environmental resources that would be unacceptable to the overseeing regulatory authority. **Therefore, sites where the contaminant plumes are no longer increasing in extent, or are shrinking, would be the most appropriate candidates for MNA remedies.**

An example of a situation where MNA may be appropriate is a remedy that includes source control, a pump-and-treat system to mitigate the highly-contaminated plume areas, and MNA in the lower concentration portions of the plume. In combination, these methods would maximize groundwater restored to beneficial use in a timeframe consistent with future demand on the aquifer, while utilizing natural attenuation processes to reduce the reliance on active remediation methods and reduce remedy cost. If, at such a site, the plume was either expanding

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<sup>19</sup> In determining whether a plume is stable or migrating, users of this Directive should consider the uncertainty associated with defining the limits of contaminant plumes. For example, a plume is typically delineated for each contaminant of concern as a 2- or 3-dimensional feature. Plumes are commonly drawn by computer contouring programs which estimate concentrations between actual data points. EPA recognizes that a plume boundary is more realistically defined by a zone rather than a line. Fluctuations within this zone are likely to occur due to a number of factors (e.g., analytical, seasonal, spatial, etc.) which may or may not be indicative of a trend in plume migration. Therefore, site characterization activities and performance monitoring should focus on collection of data of sufficient quality to enable decisions to be made with a high level of confidence. See USEPA, 1993b, USEPA, 1993c, USEPA, 1994b, and USEPA, 1998b, for additional guidance.

or threatening downgradient wells or other environmental resources, then MNA would **not** be an appropriate remedy.

#### Reasonable Timeframe for Remediation

EPA recognizes that determination of what timeframe is "reasonable" for **attaining remediation objectives** is a site-specific determination. The NCP preamble suggests that a "reasonable" timeframe for a remedy relying on natural attenuation is generally a "...timeframe **comparable** to that which could be achieved through active restoration" (USEPA, 1990a, p.8734; emphasis added). The NCP preamble further states that "[t]he most appropriate timeframe must, however, be determined through an analysis of alternatives" (USEPA, 1990a, p.8732). To ensure that these estimates are comparable, assumptions should be consistently applied for each alternative considered. Thus, determination of the most appropriate timeframe is achieved through a comparison of estimates of remediation timeframe for **all** appropriate remedy alternatives.

If **restoring groundwaters to beneficial uses** is a remediation objective, a comparison of restoration alternatives from most aggressive to passive (*i.e.*, MNA) will provide information concerning the approximate range of time periods needed to attain groundwater cleanup levels. An excessively long restoration timeframe, using the most aggressive restoration method, **may** indicate that groundwater restoration is technically impracticable from an engineering perspective (USEPA, 1993a). Where restoration is technically **practicable** using either aggressive or passive methods, the longer restoration timeframe required by the passive alternative may be reasonable in comparison with the timeframe needed for more aggressive restoration alternatives (USEPA, 1996a).

The advantages and disadvantages of each remedy alternative, including the timeframe, should be evaluated in accordance with the remedy selection criteria used by each OSWER program. Whether a particular remediation timeframe is appropriate and reasonable for a given site is determined by balancing tradeoffs among many factors which include:

- Classification of the affected resource (*e.g.*, drinking water source, agricultural water source) and value of the resource<sup>20</sup>;

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<sup>20</sup> In determining whether an extended remediation timeframe may be appropriate for the site, EPA and other regulatory authorities should consider state groundwater resource classifications, priorities and/or valuations where available, in addition to relevant federal guidelines. Individual states may provide information and guidance relevant to groundwater classifications or use designations as part of a Comprehensive State Groundwater Protection Program (CSGWPP). (See USEPA, 1992a and USEPA, 1997b).

- Relative timeframe in which the affected portions of the aquifer might be needed for future water supply (including the availability of alternate supplies);
- Subsurface conditions and plume stability which can change over an extended timeframe;
- Whether the contamination, either by itself or as an accumulation with other nearby sources (on-site or off-site), will exert a long-term detrimental impact on available water supplies or other environmental resources;
- **Uncertainties** regarding the mass of contaminants in the subsurface and predictive analyses (*e.g.*, remediation timeframe, timing of future demand, and travel time for contaminants to reach points of exposure appropriate for the site);
- Reliability of monitoring and of institutional controls over long time periods;
- Public acceptance of the timeframe required to reach remediation objectives; and
- Provisions by the responsible party for adequate funding of monitoring and performance evaluation over the time period required for remediation.

It should be noted that the timeframe required for MNA remedies is often longer than that required for more active remedies. **As a consequence, the uncertainty associated with the above factors increases dramatically. Adequate performance monitoring and contingency remedies (both discussed in later sections of this Directive) should be utilized because of this higher level of uncertainty.** When determining reasonable timeframes, the uncertainty in estimated timeframes should be considered, as well as the ability to establish performance monitoring programs capable of verifying the performance expected from natural attenuation in a timely manner (*e.g.*, as would be required in a Superfund five-year remedy review).

A decision on whether or not MNA is an appropriate remedy for a given site is usually based on estimates of the rates of natural attenuation processes. Site characterization (and monitoring) data are typically used for estimating attenuation rates. These calculated rates may be expressed with respect to either time or distance from the source. Time-based estimates are

used to predict the time required for MNA to achieve remediation objectives and distance-based estimates provide an evaluation of whether a plume will expand, remain stable, or shrink. For environmental decision-making, EPA requires that the data used be of "adequate quality and usability for their intended purpose." (USEPA, 1998b). Therefore, where these rates are used to evaluate MNA, or predict the future behavior of contamination, they must also be of "adequate quality and usability." Statistical confidence intervals should be estimated for calculated attenuation rate constants (including those based on methods such as historical trend data analysis, analysis of attenuation along a flow path in groundwater, and microcosm studies). When predicting remedial timeframes, sensitivity analyses should also be performed to indicate the dependence of the calculated remedial timeframes on uncertainties in rate constants and other factors (McNab and Doohar, 1998). A statistical evaluation of the rate constants estimated from site characterization studies of natural attenuation of groundwater contamination often reveals that the estimated rate constants contain considerable uncertainty. For additional guidance on data quality, see USEPA, 1993c, 1994c, 1995b, and 1995c.

As an example, analysis of natural attenuation rates from many sites indicates that a measured decrease in contaminant concentrations of at least one order of magnitude is necessary to determine the appropriate rate law to describe the rate of attenuation, and to demonstrate that the estimated rate is statistically different from zero at a 95% level of confidence (Wilson, 1998). Due to variability resulting from sampling and analysis, as well as plume variability over time, smaller apparent reductions are often insufficient to demonstrate (with 95% level of confidence) that attenuation has in fact occurred at all.

Thus, EPA or other regulatory authorities should consider a number of factors when evaluating reasonable timeframes for MNA at a given site. These factors, on the whole, should allow the overseeing regulatory authority to determine whether a natural attenuation remedy (including institutional controls where applicable) will fully protect potential human and environmental receptors, and whether the site remediation objectives and the time needed to meet them are consistent with the regulatory expectation that contaminated groundwaters will be restored to beneficial uses within a reasonable timeframe. **When these conditions cannot be met using MNA, a remedial alternative that more likely would meet these expectations should be selected.**

### Remediation of Sources

Source control measures should be evaluated as part of the remedy decision process at **all** sites, particularly where MNA is under consideration as the remedy or as a remedy component. Source control measures include removal, treatment, or containment, or a combination of these approaches. EPA prefers remedial options which remove free-phase NAPLs and treat those source materials determined to constitute "principal threat wastes" (see Footnote 13).

Contaminant sources that are not adequately addressed complicate the long-term cleanup effort. For example, following free product recovery, residual contamination from a petroleum

fuel release may continue to leach significant quantities of contaminants into the groundwater as well as itself posing unacceptable risks to humans or environmental resources. Such a lingering source often unacceptably extends the time necessary to reach remediation objectives. This leaching can occur even while contaminants are being naturally attenuated in other parts of the plume. If the rate of attenuation is lower than the rate of replenishment of contaminants to the groundwater, the plume can continue to expand thus contaminating additional groundwater and potentially posing a threat to downgradient receptors.

Control of source materials is the most effective means of ensuring the timely attainment of remediation objectives. **EPA, therefore, expects that source control measures will be evaluated for all contaminated sites and that source control measures will be taken at most sites where practicable.** At many sites it will be appropriate to implement source control measures during the initial stages of site remediation (“phased remedial approach”), while collecting additional data to determine the most appropriate groundwater remedy.

#### Performance Monitoring and Evaluation

Performance monitoring to evaluate remedy effectiveness and to ensure protection of human health and the environment is a critical element of all response actions. Performance monitoring is of even greater importance for MNA than for other types of remedies due to the potentially longer remediation timeframes, potential for ongoing contaminant migration, and other uncertainties associated with using MNA. This emphasis is underscored by EPA’s reference to “monitored natural attenuation”.

The monitoring program developed for each site should specify the location, frequency, and type of samples and measurements necessary to evaluate whether the remedy is performing as expected and is capable of attaining remediation objectives. In addition, all monitoring programs should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring according to expectations;
- Detect changes in environmental conditions (*e.g.*, hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes<sup>21</sup>;
- Identify any potentially toxic and/or mobile transformation products;
- Verify that the plume(s) is not expanding (either downgradient, laterally or vertically);

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<sup>21</sup> Detection of changes will depend on the proper siting and construction of monitoring wells/points. Although the siting of monitoring wells is a concern for any remediation technology, it is of even greater concern with MNA because of the lack of engineering controls to control contaminant migration.

- Verify no unacceptable impact to downgradient receptors;
- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy;
- Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors; and
- Verify attainment of remediation objectives.

The frequency of monitoring should be adequate to detect, in a timely manner, the potential changes in site conditions listed above. At a minimum, the monitoring program should be sufficient to enable a determination of the rate(s) of attenuation and how that rate is changing with time. When determining attenuation rates, the uncertainty in these estimates and the associated implications should be evaluated (see McNab and Dooher, 1998). Flexibility for adjusting the monitoring frequency over the life of the remedy should also be included in the monitoring plan. For example, it may be appropriate to decrease the monitoring frequency at some point in time, once it has been determined that natural attenuation is progressing as expected and very little change is observed from one sampling round to the next. In contrast, the monitoring frequency may need to be increased if unexpected conditions (e.g., plume migration) are observed.

**Performance monitoring should continue until remediation objectives have been achieved, and longer if necessary to verify that the site no longer poses a threat to human health or the environment.** Typically, monitoring is continued for a specified period (e.g., one to three years) after remediation objectives have been achieved to ensure that concentration levels are stable and remain below target levels. The institutional and financial mechanisms for maintaining the monitoring program should be clearly established in the remedy decision or other site documents, as appropriate.

Details of the monitoring program should be provided to EPA or the overseeing regulatory authority as part of any proposed MNA remedy. Further information on the types of data useful for monitoring natural attenuation performance can be found in the ORD publications (e.g., USEPA, 1997a, USEPA, 1994a) listed in the "References Cited" section of this Directive. Also, USEPA (1994b) published a detailed document on collection and evaluation of performance monitoring data for pump-and-treat remediation systems.

### Contingency Remedies

A contingency remedy is a cleanup technology or approach specified in the site remedy decision document that functions as a “backup” remedy in the event that the “selected” remedy fails to perform as anticipated. A contingency remedy may specify a technology (or technologies) that is (are) different from the selected remedy, or it may simply call for modification of the selected technology, if needed. Contingency remedies should generally be flexible—allowing for the incorporation of new information about site risks and technologies.

Contingency remedies are not new to OSWER programs. Contingency remedies should be included in the decision document where the selected technology is not proven for the specific site application, where there is significant uncertainty regarding the nature and extent of contamination at the time the remedy is selected, or where there is uncertainty regarding whether a proven technology will perform as anticipated under the particular circumstances of the site (USEPA, 1990c).

It is also recommended that one or more criteria (“triggers”) be established, as appropriate, in the remedy decision document that will signal unacceptable performance of the selected remedy and indicate when to implement contingency remedies. Such criteria should generally include, but not be limited to, the following:

- Contaminant concentrations in soil or groundwater at specified locations exhibit an increasing trend not originally predicted during remedy selection;
- Near-source wells exhibit large concentration increases indicative of a new or renewed release;
- Contaminants are identified in monitoring wells located outside of the original plume boundary;
- Contaminant concentrations are not decreasing at a sufficiently rapid rate to meet the remediation objectives; and
- Changes in land and/or groundwater use will adversely affect the protectiveness of the MNA remedy.

In establishing triggers or contingency remedies, however, care is needed to ensure that sampling variability or seasonal fluctuations do not unnecessarily trigger a contingency. For example, an anomalous spike in dissolved concentration(s) at a well(s) might not be a true indication of a change in trend.

EPA recommends that remedies employing MNA be evaluated to determine the need for including one or more contingency measures that would be capable of achieving remediation objectives. EPA believes that contingency remedies should generally be included as part of a MNA remedy which has been selected based primarily on predictive analyses rather than documented trends of decreasing contaminant concentrations.

## SUMMARY

**EPA remains fully committed to its goals of protecting human health and the environment by remediating contaminated soils, restoring contaminated groundwaters to their beneficial uses, preventing migration of contaminant plumes, and protecting groundwaters and other environmental resources.** EPA does not view MNA to be a “no action” remedy, but rather considers it to be a means of addressing contamination under a limited set of site circumstances where its use meets the applicable statutory and regulatory requirements. MNA is not a “presumptive” or “default” remediation alternative, but rather should be evaluated and compared to other viable remediation methods (including innovative technologies) during the study phases leading to the selection of a remedy. The decision to implement MNA should include a comprehensive site characterization, risk assessment where appropriate, and measures to control sources. In addition, the progress of natural attenuation towards a site’s remediation objectives should be carefully monitored and compared with expectations to ensure that it will meet site remediation objectives within a timeframe that is reasonable compared to timeframes associated with other methods. Where MNA’s ability to meet these expectations is uncertain and based predominantly on predictive analyses, decision-makers should incorporate contingency measures into the remedy.

EPA is confident that MNA will be, at many sites, a reasonable and protective component of a broader remediation strategy. However, EPA believes that there will be many other sites where either the uncertainties are too great or there is a need for a more rapid remediation that will preclude the use of MNA as a stand-alone remedy. This Directive should help promote consistency in how MNA remedies are proposed, evaluated, and approved.

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## **OTHER SOURCES OF INFORMATION**

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