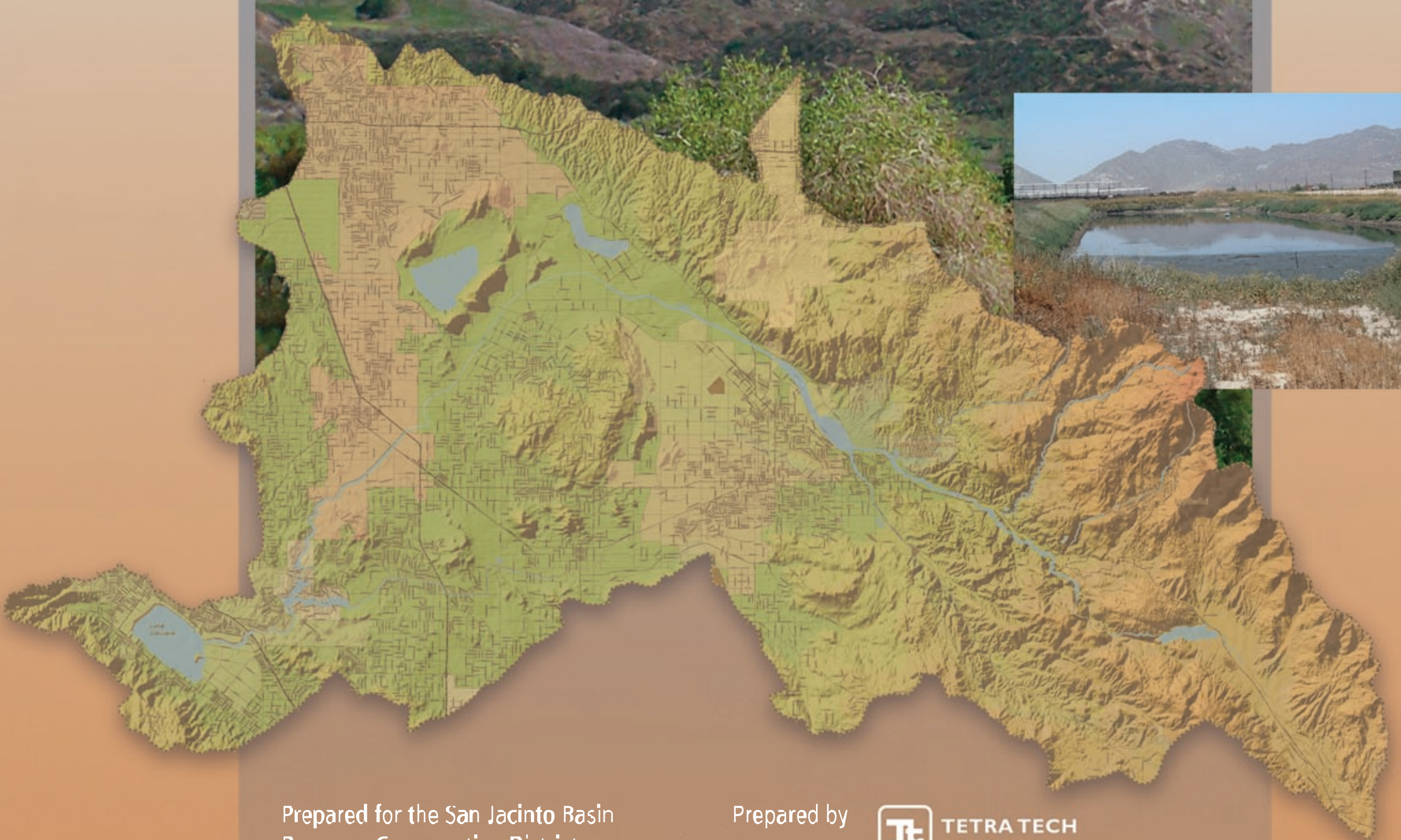
San Jacinto Watershed Integrated Regional Dairy Management Plan

December 2009



Prepared for the San Jacinto Basin Resource Conservation District

Prepared by TETRA TECH

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San Jacinto Watershed Integrated Regional Dairy Management Plan

December 26, 2009

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Acknowledgements

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This product was developed through the San Jacinto Basin Resource Conservation District (SJBRCD), the grantee for developing the San Jacinto Basin IRDMP. Completion of this plan depended on generous support from various stakeholders in the watershed.

SJBRCD would like especially to thank WRCAC, a key teaming partner for its strategic leadership, cooperation, and input in identifying dairy issues of concern, IRDMP objectives, and technology solutions. In particular, Bruce Scott worked tirelessly to ensure that all members of the IRDMP team had access to up-to-date information on changes in the watershed as well as innovative and creative technologies for consideration in the plan. Mr. Scott also provided the location and significant in-kind support for the U.S. Department of Agriculture best management practice (BMP) field pilot.

As Project Director, Pat Boldt was responsible for securing the grant funding and navigating the IRDMP development team through the various requirements and pitfalls encountered during project inception, execution and completion. Ms. Boldt was diligent in her efforts to ensure a high-quality project that meets the grant requirements as well as the needs of San Jacinto dairy operators through all the complexities of unforeseen and extremely difficult budget and scheduling challenges.

Special thanks also to Ron Abacherli for allowing us use of his dairy for the Vibratory Shear Enhanced Processing BMP pilot-scale study location. Special thanks also to Eastern Municipal Water District for its assistance in obtaining data on groundwater quality and groundwater use at San Jacinto dairies.

SJBRCD would like to acknowledge the Santa Ana Regional Water Quality Control Board staff, especially Mr. Ed Kashak, our grant manager, as well as Pam Nichols, financial analyst, of the State Water Resources Control Board for their efforts on this project.

SJBRCD is also grateful to those stakeholders who continue to support us financially each year to contribute to the success of this and all our projects.

Roy B. Mason
President, SJBRCD

Photo credits:
Nanette Scott, Pat Boldt, Don Meals, NRCS, Pat Makarewicz

Executive Summary

Introduction

The San Jacinto River watershed faces critical issues including groundwater basin overdraft, poor quality groundwater that limits opportunities for recycled water use, and nutrient runoff contributing to nutrient overloading in Canyon Lake and Lake Elsinore. The principal objective of the Integrated Regional Dairy Management Plan (IRDMP) is to provide an integrated regional plan, or roadmap, for the dairy industry in the San Jacinto Watershed that will address regulatory requirements and issues of concern for dairy operators in the basin. The plan will assist dairy operators in the San Jacinto River watershed in their efforts to implement all management practices necessary to help solve groundwater, surface water, air quality and salts problems in the watershed and meet regulatory requirements while maintaining the long-term sustainability of the dairy industry in the area.

Aerial view of a San Jacinto dairy and associated cropland

The San Jacinto Basin Resource Conservation District (SJBRCD) secured and administered the grant funding used to develop the IRDMP. Development of the IRDMP was led by the Western Riverside County Agriculture Coalition (WRCAC), an active stakeholder group that includes individual farmers and dairy producers, Riverside County Farm Bureau, Western United Dairymen, Milk Producers Council, representatives from the Eastern Municipal Water District and Nuevo Water District, the SJBRCD, the University of California Riverside Cooperative Extension, the USDA-ARS Salinity Lab, and the USDA Natural Resources Conservation Service (NRCS).

As a foundation for this planning effort, the IRDMP sponsored a number of data collection efforts to characterize the San Jacinto River watershed and to evaluate the performance of some potential management practices:

- Technical Memo Concerning Existing Data on the San Jacinto Watershed (2007);
- Water quality monitoring of Mystic Lake and surface waters in the San Jacinto Watershed (2008);
- Spatio-Temporal Assessment of Nutrient Management Plan Performance for Field-Scale Lagoon Water Application (USDA-ARS Salinity Laboratory, 2007-2009); and
- Vibratory Shear Enhanced Processing (VSEP®) system using reverse osmosis (RO) membranes to separate and concentrate suspended solids and dissolved solids dairy manure and wastewater (New Logic Research, Inc., 2007 – 2008)

Results of these studies are presented and discussed in the full IRDMP.

Dairy Issues of Concern

The need for the IRDMP is largely driven by several major issues that represent challenges to the dairy industry in the San Jacinto Watershed. These issues include:

- **Salt Offset Requirements.** San Jacinto dairies overlie groundwater management zones (GWMZs) that lack assimilative capacity for total dissolved solids (TDS) and nitrate. As of September 2012 the Santa Ana Regional Water Quality Control Board (RWQCB) Order No. R8-2007-0001 (the dairy discharge permit) will prohibit the application of manure, process wastewater, or stormwater from manured areas on land associated with dairies that overlie GWMZs lacking assimilative capacity for TDS or nitrate-nitrogen unless a plan, acceptable to the Executive Officer, is implemented that offsets the effects of that application on the underlying ground water management zone.
- **Total Maximum Daily Load (TMDL) Requirements.** The Lake Elsinore/Canyon Lake nutrient TMDL establishes phosphorus (P) and nitrogen (N) load allocations to watershed sources that contribute excessive nutrient loads to the lakes. Substantial P and N load reductions will be necessary in the San Jacinto Watershed. And some of these reductions must come from CAFOs.
- **Manure Issues.** Manure from dairies in the San Jacinto watershed is a significant source of nutrients, bacteria, and other pollutants. Although dairy manure is substantially regulated under the dairy discharge permit, problems commonly occur in the watershed relative to manure that is imported from outside the watershed and to untracked, improper, or illegal dumping of manure.
- **Agricultural cropland.** Despite the obvious potential linkage between dairy manure generated in the San Jacinto River watershed and

San Jacinto dairy cows

agricultural cropland needing fertilizer in the watershed, there is a need to strengthen such relationships so that manure nutrients are used according to good nutrient management practices and a balance is achieved between nutrients imported to and exported from the San Jacinto River watershed. This is of particular concern because of the upcoming implementation of the conditional waiver of agricultural waste discharge requirements ("ag waiver" or CWAD) requiring additional management of nutrients on cropland.

- **Ground water.** Ground water quantity and quality are both issues for San Jacinto dairies. Local ground water is not only limited in quantity and increasingly expensive to extract but also limited in assimilative capacity for salts (TDS and nitrate) from dairy wastewater and manure.
- **Air quality.** San Jacinto dairies are subject to a number of air quality regulations under the South Coast Air Quality Management District (SCAQMD). These regulations impose certain requirements and practices on dairy operations and may influence what options may be available for future dairy waste management, such as composting or manure digestion.
- **Cost-effectiveness and sustainability.** San Jacinto River watershed dairy operators are concerned with the sustainability—economic, agronomic, and environmental—of their livelihood. The cost-effectiveness of measures proposed to address the issues facing San Jacinto dairies must be a major consideration.

Recommendations to Address Dairy Issues

The IRDMP includes a variety of specific recommendations, outlined below, to address regulatory requirements for surface water, groundwater, and air quality protection; issues related to manure quantity, quality, and disposition in the watershed; and concerns for the economic and environmental sustainability of the dairy industry in the San Jacinto River watershed. Specific recommendations will be selected and implemented according to 3 overarching priorities that will guide dairy-specific and watershed-scale decisions about practices to address dairy issues of concern:

1. Prioritize projects that recognize the close relationship between dairy and agricultural operators in the San Jacinto River watershed and seek to implement solutions that benefit the broader agricultural industry to ensure long-term sustainability and resource protection.
2. Select projects with an eye toward watershed-scale effects and surface water and ground water quality responses. Where possible, locate projects and BMPs in targeted priority areas to maximize pollutant reduction potential.

Cropland at a San Jacinto Dairy

3. Collect and analyze data that accurately characterize the impact of dairies on surface water, groundwater and air quality relative to other point and nonpoint sources in the watershed. Focus on scientifically valid data collection and analysis to inform watershed-scale decisions.

1. Data collection and analysis

The following types of watershed data should be collected and maintained to support implementation of the IRDMP:

- Land use/land cover and demographic data, including current population data, municipal growth management plans, land development requirements, and land use/land cover
- Pollutant source data
  - Track location, characteristics, and status of dairies.
  - Monitor salt loads in dairy manure and wastewater.
  - Determine if manure or wastewater can be applied to San Jacinto cropland using rates and methods that do not result in salt or nitrate loading to groundwater.
  - Implement the Manure Manifest System (Appendix I) to track quantity and disposition of manure in the watershed and import of manure from outside the watershed.
  - Track the implementation of, adherence to, and results of nutrient management plans (NMPs) adopted by San Jacinto dairies relative to manure and fertilizer use, soil nutrient levels, and crop yields.
- Waterbody Monitoring Data
  - Conduct storm event monitoring at the San Jacinto River watershed and Mystic Lake stations.
  - Examine existing waterbody data for temporal and spatial trends that would shed light on the possible influence of dairies on observed levels of nutrients and bacteria.
  - Track Mystic Lake subsidence to inform future TMDL and other modeling efforts that characterize the impact of Mystic Lake overflows on Canyon Lake and Lake Elsinore.
  - Dairies should participate in the watershed-wide monitoring activities required by the TMDL.

Mystic Lake wildlife area

- The IRDMP
  - Establish and maintain a system to track the adoption of management practices by San Jacinto dairies.
  - Incorporate the Manure Manifest System outputs as part of an overall monitoring strategy that includes inputs (i.e., manure), soils, and water quality to determine how the IRDMP is performing.
  - Design and implement a water quality monitoring program to assess the effectiveness of best management practices (BMPs) implemented in the San Jacinto River watershed and of the overall progress of the IRDMP, using existing monitoring networks to the extent possible.

- Dairy Salt Loads
  - Track each transfer of manure within each dairy as well as removal from the dairy to facilitate calculating the salt load. The following key variables need to be quantified to calculate and balance the manure budget and the associated salt load for a given time period:
    - Manure generation rates, by cattle type;
    - Cattle counts, by cattle type ;
    - Amount of time spent in each manure generation site, by cattle type ;
    - Mass of manure applied to on-site cropland;
    - Mass of manure exported from the dairy;
    - Manure hauling location (the type and location of the hauling site will determine if the exported manure requires a salt offset, i.e., manure hauled to a location overlying a GWMZ that lacks assimilative capacity for salt will require a salt offset);
    - Mass of manure stored in on-site stockpiles; and
    - Manure salt content.
  - Track water use and transfers to ensure that the dairy wastewater salt load can be calculated. The following key variables need to be quantified to calculate and balance the dairy water budget and the associated salt load:
    - Water use, by source;
    - Cattle water consumption, by cattle type;
    - Milk barn water use;
    - Source water quality;
    - Amount of time spent in the milk barn, by cattle type;
    - Wastewater quality;
    - Distribution of wastewater among disposal areas;
    - Potential lagoon evaporation;
    - Type of crop grown and duration of growth;
    - Crop field area;
    - Reference evapotranspiration;
    - Crop coefficient;
    - Salt uptake by crop type; and
    - Volume of water added to lagoons from precipitation.

Wastewater conveyance at a San Jacinto dairy

- In addition to the operational variables listed above, it is strongly recommended that manure and wastewater be monitored for quality and quantity.
  - Each dairy should meter and maintain records of the quantity of water from all water sources used in dairy operations.
  - Each dairy should meter and maintain records of movement of wastewater from lagoons to crop fields or disposal fields within the facility.
  - Each dairy should analyze all manure leaving the facility or being applied to on-site cropland for moisture content and salt content.
  - Each dairy should test wastewater at least annually for TDS, nitrate, and other constituents; initial wastewater sampling should be more frequent (e.g., weekly or monthly) to characterize variability.
  - Each dairy should obtain and keep on file results from the periodic EMWD analysis of well water, as well as water extraction data reported by EMWD.

- Watershed Nutrient Assimilative Capacity
  - Work with the Riverside County Agriculture Commissioner, NRCS, and University of California Cooperative Extension to collect data and conduct research to facilitate quantification of crop nutrient needs in the watershed.
    - Types of crops grown
    - Location of crops grown
    - Watershed-specific crop nutrient uptake rates
    - Watershed-specific crop yields

2. Salt offset options for San Jacinto River watershed dairies

An analysis of salt offset requirements and a proposed salt offset program (Wildermuth Environmental, Inc. 2008) recommends the following options to address the salt loading produced by dairy activities:

- Eliminate application of corral manure to croplands;
- Reduce the TDS concentration of process wastewater by changing in source water or treating wastewater;
- Implement a salt management plan; and
- Participate in local groundwater improvement projects.

In addition, the IRDMP further recommends that:

- WRCAC should explore the option of eliminating the use of corral manure as fertilizer. The best chance the San Jacinto dairies have to continue operating in the future is to entirely remove the primary loading factor from the region.
- WRCAC and individual dairies in the San Jacinto River watershed should investigate the practicality and cost-effectiveness of on-site wastewater treatment for TDS reduction, both on individual dairies and as one or more centralized facility
- WRCAC should engage the EMWD as soon as possible to consider the regional groundwater strategies being implemented.

In November 2009, manure and wastewater on 10 San Jacinto Watershed dairies were sampled to estimate more locally-accurate dairy salt load factors. Sampling included manure from feed alleys, corrals, and stockpiles and wastewater discharged from milk barns and in lagoons. Data on well water were also obtained from the Eastern Municipal Water District (EMWD). Specific conclusions from this effort include:

- Manure represents by far the dominant source of salt and nutrient loads from dairies; it is clear that any solutions to the salt offset issue must address manure export. The IRDMP estimates that 80 percent of the dairies' salt load could be eliminated by exporting all solid manure from the watershed.
- The salt and nutrient content of manure in dairies was reasonably consistent among the sampled dairies; this consistency may be beneficial for the processing of manure into a uniform product for sale or export from the watershed.
- Salt and nutrient loads in dairy wastewater generally accounted for 20 percent or less of total dairy loads.
- Estimated dairy wastewater volumes were substantially lower than the assumptions used in previous salt offset assessments, but measured TDS concentrations were substantially higher than previous estimates. As a result, wastewater TDS loads calculated in this project are substantially higher than those previously estimated. Salt load estimates should be updated using these results to more accurately characterize the dairies' water quality impacts and offset requirements.
- The quality of dairy wastewater was substantially more variable than manure quality among the sampled dairies. To some extent, this may be due to management variations, suggesting that opportunities might exist to reduce wastewater TDS and nitrate levels.
- Well water quality data provided by EWMD suggest some trends toward declining ground water TDS; investigation and documentation of such trends should be an important part of a salt offset program.

Cropland and production area at a San Jacinto dairy

Future investigations of the dairy nutrient and salt issue should include the following activities:

- Obtain more accurate data on dairy wastewater generation by metering source water at the point of use rather than relying on well extraction data.
- Collect detailed, site-specific data to support an analysis of N mineralization and nitrification rates in dairy wastewater management.
- Assess regional trends in ground water TDS and nitrate to evaluate the ongoing status of GWMZ assimilative capacity.
- Sample local ground water to assess actual delivery of TDS and nitrate to ground water.
- Conduct research to determine the fate and transport of individual TDS components applied to San Jacinto croplands to answer the question, "Can manure or wastewater be applied under a strict NMP so that TDS and nitrate do not leach to groundwater?"

Calf

3. Manure Manifest System

As part of IRDMP development, a Manure Manifest System was proposed to track manure generation, transport, and use in the watershed to help meet the many surface water, ground water, air quality, and local ordinance requirements. The Manure Manifest System should be implemented to provide information on nutrient generation, transportation, importation, and use to improve analyses for the nutrient TMDL, to address air quality concerns and reduce nuisance complaints from neighbors through guidance and site-specific limitations for manure application, and to improve accountability for manure use and disposal and reduce dairy operators' risk of fines or litigation due to improper disposal outside of their control.

4. Recommended management practices

San Jacinto dairies will be required to reduce discharge of nutrients and salts in the very near future; much of this requirement will have to be met by changing the ways dairies deal with wastewater and manure quantity, quality, storage, treatment and disposition. Based on analysis of the issues facing San Jacinto dairies and the characteristics of practices available to address those issues, this IRDMP recommends the following practices for implementation in the San Jacinto River watershed:

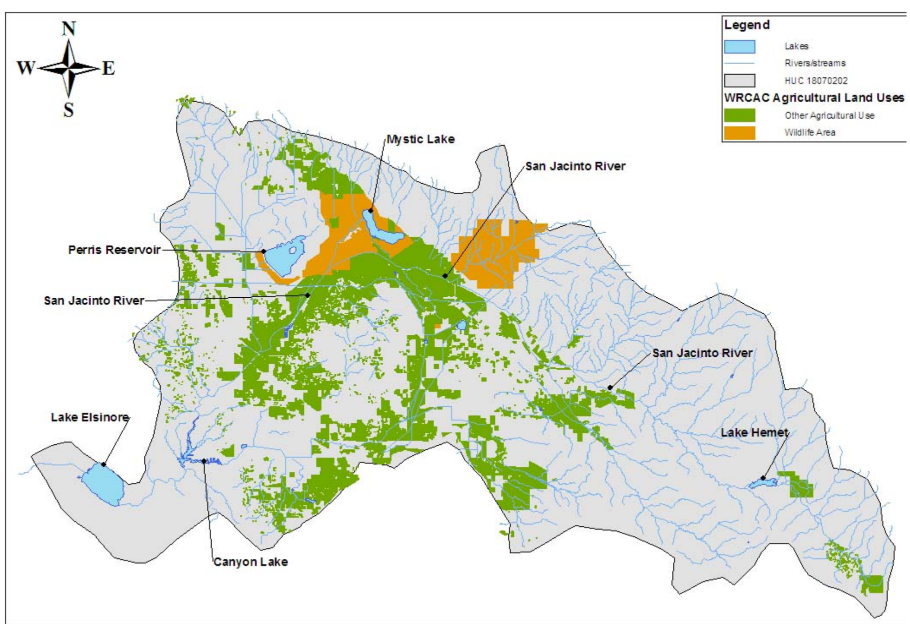
- Source Reduction. Reducing nutrient and salt inputs to dairy waste systems using the following practices:
  - Precision feeding
  - Nutrient management (both dairy and other cropland)
  - Phytoremediation
  - Waste amendment
- Manure Export. Because most available practices do not get rid of manure nutrients or salts, export of manure from the San Jacinto River watershed is a key component of the IRDMP. Manure nutrients and salts can be exported from the watershed in several different forms:
  - Raw manure
  - Compost and/or digestion residuals

- Structural Practices. BMPs implemented to reduce the salt and nutrient loads delivered to surface water and groundwater resources, including the following:
    - Pond Lining
    - Multi-pond treatments
    - Constructed wetland
    - Composting
    - Cooperative/regional digester
- Specialized practices. Any number of innovative practices to facilitate dairy waste management for salt and nutrient load reduction may be available in the future:
    - VSEP® (specifically, conduct a full-scale cost analysis to see if the process if feasible for a dairy)
    - Innovative practices that can be shown to be practical and cost-effective

5. Interaction between dairy operators and agricultural operators in the San Jacinto River watershed

Because the manure produced by San Jacinto River watershed dairies can supply essential nutrients to agricultural crops and thereby provide an acceptable outlet for dairy manure nutrients, the IRDMP explores potential interactions between dairy and agricultural operations in the watershed to assess the degree to which manure nutrients might be recycled for crop production within the watershed. Although it was necessary to employ several simplifying assumptions because specific data were lacking, the analysis clearly showed that cropland in the San Jacinto River watershed cannot accept all N and P contained in dairy manure, even if application at agronomic rates to cropland overlying GWMZs is allowed. Even under the most optimistic scenarios, only 74 percent of manure N and 30 percent of manure P generated in the watershed could be recycled on cropland in the watershed. A possible exception is turf production, which is a special case of cropland in the San Jacinto. Turf is a high-value commodity that could offer unique opportunities for exporting manure nutrients and salts from the watershed.

Some research has indicated that turf can accept high manure or compost applications and export additional nutrients in a high value export product that could help finance application of manure and transportation out of the watershed. Enhanced manure application to turf should be explored as one means of exporting manure nutrients from the watershed.



Distribution of agricultural land in the San Jacinto River watershed

6. The watershed scale

While many management practices can be adopted by individual dairy operators and installed on individual facilities, it is clear that a cooperative, watershed-scale approach will be necessary to meet the challenges to the San Jacinto River watershed dairy industry. The IRDMP recommends that the following strategies be adopted at the watershed scale:

- Treat raw manure and wastewater before use to stabilize nutrients and/or reduce bulk;
- Consider a regional digester that could generate revenue through biogas and energy production, for subsequent management of the residuals containing all the original nutrients and salts are managed;
- Develop a centralized or cooperative composting facility, including a marketing effort to encourage composted manure export from the watershed;
- Conduct an organized manure export operation that might include a manure brokering system to match suppliers of manure with those needing manure nutrients, manufacture of value-added products from manure for export, or back-hauling manure to forage-producing areas where manure nutrients are needed;
- Cooperate with other regional entities like EMWD to approach salt issues;
- Coordinate with the RWQCB to develop an NMP template and specific technical standards for nutrient management to ensure nutrient application at appropriate agronomic rates throughout the watershed; and
- Consider participating in a pollutant trading system.

IRDMP Implementation and Performance Assessment

1. Implementation strategy and leadership

To support implementation and adaptive management, the IRDMP discusses some of the strategic and tactical decisions about management changes being made by stakeholders, needs for coordination in the implementation process, and a plan for long-term monitoring to track the effectiveness of IRDMP implementation.

San Jacinto River watershed dairy operators appear to be ready and willing to engage in both individual and community efforts to address the challenges facing them. Cost is a major factor, of course, and manure composting and digestion for biogas are particularly attractive options because of the potential for income to offset the costs of new practices. Dairy operators are concerned about the economic sustainability of their industry in the future, but they remain strongly committed to dairying.

Aerial view of dairies, the San Jacinto River, and Mystic Lake.

Leadership and effective partnerships are the keys to successful implementation of the IRDMP. Because of its function as a partnership representing dairy and agricultural interests in addressing environmental and regulatory issues in the San Jacinto River watershed, and its participation on the TMDL Task Force and other regional efforts, WRCAC is uniquely poised to serve as the focal point for implementing the IRDMP.

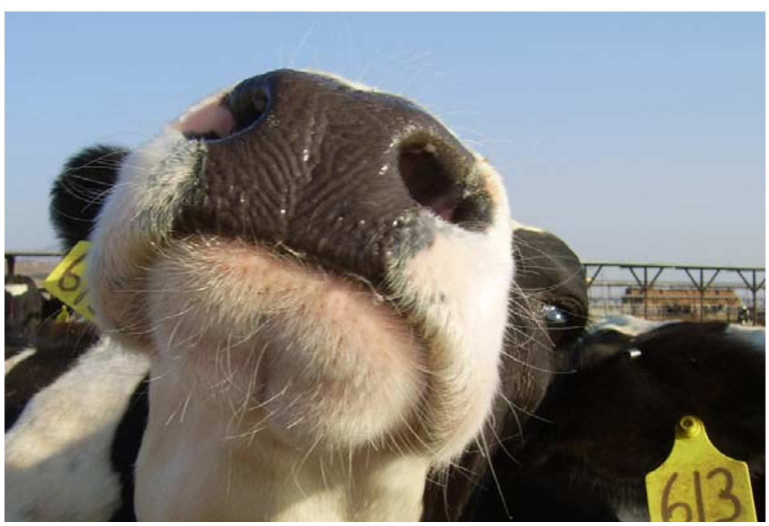
2. Mechanisms for evaluating implementation plan performance and updating the IRDMP

Evaluating progress and effectiveness is an essential part of the IRDMP. Any plan of this magnitude should have mechanisms for evaluating plan performance and for supporting long-term adaptive management. The IRDMP recommends the following structure for monitoring plan effectiveness over the long term:

- Track implementation of the IRDMP to demonstrate compliance with regulatory requirements and to detect changes in application and management of dairy manure and process wastewater. Key indicators to be monitored include:
    - Dairy operational data, including number and type of animals and quantities of manure and wastewater generated on watershed dairies (surface water, groundwater, and air quality);
    - Estimates of dairy-derived salt application to watershed lands (groundwater);
    - Estimates of field, farm, and watershed-scale nutrient balances (surface and groundwater); and
    - Inventory of practices implemented to address groundwater, surface water, and air quality concerns.
- Measure the effectiveness of individual management practices on dairies and lands receiving dairy manure or process wastewater. Key indicators to be monitored and appropriate monitoring designs include:
    - To monitor the effectiveness of source reduction practices such as precision feeding or manure amendment, comparison of treated and control dairies is an appropriate design.
    - To assess the effectiveness of treatment BMPs such as digestion, constructed wetlands, or composting, an input/output design is recommended.
    - Monitoring manure export effectiveness should focus on tracking the export of manure from individual dairies and from the San Jacinto River watershed. Manure production data are available from individual dairy records and from annual reports submitted by dairies to the RWQCB. Data on manure hauling and destinations can be collected from individual dairy records and from the Manure Manifest System.
- Monitor water quality in selected receiving waters to detect changes as a result of implementing the IRDMP and to fill information gaps. Emphasis should be placed on monitoring every storm event at seven stream and ditch sites in those areas where water quality is primarily affected by dairies and cropland. Appropriate indicators to be monitored at the watershed scale include:
    - Surface water nutrient and TDS loads;
    - Surface water bacteria and BOD concentrations and loads as indicators of manure runoff;
    - Stream and ditch water chemistry;
    - Mystic Lake nutrient and TDS loads, both inflow and outflow;
    - Mystic Lake nutrient and TDS concentrations; and
    - Mystic Lake water chemistry.

Additional recommendations for long-term monitoring include:

- Seek improvement in the RWQCB's review and oversight of the information reported by dairies under their permits. Adoption of a specific NMP template as part of the dairy permit would help to generate reliable and complete data from dairies and others adopting NMPs.
- Adopt the Manure Manifest System and use its records as a continuing source of data to monitor manure generation and disposition in the watershed.
- Conduct an assessment of agricultural fertilizer application and spatial variability of crop types in the watershed that would include a spatial inventory of crop distribution, estimates of seasonal nutrient application rates for each crop type, and estimates of agronomic rates associated with each crop type for both N and P.
- Consult expert technical guidance on monitoring design and operation before committing resources to specific monitoring projects.
- Ensure that watershed-scale monitoring maximizes reliance on ongoing monitoring conducted in support of the TMDL and other efforts.
- Continue to monitor Mystic Lake monthly at a single station—ML2.
- Monitor streams and channels to assess watershed-scale effects of the IRDMP and to help fill data gaps associated with pollutant sources and transport.
- If new monitoring stations are developed, perform initial reconnaissance before monitoring begins to ensure that potential stations are viable, technically feasible, and representative of the pollutants and pollutant sources described in this plan. Conducting a synoptic survey during a significant runoff event would be a good first step before making final decisions about the monitoring locations to use to address Objective 3 of the long-term monitoring plan.
- Summarize land use and management data and BMP implementation data at the watershed scale to support interpretation of watershed-scale monitoring data.
- Manage monitoring data from all sources together in a single platform, under the direction of a single individual. Report data frequently to detect any problems in data collection.



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Acronyms

AF	Acre-foot
AFY	Acre-feet per year
AIS	Aerial Information Systems, Inc.
ANOVA	Analysis of Variance
APN	Assessor's parcel information
ASP	Aerated static pile
BARCT	Best available retrofit control technology
BMP	Best management practice
BOD	Biochemical oxygen demand
CAD	Canadian dollars
CAF	Confined animal facility
CAFO	Concentrated animal feeding operation
CIWMB	California Integrated Waste Management Board
CL	Canyon Lake
CMP	Congestion Management Program
CNMP	Comprehensive nutrient management plan
CSTR	Continuous stirred tank reactor
CWAD	Conditional waiver of waste discharge requirements for agricultural discharges
DDWEN	California Department of Public Health's Division of Drinking Water and Environmental Management
ECa	Soil electrical conductivity
ECe	Soil salinity
EMWD	Eastern Municipal Water District
ESPA	Energy Saving PolyAmide
EQIP	Environmental Quality Incentives Program
ET	Evapotranspiration
EVMWD	Elsinore Valley Municipal Water District
EWMP	Engineered Waste Management Plan
GPS	Global positioning system
GWMZ	Ground water management zone

IERCA	Inland Empire Regional Composting Authority
IEUA	Inland Empire Utilities Agency
IRDMP	San Jacinto Watershed Integrated Regional Dairy Management Plan
IRRP	Hemet/San Jacinto Integrated Recharge and Recovery Program
IRWMP	San Jacinto River Watershed Integrated Regional Watershed Management Plan
kWh	Kilowatt hour
LA	Load allocations
LE	Lake Elsinore
LESJWA	Lake Elsinore and San Jacinto Watersheds Authority
MCL	Maximum contaminant level
MDP	Master drainage plan
MOS	Margin of safety
MPG	Miles per gallon
MRLC	USGS Multi-Resolution Land Characteristics
MSHCP	Western Riverside County Multiple Species Habitat Conservation Plan
MW	Megawatt
NCDC	National Climatic Data Center
NMP	Nutrient management plan
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PG&E	Pacific Gas and Electric
PSNT	Pre-sidedress nitrogen test
QAPP	Quality Assurance Project Plan
RCFC&WCD	Riverside County Flood Control and Water Conservation District
REEP	Renewable Energy Efficiency Project
RO	reverse osmosis
RWQCB	Santa Ana Regional Water Quality Control Board
SARI	Santa Ana Regional Interceptor
SAWA	Santa Ana Watershed Association
SAWPA	Santa Ana Watershed Project Authority
SCAG	Southern California Association of Governments
SCAQMD	South Coast Air Quality Management District
SJBRCD	San Jacinto Basin Resource Conservation District

SJUP	San Jacinto Upper Pressure Ground Water Management Zone
SRP	Soluble reactive phosphorus
SRP	Soluble reactive phosphorus
TDS	Total dissolved solids
TIN	Total inorganic nitrogen
TKN	Total Kjeldahl nitrogen
TMDL	Total Maximum Daily Load
TN	Total nitrogen
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
USACE	U.S. Army Corps of Engineers
USD	U.S. dollars
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VOC	Volatile organic compound
VSEP®	Vibratory Shear Enhanced Processing
WLA	Wasteload allocation
WRCAC	Western Riverside County Agriculture Coalition
WRCOG	Western Riverside Council of Governments
WTS®	Wastewater Treatment Solution System
WY	Water years

1. Overview of the Integrated Regional Dairy Management Plan

The San Jacinto River watershed faces many critical issues such as groundwater basin overdraft, poor quality groundwater that limits opportunities for recycled water use, and nutrient runoff contributing to nutrient overloading in Canyon Lake and Lake Elsinore. The principal objective of this project is to provide an integrated regional plan for the dairy industry in the San Jacinto River watershed that will address specific ways to solve water quality issues including salts and nutrients, as well as air quality issues including particulates and odors, that are associated with the dairy industry.

The *San Jacinto Watershed Integrated Regional Dairy Management Plan* (IRDMP) incorporates several key components into an overall plan for dairies in the San Jacinto River watershed. Developing the IRDMP involved defining issues and objectives and identifying appropriate solutions. A primary objective of the IRDMP is to meet surface water and groundwater regulatory requirements in a manner that is also consistent with requirements related to air quality. Recommendations for meeting these requirements are made within the context of other issues of concern such as manure imports to the watershed, illegal dumping of manure, and nuisance complaints. The IRDMP provides a state-of-the-art, new approach for dairy management that can be applied on a regional or larger scale embracing stakeholder participation.

The IRDMP takes a unique, comprehensive approach to dairy management on a watershed scale rather than focusing solely on regulatory compliance at individual dairies. The plan is consistent with broader, watershed-based planning and management activities in the region and complements the activities of a wide range of stakeholders.

Dairies in the San Jacinto River watershed

The IRDMP incorporates a number of individual studies and reports into a comprehensive plan. These include a survey of existing data, several best management practice (BMP) demonstration projects, a Mystic Lake and watershed monitoring program, a proposed manure tracking system, and an analysis of salt offset program options. The plan is intended to be a living, dynamic document and, as such, includes provisions for periodic evaluation and updating—and guidelines for assessing—plan performance. Such an approach is necessary to ensure that the plan can be adapted to changing economic and environmental conditions in the watershed.

1.1 Purpose for Developing an IRDMP for the San Jacinto River Watershed

The IRDMP was developed to provide an integrated regional plan, or roadmap, for the dairy industry in the San Jacinto River watershed that will address regulatory requirements and issues of concern for dairy operators in the basin. The plan will assist dairy operations in the San Jacinto River watershed in their efforts to implement all management practices necessary to help solve groundwater, surface water, air quality, and salt problems in the watershed and meet regulatory requirements while maintaining the long-term sustainability of the dairy industry in the area. The regulatory requirements and issues of concern addressed by the IRDMP are described briefly below.

1.1.1 Regulatory Compliance

San Jacinto dairy operators must comply with a number of environmental regulations concerning surface and groundwater quality as well as air quality. Those include the following:

1.1.1.1 Discharge Permit for Concentrated Animal Feeding Operations (CAFOs)

All dairies in the San Jacinto River watershed are covered under the General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities) within the Santa Ana Region (R8-2007-0001) (dairy discharge permit). The dairy discharge permit, which serves as a permit under the National Pollutant Discharge Elimination System (NPDES) contains a number of requirements specific to the production areas at dairies, including the following:

- Prohibitions on wastewater discharge
- A ban on animals in waterways
- Requirements to develop an Engineered Waste Management Plan (EWMP) and, for dairies that apply manure/wastewater to their own lands, a Nutrient Management Plan (NMP)
- Requirements for wastewater holding systems and run-on diversions
- Requirements to remove and track transfers of manure
- Requirements to measure nutrient content of manure
- Prohibition on land disposal of manure
- Restrictions on land application of manure and wastewater in groundwater management zones that cannot assimilate additional total dissolved solids (TDS) or nitrate

Any dairy operating in a region that lacks assimilative capacity for TDS or nitrate-nitrogen and plans to continue to apply manure and other dairy process wastes to land must design a work plan to offset its salt load by September 2012.

1.1.1.2 Lake Elsinore/Canyon Lake Nutrient TMDL

The Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Load (TMDL) identifies agriculture and CAFOs, including dairies, as significant sources of nutrients to the two impaired waterbodies.

The TMDL distributes the portions of the waterbodies' modeled assimilative capacities to various pollution sources so that the waterbodies achieve their water quality standards.

The San Jacinto dairies are complying with requirements of the TMDL for nutrients in Lake Elsinore and Canyon Lake either individually on agriculture-specific tasks or through a TMDL Task Force stakeholder group. The TMDL requirements include the following:

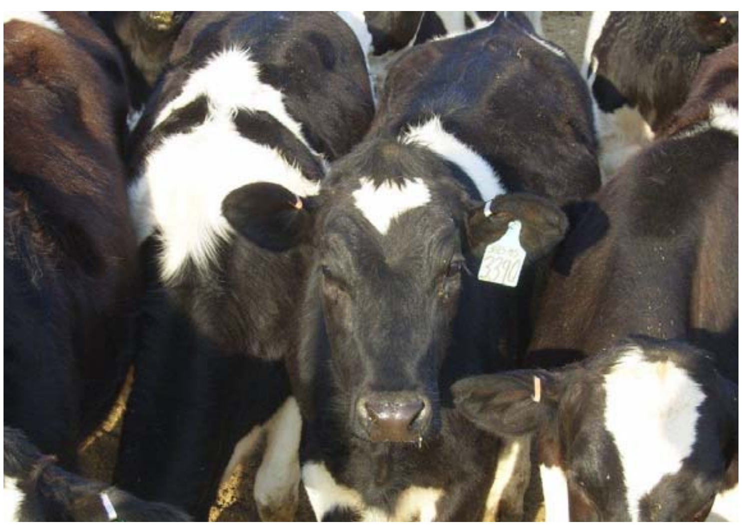
- Develop watershed and in-lake monitoring programs to update the Lake Elsinore and Canyon Lake Nutrient TMDL
- Develop a CAFO NMP that includes steps to identify nutrient sources and develop nutrient reduction strategies
- Develop a plan and schedule for in-lake nutrient reduction for Lake Elsinore
- Develop a plan for evaluating in-lake sediment nutrient reduction strategies for Canyon Lake
- Develop a proposal and schedule for updating the existing Lake Elsinore/San Jacinto River Nutrient Watershed Model and the Canyon Lake and Lake Elsinore in-lake models
- Develop a Pollutant Trading Plan

1.1.1.3 Riverside County Ordinance 427.2

Riverside County regulates the transportation and application of manure in certain districts of the county. It requires registration of all farm and agricultural operations or landowners who wish to apply bulk manure. Registration requires operators and landowners to report manure application and agree to minimize effects on neighboring properties, local waterways, underground water supplies, and soil resources. Landowners must apply for an exemption to use manure or allow manure transporters to apply manure to their land. Landowners also need to have demonstrated conformity with the *Standards for Manure Use at Approved Sites* in prior manure applications.

1.1.1.4 South Coast Air Quality Management District Rule 1127

Dairy operators in the San Jacinto River watershed are subject to the South Coast Air Quality Management District's (SCAQMD's) Rule 1127, Emission Reductions from Livestock Waste. The rule is intended to reduce emissions of ammonia, volatile organic compounds, and particulate matter smaller than 10 micrometers from livestock waste. It specifies BMPs to reduce air emissions, including manure removal, minimization of excess water, paving, cleaning frequency, and stockpiling requirements. It limits disposal of manure to an approved manure processing operation or agricultural land within the SCAQMD approved by local ordinance or the RWQCB for the spreading of manure. The rule sets forth a set of mitigation measures with which operators must comply, including controls for feed and silage, milk parlor, freestall barns, corrals, handling solid manure or separated solids, handling liquid manure, and land application.



Cows

1.1.1.5 South Coast Air Quality Management District Rule 223

All dairies with 1,000 or more milking cows were required to apply for air emission reduction permits under Rule 223. Permit applications are to include an emissions mitigation plan that demonstrates that the facility will use best available retrofit control technology (BARCT) to reduce emissions of pollutants that contribute to the nonattainment of any ambient air quality standard and that are within the SCAQMD's regulatory authority. Required mitigation measures must address feed and silage operations, milk parlors, freestall barns, corrals, handling solid manure or separated solids, handling liquid manure, and land application of liquid or dry manure. In addition, owners or operators must submit annual compliance plans and maintain records of monthly animal populations for at least 3 years.

1.1.1 Other Rules

Management decisions made by dairy operators can lead to additional compliance requirements with other rules. For example, a decision to generate electricity from biogas using an internal combustion engine could subject the owner to requirements under SCAQMD Rule 1110.2. Establishing a co-composting facility on a dairy would subject the owner to the requirements of SCAQMD Rule 1133.2 if feedstock is imported. Thus, assessing changing regulatory requirements that result from management decisions is a critical element of planning for San Jacinto dairies.

1.1.2 Manure Imports

Manure being land applied in the San Jacinto River watershed does not solely originate at San Jacinto dairies. Dairies in the Chino Basin are exporting manure, and haulers are applying the manure at sites in the San Jacinto River watershed. Because the San Jacinto River watershed has limited assimilative capacity for nutrients and salts, that additional manure from outside the watershed limits options for San Jacinto dairies to dispose of their manure.

1.1.3 Illegal Dumping

When CAFO operators from within or outside the San Jacinto River watershed contract with haulers, a mechanism of accountability for the final destination of the manure is lacking. Many hauling events result in authorized land application on San Jacinto cropland, but anecdotal evidence suggests that some haulers are illegally dumping manure on non-authorized sites, posing a nuisance, increasing the risk of surface and groundwater pollution, and violating conditions of the Riverside County ordinance.

Example of manure dumping near the San Jacinto River

1.1.4 Nuisance Complaints

The IRDMP offers the opportunity for land application sites to be reviewed in detail for soil and crop conditions, proximity to waterbodies and sensitive resources, and potential nuisance complaints on the basis of neighboring land uses. For example, sites adjacent to schools or public parks might be less desirable for manure application during certain times of the year because of odor or public health concerns. The site visits afforded by the proposed Manure Manifest System can identify and address potential conflicts before they occur to eliminate discord and ensure communication between landowners and the public.

1.2 A Unique Comprehensive Approach

Nutrients and other pollutants from dairies and livestock operations are typically managed at the facility level. Regulations require farm-specific NMPs, and TMDLs often allocate wasteloads to each facility. Clearly, management changes will be required for San Jacinto dairies to address salt offset requirements, the nutrient TMDL, and other regulations. The changes will need to occur at the individual dairy level and at a watershed scale. Stakeholders need to make strategic decisions on how best to approach these challenges as a group, then make tactical choices on the changes that best suit their individual operations.

The IRDMP is unique in its comprehensive approach to regulatory compliance and managing environmental effects from dairies. This watershed-based “roadmap” for dairy compliance can be used as a model for watersheds across California and the nation where CAFOs contribute to TMDL impairments.

Specific causes of the problems addressed by this plan include solid and liquid manure application to cropland, dairy wastewater storage and discharges, and stormwater runoff from dairies and associated land application areas. The plan recommends practices to address the dairy industry’s contribution to these problems on the basis of careful consideration of a range of contributing factors including importing manure, applying manure at greater than agronomic rates, gaps in information about manure generation and use or disposal, and gaps in understanding of flow patterns and nutrient fate and transport in the watershed.

1.2.1 Objectives of the IRDMP

The goal of the IRDMP is to select and implement BMPs for the dairy industry in the San Jacinto River watershed consistent with regional goals for water quality and environmental protection and the sustainability of the region’s dairy industry. Achieving multiple complementary objectives will help accomplish the overall goal of the IRDMP. These objectives include the following:

- To ensure that all dairies have the necessary cost-effective tools to meet the TMDL and General Waste Discharge Requirements through
  - Conducting demonstration projects to test the performance of comprehensive NMPs when lagoon water is applied to cropland and to examine the use of a state-of-the-art treatment process to clean dairy wastewater to reduce salt and nutrient loading and free up assimilative capacity for recycled water use
  - Developing options for salt offset programs that will allow continued application of manure to cropland in the watershed
  - Exploring the potential to cost-effectively address IRDMP objectives using other proven and experimental technologies and management practices
- To ensure that the nutrient TMDL allocations accurately reflect contributions from Mystic Lake and surrounding dairies and agricultural land by collecting water quality data from Mystic Lake and watershed monitoring sites
- To ensure that existing watershed data and future data collection efforts are sufficient to characterize problems and facilitate development of solutions for the problems
- To catalog and fully characterize issues of concern to dairy operators associated with the environmental problems addressed by the IRDMP
- To integrate solutions to groundwater, surface water, air quality, and salts problems regionally to ensure that all sources and causes are addressed sustainably, including
  - Developing a feasible manure manifest system approach

- o Identifying BMPs that will enable CAFOs and associated agricultural operations to achieve TMDL nutrient load targets, compliance with applicable air quality and salt offset requirements, and water management objectives

1.2.2 Other Activities

It is important to acknowledge additional activities that are underway in the San Jacinto River watershed to address TMDL and regulatory compliance. Because those activities focus on non-dairy agricultural operations, they are not explored in detail in the IRDMP. However, they are critical to developing scientifically valid TMDL load allocation and achieving water quality goals shared by all watershed stakeholders. The Western Riverside County Agriculture Coalition (WRCAC) under a grant from the California State Water Resources Control Board, known as the TMDL Agricultural Operator Voluntary Program (Grant # 06-280-558-1), has undertaken such activities.

1.2.2.1 Agricultural Land Uses Mapping Project

WRCAC contracted with Aerial Information Systems, Inc. (AIS) to create a geographical information system (GIS) cataloging agricultural land uses in the San Jacinto River watershed. The primary goals of the project were to

- Enable WRCAC to identify existing and potential sources of nutrient flow into waterbodies
- More readily identify and contact the responsible owners
- Develop accurate land use data to benefit future modeling needs

AIS created the agricultural land uses data set through a combination of aerial photo interpretation and limited, on-the-ground, field verification. Agriculture and dairy land uses were identified for greater than 20-acre parcels and categorized as irrigated agriculture, turf farms, citrus, livestock, dairy, vacant land, tree farms, non-irrigated agriculture, and other categories. Agricultural land uses were linked to existing digital Riverside County assessor's parcel information (APN) to create an Ag-parcel layer. A dairy GIS layer and accompanying tabular data were created linking dairy owner, address, and APN information to the agricultural land uses and Ag-parcel data. The data created by AIS were used to develop Section 5.4.2.5 of the IRDMP (Interaction between dairy operators and agricultural operators in the San Jacinto River watershed).

1.2.2.2 Agricultural BMPs Report

WRCAC contracted with Tetra Tech, Inc., to prepare the *Management Practices to Reduce Nutrient Loads from Agricultural Operations in the San Jacinto Watershed* report, which identifies a prioritized list of agricultural management practices that will help stakeholders reduce nutrient loads from cropland in the San Jacinto River watershed. Tetra Tech worked closely with stakeholders to compile information on BMPs implemented in the region to control nutrients in runoff. In addition, Tetra Tech reviewed national and regional literature to identify nutrient-control BMPs in areas where climate and agricultural practices are similar to the San Jacinto River watershed. The report identifies specific nutrient management, irrigation water management, erosion control, crop-specific management, and education and outreach practices and discusses approaches to implementing those practices at both the farm and watershed scales, including cost-benefit and applicability information. The report also identifies important information gaps and includes recommendations for future work.

1.2.2.3 TMDL Agricultural Operator Voluntary Implementation Program

The primary focus of the TMDL grant is to develop an implementation process to assist agriculture and dairy operators with TMDL compliance. The TMDL requirements can be met as individuals or through a group effort. The first phase of the Voluntary Implementation Program process, which began in 2008, addressed dairy allocations for 2006 through 2009. Those allocations are fees paid to the Lake Elsinore and San Jacinto Watersheds Authority (LESJWA) TMDL Task Force to implement programs to address agricultural load allocations established in the TMDL.

The benefits of a group approach to TMDL compliance include lower compliance cost to individual stakeholders as well as greater environmental benefits achievable through a coordinated, watershed-based approach. This program has several components, including

- A dairy pilot program
- An agricultural operator program
- A third-party review process
- Compliance with the TMDL, including coordination with the Santa Ana Regional Water Quality Control Board (RWQCB) and the TMDL Task Force

By the end of 2008, dairy and agricultural operators were identified, outreach to the groups was underway, and fees for administration of the TMDL process were determined. The dairy pilot program was completed in 2008 with 100 percent participation (i.e., fees paid by 100 percent of dairies), and dairy stakeholder allocations were paid to the TMDL Task Force. The agricultural operator program completed aerial mapping and development of the membership fee and allocation structure. Three stakeholder outreach meetings were held in January 2009 to explain the purpose of the program and the methods for fee allocation. A land use verification process was also implemented for those who believe their properties might be exempt from TMDL implementation requirements, including a third-party review/smaller parcel stewardship program for cropland or citrus parcels smaller than 20 acres.

1.3 IRDMP Stakeholders

1.3.1 Lead Organization: San Jacinto Basin Resource Conservation District

The San Jacinto Basin Resource Conservation District (SJBRCD)—charged with helping people conserve, protect, and restore natural resources through programs of information, education, and technical assistance—is an active advocate for the dairy community in the San Jacinto River watershed. SJBRCD secured and administered the grant funding used to develop the IRDMP. That included identifying and hiring staff and consultants as well as coordinating closely with WRCAC to ensure that IRDMP efforts would meet the needs of dairy stakeholders and were consistent with programs implemented under the TMDL grant. SJBRCD oversaw all aspects of developing the IRDMP and reviewed all draft reports and other documents incorporated into the IRDMP.

1.3.2 Other Participating Agencies and Organizations

WRCAC was a close partner with SJBRCD in its efforts. WRCAC was formed in March of 2004 by stakeholders in Western Riverside County to inform, educate, and find solutions to problems facing individual dairy producers, farm applicators, and county and state regulatory agencies. The stakeholder group comprises individual farmers, individual dairy producers, supporting trade groups (Riverside County Farm Bureau, Western United Dairymen, Milk Producers Council), representatives from local water agencies (Eastern Municipal Water District, Nuevo Water District), SJBRCD, the University of California Riverside Cooperative Extension, the U.S.

WRCAC logo

Department of Agriculture (USDA) Salinity Lab, and the Natural Resources Conservation Service (NRCS). Additionally, WRCAC is the official representative for the agricultural community on the TMDL Stakeholder Task Force.

WRCAC provided in-kind support and key input from dairy producers to develop the IRDMP. The input was critical in identifying issues of concern to the San Jacinto dairy community and workable solutions to address those issues.

The following individuals, agencies, and groups (listed alphabetically) also participated in the IRDMP's development, through participation and support as WRCAC stakeholders, by providing financial or in-kind support for the project, by drafting sections of the report, or by reviewing and providing input on identified problems and suggested solutions:

- Abacherli Dairy
- AIS, Inc.
- City of San Jacinto
- Eastern Municipal Water District (EMWD)
- Essie Bootsma
- Garrett DeVries
- Gayle Holyoak
- John Hunt, USDA Forest Products Laboratory
- LESJWA/TMDL Task Force
- Milk Producers Council
- Nanette Scott
- Natural Resources Conservation Service
- New Logic Research, Inc.
- Nuevo Water District
- Pat Boldt Consulting
- Pat Makarewicz
- Riverside County Farm Bureau
- Santa Ana Regional Water Quality Control Board
- Santa Ana Watershed Association (SAWA)
- Santa Ana Watershed Project Authority (SAWPA)
- Scott Brothers Dairy Farms
- SeaHold
- Tetra Tech
- USDA Salinity Lab
- University of California, Riverside Cooperative Extension Service
- Walco International Environmental Services
- WRCAC
- Western United Dairymen

WRCAC partners from the Cooperative Extension Service and USDA Salinity Lab also conducted research used to develop portions of the IRDMP.

1.4 Relationship of IRDMP to Other Plans in the San Jacinto River Watershed

Although its focus is on issues specific to San Jacinto dairies, the IRDMP was developed with a strategic vision toward holistic, watershed-based solutions. To that end, the goals and objectives of other watershed-based plans were considered in developing the IRDMP.

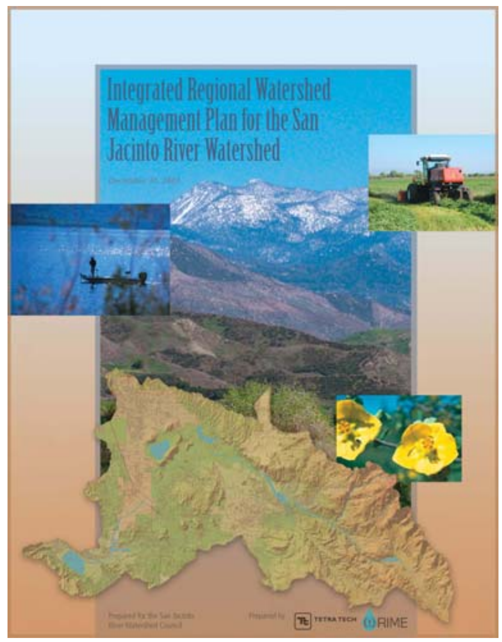
1.4.1 San Jacinto River Watershed Integrated Regional Watershed Management Plan

The *San Jacinto River Watershed Integrated Regional Watershed Management Plan* (IRWMP) was developed in December 2007 by the San Jacinto River Watershed Council (SJRWC) a 501(c) 3 non-profit organization. That plan served as a model for the IRDMP. The San Jacinto River IRWMP integrates input from a wide variety of stakeholder organizations and individuals to develop a watershed-based approach to meeting objectives related to improving surface and groundwater quality; ensuring the long-term viability of water supplies; providing adequate stormwater and flood control; protecting, enhancing, and creating habitat for wildlife; promoting water recycling; expanding water conservation programs; enhancing opportunities for parks, recreation, and open space; weighing environmental justice concerns in watershed decision making; and exploring opportunities to address climate change issues with watershed projects. The IRDMP directly supports a number of sub-objectives identified for the IRWMP, including

- Reduce impacts of dairy runoff
- Improve groundwater quality
- Achieve salt balance in the watershed
- Promote projects that sustain agriculture in the San Jacinto River watershed
- Expand water use efficiency

The IRDMP also directly supports three of the five main watershed priorities identified in the IRWMP to guide future water management projects:

1. Prioritize projects that offer multiple benefits rather than a single benefit. These include projects that address more than one resource management strategy, incorporate other natural resource priorities such as clean air and climate change, or provide community amenities such as recreation areas.
2. Ensure that future water management projects further efforts to comply with pollutant load allocations established in the nutrient TMDL for Lake Elsinore and Canyon Lake.
3. Assist crop agriculture and dairy producers in implementing BMPs to reduce nutrients in surface waters and to meet salt offset requirements for groundwater.



San Jacinto River Watershed IRWMP

1.4.2 Santa Ana Integrated Watershed Plan

As described in the IRWMP, SAWPA's *Santa Ana Integrated Watershed Plan* addresses watershed management issues in an integrated fashion within the larger Santa Ana River watershed, which includes the San Jacinto River watershed. The IRWMP was developed to complement and build on the work already completed by watershed stakeholders in developing and implementing the *Santa Ana Watershed Integrated Plan.* By directly supporting IRWMP objectives and priorities, as described above, the IRDMP serves as an additional complementary planning process to further enhance the overall watershed management efforts in the greater Santa Ana River watershed.

1.4.3 TMDL Agricultural Operator Voluntary Implementation Plan for the San Jacinto River Watershed

The Voluntary Implementation Program, described in detail above, is administered by WRCAC and includes components addressing TMDL compliance for dairies as well as agricultural operators. Recognizing the substantial overlap and interrelationship in economic and environmental concerns, including TMDL requirements, of these groups, the IRDMP was developed in close coordination with WRCAC to ensure that the recommended actions support achievement of shared goals for environmental and economic sustainability for all agricultural enterprises in the watershed.

1.5 Process for Developing the IRDMP

Development of the IRDMP began in August 2007 with a meeting of WRCAC to begin identifying dairy issues of concern that the plan should address. The stakeholders and IRDMP development team continued constructing the plan throughout 2007 and 2008. In December, 2008, California budget shortfalls precipitated a freeze on all state-funded grant activity. Because of that, IRDMP development was suspended from mid-December 2008 through early September 2009, when funding was reinstated. As a condition of grant continuance, the state required completion of all grant-funded activities by December 31, 2009, rather than the previously-extended project deadline of June 2010. That obligated SJBRCD to revise the scope of the grant to accommodate the shortened time frame for completion.

Portions of the IRDMP—including a summary of existing data, the Mystic Lake and Watershed Monitoring Program, Identification of Salt Offset Program Options, two BMP demonstration technologies—were developed as a series of individual components that are integrated by the overall plan. Table 1-1 shows the schedule of completion for individual IRDMP components. Other sections were outlined at the outset of plan development on the basis of stakeholder input and evolved over the course of the project to accommodate new data and changing conditions in the watershed. For example, 34 dairies, with approximately 69,000 animals existed in the watershed in 2005. Development pressure and other stressors led to the loss of several dairies during the housing boom that occurred in 2005 and early 2006. Economic hardships in the dairy industry in 2008 and 2009 precipitated the loss of several more dairies to herd reduction programs. Others moved dairy operations out of the watershed. As of December 2009, 25 dairies with approximately 51,000 cows are in the watershed; SJBRCD anticipates that this number will decline further. Such changes have been monitored throughout the course of IRDMP development to ensure that analyses and recommendations are consistent with current conditions.


Cows at a San Jacinto dairy

Several IRDMP elements—Individual Dairy Sampling and Analysis, Cost Analysis for IRDMP/Salt Offset Options, Salt Offset Conceptual Model, a Long-Term BMP Analysis Plan, and Waste Revenue Path Technology Options —were added to the scope of the IRDMP in September 2009 as a result of the shortened development schedule described above. The change in schedule precluded completion of the comprehensive nutrient management plan (CNMP) pilot project as anticipated; the new projects were added to use the grant funding that could not be used to complete the CNMP pilot project.

Table 1-1. Schedule for completion of IRDMP elements

IRDMP element	Completion date
Technical Memorandum Summarizing Existing Data	December 2007
Mystic Lake and watershed monitoring program	July 2008
BMP Demonstration Technologies—Innovative Treatment System for Quality Improvement of CAFO Wastewater Using Vibratory Shear Enhanced Processing (VSEP®)	October 2008
Manure Manifest Tracking System	October 2008
Technical Memorandum Identifying Salt Offset Program Options	October 2008
BMP Demonstration Technologies—Spatio-Temporal Assessment of NMP Performance for Field-Scale Lagoon Water Application at Scott Brothers Dairy, San Jacinto, California (CNMP pilot project)	December 2009
Individual Dairy Sampling and Analysis	November 2009
Cost Analysis for IRDMP/Salt Offset Options	December 2009[a]
Salt Offset Conceptual Model	December 2009
Long-Term BMP Analysis Plan	December 2009[a]
Using Waste Revenue Projections for Technology Development Options	December 2009
IRDMP final report	December 2009

a. To be developed as an element of the final IRDMP

1.5.1 Identification of Dairy Requirements and Concerns

The first step in developing the IRDMP was to identify the requirements and concerns to be addressed by the plan. This process involved ongoing communication among IRDMP stakeholders, primarily through WRCAC, as well as reviewing applicable regulations for surface and groundwater quality and air quality protection summarized in Section 1.1.1, including the General Waste Discharge Requirements for Dairies and Related Facilities, the Lake Elsinore/Canyon Lake Nutrient TMDL, air quality rules, and various local ordinances related to composting and manure management. On the basis of ongoing stakeholder input and review of applicable requirements, the objectives for the IRDMP were set forth.

1.5.2 Technical Approach for Plan Development

SJBRCD led and coordinated development of the technical approach in close cooperation with WRCAC and with participation of other stakeholder groups and individual dairy operators. A number of consultants contributed to the process, including Tetra Tech, Inc.; Wildermuth, Inc.; Weston Solutions, Inc.; and Walco International. The technical approach to the IRDMP included a number of coordinated efforts described below.

1.5.2.1 Watershed characterization and summary of existing data

Developing and implementing the IRDMP depends on accurate, current, and readily accessible data. A summary of existing data, completed in 2007 (see Appendix A) includes recommendations for how data can be used to support recommended projects and makes recommendations on activities needed to address gaps in existing data. A detailed characterization of features, conditions, and resources in the San Jacinto River watershed is also in Section 2 of the IRDMP.

1.5.2.2 Identifying issues of concern for San Jacinto dairies

Through analysis of existing data and regulations and extensive discussions with stakeholders, the primary issues facing San Jacinto dairies were identified, including wastewater/manure quantity and quality; wastewater/manure storage, treatment, and disposition; relationships between dairies and cropland; surface water, groundwater and air quality; and issues of cost-effectiveness and dairy sustainability.

1.5.2.3 Mystic Lake and watershed monitoring

Water quality monitoring at three watershed locations and two stations in Mystic Lake was designed to provide data needed to characterize nutrient loads from watersheds dominated by dairy and agricultural uses and to validate modeling assumptions used to estimate nutrient transport through Mystic Lake for the Lake Elsinore nutrient TMDL.

1.5.2.4 BMP demonstration projects

Pilot projects on two San Jacinto dairies assessed the performance of innovative management practices, including *Vibratory Shear Enhanced Processing* (VSEP) to reduce salt content of dairy wastewater and nutrient management using field-scale lagoon water application to improve efficiency of use of dairy wastewater nutrients for crop production.

1.5.2.5 Proposed Manure Manifest System

Recommendations and guidelines are included for a Manure Manifest System to facilitate tracking of manure importation, generation, and distribution in the San Jacinto River watershed.

1.5.2.6 Identifying salt offset options

The IRDMP includes an assessment of options for a salt offset program, with recommendations for strategies to offset the dissolved solids and nitrate content of dairy manure and wastewater to allow continued application of these materials to land (Appendix F). As part of the project scope revisions approved in September 2009, two components were added to complement the initial report of salt offset options. First, a sampling program to verify assumptions about the TDS and nitrate loads from dairy sources was included in this effort (Section 5.2.2 and Appendix H). Second, a conceptual *Design and Implementation for a Salt Load Tracking Database* and a methodology for evaluating individual dairy operations to define dairy-specific salt load input were added to the IRDMP (Appendix G).

1.5.2.7 Recommendations to address dairy issues

On the basis of technical analysis of conditions in the San Jacinto River watershed, available technology and BMPs, and the choices/priorities voiced by San Jacinto dairy operators, a list of specific BMPs was generated that can be part of the effort to meet the challenges facing San Jacinto dairies. Those BMPs and recommendations for long-term monitoring of the effectiveness of the implemented IRDMP are included.

2.0 Current Conditions in the San Jacinto River Watershed

Understanding of the San Jacinto River watershed's physical and biological characteristics is an important foundation to formulating the IRDMP. Much of the information in this section is from other sources, including the following:

- The *San Jacinto River Integrated Regional Watershed Management Plan* (Tetra Tech and WRIME 2007)
- *Lake Elsinore and Canyon Lake Nutrient Source Assessment* (SAWPA 2003)
- *Lake Elsinore and Canyon Lake Nutrient Total Maximum Daily Loads* (Li 2004)
- *Western Riverside County Multiple Species Habitat Conservation Plan* (Riverside County 2003).

Those and other sources are cataloged in a *Technical Memo Concerning Existing Data on the San Jacinto Watershed* (Tetra Tech 2007). For more detailed information on the San Jacinto River watershed, see those sources.

2.1 Physical Watershed Features

2.1.1 Location and Size

The San Jacinto River watershed (U.S. Geological Survey—Hydrologic Unit Code 18070202) covers approximately 780 square miles and is approximately 80 miles southeast of Los Angeles. It extends from the San Jacinto Mountains in the north and east to Lake Elsinore in the west (Figure 2-1). Most of the watershed (99.8 percent) falls within Riverside County; only a small portion (0.25 percent) extends into an undeveloped portion of Orange County.

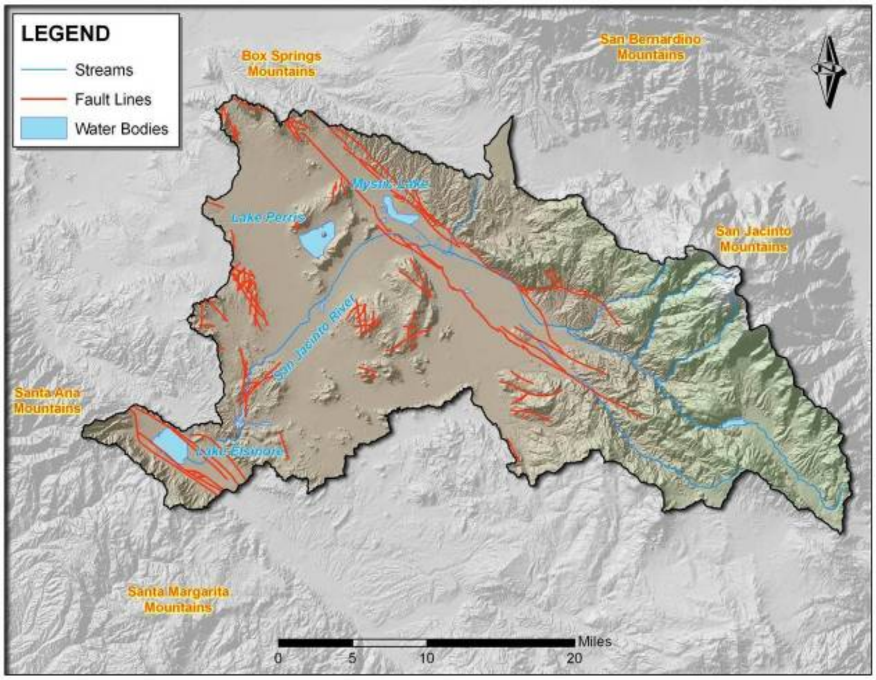


Figure 2-1. Physical geography of the San Jacinto River watershed.

2.1.2 Climate

The San Jacinto River watershed is a semi-arid region that is considered to have a Mediterranean climate. Annual rainfall in the watershed averages 15 inches in the valleys (RWQCB 1995). Rainfall patterns are shown in Figure 2-2. The western (valley) part of the watershed receives less rainfall on average than the eastern (mountainous) part. The effect from orographic lift can be observed by comparing the monthly average precipitation gages in the eastern part of the watershed (National Climatic Data Center (NCDC) stations Idyllwild Fire Dept. CA4211 and Hurkey Creek Park CA4181) to the precipitation gages in the western part of the watershed (NCDC stations Elsinore CA2805 and San Jacinto CA7813) (Figure 2-3).

Three types of storms dominate the region: general winter storms, general summer storms, and high-intensity thunderstorms. Winter storms typically last for several days and occur in the wet period that extends from November through May. Thunderstorms can occur at any time of the year but are most common between July and September. The storms are characterized by short periods of high-intensity rainfall. Summer storms, occurring from July through September, are rare events. When those storms occur, they can result in heavy rainfalls over the course of several days.

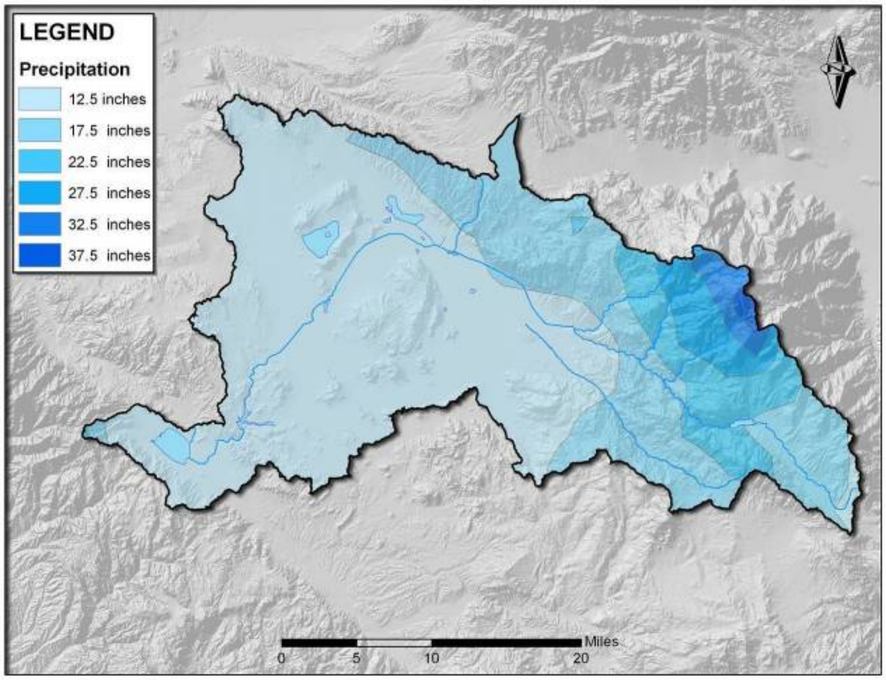


Figure 2-2. Average annual precipitation in the San Jacinto River watershed.

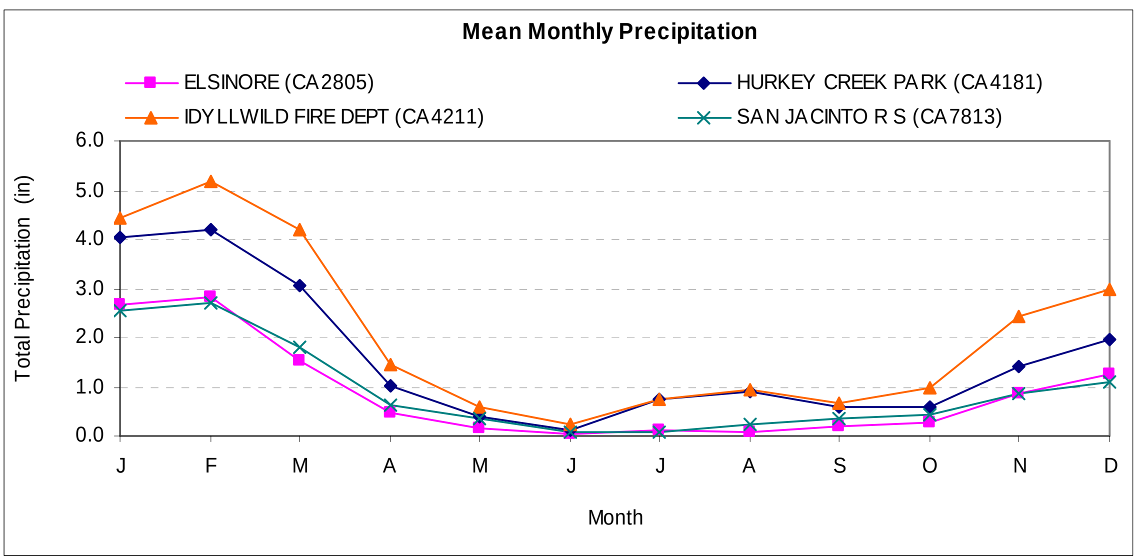


Figure 2-3. Mean monthly precipitation in the San Jacinto River watershed.

2.1.3 Physiography

Soils. Soil composition varies widely across the watershed and plays an important role in hydrology. Hydrologic soil groups categorize soils on the basis of infiltration characteristics and are used to estimate potential to generate surface runoff. Type A soils tend to be the most pervious, while D soils are the least pervious and have the highest runoff potential. Soils in the San Jacinto River watershed fall into each of the four major hydrologic soil groups as defined by the USDA–Natural Resources Conservation Service (USDA–NRCS 2009). Characteristics of the four soil groups and percentages of each in the watershed (based on dominant soil type in each U.S. General Soil Map [STATSGO] region) are shown in Table 2-1. Figure 2-4 presents the soil distributions for the San Jacinto River watershed. The majority of soils in the watershed are hydrologic soil group C, indicating a low infiltration rate and a moderate runoff potential, with type B soils (well-drained soils with low runoff potential) also present in large areas of the basin.

Geology. The watershed can be divided into three distinct geomorphic regions: the San Jacinto Mountain Block is recently elevated and could still be rising. The mountains are granitic with shallow and stony soils (RCFC&WCD 1994). The Perris Block consists of a relatively stable block of crystalline rock covered in deep, alluvial fill transported via streams from the San Jacinto Mountains. Several large areas of the Perris Block are underlain by bedrock with a thin covering of alluvium (~15 feet deep). The underlying bedrock is cut by steep-walled canyons that have filled with alluvium. Southwest of the Perris Block is the Elsinore Trough, bounded on three sides by faults. The southwest boundary of Lake Elsinore is described by the Elsinore Mountains.

Table 2-1. Characteristics of the Soil Conservation Service soil groups

Runoff potential	Infiltration rates (when thoroughly wetted)	Soil texture and drainage	Area (acres)	Percent of total watershed area
Low	High	Typically deep, well-drained sands or gravels	12,752	3%
Moderately Low	Moderate	Typically deep, moderately well to well-drained, moderately fine to coarse-textured soils	193,222	40%
Moderately High	Slow	Typically poorly drained, moderately fine to fine-textured soils containing a soil layer that impedes water movement or exhibiting a moderately high water table	219,830	45%
High	Extremely Slow	Typically clay soils with a higher water table and high swelling potential that can be underlain by impervious material, has very slow infiltration rates	56,736	12%
		Total	482,540	100%

Topography. The San Jacinto River watershed is generally characterized by mountains in the east and valleys in the west (Figure 2-5). Mountains and foothills account for 471 square miles, while 288 square miles are considered valley floors (SWRB 1955). Elevations range from less than 1,250 feet above sea level at Lake Elsinore to 1,400 to 1,700 feet on the valley floor to 10,834 feet at Mt. San Jacinto's peak. The Box Springs Mountains are in the northwest, the San Jacinto Mountains in the north and east, and the Santa Ana Mountains are in the southwest. Major waterbodies include the San Jacinto River, Lake Hemet, Lake Perris, Canyon Lake, Lake Elsinore, and Mystic Lake.

Faults and seismicity. The watershed is traversed northwesterly by two major faults, the Claremont and the Casa Loma, which are nearly parallel to each other (RCFC&WCD 1994). Mystic Lake was formed from settlement of deep alluvial deposits between these two faults. Collectively, the two faults along with the Hot Springs, Park Hill, and other faults are known as the San Jacinto Fault Zone, which is considered one of the most active in Southern California (DWR 1978). Several hot springs are in this fault zone with water temperatures reaching nearly 100 °F. Also present is the Elsinore Fault system, consisting of the Glen Ivy, Major Cross, and Willard faults. These faults bound Lake

Elsinore and the neighboring valleys on the northeast, northwest, and southwest, respectively. Other, major faults include Mark Hill Fault, Bautista Creek Fault, the Wildomar Fault Zone and faults in the San Jacinto Mountain Block (SWRB 1955). A number of minor faults and fractures are apparent elsewhere in the watershed, such as northwest of Perris, southeast of Hemet, in the Lakeview Mountains southeast of Nuevo and north and northeast of Canyon Lake extending to Perris Valley (SWRB 1955).

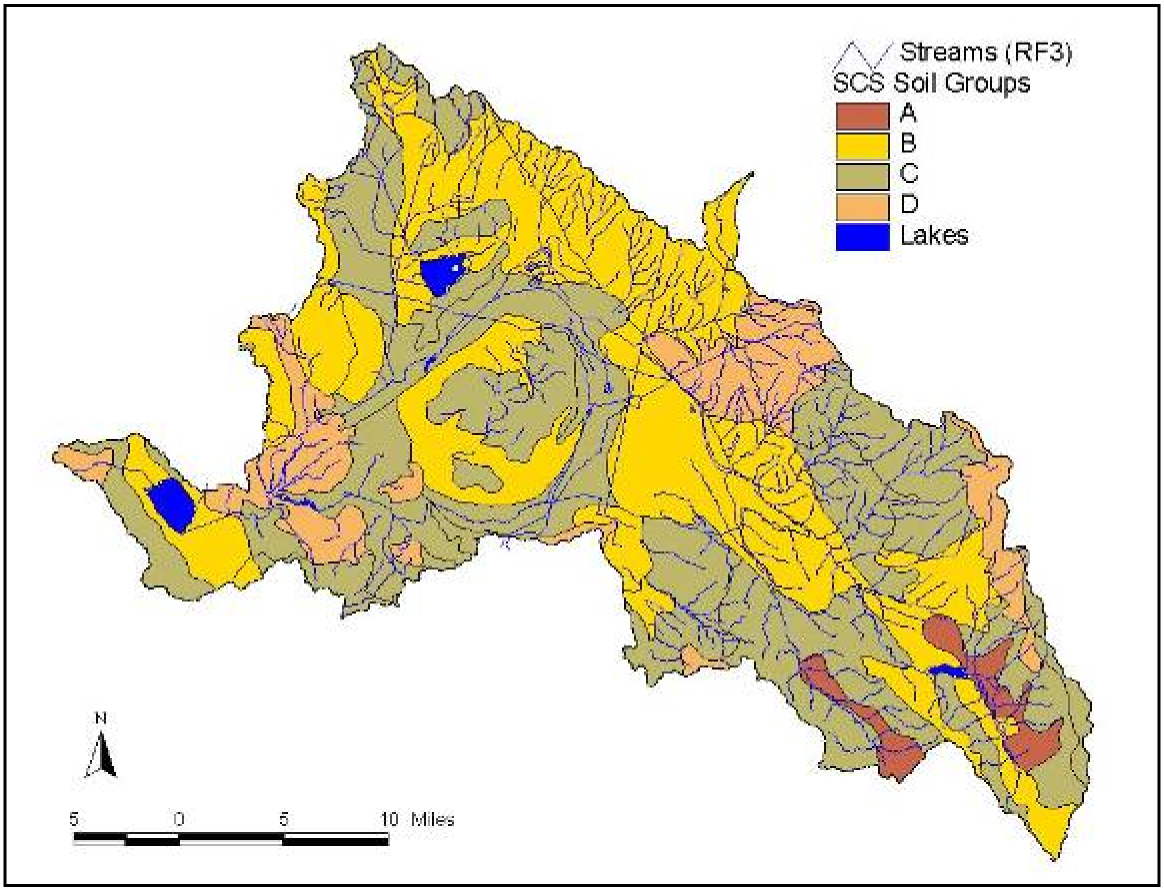


Figure 2-4. Soil groups data for the San Jacinto River watershed.

The rate of slip along the San Jacinto Fault Zone is 10 to 12 mm per year. The San Jacinto Fault Zone is more seismically active than the San Andreas Fault, possibly because of its greater geometric complexity and the tendency for earthquakes to initiate and terminate at segment boundaries and fault step-overs (Dorsey 2002).

Earthquakes. According to the USGS (1990), the San Jacinto Fault Zone is marked by irregular clusters of epicenters that run along the southwest base of the Santa Rosa and San Jacinto mountains. Clustering is concentrated near bends and junctions in the complex fault zone. Epicenters track linearly with mapped fault traces. Ten earthquakes of magnitude 6.0 to 6.6 have occurred since 1890, the most recent of which were the magnitude 6.2 earthquake of 1954, the magnitude 6.6 Borrego Mountain earthquake of 1968, and the magnitude 6.6 Superstition Hills earthquake of 1987. Two seismic gaps exist along the fault zone, one along the northern stretch of the fault and the other along a 20-km stretch of the central fault (the Anza gap).

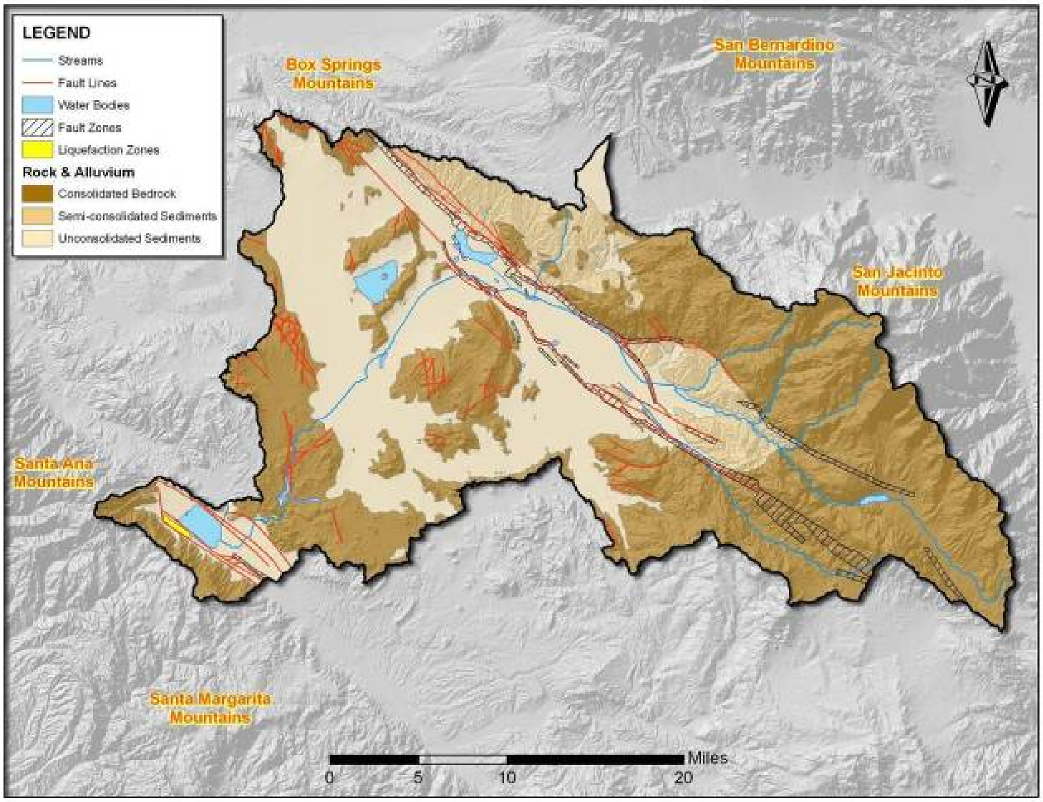


Figure 2-5. Geologic features of the San Jacinto River watershed.

Geologic Hazards. Subsidence due to parallel faults can pose a geologic hazard. This phenomenon resulted in the formation of Mystic Lake. Subsidence can be exacerbated by groundwater withdrawals.

2.1.4 Surface Water Resources

Hydrology. The San Jacinto River watershed is a dynamic system with unique conditions that either enhance or restrict flows through the watershed. The San Jacinto River, Mystic Lake, Perris Valley Storm Drain, Salt Creek, Perris Reservoir, Canyon Lake, and Lake Elsinore are the dominant hydrologic features in the watershed (Figure 2-6).

Normally, only low flows occur on the San Jacinto River except during and immediately after rainstorms (RCFC&WCD 1994). Flow is perennial in the headwater tributaries and intermittent in the valley reaches. During major storms, periods of intense rainfall result in rapid increases in stream flow in the steep, mountainous portions of the watershed. For analysis of historical trends, six U.S. Geological Survey (USGS) gages have measured average daily flow in the watershed over extended periods (Figure 2-7). These data helped to characterize the river as an ephemeral system, with flow reaching Canyon Lake and Lake Elsinore only during prolonged wet periods.

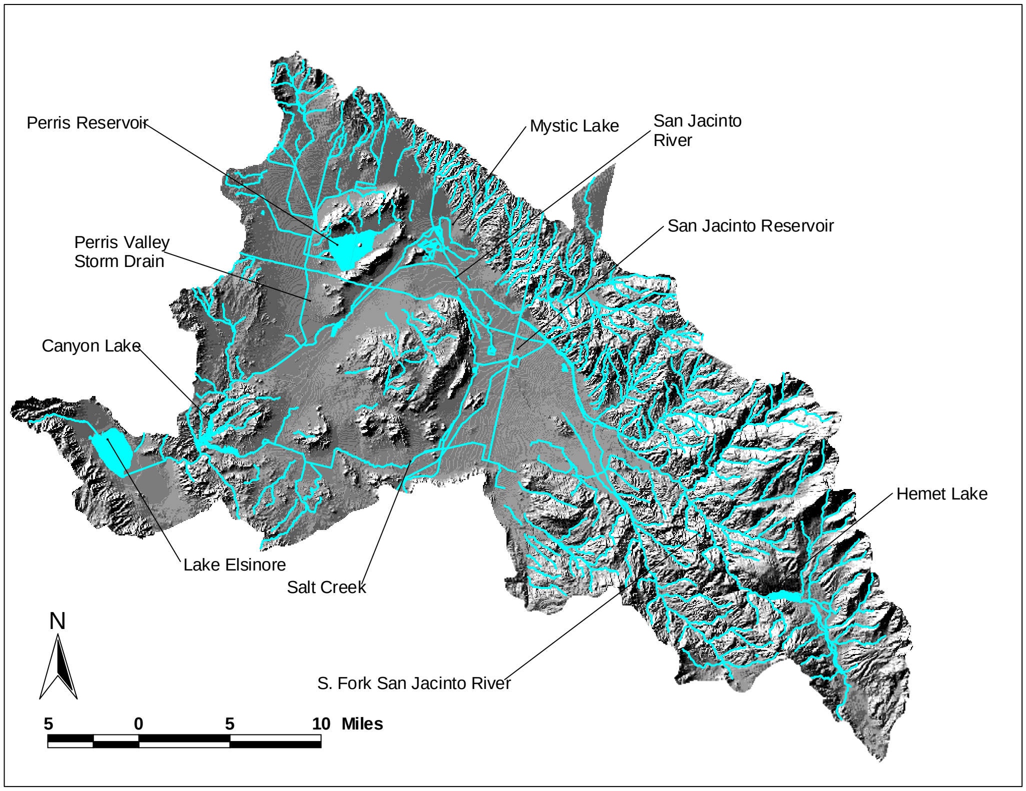


Figure 2-6. Dominant hydrologic features in the San Jacinto River watershed.

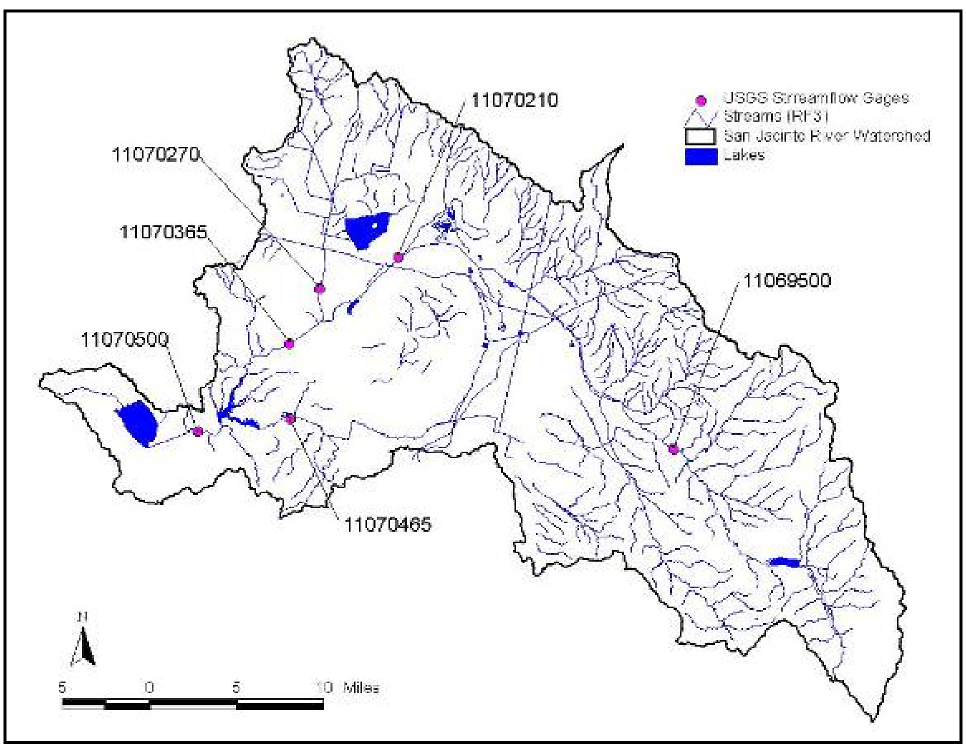


Figure 2-7. USGS streamflow gages in San Jacinto River watershed.

Streamflows in the headwater portions of the San Jacinto River are quantified by USGS flow gage 11069500 (Figure 2-8). The hydrograph for the flow gage shows a gradual increase and decline of flow throughout storm seasons. That pattern suggests that the headwater portions of the watershed are influenced by groundwater, interflow, or both.

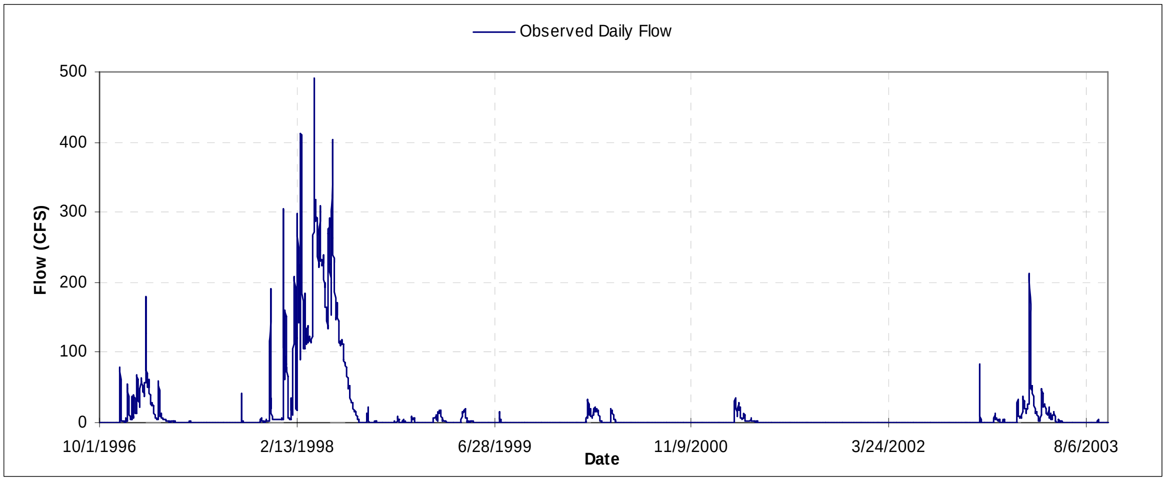


Figure 2-8. Average daily flow data for San Jacinto River near San Jacinto (USGS 11069500) from October 1996 to August 2003.

Runoff collecting in the valley flows rapidly to Mystic Lake, a natural sump formed by subsidence. When water from the upper San Jacinto River is conveyed to this area following large storms, a shallow lake with a large surface area forms. The lake itself is ephemeral, losing water to evaporation and infiltration during dry periods. In the past, the San Jacinto River was channelized between Sanderson Avenue and Nuevo Road by local interests in an attempt to route flows past Mystic Lake. Those channels have been blocked by siltation and are no longer active during low-flow periods. Therefore, all the river flow drains directly to Mystic Lake, where it is impounded during average and low-flow years (personal communication with Stephen Stump, RCFC&WCD, and Tom Paulek, California Department of Fish and Game).

When full, Mystic Lake has been observed to maintain a substantial amount of volume for more than a year with little or no transport back to the San Jacinto River. Because of the significant loss from evaporation, infiltration, and groundwater recharge, much of the volume stored in the lake is lost from the San Jacinto River system. During torrential rainfall events or periods of prolonged rain, however, the storage capacity of Mystic Lake can be exceeded, resulting in overflow back to the San Jacinto River. The subsidence that formed Mystic Lake is ongoing; some report that the lake’s depth increases by 8 to 10 inches each year. Because of this, increasingly large rain events will be necessary to cause overflow from Mystic Lake to the San Jacinto River.

Downstream of Mystic Lake, the San Jacinto River forms a wide fluvial plain. When Mystic Lake does not overflow, downstream river reaches are often dry. The majority of water that infiltrates the ground is believed to be lost from the surface water system, as the groundwater table has been lowered by excessive withdrawal and limited recharge.

The U.S. Army Corps of Engineers (USACE) and the Riverside County Flood Control and Water Conservation District (RCFC&WCD) constructed 3.8 miles of left-bank levee from the Bautista Creek confluence to a point approximately 1.7 miles downstream of Soboba Road. RCFC&WCD has constructed approximately 1.7 miles of right/bank levee in this area extending approximately 1 mile downstream of Soboba Road. USACE also constructed collector dikes at the mouth of Bautista Creek Canyon and a concrete-lined channel from the dikes to the river. Those facilities all provide control in excess of the 100-year storm.

RCFC&WCD constructed some levee improvements between the USACE levee and Sanderson Avenue. It also constructed a low-flow channel from Interstate 215 to the entrance to Railroad Canyon. Those improvements are not considered capable of containing a 100-year storm (RCFC&WCD 1994).

RCFD&WCD also constructed the following improvements on tributaries to the river: Pigeon Pass Dam in Moreno Valley, a small flood-control reservoir, the Perris Valley Storm Drain, and numerous smaller earth channels, concrete-lined channels, and underground storm drains throughout the basin, none of which would have a significant effect on runoff rates during a major flood (RCFC&WCD 1994). The Perris Valley Storm Drain collects runoff from the cities of Perris and Moreno Valley. That flow is measured by USGS gage 11070270 before entering into the mainstem of the San Jacinto River. The hydrograph for the gage shows dry periods between storms; the streamflow rises in sharp peaks and then abruptly declines (Figure 2-9). The peaks are likely the result of stormwater runoff with very little contribution from groundwater or interflow.

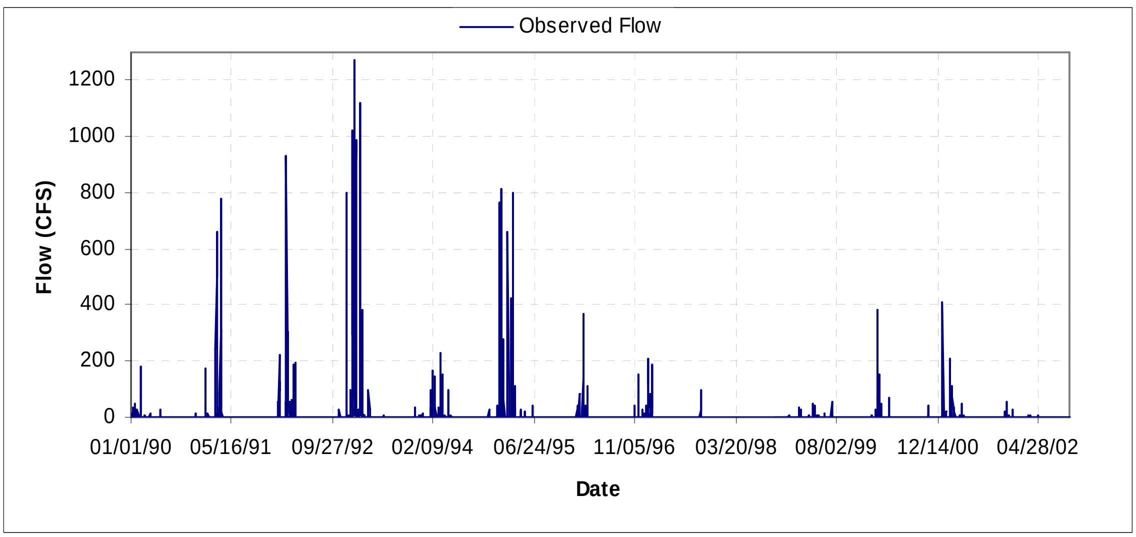


Figure 2-9. Average daily flow data for Perris Valley storm drain–Nuevo Rd (USGS 11070270).

Salt Creek is one of the main tributaries to Canyon Lake, with headwaters in the city of Hemet. USGS gage 11070465 records the streamflow before Salt Creek drains into Canyon Lake (Figure 2-10). The available data are limited to the period of September 2000 to September 2002. As with Perris Valley Storm Drain, sharp peaks in flows are primarily the result of surface runoff from urban areas with little contributions from groundwater or interflow.

Water conservation improvements, such as reservoirs and spreading grounds, have been constructed and are being maintained by local interests. Lake Hemet, on the South Fork San Jacinto River, is a water conservation reservoir constructed in 1895 with a capacity of 14,000 acre-feet. By 1940, sedimentation had reduced the capacity to 11,700 acre-feet. The tributary drainage area is 66 square miles. The effect of Lake Hemet on major flood runoff is considered negligible because no provision has been made for storage of major flood flows (RCFC&WCD 1994).

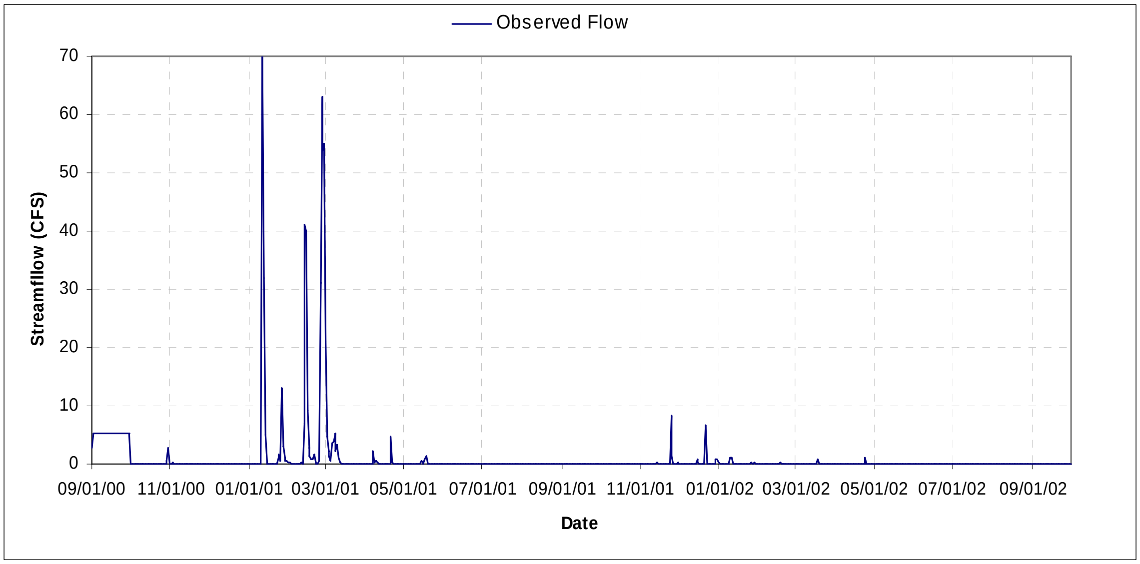


Figure 2-10. Average daily flow data for Salt Creek near Sun City (USGS 11070465) from September 2000 to September 2000.

Just west of Mystic Lake is another major impoundment in the San Jacinto River watershed. Perris Reservoir is a State Water Project reservoir constructed in 1973 and the largest drinking water reservoir in the San Jacinto River watershed. The Perris Reservoir is on a northwest tributary to the San Jacinto River and, because of its small size, has no effect on major floods in the river. Many of the local water districts receive State Water Project water from Perris Reservoir along with water from the Colorado River, groundwater, and recycled water. Water from Perris Reservoir helps meet the demands of Elsinore, Corona, Norco, Riverside, Moreno Valley, Perris, San Jacinto, Hemet, Temecula, Coachella Valley, and Palm Springs.

USGS gage 11070365 is at the Railroad Canyon Gorge and records flows from the upstream watershed including the Perris Valley Storm Drain, Mystic Lake overflow, and additional San Jacinto River streamflow downstream of Mystic Lake. The available data for this gage are limited from August 1996 to September 2002 (Figure 2-11).

The San Jacinto River flows through the narrow Railroad Canyon before draining into Canyon Lake (Figure 2-12), which was created in 1928 by the Railroad Canyon Dam (RCFC&WCD 1994). More than 90 percent of the San Jacinto River watershed drains to Canyon Lake. Runoff from as far as Moreno Valley, San Jacinto, Hemet, and Perris contribute to surface flows that reach Canyon Lake during rainfall events. During normal to dry periods, when the San Jacinto River and the surrounding tributaries are essentially dry, little or no flow enters Canyon Lake.

The modeling efforts described in the *Lake Elsinore and Canyon Lake Nutrient Source Assessment* (SAWPA 2003) incorporated a detailed study of the water budget of Canyon Lake and its effect on Lake Elsinore. That effort ultimately used Canyon Lake historical water surface elevation measurements, which display significant seasonal fluctuations (Figure 2-13), to predict flows in the reach of the San Jacinto River downstream of Canyon Lake (measured by USGS gage 11070500) and inflows to Lake Elsinore. The historical water surface elevations of Canyon Lake emphasize the flow patterns of the San Jacinto River. The lake fills quickly during the wet season, and the water level declines slowly over time during the normal to dry periods.

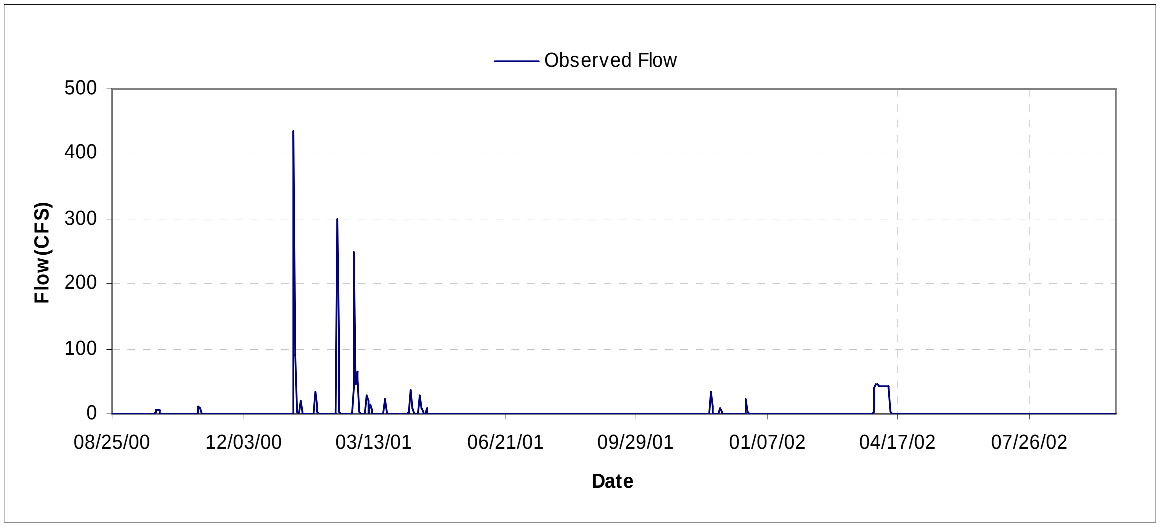


Figure 2-11. Average daily flow data for San Jacinto River upstream of Canyon Lake (USGS 11070365) from August 2000 to September 2002.

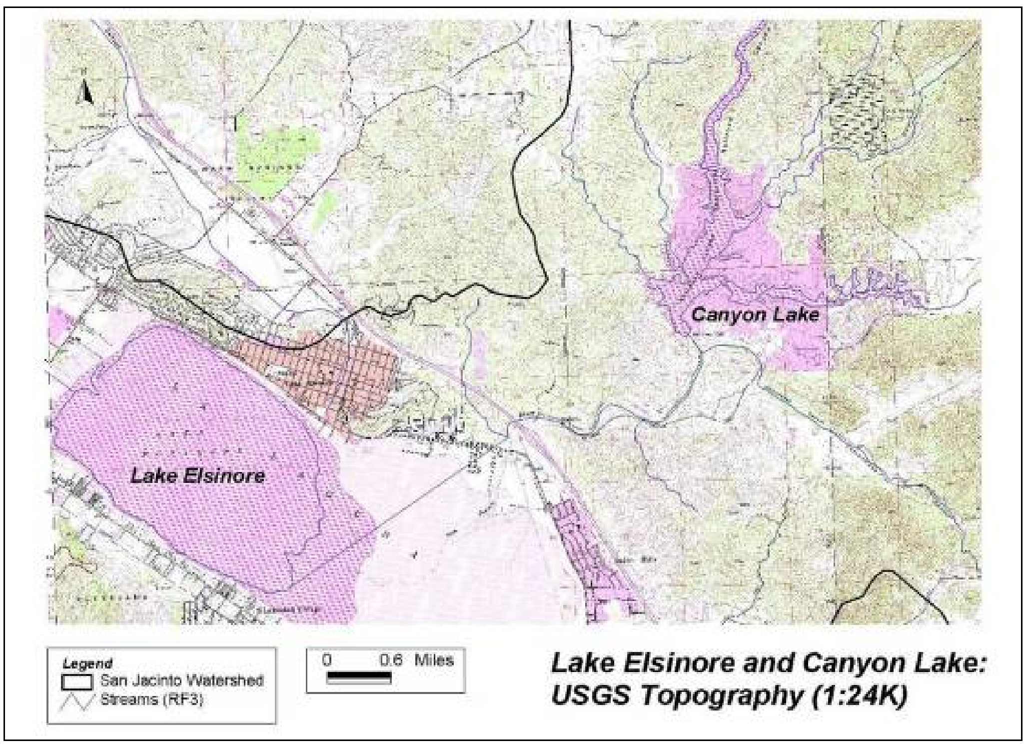


Figure 2-12. Locations of Lake Elsinore and Canyon Lake.

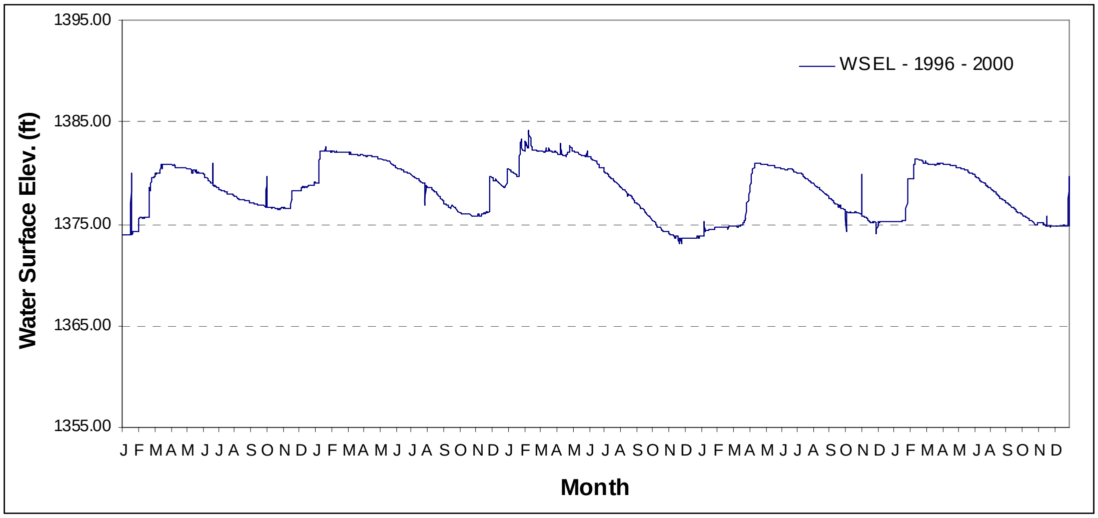


Figure 2-13. Historical Canyon Lake water surface elevations.

The last streamflow gage on the San Jacinto River is just above Lake Elsinore. The streamflow at USGS gage 11070500 displays extended dry periods followed by sharp peaks and abrupt recessions of flow (Figure 2-14). Those flows are likely the result of stormwater runoff and overflows of Canyon Lake dam; there is very little contribution from groundwater or interflow in the subwatershed directly tributary to Lake Elsinore. The San Jacinto River terminates at Lake Elsinore, a natural sump in the watershed.

Lake Elsinore is approximately 3 miles downstream of Canyon Lake at the bottom of the San Jacinto River watershed (Figure 2-12). Surface flow from the San Jacinto River watershed reaches Lake Elsinore only through release, overflow, or seepage from the Canyon Lake dam. Lake Elsinore acts much like a sink, with almost nonexistent outflow. In rare situations, including torrential rains and extended rain periods, the lake overflows into Temescal Creek, which ultimately drains to the Santa Ana River (Santa Ana RWQCB 1995).

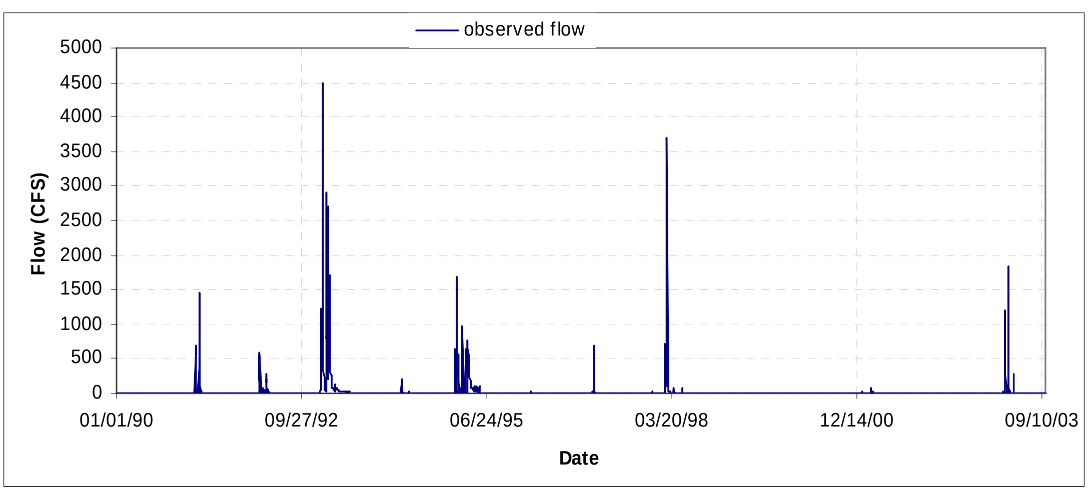


Figure 2-14. Average daily flow data for San Jacinto River near Lake Elsinore (USGS 11070500).

Water Quality. The RWQCB has identified Lake Elsinore and Canyon Lake on its 2006 Clean Water Act section 303(d) list as impaired waterbodies. The RWQCB lists causes of impairments including excessive levels of nutrients in both lakes; high bacteria levels in Canyon Lake; and low dissolved oxygen, excessive sedimentation, and unknown sources of toxicity in Lake Elsinore. Excess nutrients from development and agriculture in the San Jacinto River watershed delivered to the lakes contribute to significant algae growth, resulting in unpleasant odors, adverse effects on aesthetics, and impaired recreational use. Moreover, excessive algae growth causes depletion of dissolved oxygen in Lake Elsinore and results in occasional massive fish kills.

Nutrient contributions to the San Jacinto River system, including Canyon Lake and Lake Elsinore, are dominated by nonpoint sources. Nonpoint sources are diffuse in nature, extremely variable in location and in how and when they contribute pollutants. Nonpoint sources that contribute loads through surface runoff during rainfall events were predicted using a rainfall/ runoff model (SAWPA 2003). These contributions are highly influenced by management and land use practices that can magnify or inhibit the transport of nutrients from the land surface.

In addition to surface runoff processes, other potential nutrient sources include discharges from failed septic systems, unimpeded access of cattle to streams, and illegal discharges.

Once nutrients are delivered to Canyon Lake and Lake Elsinore, they are subject to in-lake cycling processes that can positively or negatively affect water quality over extended periods. Such processes can have long-term effects as nutrients continue to accumulate in the lake sediments. Under the right conditions, these bound nutrients can be released into the water column, further impairing water quality.

The 2003 *Lake Elsinore and Canyon Lake Nutrient Source Assessment* (SAWPA 2003) provides a detailed inventory of the relative nutrient loads to both Canyon Lake and Lake Elsinore from multiple sources throughout the San Jacinto River watershed under various hydrologic conditions based on a comprehensive watershed model. The Loading Simulation Program C++ (Shen et al. 2004) was used to simulate watershed processes, including hydrology and pollutant accumulation and washoff. The modeling system was calibrated and validated with in-stream flow and water quality data collected at various instream stations throughout the watershed from 1991 through 2001, as well as stage data and water quality data collected from four Canyon Lake stations from 1997 through 2000. However, few water quality data were available for a significant wet-weather event that resulted in the fill and overflow of Mystic Lake and subsequent transport of nutrients from the upper portions of the San Jacinto River watershed to Canyon Lake and Lake Elsinore. Therefore, the predictive capability of the model during larger storm events was not thoroughly tested.

To assist in watershed management and identify specific measures to best control pollutant loads to the lakes, modeling analysis was used to predict the sources of nutrients throughout the watershed and the transport to Lake Elsinore and Canyon Lake. To provide insight into nutrient loads under a range of hydrologic conditions, results were reported for three different scenarios representing extreme wet and dry conditions:

1. Mystic Lake and Canyon Lake overflowed (wet year, WY 1998)
2. Canyon Lake overflowed but Mystic Lake did not (moderately wet year, WY 1994)
3. Neither Mystic Lake nor Canyon Lake overflowed (dry year, WY 2000)

Water years (WY) extend from October 1 through September 30.

The watershed was divided into nine zones for analysis of spatial variability of nutrient sources and transport throughout the watershed. Total phosphorus (TP) and total nitrogen (TN) loads are reported for various sources including 11 land uses, failed septic systems, and loads resulting from overflow of Canyon Lake to Lake Elsinore. For zones 1 and 2, loads were reported as contributions *to* Lake Elsinore and Canyon Lake, respectively. This aided in analyzing the effects on the lakes. However, for zones 3 through 9, loads were reported in terms of the amount transported *from* the zone (including transport of loads from upstream zones). This allowed tracking nutrients loads (by source) as they are transported through the watershed. For illustration of model results, TP and TN loads for 1998 (extreme wet year) are shown in Figures 2-15 and 2-16.

Results of the Nutrient Source Assessment provide information useful for identifying significant areas and nutrient sources for application of future management practices. Unfortunately, this cannot be done with precision because watershed land use was not known precisely at the time and has changed since 2002 (e.g., the proportion of agricultural land has decreased and urban and residential land uses have increased). As of December 2009, development of updated land use data is nearly complete. In addition, the model used to evaluate nutrient sources in the watershed is being revised using the new land use data. Nevertheless, the Nutrient Source Assessment provides insight regarding specific sources that can be reduced to substantially decrease overall loads to Canyon Lake and Lake Elsinore. Among these, sources of greatest interest for the IRDMP are described below.

Dairy/Livestock—For very wet conditions when Mystic Lake is full and overflowing, dairy/livestock land uses are relatively large contributors of TN in zones 6 and 7. Proportions of nutrient loads to Canyon Lake and Lake Elsinore from dairies for all three scenarios are shown in Table 2-2. Relative to the proportion of the watershed area used by dairies, percentages reported in Table 2-2 are high compared to the large areas associated with croplands and urban/residential land uses.

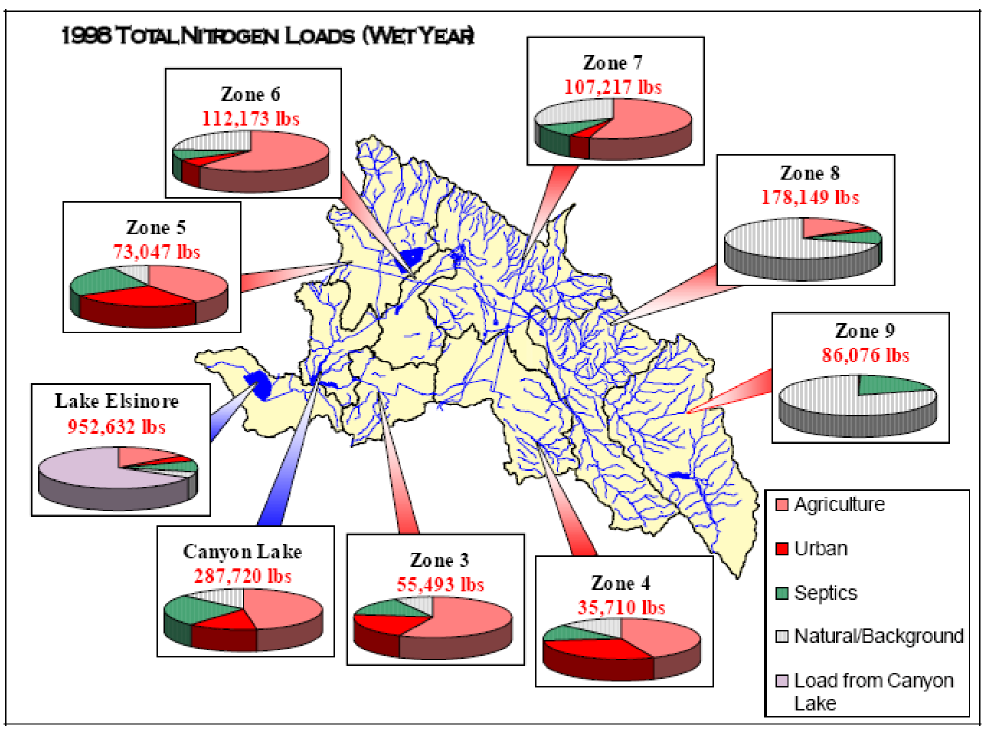


Figure 2-15. TN load assessment for extreme wet conditions, San Jacinto River watershed.

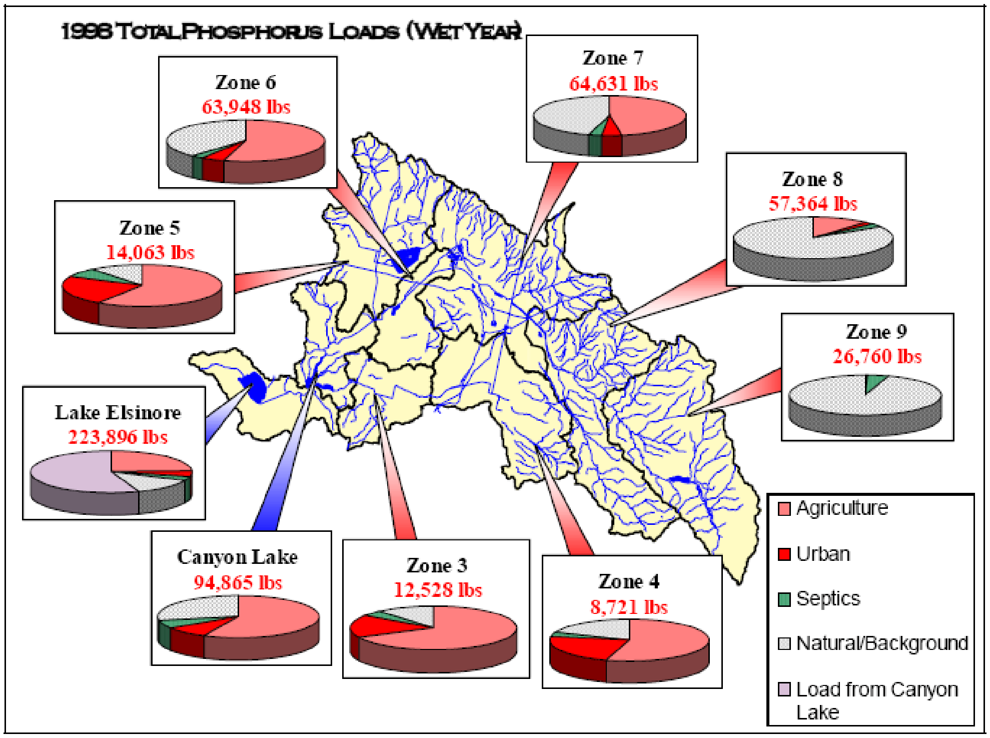


Figure 2-16. TP load assessment for extreme wet conditions, San Jacinto River watershed.

Table 2-2. Percent of nutrient loads to Canyon Lake and Lake Elsinore from dairies

Nutrient	Total nitrogen			Total phosphorus		
Scenario	**1 (WY 1998)**	**2 (WY 1994)**	**3 (WY 2000)**	**1 (WY 1998)**	**2 (WY 1994)**	**3 (WY 2000)**
Canyon Lake	11.0%	5.7%	4.7%	6.7%	2.0%	1.8%
Lake Elsinore	3.3%	3.3%	2.7%	2.8%	1.4%	1.6%

Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year).
Scenario 2: Canyon Lake overflowed, but Mystic Lake did not overflow (moderately wet year).
Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year).

Cropland—For all scenarios, wet-weather runoff from croplands contributed a significant portion of the overall nutrient loads for all zones. Proportions of nutrient loads to Canyon Lake and Lake Elsinore from croplands for all three scenarios are shown in Table 2-3. For all zones, reductions of nutrients from cropland areas, through either improved control of manure/fertilizer application or use of BMPs that treat runoff from these areas, would result in overall benefits to Canyon Lake and Lake Elsinore.

Table 2-3. Percent of nutrient loads to Canyon Lake and Lake Elsinore from croplands

Nutrient	Total nitrogen			Total phosphorus		
Scenario	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)
Canyon Lake	32.7%	33.6%	32.2%	48.5%	48.8%	54.1%
Lake Elsinore	10.0%	20.0%	20.4%	20.7%	36.8%	49.2%

Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year).
Scenario 2: Canyon Lake overflowed but Mystic Lake did not (moderately wet year).
Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year).

2.1.4.1 Total Maximum Daily Loads

On the basis of the pollutant source assessments described above and further analysis of the assimilative capacity of pollutants with the lakes, the RWQCB has developed and approved nutrient TMDLs for Lake Elsinore and Canyon Lake (RWQCB 2004). The nutrient TMDLs prescribe allocations of allowable loads to each source to meet TMDLs. The load estimates, load allocations, and load reduction targets associated with the TMDLs are discussed in Section 4.3.

2.1.4.2 Bacteria Source Assessment

Watershed sources of bacteria to the San Jacinto River watershed and Canyon Lake are dominated by nonpoint sources and can be categorized as wet- or dry-weather inputs. During normal dry periods, the tributaries to Canyon Lake are essentially dry, contributing little or no flow. During dry weather any flow contributions to the lake occur from urban runoff. The flows are generally understood to result from various urban land use practices such as lawn irrigation runoff, car washing, and sidewalk washing that cause water to enter storm drains and creeks. This type of runoff is a predominant component of dry-weather flows throughout the year in Southern California (McPherson et al. 2002). As the flows travel across lawns and urban surfaces, bacteria are carried from these areas to the receiving waterbody. During dry weather, external watershed sources of bacteria to Canyon Lake primarily result from urban runoff (Anderson et al. 2002).

During wet weather, wash-off of bacteria from various land uses is considered a major source of bacteria because of the relatively large bacteria levels observed at the mouths or within the watershed during wet conditions. After bacteria build up on the surface as the result of various land use sources and associated management practices (e.g., management of livestock in agricultural areas, pet waste in residential areas), many of the bacteria are washed off the surface during rainfall events. The amount of runoff and associated bacteria concentrations are therefore highly dependent on land use.

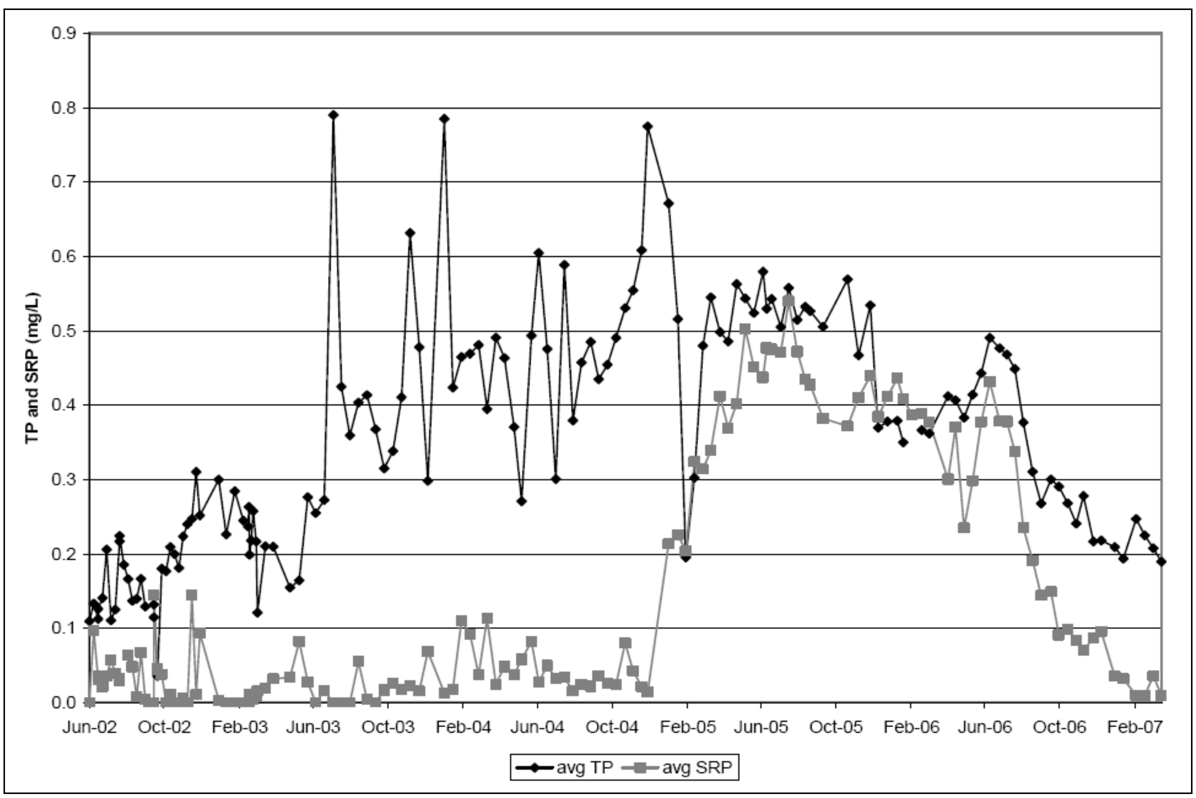
In 2003 LESJWA updated the watershed model developed for the Nutrient Source Assessment to simulate two types of indicator bacteria in the watershed: fecal coliform bacteria and total coliform bacteria (LESJWA 2004). The RWQCB further modified that model to include simulation of *Escherichia coli* (Tetra Tech 2005). Wet-weather bacteria loads from the watershed were predicted for WY 1994, 1998, and 2001 for analysis of loading conditions resulting from variations in hydrology. Annual loads of fecal coliform, total coliform, and *E. coli* to Canyon Lake resulting from wet-weather runoff are estimated to be on the order of 10^{14}–10^{15} MPN/year.

2.1.4.3 Internal Bacteria Sources within Canyon Lake

Anderson et al. (2002) concluded that urban runoff and waterfowl were leading sources of enterococci and *E. coli* loading to Canyon Lake during dry periods. Urban runoff and waterfowl were also identified as sources of coliform bacteria to the lake, although internal production of coliform bacteria was also considered to be a dominant source.

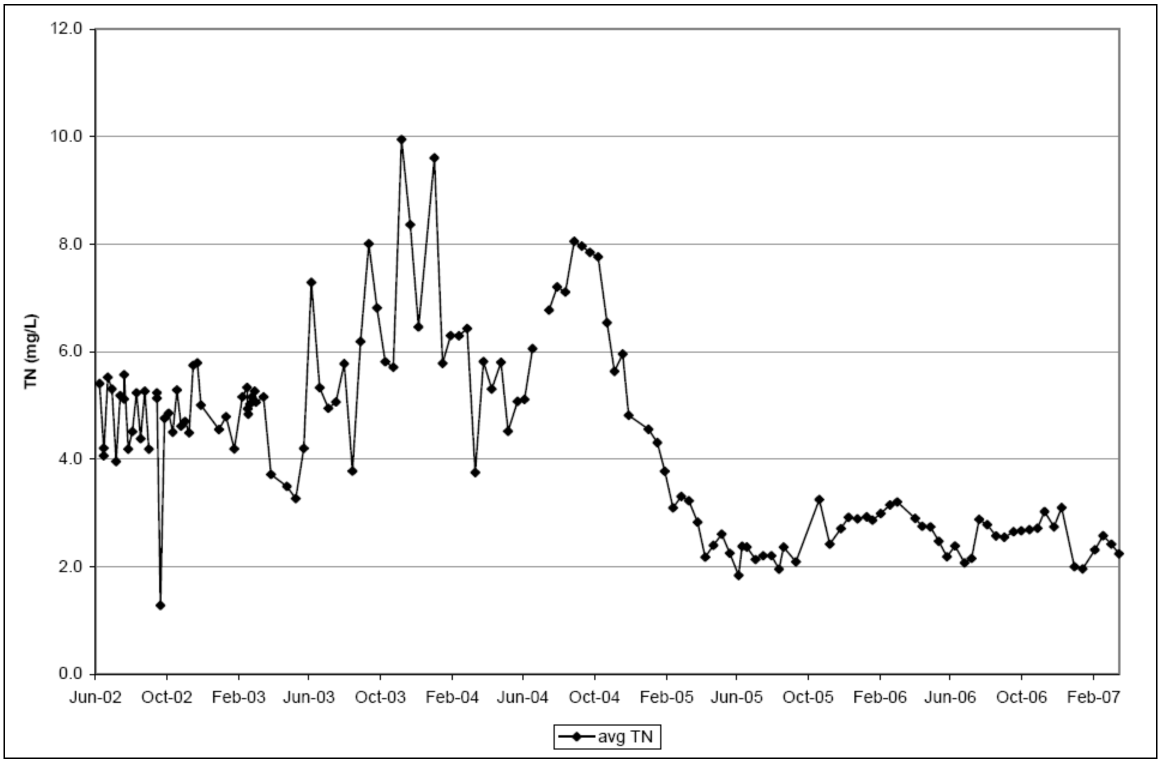
Because of limnological processes such as thermal stratification, sediment chemistry, and biological nutrient cycling, water quality in Lake Elsinore and Canyon Lake reflects not only nutrient loading from the watershed, but also in-lake phenomena. Historic monitoring studies performed in Lake Elsinore by the University of California, Riverside, have provided useful information for tracking the performance of initial in-lake management measures and evaluating conditions in the lake relative to water quality objectives and TMDL numeric targets set by the RWQCB. Elsinore Valley Municipal Water District (EVMWD 2007) provides a summary of monitoring performed in the lake, including historic trends in concentrations of soluble reactive phosphorus (SRP), TP, and TN. Those results are presented in Figures 2-17 and 2-18 for a single station near the center of the lake. Results show and increasing trend in nutrient concentrations through 2004, and a gradual decrease in concentrations from 2005 to 2007.

Record-setting rainfall in 2005 sent large volumes of water and nutrients into Lake Elsinore. Those nutrient loads, on the basis of similar historic conditions, should have resulted in odor, algal blooms, and fish kills. The fact that water quality has actually improved since the storms indicates that ongoing lake management measures are likely having a significant effect.



Source: EVMWD 2007

Figure 2-17. TP and SRP concentrations in Lake Elsinore—2001 to 2007.



Source: EVMWD 2007

Figure 2-18. TN concentrations in Lake Elsinore—2001 to 2007.

Although nutrients and other water quality constituents (i.e., dissolved oxygen, ammonia-nitrogen, chlorophyll *a*) are still not meeting TMDL numeric targets, there appears to be a general improvement in water quality over time. The improvement could be, at least in part, from lake management measures undertaken, including lake mixing, lake level management, carp removal, and predatory fish stocking. It is clear that progress has been made at improving Lake Elsinore water quality, but more efforts are required to ensure that the lake meets the TMDL and is ultimately unimpaired. This can be achieved only through a combination of in-lake BMPs and watershed BMPs that focus on achieving nutrient load reductions for the various sources. It is also clear that biomanipulation of the lake might be the key to attaining water quality standards.

Anderson et al. (2007a and 2007b) performed a detailed study of the water quality of Canyon Lake from June 2006 to June 2007 to evaluate the current status of water quality and changes since the last monitoring survey performed by Anderson and Oza (2003) from July 2001 to August 2002. Anderson et al. (2007b) collected water column samples over a 13-month period at five sites in the lake at multiple depths. Results of the study provided assessment of water quality trends that varied seasonally, vertically, and between sites.

Anderson et al. (2007b) found that temperature, dissolved oxygen, chlorophyll concentrations, nutrients concentrations had noticeable seasonal trends. Typically, the lake was stratified for the study period but exhibited well-mixed conditions from December through February. During stratification, oxygen exchange between the sediments and bottom waters was limited, resulting in high chemical gradients in the water column. With limited transfer of nutrients from the hypolimnion to the surface layer, Anderson et al. (2007b) were able to infer rates of internal nutrient recycling in the lake. The estimates were corroborated by sediment core-flux studies performed by Anderson et al. (2007a), which show that silty sediments and other shallow embayments exhibit higher rates of nutrient release than shallow, sandy sediments and deeper sediments.

Comparison of 2006–2007 with 2001–2003 water quality data show that conditions remained practically unchanged. Table 2-4 provides a comparison of data sets for the two periods, specifically secchi depth, SRP, ammonia-nitrogen (NH_4-N), TP, and TN. These results, in addition to assessments of the trophic state of the lakes during both periods, indicate poor water quality in the lake that continues to persist (Anderson et al. 2007b). Canyon Lake TP and TN were equivalent, or slightly better than, current Lake Elsinore concentrations.

Table 2-4. Comparison of nutrient concentrations from 2001–2002 and 2006–2007 monitoring studies

Constituent	Main Basin		East Bay	
	2006–07	2001–02	2006–07	2001–02
Secchi Depth (m)	0.98 ± 0.30	1.34 ± 0.40	0.84 ± 0.39	0.81 ± 0.30
SRP (mg/L)	0.38 ± 0.29	0.33 ± 0.19	0.19 ± 0.10	0.18 ± 0.05
NH_4-N (mg/L)	0.44 ± 0.52	0.41 ± 0.46	0.27 ± 0.26	0.12 ± 0.01
TP (mg/L)	0.43 ± 0.27	0.51 ± 0.42	0.29 ± 0.10	0.22 ± 0.18
TN (mg/L)	1.34 ± 0.51	1.86 ± 1.65	1.50 ± 0.33	1.81 ± 0.37

Source: Anderson et al. 2007b

Improvement of Canyon Lake water quality will likely be achieved through a combination of BMPs to achieve both watershed and in-lake nutrient load reductions. In-lake measures are likely to be more effective than watershed-based BMPs. Watershed BMPs are specific to diffuse land use source categories, which must be addressed to achieve load reductions to meet TMDLs. Simultaneous implementation of in-lake BMPs can improve water quality through the reduction of internal cycling of nutrients and biomanipulation. Some recommendations for both watershed and in-lake BMPs were identified by LESJWA (2004) in the Nutrient Management Plan. Other efforts of the SJRWC have included assessment of alternative, in-lake BMPs that inhibit the release of nutrients from sediments within the lake, including alum treatment, aeration, and hypolimnetic oxygenation (Anderson et al. 2007a). More study is required to identify and test watershed and in-lake BMPs to ensure that strategies will achieve their intended purpose. A study is underway to model the recommended in-lake alternatives from the Canyon Lake sediment study to obtain confidence levels for the various alternatives and to determine which strategies will meet numeric targets. Nutrient load reductions and ultimate improvement of lake water quality, however, cannot be achieved until projects are implemented to address the multiple sources.

2.1.5 Groundwater Resources

The San Jacinto River watershed area has significant groundwater in storage, estimated to be 1.45 million acre-feet. In addition to the groundwater in storage, the aquifer has space for an additional 1.15 million acre-feet of water to be stored, either through natural or artificial recharge. An additional 500,000 acre-feet of unused space in the aquifer is not ideal for recharge purposes because of poor groundwater quality (MWD 2007).

Groundwater levels are shown in Figure 2-19. For each groundwater management zone (Figure 2-20), historical change in groundwater levels is shown for selected wells in Figure 2-21. The historical groundwater levels in individual wells show a complex system with conditions that vary across the area. Water levels in some wells have historically dropped, while others are rising. Such conditions are a result of local historical groundwater production and recharge near the well. Changing water levels affect the amount of groundwater in storage and can change the direction of groundwater flow, potentially to the detriment of groundwater quality.

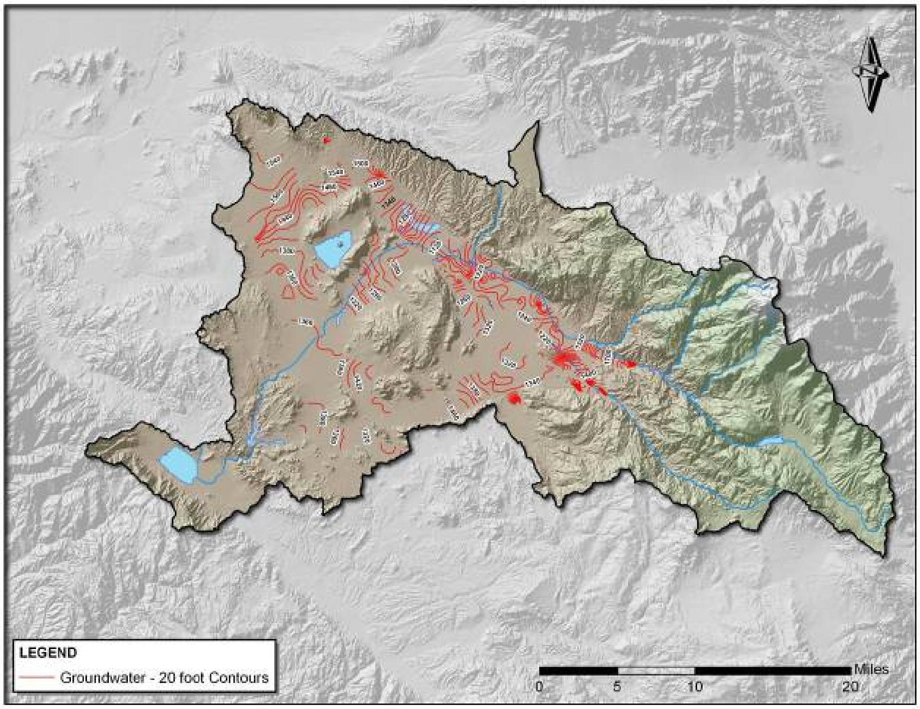


Figure 2-19. 2006 groundwater levels.

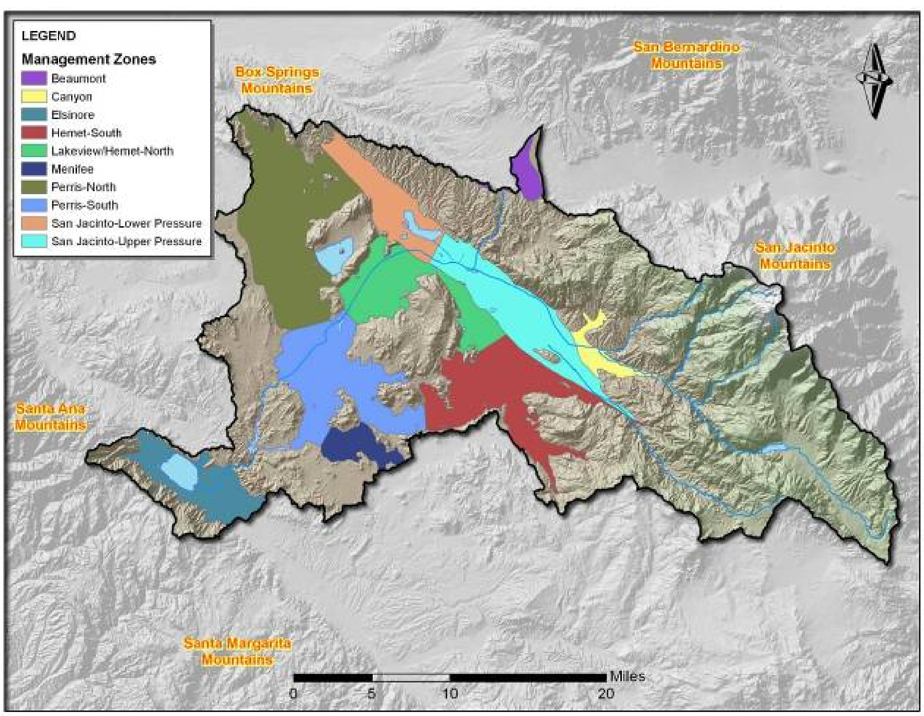


Figure 2-20. Groundwater management zones in the San Jacinto River watershed.

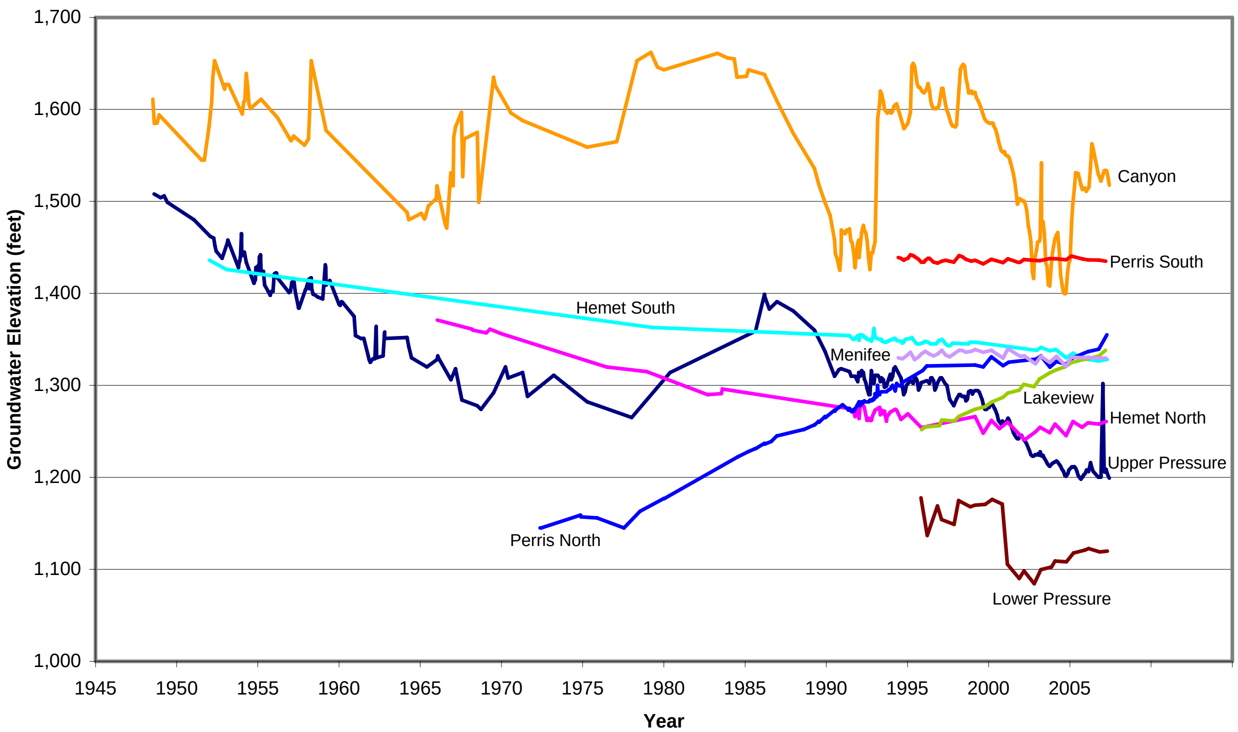


Figure 2-21. Historical change in groundwater levels, San Jacinto River watershed.

Managing water levels requires knowledge of the inputs to and outputs from the system. In the San Jacinto River watershed, inputs are recharge from natural and artificial sources and outputs are mostly groundwater withdrawal. If recharge is less than groundwater withdrawal, groundwater levels and groundwater in storage decline; if recharge exceeds groundwater production, groundwater levels and groundwater in storage increase. To maintain current groundwater levels and groundwater in storage over the long-term, recharge must balance groundwater production.

Groundwater production is used to meet a portion of the water needs in the San Jacinto River watershed, including urban and agricultural uses. Table 2-5 displays the annual groundwater production by management zone (see Figure 2-16) for 2004–2007 on the basis of annual reports for the Hemet/San Jacinto Water Management Area and the West San Jacinto Groundwater Basin (EMWD 2005a, 2005b, 2006a, 2006b, 2007a, 2007b, 2008, 2009). Notable changes in groundwater production include an increase in production in Perris South from 2005 to 2006 because of new desalting wells.

2008 data for the Hemet/San Jacinto Water Management Area were not available for inclusion in this report. 2008 data for the West San Jacinto Management Area were available. These data show significantly lower extraction totals for the Lakeview/Hemet North (21 percent less than 2007) and Perris South (37 percent less) and San Jacinto Lower Pressure (64 percent less) management zones. 2008 extraction totals for the other West San Jacinto Management Area groundwater management zones included in Table 2-5 were similar to 2007 totals. The 2008 total groundwater extraction (19,086 acre-feet) for the West San Jacinto Management Area was 14 percent lower than the total 2007 extraction.

Table 2-5. Groundwater production by management zone

Management zone	Groundwater production (acre-feet)			
	2004	**2005**	**2006**	**2007**
Canyon	7,870	9,571	12,043	10,737
San Jacinto Upper Pressure	30,373	26,669	31,312	33,075
Hemet North portion of Lakeview/Hemet North	2,690	2,248	2,401	2,540
Hemet South	10,454	8,694	8,774	8,612
Subtotal: Hemet/San Jacinto Management Area	51,387	47,182	54,530	54,692
Lakeview portion of Lakeview/Hemet North	3,943	2,763	3,049	2,791
Perris North	7,509	7,739	8,284	8,066
Perris South	2,316	1,475	6,455	6,630
San Jacinto Lower Pressure	345	309	408	416
Menifee	4,539	4,407	4,860	4,725
Subtotal: West Basin[a]	18,652	16,693	23,056	22,628
Total	70,039	63,875	77,586	77,320

Note a: West Basin subtotal does not include the portion of Hemet South inside the AB3030 area to avoid double-counting with the Hemet/San Jacinto Management Area.

The relationship between groundwater production and recharge can be better understood through the *safe yield* of the basin. The safe yield is the long-term, average quantity of water that can be pumped without causing undesirable results, including the gradual reduction of natural groundwater in storage over long-term hydrologic cycles. Safe yield has been estimated to be between 40,000 and 45,000 acre-feet per year (AFY) in the Hemet/San Jacinto Groundwater Management Area (WRIME 2003) and 36,000 AFY in the West Basin (EMWD 1995). The estimate of the safe yield for the combined groundwater basin is 79,000 AFY (TechLink Environmental 2002).

Water quality plays an important role in groundwater production in the area. The majority of groundwater production occurs in the Hemet/San Jacinto Management Area, largely from higher quality groundwater in that area. Thus, it is important to consider the balance of safe yield and groundwater production on a localized scale in additional to a basin-wide scale.

Water deemed as being of lower quality in the San Jacinto River watershed typically contains concentrations of salts that are too high for drinking water purposes. Such water can be used for drinking water if treated. EMWD operates desalination facilities that remove salts at a cost of approximately $500 per acre-foot (EMWD 2007a).

Overdraft is the condition whereby groundwater production exceeds the safe yield, creating undesirable conditions in the basin. The amount of overdraft is calculated as the difference between long term average annual groundwater production and safe yield. On the basis of the estimated safe yield values reported above relative to groundwater production in Table 2-5, the West Basins are not overdrafted, but the Hemet/San Jacinto Groundwater Management Area is overdrafted by 10,000 to 15,000 AFY. Efforts are underway to address the overdraft situation in the Hemet/San Jacinto Groundwater Management Area through the Water Management Plan, completed in November 2007.

The ability and cost to use groundwater as a water source are greatly affected by water quality. Water quality is important for drinking water, irrigation water, and other uses, including habitat and recreation. Groundwater quality in a significant portion of the San Jacinto River watershed is poor because of natural causes and agricultural and urban effects. Portions of the watershed contain good quality groundwater, particularly in the east.

Drinking water quality is enforced by the California Department of Public Health's Division of Drinking Water and Environmental Management (DDWEN). DDWEN regulates public water systems, ensuring that they meet the limits set forth in Title 22 of the California Code of Regulations (sections 64431–64444). If groundwater does not meet the limits, it must be treated or blended with other water sources. High TDS in many parts of the area requires blending with other water sources or desalination to meet secondary standards. In some areas, TDS is high enough that desalination is the only option for drinking water use of the groundwater. Drinking water standards are also critical when designing recharge projects, so that it can be assured that the recharged water will be able to be put to beneficial use after recovery.

Irrigation water is not directly regulated, but high levels of certain constituents can harm crops, forcing a change to more tolerant crop types, a change to better quality water, or even a change of land use away from agriculture. High salinity, as indicated by TDS, is one such constituent that is a concern in the area. With regard to irrigation water use by dairies, permit requirements to offset dairy TDS and nitrate loads may limit use of certain sources for irrigation water.

Basinwide water quality concerns are enforced by the RWQCB. The study area is within the jurisdiction of the RWQCB, Santa Ana Region 8. The RWQCB implements state and federal laws through adoption of Water Quality Control Plans or Basin Plans (RWQCB 1995). The Basin Plan establishes both the legal beneficial use designations and sets the standards to protect these uses. The Basin Plan was amended in 2004 to incorporate an updated TDS and Nitrogen Management Plan for the Santa Ana Region, including revised groundwater management zones (combining Hemet North and Lakeview into one management zone, see Figure 2-22), TDS and nitrate objectives for groundwater, TDS and nitrogen wasteload allocations, and stream reach designations. A 2008 Basin Plan revision was limited to non-substantive changes to the format of the plan and incorporating all previous amendments, including the 2004 amendments, into the text of the plan.

TDS and nitrate levels are important water quality parameters and are indicators for overall water quality. While other constituents are in the area that are of concern, including arsenic and point source contaminants such as volatile organic compounds and methyl tertiary butyl ether (MTBE), TDS, and nitrate are the focus of most recent water quality assessments because of their widespread, regional nature and the ability to use constituents as surrogates for other contaminants. This is consistent with the total inorganic nitrogen (TIN)/TDS studies (Wildermuth 2000), the emphasis on TDS and nitrate in the Basin Plan as amended (RWQCB 2004), as well as the baseline criteria being used in the Hemet/San Jacinto Water Management Plan.

In the Santa Ana watershed, a statistical method has been developed to use nitrate-N and TDS to evaluate the status of water quality, to compare subbasin concentrations, and to trigger management actions (RWQCB 2004; Wildermuth 2000, 2005). Point statistics were used to show (1) historical ambient water quality conditions as represented by the 1954–1973 period, (2) 1997 current ambient water quality conditions as represented by the 1978–1997 period, and (3) 2003 current ambient water quality conditions as represented by the 1984–2003 period. A summary of the data is shown in Table 2-6, revealing nitrate-N levels below the maximum contaminant level (MCL) of 10 mg/L for all cases. Historical and current TDS concentrations exceed the recommended secondary MCL of 500 mg/L in all management zones except Canyon and Upper Pressure, and TDS exceeded the upper secondary MCL of 1,000 mg/L in the 1997 current levels in Hemet South and for historical and current concentrations in Perris South and Menifee.

The RWQCB used the point statistics and water quality objectives to develop estimates of assimilative capacity. Areas with assimilative capacity are able to accept waters with higher concentrations of a constituent than the concentration in the receiving waters because natural processes such as recharge and dilution will allow for the water quality objectives to continue to be met. The most recent computations indicate that the management zones do not have assimilative capacity for TDS. For nitrate, only the Canyon Management Zone has assimilative capacity, and that is only for a very small amount of nitrate (0.4 mg/L nitrate-N) (Wildermuth 2005).

Table 2-6. Historical (1954–1973), 1997 current (1978–1997), and 2003 current (1984–2003) ambient nitrate-N and TDS concentrations

Management zone	Nitrate-N[a] (mg/L)				TDS[b] (mg/L)			
	Basin plan objective[c]	Historical	1997 current	2003 current	Basin plan objective[d]	Historical	1997 current	2003 current
Canyon	2.5	2.5	1.6	2.1	230	234	220	420
Upper Pressure	1.4	1.4	1.9	1.7	320	321	370	370
Hemet South	4.1	4.1	5.2	5.4	730	732	1030	850
Lakeview/ Hemet North	1.8	1.8	2.7	3.4	520	519	830	840
Lower Pressure	1.0	1.0	1.9	1.8	520	520	730	950
Perris North	5.2	5.2	4.7	6.7	570	568	750	780
Perris South	2.5	2.5	4.9	5.9	1,260	1,258	3,190	2,200
Menifee	2.8	2.8	5.4	6.0	1,020	1,021	3,360	2,220

Source: Wildermuth 2005. (2003 update 1984–2003)
a. Table 2-3
b. Table 2-2
c. Basin Plan Amendment 2004 (Table 5-4)
d. Basin Plan Amendment 2004 (Table 5-3)

Table 2-7 shows the changes seen over the 30-year period between the historical and 2003 periods. The Canyon Management Zone shows a decrease in nitrate-N concentrations while all other nitrate-N and TDS concentrations for all other management zones show increases in concentrations of between 0.3 and 3.4 mg/L nitrate-N and 49 to 1,199 mg/L TDS. Note that changes seen between these periods are a combination of true changes in ambient water quality and artificial changes because of limitations in monitoring data and the estimation technique (Wildermuth 2005). In the future, as current monitoring programs assemble more data, a long-term record of analytical data at specific wells will be available to better show changes over time at specific locations.

Data from public and private wells, as compiled by EMWD for use in the *West San Jacinto Groundwater Basin Management Plan 2006 Annual Report* and in the *Hemet/San Jacinto Water Management Area 2006 Annual Report*, were used to plot the 2006 nitrate-N and TDS conditions as shown in Figures 2-22 and 2-23. While these values are taken from wells screened at different depths, the plots show the general variability in and magnitude of concentrations across the management area.

Table 2-7. Change in ambient concentration of nitrate-N and TDS between historical (1954–1973) and 2003 current (1984–2003) periods

Management zone	Change in nitrate-N (mg/L)	Change in TDS (mg/L)
Canyon	–0.4	186
Upper Pressure	0.3	49
Hemet South	1.3	118
Lakeview/Hemet North	1.6	321
Lower Pressure	0.8	430
Perris North	1.5	212
Perris South	3.4	942
Menifee	3.2	1,199

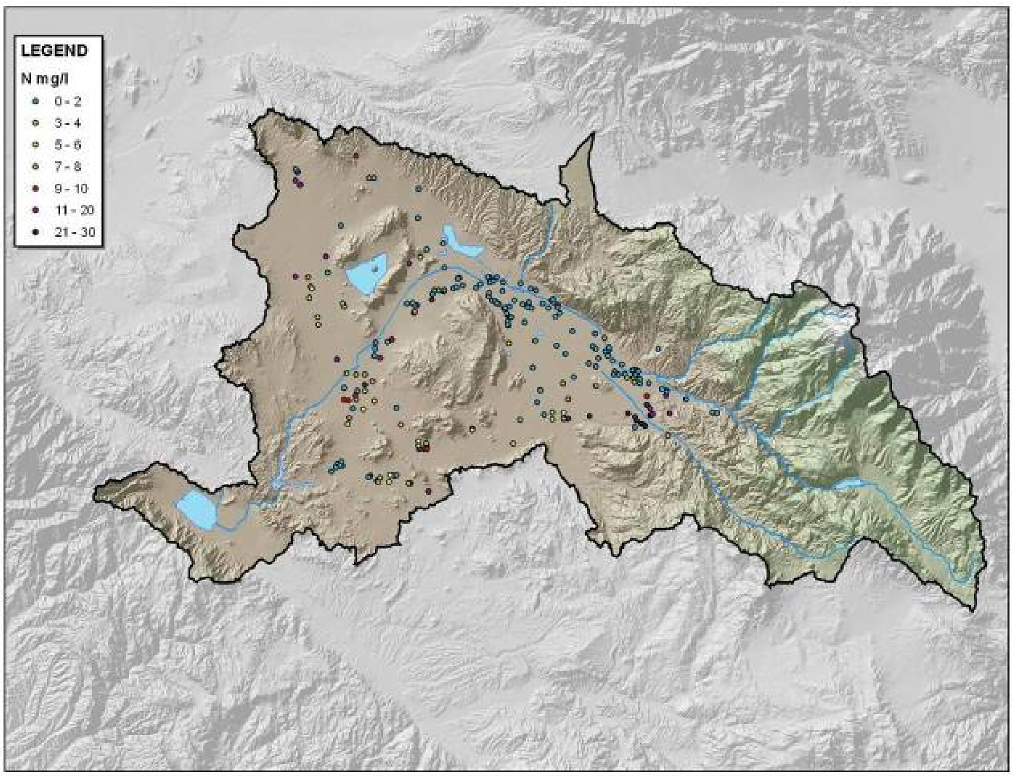


Figure 2-22. 2006 nitrate-N levels, San Jacinto River watershed.

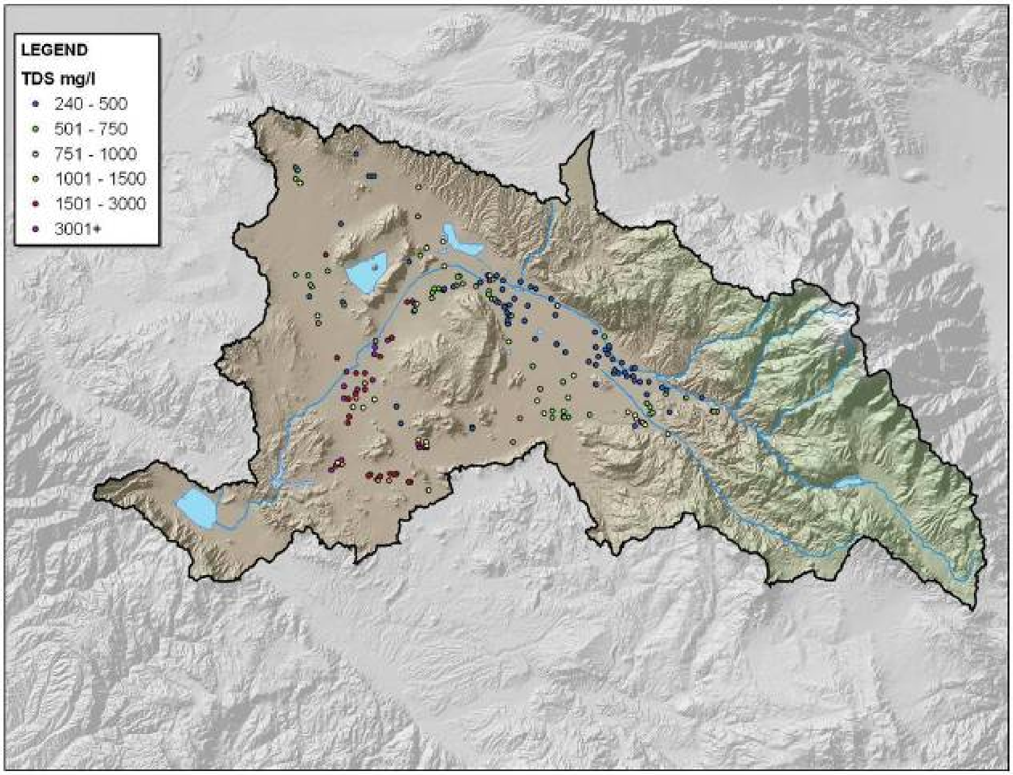


Figure 2-23. 2006 TDS levels, San Jacinto River watershed.

2.2 Biological Resources

Although detailed inventories of biological resources specifically within the San Jacinto River watershed are not available, important applicable information is in the *Western Riverside County Multiple Species Habitat Conservation Plan* (MSHCP) (Riverside County 2003). The MSHCP area encompasses approximately 1.26 million acres (1,966 square miles) in Riverside County and extends well beyond the boundaries of the San Jacinto River watershed. Although not all habitats and species found in the MSHCP area occur in the San Jacinto River watershed (e.g., those found in the desert transition region to the southeast), information from the MSHCP inventory is clearly relevant to the San Jacinto River watershed.

The MSHCP identifies seven distinct bioregions describing the diversity of habitats in the region (Riverside County 2003). The San Jacinto River watershed falls within three of the bioregions described:

- *Riverside Lowlands Bioregion*—The Riverside Lowlands Bioregion characterizes areas east of the Santa Ana Mountains Bioregion, south of the Riverside/San Bernardino County line, west of Diamond Valley Lake, Lake Skinner, and Gilman Hot Springs, and north of the Riverside/San Diego County line. This bioregion encompasses Estelle Mountain, Lake Mathews, Reche Canyon/Badlands, the San Jacinto Valley, Gavilan Hills, Lakeview Mountains, and French Valley. The Riverside Lowlands Bioregion generally occurs at elevations below 600 m (2,000 ft) and is characterized by Riversidean sage scrub and annual grasslands. The relatively arid climate is in part the result of the rain shadow cast by the Santa Ana Mountains. A high level of disturbance and urbanization are noted within this bioregion.

- *San Jacinto Foothills Bioregion*—The San Jacinto Foothills Bioregion generally includes areas north of SR-79, east of the Riverside Lowlands Bioregion and west of the San Jacinto Mountains Bioregion. This bioregion encompasses Vail Lake, Sage, and Cactus Valley. The San Jacinto Foothills Bioregion occurs at elevations of 600–900 m (2,000–3,000 ft) and is dominated by Riversidean sage scrub and xeric chaparral associations. This bioregion receives less frequent frost and snow than the mountainous areas. This bioregion has not been heavily disturbed or urbanized.

San Jacinto Mountains Bioregion—The San Jacinto Mountains Bioregion occurs in the eastern portion of the MSHCP area and encompasses the San Bernardino National Forest, Pine Cove, Idyllwild, and upper San Jacinto River and Bautista Canyon Creek. This bioregion supports coniferous forests, montane chaparral, and broad-leaved forest; it generally occurs at elevations above 900 m (3,000 ft). The San Jacinto Mountains Bioregion is floristically distinct from the San Bernardino Mountains Bioregion. This bioregion has not been heavily disturbed or urbanized.

The MSHCP area supports approximately 871,000 acres of natural vegetation, an additional 169,480 acres are in agriculture, and the remaining 218,260 acres are considered disturbed or developed land. A brief description of each vegetation community likely to occur in the San Jacinto River watershed is provided below.

- *Agriculture*—Agricultural lands include areas occupied by dairies and livestock operations or areas that have been tilled for use as croplands or groves/orchards.
- *Chaparral*—Chaparral vegetation is the most abundant and widespread vegetation type in western Riverside County, covering approximately 35 percent (434,950 acres) of the MSHCP area. Chaparral is a shrub-dominated vegetation community that is composed largely of evergreen species that range from 1 to 4 m in height. The most common and widespread species within chaparral is chamise (*Adenostoma fasciculatum*). Other common shrub species include manzanita (*Arctostaphylos spp.*), wild-lilac (*Ceanothus spp.*), oak (*Quercus spp.*), redberry (*Rhamnus spp.*), laurel sumac (*Malosma laurina*), mountain-mahogany (*Cercocarpus betuloides*), toyon (*Heteromeles arbutifolia*), and mission manzanita (*Xylococcus bicolor*).
- *Cismontane alkali marsh*—Cismontane alkali marsh vegetation communities are scattered sparsely over the Western Riverside County region. Typical cismontane alkali marsh species include yerba mansa (*Anemopsis californica*), saltgrass (*Distichlis spicata*), alkali-heath (*Frankenia salina*), cattails (*Typha spp.*), common pickleweed (*Salicornia virginica*), rushes (*Juncus spp.*), marsh flea-bane (*Pluchea odorata*), and sedges (*Carex spp.*).
- *Coastal sage scrub*—Coastal sage scrub is distributed throughout western Riverside County. Coastal sage scrub is dominated by a characteristic suite of low-statured, aromatic, drought-deciduous shrubs and subshrub species. Characteristic species include California sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), laurel sumac (*M. laurina*), California encelia (Encelia californica), and several species of sage (e.g., *Salvia mellifera, S. apiana*).
- *Developed or disturbed land*—Developed or disturbed lands consist of areas that have been disced, cleared, or otherwise altered. Developed lands can include roadways, existing buildings, and structures. Disturbed lands can include ornamental plantings for landscaping, escaped exotics, or ruderal vegetation dominated by nonnative, weedy species such as mustard (*Brassica sp.*), fennel (*Foeniculum vulgare*), tocalote (*Centaurea melitensis*), and Russian thistle (*Salsola tragus*).

- *Grasslands*—Nonnative, primarily annual grasslands occur throughout the MSHCP area (11.6 percent), usually within close proximity to urbanized or agricultural land uses. Nonnative grasslands are likely to be dominated by several species of grasses that have evolved to persist in concert with human agricultural practices: slender oat (*Avena barbata*), wild oat (*A. fatua*), fox tail chess (*Bromus madritensis*), soft chess (*B. hordeaceus)*, ripgut grass (*B. diandrus*), barley (*Hordeum spp.*), rye grass (*Lolium multiflorum*), English ryegrass (*L. perrene*), rat-tail fescue (*Vulpia myuros)*, and Mediterranean schismus (*Schismus barbatus*). Where they occur, native perennial valley and foothill grasslands typically contain the perennial bunch grasses Nassella pulchra and Nassella lepida. Lesser amounts of other native grasses, such as *Melica spp., Leymus spp., Muhlenbergia spp.,* and beard grass (*Bothriochloa barbinodis*), might also be present.
- *Meadows and Marshes*—Meadow and marsh vegetation communities , including coastal and valley freshwater marsh, undifferentiated marsh, and wet montane meadow, can occur in both flowing and still water. This vegetation community includes cattails (*Typha spp.*), bulrush (*Scirpus spp.*), sedges (*Carex spp.*), spike rushes (*Eleocharis spp.*), flatsedges (*Cyperus spp.*), smartweed (*Polygonum spp.*), watercress (*Rorippa spp.*) and yerba mansa (*Anemopsis californica*) and contains perennial and biennial herbs (e.g., *Oenothera spp., Polygonum spp., Lupinus spp., Potentilla spp.,* and *Sidalcea spp.*) and grasses (e.g., *Agrostis spp., Deschampsia spp.,* and *Muhlenbergia spp.*). Rooted aquatic plant species with floating stems and leaves also could be present, such as pennywort (*Hydrocotyle spp.*), water smartweed (*Polygonum amphibium*), pondweeds (*Potamogeton spp.*) and water-parsley (*Oenanthe sarmentosa*). Wet montane meadows that dry out by mid-summer have a higher percentage of perennial grasses than meadows that remain moist during the entire growing season.
- *Montane Coniferous Forest*—Montane coniferous forest, including Jeffrey pine, lodgepole pine forest, lower montane coniferous forest, mixed evergreen forest, Southern California white fir forest and subalpine coniferous forest, occupies 2.4 percent (29,910 acres) of the MSHCP area. Montane coniferous forest is dominated by Jeffrey pine (*Pinus jeffreyi*), ponderosa pine (*Pinus ponderosa*), Coulter pine (*Pinus coulteri*), lodgepole pine (*Pinus contorta* spp. *murrayanna* spp. *murrayana*), limber pine (*Pinus flexilis*), bigcone Douglas-fir (*Pseudotsuga macrocarpa*), Pacific madrone (*Arbutus menziesii*), bigleaf maple (*Acer macrophyllum*), Rocky Mountain white fir (*Abies concolor* var. concolor), and sugar pine (*Pinus lambertiana*). Common understory shrubs include manzanita (*Arctostaphylos spp*.), California lilac (*Ceanothus spp*.), chinquapin (*Chrysolepis*), currant (*Ribes*), and dwarf mistletoe (*Arceuthobium campylopodum*). The herbaceous layer is composed of morning-glory (*Calystegia occidentalis spp*. fulcrata), sedge (*Carex multicaulis*), clarkia (*Clarkia rhomboidea*), and mountain-heather (*Phyllodoce breweri*).
- *Playas and vernal pools*—Vernal pools are ephemeral wetlands that form in shallow depressions underlain by a substrate near the surface that restricts the downward percolation of water. Depressions in the landscape fill with rainwater and runoff from adjacent areas during the winter and can remain inundated until spring or early summer, sometimes drying more than once during the wet season. Smaller pools can fill and dry, and larger pools can hold water longer and can in the deeper portions support species that are more representative of freshwater marshes. Vernal pools are well known for their specificity to a particular location and abundance of rare, threatened, or endangered species. Many vernal pools are characterized by concentric rings of plants that flower sequentially as the pools dry. Vernal pools are dominated by native annual plants, with low to moderate levels of perennial herbaceous cover. Common vernal pool plant species in western Riverside County include woolly marbles (*Psilocarphus brevissimus*), toad rush (*Juncus bufonius*), and spike rush (*Eleocharis spp*.). In addition, the following sensitive or listed plant species are found in

one or more of these pools: California Orcutt grass (*Orcuttia californica*), Coulter's goldfields (*Lasthenia glabrata spp*. coulteri), little mousetail (*Myosurus minimus spp*. apus), spreading navarretia (*Navarretia fossalis*), low navarretia (*N. prostrata*), Orcutt's brodiaea (*Brodiaea orcuttii*), thread-leaved brodiaea (*Brodiaea filifolia*), Parish brittlescale (*Atriplex parishii*), Parish meadowfoam (*Limnanthes gracilis spp*. parishii), San Diego button-celery (*Eryngium aristulatum* var. parishii), Wright's trichocoronis (*Trichocoronis wrightii* var. wrightii), San Jacinto Valley crownscale (*Atriplex coronata* var. notatior), and smooth tarplant (*Hemizonia pungens spp*. laevis). The Santa Rosa Plateau fairy shrimp (*Linderiella santarosae)* occurs only in Western Riverside County, which is also the location of the southernmost record for the vernal pool fairy shrimp (*Branchinecta lynchi*).

- *Riparian forest/woodland/scrub*—Riparian vegetation, including forest, woodland, and scrub subtypes, is distributed in waterways and drainages throughout much of western Riverside County. Southern cottonwood/willow forest makes up the largest proportion of the riparian vegetation in the MSHCP area, composing nearly one-half (6,610 acres) of the acreage. Riparian communities typically consist of one or more deciduous tree species with an assorted understory of shrubs and herbs. Depending on community type, a riparian community can be dominated by any of several trees/shrubs, including box elder (*Acer negundo*), big-leaf maple (*A. macrophyllum*), coast live oak (*Q. agrifolia*), white alder (*Alnus rhombifolia*), sycamore (*Platanus racemosa*), Fremont's cottonwood (*Populus fremontii*), California walnut (*Juglans californica*), Mexican elderberry (*Sambucus mexicana*), wild grape (*Vitis girdiana*) giant reed (*Arundo donax*), mulefat (*Baccharis salicifolia*), tamarisk (*Tamarix spp.*), or any of several species of willow (*Salix spp*.).
- *Riversidean alluvial fan sage scrub*—Riversidean alluvial fan sage scrub is a Mediterranean shrubland type that occurs in washes and on gently sloping alluvial fans. Alluvial scrub is made up predominantly of drought-deciduous, soft-leaved shrubs but with significant cover of larger perennial species typically found in chaparral. Scalebroom generally is regarded as an indicator of Riversidian alluvial scrub. In addition to scalebroom, alluvial scrub typically is composed of white sage (*Salvia apiana*), redberry (*Rhamnus crocea*), flat-top buckwheat (*E. fasciculatum*), our lord's candle (*Yucca whipplei*), California croton (*Croton californicus*), cholla (*Opuntia spp.*), tarragon (*Artemisia dracunculus*), yerba santa (*Eriodictyon spp*.), mule fat (*Baccharis salicifolia*), and mountain-mahogany (*C. betuloides*). Two sensitive annual species are endemic to alluvial scrub vegetation in the MSHCP area: slender-horned spine lower (*Dodecahema leptocerus*) and Santa Ana River woollystar (*Eriastrum densifolium spp.* sanctorum).
- *Woodlands and forests*—The MSHCP area supports approximately 34,300 acres (2.7 percent of the MSHCP area) of woodlands and forests composed of black oak forest, broad-leaved upland forest, oak woodlands, and peninsular juniper woodland vegetation communities. Woodland and forest vegetation communities are dominated by Englemann oak (*Quercus englemannii*), coast live oak (*Q. agrifolia*), canyon live oak (*Q. chrysolepis*), interior live oak (*Q. wislizenii*), and black oak (*Q. kelloggii*) in the canopy, which can be continuous to intermittent or savannah-like. Four-needle pinyon (*Pinus quadrifolia*), single-leaf pinyon pine (*Pinus monophylla*) and California juniper (*Juniperus californica*) are the canopy species of peninsular juniper woodland that most commonly occur in Southern California, forming a scattered canopy from 3 to 15 m tall.

2.3 People and Infrastructure

The cities of Canyon Lake, Perris, and San Jacinto, and the communities of Sun City, Lakeview, Nuevo, and Romoland, are adjacent to the river. The cities of Moreno Valley, Hemet, Murrieta, and portions of the cities of Banning, Beaumont and Riverside, and the communities of Homeland, Idyllwild, Quail Valley, and Valle Vista, and March Air Reserve Base and portions of the community of Cherry Valley, are all within the San Jacinto River watershed." The jurisdictional boundaries for these areas are identified in Figure 2-24.

Population and demographics. According to the California Department of Finance, in 2009 Riverside County's population was estimated at 2,107,653, approximately 5.5 percent of California's total population. That estimate makes Riverside County the state's fourth most populous of 58 counties. In 2009 the county was ranked ninth in numerical change in California, with an influx of 29,000 people since 2008, and ninth in percentage change at about 1.4 percent (California Department of Finance 2009).

County population grew by approximately 60,000 from 2000 to 2009. The largest racial groups are white (non-Hispanic) and persons of a Hispanic or Latino origin (see Table 2-8). The majority of the population is between the ages of 20 and 64 (see Table 2-9), and the population is split evenly by gender (Riverside County Center for Demographic Research 2009).

The county has been adding about 16,000 people per year because of natural increase since 1999. Death rates have remained relatively stable while birth rates have increased yearly since 1999. International immigration has remained almost constant over time, but domestic migration has fluctuated dramatically. Since 1999, net migration averaging 36,493 persons per year, has been the greatest source of the county's population growth (Riverside County Center for Demographic Research 2009).

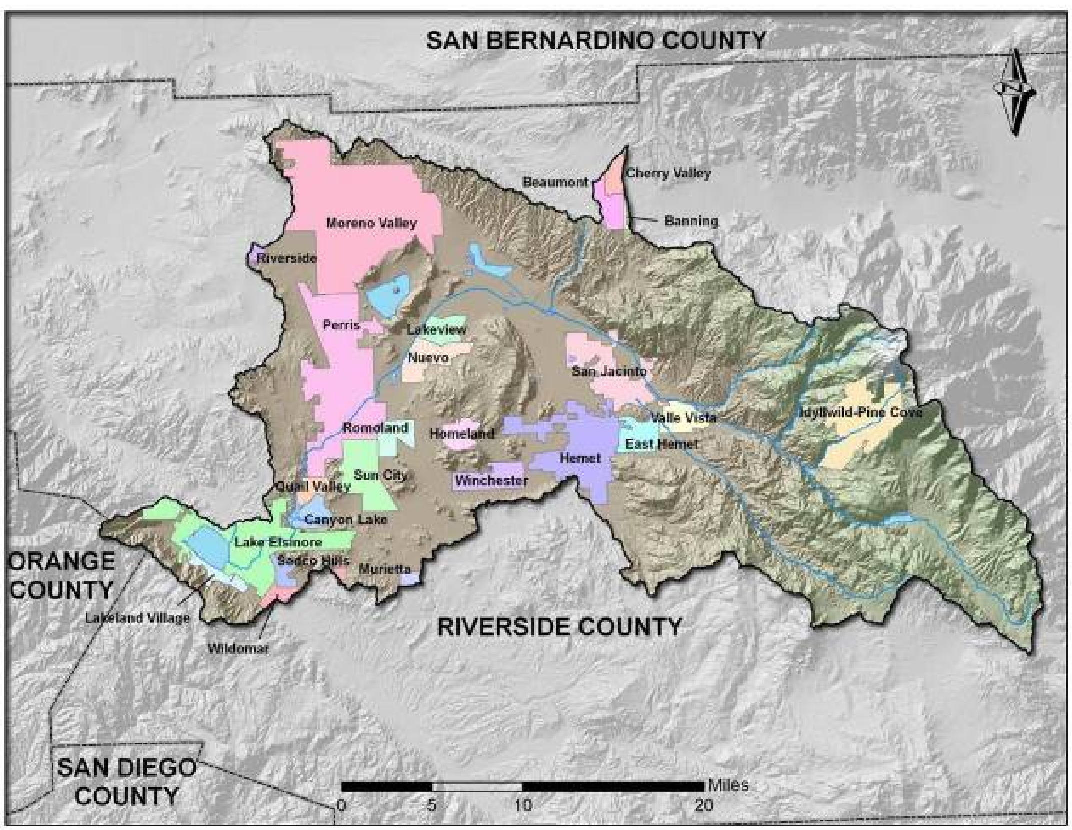


Figure 2-24. Jurisdictional boundaries in the San Jacinto River watershed.

Table 2-8. Demographic statistics: race, Riverside County, 2007

Race	Percent of population
White (not Hispanic)	44%
Hispanic or Latino origin	42%
Black	6%
Asian	5%
Others	3%

Source: U.S. Census Bureau 2009

Table 2-9. Demographic statistics: age, Riverside County, 2009

Age group	Percent of population
0–19	31.1%
20–64	57.7%
65 or older	11.2%

Source: Claritas, ACS, and California State Department of Finance 2009

Political units. The San Jacinto River watershed is almost entirely in Riverside County and includes 9 incorporated cities, 14 communities (see Table 2-10), and other unincorporated area. Riverside County is administered by the county government. A regional government, the Western Riverside Council of Governments (WRCOG), was formed to address emerging special issues ranging from environmental concerns to local infrastructure. Each municipality has its own government that works on more local issues (Riverside County 2007).

Table 2-10. Incorporated cities and communities in the San Jacinto River watershed

Cities	Beaumont	Lake Elsinore	Perris
	Canyon Lake	Moreno Valley	Riverside
	Hemet	Murrieta	San Jacinto
Communities	Cherry Valley	Lakeview	Sun City
	East Hemet	Nuevo	Valle Vista
	Homeland	Quail Valley	Wildomar
	Idyllwild-Pine Cove	Romoland	Winchester
	Lakeland Village	Sedco Hills	

Economic conditions. Riverside County has seen positive job growth each year from 1990 to 2006. More recent data were not available, but it is expected that jobs were lost during the subsequent economic downturn. As of 2007 the government sector was the largest employer (106,600 jobs) in Riverside County, followed by construction (97,721) and retail (92,386). The county offered 16,196 jobs in agriculture, natural resources and mining (including self-employment) (Riverside County Center for Demographic Research 2009).

As of 2009 Riverside County had more than 780,000 housing units with the addition of more than 195,000 units since 2000, more than double the increase seen in the previous decade (Riverside County Center for Demographic Research 2009). In 2000 the home ownership rate was 69 percent, and households averaged 3 persons per household (U.S. Census Bureau 2009).

In 2007 median household income for Riverside County was $57,736, with about 12 percent of the population living below poverty (U.S. Census Bureau 2009). In 2007, 79.6 percent of percent of persons over age 25 were high school graduates, and 20.1 percent of those persons over age 25 had earned a bachelor's degree or higher (Riverside County Center for Demographic Research 2009).

Land Use. USGS Multi-Resolution Land Characteristics (MRLC) 1993 data were used to assess the land use characteristics of the San Jacinto River watershed. Land use in the watershed is primarily deciduous shrubland in the headwaters. In the central and lower portions of the basin, agricultural and urban lands dominate. Table 2-11 provides a summary of the overall land use distribution in the watershed.

Land use data collected by EMWD were used to supplement the MRLC data for the San Jacinto River watershed. EMWD data provide a more detailed characterization of land uses in the district. In 1999 EMWD modified the 1993 Southern California Association of Governments (SCAG) land use data to represent conditions for 1998 within the district's boundaries (Figure 2-25). This land use coverage provides the most recent representation of the area, and additional detail (with field verification) regarding urban categories, irrigated and non-irrigated cropland, and the location of CAFOs.

Table 2-11. Land use distribution in the San Jacinto River watershed, 1993 MLRC data

Land use type	Area (acres)	Percent of watershed
Deciduous Shrubland	236,052	47.9%
Row Crops	65,546	13.3%
Forested	60,614	12.3%
Grassland/Herbaceous	53,465	10.8%
Developed	39,202	8%
Small Grains/Fallow/Urban Recreational Grasses	16,228	3.3%
Barren	7,752	1.6%
Pasture/Hay	6,302	1.3%
Water	5,650	1.1%
Planted/Cultivated	1,893	0.4%
Wetlands	284	0.1%

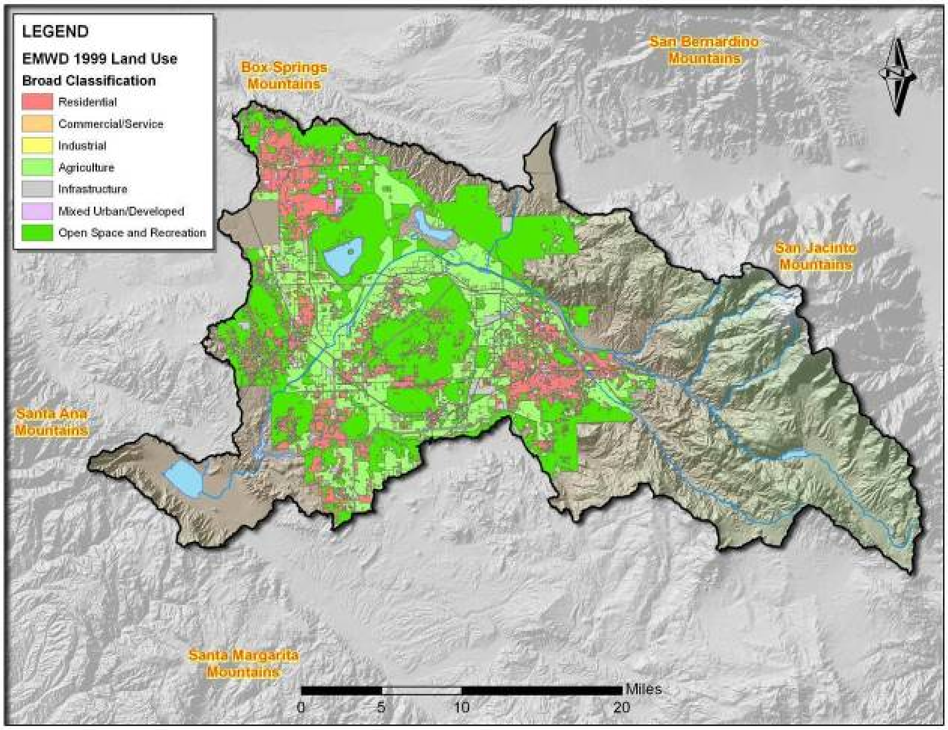
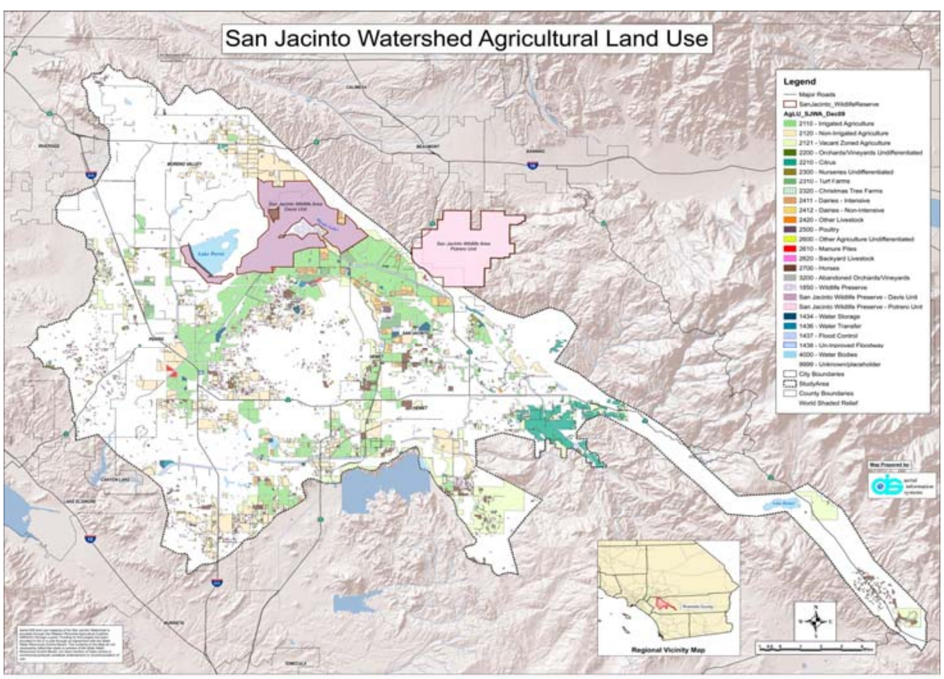


Figure 2-25. EMWD land use in the San Jacinto River watershed, 1998.

In 2008, a land use mapping effort (AIS 2009) produced a more detailed, current land use classification for agricultural land in the San Jacinto River watershed (Figure 2-26). The land use data are shown in Table 2-12.



Source: AIS 2009

Figure 2-26. Agricultural land uses in the San Jacinto River watershed, 2008.

Table 2-12. Agricultural land use in the San Jacinto River watershed, 2008

Land use code	Land use description	Area[a] (acres)
1850	Wildlife Preserve (including the San Jacinto Wildlife Area)	20,054
2110	Irrigated Agriculture	18,919
2120	Non-Irrigated Agriculture	9,908
2121	Vacant Zoned Agriculture	7,759
2200	Orchards/Vineyards Undifferentiated	27
2210	Citrus	2,573
2300	Nurseries Undifferentiated	261
2310	Turf Farms	948
2411	Dairies - Intensive	1,044
2412	Dairies - Non-Intensive	1,187
2420	Other Livestock	34
2500	Poultry	224
2600	Other Agriculture Undifferentiated	206
2610	Manure Piles/Composting	136
2620	Backyard Livestock	16
2700	Horses	821
3200	Abandoned Orchards/Vineyards	3
	Total	**64,120**

Source: AIS 2009

a. The data in this table reflect all agricultural land in the SJR watershed. The data include land currently being farmed, land exempt from the TMDL process but still zoned as agriculture (25,948 acres), and those parcels zoned agricultural that have not been identified at the time of this writing (non-compliant and undeliverable). These data are current estimates as of December 2009. The final estimates developed by WRCAC and AIS may differ slightly from these estimates.

Wastewater Infrastructure. EMWD provides wastewater treatment for the San Jacinto River watershed and shares collection responsibilities with some agencies, including LHMWD, and the cities of Hemet and Perris. EMWD's treatment facilities' locations are shown in Figure 2-27 and summarized in Table 2-13.

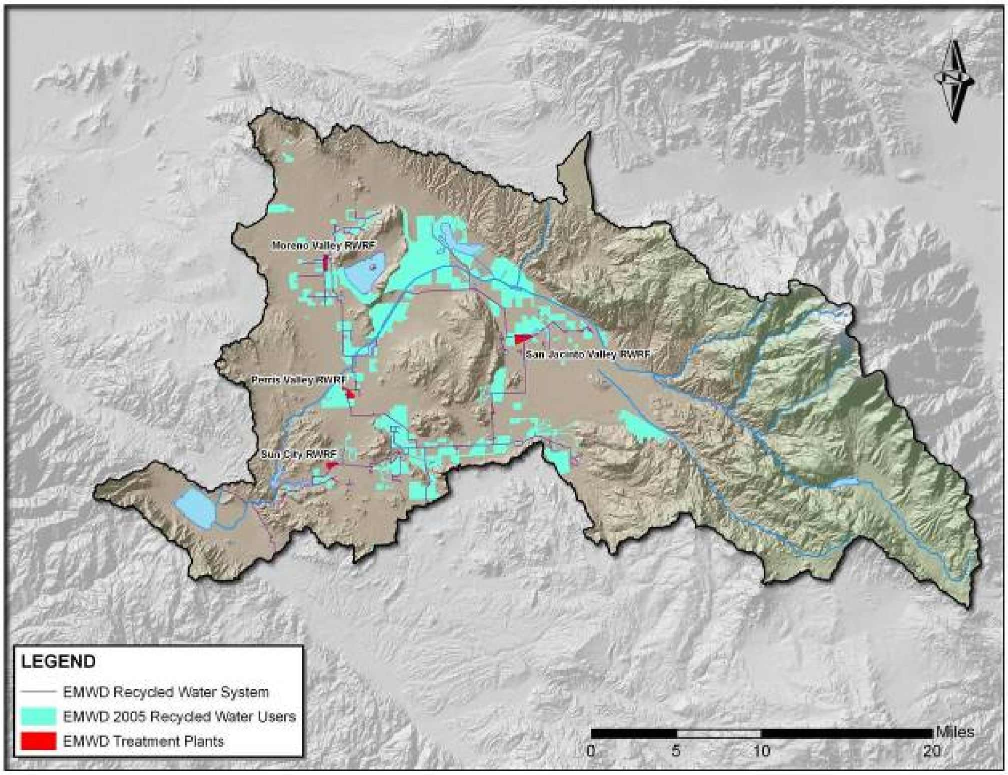


Figure 2-27. EMWD's treatment facilities and recycled water system.

Table 2-13. Characterization of EMWD's wastewater treatment plants

Treatment plant	Level of treatment	Capacity (AFY)	2000 flow	2005 flow
San Jacinto Valley RWRF	Tertiary	12,300	7,800	9,400
Moreno Valley RWRF	Tertiary	17,900	12,200	14,200
Perris Valley RWRF	Tertiary	12,300	8,600	12,200
Sun City RWRF	Tertiary	3,400	Not in service	Not in service
Temecula Valley RWRF	Tertiary	15,700	8,500	14,200
Total System	Tertiary	61,600	37,100	50,000

Source: EMWD 2005b, 2007b
RWRF= Regional Water Reclamation Facility

A key component of the wastewater infrastructure relative to this plan is recycled water. EMWD recycles effluent from four wastewater treatment plants, which produce tertiary quality water. The Department of Fish and Game, agriculture, golf courses, and schools purchase recycled water, thereby reducing the consumption of potable water. What is not resold is used for groundwater recharge or storage. EMWD is the state's fourth largest producer of recycled water for beneficial use. Recycled water pipelines and users are shown in Figure 2-27. In the near-term, future recycled water users will likely be near the treatment plants or existing recycled water infrastructure, to minimize costs.

Hydrologic Infrastructure. The San Jacinto River watershed is served by two major water suppliers, Eastern Municipal Water District and Western Municipal Water District (Figure 2-28). The major hydrologic infrastructure is the imported water pipelines owned and operated by the Metropolitan Water District of Southern California (Metropolitan). The pipelines are important for planning and implementation of water supply projects, including in-lieu and direct recharge projects, because they provide a large percentage of water to the area, including 80 percent of EMWD's potable supply. The imported water distribution system is shown in Figure 2-29. EMWD, as a member agency of Metropolitan, is capable of purchasing imported water. EMWD's connections to the imported water system are known as *EM* connections and are shown in Figure 2-29.

Drainage Master Plan. The San Jacinto River watershed includes 20 flood control master drainage plan (MDP) areas. Since 1969 MDPs had been prepared and updated for the populated portions of the watershed. The master planned facilities are designed to safely pass the runoff of a 100-year storm. Procedures outlined in the *Riverside County Flood Control and Water Conservation District Hydrology Manual* (Peairs 1978) were used when preparing the MDPs. The *County Hydrology Manual* uses the National Oceanic and Atmospheric Administration (NOAA) Atlas 2 rainfall data (1973) and Soil Survey data prepared by the Natural Resources Conservation Service (formerly Soil Conservation Service) and the U.S. Forest Service. MDP hydrology requires periodic updates to reflect additional rainfall data or changes to projected land uses in city and county general plans. In 2003 the NOAA Atlas 2 rainfall maps were superseded by the release of NOAA Atlas 14. Many of the older MDPs must be updated to reflect the additional growth that has been projected for this watershed in recent years.

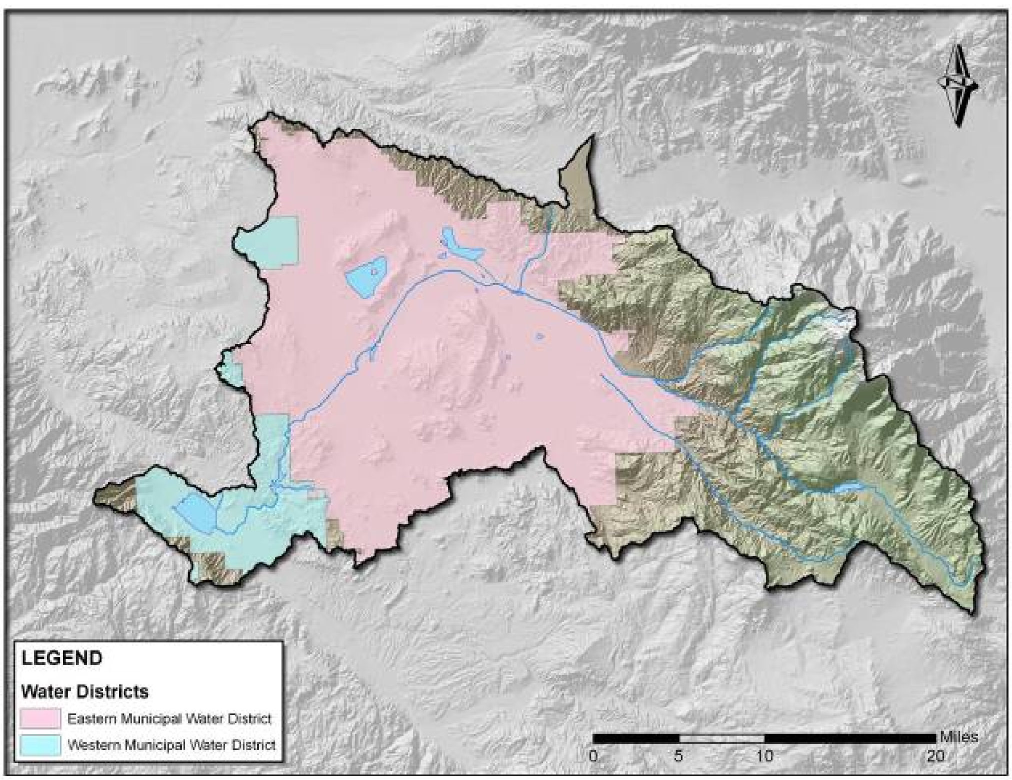


Figure 2-28. Water suppliers in the San Jacinto River watershed.

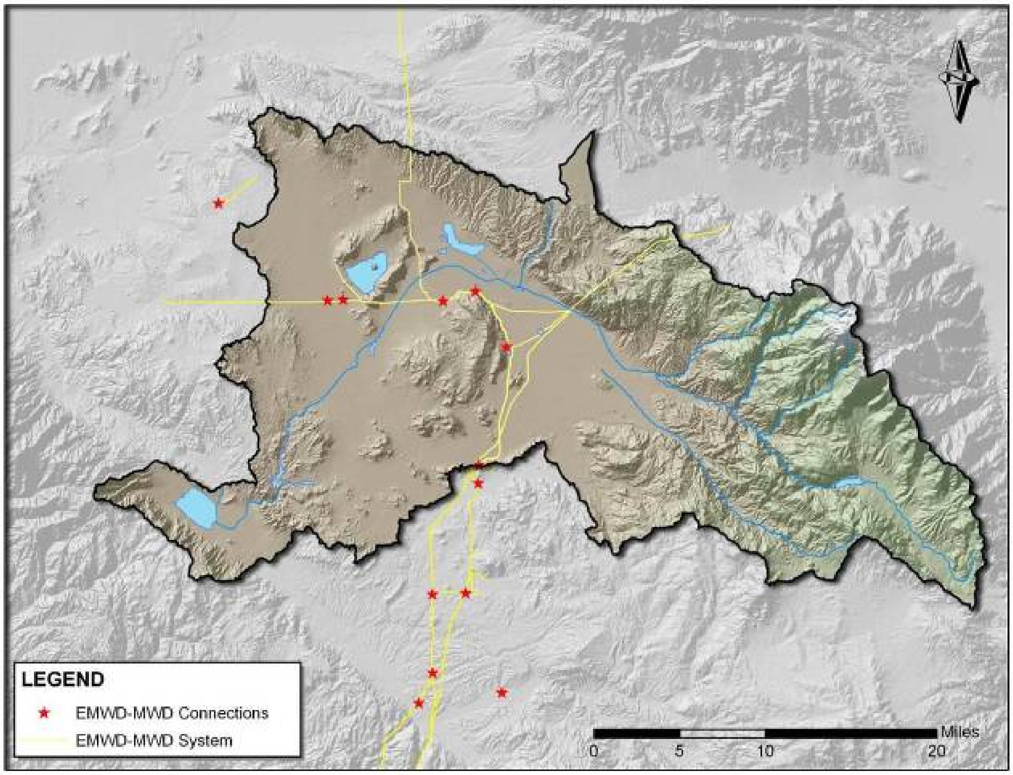


Figure 2-29. Imported water system and EM connections, San Jacinto River watershed.

Transportation Infrastructure. Major highways in the San Jacinto River watershed include the east-west Highway 60 in the north, the north-south Interstate 215 in the west, and Interstate 15 in the southwest corner. Secondary roads include the north-south Highway 79 and the east-west Highway 74 in the San Jacinto Valley as well as Highway 243 in the San Jacinto Mountains (Figure 2-30).

Transportation infrastructure will be increasingly problematic as populations grow and traffic congestion continues to rank among the most critical issues facing the county. Rapid economic and residential growth has outpaced the ability to provide adequate transportation facilities, resulting in increased roadway congestion and decreased air quality. As part of the county's Transportation and Land Management Agency's general plan, employment, service, and housing opportunities will be in close proximity to each other to reduce the need to use an automobile for every trip, reduce roadway congestion, and improve the opportunity to use alternative transportation (RCTLMA 2003).

In 2006 the Riverside County Transportation Commission revised the Congestion Management Program (CMP) for the county. The CMP is written to promote reasonable growth management programs that will effectively use new transportation funds, alleviate traffic congestion and related impacts, and improve air quality (RCTC 2006).

Forest and open space. Forests are an important resource in the San Jacinto River watershed. The watershed is home to the Cleveland and San Bernardino National Forests. The San Bernardino National Forest recently completed its 2006 forest plan. The plan describes the strategic direction at the broad program-level for managing the land and its resources over the next 10 to 15 years.

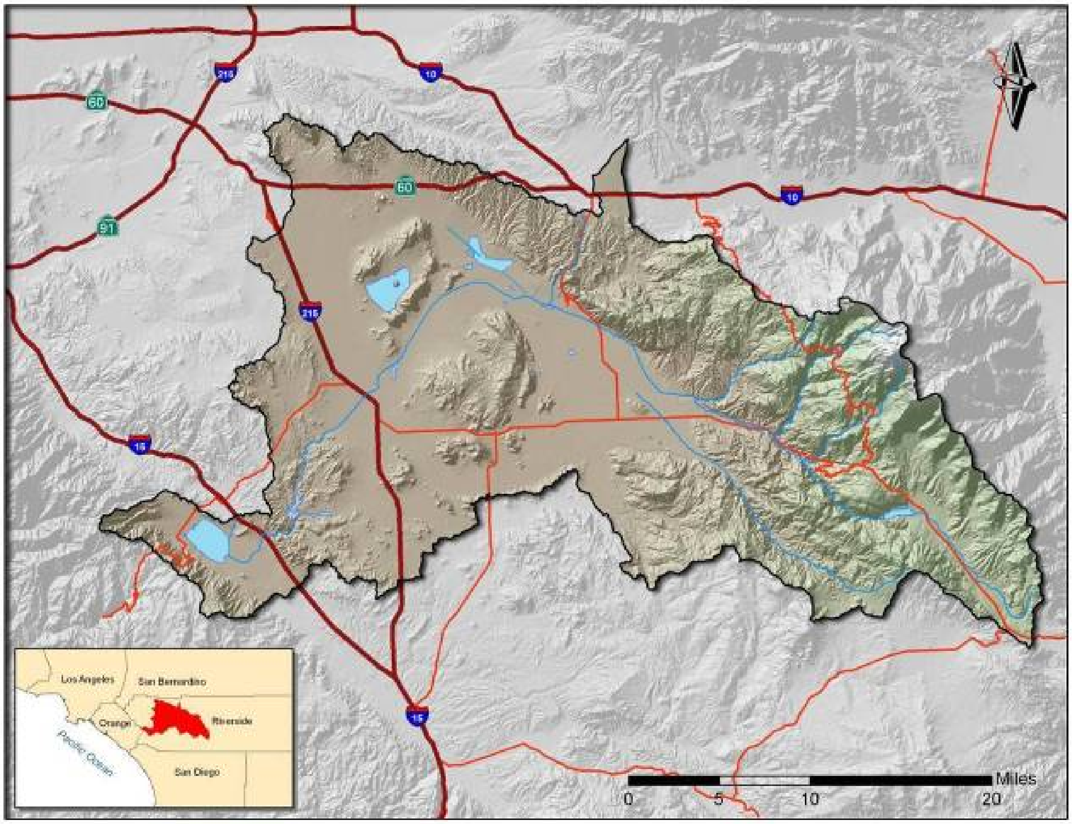


Figure 2-30. Major roads in the San Jacinto River watershed.

In the San Jacinto River watershed, riparian corridors, and the foothills and mountains are important habitat for wildlife such as deer, quail, fox, ground squirrels, and raptors. In addition, local lakes and reservoirs provide food and habitat for wintering raptors and migrating waterfowl. The Stephen's kangaroo rat, which is on the federal endangered species list and the California threatened species list, can also be found in the foothills.

San Jacinto Wildlife Area

Open space is one of the defining characteristics of the county's character and livability; in 2005 open space accounted for 74 percent of the watershed area (Figure 2-31) (RCTLMA 2003). Open spaces also provide separation between developed areas, enhance the quality of life for local residents, yield economic benefits to the county in terms of tourism, and are central to the health of biologic communities. As development increases, additional stresses are placed on open space and decisions must be made to accommodate future growth while preserving and enhancing open space. To ensure that open space can be maintained, growth must be managed carefully to achieve a balance between open space and urban uses. In the general plan, the county has committed to maintaining open space by identifying open space areas for preserving habitat, water, and other natural resources; protection from natural hazards; providing recreational areas; and protecting scenic resources (RCTLMA 2003).

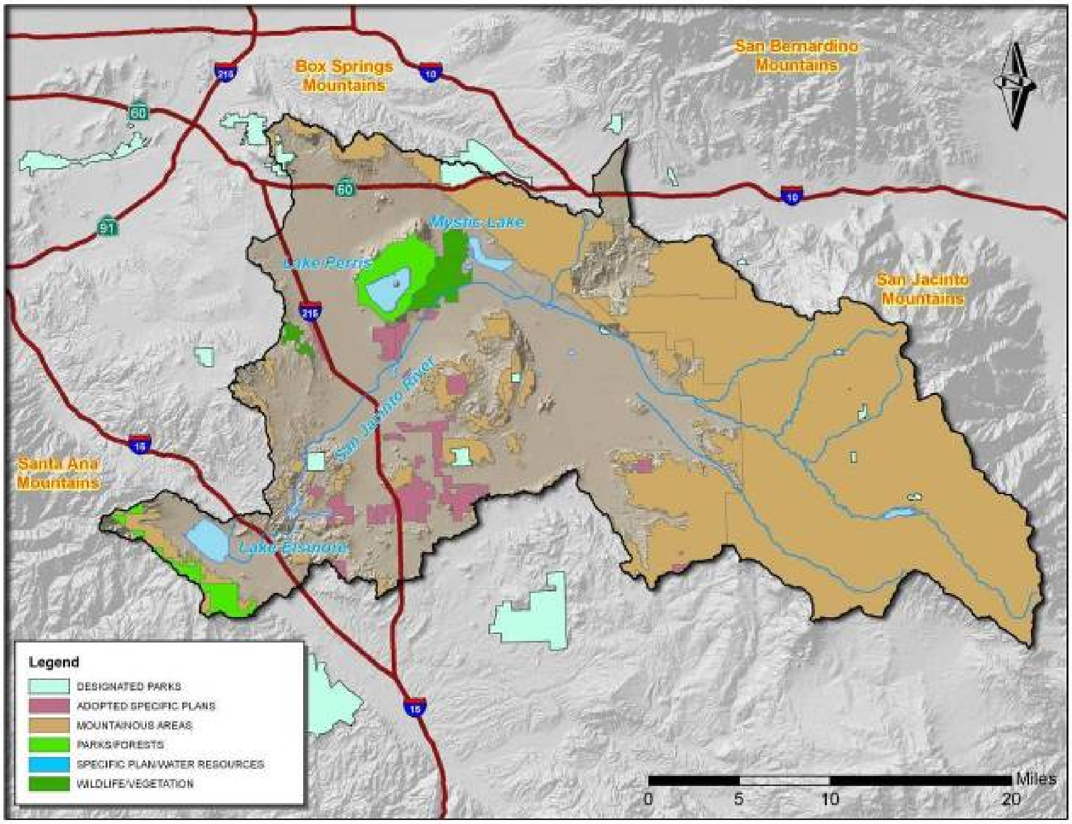


Figure 2-31. Parks and open space in the San Jacinto River watershed.

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3.0 Results of IRDMP Monitoring and BMP Demonstration Projects

IRDMP stakeholders identified a need for additional data to more fully characterize the water quality in the watershed. In particular, the IRDMP includes a monitoring program designed to verify assumptions made in the Lake Elsinore and Canyon Lake Nutrient TMDL. In addition, several demonstration projects were conducted to evaluate dairy BMPs that could contribute to addressing nutrient and salt issues for the IRDMP.

3.1 Results of IRDMP Monitoring Program

To address implementation of the nutrient TMDL for Lake Elsinore and Canyon Lake and to provide information for future management and planning, SJBRCD conducted monitoring in Mystic Lake and in key areas within the San Jacinto River watershed. From November 2007 through April 2008, monthly sampling was conducted at two stations on Mystic Lake. The watershed monitoring plan called for continuous flow monitoring and water quality sampling of one storm event over the storm season (September 1 to April 30) and was conducted at stream channel locations in the San Jacinto River watershed. Monitoring site locations are described in Table 3-1 and identified in Figure 3-1. Weston Solutions, Inc., collected the data under an approved Quality Assurance Project Plan (QAPP) (WRCAC and SJBRCD 2007).

IRDMP Monitoring Station SJBRCD1

Table 3-1. Description of Mystic Lake and San Jacinto River watershed IRDMP monitoring stations

Site name	Location (Long/Lat)	Purpose	Type of sampling
ML1	-117.0909, 33.8906 north end of Mystic Lake	Quality of receiving waterbody	Grab
ML2	–117.0694, 33.8742 south end of Mystic Lake	Quality of receiving waterbody	Grab
SJBRCD 1	–117.0640, 33.8398 Ramona Expy near Bridge St., Te Velde property	Captures runoff flow from a watershed dominated by dairy land use	Continuous flow monitoring and time weighted grabs
SJBRCD 2-1	–117.0284, 33.8233 Ramona Expy east of Warren Rd., Bert Lauda property	Captures runoff from the urban portion of the watershed characterized by LESJWA-3	Continuous flow monitoring and time weighted grabs
SJBRCD 2-2	–117.030036, 33.827732 near Ramona Expressway and Warren Road 0.5 km N of SJBRCD2-1	Captures runoff from the urban portion of the watershed characterized by LESJWA-3 (replaced SJBRCD 2-1)	Continuous flow monitoring and time weighted grabs
LESJWA 3	–117.0684, 33.8531 San Jacinto R. at Bridge St.	Captures runoff from a watershed dominated by urban and crop agriculture land uses	Continuous flow monitoring and time weighted grabs

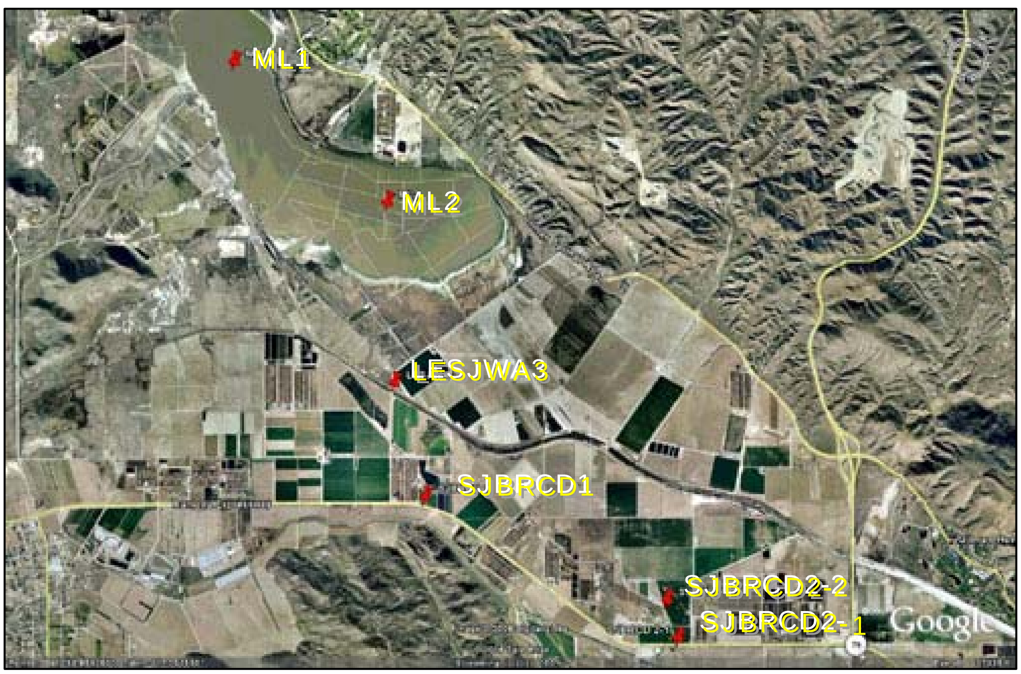


Figure 3-1. Location of Mystic Lake and San Jacinto River watershed monitoring stations.

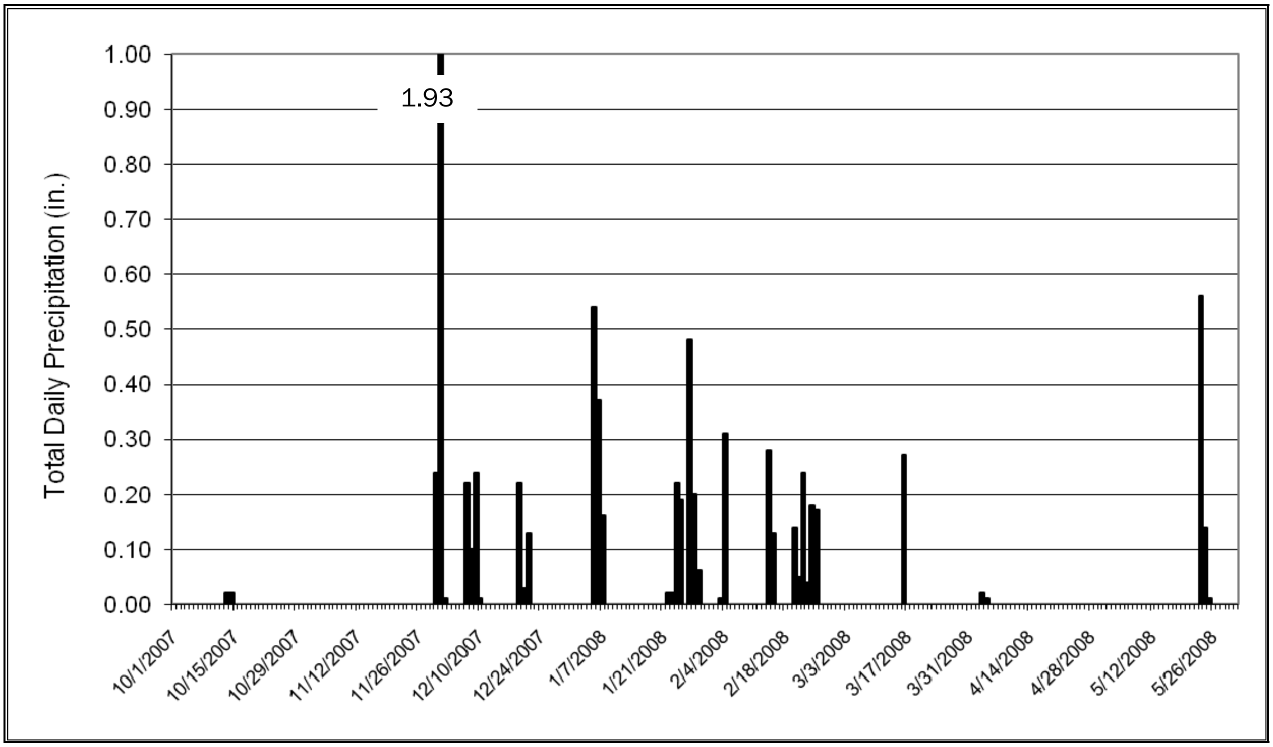
3.1.1 Watershed Monitoring

The monitoring plan called for continuous flow monitoring at three channel stations over the storm season (September 1 to April 30) and water quality sampling of one storm event during that period. Stations SJBRCD1, SJBRCD2, and LESJWA3 were established in 2007 (see Table 3-1 and Figure 3-1 above). Initial flow monitoring at SJBRCD2 in 2007 revealed backwater issues that prevented accurate flow measurement; because that situation could not be corrected, the station (now designated SJBRCD2-1) was abandoned on February 21, 2008. On the same day, monitoring began at a new location designated SJBRCD2-2 approximately 0.5 km north of SJBRCD2-1. Although the new station is better drained and not subject to ponding, shortly after the relocation, it was discovered that the city of San Jacinto had diverted some of the flows that normally would have been captured at SJBRCD2-2 to alleviate severe erosion issues along Ramona Expressway, east of Warren Road. The diverted flow was not captured at SJBRCD2-2. Thus, the data collected at the stream monitoring sites do not completely capture the runoff from the urban portion of the watershed, making it impossible to separate urban and agricultural runoff in data collected for LESJWA3.[1]

Precipitation data for the monitoring period were obtained from several National Weather Service and Riverside County Flood Control District weather stations. Because none of the available stations has a complete record for the period, data from San Jacinto, Hemet, Winchester, and Perris weather stations were combined to yield a *best professional judgment* estimate of precipitation. That precipitation record is shown in Figure 3-2. Total precipitation from September 2007 through May 2008 was 7.99 inches, about 3 inches (28 percent) below the normal rainfall of 11.05 inches for the period. Little rainfall was recorded in October and November 2007. The largest storm during the monitoring period was the 2.18 inches of rain that fell from November 30 through December 2, 2007; that storm occurred before flow monitoring equipment was operational. Moderate storms of ~0.5 inch or less were scattered through the December 2007 through March 2008 period, with a 0.7-inch storm ending the rainy season on May 23–24, 2008.

IRDMP Monitoring Station LESJWA3

[1] On November 16, 2009, the city of San Jacinto confirmed that the drainage repair work was complete, and runoff flow had been restored to its original flow path.



Source: Weston Solutions, Inc.

Figure 3-2. Precipitation recorded in the San Jacinto region, October 2007–May 2008.

Examples of event hydrographs observed at the three channel monitoring stations are shown in Figure 3-3. The three stations behaved quite differently in their response to precipitation and the magnitude of flow. In fact, it was quite rare to record flow at all three stations during the same event. Total discharge at each station over the monitoring period is summarized in Table 3-2. Clearly, the SJBRCD1 station exhibited the smallest flows, while the LESJWA3 station recorded the largest flows.

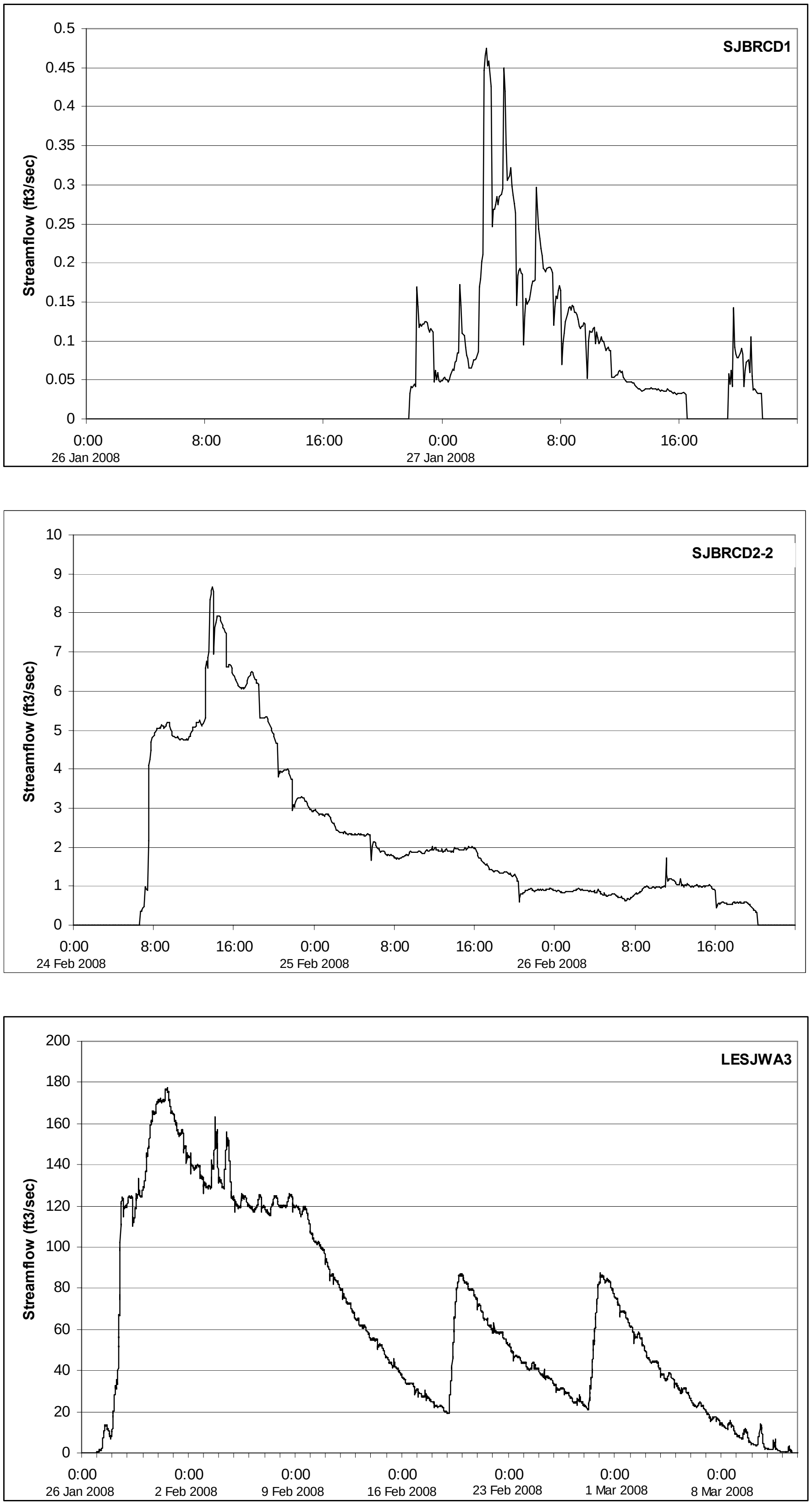


Figure 3-3. Examples of hydrographs from three different events at monitoring stations SJBRCD1, SJBRCD2-2, and LESJWA3.

Table 3-2. Summary of event discharge from monitoring stations, November 2007–April 2008

SJBRCD1		SJBRCD2-2[a]		LESJWA3	
Date	Discharge (ft^3)	Date	Discharge (ft^3)	Date	Discharge (ft^3)
Nov 30-Dec 1, 2007	15,916			Nov 30-Dec 9, 2007	2.12 x 10^7
Jan 5–7, 2008	4,270			Jan 5–13	1.62 x 10^7
Jan 23–24	2,848				
Jan 26-27	8,890			Jan 26–Mar 12	2.66 x 10^8
Feb 3–4	3,526				
Feb 6	1,052				
Feb 14–15	2,281	Feb 22–23	206,370		
Feb 24–25	2,278	Feb 24–26	531,337		
		Feb 27	12,292		
		Mar 25–26	170,540		
		Mar 30–31	182,170		
		Apr 1–4	583,719		
Period total	**4.10 x 104**		**1.69 x 106**		**3.03 x 108**

a. Discharge data from monitoring station SJBRCD2-1 are not included because the backwater issue at the station prevents meaningful interpretation of the data.

On May 22, 2008, flow from a small storm event of about 0.70 inch was monitored at the three watershed stations. Runoff began the evening of May 22 and lasted only a few hours at the SJBRCD1 and LESJWA3 stations; flow at the SDBRCD2-2 station lasted from May 22 into May 24. Total discharge for the event was 113 ft^3 at SJBRCD1, 209,866 ft^3 at SJBRCD2-2, and 3,158 ft^3 at LESJWA3. Grab samples were collected manually at each of the stations during the event. Because event flow was so brief, a single sample was collected at the SJBRCD1 and LESJWA3 stations; three samples were collected at the SJBRCD2-2 station.

Data from samples collected during the monitoring event are presented in Table 3-3 and 3-4. Note that for SJBRCD1 and LESJWA3, the values represent the analysis of the single event sample; for SJBRCD2-2, values in the tables represent the flow-weighted event mean.

Table 3-3. Field measurements and bacteria counts in event samples, May 22–24, 2008

Station	pH	Temp	COND	TC	FC	EC
		(°C)	(µS/cm)	MPN/100 mL		
SJBRCD1	8.82	15.5	183.2	17,000	8,250	11,912
SJBRCD2-2	9.03	18.6	1,607	154,511	4,913	2,410
LESJWA3	8.32	15.4	168.2	20,000	9,500	5,028

COND = electrical conductivity; TC = total coliform; FC = fecal coliform; EC = *E. coli*

Table 3-4. Chemistry results for event samples, May 22–24, 2008

Station	SRP	TP	NH_3	NO_2	NO_3	TKN	TSS	TOC
	(mg/L)							
SJBRCD1	1.166	9.120	3.56	0.18	4.5	10.4	1,792	40.4
SJBRCD2-2	2.732	3.410	3.26	0.25	0.81	10.3	30	62.9
LESJWA3	1.052	5.48	2.95	0.14	0.94	8.2	1,957	29.8

SRP= soluble reactive phosphorus; TP = total phosphorus; NH_3 = ammonia; NO_2 = nitrite; NO_3 = nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids; TOC = total organic carbon

Nutrient and sediment loads from the monitored event were calculated as the product of concentration and discharge. For stations SJBRCD1 and LESJWA3, the estimated load was simply the product of total event discharge and measured concentration because the entire event was represented by a single sample. For station SJBRCD2-2, event load was estimated as the product of the event mean concentration and the total event discharge. Event loads calculated in this manner are given in Table 3-5.

Table 3-5. Estimated chemical loads for May 22–24, 2008 runoff event

Station	Discharge	SRP	TP	NH_3	NO_2	NO_3	TKN	TSS	TOC
	(L)	(kg)							
SJBRCD1	3,203	0.004	0.029	0.011	0.001	0.014	0.033	5.7	0.13
SJBRCD2-2	5.94×10^6	16.237	20.3	19.4	1.5	4.8	61.3	178.7	373.9
LESJWA3	89,437	0.094	0.490	0.264	0.013	0.084	0.733	175.0	2.7
Total	**6.04×10^6**	**16.335**	**20.786**	**19.67**	**1.52**	**4.91**	**62.0**	**359.5**	**376.7**

SRP= soluble reactive phosphorus; TP = total phosphorus; NH_3 = ammonia; NO_2 = nitrite; NO_3 = nitrate; TKN = total Kjeldahl nitrogen; TSS = total suspended solids; TOC = total organic carbon

It is difficult to draw firm conclusions from the results of monitoring such a small, single event. Event discharge at the SJBRCD1 and LESJWA3 stations was very small and very brief; discharge from SJBRCD2-2 was higher and more prolonged. Peak flow rates and total event discharge from all three stations during the event were substantially lower than for other events recorded earlier in 2008.

Temperature and pH were similar among all three stations during the event. Conductivity at SJBRCD2 was an order of magnitude higher than at the other two stations, indicating that, coupled with the high event discharge, the SJBRCD2 drainage area carried a substantially higher dissolved solids load to Mystic Lake than that from the other two drainage areas.

Bacteria levels in discharge measured during the event were several orders of magnitude higher than levels measured in Mystic Lake over the past year (Table 3-8). That is not surprising, given that fecal bacteria die off rapidly in fresh water. Bacteria in event flow were likely to be of fairly recent origin in land runoff, compared to those in the waters of Mystic Lake. It is also possible that pH and high ammonia concentrations in Mystic Lake had an inhibitory effect on bacteria in the water column.

TP concentrations in event samples from all three stations were comparable to those observed in Mystic Lake, whereas SRP, NH_3-N, NO_2-N, and NO_3-N concentrations were substantially higher than those in Mystic Lake. That is to be expected, given the dilution of incoming nutrient loads in the lake and the rapid uptake of the dissolved nutrients by algae growth. In contrast, both TOC and TKN concentrations were lower in event discharge than in Mystic Lake. That is also probably a result of algal production that would fix atmospheric carbon into organic carbon and convert inorganic N into organic N, resulting in higher concentrations of both TOC and TKN in lake water. TSS in event discharge—probably mostly inorganic sediment particles—were higher in event discharge than in Mystic Lake, except in SJBRCD2-2, which showed very low TSS concentrations during the event. Sediment particles introduced into Mystic Lake in event discharge would tend to settle out over time, although direct comparison is difficult because TSS in Mystic Lake are likely predominantly of algal origin, while TSS in event discharge is probably composed mainly of inorganic soil particles.

Comparison of event water quality among the three stations is not conclusive because of the small data set. TP and NO_3-N concentrations appeared to be highest in flow at the SJBRCD1 station, suggesting that that drainage area may be a significant source of P and N. N concentrations appeared to be lowest in the event sample taken at LESJWA3. Suspended sediment concentrations seem to be substantially lower in event discharge at SJBRCD2-2, possibly suggesting lower erosion and soil loss in that drainage area, compared to the other stations. Again, it must be cautioned that inferences drawn from a single event and from a single sample during the event cannot be made with confidence.

It is clear that most of the sediment and nutrient loads during the event came from the area drained by the SJBRCD2-2 station; loads from the other two stations were essentially negligible by comparison.

3.1.2 Mystic Lake Monitoring

Data from monthly grab samples from the two Mystic Lake sampling stations are summarized in Tables 3-6, 3-7, and 3-8.

Table 3-6. Field data from Mystic Lake samples

Station	Date	Depth (ft)	pH	Temperature (°C)	Conductivity (µS/cm)	Dissolved oxygen (mg/L)
ML1	11/29/07	2	9.41	8.6	18,141	3.68
	12/17/07	1.33	9.51	13.5	14,251	20.88
	1/10/08[a]	2.0	9.62	17.2	12,653	36.84
	2/11/08	3.0	9.97	15.9	5,205	26.15
	3/11/08	2.5	9.67	23.3	5,553	17.40
	4/8/08[a]	2.0	9.58	18.3	6,820	10.88
ML2	11/29/07[a]	0.42	9.46	19.1	11,116	20.20
		0.67	9.15	16.3	17,744	19.62
	12/17/07	0.42	9.66	12.2	14,809	28.08
	1/10/08[a]	0.5	9.60	12.7	12,688	41.86
	2/11/08	2.0	10.26	20.6	4,998	42.16
	3/11/08	1.5	9.64	19.9	5,563	15.60
	4/8/08[a]	1.0	9.66	18.0	6,906	11.28

a. Values represent mean of duplicate measurements in the field.

Table 3-7. Chemistry data from Mystic Lake samples

Station	Date	TSS	TP	SRP	NO_2-N	NO_3-N	NH_3-N	TKN	TOC
		mg/L							
ML1	11/29/07[a]	470	7.012	< 0.01	< 0.05	< 0.05	19.2	130	1,658.0
	12/17/07	260	7.508	0.854	< 0.05	< 0.05	11.5	100	888.6
	1/10/08[a]	230[b]	6.372	2.405[c]	< 0.05[c]	< 0.05	0.97	85	912.8
	2/11/08	134	1.964	0.123	< 0.05[c]	< 0.05	0.28	36	242.7
	3/11/08	102	2.26	0.472	< 0.05[c]	< 0.05[c]	0.18	29	225.7
	4/8/08	170	2.934	0.412	< 0.05[c]	< 0.05	0.37	39	324.8
ML2	11/29/07	3,700	8.649	< 0.01	< 0.05	< 0.05	13	110	1,076
	12/17/07	360	7.105	0.819	< 0.05	< 0.05	13.5	120	895.3
	1/10/08	510	9.9	2.885[c]	< 0.05[c]	< 0.05	1.11	82	869.5
	2/11/08	166	2.363	0.161	< 0.05[c]	< 0.05	0.28	29	269.1
	3/11/08	92	2.29	0.647	< 0.05[c]	< 0.05[c]	0.17	29	239.5
	4/8/08	164	3.023	0.358	< 0.05[c]	< 0.05	0.36	42	338.9

TSS = total suspended solids; TP = total phosphorus; SRP= soluble reactive phosphorus; NO_2-N = nitrite; NO_3-N = nitrate; NH_3-N = ammonia; TKN = total Kjeldahl nitrogen; TOC = total organic carbon

a. Values represent mean of duplicate samples.

b. RPD of duplicate samples = 52%

c. Spike recovery failed lab QC

Table 3-8. Bacteria data from Mystic Lake samples

Station	Date	Total coliform	Fecal coliform	*E. coli*
		MPN/100 mL		
ML1	11/29/07	500	≤ 220[a]	91
	12/17/07	4	2	6
	1/10/08[2]	< 2	<2	< 2
	2/11/08	2,300	<2	2
	3/11/08	90	26	24[c]
	4/8/08	170	30	17
ML2	11/29/07	170	≤ 110[a]	96
	12/17/07	2	2	4
	1/10/08	130	130	40
	2/11/08	50	2	< 2
	3/11/08	50	14	15
	4/8/08	80	50	32

a. Results reportable only as "≤" due to technician error
b. Values represent mean of duplicate measurements
c. Lab duplicate failed QC

The waters of Mystic Lake appear to be quite alkaline, with high concentrations of dissolved solids, as indicated by the electrical conductivity values. The high dissolved oxygen levels at both stations in January and February were considerably above saturation concentration and are indicative of oxygen supersaturation, probably due to algal production. Field observations made at the time of sampling reported dense algae blooms and highly turbid water. Phosphorus concentrations were quite high; most of the P was in the particulate form, consistent with high algal production. It is also worth noting that both ammonia and TKN concentrations at both stations were an order of magnitude lower in 2008 than in November and December 2007. TOC concentrations appeared to be declining over the monitoring period. Indicator bacteria counts tended to be somewhat higher in January through April 2008 than in 2007, although all counts were below water quality standards.

Mystic Lake appears to have received a significant input of water over the period, consistent with precipitation and flow measured in the tributaries. The effects of the water input can be seen in the increasing depth and lower conductivity (dilution) noted in samples collected in February, March, and April, 2008. Dissolved oxygen levels in Mystic Lake continue to be considerably above saturation, indicating supersaturation from photosynthesis, as noted in observations of high algal production. Dissolved oxygen levels tended to be higher at the ML2 station, compared to ML1.

Concentrations of P, N, and TOC in the samples collected from February through April were lower than previous levels, consistent with the notion of dilution of Mystic Lake by new water input. Sediment and nutrient concentrations appeared to be quite similar between the two lake monitoring stations, except at the January 2008 sampling when TSS was substantially higher at ML2. It is unknown if this was because of inorganic sediment, algal production, or both. There was also a slight increase in TP at ML2 on the same sampling date; this could be due either to P in elevated suspended sediment or to higher algal production.

Indicator bacteria counts in Mystic Lake were generally low and showed no obvious trend over the monitoring period. Indicator bacteria counts in the December 17 samples were extremely low. It is possible that the very high levels of unionized ammonia, combined with the high pH inhibited bacteria survival. The *E. coli* counts reported in this monitoring effort have been considerably below the geometric means of 231–703 MPN/100 mL reported by the RWQCB in 2007 from samples collected at three locations in Mystic Lake. No explanation for this difference is available.

3.2 Results of BMP Demonstration Projects

Three BMPs were demonstrated on San Jacinto dairies as part of the IRDMP; demonstration included effectiveness monitoring.

3.2.1 Spatio-Temporal Assessment of Nutrient Management Plan Performance for Field-Scale Lagoon Water Application

The USDA, ARS, U.S. Salinity Laboratory conducted a three-year study on the performance of an NMP on the Scott Brothers Dairy in San Jacinto, CA. The study, included in full in Appendix C, followed ongoing research funded by the USEPA, which tested the performance of NMP on a small scale site and served as the foundation for the field scale pilot. The application of dairy wastewater and recycled water to agricultural soils under NMP conditions could provide a beneficial solution for the disposal of these marginal waters by using water and excess nutrients for crop production. However, improper application poses a potential environmental threat to surface and ground water sources, and a potential impairment of soil quality. Specifically,

CNMP Pilot Project test site

the benefits of using dairy wastewater and recycled water in NMPs may be partially offset by accumulation of salts in the root zone, with deleterious effects on plant growth and yield, and by the leaching of salts, nutrients and microorganisms towards ground water. Impacts to ground water are especially important because San Jacinto dairies and most cropland in the San Jacinto River watershed overlie groundwater management aones that lack assimilative capacity for TDS. Challenges to efficient NMP implementation in the San Jacinto River watershed include

- Inadequate information on soil properties, climatic data, wastewater constituents or crop water and nutrients uptake rates;
- Spatial and temporal variability of soil, wastewater, and crop properties;
- Management constraints related to water and wastewater application amounts and timing;
- Management-induced changes that influence soil properties over time.

The overall objective of this study was to assess the performance and long-term sustainability of a NMP for field-scale wastewater application. The study included intensive data collection on soils, wastewater, and crops and had these elements:

- Characterization of the soil spatial variability at the field site, using apparent soil electrical conductivity (ECa) survey that guided the soil sampling locations;
- Monitoring the spatio-temporal changes in transport-related soil properties and temporal changes in wastewater constituents and crop performance;
- Development of a field-scale NMP based upon findings from a plot-scale study and addressing potential weaknesses in the NMP design and operation processes; and
- Measurement of the fate of nitrogen, salts and indicator microorganisms under a well-designed and implemented NMP.

Study results were intended to lead to the development of science-based recommendations to improve NMP performance and sustainability, thereby protecting groundwater under a wastewater-irrigated site from nutrients, salts, and pathogens.

The study site was an 80 ac (33 ha) field with a rotation of wheat-rye, barley and sorghum. Intensive geospatial measurements of ECa were taken at the beginning of the project (May, 2007) to characterize the spatial variability of soil chemical and physical properties influencing soil quality and to temporally monitor changes in soil quality across this field. Nearly 600 soil samples were collected from 70 locations and 7 depth increments across the study field. Soils were re-sampled at the same locations at the end of the project to evaluate temporal changes in soil properties and salt and nutrient concentrations. Water flow and retention characteristics were developed by integrating detailed data on soil particle size distribution and bulk density with predictive models developed to estimate soil hydraulic parameters from simple

CNMP Pilot Project instrumented soil sampling site physical properties. Following the first ECa survey, infiltration measurements were initiated to study the spatial and temporal changes of infiltration properties.

Frequent information on water and N mass balances in the root zone required for the implementation of the NMP were obtained from four instrumented sampling sites on the field that measured soil volumetric water content over depth, soil temperature, salts and nutrients in and below the root zone, and plant biomass and N content. The N mass balance was calculated over the upper 30 cm for the wheat-rye and barley crops and 60 cm for the sorghum crop, where roots are most active in water and nutrient uptake under irrigated conditions.

A full chemical analysis (major anions and cations, EC, macro- and micro- nutrients, and pH) of wastewater and soil profiles at each sampling location was conducted at the beginning of the project. During the growing seasons, salt content in the wastewater and the root zone was estimated from sequential measurements of EC. TDS was assumed to be correlated to the EC ($1\ dS \cdot m^{-1} = 640\ mg \cdot L^{-1}$). At mid-project time (July 2008), the salinity of the upper soil profile (0-30 cm) was measured after water application of 9 to 15 cm that was applied to leach excess salts. A second full chemical analysis (major anions and cations, EC, macro- and micro- nutrients, and pH) of the soil profiles at each sampling location was conducted on November 2008.

The transport and fate of several fecal indicator microorganisms (*Enterococcus*, fecal coliforms, somatic coliphage, and *E. coli*) was monitored under ponded infiltration and redistribution of fresh dairy wastewater. These conditions were selected to mimic a worst-case transport scenario of saturated conditions that would enable dairy wastewater and microorganisms to move rapidly through the soil in macropores.

Three sources of water were used in this study: well water, recycled water and dairy wastewater. The recycled water and dairy wastewater contained macro- and micro - nutrients for plant growth. The amounts of nutrients need to be taken into consideration when developing a recommendation for commercial fertilizer or manure application based on soil tests before each growing season. The inorganic N content of the various sources was integrated and embedded into the N mass balance. Significant seasonal variations measured in NO_3-N levels in the dairy wastewater and recycled water suggested that an efficient NMP will require frequent information on the inorganic N content of this sources. Sampling of irrigation source water showed that the TDS of recycled water and dairy wastewater was double that of local well water, indicating that use of recycled water and/or dairy wastewater will require frequent leaching of salts to avoid yield effects due to increased soil salinity.

An NMP was implemented on winter (wheat-rye and barley) and summer (sorghum) crops during 2007-2009. During 2009, a rotation of three crops was tested, where a short growing season of barley was added between the wheat-rye and the sorghum. Whereas all the water was supplied through the irrigation system during summer, only 57 percent on average was supplied as irrigation water during winter due to seasonal rainfall and low evapotranspiration rates. Therefore, only a fraction of the N removed by the crop was supplied

Irrigation on CNMP Pilot Project test site during winter. The missing water and N was supplied by depleting the soil inorganic N and converting soil organic N to plant available inorganic forms (mineralization).

Scientists harvesting and weighing crop from monitoring sites

The high evaporative demands throughout summer required frequent water application for plant growth. Despite similar quantities of water application during summer 2007, 2008 and 2009, different salt loads occurred due to the use of different water sources with varying salt content. Summer 2008 and 2009 loaded 3 times more salts then summer 2007. Similarly, utilizing recycled water during winter 2009 increased the total salt per water application unit. Leaching of salts below the root zone occurred due to seasonal rainfall (20.95 cm) during fall 2008 and winter 2009. The salts were leached from the upper 60 cm and accumulated in a lower layer (-60 to -90 cm).

Nitrogen application to the crops was based on the mass balance of N in the root zone. Subsequent measurements of each component in the *N* mass balance were used to calculate the plant available N at the beginning and during the growing seasons. The three principal N sources were inorganic forms (NH_4-N and NO_2+NO_3-N) in the dairy wastewater, recycled water and soil, and organic forms in the soil and the supplied wastewater. Crop uptake was the major sink for N; volatilization, denitrification, immobilization and drainage were the major losses. Leaching of NO_3 was restricted to the upper 90 cm, where it is still available for crops with deep root system (i.e., corn, sorghum and alfalfa).

Changes in soil NH4-N were limited to the upper 30 cm of the soil profile.

Measured concentrations of fecal indicator microorganisms in fresh and stored dairy wastewater significantly exceeded the recommended standards for unrestricted irrigation. Indicator microorganisms were not detected in the soil below the depth of 20 cm. Batch survival experiments revealed much more rapid die-off rates for the bacterial indicator microorganisms in native than in sterilized soil, suggesting that the biotic factors played a dominant role in survival behavior.

The main lessons learned and recommendations from the study include the following:

- Develop a “hydrological sensitivity index” based on the soil and groundwater properties (depth, quality, hydraulic properties, and mineralogy of the vadose zone and aquifer). This index should categorize high and low potential zones of contamination from agricultural activity. Application of liquid and solid dairy wastes in low sensitivity zones would be more flexible than in other zones.
- Improve measurements of water and nutrient requirements by the crop to obtain accurate information on the required timing and quantities for application.

- Increase the water and N use efficiency by irrigating to meet plant uptake requirements using a high uniformity application system. Minimize runoff and ponding conditions by matching the water application rate to the soil infiltration rate.

Harvesting sorghum on the CNMP Pilot Project test site

- Regulations should be more specific and not based solely on TDS. Chloride is one potential indicator for salinity.
- Blending of high quality water (well water) and degraded water will decrease significantly the salt load; due to the order of magnitude difference in chloride concentrations.
- Growing salt tolerant crops will minimize the yield reduction due to salt accumulation in the root zone and will increase the uniformity of water and nutrients uptake from the soil.
- The timing of salt leaching may be a crucial management decision in NMPs because organic soil N continues to be converted to inorganic N forms (NH_4, NO_2 and NO_3) during periods of low N plant removal (fallow season). A pre-irrigation at the beginning of a new growing season, or seasonal rains during the fallow season may result in migration of inorganic N, especially NO_3, below the root zone towards groundwater, therefore leaching salts is preferred following harvests rather than prior to planting.
- Minimize application of dairy solid manure by matching to agronomic uptake rates of the crops. Alternative treatments (composting and biogas production) do not remove salts, however composting stabilizes the fresh manure to a balance fertilizer with lower potential for groundwater contamination and biogas production is a feasible bio-energy source to handle excess dairy solid manure at specific sites.
- Special caution is warranted in coarse textured and structured soils and during water flow transients where enhanced microorganism transport potential has been reported in the literature.
    - Timing of water application should allow for adequate die-off of microorganisms before leaching the root zone by irrigation or natural precipitation.
    - The potential for groundwater contamination will increase with shorter travel times and distances. The water table depth is therefore another important consideration for environmentally protective NMPs.
    - The transport potential of microorganisms can be significantly reduced by minimizing water leaching below the root zone and surface water runoff. This can be achieved by:
        - Precise estimation of the ET rate;
        - Uniform application of wastewater; and
        - Selecting water application timing and quantities based on considerations of soil permeability and ET.

3.2.2 VSEP

Collecting a permeate sample from the VSEP demonstration

The Vibratory Shear Enhanced Processing (VSEP®) system is an experimental process developed by New Logic Research, Inc., of Emeryville, California, that uses reverse osmosis (RO) membranes to separate and concentrate suspended solids and dissolved solids (primarily salts and nitrates) from dairy manure and wastewater (Stowell and Carter 2008). Pathogens, viruses, and bacteria are also removed and stay with the solids. The primary goal of the VSEP system is to concentrate solids, dissolved salts, and nutrients to facilitate improved dairy waste management, while recovering clean water for reuse for reuse on the facility including livestock drinking water. This BMP project was performed to demonstrate the capabilities of the VSEP membrane filtration system and to provide the operating parameters to size a full-scale system. Complete results of the VSEP demonstration are reported in Appendix D).

The VSEP membrane filter pack contains sheets of RO membrane that are vibrated in oscillation, similar in principle to the agitation of a washing machine. VSEP can produce extremely high shear energy at the surface of the membrane that allows the system to handle high solids concentration without fouling or with the need for pretreatment systems usually used with conventional RO membrane systems. VSEP systems are modular and can be expanded for additional capacity by adding additional units to the system. It is expected that up to approximately 80 percent of the wastewater can be recovered from the feed stream as high-quality water for reuse.

For this demonstration, lab tests were conducted to provide operational parameters and performance data needed to construct a pilot-scale system on a dairy. A series of pilot test batches were then run in the field to confirm average flux and recovery rates for VSEP system sizing, and samples were collected for analysis.

New Logic Research performed a series of lab tests to develop requirements for a full-scale VSEP wastewater treatment system to recover dairy wastewater and to gain an understanding of the quality of *reuse* dairy wastewater and the solids and nutrient concentration in the residuals. In addition to establishing optimum operating parameters for the system, output water (*permeate*) was analyzed to determine its suitability for reuse in dairy operations as livestock drinking water. Collectively, that information should lead to the development of recommendations to dairies for wastewater and nutrient reduction and water reuse, thereby protecting groundwater under dairy waste application sites from nutrients, salts, and pathogens.

Lab testing showed that the most suitable membrane is ESPA (Energy Saving PolyAmide), operated at 300 psi at a temperature of 25 °C. Those parameters gave a 77 percent water recovery at an actual average flux of 8.5 GFD (gallons of permeate produced per square foot of membrane per day). Some characteristics of feed wastewater, permeate, and final concentrate observed during the lab testing are shown in Table 3-9.

Table 3-9. Selected characteristics of feed, permeate, and concentrate from VSEP lab tests

Sample name	Color	pH	Conductivity (μm)	% Solids	Volume
Initial feed	Brown	7.25	4,600	0.54%	100%
LFC permeate	Clear	7.96	110.9	0.02%	
ESPA permeate	Clear	8.95	58.1	0.00%	
FE permeate	Clear	6.38	104.6	0.00%	
BW-30 permeate	Clear	8.75	106.9	0.02%	
Composite permeate	Clear	7.25	185.9	0.00%	77%
Final concentrate	Brown	7.25	12,200	17.20%	23%

In the lab, the VSEP process reduced conductivity by 96 percent, produced a finished water essentially free of solids, and yielded a high-solids concentrate.

A pilot-scale test was conducted on the Abacherli Dairy in Menifee, California, in March–April 2008. The batch-mode test gave an 80 percent permeate recovery at a flux rate of 17.6 GFD at 25 °C and 350 psi. Test data confirmed the ability of the VSEP to separate 80 percent of the feed volume as clean permeate while concentrating suspended and dissolved solids to a significantly reduced volume of concentrated nutrients. Test sample analysis shows that first-stage permeate from the VSEP/RO might be satisfactory for reuse, but if necessary, a second stage of spiral RO could polish permeate to a much higher quality. The most significant result, however, is waste reduction of TDS and nitrogen components from the wastewater. TDS levels went from 1,760 mg/L in the feed to 210 mg/L from stage 1 VSEP/RO and to 44 mg/L from stage 2 spiral RO permeate. Nitrogen levels were reduced to < 5 mg/L. Nitrates were completely separated from water produced from the test unit.

Comparison of dairy wastewater before and after VSEP

On the basis of the results of this pilot test, characteristics of a full-scale dairy VSEP membrane system can be estimated. Assuming a recovery rate of 77 percent, an average flux rate of 8.5 GFD, a membrane area of 1,500 ft^2, and allowance for 2 hr/day of membrane cleaning show a capacity of 10.49 gal/min and a permeate production of 11,687 gal/day.

3.2.3 Irrigation Management

Declining irrigation water supplies and increasing costs have emphasized the need for efficiency and water conservation in crop production in the San Jacinto River watershed. A study titled *A Forage Crop Irrigation Demonstration Project* (SJBRCD 2008, Appendix E) was conducted on an alfalfa field in San Jacinto to test and demonstrate modern monitoring technologies for irrigation and water use management for forage crop production. The overall goal of the project was to implement irrigation instrumentation and monitoring technologies on field crops and to determine if maximum water efficiency was achieved while maintaining crop quality and yield. The project was conducted from 2006 to 2008 on a 27-acre field in San Jacinto, bordered by Gilman Springs Road and Highway 79.

A Veris machine was used to measure EC at several depths in the field, linked to a global positioning system (GPS) to create a map showing differences in soil properties across the field. The resulting field map showed areas of heavier, medium, and lighter soils that can be further tested and sampled to manage the irrigation and nutrient needs of the soil. Soil maps and aerial maps were used to determine the quantities of water and nutrients to be applied to the different soil types in the field. Subsequently, irrigation water application and soil moisture levels were monitored at three depths across the field using Ech2o instrumentation. The objective was to develop an irrigation schedule to maintain soil moisture levels between a minimum of 10 percent and a maximum of 30 percent, taking temperature, evapotranspiration, and weather into consideration. Six months of soil moisture monitoring showed that moisture totals at 6-, 12-, and 24-inch depths remained fairly consistent over the irrigation season.

Irrigation at a San Jacinto dairy

Soil moisture graphs showed that water traveled an average of 34 inches out of the possible 28-inch rooting depth for alfalfa, indicating that the average irrigation efficiency from June to December 2007 was 70 percent. For the 2007 season, the alfalfa yield for the study field was 634 tons. One result of the project was the recognition that crop tissue nitrate testing by a hand-held meter in the field was a tedious process that did not deliver consistent accurate results; a different method is needed for future nitrate testing.

Finally, several local forage producers have expressed interest in using the tested technologies in their operations; the SJBRCD and equipment vendors involved in this demonstration have expressed interest in continuing the development of several of the technologies.

References

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Stowell, L., and S. Carter. 2008. CAFO *Dairy Wastewater Treatment, VSEP L/P Filtration System Laboratory & Pilot Test Project Pilot BMP part of Integrated Regional Dairy Management Plan.* Prepared for San Jacinto Basin Resource Conservation District, San Jacinto, CA.

USDA-ARS (U.S. Department of Agriculture–Agricultural Research Service). 2009. *Spatio-Temporal Assessment of Nutrient Management Plan Performance for Field-Scale Lagoon Water Application at Scott Brothers Dairy, San Jacinto*, CA. Draft Final Report. U.S. Department of Agriculture, U.S. Salinity Laboratory, Riverside, CA.

WRCAC (Western Riverside County Agriculture Coalition) and SJBRCD (San Jacinto Basin Resource Conservation District). 2007. *Mystic Lake Quality Assurance Project Plan.* Revision 2. Western Riverside County Agriculture Coalition, San Jacinto, CA, and San Jacinto Basin Resource Conservation District, San Jacinto, CA.

4.0 Dairy Issues of Concern

4.1 Existing Conditions

Dairy operations are a significant component of land use and economic activity in the San Jacinto River watershed. As of December 2009, the watershed has 25 dairies (Table 4-1) housing approximately 51,000 animals. These facilities annually generate some 199,000 tons of manure, as well as wastewater and stormwater runoff, all containing nutrients, salts, bacteria, and other substances that must be managed properly to protect surface and groundwater quality in the watershed and beyond. Most dairies in the watershed do not include active cropland, but in 2007 about 2,200 total acres of cropland were associated with nine of the dairies[1]. In 2008 about 11,900 tons of manure were applied to cropland associated with dairy operations, representing 6 percent of the manure produced in the watershed; the balance of the manure was shipped off the dairy facilities in 2008 to various locations, mostly in Riverside County. According to annual reports submitted to the RWQCB, in 2008 approximately 9,100 tons of manure, or 4.5 percent of the manure produced in the watershed, was exported to a location outside the watershed. The watershed also receives an unknown quantity of manure shipped in from outside its boundaries, primarily from the Chino Basin, some 40 miles to the west.

> The number of dairies in the Santa Ana Region has been in decline for a number of years. In 2009, approximately 26 percent fewer animals are on dairies in the San Jacinto River watershed than there were in 2005. The Chino Basin has seen an even more dramatic decrease—more than 50 percent—since the beginning of the decade. SJBRCD expects that this trend will continue for several more years.

The majority of dairies in the San Jacinto River watershed obtain some portion of their water from local groundwater. A number of dairies also take a portion of their water each year from EMWD's supply of imported water from the Colorado River Aqueduct. Several dairies also use EMWD's Recycled Water System to supply irrigation water for crop production. An analysis based on sampling at 10 San Jacinto dairies in November 2009 estimated that those 10 dairies generated 14 to 62 gallons of wastewater per cow per day, with a mean of 32 gallons per cow per day. Extrapolating these results to all of the dairies in the watershed results in an estimated 915,400 gallons of wastewater produced at San Jacinto dairies each day.

San Jacinto dairies generally house dairy cattle in corrals, rather than barns, and the cattle are fed from concrete feed lanes along the outer edges of the corrals (Figure 4-1). About 90 percent of the daily manure excreted is deposited in the corral and feed lanes (Bartram and Barbour 2004). Manure is generally scraped from the feed lanes back into the corral weekly and either spread or stacked. In accordance with Rule 1127; another management alternative is to collect fresh manure from the feed lane in a vacuum truck for separate handling. Accumulated manure is cleared from corrals at least four times per year, and all on-dairy stockpiles are removed at least four times per

[1] This figure has declined since 2007. Accurate data on the amount of cropland at dairies in 2009 are not available; however, there are only 5 or 6 dairies with cropland in 2009.

year. Some dairies apply manure on their own cropland, but most dairies lack cropland and their manure is hauled for direct land application elsewhere. Lactating cows are milked two to three times daily, and about 10 percent of the daily manure excreted is assumed to be deposited in the milk parlor and holding areas. Milking parlors are cleaned with water that is collected in an on-site storage lagoon, along with water used to wash the cows before milking. Manured storm runoff from within the dairy is prohibited from leaving the site by terms of the dairy discharge permit[2] and is conveyed to one or more storage lagoons along with runoff from the corrals and feed lanes. Liquid from lagoons is allowed to evaporate or percolate or, in some cases, can be applied to cropland or pasture within the facility. Lagoon solids are cleaned out every 2 to 3 years and generally are added to corral manure for hauling and land application.

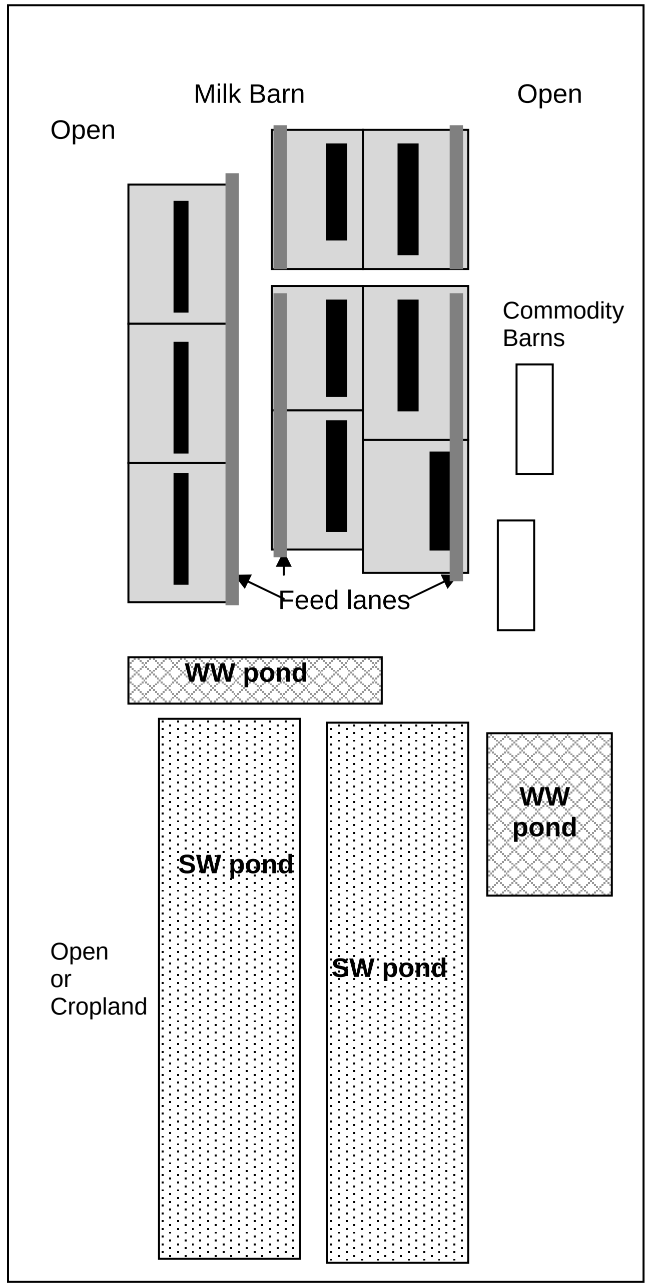


Figure 4-1. Schematic of a typical San Jacinto dairy.

Dairies in the San Jacinto River watershed are regulated by the RWQCB under order R8-2007-0001: *General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities) within the Santa Ana Region.* Among other provisions, that order prohibits the discharge of process wastewater or stormwater runoff from manured areas to property not owned by the facility and requires the adoption and implementation of an acceptable EWMP covering the handling of wastewater and stormwater runoff from the facility. Long-term storage and disposal of manure within the dairy are also prohibited, except that application of manure to cropland associated with the dairy is permitted under an approved NMP. Furthermore, section IV.B. of the dairy discharge permit prohibits the application of manure to CAFO croplands that overlie groundwater management zones lacking assimilative capacity for TDS or NO_3-N even at agronomic rates, beginning in 2012. Because of the TDS and nitrates contained in the facility water supply and wastewater, dairies that overlie groundwater management zones (Figure 4-2) face prohibition of manure or wastewater application to land under this rule unless they take action to offset the effects of such application on the underlying groundwater (see Section 4.2 below).

[2] Unless the facility has been designed and constructed and is operated and maintained to hold all process wastewater, average annual precipitation, and rainfall from a 25-year, 24-hour storm event.

Table 4-1. Selected characteristics of San Jacinto River watershed dairies

Facility	# Milkers	# Dry	# Heifers	# Calves	Total animals	Cropland (ac)[a]	Manure spread (tons)	Manure shipped (tons)	GWMZ[b]
Dairy 1	1,200	200	1,000	250	2,650	0	0	7,390	Menifee
Dairy 2	1,191	217	349	148	1,905	0	0	9,753	SJUP
Dairy 3	1,492	233	1,059	0	2,784	0	0	17,680	LHN
Dairy 4	1,350	250	800	100	2,500	unknown	0	7,820	LHN
Dairy 5	358	59	160	27	604	0	0	2,632	LHN
Dairy 6	1,125	180	0	0	1,305	0	0	15,698	LHN
Dairy 7	62	14	15	19	110	20	0	165	Elsinore
Dairy 8	1,145	181	189	3330	4,845	0	0	16,191	LHN
Dairy 9	2,500	160	20	0	2,680	unknown	unknown		LHN
Dairy 10	1,400	110	600	0	2,110	170	0	3,010	LHN
Dairy 11	820	135	600	200	1,755	0	0	3,182	LHN
Dairy 12	1,820	287	443	0	2,550	62	0	9,200	LHN
Dairy 13	0	0	450	0	450	0	0	675	SJUP
Dairy 14	1,550	270	700	0	2,520	200	0	4,000	LHN
Dairy 15	850	140	505	0	1,495	36	0	13,550	LHN
Dairy 16	1,350	200	481	555	2,586	0	0	11,150	LHN
Dairy 17	1,984	309	308	890	3,491	0	0	8,703	LHN
Dairy 18	823	155	375	369	1,722	unknown	0	7,547	LHN
Dairy 19	705	132	622	0	1,459	0	0	10,550	LHN
Dairy 20	2,350	350	50	0	2,750	0	0	10,333	SJUP
Dairy 21	450	105	95	15	665	unknown	0	3,010	SJUP
Dairy 22	1,050	120	910	450	2,530	840	6,432	0	SJUP
Dairy 23	1,002	161	92	66	1,321	0	0	6,894	
Dairy 24	1,080	200	800	0	2,080	0	0	7,190	LHN
Dairy 25	950	135	425	615	2,125	164	5,455	0	LHN
TOTALs	**28,607**	**4,303**	**11,048**	**7,034**	**50,992**	**1,492**	**11,887**	**176,323**	

Source: Animal numbers and hauling information from facility annual reports to RWQCB

a. From 2007 facility annual reports to RWQCB

b. Groundwater management zone: SJUP = San Jacinto-Upper Pressure; LHN = Lakeview/Hemet North

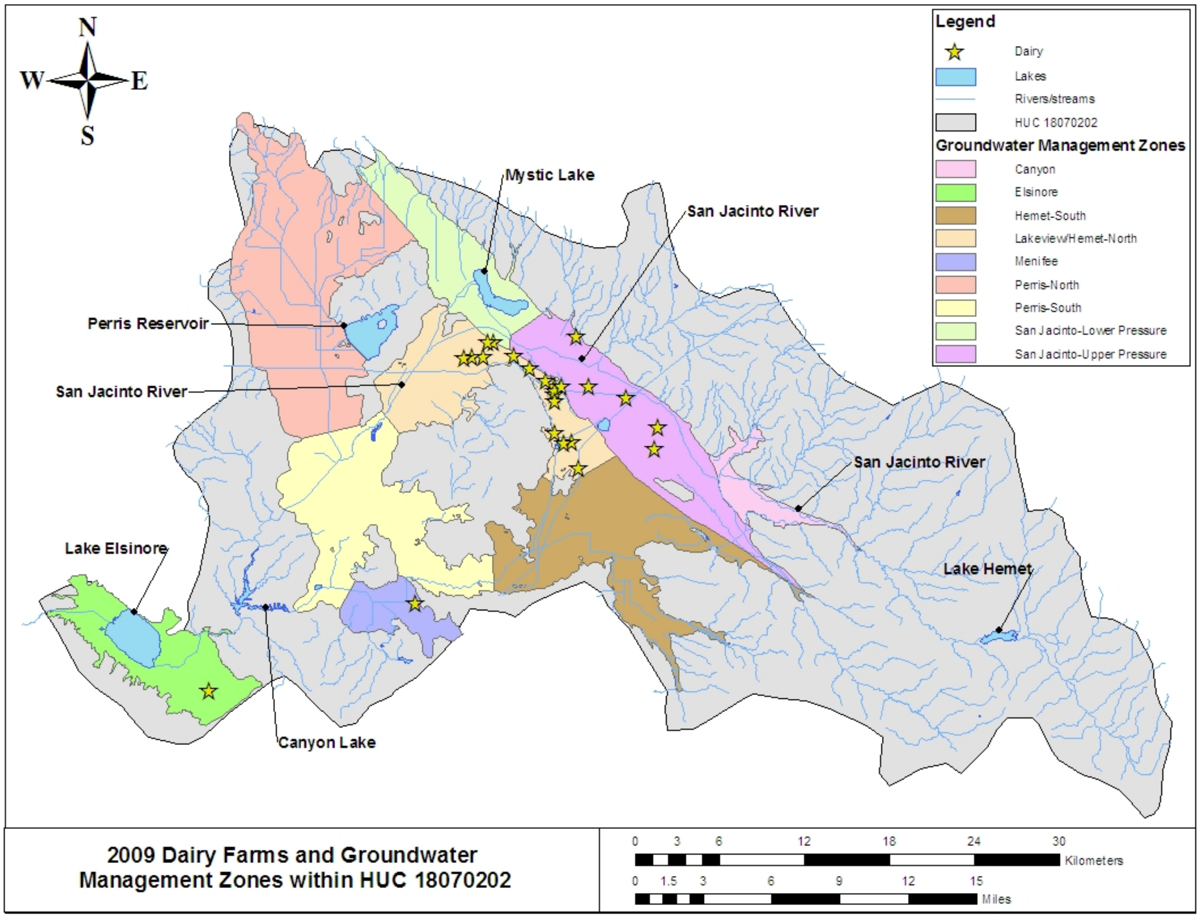


Figure 4-2. Locations of dairies and groundwater management zones in the San Jacinto River watershed.

4.2 Salt Offset Requirements

The RWQCB issued order number R8-2007-0001 (dairy discharge permit) in September 2007. One provision of the order addresses the discharge of salts from dairy operations:

> Disposal of manure to land is prohibited. The application of manure, process wastewater, and/or storm water runoff from manured areas, on cropland outside of the Chino Basin that overlie ground water management zones lacking assimilative capacity for TDS and/or nitrate-nitrogen is also prohibited unless a plan, acceptable to the Executive Officer, is implemented that offsets the effects of that application on the underlying ground water management zone. (Section IV. B.)

A complete analysis of salt offset requirements and a proposed salt offset program was conducted by Wildermuth Environmental, Inc. (2008); that document is in Appendix F.

Before 2004, all the San Jacinto groundwater subbasins in which dairies are located had assimilative capacity for planned salt wasteloads, including those produced by dairy operations. Discharging dairy wastewater and applying corral manure to cultivated croplands was therefore acceptable under the preceding dairy permit (Adopted Order 99-11). In January 2004, however, the

RWQCB amended the Basin Plan to incorporate an updated TDS and nitrate-nitrogen (NO_3-N) management plan (Adopted Order R8-2004-0001). That amendment includes revised groundwater subbasin boundaries (now called *management zones*) and revised TDS and NO_3-N quality objectives for groundwater in those zones. Figure 4-2 shows the groundwater management zones in the San Jacinto region and the updated TDS and NO_3-N water quality objectives that are set forth in the Basin Plan amendment. For a management zone to have assimilative capacity, the ambient TDS or NO_3-N (or both) concentrations must be below the water quality objectives.

The 25 dairies operating in the San Jacinto region as of December 2009 overlie four different management zones: San Jacinto Upper Pressure, Lakeview/Hemet North, Elsinore, and Menifee (Figure 4-2). The TDS and NO_3-N concentrations in all San Jacinto region groundwater management zones, except Canyon, are in excess of the new water quality objectives laid out in the Basin Plan amendment. Table 4-2 summarizes the ambient groundwater quality of each management zone compared to water quality objectives. Because there is no assimilative capacity for TDS or NO_3-N in any of the management zones underlying the San Jacinto dairies, each dairy operation in the San Jacinto region will be required to design a work plan to offset its salt load by September 2012 to continue to apply manure and other dairy process wastes to land in accordance with Order R8-2007-0001. Note that in August 2009, the Eastern Municipal Water District requested that the RWQCB revise the groundwater quality objectives for the San Jacinto Upper Pressure management zone. The proposed objectives are 500 mg/L for TDS and 7.0 mg/L for nitrate. If those proposed objectives are adopted, the San Jacinto Upper Pressure would have assimilative capacity for both nitrate and TDS, which would change the regulatory climate for dairies that overlie that management zone.

Table 4-2. Groundwater quality objectives for TDS and NO_3-N compared to ambient concentrations in San Jacinto River watershed groundwater management zones

Total dissolved solids			
Management zone[a]	TDS objective (mg/L)	TDS ambient (mg/L)[b]	Assimilative capacity?
San Jacinto Upper Pressure	320	350	No
San Jacinto Lower Pressure	520	977	No
Lakeview/Hemet North	520	1313	No
Menifee	1020	1861	No

Nitrate nitrogen			
Management zone	NO_3-N objective (mg/L)	NO_3-N ambient (mg/L)[b]	Assimilative capacity?
San Jacinto Upper Pressure	1.4	1.6	No
San Jacinto Lower Pressure	1.0	3.7	No
Lakeview/Hemet North	1.8	4.3	No
Menifee	2.8	4.8	No

a. Data for the Elsinore management zone are not included in the source documents. Only one of the San Jacinto dairies overlies that management zone.

b. 2008 volume-weighted average for San Jacinto Lower Pressure, Lakeview/Hemet North, and Menifee (EMWD 2008). Data for San Jacinto Upper Pressure are 2006 figures from the salt offset options report (Wildermuth Environmental 2008, Appendix F) as a volume-weighted average was not available for this zone.

4.3 TMDL Requirements

In 1998 the RWQCB included Lake Elsinore and Canyon Lake on its Clean Water Act Section 303(d) list of impaired waterbodies because of excessive levels of nutrients in both lakes, low dissolved oxygen in Lake Elsinore, high bacteria in Canyon Lake, and unknown sources of toxicity in Lake Elsinore. As a result of this listing, the Clean Water Act and California's Nonpoint Source Pollution Control Plan called for TMDLs to be established for the waterbodies. The RWQCB, in cooperation with various stakeholders in the watershed, has developed a nutrient TMDL for Canyon Lake and Lake Elsinore. The RWQCB discontinued development of a bacterial indicator TMDL for Canyon Lake in October 2007.

TMDLs are calculated as the sum of the wasteload allocations (WLAs) for point source discharges, the sum of the load allocations (LA) for nonpoint source discharges, and a margin of safety (MOS) (USEPA 1999). This can be expressed by the equation

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

The *WLA* and *LA* can be for existing sources, future sources or a combination of both.

The *MOS* takes into account the uncertainty or lack of data concerning the relationship between the *WLA*s and *LA*s and resulting water quality. The RWQCB adopted the Lake Elsinore/ Canyon Lake Nutrient TMDL in 2004 (Li 2004).

4.3.1 Description of the Lake Elsinore/Canyon Lake Nutrient TMDL

Both Lake Elsinore and Canyon Lake have long experienced water quality problems associated with high algal productivity because of excessive input of nutrients (phosphorus and nitrogen). Algae respiration and decay deplete dissolved oxygen in the water, adversely affecting aquatic biota, including fish. Numerous fish kills have been reported in both waterbodies. Impaired beneficial uses for both Lake Elsinore and Canyon Lake are warm freshwater aquatic habitat, contact recreation, and noncontact recreation. Furthermore, Canyon Lake serves as a domestic water supply to EVMWD customers and eutrophic conditions in Canyon Lake periodically impair the water treatment process.

The TMDL establishes quantifiable and measurable numeric targets that will ensure attainment of the nutrient-related water quality objectives specified in the Basin Plan and assure protection of all the beneficial uses (USEPA 1999). Because adequate numeric nutrient objectives that were protective of water quality did not exist, a reference state for Lake Elsinore based on historical water quality data was used as the basis for selecting interim and final numeric targets for the TMDL; the same values were used for Canyon Lake because of its proximity to Lake Elsinore. The final target values are shown in Table 4-3. Current concentrations of these indicators significantly exceed the targets in both Lake Elsinore and Canyon Lake (Li 2004).

Scenic view in San Jacinto River watershed

Table 4-3. Final numerical targets and indicators for Lake Elsinore and Canyon Lake Nutrient TMDL

Indicator	Interim target value (2015)	Final target value (2020)	Basis
Total P concentration	Annual average < 0.1 mg/L	Annual average $\leq$ 0.05 mg/L	25th percentile of Lake Elsinore monitoring data (2000-2001, considered as lake reference state)
Total N concentration	Annual average $\leq$ 1.0 mg/L	Annual average $\leq$ 0.5 mg/L	A ratio of total N to total P of 10 is used to maintain nutrient balance
Chlorophyll *a* concentration	Summer average (Lake Elsinore) or annual average (Canyon Lake) $\leq$ 40 µg/L	Summer average (Lake Elsinore) or annual average (Canyon Lake) $\leq$ 25 µg/L	Water quality objective in the Basin Plan
Dissolved oxygen concentration	Depth average > 5 mg/L	$\geq$ 5 mg/L 1 meter above lake bottom and $\geq$ 2 mg/L from 1 meter to lake sediment	Water quality objective in the Basin Plan

Source: Li 2004

To determine the reductions needed to achieve the proposed nutrient numeric targets and to allocate allowable nutrient inputs among sources, it was necessary to characterize all nutrient sources in the San Jacinto River watershed, both external and internal. That characterization included identifying the various types of sources (e.g., point, nonpoint, background, atmospheric), the relative location and magnitude of loads from the sources, the transport mechanisms of concern (e.g., runoff, infiltration), and the timescale of loading to the waterbody (i.e., duration and frequency of nutrient discharge to receiving waters) (USEPA 1999). All these factors were evaluated as part of the Lake Elsinore/Canyon Lake Nutrient TMDL source assessment.

Lake Elsinore and Canyon Lake receive runoff from the San Jacinto River, Salt Creek and local drainage areas surrounding the lakes. Land use in the watershed is predominantly shrubland and forest in the headwaters area and agriculture and urban in the middle and terminal areas of the watershed. Areas surrounding both lakes are highly developed.

The unique hydrology of the San Jacinto River largely controls the magnitude and distribution of nutrient loading from external sources. All the streams in the San Jacinto River watershed are ephemeral. External sources contribute nutrients to the lakes via storm flows during the wet season (October through April). However, under normal dry periods, the mainstem of the San Jacinto River is dry, contributing little or no flow to Canyon Lake, and pollutants from the watershed do not reach the lakes. Instead, pollutants accumulate on the land surface and are later washed off during storm events. During wet periods or large storms, Lake Hemet overflows and runoff collecting in the valley flows rapidly to Mystic Lake, which forms only when water from the upper San Jacinto River is conveyed to it in large storms. When full, Mystic Lake can maintain a substantial volume for longer than a year with little or no transport of water or pollutants back to the San Jacinto River. Because of the significant loss from evaporation, infiltration, and groundwater recharge, much of the volume stored in Mystic Lake is lost from the San Jacinto River system. During torrential rainfall events or periods of extended rain (approximately every 8 years), however, the storage capacity of Mystic Lake can be exceeded, resulting in overflow back to the San Jacinto River. Under such circumstances, pollutants from the San Jacinto River watershed can be delivered to Canyon Lake. Furthermore, when the significant rain events occur, flooding frequently occurs in the basin, causing dairies to be inundated, and resulting in nutrient-rich manure and dairy wash water being transported to the lakes.

The Gap Area is a rural area approximately 4.4 miles long within the 100-year floodplain of the San Jacinto River composed mostly of dairy farming to the south and southeast and Mystic Lake and the San Jacinto Wildlife Area to the north and northwest. A channel/levee system constructed in the early 20th century diverted flood flows away from the Mystic Lake depression and toward the better-defined river channel below the Ramona Expressway (Tetra Tech 2007). The diversion channel is typically shown as the San Jacinto River on most maps today. Typically, in wetter storm seasons, the river breaks through the levees of the diversion channel and begins to fill Mystic Lake and, in extreme years, the rest of the floodplain. However, management of ephemeral flows in the river during moderate years has become problematic, and the channel is plagued by sediment buildup and vegetative growth. Consequently, smaller flow events have caused failure of the diversion channel levees, and damage to the agricultural properties has become more frequent.

San Jacinto Wildlife Area

Potential point source and nonpoint sources of nutrients to Canyon Lake and Lake Elsinore identified in the TMDL are (Li 2004):

Point Sources

- Urban stormwater runoff
- CAFOs
- Tertiary treated wastewater and well water
    - EVMWD Regional Water Reclamation Facility
    - EMWD Regional Water Reclamation System
- Stormwater runoff associated with new development in the San Jacinto River watershed

Nonpoint Sources

- Agricultural land runoff
- Forest/shrub-land/open space
- Atmospheric deposition
- Internal nutrient source from lake sediment
- Septic systems
- Other livestock

In addition to those sources, internal loading of nutrients accumulated in lake sediments from years of excessive nutrient loading has been identified as a significant source of both P and N to Lake Elsinore and Canyon Lake (Anderson 2001; Anderson and Oza 2003).

Annual nutrient loads to Lake Elsinore and Canyon Lake were estimated under three hydrologic conditions—wet, moderate, and dry—on the basis of a complex analysis of internal loading, lake nutrient budgets, and watershed modeling (Li 2004). The weighted averages of P and N loads under all hydrologic conditions are shown in Table 4-4.

Table 4-4. Distribution of total nitrogen and phosphorus loads to Canyon Lake (CL) and Lake Elsinore (LE), weighted average of three hydrologic scenarios

Nutrient sources	Total nitrogen				Total phosphorus			
	Into CL	From CL to LE	Local LE	Into LE	Into CL	From CL to LE	Local LE	Into LE
Agriculture	11,057	9,364	371	9,735	4,413	3,670	60	3,730
Urban	5,974	4,619	606	5,225	1,142	736	124	861
CAFO	2,783	2,558	0	2,558	494	467	0	468
Open/Forest	3,586	3,233	567	3,800	2,144	1,978	178	2,157
Septics	7,071	5,773	1,058	6,831	518	441	69	511
Subtotal of LSPC simulated loads	30,291	25,547	2,602	28,150	8,712	7,294	431	7,725
EFDC simulated export from CL				48,935				9,047
Atmospheric Deposition	1,918			11,702	221			108
Supplemental Water	248			59,532	NA			14,883
Subtotal of external sources	32,457			148,319	8,933	7,294	431	31,763
Internal CL loading	13,549			NA	4,625			NA
Internal LE loading	NA			197,370	NA			33,160
Total	**46,006**			**345,689**	**13,558**			**64,923**

Source: Li 2004
All numbers are in kg/yr.

Proportions of nutrient loads to Canyon Lake and Lake Elsinore from dairies for all three scenarios are shown in Table 4-5. For very wet conditions when Mystic Lake is full and overflowing (represented by water year [WY] 1998), this modeling approach predicts that dairy and livestock land uses are significant contributors of nutrients in the lower regions of the San Jacinto River watershed[3]. The percentages reported in Table 4-5 for dairies are high relative to the proportion of land used by dairies, particularly when compared to the large areas associated with croplands and urban/residential land uses.

[3] This prediction may be incorrect as, in accordance with the dairy discharge permit, discharges from dairies occur only during a 25-year, 24-hour or larger storm event. Underlying model assumptions supporting this prediction may be revised in the model update, which is underway at the time of this report.

Table 4-5. Percent of nutrient loads to Canyon Lake and Lake Elsinore from dairies

Nutrient	Total nitrogen			Total phosphorus		
Scenario	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)	1 (WY 1998)	2 (WY 1994)	3 (WY 2000)
Canyon Lake	11.0%	5.7%	4.7%	6.7%	2.0%	1.8%
Lake Elsinore	3.3%	3.3%	2.7%	2.8%	1.4%	1.6%

Source: Tetra Tech 2004a

Scenario 1: wet year, both Mystic Lake and Canyon Lake overflowed
Scenario 2: moderate year, Canyon Lake overflowed, but Mystic Lake did not overflow
Scenario 3: dry year, neither Canyon Lake nor Mystic Lake overflowed

Allowable external (i.e., from point and nonpoint sources in the drainage basins) nutrient loads for Lake Elsinore and Canyon Lake were developed using mass balance lake models (Anderson 2002a) and on the basis of several assumptions concerning the feasibility of reducing internal nutrient loading in the lakes. For example, a 35 to 70 percent reduction in internal P loading in Lake Elsinore was assumed (Anderson 2002b), while reduction in internal P loading was determined to be impractical in Canyon Lake (Li 2004). Allowable external nutrient loads were calculated for wet, moderate, and dry hydrologic scenarios; weighted average external P and N loads required to meet final in-lake targets are summarized in Table 4-6.

Table 4-6. Nutrient TMDL to achieve the final targets for phosphorus and nitrogen for Canyon Lake and Lake Elsinore[a]

	Phosphorus (kg/yr)		Nitrogen (kg/yr)	
	Lake Elsinore	Canyon Lake	Lake Elsinore	Canyon Lake
Internal loading	9,948[b]	4,625	197,370	13,549
External loading				
CL watershed	1,385	2,064	13,850	16,123
LE watershed	1,103	0	20,302	0
Total TMDL	**12,436**	**6,689**	**231,522**	**29,672**

Source: Li 2004

a. Final targets of phosphorus (0.05 mg/L) and nitrogen (0.5 mg/L) are to be met as soon as possible, but no later than 2020.

b. Assumes 70% reduction in internal P load

WLAs for point source discharges and LAs for nonpoint sources were developed using modeling results and lake sediment studies. The reductions from all San Jacinto River watershed sources required to meet the proposed TMDLs were then determined (Table 4-7).

Federal regulations require the state to identify measures needed to implement TMDLs in the state water quality management plan, and California law requires that Basin Plans have a program of implementation to achieve water quality objectives. An implementation program must include a description of actions necessary to achieve the objectives, a time schedule for those actions, and a description of monitoring to determine compliance with the objectives.

Table 4-7. Proposed final TMDL, WLAs and LAs for Lake Elsinore and Canyon Lake

Lake Elsinore[a]	P load allocation (kg/yr)	Existing TP load (kg/yr)	Reduction (%)	N load allocation (kg/yr)	Existing TN load (kg/yr)	Reduction (%)
TMDL	**12,436**	**48,582**	**74%**	**231,522**	**271,206**	**15%**
WLA	816	15,007		7,712	60,138	
Supplemental water[b]	744	14,883	95%	7,442	59,532	87%
Urban	72	124	42%	270	606	55%
CAFO	0	0		0	0	
LA	10,235	33,575		209,960	211,068	
Internal sediment	9,948	33,160	70%	197,370	197,370	0%
Atmospheric deposition	108	108	0%	11,702	11,702	0%
Agriculture	35	60	42%	165	371	56%
Open/Forest	104	178	42%	252	567	56%
Septics	40	69	42%	471	1,058	55%
Canyon L. watershed	1,385		100%	13,850		
MOS	0			0		

Canyon Lake	P load allocation (kg/yr)	Existing TP load (kg/yr)	Reduction (%)	N load allocation (kg/yr)	Existing TN load (kg/yr)	Reduction (%)
TMDL	**6,689**	**13,558**	**51**	**29,672**	**46,006**	**36**
WLA	346	1,637		4,199	8,824	
Supplemental water[b]	0	0		248	248	0
Urban	242	1,142	79	2,670	5,794	54
CAFO	105	494	79	1,282	2,763	54
LA	6,343	11,922		25,473	37,181	
Internal sediment	4,625	4,625	0	13,549	13,549	0
Atmospheric deposition	221	221	0	1,918	1,918	0
Agriculture	934	4,414	79	5,095	11,057	54
Open/Forest	465	2,144	79	1,652	3,586	54
Septics	109	518	79	3,258	7,071	
MOS	0			0		

Source: Li 2004

LAs and WLAs are to be achieved as soon as possible, but no later than 2020.

a. The TMDL allocations for Lake Elsinore for the land use sources (urban, CAFOs, septic systems, agriculture, and open/forest) apply only to those land uses downstream from Canyon Lake.

b. The WLA for supplemental water to Lake Elsinore only considered the recycled water; the WLA for supplemental water to Canyon Lake was calculated on the basis of the recent addition of Colorado River water to Canyon Lake.

The implementation plan for the Lake Elsinore and Canyon Lake TMDL is presented in detail in the full TMDL document (Li 2004). Major elements relevant to dairies and the agricultural operations that receive manure from dairies include the following:

- The RWQCB shall review and revise, as necessary, existing National Pollutant Discharge Elimination System permits to incorporate the appropriate WLAs, compliance schedules and monitoring program requirements, including General Waste Discharge Requirements for Concentrated Animal Feeding Operations (Dairies and Related Facilities)
- The RWQCB shall review/revise water quality objectives in the Basin Plan to establish site-specific nutrient criteria for Lake Elsinore and Canyon Lake
- Agricultural operators shall develop and implement an NMP
- Agricultural operators, CAFO operators, the Riverside County Flood Control and Water Conservation District and co-permittees, Caltrans, U.S. Air Force, March Reserve Base, March Joint Powers Authority, the Riverside County Health Department, and the U.S. Forest Service shall develop and implement a plan to address the in-lake nutrient loads in Lake Elsinore and shall evaluate in-lake treatment options to control internal nutrient loading in Canyon Lake.

The RWQCB has proposed that the interim targets for both Canyon Lake and Lake Elsinore and the allocations specified be met as soon as possible but no later than 2015 and that the final targets and allocations be met no later than 2020.

Several monitoring programs are proposed to evaluate the effectiveness of actions and programs implemented pursuant to the TMDL (Li 2004):

1. **Watershed-wide Nutrient Water Quality Monitoring Program.** Continuation of a watershed-wide nutrient monitoring program initiated in 2000 by the RWQCB and watershed stakeholders is essential to track the effectiveness of the TMDL implementation plan and source load reductions. The monitoring program consists of collecting stream flow and water quality data in the San Jacinto River watershed, with a focus on collecting nutrient data from specific nutrient sources (e.g., septic systems, open space/forest lands, urban runoff, and CAFOs). The data generated will also be used calibrate the model that Tetra Tech, Inc., developed for the watershed.[4]
2. **Canyon Lake and Lake Elsinore In-lake Monitoring Programs.** Continuation of the 2000 Canyon Lake and Lake Elsinore in-lake monitoring program is needed to assess the response of the lakes to nutrient loadings and to determine if the load reductions result in achieving numeric targets.
3. **Pollutant Source Monitoring.** Monitoring of pollutant sources is needed to ensure that required reductions are being achieved to meet the WLAs, LAs, and TMDL and to refine allocations, as appropriate. Specific monitoring program requirements for the following sources are proposed in the Basin Plan amendment:
    - CAFOs
    - Urban discharges
    - Supplemental water discharges to Lake Elsinore and Canyon Lake

[4] At the time of this report revisions to the TMDL model were underway including incorporation of new data collected since the initial modeling was completed.

- Agricultural discharges—inventory crops grown in the watershed, document the amount of manure and fertilizer applied to each crop and the amount of nutrients released from cropland, and evaluate site-specific BMPs
- Septic system discharges—study the effect of septic systems on Canyon Lake and Lake Elsinore nutrient water quality; track implementation of the septic system LA

4. **Special Studies.** Special nutrient-related studies in the watershed, including evaluating in-lake treatment of sediment to remove nutrients, updating/developing nutrient models, and monitoring to determine the relationship between ammonia toxicity and total nitrogen allocation to ensure that the total nitrogen TMDL allocation will protect the lakes from ammonia toxicity.

4.3.2 TMDL Requirements Affecting the San Jacinto River Watershed

Lake Elsinore and Canyon Lake are at the terminus of the San Jacinto River watershed. Thus, most of the requirements of the Lake Elsinore and Canyon Lake Nutrient TMDL apply directly to many activities in the San Jacinto River watershed.

As detailed in the TMDL analysis and other studies (Tetra Tech 2003; Li 2004) sources of nutrients in the San Jacinto River watershed vary by land use (Table 4-8). Clearly, agricultural runoff, urban stormwater, and septic systems in the San Jacinto River watershed are important sources of nutrients to Canyon Lake. Contributions from CAFOs can also be significant, especially under wet conditions. These sources will likely be the principal focus of load-reduction efforts under the TMDL. Note that when the initial model assessment was conducted, the modeled loads were based on the 38 dairies that were in operation at that time. As of December 2009, 25 dairies are operational and a continued decline is expected.

Table 4-8. Proportion of contributions of different sources to phosphorus and nitrogen loads to Lake Elsinore and Canyon Lake from the San Jacinto River watershed[a]

Source	Lake Elsinore		Canyon Lake	
	P	N	P	N
Urban	< 1–3%	2–3%	6–12%	10–15%
CAFO	< 1–2%	0–2%	<1–6%	2–10%
Agriculture	< 1–16%	2–8%	14–45%	15–32%
Septic	< 1–2%	1–6%	1–6%	4–22%
Open/forest	< 1–10%	<1–3%	3–25%	3–12%

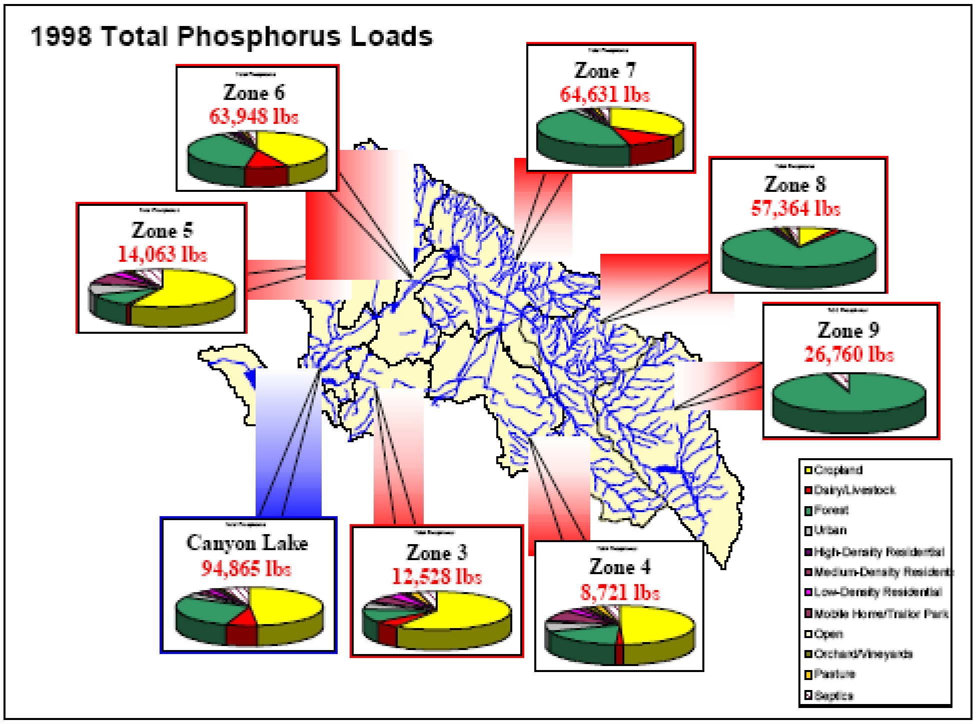
Source: Li 2004

a. Range from dry to wet conditions. Lake internal loading and loading passed from one lake to another is not included.

Nutrient sources also vary spatially within the San Jacinto River watershed. Figure 4-3 gives an example of simulated phosphorus loads from different regions of the San Jacinto River watershed under wet conditions (Tetra Tech 2003).

The distribution of nutrient loads (and load reductions required by the TMDL) across land uses and geographic regions of the San Jacinto River watershed directly influences where implementation measures need to be taken in the watershed.

Nutrient load reductions required by the TMDL from different sources in the San Jacinto River watershed are summarized in Table 4-9. Clearly, substantial P and N load reductions will be necessary in the San Jacinto River watershed. In the area draining to Canyon Lake, half of the P load reductions will need to come from agricultural land, and another 6 percent coming from CAFOs.



Source: Tetra Tech 2003

Figure 4-3. Simulated total phosphorus load in 1998 (Scenario I: wet year).

Table 4-9. Nutrient load reductions from sources in the San Jacinto River watershed required by the TMDL

Source	Lake Elsinore		Canyon Lake	
	P	N	P	N
Urban	52 (42%)	336 (55%)	900 (79%)	3,124 (54%)
CAFO	0	0	389 (79%)	1,501 (54%)
Agriculture	25 (42%)	206 (56%)	3,480 (79%)	5,962 (54%)
Septic	29 (42%)	587 (55%)	409 (79%)	3,813 (54%)
Open/forest	74 (42%)	315 (56%)	1,691 (79%)	1,934 (54%)
Total	**180**	**1,444**	**6,869**	**16,331**

Source: Li, 2004

Numbers represent kg/yr (%) reductions from present-day loads required to achieve final target phosphorus and nitrogen concentrations in Lake Elsinore and Canyon Lake by 2020

To support the TMDL and the required nutrient load reductions from watershed sources, Tetra Tech (2004a), with assistance from local stakeholders, prepared a Nutrient Management Plan for the San Jacinto River watershed. The purpose of the plan was to provide guidance for a nutrient management strategy in the watershed, including recommending projects to reduce nutrient contributions and improve water quality in the watershed, i.e., a road map for implementing portions of the TMDL.

In addition to 4 projects addressing in-lake treatments in Lake Elsinore and Canyon Lake, the Nutrient Management Plan recommends 15 projects to address a wide range of issues in the watershed specific to nutrient loading characteristics in the lakes and various sources in the watershed:


TMDL monitoring site visit

- Continued Lake Elsinore Water Quality Monitoring
- Developing a Dynamic Water Quality Model of Lake Elsinore
- Continued Canyon Lake Water Quality Monitoring
- Developing a Dynamic Water Quality Model of Canyon Lake
- Implementing Structural Urban BMPs
- Making Sewer and Septic Improvements
- Controlling Trash in Stream Channels
- Intercepting and Treating Nuisance Urban Runoff
- Restoring Riparian Habitat and Developing Agricultural Buffers
- Determining Crop-Specific Agronomic Rates for Guidance in Fertilizer and Manure Application Management
- Assessing Nutrient Loads to the San Jacinto River watershed as a Result of Flooding in Agricultural Areas
- Implementing a Regional Organic Waste Digester
- Developing a Pollutant Trading Model
- Data Collection for Mystic Lake to Support Development of Future Projects
- Continued Monitoring of Streamflow and Water Quality throughout the watershed

Detailed discussion and comprehensive information concerning each project proposed for nutrient management in the San Jacinto River watershed is provided in the *San Jacinto Nutrient Management Plan* report (Tetra Tech 2004b).

4.3.3 Bacteria Impairments

Canyon Lake is also included on California's 303(d) list of impaired waters because of high indicator bacteria counts. Although a proposed bacteria TMDL has been discontinued, it is still useful to consider the results of several studies of bacteria sources in the San Jacinto River watershed undertaken for TMDL development.

Contributions of bacteria to the San Jacinto River watershed and Canyon Lake are dominated by nonpoint sources and can be categorized as wet- or dry-weather inputs. Modeling studies, supplemented by bacteria monitoring in the San Jacinto River watershed (Tetra Tech 2004a; Tetra Tech 2005), provide estimates of annual wet-weather loads of fecal coliform, total coliform, and *E. coli* to Canyon Lake resulting from wet-weather runoff under dry-, moderate-, and wet-hydrologic conditions (Table 4-10).

Table 4-10. Estimated annual loads of indicator bacteria to Canyon Lake

Indicator bacteria	Bacteria load (MPN/yr)		
	Dry (WY 2000)	Moderate (WY 1994)	Wet (WY 1998)
Total coliform	1.80×10^{15}	1.44×10^{15}	5.54×10^{15}
Fecal coliform	3.06×10^{14}	2.71×10^{14}	8.85×10^{14}
E. coli	3.06×10^{14}	2.71×10^{14}	8.85×10^{14}

Source: Tetra Tech 2004a; Tetra Tech 2005

During wet weather, wash-off of bacteria from various land uses is considered a major source of bacteria because of the high bacteria counts observed at the watershed outlet or upstream during wet conditions. After bacteria buildup on the land surface as the result of various land use sources and associated management practices (e.g., management of livestock in agricultural areas, pet waste in residential areas), many of the bacteria are washed off the surface during rainfall events. There is also evidence that septic system failures from developed areas near Canyon Lake contribute a significant proportion of the bacteria load to the lake. The amount of runoff and associated bacteria concentrations are therefore highly dependent on land use.

The tributaries to Canyon Lake are essentially dry during normal dry periods, with the only flow contributions to the lake resulting from various urban land use practices that cause water to enter storm drains and creeks. Such practices include lawn irrigation runoff, car washing, sidewalk washing, and the like, that create flows traveling across lawns and urban surfaces, carrying bacteria to the receiving waterbody. That type of runoff is a predominant component of dry-weather flows throughout the year in Southern California (McPherson et al. 2002). During dry weather, external watershed sources of bacteria to Canyon Lake primarily result from urban runoff (Anderson et al. 2002). Anderson et al. (2002) also determined that bacteria growth within the lake's water column, resuspension of sediments, and direct contributions by waterfowl, were significant sources of bacteria to Canyon Lake during dry periods.

4.4 Manure Issues in the San Jacinto River Watershed

Manure from dairies is an important commodity in the San Jacinto River watershed. Dairy manure is not only a source of nutrients, bacteria, and other pollutants, but also represents an important resource for soil fertility and crop production, especially considering current economic constraints on fertilizer use. According to a 2004 survey of watershed dairies (Tetra Tech 2006), dairy operators reported on their manifests in 2004 moving a total of 229,346 tons of manure. Some 28,993 tons of manure were estimated to be stored in lagoons in wet form, yielding a total of 258,339 tons per year in the watershed. Of that total, about 95 percent was believed to be used within the San Jacinto River watershed, with only about 7,000 tons shipped out of the basin (Figure 4-4). Recent analysis of 2008 facility annual reports to the RWQCB from San Jacinto dairies (see Table 4-1) showed an estimated 198,774 tons of manure generated by 26 dairies, a 23 percent reduction since 2004. Of that total, less than 5 percent was applied to cropland associated with San Jacinto dairies; about 95 percent was shipped off the dairies and less than 5 percent of raw manure, 9,118 tons, was hauled to various locations outside of the watershed. Approximately 6 percent was transferred to a composting facility in the San Jacinto River watershed. The remainder, 165,879 tons, was spread on land within the San Jacinto River watershed.

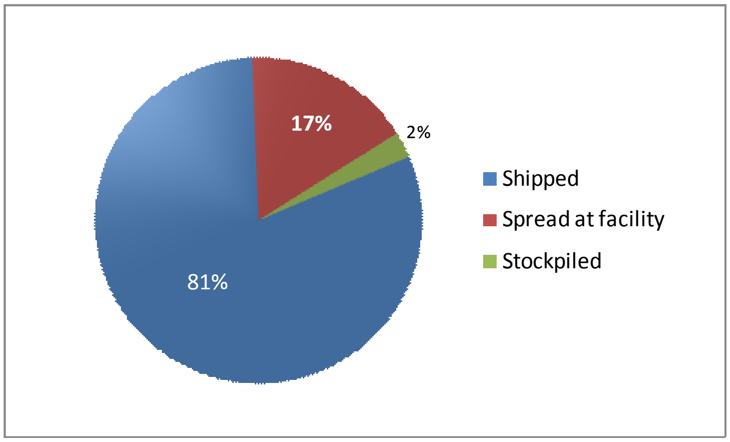


Figure 4-4. Reported disposition of the 228,347 tons of manure generated on San Jacinto dairies in 2000.

Manure is substantially regulated in the San Jacinto River watershed. All dairies in the watershed are covered under the dairy discharge permit that includes requirements based on applicable federal and state regulations, the Basin Plan, and the Lake Elsinore and Canyon Lake Nutrient TMDLs (Santa Ana RWQCB 2007). Several of the requirements pertain to managing manure associated with dairies, including the following:

- Manure removed from corrals must be removed from the facility within 180 days.
- Disposal of manure to land is prohibited.
- Land application of manure and process wastewater in areas that overlie groundwater management zones lacking assimilative capacity for TDS or nitrate will be prohibited as of 2012, unless a plan is implemented to offset the effect of land application on the groundwater management zone.
- Dairies that apply manure or process wastewater to their own croplands must develop an NMP, in accordance with federal regulations and NRCS Conservation Practice Standards.
- With regard to manure transfers
    - Dairies must provide the manure recipients with information on the nutrient content of the transferred manure or wastewater.
    - Dairies must complete a Manure Tracking Manifest Form for each manure hauling event.

The transportation and application of manure in the San Jacinto River watershed is also regulated under Riverside County Ordinance 427.2 (Riverside County Board of Supervisors N.d.), which requires that all farm and agricultural operations or landowners who wish to apply bulk manure register with the county agricultural commissioner. Registrants are required to report manure application, agreeing to a set of conditions described in the ordinance, to minimize effects on neighboring properties, local waterways, underground water supplies, and soil resources. The ordinance includes the following prohibitions:

- No manure transporter shall deliver manure to a site for the purposes of disposal, land application or storage within the unincorporated portions of the area generally subject to regulation by the Santa Ana and San Diego Regional Water Quality Control Boards…unless the landowner of the site has a current and valid exemption as issued by the county commissioner.

- No manure transporter shall deliver manure to a site within the regulated area without having in the possession of the driver each of the following: (1) a copy of a valid exemption for the site issued by the county commissioner, (2) the written permission from the landowner if not a part of the exemption, and (3) a copy of the delivery contract between the transporter and the landowner or occupant.
- No landowner shall accept manure or knowingly allow manure to be deposited on land owned or controlled by him or her in areas prohibited by this ordinance.
- No manure transporter, manure applier, or landowner, including tenant or occupant, shall transport, apply, or allow the application of manure in a manner that could violate any conditions established through an exemption, the standards established by the ordinance, or other laws or regulations.

Operating farms registered with the county agricultural commissioner that have received approval to apply manure are exempted from the prohibitions if they meet the following conditions:

- The site has a minimum of 5 acres of tillable soil or as otherwise accepted by the county commissioner.
- There is a distance no less than one-quarter mile from all public schools in session during the time in which manure is to be applied and incorporated.
- The manure application is conducted by or for the operating farm, at agronomic rates, using only quality manure, at application rates approved by the county commissioner.
- Crops are planted after manure application in a time frame approved by the county commissioner.

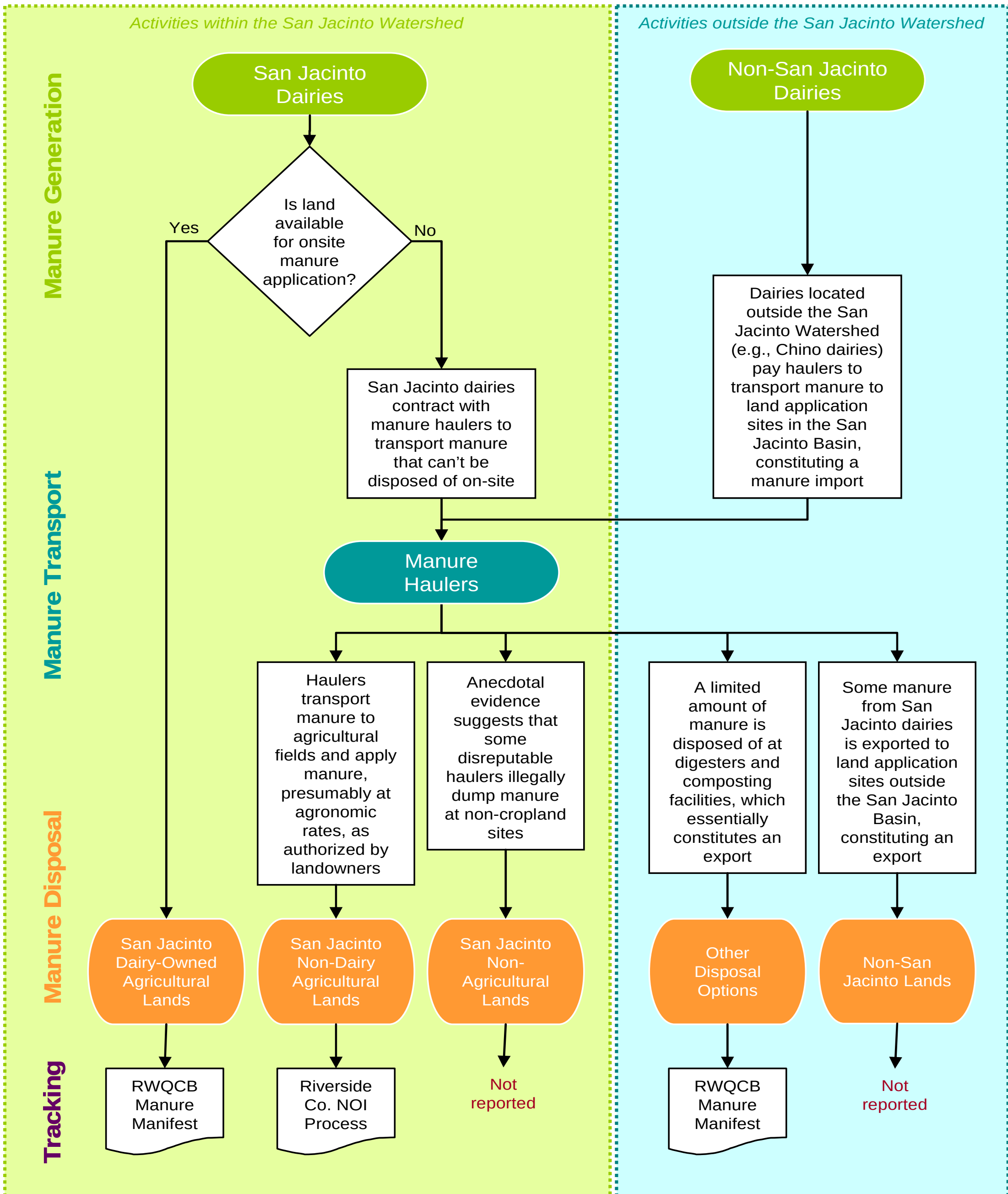
There is no reason to believe that dairy operators in the San Jacinto River watershed are violating these regulations. However, according to two memoranda from WRCAC (Sybrandy 2005) and the Riverside County Farm Bureau (Scott 2006), not all local jurisdictions are complying with the ordinance, notably the city of Perris, resulting in untracked manure dumping at a variety of sites.

Unfortunately, in addition to the challenges posed by the requirements for managing its own manure, the San Jacinto River watershed also receives manure from outside its borders. Dairies in the Chino Basin, for example, are exporting manure, and haulers are applying it at San Jacinto sites. An analysis of 2007 reports from Chino dairies to the RWQCB indicates that in that year, approximately 140,000 tons of manure were shipped from 36 Chino dairies into the San Jacinto River watershed.

Improperly stockpiled manure in the San Jacinto River watershed

Illegal or improper dumping is another issue. When producers from within or outside the San Jacinto basin contract with haulers, a mechanism of accountability for the final destination of the manure is lacking. Many hauling events result in authorized land application on San Jacinto cropland, but anecdotal evidence suggests that some haulers are illegally dumping manure on unauthorized sites, posing a nuisance, increasing the risk of surface and groundwater pollution, and violating conditions of the Riverside County Ordinance and NPDES permit.

The broad outline of the process of interactions among parties in dealing with manure transport, use, and disposal in and around the San Jacinto River watershed is diagramed in Figure 4-5. At present, gaps in specific knowledge of the magnitude of some of the pathways (e.g., manure imported from outside the watershed, manure shipped out of the watershed) impair the optimal management of dairy manure in the watershed. Because the San Jacinto River watershed has limited assimilative capacity for nutrients and salts, additional manure from outside the basin limits options for San Jacinto dairies to dispose of their manure. A manure manifesting system for the San Jacinto River watershed has been proposed to help address this issue (see Section 5.3).



Source: Tetra Tech 2008

Figure 4-5. Schematic of interactions among parties dealing with manure generation, transport, and use/disposal in the San Jacinto River watershed.

4.5 Current San Jacinto River Watershed Dairy Issues

San Jacinto dairies face a number of pressing issues deriving from the requirements and concerns discussed above. Paramount among the issues are the need to comply with discharge permits, reduce nutrient loading under the terms of the Lake Elsinore and Canyon Lake Nutrient TMDL, and take steps to offset salt loads from dairies to groundwater. Those are the issues to be addressed by the IRDMP.

4.5.1 Wastewater and Manure Quantity and Quality

Dairies produce large quantities of wastewater and manure that represent significant pollution potential and must be managed accordingly. Many management issues are addressed directly by a facility EWMP and other terms of the dairy discharge permit. However, also under the terms of their permit, dairies are required to implement a plan to offset salts or cease discharge of process wastewater and land application of manure by 2012. In particular, because of the lack of assimilative capacity in the groundwater management zones that underlie portions of the watershed, many San Jacinto dairies will be required to take steps to offset their salt loads or cease application of wastewater and manure.

Some of the requirements could be addressed by dealing with the quantity and quality of process wastewater and manure at the individual dairy level. Options could include managing flushing frequency at dairies that flush their feed alleys with water; managing sources, volumes, and salinity of water used in dairy operations; and treating wastewater and manure to reduce salt loads and nutrient content.

> There is a need for specific strategies and practices applicable to reduce the quantity, improve the quality, or both, of process wastewater, stormwater, and manure generated on individual dairies.

4.5.2 Wastewater and Manure Storage, Treatment, and Disposition

Process water and manured stormwater generated on a dairy must be contained on the facility unless the facility has been designed to hold all process wastewater, average annual precipitation, and rainfall from a 25-year, 24-hour storm event.. Manure, on the other hand, cannot accumulate on a facility but must be stockpiled safely for a limited time, then land applied or shipped off the facility. The design, capacity, and integrity of storage lagoons, ponds, and manure stockpiles are defined and assured by the EWMP and the facility permit. Management systems for wastewater and manure vary among facilities; processes such as solids separation can simplify storage and disposition of wastewater and manure nutrients. At the watershed scale, transfers of manure from dairies within the San Jacinto River watershed, illegal dumping of manure, and manure imports from outside the watershed pose a threat to effective management of manure nutrients in the watershed. A manure manifesting system will help prevent illegal and unwanted manure disposal and manage the appropriate disposition of manure within the watershed. Furthermore, to meet the goals of the TMDL, it might be necessary to either limit the import of manure nutrients into the San Jacinto River watershed or take steps to ship more manure out of the watershed, or both.

> There is a need for specific strategies and practices at the watershed scale to manage the transfer and disposition into, within, and out of the watershed to better manage the balance of manure nutrients in the watershed.

4.5.3 Relationships Between Dairies and Cropland

An obvious linkage exists between San Jacinto dairies that produce the manure nutrients and cropland in the watershed and those that currently do or could use the manure nutrients for crop production. Dairies that apply manure or process wastewater to their own croplands must develop an NMP, in accordance with government regulations and NRCS standards. As noted earlier, however, a minority of San Jacinto dairies have cropland on which facility manure is applied; by far, the majority of manure generated on watershed dairies is applied off the facility. Approximately 26,451 acres of active cropland are in the San Jacinto River watershed in 2009. When the TMDL modeling was conducted some 60,000 acres of cropland in the watershed were estimated to provide up to 34 percent of the nitrogen load and up to 54 percent of the phosphorus load to Canyon Lake (Tetra Tech 2004b). WRCAC has generated more recent data showing that of approximately 64,000 acres of land in the watershed that is zoned "agricultural", only about 38,000 acres actually support agricultural land uses[5]; WRCAC has confirmed that the remaining acres have not been used for agricultural activities for at least 5 years. About 52 percent of San Jacinto cropland overlies critical groundwater management zones and might therefore be limited in capacity to accept dairy manure (see Section 5.4.2.5). BMPs to control nutrients and other pollutants from cropland in the San Jacinto River watershed have been discussed and recommended elsewhere (Tetra Tech 2008). An essential element of dairy manure management in the watershed is to promote the adoption and continued use of NMPs on croplands that receive manure. This could be partially accomplished through the manure manifest system, although other steps might be necessary. In the long run, there might be a need to foster a balance between manure nutrients generated in the San Jacinto River watershed and manure nutrients that can be effectively used by crops in the watershed (see Section 5.4.2.5). In the long run, it might be necessary to consider systematic export of manure to cropland outside the San Jacinto River watershed.

> There is a need to strengthen the relationship between manure generated on San Jacinto dairies and cropland both within and outside the watershed so that manure nutrients are used according to good nutrient management practices and a balance is achieved between nutrients imported to and exported from the San Jacinto River watershed.

4.5.4 Other Issues

4.5.4.1 Groundwater

Groundwater quantity and quality are both issues for San Jacinto dairies. As noted earlier, the majority of San Jacinto dairies obtain their water from local groundwater. Local groundwater is not only limited in quantity and increasingly expensive to extract, but also limited in assimilative capacity for salts from dairy wastewater and manure. A supply of recycled water and a salt offset program including potential wastewater treatment are options to address such issues.

> Issues of groundwater quantity and quality are a concern for San Jacinto dairies, particularly with regard to offset of salt loading from dairy operations. Options for dairy waste management must be considered within the constraints of air quality protection, cost-effectiveness, and the long-term sustainability of dairying in the San Jacinto River watershed.

[5] More than 7,000 acres of this total are classified as "unknown use/undeliverable."

4.5.4.2 Air quality

Because of regional air pollution concerns, San Jacinto dairies are subject to a number of regulations with regard to air quality. Regulatory programs under the South Coast Air Quality Management District (Air Resources Board 2009) include the following:

- Rule 223: Emission Reduction Permits for Large Confined Animal Facilities
- Rule 403: Fugitive Dust
- Rule 1127: Emission Reductions from Livestock Waste
- Rule 1133.2: Emission Reductions from Co-Composting Operations

In addition to imposing their own requirements and practices on dairy operations, those air quality programs influence what options might be available for dairy waste management, especially innovative or emerging technologies. For example, the potential for composting could be limited because volatilization of ammonia can cause violations of air quality standards. Dairy operators must take care to ensure that any practices or processes undertaken for improved dairy waste management do not transfer pollutants to the air.

4.5.4.3 Cost-effectiveness and sustainability

In challenging economic times, the cost-effectiveness of measures proposed to address the issues facing San Jacinto dairies must be a major consideration. Moreover, dairy operators in the watershed are concerned with the sustainability—economic, agronomic, and environmental—of their livelihood. Thus, considerations of cost-effectiveness and sustainability must be applied to all recommendations and decisions embodied in the IRDMP.

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5.0 Recommendations to Address Dairy Issues

5.1 Recommendations for Data Collection and Analysis

Planning is always done in the absence of all possible desirable data; the IRDMP is no exception. After compiling and analyzing available data from the San Jacinto River watershed, several gaps in existing data have been identified. An initial review of existing data was completed in 2008 (Appendix A). Some of the data gaps identified in that review have been addressed in the interim. A current list of recommendations for additional data collection and analysis is presented in the following sections. Note that some of these issues are being addressed by current, ongoing efforts, as described below.

5.1.1 Land Use/Land Cover and Demographic Data

- Assemble current population data for the San Jacinto River watershed from available sources, along with any available forecasts (spatial and numerical); those data should be incorporated into GIS and other useful formats.
- Compile and monitor information concerning municipal growth management plans, zoning regulations, and related data.
- Compile information on land development requirements for builders/developers that pertains to water quality, air quality, salinity, or other issues that also involve dairies.
- Update land use/land cover in the San Jacinto River watershed on the basis of recent satellite imagery and professional photointerpretation and classification, as well as appropriate ground-truthing. Particular emphasis should be given to agricultural land use, other watershed land where manure is or could be spread, and contemporary land development patterns. A land use/land cover data layer focusing on agricultural cropland was developed by WRCAC in 2009 (AIS 2009); that should serve as a basis for periodic updates to maintain data accuracy.


Scenic view in the San Jacinto River watershed

5.1.2 Pollutant Source Data

- Search the RWQCB dairy database to assemble up-to-date information on locations and characteristics of permitted dairies in the San Jacinto River watershed; that information should be incorporated into a GIS data layer.
- Develop and compile information on the current status of dairy and land management regularly, for example, through review of existing dairy permit information such as Engineered Waste Management Plans, permit inspections, other records, and field surveys (see also Section 6.2).
- Implement a monitoring program that will quantify the actual salt impacts of San Jacinto dairies, including the analysis of manure salt content, water usage and quality monitoring, and measuring the general water quality of process wastewater. The first step in such a program has begun (Individual Dairy Sampling and Analysis, Section 5.2).
- Determine if manure or wastewater or both can be applied to San Jacinto cropland at rates determined by an NMP and by methods that do not result in salt or nitrate loading to groundwater (see Section 3.2.1, Appendix C).
- Compile and review data from the Manure Manifest System , once implemented, at least annually to track the performance of the system and to maintain understanding of the quantity and disposition of manure in the watershed (see also Section 6.2).
- Annually track the implementation of, adherence to, and results of NMPs adopted by San Jacinto dairies on manure and fertilizer use, soil nutrient levels, and crop yields.

Mystic Lake wildlife area

5.1.3 Waterbody Monitoring Data

- Conduct storm event monitoring at the San Jacinto River watershed and Mystic Lake stations (see Sections 3.1 and 6.2).
- Examine existing waterbody data for temporal and spatial trends that would shed light on the possible influence of dairies on observed levels of nutrients and bacteria.
- Historical water quality data and ongoing monitoring programs in the San Jacinto River watershed should be more closely examined to determine its utility for monitoring the influence of dairies on observed water quality, to assess its utility in long-term monitoring of the effectiveness of the IRDMP, and to identify any spatial and temporal gaps that should be addressed by additional monitoring in the future (see Section 6.2).
- Dairies should participate in the watershed-wide monitoring activities required by the TMDL.

5.1.4 The IRDMP

- Establish and maintain a system to track the adoption of management practices by San Jacinto dairies.
- Incorporate the manure manifest system outputs as part of an overall monitoring strategy that includes inputs (i.e., manure), soils, and water quality to determine how the IRDMP is performing.
- Design and implement a water quality monitoring program to assess the effectiveness of BMPs implemented in the San Jacinto River watershed and of the overall progress of the IRDMP (see Section 6.2).
- Use existing monitoring networks as the primary basis for monitoring the effectiveness of the IRDMP at the watershed scale.

5.1.5 Salt Offset Conceptual Model

A report describing *Design and Implementation of a Salt Load Tracking Database* (Wildermuth Environmental, Inc. 2009b) provides a framework for designing a salt load tracking database that can be used in support of a salt load offset program. The data for a salt offset program are to be collected to meet two primary goals: (1) to calculate the salt load produced on a dairy and (2) to calculate the salt load offset requirement for that dairy. The full report is in Appendix G.

The *salt load* of a dairy is defined as the entire mass of salt in the solid and liquid wastes generated by dairy operations. The *salt offset requirement* is the total mass of salt that contributes to a TDS concentration in excess of the regulatory TDS objective defined for the underlying groundwater management zone. The report did not address nitrate loads from dairies, although the salt offset program that would be supported by the tracking database must also include provisions for offsetting dairy nitrate loads.

The data required to calculate salt load and salt offset requirement for TDS include the elements listed below.

A San Jacinto dairy

5.1.5.1 The dairy manure budget

Careful tracking of each transfer of manure within the dairy as well as removal from the dairy will facilitate calculating the salt load. The following key variables need to be quantified to calculate and balance the manure budget and the associated salt load for a given time period:

- Manure generation rates, by cattle type
- Cattle counts, by cattle type
- Amount of time spent in each manure generation site, by cattle type

- Mass of manure applied to on-site cropland
- Mass of manure exported from the dairy
- Manure hauling location (the type and location of the hauling site will determine if the exported manure requires a salt offset, i.e., manure hauled to a location overlying a GWMZ that lacks assimilative capacity for salt will require a salt offset)
- Mass of manure stored in on-site stockpiles
- Manure salt content

5.1.5.2 The dairy water budget

Balancing the water budget is more challenging than balancing the manure budget because of environmental factors such as evaporation, that remove water from the system but leave the salt behind. Furthermore, each dairy has a unique set of water supply sources, e.g., local groundwater, water from the EMWD, or imported Colorado River water. Careful tracking of each transfer of water will ensure that the salt load can be tracked and calculated. The following key variables need to be quantified to calculate and balance the water budget and the associated salt load:

Wastewater conveyance at a San Jacinto dairy

- Water use, by source
- Cattle water consumption, by cattle type
- Milk barn water use
- Source water quality
- Amount of time spent in the milk barn, by cattle type
- Wastewater quality
- Distribution of wastewater among disposal areas
- Potential lagoon evaporation
- Type of crop grown and duration of growth
- Crop field area.
- Reference evapotranspiration
- Crop coefficient
- Salt uptake by crop type
- Volume of water added to lagoons from precipitation

The proposed database assesses the potential to collect valid data or produce reasonable estimates for each of the above parameters. The report details an approach to calculating salt loads from manure and wastewater using the data collected. The conceptual structure for the salt load tracking database is designed based on this approach. The report includes a database structure diagram and a data dictionary for the tables, columns, and fields included in the conceptual salt load tracking database (see Appendix G).

The next step toward implementing the database would be to verify the database design by conducting a trial data collection event. The trial would be used to collect all the requisite data from two to three dairies to confirm that the data can be collected and salt load calculated as conceived. The second step would be a two-part data collection program applied to each dairy to include: (1) an initial audit of the dairy to obtain operational characteristics and data that are not likely to change from year to year (e.g., lagoon capacity), primarily from information available in the facility EWMP or permit reports; and (2) an annual dairy survey to collect the data needed to compute the dairy's annual salt load offset requirement for the preceding calendar year.

In addition to the data collection and estimation procedures envisioned in the conceptual design of the salt load tracking database, the following monitoring elements are strongly recommended:


Wastewater lagoon at a San Jacinto dairy

1. Each dairy should meter and maintain records of the quantity of water from all water sources used in dairy operations.
2. Each dairy should meter and maintain records of movement of wastewater from lagoons to crop fields or disposal fields within the facility.
3. Each dairy should analyze all manure leaving the facility or being applied to on-site cropland for moisture content and salt content. At a minimum sampling should occur during each hauling event where manure is exported from the facility. Dairies should also sample and analyze manure that is stockpiled for crop field application, probably quarterly.
4. Each dairy should test wastewater at least annually for TDS, nitrate, and other constituents; initial wastewater sampling should be more frequent (e.g., weekly or monthly) to characterize variability. Sampling could possibly be scaled back after temporal variability in salt content is adequately characterized. Each dairy should maintain records of data from wastewater analyses.
5. Each dairy should obtain and keep on file results from the periodic EMWD analysis of well water, as well as water extraction data reported by EMWD.

While data from water metering or laboratory analysis are probably the most accurate sources of information from which to calculate a dairy salt balance, it is recognized that equipment malfunctions and other interruptions may compromise such monitoring. Therefore, the operational data described in proposed salt offset database should be collected to make appropriate estimates in the absence of good monitoring data. In the event that a dairy monitoring program is not undertaken, the conceptual database design presented in this report provides a practical approach for the collecting and storing dairy specific data and for calculating dairy salt load offset requirements.

5.2 Salt Offset Program

5.2.1 Salt Offset Options for San Jacinto River Watershed Dairies

As discussed in Section 4.2, dairy operations in the San Jacinto River watershed contribute salts to underlying groundwater basins by applying corral manure to cultivated croplands and by applying or disposing of process wastewater to ponds, pastures, or cropland. A complete analysis of salt offset requirements and a proposed salt offset program (Wildermuth Environmental, Inc. 2008) is presented in Appendix F. That analysis recommends the following options to address the salt loading produced by dairy activities:[1]

- **Eliminate Application of Corral Manure to Croplands.** Section IV. B. of R8-2007-0001 prohibits applying manure to croplands that overlie groundwater management zones (GWMZ) lacking assimilative capacity for total dissolved solids (TDS) or nitrate-nitrogen even at agronomic rates, unless a program is implemented to offset the entire TDS and nitrate load. According to annual reports required by the permit, San Jacinto dairies reported hauling 210,314 tons of manure in 2007. As reported earlier, 24 of the region's dairies either applied corral manure to cropland on their own property or exported it locally to neighboring San Jacinto farms. Seven dairies in the San Jacinto River watershed apply all or a majority of their manure to cropland in the San Jacinto, contributing more than 36,000 tons of manure annually. According to the permit, applying manure to cropland contributes to more than 90 percent of each dairy's TDS and nitrate loading problems (Wildermuth Environmental, Inc. 2008). Thus, 90 percent of the salt loading problem from animal waste could be solved by eliminating the use of corral manure as fertilizer in the San Jacinto River watershed. Chino Basin dairies followed similar logic in 1999 when faced with the same land application prohibitions under the previous dairy permit (Order 99-11). Exporting manure from Chino Basin to San Jacinto continues to this day; more than 196,000 tons of manure were exported to the San Jacinto River watershed in 2006, and some 140,000 tons were exported to the San Jacinto River watershed in 2007.

Cropland in the San Jacinto River watershed

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[1] Note that the information in this section reflects a report that was prepared in 2008 based on data reported to the RWQCB by the dairies for 2007. As described elsewhere in this report, the number of dairies in the San Jacinto River watershed has declined since 2007 and the trend is expected to continue.

San Jacinto dairies should consider eliminating applying corral manure to cropland in the San Jacinto River watershed and partnering with other Santa Ana Region dairies to eliminate using manure as fertilizer in the entire Santa Ana River Basin. The challenge of discontinuing such use of manure, of course, is that an appropriate location must be found for disposing of more than 150,000 tons of manure—nearly 400,000 tons including manure imported from the Chino Basin. Potential solutions include the following:

- Exporting manure out of the San Jacinto River watershed to a location capable of accommodating this loading;
- Transporting the manure to a local composting facility to process the waste to compost for subsequent export out of the watershed;
- Constructing a local, centralized manure-to-energy facility that has the potential to provide revenue that can be used to offset the cost of solving the solid manure loading problem

Note that composting, digestion, and other manure processing options will leave residual wastes containing salts that will require proper handling and disposal. See section 5.4.2 for additional detail on these and other options.

- **Reduce TDS Concentration of Process Wastewater.** Compliance with the discharge prohibitions of R8-2007-001 will likely require dairies to mitigate the entire mass of TDS that contributes to wastewater TDS concentrations in excess of the underlying GWMZ, including the TDS contributed by source water that exceeds the TDS objective for the GWMZ. Options for reducing the final TDS concentration of dairy wastewater include the following:
  - Reduce the TDS Concentration of Operations Source Water. Many San Jacinto dairies have elevated salt concentrations in their local water supplies. In some cases, it might be possible to reduce the final wastewater TDS concentration by reducing the source water concentration. Reductions in source water TDS concentrations can be achieved by purchasing alternative, low TDS source waters, such as State Water Project water, or through pretreating local groundwater. The practical and economic feasibility of purchasing alternative water is limited by increasing costs, the availability of pipelines to deliver water to the area, and restrictions on delivery of water because of drought. An additional option for reducing the TDS concentration of a dairy's source water supply involves installing a wellhead treatment system. However, the advanced treatment technology required, such as RO, could prove to be very expensive for an individual dairy to execute. Furthermore, if the additional TDS load produced by dairy operations exceeds the underlying groundwater management objective, treating source water alone will not be enough to comply with discharge prohibitions.

Wastewater lagoon and cropland

- **On-site Wastewater Treatment.** Because reducing TDS in source water might be difficult and insufficient to comply with discharge prohibitions, dairies could consider the option of implementing an on-site wastewater treatment system. Removing TDS from wastewater is expensive because it requires the use of RO or other advanced treatment technologies. The capital cost for such a system can be as high as $11 to $15 per gallon of treatment capacity needed. Operations and maintenance costs can range from $1 to $2 per gallon treated. Recent advances in industry technology might however provide additional solutions that are more economically feasible. For example, the WRCAC has tested an on-site treatment technology known as Vibratory Shear Enhanced Processing or VSEP® for reducing TDS in dairy wastewater (see Section 5.4.2.3.1)
- **Regional Wastewater Treatment.** Given the high costs associated with removing TDS from wastewater, a centralized regional facility might be more cost-effective than several individual on-site treatment systems. Such a cooperative opportunity would also reduce the time and money spent by the dairies and by the RWQCB in evaluating, approving, and implementing this strategy. Clustering dairies in close proximity could make a centralized facility more attractive, while on-site treatment facilities might be better for more isolated dairies.

- **Implement a Salt Management Plan.** If a dairy wishes to continue to apply process wastewater to pastures or croplands, a detailed salt management plan that demonstrates thorough site-specific data and computer models that no TDS reaches the groundwater table will be required. In the absence of locally derived data and modeling demonstrations, the RWQCB will assume that 100 percent of TDS added to the system from manure and process wastewater reaches the groundwater table. A dairy can also implement an NMP to demonstrate that applied nitrate is taken up by crops, rather than leached to groundwater if the dairy wishes to continue to apply manure as a fertilizer.

The USDA-ARS Salinity Laboratory conducted a pilot nutrient management project on a San Jacinto dairy to investigate the efficacy of implementing an NMP that included applying dairy wastewater (see Section 3.2.1). The study demonstrated that with accurate water application, at local evapotranspiration rates and careful attention to variable soil, wastewater, and crop conditions, very little leaching of salts occurred below the root zone. After completing the pilot project, WRCAC should work closely with the RWQCB to demonstrate the effect of implementing a salt or nutrient (or both) management plan on the underlying groundwater basin to determine the resultant salt offset that might still be required.

Aerial view of the San Jacinto River watershed

The use of salt or nutrient management plans to reduce overall salt offsets can be implemented by any dairy applying wastewater to the land, regardless of location.

- **Participate in Local Groundwater Improvement Projects.** Implementing a groundwater quality improvement program that will remove, ton for ton, the TDS loads added to underlying groundwater basins through dairy operations might be an acceptable salt offset option, provided that the salt offset occurs within the same management zone as the loading. Implementing a groundwater desalination facility, or desalter, in the Chino North Management Zone has been an acceptable salt offset for TDS and nitrate loads produced by dairies that discharge to that management zone. That offset was allowed under the condition that all corral manure continues to be exported from the basin.

  While a regional groundwater desalination facility would have high costs, the opportunity exists for sharing costs with other local entities and creating economies of scale savings through partnerships. Dairy operations are not the only activities in the San Jacinto region affected by limitations imposed by a lack of assimilative capacity in the San Jacinto region. Local water supply agencies are also limited in their ability to implement groundwater management strategies, such as recycled water recharge. As such, these agencies are exploring their own salt offset options that would allow them to improve local water supply reliability within the constraints of the TDS and nitrate-nitrogen objectives.

  One such program being explored in the San Jacinto region by EMWD focuses on the San Jacinto Upper Pressure (SJUP) GWMZ. EMWD is seeking a Basin Plan Amendment to increase the management zone TDS and nitrate-nitrogen objectives, which will create assimilative capacity in the SJUP to enable the use of recycled water, allow for the recharge of imported water, and require the EMWD to implement a groundwater desalter. While the RWQCB has yet to review and approve the proposed plan, it could be an opportunity for San Jacinto dairies to propose a partnership that can achieve the goals of both parties.

  If a groundwater desalter is implemented in the SJUP, only those dairies discharging to that management zone could benefit from the offset provided by the desalter. Nonetheless, if the dairies were able to engage EMWD early enough in the process and provide financial backing, it might be possible to explore a regional desalter that targets two adjacent management zones. One further obstacle to participating in local groundwater quality improvement programs relates to the implementation schedules for such projects. The dairies are working under a timeline that requires salt offset options to be in place by 2012. A project like the SJUP desalter, on the other hand, might not be slated for construction and operation until 2020.

Recommendations

- WRCAC should explore the option of eliminating the use of corral manure as fertilizer. The best chance the San Jacinto dairies have to continue operating in the future is to entirely remove the primary loading factor from the region.
- WRCAC and individual dairies in the San Jacinto River watershed should investigate the practicality and cost-effectiveness of on-site wastewater treatment for TDS reduction, both on individual dairies and as one or more centralized facility.
- WRCAC should engage the EMWD as soon as possible to consider the regional groundwater management strategies being implemented.

5.2.2 Dairy Sampling 2009

The Dairy Sampling and Analysis project was conducted to improve the knowledge of dairy salt loads in the San Jacinto River watershed by measuring TDS, NO_3-N, and other waste constituents at selected points in the dairy process. Ten representative dairies were selected for sampling and the dairy operators gave written consent to collect and use data from their facility. The project focused on collecting samples of alley, corral, and stockpiled manure and of wastewater as discharged from milk barns and as contained in lagoons; analyzing ground water quality and quantity data provided by EMWD; and analyzing operational data from the sampled facilities. Manure quantities and distribution with the facility were estimated based on 2008 reported data and assumptions recommended in the RWQCB's annual dairy report template. Sampling was conducted in November 2009 by Walco International Environmental Services under contract with the SJBRCD. Complete discussion of this sampling project is in Appendix H.

Cows

The sampled dairies' herd sizes ranged from 870 to 2,500 milk cows, with an average of 1,584. Sampled dairies overlie three GWMZs (San Jacinto Upper Pressure, Lakeview/Hemet, and Menifee). Concentrations of nutrients and salts in dairy manure were determined by sampling and laboratory analysis of manure of different types depending on the management used on individual dairies. Samples were collected from corral manure, manure stockpiles (if any) and manure removed from the cattle feeding alleys if it is managed separately from corral manure. Manure deposited in the milk barn was assumed to be represented in samples of the wastewater stream. Dairy wastewater generated from the milk barn was sampled for quality at a well-mixed point just before it is discharged into the first containment lagoon. Samples were also collected from wastewater lagoons on four of the dairies to shed light on changes in wastewater quality with storage. Quantity and quality of source water extracted by sampled dairies was assessed using data reported on 26 wells by the EMWD. Rather than apply an assumption of 100 gal/cow/day of wash water, as has been done in previous analyses, dairy-specific estimates of daily washwater used were obtained from dairy EWMPs or were calculated from information on sprinkler use and milk barn washing practices collected from dairies during sampling visits. Manure and wastewater samples were analyzed for a full range of nutrients and salts; all manure data are reported as mg/kg, dry weight basis. Ground water samples collected by EMWD were analyzed for an extensive list of constituents.

5.2.2.1 Manure

Samples of corral manure were collected from all 10 participating dairies. Because the timing of sample collection coincided with many dairies' manure hauling schedules, only 3 manure stockpiles available for sampling; two samples of alley manure were collected. Table 5-1 provides descriptive statistics for corral manure samples.

Table 5-1. Descriptive statistics for corral manure, San Jacinto dairies sampled November 2009

	NH_3-N	TKN	NO_3-N	TP	K	Cl
Mean	3,386	25,016	43	5,367	35,804	18,906
Median	3,347	25,293	48	5,482	33,678	17,909
Range	2,069 – 5,453	19,611 – 29,733	<1 – 87	3,379 – 7,245	21,060 – 59,856	11,870 – 26,605
s.d.a	954.5	3378.5	32.2	1,221.0	10,588.9	5,582.9
C.V.b	0.28	0.14	0.75	0.23	0.29	0.30
n	10	10	10	10	10	10

	SO_4	Ca	Na	Mg	% solids
Mean	7,954	21,207	10,143	8,208	63
Median	8,145	20,224	10,134	8,298	62
Range	5,068 – 12,061	17,689 – 27,829	6,700 – 14,230	6,916 – 9,774	46 – 80
s.d.a	2,064.8	3490.9	2,225.0	959.8	10.3
C.V.b	0.26	0.16	0.22	0.12	0.16
n	10	10	10	10	10

All data except % solids in mg/Kg, dry weight basis.

a. Standard deviation

b. Coefficient of variation = standard deviation/mean, a measure of variability in the data

Corral manure ranged from 46 to 80 percent solids, equivalent to 20 to 54 percent moisture. As expected, about 90 percent of total N was in the organic form (TKN minus NH_3-N); very little NO_3-N was present as mineralization of organic N to ammonia and nitrification of ammonia to nitrate had not progressed. Variability among the dairies was low (C.V. $\leq$ 30 percent), suggesting that the quality of corral manure was fairly consistent across the different dairies. Nitrate was an exception, showing a higher variability among dairies, probably in response to variation in age of corral manure deposits.

Because it is older, stockpiled manure was drier than corral manure, ranging from 76 to 82 percent solids, equivalent to 18 to 24 percent moisture. Like corral manure, about 90 percent of total N was in the organic form and little NO_3-N was present. Total N (TKN + NO_3-N) in stockpiled manure averaged about 25 percent lower than that of corral manure; loss of ammonia by volatilization is a likely cause. Variability among the dairies was again low (C.V. $\leq$ 35 percent), although a bit higher than for corral manure, possibly due to the low number of samples. The low variability suggests a consistent quality of stockpiled manure among the sampled dairies. Nitrate was again an exception, showing a higher variability among stockpiles, probably in response to variation in age or aeration of the stockpiles. Only two samples of alley manure were collected; as would be expected for fresh manure, percent solids was less than 20 percent and about 30 percent of N was in the ammonia form.

Corral manure sampling

Concentrations of measured constituents were compared among sampled manure groups by Analysis of Variance (ANOVA); results are summarized in Table 5-2.

Table 5-2. Comparison of mean concentrations within manure groups by ANOVA

	Alley	Corral	Stockpile
NH_3-N	10,971a	3,385b	2,099c
TKN	33,590a	25,015b	18,438c
NO_3-N	30a	43a	57a
TP	6,522a	5,367a	4,825a
K	30,023a	35,804a	33,198a
Cl	17,812a	18,906a	15,293a
SO_4	4,254b	7,954a	6,469ab
Ca	17,162a	21,207a	19,187a
Na	6,531b	10,143a	8,455ab
Mg	7,075a	8,208a	7,907a
% solids	18c	63b	80a

Within each row, means followed by the same letter(s) are not significantly different, P< 0.10.

As shown in Table 5-2, alley manure tended to have lower percent solids and higher ammonia concentrations than either corral or stockpiled manure. Mean SO_4 concentration was lower in alley manure than in other manure forms, probably because sulfur had less opportunity to oxidize in fresher manure. NO_3-N concentrations followed a similar pattern of increasing concentration with manure age. Concentrations of P, K, Cl, Ca, Na, and Mg did not differ significantly among the different manure groups. It should be cautioned that the number of alley manure samples is too low to assign high statistical confidence to comparisons across groups.

The mass of nutrients, salts, and other constituents contained in dairy manure was computed for each sampled dairy as the product of manure generated and the concentrations measured in corral manure for that dairy. It was assumed that 90 percent of milk cow manure goes into the corral, along with 100 percent of manure excreted by other animals on the dairy. It was further assumed that corral manure best represents the quality of manure from the dairy, although for an accurate N balance at any given time, corral manure and stockpiled manure should be considered separately because of ammonia losses over time. The mass of selected nutrients and salts contained in the manure of sampled dairies is summarized in Table 5-3.

Table 5-3. Calculated mean annual mass of manure constituents available in corral manure of sampled dairies based on 2009 samples and livestock numbers reported by dairy operators

	NH_3-N	TKN	NO_3-N	TP	K	Cl	Na	SO_4
kg/yr	23,943	177,410	311	38,276	251,060	137,047	72,526	57,529
t/yr	26.3	195.2	0.3	42.1	276.2	150.8	79.8	63.3

5.2.2.2 Wastewater

Samples of wastewater as discharged from the milk barn were collected from all 10 participating dairies. Descriptive statistics for sampled dairy wastewater are shown in Table 5-4.

Table 5-4. Descriptive statistics for dairy wastewater, San Jacinto dairies sampled November 2009

	Cl	NO_3	SO_4	COND	TDS	TN	TP
Mean	350	2.8	224	3,781	2,984	399	51
Median	284	1.0	169	2,255	1,900	222	44
Range	93 – 1,051	<0.2 – 16.0	30 – 915	1644 – 7660	1,060 – 7,425	75 – 976	11 – 128
s.d.[a]	279.8	4.5	244.6	2,384.4	2,180.9	316	36.8
C.V.[b]	0.20	1.58	1.09	0.63	0.73	0.79	0.73
n	11	11	11	11	11	11	11

	NH3	Ca	Mg	K	Na	TKN
Mean	46	205	76	433	283	396
Median	28	144	53	291	291	221
Range	9 – 188	79 - 494	22 – 195	75 – 1,121	147 – 645	74 – 969
s.d.[a]	52.8	139.7	60.6	389.1	151.6	313.7
C.V.[b]	1.14	0.68	0.79	0.90	0.54	0.79
n	11	11	11	11	11	11

All values in mg/L except conductance in µS/cm.

a. Standard deviation

b. Coefficient of variation = standard deviation/mean, a measure of variability in the data

Dairy wastewater was high in TDS and conductance and in N and P. About 10 percent of N was in the NH_3-N form and less than 1 percent of total N was present as NO_3-N. This is expected for relatively fresh wastewater where substantial N mineralization and nitrification had not yet occurred. Variability among sampled dairies (as reflected in values of the C.V.) was substantially higher than was observed for manure. This higher variability may reflect differences in management among the sampled dairies or differences in the quality of source water used in the facility.

Statistically significant differences between fresh and stored wastewater were few, likely the result of the low sample size for lagoon wastewater. Mean NH_3-N concentration was significantly higher in lagoon compared to fresh wastewater. Nitrate levels were negligible in lagoon wastewater, probably because the lagoons tended to be anaerobic. Although not statistically significant, conductivity and concentrations of TDS, Cl, and Na were somewhat higher in lagoons than in fresh wastewater, possibly reflecting concentration of constituents due to evaporation of water during storage. An apparent decrease in total N concentration in lagoon wastewater may be due to ammonia volatilization losses.

As was done for manure, the mass of nutrients, salts, and other constituents contained in dairy wastewater as discharged from the milk barn was computed for each sampled dairy as the product of wastewater generated and the concentrations measured in wastewater for that dairy. Wastewater volume for each dairy was taken from site-specific calculations based either on EWMP data or data concerning wash water use reported in the 2009 sampling procedure. Note that these wastewater volume estimates are substantially lower than the 100 gal/cow/day assumed in some facility EWMPs. The volumes used in this calculation range from 14 to 62 gal/cow/day, with a mean of 32 gal/cow/day. The wastewater volume and associated mass of nutrients and salts contained in the manure of sampled dairies is summarized in Table 5-5.

Table 5-5. Calculated mean annual mass of manure constituents available in wastewater as discharged from milk barn based on 2009 samples and water use reported by dairy operators

	NH_3-N	TKN	NO_3-N	TP	K	Cl	Na	SO_4	TDS
kg/yr	2,259	20,672	144	2,872	23,387	17,990	14,927	11,647	163,847
t/yr	2	23	0.2	3	26	20	16	13	180

5.2.2.3 Dairy well water

EMWD provided annual data from 2001 – 2008 for 26 wells among the 10 participating dairies. This analysis included only data from 19 wells with samples collected in 2008 and used only 2008 data. Because of possible long-term changes in ground water quality, the use of contemporary data was deemed appropriate. Descriptive statistics for sampled dairy wells are shown in Table 5-6.

Table 5-6. Descriptive statistics for EMWD data from dairy wells, San Jacinto dairies sampled 2008

	HCO_3	B	Ca	Cl	Conductivity	Fl	Hardness
Mean	175	1.0	77	175	1,118	5.5	263
Median	140	0.8	41	120	960	0.6	130
Range	100 – 420	<0.1 – 3.6	18 – 410	18 – 930	90 – 4,290	0.2 – 90	52 – 1,500
s.d.[a]	86.7	0.99	118.2	249.3	1,062.0	20.5	437.6
C.V.[b]	0.49	0.99	1.54	1.42	0.95	3.73	1.66
n	19	19	19	19	19	19	19

	Fe	Mg	Mn	NO_3-N	pH	K	Si
Mean	177	17.4	53	1.4	7.6	4.2	24
Median	65	6.4	6.5	0.7	7.8	3.8	17
Range	<5 – 1,300	1.6 – 120	5 – 330	<0.1 – 9.7	6.5 – 8.2	1.5 – 9.8	14 – 64
s.d.[a]	314.5	36.6	96.1	2.3	0.50	2.2	14.4
C.V.[b]	1.77	2.08	1.82	1.62	0.06	0.53	0.60
n	19	19	19	19	19	19	19

	Na	SO_4	Alkalinity	TDS	Total Inorganic N	Zn	Extraction
Mean	140	175	144	690	2.0	20	63.4
Median	133	140	110	530	1.1	10	59
Range	27 – 360	12 – 770	86 – 340	210 – 2,760	<0.5 – 9.7	<5 – 79	4.5 – 214
s.d.[a]	75.2	176.7	69.4	680.9	2.4	23.5	58.8
C.V.[b]	0.54	1.01	0.48	0.99	1.16	1.19	0.93
n	19	19	19	19	19	19	18

All values in mg/L except COND (μS/cm), Cu, Fe, Mn, and Zn (μg/L), and extraction (AFY).

a. Standard deviation

b. Coefficient of variation = standard deviation/mean, a measure of variability in the data

Note that the values shown in Table 5-6 are heavily skewed by very high values (e.g., TDS 2,400 – 2, 700 mg/L, NO_3-N 5.2 – 9.7 mg/L) from two wells located on one dairy overlying the Menifee GWMZ. As shown in Table 5-7, wells sampled in the San Jacinto Upper Pressure and Lakeview-Hemet North GWMZs were generally consistent with management objectives for TDS and nitrate, although there were a few exceedances of those objectives in some wells. The two wells sampled in the Menifee GWMZ, however, greatly exceeded the TDS and nitrate objectives, even for the lower water quality of that ground water zone.

Table 5-7. Mean TDS and NO_3-N concentrations in sampled wells compared to GWMZ management objectives

GWMZ	TDS (mg/L)		NO3-N (mg/L)	
	Objective	Sampled wells	Objective	Sampled wells
San Jacinto Upper Pressure	320	285 (210-370)	1.4	0.2 (<0.1-0.7)
Lakeview-Hemet North	520	524 (400-640)	1.8	0.9 (<0.1-2.3)
Menifee	1,020	2,585 (2,410-2,760)	2.8	7.4 (5.2-9.7)

Number of sampled wells: San Jacinto Upper Pressure = 4; Lakeview-Hemet North = 13; Menifee = 2

As was done for manure and wastewater, the 2008 mass of nutrients, salts, and other constituents contained in dairy well water was computed for each sampled dairy as the product of recorded water extraction and the concentrations measured in the well. Note that the mass of nutrients, salts, and other constituents is already included in the mass estimated for dairy wastewater. The well water extractions and associated mass of nutrients and salts contained in the water are summarized in Table 5-8. Data for all constituents analyzed by EWMD are not reported. Also, note that chemistry data have not been reported for two wells and that lack of data may skew the reported means and medians.

Table 5-8. Calculated mass of constituents in water extracted from dairy wells in 2008 based on data provided by EMWD

	Total Inorganic N	NO_3-N	K	Cl	Na	SO_4	TDS
kg/yr	316	170.2	868	28.930	30.363	28.183	124.881
t/yr	0.4	0.2	1	31.9	33.5	31.1	137.7

Note that the estimates for Cl, Na, and SO4 in Table 5-8 exceed the estimated mass contained in dairy wastewater (Table 5-5). There are several possible explanations for this. First, not all well water extracted may contribute to dairy wastewater. Second, estimates of the mass of wastewater constituents may be underestimates if wastewater volumes are underestimated. Third, comparison of data based on a single well sample analysis in 2008 with estimates based on a single wastewater sample in 2009 may introduce some discrepancy. Finally, some of the mass of nutrients and salts in the well water may be assimilated by livestock and not excreted into the diary waste stream.

Irrigating dairy wastewater blended with well water

Because the annual EMWD well data go back as far as 2001, it is useful to look at changes in well water chemistry over time to see if any trends are apparent. An example is shown in Figure 5-1, where TDS levels appear to be decreasing over time; this pattern is observed in several of the sampled dairy wells. This trend is by no means universal as some other wells show either no pattern or an increasing trend. The suggestions of temporal patterns in well water quality suggest that a systematic evaluation of ground water quality trends in the region may be useful.

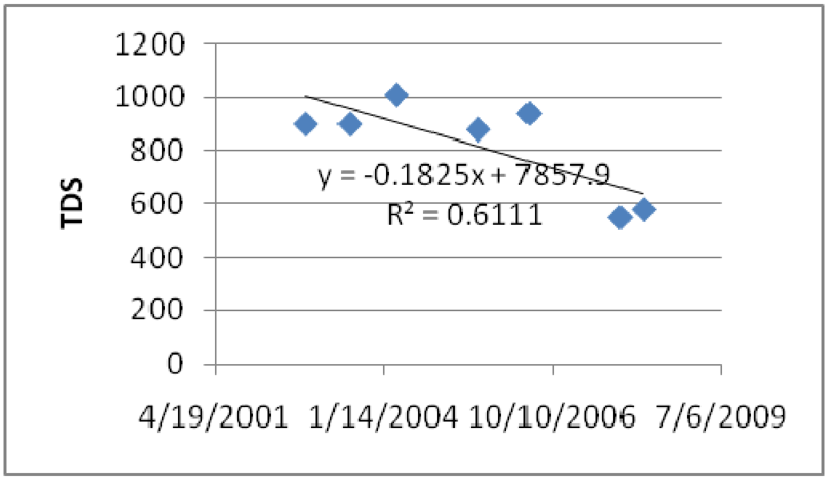


Figure 5-1. Time series of annual TDS values for a well in Lakeview-Hemet North GWMZ.

5.2.2.4 Discussion

The dairy wastewater sampled in this project was substantially higher in TDS than was estimated in the recent *Salt Offset Options for the San Jacinto River Basin Dairies* analysis (Wildermuth, Inc. 2008). That study estimated wastewater TDS from source water TDS and assumed manure contribution to the waste stream to result in a mean TDS of 1,020 mg/L (range 438 – 1,770 mg/L). However, this project observed TDS more than double those values (Table 5-4): mean TDS 2,984 mg/L (range 1,060 – 7,425 mg/L). Thus, it appears that dairy wastewater in the San Jacinto River watershed may be a more potent source of salts and nitrate than previously believed.

However, dairy wastewater is only a small part of the total salt and nitrate load from dairies. As shown in Table 5-9, manure contributes the overwhelming majority of salts and other constituents to the overall dairy salt load. Manure contributes an average of 80 to 90 percent of N, P, and other constituents to the total annual mass load from sampled dairies. Nitrate, a relatively minor fraction of total N load, showed a higher proportional contribution in wastewater than other constituents, but manure still contributes two-thirds of the nitrate load. This pattern reinforces the importance of dealing with manure in the San Jacinto River watershed, because even a high level of treatment applied to wastewater would solve only about 20 percent or less of the TDS and nitrate problem.

Table 5-9. Estimated mean annual mass of nutrients and salts in manure and wastewater from sampled San Jacinto dairies

Constituent	Mean annual mass in manure (t)	Mean annual mass in wastewater (t)	Mean annual total mass (t)	% of annual load in manure	
NH3-N	26.4	2.7	29.1	91%	(82-96%)
NO3-N	0.34	0.17	0.51	66%	(2-92%)
TKN	195.6	25.1	220.7	89%	(75-96%)
P	42.2	3.5	45.7	92%	(82-98%
Ca	168.2	13.7	181.9	92%	(81-98%)
K	276.8	28.4	305.2	91%	(75-97%)
Mg	65.3	5.1	70.4	93%	(84-98%)
Na	80.0	18.1	98.1	82%	(70-89%)
Cl	151.1	21.8	172.9	87%	(67-95%)
SO4	63.4	14.1	77.5	82%	(53-94%)

Numbers in parentheses in far right column represent the range observed on individual sampled dairies.

Analysis of manure sample results indicates that corral manure is of relatively consistent quality among the sampled dairies. This consistency could be a significant benefit in composting or other processing of manure into a marketable product for export out of the watershed. Dairy wastewater appears to be somewhat more variable in quality, perhaps at least partially reflecting variations in management among the sampled dairies. This pattern suggests that the quality of dairy wastewater can be influenced by management, an important element in long-term salt offset planning.

The role of source water quality in wastewater quality is obvious in principle, but the data developed in this project do not support a clear conclusion. Obviously, source water high in TDS will produce wastewater high in TDS. The dairy overlying the Menifee GWMZ had the highest TDS source water and had among the highest TDS wastewater among those dairies sampled; however several other dairies with lower TDS source water produced wastewater higher in TDS. However, the estimated mass of TDS and salts contributed by well water exceeded the mass in dairy wastewater for a number of dairies and it is not known if this is due to data irregularities, or some other cause.

This dairy sampling and analysis project quantified the nutrient and salt loads associated with manure and wastewater on a group of San Jacinto dairies. These loads can be used for planning purposes in a salt offset program. Some specific conclusions are:

- Manure represents by far the dominant source of salt and nutrient loads from dairies; it is clear that any solutions to the salt offset issue must address manure export.
- The salt and nutrient content of manure in dairies was reasonably consistent among the sampled dairies; this consistency may be beneficial for the processing of manure into a uniform product for sale or export from the watershed.
- Salt and nutrient loads in dairy wastewater generally comprised 20% or less of total dairy loads.
- Estimated dairy wastewater volumes were substantially lower than the assumptions used in previous salt offset assessments, but measured TDS concentrations were substantially higher than previously estimates. As a result, wastewater TDS loads calculated in this project are substantially higher than those previously estimated.
- The quality of dairy wastewater was substantially more variable than manure quality among the sampled dairies. To some extent, this may be due to management variations, suggesting that opportunities might exist to reduce wastewater TDS and nitrate levels.

- Well water quality data provided by the EWMD suggest some trends toward declining ground water TDS; investigation and documentation of such trends should be an important part of a salt offset program.

In future investigations of the dairy nutrient and salt issue, the following steps are recommended:

- Obtain more accurate data on dairy wastewater generation by metering source water at the point of use rather than relying on well extraction data.
- Collect detailed, site-specific data to support an analysis of N mineralization and nitrification rates in dairy wastewater management.
- Sample local ground water to assess actual delivery of TDS and nitrate to ground water

5.3 Manure Manifest System

An important component of the San Jacinto IRDMP was developing a Manure Manifest System to track manure generation, transport, and use in the watershed. The purpose of this system is to come up with a holistic tracking system to self-regulate transport and use of manure in the watershed to help meet the many surface water, groundwater, air quality, and local ordinance requirements in the watershed.

Calf

Previous studies in the San Jacinto River watershed examined the dairy industry and quantified the amount of manure generated in the watershed. The studies identify a need for additional cropland beyond what is owned by dairies to spread manure at environmentally responsible rates. Because of this deficit, coordination between CAFO operators and crop producers is essential to ensure that a market exists for disposing of and using manure.

A report on developing the recommended Manure Manifest System was completed in 2008 (Tetra Tech 2008b) (Appendix I). The report outlines the status of manure generation, transport, and use, including interactions among CAFO operators, haulers, and landowners as well as information that is and is not reported. The two existing programs that track manure—the NPDES Permit for CAFOs and Riverside County Ordinance 427.2—are each missing key features of a holistic tracking program because the former focuses on manure generation and transport, and the latter focuses on land application. Tracking requirements are expected to increase, particularly for agricultural producers as a result of the conditional waiver of waste discharge requirements for agricultural discharges (the so-called *ag waiver* or CWAD)—a BMP-based waiver program that the RWQCB is considering for irrigated agriculture (RWQCB 2009).

The manifest system is expected to meet a variety of goals and produce the following benefits:

- Reduce groundwater contamination concerns by providing a mechanism to ensure prudent nutrient management by all manure users

- Provide information on nutrient generation, transportation, and use to improve analyses for the Canyon Lake and Lake Elsinore Nutrient TMDL, as well as information on BMPs implemented to mitigate nutrients
- Address air quality concerns and reduce nuisance complaints from neighbors through guidance and site-specific limitations for manure application
- Improve accountability for manure use and disposal and reduce dairy operators' risk of fines or litigation due to improper disposal outside of their control
- Provide detailed spatial information on crop production and manure import, application, and export, which were identified as gaps in previous analyses
- Improve communications and provide outreach to CAFO operators, haulers, and agricultural producers
- Provide a head start for meeting irrigated agriculture waiver requirements
- Provide an opportunity for funding regional implementation projects that benefit the entire watershed

A multi-phase process is proposed for establishing and running the Manure Manifest System. The first phase involves recruiting participants through a notice of intent (NOI) process. Dairy operators will provide basic information about the business, including contact name and address, facility location, and manure product amount and condition. Haulers will provide basic information about the business, including contact name, address, business license number, number of trucks, and other relevant information. The owner of the property receiving manure would submit information about the property, including contact information, ownership, available acreage, crop history (past and current), soil information, GWMZ, and other site information.

Once applications are submitted, Manure Manifest System staff review and verify the information, conduct site visits, and enter participant data into a manifest system database (Phase 2). During Phase 3, Manure Manifest System staff will approve or deny applications and set any conditions for approval. Ongoing staff activities include processing manure transfers, conducting additional inspections, maintaining the manifest system database, and analyzing and synthesizing data for regulatory reporting. Ongoing activities for participants are to meet any conditions for approval, complete and submit paperwork for manure transfers, and renew their NOIs annually.

Scenic view of a San Jacinto dairy with cropland

The report proposes series of steps and activities for each phase of the Manure Manifest System, and includes the following forms:

- NOI Forms (CAFO operator, hauler, and landowner)
- Landowner/Tenant Agreement Form
- Manure Transfer Form
- Annual Renewal Form (CAFO operator, hauler, and landowner)

The Manure Manifest System report identified SJBRCD as the organization best equipped to administer the Manure Manifest System. SJBRCD or a similar group should seek sources of funding to implement and manage the Manure Manifest System. One-time start-up costs (labor and capital costs) are estimated to be approximately $62,600, and ongoing, annual costs are estimated at $49,900, some of which could be recovered by billing costs back to landowners). A hybrid funding approach has been recommended that combines annual membership fees with per-transfer fees and cost recovery for soil sample analysis to fund the program's operating expenses.

5.4 Management Practices

Changes in management on San Jacinto dairies will be required to meet the demands of both the *Lake Elsinore and Canyon Lake Nutrient TMDL* and the salt offset requirement. The nutrient TMDL specifically identifies CAFOs as significant point sources of nutrients in the watershed; Section IV. B. of R8-2007-0001 will likely prohibit or at least severely restrict applying manure and dairy wastewater to most land overlying GWMZs in the San Jacinto River watershed. Thus, San Jacinto dairies will be required to reduce discharge of both nutrients (N and P) and salts in the very near future; much of this requirement will have to be met by changing the ways dairies deal with wastewater and manure quantity, quality, storage, treatment and disposition. Furthermore, San Jacinto dairies face other issues that might require management changes, including groundwater quantity and quality, air quality, the relationship between dairies and cropland, and—most importantly—the sustainability of dairy operation in the watershed.

Management practices can have different names in different contexts, including *BMPs*, *management measures*, and *conservation practices*; these are related and overlapping terms that describe approaches and activities that are used to reduce the availability, transport, or delivery of pollutants from land to water. Some management practices that are funded and implemented by the USDA- NRCS must meet standards and specifications defined in the NRCS *Electronic Field Office Technical Guide* (NRCS N.d.); other practices could be designed by engineers, researchers or others, including dairy operators or crop producers themselves. Changes applicable to San Jacinto dairies might take the form of management measures that change the storage, handling, or use of nutrients or wastes on diaries; structural measures that contain, treat, or process wastes; or innovative practices that process dairy wastes change their characteristics, and facilitate new uses or destinations for San Jacinto dairy manure.

5.4.1 Principles of Control

While the exact combination of specific measures could differ among individual dairies, most management practices that San Jacinto dairies could implement share one or more common principles of nutrient or salt control:

- **Availability.** Potential nutrient or salt loads can be reduced by limiting the quantity of the pollutant available to be lost; this process is also known as source reduction or pollution prevention. Nutrient management that reduces the amount of fertilizer applied to cropland, precision feeding that reduces the quantity of P excreted by livestock, and conversion of manure nutrients to less available forms are examples of practices that act on the availability of potential pollutants.
- **Detachment.** Some management practices act to prevent soil particles or other pollutants from being detached from their point of origin by raindrop impact, moving water, or wind.

Examples of practices that act to minimize detachment of soil particles include conservation crop rotation and residue management.

- **Transport.** Controlling runoff and the effective velocity of water or wind will reduce the capacity of water or wind to transport particulate materials and promote redeposition through settling. Grassed waterways, stripcropping, and windbreaks are examples of practices that can reduce transport of pollutants.
- **Delivery.** Practices that intercept or capture pollutants before they can be delivered to a waterbody could be the last line of defense to control nonpoint source pollution before pollutants enter water. Filter strips, irrigation tailwater ponds, and water and sediment control basins are practices that can be used to prevent pollutants from being introduced into waterways.

Single, individual management practices might not provide the full control needed for all pollutants or for all pollutant pathways. For this reason, multiple management practices are often combined to build systems that can comprehensively address multiple treatment needs and opportunities.

Certainly not all these principles apply to San Jacinto dairies as CAFOs; measures that affect detachment and transport, for example, are of limited relevance to dairies that meet all the containment requirements of their permits. However, such principles do apply to management needs for the more than 2,000 acres of cropland associated with dairies in the watershed (see Section 5.4.2.5), as well as some 60,000 acres of San Jacinto River watershed cropland, some of which could receive manure from San Jacinto dairies, now or in the future.

The San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel (2005) evaluated a broad array of technology (mostly proprietary processes or systems) available to treat dairy wastewater and manure to reduce salt and nutrient pollution potential. It evaluated 44 specific technologies and grouped them into several categories:

- Gasification for biogas production
- Solids separation for wastewater
- Composting
- Anaerobic digestion in open ponds
- Anaerobic digester with methane capture
- Enhanced mixing of anaerobic pond
- Aeration/aerobic pond
- Nitrification-denitrification
- Constructed wetland
- Covers for wastewater ponds
- Biological additives for wastewater ponds
- Desalination (RO)

The expected effects of these treatment types are summarized in Table 5-10. While some general treatment approaches such as composting, digestion, nitrification-denitrification, and constructed wetlands offer significant benefits for nutrient or salt reduction, others are less relevant to these goals (e.g., solids separation, covers for ponds). It is important to note that the San Joaquin Valley study was unable to determine the environmental and economic performance of most of the technologies submitted because of insufficient scientific data and lack of testing on California dairies. The study also found that most of the technologies evaluated address only a limited portion of the environmental issues associated with manure. Finally, the authors of the study note that high costs associated with most of the technologies are a significant barrier to wider adoption of manure treatment technology, even when offset by the value of products—such as bedding, compost, fertilizer, and electricity—that result from treatment.

5.4.2 Candidate Practices

Candidate Practices of potential utility to San Jacinto dairies to meet the requirements of nutrient load reduction and salt management are presented below.

5.4.2.1 Management practices

These practices represent changes in dairy management and focus primarily on source reduction and prevention.

5.4.2.1.1 Precision livestock feeding


Feeding dairy cows

Livestock are generally inefficient in using P from their diet, and nutritional standards for livestock have historically provided more P than is necessary for animal health, growth, and lactation. The same is sometimes true for N and salts. The concentration of P in the diet of dairy cows has a significant effect on the P content of excreted manure, with higher manure P content resulting from excess P in the diet. Reducing the amount of P in manure by managing animal nutrition is a powerful, cost-effective approach to reducing potential P losses from dairy farms. The NRCS includes Practice 592 Feed Management in its *Field Office Technical Guide* (NRCS N.d.) and defines it as managing the quantity of available nutrients fed to livestock to supply the required quantity of available nutrients by livestock and poultry, while reducing the quantity of nutrients, especially P, excreted in manure by minimizing the over-feeding of these nutrients.

Applicability: Precision feeding is a management practice that could be adopted by all San Jacinto dairies.

Advantages: Reduces quantity of nutrients brought into the dairy and the watershed; reduces concentrations of nutrients in manure. To the extent that reduction dietary P and N content involves the reduction of purchased supplements, this practice could save money directly

Disadvantages: Purchasing lower-P feed may represent a low to moderate added cost; management effort may increase slightly

Cost: low

Table 5-10. Expected effects of different types of manure/wastewater treatment technologies

	Effects on wastewater						Effects on manure solids						Effects on air emissions							
Type of technology	Reduces organic N	Reduces ammonia N	Reduces P	Dissipates solids	Reduces TDS	Forms nitrate N	Reduces organic N	Reduces ammonia N	Reduces P	Reduces pathogens	Stabilize manure	Reduce manure volume	Reduces ammonia	Reduces VOC	Reduces methane	Reduces H2S	Reduces particulates	Reduces Odors	Produces CO	Produces NOx
Gasification	?	?	?	?	N	?	?	?	N	Y	Y	Y	Y	?	Y	Y	?	Y	?	?
Solids separation for wastewater	1	2	Y	N	N	N							N	N	N	N	N	N		
Composting							N	Y	N	Y	Y	Y	N[8]	N[8]	N[8]	N[8]	N[8]	Y	4	4
Anaerobic digestion in open ponds	N	N	N	Y	N	N							N	N	N	N	N	N		
Anaerobic digester with methane capture	3	N	N	Y	N	N	N	?	N	Y	Y	N	Y	Y	Y	Y	N	Y	?	?
Enhanced mixing of pond	N	N	N	Y	N	?							?	?	?	?	?	?	4	4
Aerobic digestion	Y	Y	N	Y	N	Y							Y	5	5	5	N	N	6	6
Nitrification-denitrification	Y	Y		?		Y							Y	Y	?	?	N	?	6	6
Constructed wetlands	9	Y	N	N	N	10							Y	Y	Y	Y	Y	Y	?	?
Storage covers for wastewater ponds													Y	Y	Y	Y	N	Y		
Biological additives for wastewater ponds	3	N	N	Y	N	N							?	?	?	?	N	?		
Desalination	Y	Y	Y		Y	N							?	?	?	?	N	Y	4	4

Legend: Y = yes N = no ? = unknown [shaded] = not applicable

1 Transfers some of the pollutants to manure solids
2 Releases some of the pollutants to the air
3 Could convert some organic N to ammonia
4 Minimal effect, if any
5 Will increase emissions
6 If diesel motors are used, it could increase emissions
7 Could increase emissions of particulates
8 Emissions can be reduced through air capture/treatment
9 If wetland plants are harvested
10 Nitrate is available for plant uptake.

Adapted from San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel 2005

Changes in feed formulation and management (sometimes referred to as precision feeding) can decrease the P content of manure by more accurately applying published P dietary requirements, more precise ration formulation, improved grouping strategies to decrease variation within groups of animals, and reduced feed waste. Together, such strategies can reduce the P content of dairy manure by 25 to 40 percent (Knowlton et al. 2004). While most research in dairy feed management has focused on P, some work has shown that precision feeding can reduce both N and P content of manure by 17 to 35 percent (Arriaga et al. 2009). Reducing the nutrient content of manure has two main benefits. First, reducing the nutrients in feed and manure reduces the quantity of nutrients available in the watershed for loss. Second, lower manure nutrient concentrations could increase the flexibility of nutrient management planning for land application of manure by reducing the land base required to assimilate manure nutrients.

5.4.2.1.2 Nutrient management

Crop irrigation and harvesting

Crop nutrients should be supplied in quantities that take into consideration the amounts needed to produce a reasonable crop yield, the amounts already present in the soil, and the amounts contributed by all nutrient sources, including commercial fertilizers, animal manure, irrigation water, and other sources. Nutrients should be applied using rates, timing, and methods designed to minimize losses to surface water and groundwater. Many provisions of nutrient management are included in the NRCS Conservation Practice Standard Code 590. Dairy operators in the San Jacinto River watershed that apply manure, litter, or process wastewater to croplands under their ownership or operational control are required by their permit (RWQCB Order No. R8-2007-0001) to develop and fully implement an approved, site-specific NMP following the guidelines of the NRCS 590 practice standard.

The specific elements of nutrient management vary by crop type, but they typically include these activities:

- *Nutrient and soil assessment*
    - Field maps
    - Soil hazards and limitations, e.g., slopes, erosion potential
    - Soil sampling and analysis
    - Analysis of irrigation water for nutrient contribution
    - Analysis of animal manure and other organic additions
- *Applying nutrients to croplands*
    - Application of amendments and organic materials to provide nutrients and improve soil quality
    - Methods of fertilizer delivery and placement to reduce the potential for surface runoff, dust, groundwater leaching, and volatilization of materials
    - Selection of materials considering all formulations of plant-available nutrients relative to the growth stage requirements of the plant
    - Calibration of equipment to deliver a known amount of material uniformly

    - Storage and handling of materials away from surface waters and in an area where spills can be easily cleaned up

- *Timing of nutrient applications* to coincide as closely as possible with the crop growth stage requirements and short-term weather conditions
- *Record keeping* to provide information used to evaluate management effectiveness and help refine ongoing nutrient management.

Effective nutrient management reduces the amounts of nutrients available on agricultural land to be washed into surface or groundwater, while providing for adequate crop growth. Note that careful nutrient management can help reduce or eliminate leaching of nitrates and other salts below the root zone as noted in Section 5.2 above.

Applicability: Nutrient management can apply to all San Jacinto dairies that have cropland

Advantages: Increases the efficiency of crop fertilization; generally reduces amount of nutrients applied to cropland. Reduces quantities of N and P available to be lost from cropland by runoff and leaching.

Disadvantages: Requires some increased management effort, soil, manure, and crop testing, and record-keeping, some of which could be done by an external crop consultant

Cost: low to moderate

5.4.2.1.3 Phytoremediation

Phytoremediation is defined as the use of plants for the extraction, immobilization, containment or degradation of contaminants. Research has revealed a number of plant varieties to be effective in reducing salt levels in soils in arid and Mediterranean environments. Salt-tolerant plants such as Saltwater cordgrass (*Spartina alterniflora*) and great bulrush (*Scirpus validus*) have been shown to be effective in treating even highly concentrated brine generated while producing oil and gas (Negri et al. 2003). To be cost-effective in agricultural systems, however, phytoremediation must involve plant species that have economic or agronomic value and the potential to remove salts from the soil.

Considerable research has been done on such applications of phytoremediation. These studies typically focus on removal of sodium from salt-laden soils to improve growing conditions and reduce crop salt stress. For example, a study in India found that sunflower removed large quantities of sodium, chloride, and sulfate (Bhatt and Indirakutty 1973). An Egyptian study identified several types of halophytes (salt-tolerant plants) as the most efficient of 15 wild plant species investigated at removing salt from soils (Shaaban and El-Fouly 2002). Southern California halophyte species are typically found in salt marshes and therefore are likely not good candidates for salt removal crops at San Jacinto dairies. More relevant is a 2002 study that found barley to have a higher salt-removal potential than alfalfa and two halophyte species in a Mediterranean environment (Cuartero et al. 2002). Purslane has been found to be effective at removing a significant amount of salt from saline soils in northern Uzbekistan (Hamidov et al. 2007) and Turkey (Kiliç et al. 2008). Similarly, researchers in California's Central Valley are investigating use of canola to reduce selenium levels in soils. The research also includes using the oil from the canola seeds to produce biodiesel. The seed meal by-product from the oil extraction is being evaluated for use as an organic source of selenium for dairy cow feed rations (Banuelos 2009). Researchers at the University of California–Berkeley are testing an agroforestry drainage water disposal system (Terry 2009). Agricultural drainage water is collected from one crop and then reused by supplying to a succession of crops, including Eucalyptus trees and other salt-tolerant crops, before being deposited in a solar evaporator for producing salt. By this means, drainage water is consumed totally, generating commercially useful crops, timber, and salt.

Phytoremediation appears to have potential to reduce the salt content of soils in an arid environment such as is found in the San Jacinto River watershed. However, research is needed to determine what species of crops can achieve the greatest salt reductions given local soils and climatic conditions, while providing economic return to producers. In addition, dairy operators must also determine how the salts removed from the soil in crop biomass would be managed. If crops are refed to animals on San Jacinto dairies, the TDS and nitrate removed from the soils would simply be recycled back into the wastestream, thereby negating the benefits of phytoremediation. Oilseed crops like canola or sunflower that allow for alternative end uses like biodiesel production might be a viable option depending on the processing costs and by-products. As in the Central Valley study, by-products of such processes could be explored as feed supplements—if the TDS and nitrate are substantially removed before refeeding—or for other beneficial uses. Other potential uses for the salt-removing crop might be as a carbon source for on-farm or regional composting operations if the compost ultimately will be marketed outside the watershed. Failing these, the crop could simply be hauled from the watershed. This option would be subject to the same considerations in terms of hauling costs and logistics as discussed in reference to manure hauling (see Section 5.4.2.1.6).

Canola

Applicability: Phytoremediation can apply to all San Jacinto dairies that have cropland and to other agricultural cropland that receives dairy manure or wastewater

Advantages: Removes salts from soils and wastes while providing economic crops; potential to export salts from the watershed for beneficial use; potential contribution to other processes such as biofuel production or composting

Disadvantages: Requires change in crops grown on dairies and other cropland; need to export accumulated salts to avoid re-application to San Jacinto soils

Cost: low to moderate

5.4.2.1.4 Waste amendment

Using amendments or treatments to immobilize P in animal waste or P already present in excess in soils could decrease the risk of soluble P losses from land application of manure. Materials rich in certain aluminum or iron oxides, such as alum and drinking water treatment residuals, can adsorb available P, converting P into less soluble and therefore less mobile aluminum- and iron-bound fractions. Such reactions could effectively reduce runoff losses of soluble P to surface waters by rendering a portion of manure P unavailable.

Published research, predominantly from regions of intense poultry production, has demonstrated that adding alum-based materials can substantially reduce soluble P in both manure and soils (e.g., Moore et al. 2000; Sims and Luka-McCafferty 2002). Depending on the quality of the specific amendment and the dose, treating manure has been shown to reduce soluble P concentrations in manure by 50 to more than 90 percent. Recent bench-scale experiments suggest that adding alum-based materials to dairy manure can reduce manure soluble P concentrations by up to 80 percent (Meals et al. 2008). Other amendments—including lime (calcium) and iron—have also been discussed for precipitating P in animal waste.

Amending manure before application would reduce the soluble P content of the manure, thereby preventing excessive enrichment of soils and reducing the quantity of P available for loss. Some reductions in available N concentrations have also been reported after manure amendment. However, the most important effect observed on N has been reduction of ammonia volatilization (e.g., Moore et al. 1995, 1998, and 2000). While this could be a benefit for air emissions and odor control in some circumstances, the net result could be to preserve a larger pool of N for subsequent conversion to nitrate, exacerbating the salt offset issue.

Applicability: Manure amendment can apply to all San Jacinto dairies; amendment of dairy wastewater applies only to dairies that store wastewater in a pond or other structure.

Advantages: Reduces P solubility of and therefore its availability for runoff or leaching from soils. Can reduce ammonia volatilization and may reduce odors.

Disadvantages: Net effects on N uncertain; might increase total N pool as ammonia loss is reduced. Small potential for metals addition and pH effects, depending on material used for amendment.

Cost: Low to moderate; use of water treatment residuals might involve no cost

5.4.2.1.5 Wash water minimization

One or two San Jacinto dairies employ a flushing system to wash accumulated manure and other waste from alleyways and other paved areas of their facilities. Most of the time, recycled water from wastewater ponds, rather than fresh water, is used for that purpose. On most dairies, water is also used for washing animals and for cleaning milking parlors and other areas of the facility. Minimizing the quantity of fresh water used in such processes will reduce the volume of water generated by the dairy requiring additional management. Furthermore, minimizing the volume of wash water generated could improve the cost-effectiveness of wastewater treatment conducted to meet salt offset requirements. However, reducing wash water volumes will reduce the quantity of P or salts to be managed in wastewater only by reducing the incoming salt load from the source water, and any net reduction in wastewater volume would be tempered by using recycled wastewater for flushing.

San Jacinto dairy wash pen sprinkler

Applicability: Wash water management applies only to the few San Jacinto dairies that employ a flushing system.

Advantages: Reduces volume of wastewater generated

Disadvantages: Net wastewater reduction may be lowered the more recycled water is used in flushing

Cost: very low

5.4.2.1.6 Manure Export

Cropland acreage within the San Jacinto River watershed is inadequate to handle all the nutrients from manure and process dairy wastewater generated by dairies in the watershed, especially if cropland acres overlying critical GWMZs are excluded (see Section 5.4.2.5). The P and N loads from

CAFOs and cropland can be reduced by spreading manure at agronomic rates as part of an approved NMP, but it is very unlikely that NMPs alone will achieve the CAFO and agricultural TP and TN load reductions needed to meet the TMDL targets for Lake Elsinore and Canyon Lake. However, P and N loads to Lake Elsinore and Canyon Lake can be reduced substantially if 90 percent of the dairy manure is hauled to locations outside the San Jacinto River watershed. TDS and nitrate loading and the 2012 salt offset deadline is another major challenge compounded by the large volume of dairy manure and wastewater generated in the watershed. Because most of the available technology for animal waste treatment and management will not substantially reduce either nutrients or TDS in dairy manure and process wastewater, manure or manure products must be exported from the San Jacinto River watershed to meet current and upcoming regulatory requirements.

Some fundamental questions associated with hauling must be addressed:

- How much must be hauled?
- Where to haul?
- When to haul?
- Who should haul and how?
- What should be hauled?
- What are the costs and returns of hauling?

How much?

The dairy discharge permit imposes clear boundaries on where and how manure and process wastewater can be spread within the San Jacinto River watershed and on lands overlying critical GWMZs. It is estimated from the nutrient mass balance (Section 5.4.2.5) that less than 10 percent of manure nutrients produced by San Jacinto dairies can be spread within the watershed under such constraints. Thus, about 90 percent of the manure produced in the watershed (more than 150,600 tons/year) must be handled in one of the following ways:

- Hauled outside the San Jacinto River watershed for land application as manure
- Digested, composted, or processed into an alternative manure product
    - Biosolids and compost are hauled outside the San Jacinto River watershed
    - Alternative products can be sold but not land-applied in the San Jacinto River watershed
- Hauled off farm as manure for processing at a central digester, central composting facility, or manufacturer of alternative manure products (see Section 5.4.2.1.6)
    - Products from processing (e.g., biosolids, compost) or manufacturing (e.g., cowpots) cannot be land-applied within the San Jacinto River watershed

Calf

Where?

An analysis of information reported by San Jacinto dairies in their 2008 reports and EWMPs shows that 3 dairies apply manure on the dairy, 19 haul to a location in Riverside County (assumed western Riverside County), one hauls to San Bernardino County (40 miles), and one hauls to Blythe on the eastern end of Riverside County (160 miles). Communication with dairy operators also indicates that hauling as far as the Bakersfield area (200 miles) has occurred. Backhauling to Utah (>300 miles), the source of most of the high-quality alfalfa hay trucked into the San Jacinto River watershed and an area where manure is needed for fertilizer, has been discussed by some dairy operators in the San Jacinto. Some of these distances greatly exceed the 50-mile maximum practical haul-zone considered typical for compost in an assessment of technologies to manage and treat dairy manure (San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel 2005).

Data from 2004 show approximately 108,000 acres of cultivated agricultural land in the Palo Verde Valley near Blythe (Barrows 2007). Principal crops by acreage are alfalfa (64,588 acres), cotton (11,865 acres), wheat and barley (6,448 acres), various vegetables (4,744 acres), grasses (4,910 acres), various melons (5,199 acres), miscellaneous field crops (4,717 acres), and citrus and orchards (2,811 acres). Approximately 400,000 acres of cropland are also in the Imperial Valley south of the Salton Sea, about 140 miles from San Jacinto (USDA 2007). This combined acreage (508,000 acres) is considerable when compared to the 60,000 acres of agricultural land in the San Jacinto River watershed (see Section 5.4.2.5), but the availability of this land for receiving San Jacinto dairy manure is unknown. Interest in receiving dairy manure and manure products from the San Jacinto River watershed will likely be dampened to some degree by reluctance to apply raw manure to food crops and the fact that manure is generated locally by livestock raised in both areas. Areas to the north of the San Jacinto River watershed are also potential destinations for San Jacinto dairy manure, but competition from Chino dairies and even Central Valley dairies might be significant. An assessment of available land, however, has not been performed. In the past, there was some discussion of hauling manure south to the Anza area, where there is demand for manure. Another factor that could reduce the capacity for San Jacinto dairy manure and manure products in the other areas is the potential that land application of manure could be restricted there by regulations similar to those in place in the San Jacinto River watershed, but that has not been explored.

California cropland

When?

Current regulations dictate to a large degree when manure must be hauled from San Jacinto dairies. Air quality Rule 1127 (Emission Reductions from Livestock Waste), requires that all dairies with more than 50 head (i.e., all San Jacinto dairies) remove manure stockpiles at least four times per year. More frequent manure removal and hauling, of course, is an option. If manure is hauled as a feedstock to a processing facility such as a digester, timing of hauling will need to match the requirements of the facility for a constant feedstock supply. The timing of manure hauling is particularly relevant if the manure is to be applied to cropland. Hauling manure from San Jacinto dairies must coincide with the need for manure by crop producers and their capacity to apply manure to their land. These issues are determined by the crops grown, tillage and harvest schedules, and weather.

Who and How?

Information from the 2008 dairy reports and EWMPs shows that 17 dairies contract out some portion of their hauling, while seven do at least some of their own hauling. Another option for hauling that is not employed in the watershed is cooperative hauling where a few or all San Jacinto dairies negotiate joint hauling contracts with customers or haulers to optimize transport patterns for the customers' benefit (e.g., a central composting or digester facility that needs a steady supply of raw material), achieve potential cost savings, and develop more secure contracts for the dairy operators. Because most San Jacinto dairies haul within Riverside County but will need to begin hauling to more distant locations, a cooperative venture might be more attractive in the coming years.

Back-hauling (sending manure back to a crop-producing area on trucks that bring forage or other commodities to the dairy) is used by at least one dairy operator in the San Jacinto River watershed as well as some other dairy operators in the region. Key considerations for back-hauling include

- Products (e.g., grain, hay) regularly coming into the dairy
- Labor and equipment needed for loading and transporting the manure on the back-haul
- Customers, demand, and capacity for the back-hauled manure or manure product
- Labor and equipment needed for delivery, unloading, and spreading at the destination
- Hauling distances to the various sources and customers on both ends
- Timing of hauling trips
- Assessment of and compliance with applicable regulations at both the source and destinations

Walking-floor trailers are well suited to the task of back-hauling because they provide automatic unloading of bulk materials (Keith Manufacturing 2009). A 45-foot-long, basic walking-floor trailer with a rollover-type tarp holds 70–80 cubic yards (yd^3) of material that can be loaded with a front-end loader (Drener 2009). These trailers work best with bulk products and can self-unload in 8-10 minutes. The operator will likely need to rinse or steam clean the trailer between loads when back-hauling different products.

Compost and composted biosolids should be both easier and less expensive to haul than manure because they are drier products with reduced bulk density. Regulations limit the gross vehicle weight to 80,000 pounds, leaving 56,000–58,000 pounds for the load after subtracting the weight of the tractor (18,000 lbs) and the trailer (14,000–16,000 lbs) (Drener 2009). Maximum weight capacity for dairy manure at 33 percent moisture with a bulk density of about 1,600 lb/yd^3 (USDA 1999) would fill half a trailer, whereas the trailer could be completely filled with composted dairy manure at a bulk density of 800 lbs/yd^3 (Rosenow and Tiry 2009). Assuming a bulk density of 1,600 lb/yd^3, it would take about 5,400 trailer loads (56,000 lbs each) to ship 90 percent of the 167,320 tons of manure produced each year by dairies in the watershed. Thus, on average, 15 trailer loads per day would be leaving the San Jacinto River watershed.

What to Haul and Costs

The preferred composition of the hauled manure or manure product depends primarily on the needs of the customer. The net profit or loss, however, depends on the unit cost to process the manure if needed; the unit cost of loading, hauling, and unloading the manure or manure product; and the unit price paid by the customer:

$$Net = UnitsSold \times (UnitPrice - UnitProcessingCost - UnitLoadHaulUnloadCost)$$

The goal for San Jacinto dairies will be to optimize their operation to export all manure at a maximum net profit. Thus, under optimal conditions the units sold (e.g., tons of manure) would equal the tons of manure that must be removed from the dairy to meet regulatory requirements. In simple terms, that becomes profitable when the unit price exceeds the sum of the unit processing cost and unit load/haul/unload cost. In this simple analysis, the manure itself is assumed to be produced at zero cost, the baseline condition.

Various practices described in this section have been demonstrated to change the water content or volume of manure (e.g., composting), and precision livestock feeding strategies have been shown to change the N and P content of manure. While changes in N and P content could appeal to customers and affect demand for the manure, changes in water content have a far more predictable effect on the unit cost of hauling the manure or manure product. For example, the information above on walking-floor trailers indicates that the cost of hauling each cubic yard of composted dairy manure is one-half the cost of hauling a cubic yard of fresh manure at 33 percent moisture content; the cost of composting the dairy manure, however, must be factored into the equation as well. Cost data for hauling are described in greater detail in Section 5.4.3.

San Jacinto dairies can use multiple strategies to export the manure that must be removed from the watershed, and the net cost equation above should be applied as a guide to help determine the best form of manure (raw or manure product) for each export strategy. Where multiple strategies are employed, such as a combination of hauling some raw manure locally to a central composting facility, hauling another portion of the raw manure for land application outside the watershed, hauling residuals from manure processing (e.g., digestion), and using the remaining manure for small-scale production of alternative beneficial use products on the dairy, it would be most appropriate to focus on the overall net cost rather than the net cost of each strategy used. While more complicated to manage, such a *mixed portfolio* of strategies might be less costly over the long term if the balance could be shifted to reflect changing costs of each strategy used. Such farm-based approaches to manure export are incorporated within a more holistic, watershed-scale discussion of approaches to address manure management in Section 5.5.

San Jacinto cropland overloaded with manure

The proposed Manure Manifest System described in Section 5.3 provides a framework that could help dairy operators manage the potentially complicated flow of manure and manure products from the dairies to the various customers. Under this system, CAFO operators would pay a hauling fee to the hauler according to the total amount of manure, with approval from the Manure Manifest System. CAFO operators would also pay a tipping fee (based on the amount of manure) for loads that are applied in the San Jacinto Basin, helping to create an incentive for alternative disposal options and export of manure to other watersheds. Note that CAFO operators outside the San Jacinto Basin that wish to have manure hauled into the Basin would be required to pay membership and tipping fees to the Manure Manifest System to offset administrative and regulatory costs associated with the manure imports.

Summary and Next Steps

Manure export is a central focus of the IRDMP because about 90 percent of the manure produced by San Jacinto dairies will have to be removed from the watershed in one form or another beginning in 2012. The complexities associated with finding customers, determining whether to export manure or manure products, making the best arrangements for hauling materials, assessing options for back-hauling, looking out for the competition, and seeking long-term agreements that minimize costs while achieving the needed level of manure export can intimidate even the best dairy manager. Market fluctuations will have the potential to change consumer demands for manure and manure products, and while dairy operators will need to have secure agreements to comply with air and water quality regulations, they will also need to maintain some flexibility to be nimble enough to avoid major losses and take advantage of major opportunities created by such markets.

Mechanisms to address manure export must be in place before 2012. To increase the likelihood of making the best decisions regarding hauling, dairy operators in the San Jacinto River watershed should address the following needs immediately:

- Assess the market for San Jacinto dairy manure (raw or processed) in Riverside County, the Palo Verde Valley, the Imperial Valley, and areas north of Riverside County.
- Assess the market for alternative beneficial use products, and determine the cost and feasibility of incorporating these options in hauling plans.
- Assess back-hauling needs and opportunities for back-hauling manure to remote locations such as the Palo Verde Valley, Imperial Valley, and areas north of Riverside County.
- Consider a cooperative effort among San Jacinto dairies to negotiate contracts with customers.
- Consider a cooperative effort among San Jacinto dairies to negotiate contracts with haulers. Alternatively, explore options to purchase/rent trucks and trailers for hauling in a cooperative effort.
- Consider investing in a detailed cost and feasibility analysis such as the one performed to determine the feasibility of regional anaerobic digesters in California (Hurley, et al. 2006). The regional manure management model is another useful example that could possibly be applied to the San Jacinto River watershed (Aillery, et al. 2005; Aillery and Gollehon 2005).

While hauling is a very important aspect of addressing the objectives of the IRDMP, it is important that decisions regarding hauling be made within the greater context of the watershed-scale recommendations described in Section 5.5.

Applicability: Manure export potentially applies to all San Jacinto dairies, individually and collectively.

Advantages: Removes manure nutrients and salts from the watershed; uses manure nutrients responsibly

Disadvantages: Locating receiving land/sites is challenging; threat of pathogen contamination could affect marketability of raw manure and some compost; some logistical issues in shipment; likely to be expensive

Cost: high

5.4.2.1.7 Beneficial Use Products

A step beyond simple exporting raw manure from the San Jacinto River watershed is to use dairy manure in manufacturing beneficial use products that could combine export of some manure with an economic return for the producers. Composting (see Section 5.4.2.2.4 below) is a large-scale example of this concept, but smaller-scale, value-added products for the retail market might fill a different niche in the effort to manage manure nutrients and salts in the watershed.

Several examples of existing products derived from dairy manure illustrate the potential of this approach:

- ***Cowpots™*** http://www.cowpots.com/
  Cowpots are manure-fiber-based seed starter pots, made with biodegradable, composted cow manure. The manufacturing process removes weed seeds, pathogens, and odors. The pots are marketed as an alternative to plastic and peat pots.
- ***Poopoopaper™*** http://www.poopoopaper.com/
  Poopoopaper is paper made from processed manure from a variety of animals, including elephant and cow. The dried manure is rinsed in water, leaving the undigested fibrous materials, boiled, and mixed with other natural fibers to manufacture a variety of paper products.
- **Additives for structural materials** http://www.fpl.fs.fed.us/video/video_fiberBoard.html
  Fiber from digested dairy manure is being investigated as a possible source for engineered composites for a variety of applications including building materials. Research by the USDA Forest Products Laboratory has shown it is possible to make composite panels using a variety of methods. Winandy and Cai (2008) determined that a 50/50 mixture of wood fiber and digested manure fiber compared favorably with commercial requirements for wood-based, medium-density fiberboard and particleboard. Rowell et al. (2007) proposed the incorporation of dry dairy manure as a reinforcing filler in plastic composite materials. The Forest Products Laboratory continues to conduct research to determine engineering and economic feasibility of using this fiber source. A small fabrication facility might be co-located with a farm or cooperative such that there are integral benefits for both the farm and the panel fabrication facility. While the size and product production are yet to be determined, the amount of fiber and nutrients captured by the process for composite panel production could be significant relative to both fibers and nutrients.
- ***Poopets™*** http://www.gardengazebo.com/poopets
  Poopets are handmade, sculptural garden ornaments made from compressed, dried manure. The *poopet* is placed in a flowerbed or planter and rainfall or irrigation water slowly dissolves the nutrients into the soil.
- ***Cowpeat™*** http://www.cowpeat.com/
  Cowpeat is a specialized compost product produced using separated cow manure solids with less than 60 percent moisture in a rotating drum digester. The resulting compost resembles peat and is free of weed seeds and pathogens; cowpeat is intended to replace soil and peat (a regulated and increasingly scarce resource) as a commercial potting medium.

Manufacture and sale of such manure-based products would help export manure out of the watershed, provide an income stream to the producers, and demonstrate a commitment to renewable resources and sustainability on the part of the dairy industry. Sales of such products could be one tool to be applied as part of the overall management of manure nutrients and salts in the San Jacinto River watershed.

It must be noted, however, that the real effect of such beneficial use products on the problems facing dairies in the San Jacinto River watershed is likely to be very small. With a *poopet* and a 12-pack of 4-inch *cowpots* each weighing in at less than 1 lb., an enormous marketing and sales effort would be required to export a significant quantity of manure nutrients and salts out of the watershed. Furthermore, an intensive washing process like that used to manufacture *poopoopaper* would very likely remove most of or all the soluble nutrients and salts from the manure, exporting a minuscule quantity of nutrients and salts from the watershed and leaving most of the original manure components in a residual waste that would still require management.

Applicability: Can apply to all San Jacinto dairies

Advantages: Removes some manure nutrients and salts from the watershed; produces income through sales of a value-added product; demonstrates dairy industry commitment to sustainable practices.

Disadvantages: Probably involves a tiny fraction of manure nutrients and salts requiring management or export from the watershed; requires aggressive marketing and sales efforts

Cost: unknown; possible income stream from sales

5.4.2.2 Structural practices

Structural practices focus primarily on treatment of dairy wastewater and manure to reduce its nutrient or salt content, to improve its handling characteristics, or to obtain some other benefit.

5.4.2.2.1 Pond lining

Geosynthetic pond liner

All storage ponds on San Jacinto dairies are unlined, in part to promote infiltration of stored wastewater or stormwater runoff. Lining ponds with an impermeable membrane would prevent infiltration of wastewater and associated TDS and nitrates and protect the groundwater. If ponds were lined, however, dairies would have to rely on evaporation alone for removal of stored water. For some dairies, all facility wastewater could be evaporated from existing ponds; for others, expansion of pond surface area would be required. In the example shown in Table 5-11, the average annual net evaporation (pan evaporation minus precipitation) in San Jacinto is assumed to be 65 in/yr. Evaporation from the small wastewater pond of Dairy M could account for just under half of the wastewater the dairy generates annually, whereas the larger pond area of Dairy S could evaporate all facility wastewater several times a year.

Table 5-11. Example annual evaporation potential for different size ponds

Dairy	ww pond area (ac)	ww volume (ft^3/yr)	Net evaporation loss (ft^3/yr)	# of ww volumes evaporated/yr
M	1.8	9.4×10^5	4.2×10^5	0.45
S	18.2	1.6×10^6	4.3×10^6	2.9

Some constraints apply to this concept. First, average annual values do not consider extreme short-term conditions; lined wastewater ponds would need to be sized to account for both facility wastewater and input from a design storm at the same time, without infiltration losses. Second, similar calculations would be required for ponds designed to contain facility runoff and stormwater with appropriate freeboard at any given time. Some dairies might have adequate capacity for this purpose; others might need to construct additional storage.

Pond liners can consist of synthetic membranes or a layer of compacted clay. Installing a clay liner can cost as much as \$1.84/ft^2 (\$80,000 for a 1-acre pond); plastic liners are slightly less expensive at \$1.60/ft^2 (\$70,000 for a 1-acre pond) (Tetra Tech 2000); operation and maintenance is estimated to add 5 percent to liner costs. Expansion of pond capacity would involve additional earth moving at \$2–\$3/yd^3 (Tetra Tech 2002).

Applicability: Applicable to all San Jacinto dairies that manage their wastewater in ponds; some dairies with limited land area and small pond surface area might not be able to evaporate all their wastewater.

Advantages: Reduce or eliminate the volume of wastewater requiring disposal

Disadvantages: No net effect on salts or nutrients. Dairies with small pond surface area might need to expand the surface area of stored wastewater management while maintaining required stormwater capacity could be challenging.

Cost: high

5.4.2.2.2 Wastewater treatment

In the San Jacinto River watershed, most dairies contain the wastewater generated in milking, cleaning, stormwater runoff, and other processes in ponds or lagoons within their facilities. In some cases, the wastewater could be later land applied either for crop irrigation or for disposal. In other cases, the dairy depends on infiltration and evaporation directly from ponds for disposal of the wastewater. As noted in section 5.2, salt offset requirements will prohibit or severely restrict land application or infiltration of dairy wastewater because of excessive salt and nitrate loads to groundwater.

One approach for dealing with such restrictions or to manage nutrients is to treat the wastewater to modify or reduce its salt and nutrient content before it reaches the land. Several options are available for dairy wastewater treatment.

- **Anaerobic ponds.** Wastewater ponds that continuously contain liquid can be considered to be functioning as anaerobic waste stabilization ponds. These ponds tend to be anaerobic because the decomposition of organic material consumes oxygen as rapidly as it can be taken up from the atmosphere. While such ponds are generally effective at reducing biochemical oxygen demand (BOD) and TSS, they do little for salts or nutrients, with the exception of mineralization of organic N to ammonia-N. Increases in ammonia-N can reduce the total N content of the waste through volatilization loss of ammonia, although this could represent a significant air quality concern. Mineralization is also a step in the process of converting organic N to nitrate, so further treatment would be necessary to address nitrate loading issues.
- **Pond aeration.** Oxygen can be introduced into dairy lagoons to assist in the digestion and stabilization of organics and minerals or to reduce odors and, potentially, to reduce nitrogen. The interest in aerating dairy lagoons in California has been primarily to provide an economical way to control odors. Providing adequate oxygen supply will promote nitrification (conversion of ammonia N to nitrate N) but the resulting nitrate N will require further management. Aeration has no effect on P in wastewater.

- **Multi-pond systems.** Wastewater ponds can be upgraded to provide better treatment, including nutrient reduction. Mechanical aeration (by agitation or pumping air into the pond) can add oxygen and promote nitrification (transforming ammonia-N to nitrate-N); however the nitrate-N continues to pose a problem for disposal and aeration does little for other wastewater constituents. Craggs et al. (2003) tested a multiple pond system for treating dairy wastewater that included four ponds in sequence with different conditions designed to optimize natural treatment processes. An important component of this system was a shallow mixed pond where algal growth was promoted for nutrient uptake. The tested system achieved a 68 percent reduction in TSS, an 81 percent reduction in TKN, and a 43 percent reduction in total P concentrations. Lansing and Martin (2006) tested a small-scale, multi-pond *ecological treatment system* composed of a series of anaerobic and aerobic reactors, clarifiers, and wetlands. The system promoted biological removal of both N and P by including alternating anaerobic and aerobic reactors which, for example, promote first nitrification from ammonia-N to nitrate-N (an aerobic process), then denitrification of nitrate-N to N gas (an anaerobic process). The system was able to treat dairy wastewater with over 99 percent removal of ammonium-N and BOD and 79 percent removal of soluble P. Nitrate-N was produced, then removed from the wastewater, leaving an effluent nitrate concentration of 0.5 mg/L. Note that this pilot-scale system treated only ~10 percent of the dairy's wastewater and needs further testing at full scale.

  Vanotti and Szogi (2009) reported on a full-scale test of another multi-pond system for treating swine waste. The system combined liquid–solids separation with N removal by nitrification/ denitrification and P precipitation to remove 98 percent of TSS, 76 percent of total solids, 100 percent of BOD_5, 98 percent of TKN and NH_4–N, 95 percent of TP, and 51 percent of EC. The high treatment efficiencies were consistent over a 2-year period under all weather conditions and variations in manure over typical livestock growth cycles.

  San Jacinto dairy wastewater pond

  Denitrification, such as that provided through multi-pond systems, is essentially the only pathway for true N removal from dairy manure and wastewater other than by crop uptake and harvest or ammonia volatilization. Note that denitrification produces the same inert N gas that composes 80 percent of our atmosphere and, therefore, does not represent a significant air quality concern.

- **Mechanical treatment.** Numerous mechanical treatment systems have been developed for wastewater, primarily aimed at P removal, bedding recovery, and decreasing disposal costs by concentrating wastewater constituents. Screening and mechanical separation of solids from liquids or slurries, for example, are used to concentrate solids and soluble nutrients. Unfortunately, most of these systems are applied to flush dairies or facilities in other climates that handle waste as a slurry; such systems are not widely applicable to the dry-lot dairies of the San Jacinto River watershed. Some simple devices such as gravity screens and weeping walls are used in the region to collect solids from wastewater before lagoon storage.

Relatively simple dewatering technology using *Geotube*™ containment systems (permeable geotextile bags) can capture solids from dairy wastewater (Mastin and Lebster N.d.).

- **Chemical treatment.** Both particulate and dissolved constituents can be removed from wastewater by chemical precipitation. Vanotti et al. (1996), for example, reported 80 percent removal of TSS, N, and P from dilute swine wastewater by adding polyacrylamide (PAM). Although nutrients precipitated by chemical treatment are removed from the wastestream and are relatively insoluble, the residuals from chemical treatment will require management and disposal and could be subject to regulatory requirements.
- **Constructed wetlands.** Wetlands have been used for advanced treatment of municipal wastewater in the United States and around the world for nearly 40 years. Compared to mechanical systems, constructed wetlands can have lower construction, operation, and energy costs and more flexibility in pollution removal (Hunt and Poach 2001). Plants are, of course, a major component of constructed wetlands and facilities for animal wastewater treatment typically contain a variety of submerged, floating, and emergent plants. Oxygen transported from plant leaves and stems to roots provides an oxidized environment within the anaerobic root zone that is critical to treating the wastewater. Aerobic zones contribute to nitrification of ammonia to nitrate, while the anaerobic zone can provide for denitrification of nitrate to N gas. Nitrogen removal in constructed wetlands occurs through filtration, sedimentation, uptake by plants and microorganisms, adsorption, nitrification-denitrification, and volatilization; ammonium can be absorbed by plants or microorganisms or immobilized in soil, while gaseous loss of N through denitrification is generally the most significant N removal mechanism. Phosphorus removal occurs through sedimentation, plant uptake, organic matter accumulation, soil sorption, and immobilization. Very high levels of treatment have been reported in constructed wetlands: BOD 66–93 percent, TSS 0–94 percent, NH_3-N, 54–89 percent, TKN 37–86 percent, TP 43–83 percent, and bacteria 90–99 percent (Hunt and Poach 2001). Note that constructed wetlands are a USDA-NRCS-recognized practice with standards and specifications for design, construction, and maintenance (Conservation Practice Standard Code 656 in the *Electronic Field Office Technical Guide* (NRCS N.d.)).

  Some important constraints exist on wastewater treatment by constructed wetlands. Because most systems cannot tolerate high solids loading, solids separation of the inflow is essential. Maintaining aerated zones depends on the oxygen demand of the incoming wastewater (which is likely to be high for dairy wastewater) and could be a challenge in high temperatures, such as those often experienced in the San Jacinto River watershed, where oxygen solubility in water is low. Ammonia can be lost from the system through volatilization, especially if low oxygen limits nitrification; that could lead to ammonia accumulation in surrounding areas. Finally, there is some evidence that the performance of constructed wetlands for wastewater treatment can decline over time; periodic maintenance such as sediment removal and replanting vegetation might be required.

  A wetland-based treatment system using floating treatment wetlands called *BioHavens* (http://www.floatingislandinternational.com/fi_pages.php?name=m40) can be highly applicable to dairy wastewater ponds. These floating islands function as constructed wetlands but do not require additional land area or water supply.

In sum, dairy wastewater treatment could afford significant opportunities to reduce the nutrient and salt content of dairy wastewater. It must be recognized that, except for removal of N by volatilization or denitrification, wastewater treatment in ponds or lagoons on a dairy will leave a residual or by-product containing most of the constituents removed from the wastewater. Even if the treated wastewater is of a quality that is acceptable for land application, the residuals will require proper management and might need to be collected and removed from the dairy for disposal elsewhere, possibly with solid manure.

Applicability: Treatment practices can apply to individual San Jacinto dairies that store wastewater in a pond or other structure. Multi-pond and constructed wetland systems require additional space that might prevent consideration on some facilities.

Advantages: Some treatments can promote N removal by denitrification. Chemical treatment can concentrate nutrients and reduce their solubility, improving handling characteristics

Disadvantages: Residuals from chemical treatment require management/disposal. Operating multi-pond and constructed wetland systems requires water and energy inputs, a high degree of management, and some regular maintenance.

Cost: moderate (aeration, chemical treatment) to high (multi-pond, wetland)

5.4.2.2.3 Digestion

Anaerobic digestion is the process by which organic materials in an enclosed vessel are broken down by microorganisms in the absence of oxygen. Anaerobic digestion produces biogas consisting primarily of methane and carbon dioxide, containing about 60 percent of the energy value of the same amount of natural gas. Depending on the system design, biogas can be burned as a fuel in a boiler or furnace, used to run a generator producing electricity and heat, or cleaned and used as a natural gas replacement. Digestion produces a liquid or semisolid effluent that contains all the water, all the N, P, and other minerals and approximately half of the carbon from the incoming materials.

Three main temperature ranges exist for anaerobic digestion systems:

- **Thermophylic (120–140 °F)** systems operate at a high temperature; micro-organisms rapidly break down organic matter and produce large volumes of biogas. The quick breakdown means that the digester volume can be smaller than in other systems (average retention times in the range of 3–5 days). Thermophylic systems are more effective in pathogen removal than other types.
- **Mesophylic (95°C–105 °F)** systems need a longer treatment time (retention times of at least 15–20 days or more) for the lower temperature microorganisms to break down organic matter. Mesophylic systems are generally more tolerant of temperature variation than other types.
- **Psychrophylic (60–80 °F)** systems operate at lower temperatures, are very stable and easy to manage, but require longer retention times to achieve gas production and pathogen removal comparable to other systems.

Three types of anaerobic digestion systems are commonly used to process livestock waste: *covered lagoons,* where an existing anaerobic lagoon is covered to capture biogas that is already being generated, *plug-flow systems,* which consist of long channels in which the manure and other inputs move along as a batch, and *completely mixed systems,* wherein fresh material is continuously mixed with partially digested material in a large tank, and. Plug-flow systems are suitable for thick materials with 11–13 percent dry matter or more, while continuous flow systems are appropriate for wastes with lower dry matter content, although material with high dry matter content can be digested in a continuous system if the liquid effluent is recirculated.

The covered-lagoon, plug-flow digester, and continuous stirred tank reactor (CSTR) are three types of digesters recognized by the USDA-NRCS in its national guidance. Covered lagoons are typically earthen impoundments fitted with a floating cover that contains the biogas that is produced. Biogas yields are usually less than with other types of digesters, but capital costs are generally lower. The basic plug-flow digester design is a linear trough, often built below grade, with an airtight expandable cover. Plug-flow systems are simple, relatively inexpensive to build and operate, and are adaptable to small- and large-scale operations. The CSTR digester is typically a large, circular container made of poured-concrete or steel and can handle organic wastes with a solids range of 3 to 10 percent. Unlike other digester systems, materials in a CSTR digester are continuously mixed by pumps, mechanical stirring, or gas recirculation to prevent solids settling and to increase the rate of digestion. Consequently, energy is required to run the mixing equipment.

Anaerobic digestion systems can be built and operated at a single-farm scale or in centralized systems that process wastes from many farms hauled to a single location. Single-dairy digesters can sell generated electricity back to the power grid through net metering. California incentives for renewables and efficiency permit up to 1 megawatt (MW) of electricity (10 MW for up to three biogas digesters) to be credited to customers' next monthly bill at retail rate (DSIRE 2009). After 12 months, a customer could opt to have net excess generation roll over indefinitely or to have the utility pay for any net excess. Demand for net-metered generation is expanding; Pacific Gas & Electric (PG&E) recently raised its cap on the aggregate capacity of net metered systems from 2.5 percent to 3.5 percent of its peak demand.

Note that permitting manure digesters could present major challenges for individual dairy operators and for regional facilities. Competing and evolving regulations from air and water quality agencies have raised expenses and slowed development of manure digesters in other parts of California (Merlo 2009a).

Hurley et al. (2006) studied the feasibility of central anaerobic digesters for biogas/energy production in California's Central Valley. The authors concluded that a 10-MW facility would be economically feasible at a minimum price of $0.0925 per kilowatt-hour (kWh) for electricity if privately financed with 50 percent of eligible dairies participating. With public funding and 100 percent participation of surrounding dairies, the price necessary to make a digester economically feasible would drop to $0.05 per kWh of electrical generation. Both of those scenarios would require dairies to employ scrape systems for manure management; nearly all San Jacinto dairies already use such systems. Local electricity costs are probably high enough to make a digester cost-effective; in May 2009, customers in the Los Angeles-Riverside-Orange counties region paid an average of $0.193 per kWh, 53 percent more than the U.S. city average (U.S. Department of Labor 2009).

Alternatively, biogas from manure digestion can be fed directly into utility natural gas pipeline. A number of California dairies are participating in digester systems that capture methane, process it through scrubbers, and inject the renewable natural gas directly into the PG&E natural gas pipeline (Merlo 2009b). The dairies not only receive income from the sale of natural gas to PG&E, but also earn carbon credits and reduce their greenhouse gas emissions. Additional information on incentive programs that might apply to energy from manure digestion is available through the California Public Utilities Commission's Self-Generation Incentive Program (http://www.cpuc.ca.gov/PUC/energy/DistGen/sgip/).

SeaHold, LLC prepared waste revenue projections for technology development options as part of the grant that funded the IRDMP. That report, which focuses primarily on the revenue potential for anaerobic digesters in the San Jacinto River watershed, is in Appendix M.

The Inland Empire Utilities Agency (IEUA), a municipal water district serving the Chino Basin developed a manure digestion demonstration project using anaerobic digesters to produce biogas in a centralized facility processing manure from 14 dairies in the Chino Basin. The project includes two digesters: RP-1, a complete mix, mesophilic and thermophilic digester; and RP-5, a mesophylic plug-flow digester. While in operation, the process generated 400,000 to 600,000 cubic feet/day of methane gas (biogas) used to operate electrical generators. An analysis of baseline and post-digester emissions (Bartram and Barbour 2004) showed that greenhouse gas emissions were reduced by 58 percent (8,281 tons CO_2-equivalent/yr) by digesting manure at the centralized facility. Following the anaerobic digestion process, the solids or biosolids are dewatered by rotary presses and subsequently disposed of by land application or made into compost at the Inland Empire Regional Composting Facility (see below). At the time of this plan, the digestion facility is not operational because of regulatory issues, coupled with declining milk prices (see Section 5.5).

Other possible approaches to biogas generation from anaerobic digestion of manure include co-digestion with urban solid waste (Mettler 2009) and the use of collected and compressed biogas as vehicle fuel. A California dairy recently became the first dairy in the United States to produce compressed biomethane for use as vehicle fuel (Richardson 2009).

The digestion process removes only carbon, hydrogen, and water from the feedstock; the residuals from digestion contain all the N, P, and trace materials of the original manure. However, some potential benefits of manure digestion to dairies include direct economic return (through energy recovery or through investment credits) and improved waste handling. Digestion for biogas, for example, reduces waste volume; ~1.1 kg of mass is removed from digester effluent per m^3 of gas produced. Pathogen content and odor production are also reduced through digestion. However, it must be clearly noted that the effluent from digestion from biogas will present the same management challenges with respect to nutrients and salts as the raw wastestream. Furthermore, the solid material that accumulates in the bottoms of anaerobic lagoons is highly enriched in P and would, therefore, require careful management, especially if land-applied. This material is highly compostable, although plug-flow systems generally produce a residue that is 92 percent moisture, increasing hauling costs relative to the raw dairy manure that has 88 percent moisture content (Wright 2001).

Applicability: Digestion can apply to all San Jacinto dairies; digestion is much more likely to be economically feasible at a multi-dairy or regional scale than for individual dairies

Advantages: Reduces mass/volume of waste for subsequent management. Generates energy and income stream that could offset other management costs

Disadvantages: Has no net effect on nutrients and salts in dairy wastestream. Technically demanding; regional or multi-dairy facilities require transport of waste feedstocks. Dairies may recover less than 100 percent of benefits, but could be responsible for all residuals; permitting could be challenging

Cost: High (offset by returns on biogas and energy generated)

5.4.2.2.4 Composting

Composting is the aerobic microbiological degradation of manure or other organic materials in a thermophilic temperature range (104–149 °F). The resulting composted material is odorless and low-moisture. Composted manure is a value-added soil amendment that can be a source of income when sold in local or regional markets. High temperatures during composting kill manure microorganisms, largely eliminating the risk of contaminating crops with pathogens where composted manure is land-applied. Because it reduces the volume and weight of manure, improved handling characteristics of compost can be an important element of exporting manure from a region. Green waste can be added to manure to improve composting efficiency.

For example, a study of co-composting of dairy manure with green waste in the Central Valley used dairy manure at 61 percent and green waste at 32 percent moisture content to create a finished compost at 29 percent moisture content (Hughes and Dusault 2005). Composting reduces the mass and volume of manure by 50 percent or more, while P content remains essentially the same (Aldrich and Bonhotal 2006). Nitrogen losses of 50 percent or more can occur, however, through volatilization of ammonia N (created by decomposition of organic N) and conversion of organic N to nitrate followed by leaching. Other research has shown manure N losses of 2–38 percent during composting, with an initial carbon to nitrogen (C:N) ratio of greater than 40 resulting in nitrogen losses less than 10 percent (Michel et al. 2004). That same research showed that composting can reduce the volume and weights of material to be hauled by 50 to 80 percent based on equivalent nitrogen values of the stabilized compost as compared to unamended, raw dairy manure. In simple terms, then, the effects of composting on hauling costs can range from cost-neutral to a reduction of 50 percent or more according to N content.

The main disadvantages of composting include loss of nitrogen and other nutrients and air quality issues, predominantly volatilization of nitrogen and release of large quantities of CO_2. Emissions of ammonia and volatile organic compounds (VOCs) from the composting area might need to be controlled. Dairy manure composted in open windrows would emit less ammonia and VOCs compared to manure that is naturally degraded. Biofilters can be incorporated into the compost process and can reduce emissions of ammonia and VOCs by 90 to 95 percent. If manure composting includes wastewater solids and corral manure, composting generally requires solids separation as a pretreatment, which means that a significant portion of the nutrients and salts do not enter the composting process and must be managed separately.

California on-farm and co-composting regulations allow composting by individual dairy operators (San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel 2005). A dairy in California that sells or gives away less than 1,000 cubic yards of compost annually made exclusively from on-farm materials is not subject to the California Integrated Waste Management Board's (CIWMB's) permitting requirements. Dairies that sell or give away more than 1,000 cubic yards of such compost must notify the local enforcement agency that regulates waste disposal activities, but no permit is required. However, the state's minimum standards and annual inspections apply as described in the California Code of Regulations, Title 14, Section 17856. CIWMB regulations allow a considerable amount of municipal green material to be brought on the dairy for composting. If less than 1,000 cubic yards of compost is sold or given away, there is no limit on the amount of municipal green material that is used. If the 1,000 cubic yards limit is exceeded, the dairy can compost up to 12,500 cubic yards of green material on-site at any one time. Under both scenarios, the dairy would be required to notify the local enforcement agency and comply with the state's minimum standards and annual inspections.

Compost

Co-composting of manure with green waste (leaves, grass clippings and yard trimmings) could represent an opportunity to partner with nearby urban areas to address common waste management issues. Because of state recycling mandates (such as AB 939), green-waste composting can be an important means to reduce the volume of waste entering landfills. Green-waste, compost-nutrient content can be enhanced by adding dairy manure, improving the market value of the final compost product. The feasibility of co-composting depends largely on proximity to urban areas, where sources of green waste and markets for compost coincide. A study in the Central Valley determined that adding manure to green-waste compost increased the nutrient value of the final product and was economically feasible in an area where both manure and green-waste sources were in close proximity to a landfill and population center (Hughes and Dusault 2003).

The Inland Empire Regional Composting Authority (IERCA) operates the nation's largest indoor biosolids composting facility, in Rancho Cucamonga, California. The $62.5 million facility uses the aerated static pile (ASP) composting process where air is forced through loosely piled organic feedstocks such as biosolids, manure, and green waste. Exhaust air is cleaned through a biofilter to control odor emissions and meet air quality regulations. Every year, the IERCA produces approximately 250,000 cubic yards of high-quality compost.

The direct cost to the dairy operator of composting dairy manure will be greater than the cost of directly applying manure to land, or hauling the manure off-site. Composting on a dairy requires equipment, labor, and management, and an on-farm composting system could easily exceed $100,000, depending on the equipment purchased (San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel 2005). A large, enclosed, ASP composting system with a biofilter could cost several million dollars. Depending on the composting system used, composting could still be one of the lower-cost manure management technologies available. Adding a fee for bringing municipal green material or manure or both from other dairies on-farm for composting and income from selling of compost could improve the economics of a compost operation.

Applicability: Applicable to all San Jacinto dairies; might be most cost-effective as a multi-dairy or regional facility. Linkages to urban waste generators possible.

Advantages: Stabilizes manure and reduces bulk; results in a potentially value-added product. Potential inclusion of urban green wastes.

Disadvantages: No net effect on nutrient or salt content of waste; volatilization losses could pose air quality issue. Requires market for product.

Cost: moderate to high

5.4.2.3 Innovative practices

The practices discussed in this section represent innovative measures developed through research or proposed by private enterprise. Some of the measures such as the VSEP system, are supported by research and testing; others such as manure to fuel processes are more speculative. Few if any of these practices are yet supported by thorough cost analyses. Most of these practices will require additional development and testing before application in the San Jacinto River watershed.

5.4.2.3.1 The Vibratory Shear Enhanced Processing (VSEP®) system

The San Jacinto Basin Resource Conservation District, as part of the grant that funded the IRDMP, funded a project to demonstrate the liquid/solids separation capabilities of a patented VSEP membrane filtration system for removing suspended and dissolved nutrients (primarily salts and nitrates) from dairy wastewater (Stowell and Sommer 2008). The VSEP system uses an array of vibrating RO membranes to separate and concentrate all suspended solids and most of the dissolved solids in the wastestream to produce clean, safe water for reuse as cattle wash and possibly drinking water. The technique also has the potential to contribute to salt offset from dairy wastewater. The project results provide the operating parameters to size a full-scale system and performance data from the BMP pilot system to be used for evaluating its cost-effectiveness.

Laboratory testing provided data on optimum membrane type and operating parameters, while confirming that approximately 80 percent recovery of feed water from the feed volume and 96 percent reduction in conductivity (4,660 µm to 186 µm) could be achieved. Operating data from a pilot test on a San Jacinto dairy confirmed the ability of the VSEP to separate 80 percent of the feed volume as clean permeate while concentrating feed suspended and dissolved solids to a significantly reduced volume of high value concentrated nutrients. TDS concentrations in permeate were 210 mg/L from the first stage of treatment and as low as 44 mg/L from the final stage. Nitrate levels were reduced to less than 5 mg/L.

VSEP Pilot Project

While the results of the VSEP pilot testing appear to hold promise in treating dairy wastewater both to provide clean water to reuse and to reduce salt loading from dairies, no cost analysis has yet been conducted. The next step would be to conduct a full-scale cost analysis to determine if the process is feasible for a dairy.

Applicability: Applicable to all San Jacinto dairies

Advantages: The VSEP process removes high percentages of salts and nitrate from the wastewater

Disadvantages: Requires substantial technical expertise. Costs and full-scale operational capability unknown; residuals must be managed or disposed of.

Cost: Unknown, but probably very high

5.4.2.3.2 Comprehensive Nutrient Management Planning

The USDA's Agricultural Research Service, U.S. Salinity Laboratory conducted a 3-year study of the performance of a cropland NMP using dairy wastewater on the Scott Brothers Dairy in San Jacinto (USDA-ARS 2009, Section 3.2.1, Appendix C). Applying dairy wastewater to cropped soils could provide a beneficial use for wastewater nutrients, but it poses a potential environmental threat to groundwater resources and a potential impairment of soil quality.

CNMP Pilot Project test site

Although the project did detect an increase in salts in the soil profile after implementing the NMP, the salt accumulation was mainly in the upper soil layers or in areas where poor crop growth enhanced deep water percolation. The study revealed the importance of detailed knowledge of soil, wastewater, water sources, and crop growth characteristics, all of which vary in time and space. The transport potential of salts, nutrients, and microorganisms downward through the soil profile can be significantly reduced by minimizing water leaching below the root zone and surface water runoff. That can be achieved by precisely estimating evapotranspiration, uniform application of wastewater; and selecting water application timing and quantities on the basis of considerations of soil permeability and evapotransipiration. Such considerations could become part of the NMP required for dairy cropland in the San Jacinto River watershed.

Applicability: Applicable to San Jacinto dairies with cropland

Advantages: Implementing an NMP of the kind in the USDA study can recycle wastewater nutrients and salts, improve crop growth efficiency, and help control TDS and nitrate leaching to groundwater.

Disadvantages: Requires substantial site characterization and monitoring, as well as technical expertise. Costs unknown; some TDS and nitrate leaching could still occur.

Cost: Unknown, but probably high

5.4.2.3.3 Other treatments

A variety of innovative measures have been proposed to treat or process dairy wastewater or manure for a variety of purposes. Some of the measures might help directly protect surface or groundwater quality, while others extract some benefit from the waste and in the process change or improve handling characteristics that could facilitate other management.

It is impossible to list and discuss all dairy manure/wastewater treatment technologies that have been proposed by numerous research or business enterprises. The San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel (2005) evaluated the effectiveness of 44 different proposed technologies to address environmental issues associated with dairy manure. Readers should consult that report with regard to specific technologies proposed by individual vendors for the San Jacinto. Readers should also consider the suggested criteria for evaluating proposed treatments presented later.

- **Manure to fuel.** A proposal was made in early 2009 to build a manure-to-diesel fuel conversion facility in the San Jacinto River watershed (Renewable Diesel, LLC, Pasadena, California). This *AlphaKat KDV* process uses a variety of feedstocks—including manure and other agricultural waste—to produce mineral-quality liquid diesel fuel that can be used directly in diesel combustion engines. Although the specifics and current status of the proposal are unknown, it must be noted that the process does not affect the nutrient or salt content of the residual remaining after processing of the manure. Thus, a manure-to-fuel facility would do little to solve the nutrient or salt issues in the watershed. If, however, a contract between dairy operators and facility owners provided dairy operators with some income and gave responsibility for proper disposal of residuals to the facility owners, a manure-to-fuel process could facilitate the export of manure nutrients and salts from the watershed and offer some financial incentives to the dairies. At the time of this report's writing, the process is being pilot-tested with biosolids in Massachusetts; the potential for a full-scale dairy manure conversion system appears to be several years away.

  Applicability: Applicable to groups of San Jacinto dairies in a multi-dairy or regional facility

  Advantages: Provide income stream to dairies. Possible mechanism for removal or export of nutrient/salt residue, depending on contract arrangements

  Disadvantages: No inherent reduction of nutrients or salts; dairies potentially responsible for residuals

  Cost: unknown

- **Physiochemical and microbiological treatments.** A recent study at Texas A&M University (Mukhtar and Gregory 2009) evaluated four novel proprietary dairy waste treatment methodologies: (1) the Geotube® Dewatering System (applying chemical pretreatment to coagulate solids, followed by pumping into geotextile filtration tubes for dewatering); (2) the Electrocoagulation system (using chemical precipitation to coagulate and separate suspended solids, followed by flow over charged electrodes to cause coagulation of P and other metals); (3) the L4DB® Microbial Treatment System (treatment of lagoon wastewater with a microbial solution derived from milk and containing *Lactobacillus acidolphilus* and *Lactobacillus gasseri* as the active cultures); (4) and the Wastewater Treatment Solution (WTS®) System (introducing a proprietary microbial stimulant and oxygenating additive to the wastewater lagoon).

  The authors of the study concluded that the physiochemical methods (Geotube and Electrocoagulation) could remove 88 percent or more P from dairy waste; however, their costs were such that treatment would be feasible only once every 10 to 15 years. Findings from the evaluations show that microbial treatment products failed to perform as well as the other two technologies but did show some beneficial reductions in P, conductivity, total solids, and other effluent constituents. Lagoon effluent treated with the L4DB system showed TP reductions of 27 percent and 52 percent from the lagoon profile and lagoon supernatant while effluent treated with the WTS system yielded mixed results. Samples collected from the lagoon and tanks showed TP reductions of 17 and 60 percent, respectively while SRP increased over time in both environments. Treatment costs were quite high (see Table 5-12).

Table 5-12. Treatment cost for four proprietary dairy waste treatment technologies

Treatment	Unit treatment cost	Per-cow annual treatment cost
Geotube	$0.05/gal	$3/cow/yr (treatment once in 15 yr)
Electrocoagulation	$0.12/gal	$7.60/cow/yr (treatment once in 15 yr
L4DB Microbial Treatment System	Not determined	$3.60–$12.00/cow/yr
Wastewater Treatment Solution (WTS) System	Not determined	$6/cow/yr

  Perhaps the most important findings of this study are that although viable means do exist to reduce P in dairy waste by 50 percent or more, some claims by vendors of proprietary technology can be inaccurate or misleading. Anyone considering implementing such a treatment should be cautious when making that decision.

  Applicability: Most technologies applicable to individual San Jacinto dairies that contain their wastewater in ponds

  Advantages: Potential reductions in nutrients and salts in wastewater by some processes

  Disadvantages: Poorly documented performance; inaccurate or misleading claims for effectiveness. Some processes have no direct effect on nutrients or salts

  Cost: very high

- **Phosphorus removal through struvite precipitation.** Struvite is a phosphate mineral ($NH_4MgPO_4 \cdot 6H_2O$); it is sometimes referred to as Magnesium Ammonium Phosphate, or *MAP*. Struvite crystallizes under conditions of high phosphate concentration, adequate magnesium and ammonia supply, and an alkaline pH. Struvite was first noted as a problem in sewage and wastewater treatment because it forms a scale on lines and clogs system pipes. Struvite precipitation has been used as a P-recovery technique in wastewater treatment for several decades, particularly in Europe (Yoshino 2003; CEEP 2008; Technische Universität Darmstadt 2008). In recent years, removal of phosphorus from agricultural manure as struvite and recycling those nutrients into agriculture as fertilizer has been proposed as a management approach in areas of high animal density and low capacity for land application of manure.

Recovery of P from animal manure has been achieved by struvite precipitation developed for P recovery from municipal sewage. Struvite recovery from veal calf manure has been successfully achieved in the Netherlands where livestock are heavily concentrated and where the local soils are unsuitable for land disposal (Greaves et al. 2008). In the United States, nearly all work on P recovery from animal waste has been at the bench or pilot scale, rather than at the whole-farm scale; it remains to be seen if struvite recovery is practical at full scale. Much of the work has been on P recovery from swine waste, where soluble P removal rates of 60 to 90 percent have been reported (e.g., Burns et al. 2003; Laridi et al. 2005; Shepherd et al. 2007). Phosphorus removals in dairy waste have been lower than those observed for swine waste, probably because dairy waste has a lower initial P concentration than does swine waste. Sheffield (2005) reported 46 to 80 percent soluble P removal and 15 to 26 percent total P removal from dairy wastewater on a 4,000 cow Idaho dairy using a pilot-scale, fluidized-bed P crystallizer. Bowers et al. (2007) reported less than 25 percent P removal efficiency in dairy digester wastewater using a pilot-scale, struvite crystallizer system.

Although struvite can be used in fertilizer formulations and can increase the potential for exporting P from a region, recovery of P from animal manures does not appear to be economically viable in its own right. Bowers (cited in Young 2003) estimated the total annual cost of a struvite precipitation system for a 700–800 head dairy to be $66,000 ($26,000 annualized capital costs + $40,000 operating cost). Bowers et al. (2007) concluded that their struvite crystallizer system was economically unfeasible to use to remove phosphorus from dairy digester effluent. Dairy lagoon wastewater will have higher costs because of acid pretreatment that is required to achieve reasonable P removal. Greaves et al. (2008) reported that several centralized manure processing facilities employing struvite precipitation were set up in the Netherlands in the 1980s and 1990s, supported by government subsidies. However, removing the subsidies and prohibiting long-distance manure transport rendered the operations uneconomic. However, as restrictions on P applications to land increase, reducing the P content of animal manure by some means is likely to become a more attractive management option in the future.

Applicability: Applicable to individual San Jacinto dairies or groups of dairies

Advantages: Produces material useful for soil amendment and carbon sequestration; potential value-added product

Disadvantages: Effects on nutrients and salts uncertain. Requires high level of technology and management. Market for product needed

Cost: Unknown

- **Biochar.** Biochar is a porous, charcoal-like substance produced by combusting biomass under oxygen-limited conditions, usually by a process known as *pyrolysis*. It has a number of important properties, including long-term carbon sequestration, enhancing soil quality, and sorption of contaminants. Biochar is highly effective in retaining nutrients in soils and keeping them available to plants than most other types of organic matter. Biochar has been studied for mitigation of climate change (Sohi et al. 2009), for soil improvement (Thies et al. 2006), and for sorption of metals and organic contaminants (Cao et al. 2009).

Although biochar can be produced using dairy manure as a feedstock and can in fact offer significant potential for carbon sequestration, improving the nutrient-holding capacity of soils, and managing manure in the San Jacinto River watershed, a number of key factors—including production requirements, environmental constraints (e.g., air quality issues), product markets, and cost-effectiveness—are essentially unknown. This process might well deserve further investigation in the near future.

Applicability: Applicable to individual San Jacinto dairies or groups of dairies

Advantages: Removal of P from wastewater and conversion to a less available, value-added product

Disadvantages: Not likely to be economically feasible. Requires market for product.

Cost: very high

New treatment systems and technologies are constantly being developed and proposed as solutions to the nutrient and salt issues that have become so commonplace in intensive dairy areas. It is impossible for this plan to enumerate and evaluate every new or proprietary treatment process or technology that could be proposed for San Jacinto dairies. Instead, the IRDMP proposes a set of guidelines or criteria that stakeholders can apply when evaluating proposed new treatments. When a product or technology is recommended or proposed, dairy operators evaluating the technology should ask the following questions and consider the answers:

1. **Is treatment effectiveness well-documented by a reputable source?** Evaluate the potential effectiveness of a treatment on the basis of solid data, conducted by recognized methods, and published by reputable source(s). Beware of treatments that claim high percent reductions without supporting data or through anecdotal evidence only. If possible, check with others where the treatment process has been used.
2. **Has the technology been tested on dairies or operations with similar characteristics?** A treatment process or technology that has been developed or tested in regions with climate or landscape characteristics that differ significantly from the San Jacinto might not work well under local conditions. Some techniques have been used to treat poultry or swine manure but not tested on dairy wastes. Consider carefully how well a proposed process can operate for dairy waste in the San Jacinto River watershed.
3. **Is the chemistry/biology/physics of the process known and presented clearly?** The processes involved in treatment should be known and disclosed in clear language understandable to potential users. Beware of treatments that cannot or do not explain how they work.
4. **What constituents does the treatment address?** A treatment process can address one waste constituent such as P but not affect the levels of others like N or salts) in the waste. Consider whether a proposed treatment that deals with only part of the problem is worth the investment when other measures would also be required. For example, struvite precipitation is primarily a P-recovery technique, but the process will do little or nothing to address salinity issues associated with N and animal waste management in the San Jacinto River watershed.
5. **Are constituent concentrations or quantities after treatment acceptable?** The principal reported measure of treatment effectiveness is percent reduction in pollutant concentration or load. However, even after a high percent reduction, constituent concentrations might still be too high. For example, if wastewater or manure still cannot

be land applied after treatment, the value of the treatment to the dairy operator could be low.

6. **Is the proposed process cost-effective at the whole dairy scale?** It is usually difficult to project net costs of a treatment process beyond bench or field scale to the scale of the whole dairy operation. Be cautious if no cost or performance data for full-scale implementation are provided.
7. **Is the process open-ended and competitive?** Are required inputs or components available on the open market from more than one vendor? Beware of treatments that lock the user into a single supplier for essential inputs.
8. **Is there a market or use for process residuals?** Most treatment processes leave some kind of residuals or by-product that will require management. With the exception of N removal by denitrification, for example, treatment processes are unlikely to make P or salts disappear, but rather transform them into a different form. Brine from RO or material left over after biogas digestion, for example, require disposal; the feasibility and cost of managing those by-products must be factored into a decision to apply the treatment. The availability and cost of means to dispose of salts remaining after digestion, for example, must be included in the decision to undertake a regional digester. Similarly, composting can reduce the bulk of corral manure, but the compost must still be managed properly. Consider carefully whether a real market exists for sale of compost or, if not, what the real costs of exporting the compost are likely to be.
9. **Is the proposed process the best way to reduce the constituent content of animal waste or wastewater?** Consider whether the requirements for engineering, construction, management, and energy/chemical inputs are acceptable to the diary operation. Low-technology approaches to reducing the P content of manure such as change in feed formulation or treatment of manure with alum can be simpler to incorporate into a dairy operation than structural treatments, even if the percent P reduction is lower.
10. **Is the process the right thing to do?** Ideally, management of animal waste—for P and for other constituents—focuses on recycling nutrients to crop production, provided, of course, that measures are taken to manage runoff and leaching issues and to ensure nutrient application appropriate to crop need. Waste management measures in the San Jacinto River watershed should strive toward this principle; be cautious when considering complex treatment systems using exotic chemicals that could result in a by-product or waste that creates other environmental problems. Excessive release of ammonia N from anaerobic ponds, for example, can create a N issue in neighboring areas.
11. **Under a contract signed with a service provider, what are the dairy's responsibilities with regard to costs, financial returns and especially for subsequent management of residuals or waste products?** When evaluating a proposal from a vendor for wastewater or manure treatment such as digestion, consider the costs and returns to the dairy. Most importantly, consider who is responsible for the residuals or by-products that can still contain the bulk of P, N, and salts. If the dairy is still responsible for managing those residuals, the net benefit of the treatment might be low.

While it is not possible for the San Jacinto River watershed stakeholders to systematically research and evaluate new dairy waste technologies on their own, it is useful to consider the recommendations made by the San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel (2005) for evaluating dairy manure technology feasibility in the San Jacinto River watershed. The recommendations for the San Joaquin Valley dairies include the following:

- **Develop standard test methods so that the environmental and economic performance of technologies can be fairly evaluated and compared.** Technology assessments are not worthwhile unless the quality of the submitted data can be improved. Data submitted by vendors on environmental performance should include results from properly controlled, replicated studies, preferably at commercial-scale dairies. They should also include an accounting of the fate and form of all components of the manure as it is treated.

- **Conduct applied research on key data gaps**
  - **Technology Verification.** An independent program to test and compare technologies under controlled conditions in the field would provide the dairy industry, technology providers, and regulatory agencies with a better understanding of the required environmental performance standards, and provide information about the ability of particular products to meet those standards.
  - **Salts.** Data are needed on the contribution of dairy manure relative to other sources of salts, such as fertilizers, compost, and irrigation water; on the efficacy and costs of technologies that remove salts from manure; and on disposal options, especially the merits of diluting versus concentrating salts for relocation or disposal.
  - **Volatile Organic Compounds.** Significant questions remain about the quantities of VOCs emitted from various portions of dairies (animals and housing, liquid and solid manure, lagoons, feed, compost, and land application) and about the chemical species and processes involved in forming ground-level ozone. Without that information, it is difficult to assess how various technologies will reduce VOC emissions.
- **Establish pilot projects to assess comprehensive technology combinations for treating dairy manure.** The projects should monitor and assess environmental and economic performance and demonstrate the technologies to the wider community so that the best technologies can be more widely adopted.

It might be advantageous for San Jacinto dairy operators, WRCAC, and other organizations to participate in regional or statewide efforts to accomplish those recommendations.

5.4.2.4 Irrigation and Reclaimed Water

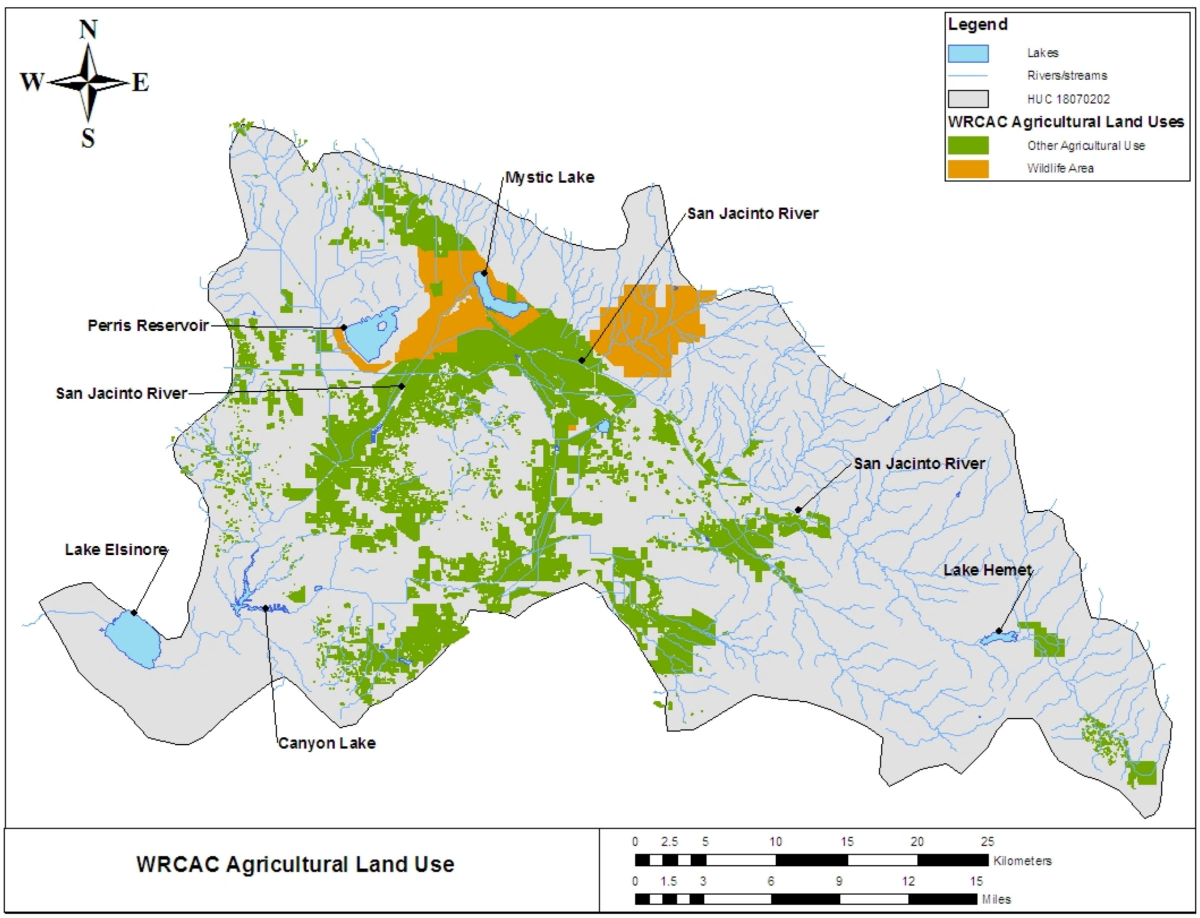
While crop irrigation is not a major issue for most San Jacinto dairies, the source of water used in dairy washing operations and for crops on those dairies that irrigate cropland has a major influence on potential TDS and nitrate loads from dairies. The USDA-ARS study of NMP operations (USDA-ARS 2009, Section 3.2.1) documented the variability in the quality of groundwater versus reclaimed water and its strong influence on TDS and nitrate delivered to the crop field through wastewater irrigation. The 2009 IRDMP dairy sampling data (see Section 5.2.2) document the variability among sampled San Jacinto dairies in the quality of make-up water in their operations. Clearly, the options available to San Jacinto dairies for water supply and their choices in how to use the water will influence efforts to reduce TDS and nitrate loads to local groundwater.

Declining supplies and increasing costs for irrigation water have emphasized the need for efficiency and water conservation for crop production in the San Jacinto River watershed, a need that applies to both dairy and non-dairy cropland in the watershed. The irrigation management study conducted in 2006–2008 (Section 3.2.3) demonstrated that consistent soil moisture and high water efficiency could be achieved by careful application of irrigation instrumentation and monitoring technologies on field crops. All crop producers in the San Jacinto River watershed, including dairy operators, should strive for efficient use of irrigation water to minimize costs, maintain crop yields, and reduce the tendency for excess water to promote leaching of TDS and nitrates to local groundwater.

5.4.2.5 Interaction between dairy operators and agricultural operators in the San Jacinto River watershed

Because the manure produced by San Jacinto River watershed dairies (whether in raw form or after composting or digestion) can potentially supply essential nutrients to agricultural crops and thereby provide an acceptable outlet for dairy manure nutrients, it is important to explore potential interactions between dairy and agricultural operations in the watershed. It is useful, for example, to assess the degree to which manure nutrients might be recycled for crop production within the watershed. To do that, it is necessary to estimate the capacity of crops grown in the watershed to use N and P.

Agricultural land in the San Jacinto River watershed. In addition to the about 2,000 acres of cropland directly associated with dairies, about 30,000 acres of agricultural land are in the watershed. Figure 5-2 was derived from AIS's 2008 aerial mapping of agricultural land use in the watershed. The watershed's agricultural lands are shown in Figure 5-2 and summarized in Table 5-13.



Source: AIS 2009

Figure 5-2. Agricultural land use in the San Jacinto River watershed, 2008.

Table 5-13. Agricultural land in the San Jacinto River watershed, 2008

Land use code	Land use description	Total area (acres)	Area outside GWMZ (acres)(%)
(dairies)	Cropland on dairies	2,000	
2110	Irrigated Agriculture	13,882	5,826 (42%)
2120	Non-Irrigated Agriculture	7,888	3,282 (42%)
2121	Vacant Zoned Agriculture	3,338	2,647 (79%)
2200	Orchards/Vineyards	6	6 (100%)
2210	Citrus	2,445	1,952 (80%)
2300	Nurseries	960	343 (36%)
2310	Turf Farms	941	94 (10%)
2320	Christmas Tree Farms	14	4 (32%)

Source: AIS 2009

Note: The data reported here may not be consistent with agricultural land use acreages reported elsewhere in this IRDMP as the land use estimates were still being finalized at the time of this writing. The data shown here may overestimate the actual area of some land use categories. However, this serves to underscore the conclusion of the analysis that there is not enough cropland acreage in the San Jacinto River watershed to assimilate all manure nutrients generated at San Jacinto dairies.

Crop Production in the San Jacinto River watershed. Specific crops grown in the categories shown in Table 5-4 are unknown. It is not known, for example, which crops are produced on irrigated and non-irrigated agricultural land, and the specific citrus, orchard, or vineyard crops grown in the watershed are not documented. Because crops have different nutrient requirements and uptake capacities, it is necessary to make some assumptions about the specific crops grown to estimate the capacity of agricultural crops in the watershed to use N and P.

The Riverside County *2008 Agricultural Production Report* (Riverside County Agricultural Commission 2009) provides statistics on specific crops produced in the county, including acres planted, acres harvested, yields, and value of harvested crops. Unfortunately, the data are reported for the entire county, or in some cases, for districts within the county (e.g., San Jacinto/Temecula Valley), and information specific to the San Jacinto River watershed cannot readily be determined. Statistics for crops produced in Riverside County in 2008 that could be important in the San Jacinto River watershed are summarized in Table 5-14.

Table 5-14. Selected crops produced in Riverside County, 2008

Crop	Harvested acreage	Yield	Units
Potatoes	4,618	200	cwt/ac
Pumpkins	209	6.6	t/ac
Wheat	20,564	1.6	t/ac
Alfalfa (green chop)	1,153	47	t/ac
Sorghum	1,127	19	t/ac
Grapefruit—red/Ruby	5,031	32,000	lb/ac
Lemons	5,747	25,200	lb/ac
Oranges-navel	1,323	17,800	lb/ac
Oranges-valencia	2,360	11,500	lb/ac
Tangerines	1.960	14,000	lb/ac
Avocados	7.960	5,600	lb/ac
Dates	5.224	4	t/ac
Grapes	10,736	4	t/ac

Source: Riverside County Agricultural Commissioner 2009

To estimate potential crop nutrient use in the San Jacinto River watershed, the acreage of specific crops grown on watershed cropland was estimated using the following assumptions:

- Citrus—citrus crops grown in the San Jacinto correspond to the major citrus crops grown in Riverside County, i.e., grapefruit (red and Ruby), lemons, oranges (navel and Valencia), and tangerines.
- Orchards/Vineyards—orchard and vineyard crops grown in the San Jacinto match the major orchard and vineyard crops grown in Riverside County, i.e., avocados, dates, and grapes (table and wine).[2]
- Irrigated agriculture—on the basis of anecdotal reports from WRCAC members, the predominant crops grown on irrigated cropland in the San Jacinto River watershed are potatoes, pumpkins, alfalfa (for green chop), and sorghum.
- Non-irrigated agriculture—on the basis of anecdotal reports from WRCAC members, the principal crop grown on non-irrigated cropland in the San Jacinto River watershed is winter wheat.

Constraints on using dairy manure on San Jacinto River watershed cropland. The General Permit for CAFOs (R8-2007-0001) prohibits applying manure to croplands that overlie GWMZs lacking assimilative capacity for TDS or nitrate-nitrogen even at agronomic rates, beginning in September 2012, unless a program is implemented to offset the TDS and nitrate load. Because all San Jacinto dairies overlie GWMZs (see Section 4.2) and because there is no assimilative capacity for TDS or NO_3-N in any of the management zones, applying manure to cropland on dairies will effectively be

[2] Anecdotal evidence suggests that these orchard/vineyard crops may not be grown in the San Jacinto River watershed; although current land use data do suggest a small number of acres of orchards/vineyards in the watershed. However, annual uptake of N (100 lbs) and P (12 lbs) estimated for these crops is trivial relative to the total amount of estimated crop nutrient uptake. Removing these crops from the analysis would not affect the overall conclusion that there is insufficient cropland in the San Jacinto River watershed to assimilate all dairy-generated manure nutrients.

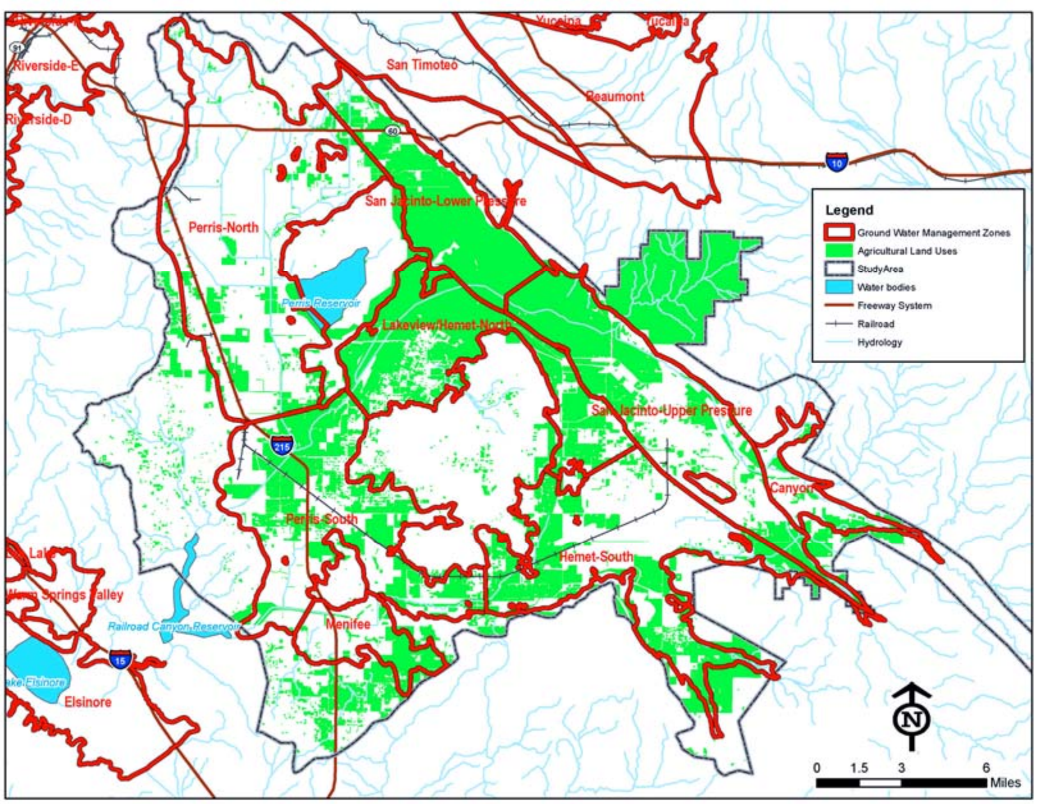
impossible under the General Permit after the 2012 deadline. While it is possible that future salt offset measures could enable some manure application to dairy cropland, it is assumed that there is effectively no capacity to recycle manure nutrients on dairy cropland.

Agricultural cropland in the San Jacinto is not under the jurisdiction of R8-2007-0001 and therefore may receive manure under certain conditions. There are, however, several major issues to be considered regarding application of dairy manure to San Jacinto agricultural land. First, even if not specifically regulated by the RWQCB's dairy permit, applying manure to cropland in GWMZs could create excessive salt and nitrate loads to groundwater, just as manure application does on dairies. Thus, it might be inadvisable to apply manure to any cropland in the watershed that overlies a GWMZ. In fact, only about 48 percent of watershed agricultural land does not overlie a GWMZ (Figure 5-3, Table 5-13).

Second, the dairy permit contains provisions that relate to application by permitted dairies of dairy manure to even that agricultural land not associated with dairies or in critical GWMZs:

> Manure applied to non-CAFO related croplands in any area that may affect a GWMZ that has TDS and nitrate nitrogen assimilative capacity shall not exceed agronomic rates. In addition, the manure shall be incorporated into the soil immediately after application, unless appropriate containment controls (based upon the specific crop grown) are provided. For any application of manure to these croplands in excess of 12 dry tons per acre per year (or 17.5 tons per acre per year @ 33% moisture), an explanation of the type of crop and the number of times it is harvested per year shall also be included in an annual report (RWQCB 2007).

Thus, application of dairy manure to agricultural land in the San Jacinto even outside the GWMZs that lack assimilative capacity must be at agronomic rates.



Source: AIS 2009

Figure 5-3. San Jacinto agricultural land areas and GWMZs.

Additionally, the RWQCB recently proposed a conditional waiver of agricultural waste discharge requirements (RWQCB 2009). That program will allow agricultural operators to continue to discharge wastes to waters of the state, provided that the operators comply with the TMDL load allocations by paying implementation fees and take steps to implement BMPs to reduce their pollutant loads. Although the specifics of the terms of the conditional waiver are under development, it is likely that this program will regulate the application of nutrients (from manure and other sources) to cropland throughout the San Jacinto River watershed. Thus, it is likely that manure application to any San Jacinto River watershed cropland will be possible only under careful management, including implementing NMPs and other BMPs to prevent runoff or leaching of nutrients (see Section 5.4.2.6 and Tetra Tech 2008a).

Another constraint on application of dairy manure to cropland is in air quality Rule 1127 (Effective January 1, 2005*)*:

(4) …a dairy operator shall clear any accumulated manure in excess of 3 inches in height in each corral at least 4 times per year with at least 60 days between clearings.…

(5) …a dairy operator shall remove all on-dairy stockpiles within three months of the last corral clearing day and no more than three months after date that the previous stockpiles were last completely cleared.

This effectively translates into a requirement that 25 percent of the annual manure produced on a dairy must be removed every 3 months. If that schedule does not align with crop producers' needs for nutrients according to planting and harvesting dates, the rule could effectively reduce the amount of manure that can be spread on local cropland. Because the rule apples to all dairies with 50 or more milk cows, all San Jacinto dairies are subject to this restriction.

Other constraints exist on applying dairy manure to San Jacinto cropland, especially if the cropland produces crops for human consumption. Past cases of contamination of food crops with pathogens in animal waste in California and elsewhere make it extremely unlikely that producers will accept raw manure to apply to food crops destined for direct human consumption. Most producers are likely to accept only composted manure that meets standards for microbial safety. As stated in California Title 14, Chapter 3.1 *Composting Operations Regulatory Requirements A*rticle 7 Environmental Health Standards (California Regulations 2009), all composting operations that sell or give away more than 1,000 cubic yards of compost annually must ensure that

(1) The density of fecal coliform in compost, that is or has at one time been active compost, [must] be less than 1,000 Most Probable Number per gram of total solids (dry weight basis), and the density of *Salmonella sp.* bacteria in compost [must] be less than three (3) Most Probable Number per four (4) grams of total solids (dry weight basis).

(2) At enclosed or within-vessel composting process operations and facilities, active compost [must] be maintained at a temperature of 55 degrees Celsius (131 degrees Fahrenheit) or higher for a pathogen reduction period of 3 days.

    (A) Because of variations among enclosed and within-vessel composting system designs, including tunnels, the operator [must] submit a system-specific temperature monitoring plan with the permit application to meet the requirements of Subdivision (b)(2) of this section.

(3) If the operation or facility uses a windrow composting process, active compost [must] be maintained under aerobic conditions at a temperature of 55 degrees Celsius (131 degrees Fahrenheit) or higher for a pathogen reduction period of 15 days or longer. During the period

when the compost is maintained at 55 degrees Celsius or higher, there [must] be a minimum of five (5) turnings of the windrow.

(4) If the operation or facility uses an [ASP] composting process, all active compost [must] be covered with 6 to 12 inches of insulating material, and the active compost [must] be maintained at a temperature of 55 degrees Celsius (131 degrees Fahrenheit) or higher for a pathogen reduction period of 3 days.

Title 14, Chapter 3.1 also regulates trace metals allowable in compost for application to food crops; such requirements could become important if dairy manure is composted jointly with municipal green waste. Thus, compost (either from raw manure or from digester effluent) will have to meet strict standards for microbiological safety before it can be applied to food crops in the San Jacinto River watershed.

Finally, the extent of organic crop production in the San Jacinto River watershed is unknown, but it is worth noting that the USDA National Organic Program Rule (USDA 2009a) sets requirements for application of manure to cropland. According to the rule, raw animal manure must be composted unless it is applied to land used for a crop not intended for human consumption, or is incorporated into the soil no less than 120 days before the harvest of a product whose edible portion has direct contact with soil; or is incorporated into the soil no less than 90 days before the harvest of a product whose edible portion does not have direct contact with the soil surface or soil particles (see 7 CFR 205.203 (c)(1) and (2)).

Potential for use of dairy manure on San Jacinto cropland. On the basis of the characteristics and constraints outlined above, the capacity of San Jacinto agricultural land to recycle dairy manure nutrients was estimated by considering an N and P mass balance between nutrients available in dairy manure and the capacity of cropland to use N and P at very limited agronomic rates. In that case, agronomic rate was defined as crop removal (the quantity of N or P removed from the field by harvest of a crop at a reasonable yield). Note that this definition ignores existing stocks of N and P present in soils and other factors that a site-specific NMP would take into account. Thus, the capacity of San Jacinto agricultural land to recycle N and P at agronomic rates is probably overestimated by this procedure.

The quantity of N and P available in manure produced on San Jacinto dairies is shown in Table 5-15. The values used for N and P concentration in corral manure are the average of analyses reported in 2008 NMPs from six San Jacinto dairies; the quantity of manure generated in the watershed is the sum of manure generation reported by San Jacinto dairies in their 2008 annual reports to the RWQCB.

Table 5-15. Estimated quantity of N and P available in San Jacinto dairy manure

N concentration (lb/t)	P concentration (lb/t)	Manure production (t/yr)	Manure N (lb/yr)	Manure P (lb/yr)
30	9.6	167,320	5,019,609	1,606,275

Estimating annual N and P crop removal in the San Jacinto River watershed was substantially more complex and required a number of assumptions. First, it was assumed that the crops grown in the San Jacinto River watershed in 2008 are represented by the specific crops and acreages shown earlier in Tables 5-4 and 5-5. Data reported in the Riverside County *2008 Agricultural Production Report* (Riverside County Agricultural Commission 2009) were used as reasonable yields for these crops. Those yield data account for multiple crops per year as reflected in the county agricultural statistics but might not exactly correspond to multiple-cropping practices in the San Jacinto River watershed. The quantities of N and P removed by harvest of the crops per unit of yield were estimated using the Crop Nutrient Tool in the USDA PLANTS database (USDA 2009b). The values used in the process are shown in Table 5-16.

Sorghum crop in the San Jacinto River watershed

Where an agricultural land use class included more than one crop, the average of N and P uptake from the component crops was used because sufficient information was not available to attribute specific acreages to specific crops within that class. For example, the N and P uptake rates for the *citrus* land use case are the average of N and P uptake rates for grapefruits, lemons, oranges, and tangerines at yields cited in the 2008 production report. Similarly, *irrigated cropland* N and P crop removal rates are the mean of crop removal rates for pumpkins, potatoes, alfalfa, and sorghum. Estimated N and P annual crop removal in the San Jacinto River watershed is summarized in Table 5-17.

Thus, cropland in the San Jacinto River watershed has the estimated potential to remove up to 3.5 million pounds of N and 0.4 million pounds of P each year. About 40 percent of that capacity is outside GWMZs lacking assimilative capacity for TDS or nitrate. The precision of these estimates would be improved by research to determine accurate crop nutrient uptake rates and crop yields specific to the San Jacinto River watershed.

Table 5-16. N and P crop removal for San Jacinto agricultural crops

Crop	Yield	Units	N removal (lb/ac)	P removal (lb/ac)
Potatoes	200	cwt/ac	73	11.3
Pumpkins	6.6	t/ac	32	4.8
Wheat	1.6	t/ac	66	12.5
Alfalfa (green chop)	47	t/ac	708[a]	62
Sorghum	19	t/ac	120	21
Grapefruit	32,000	lb/ac	25.6	3.8
Lemons	25,200	lb/ac	48.8	3.8
Oranges-navel	17,800	lb/ac	29	3.4
Oranges-Valencia	11,500	lb/ac	19	19.6
Tangerines	14,000	lb/ac	14	1.4
Avocados	5,600	lb/ac	19	2.4
Dates	4	t/ac	25	3.2
Grapes	4	t/ac	8.8	0.8
Turf[b]	--		135	20

Source: USDA 2009b
a Alfalfa is a legume and can obtain much of its N requirement from the atmosphere; N fertilizers are not usually recommended for alfalfa. Much of the N removed by an alfalfa crop, therefore, could be atmospheric rather than fertilizer-applied.
b Turf removal rates are lb/ac of harvested turf

Table 5-17. Estimated annual crop removal of N and P for San Jacinto cropland

Land use[a]	N removal rate (lb/ac/yr)	N removal (lb/yr)			P removal rate (lb/ac/yr)	P removal (lb/yr)		
		Total	In GWMZ	Out of GMWZ		Total	In GWMZ	Out of GMWZ
Irrigated Agriculture	200	2,773,346	1,609,672	1,163,974	22.3	309,849	179,819	130,030
Non-Irrigated Agriculture	66	520,635	304,009	216,626	12.5	98,605	57,577	41,028
Orchards/Vineyards	17	101	1	100	2.0	12	0	12
Citrus	27	66,693	13,440	53,253	6.4	15,646	3,153	12,493
Turf	135	127,054	114,389	12,665	20	18,823	16,947	1,876
Total (lb/yr)		**3,488,129**	**2,041,511**	**1,446,618**		**442,935**	**257,496**	**185,438**
Total (t/yr)		**1,744**	**1,021**	**723**		**221**	**129**	**93**

a *Vacant zoned agriculture* not included in analysis

Finally, Table 5-18 compares the supply of N and P in San Jacinto dairy manure to potential crop removal. In Table 5-18, a negative balance indicates that potential crop removal exceeds supply in dairy manure, whereas a positive balance indicates that more nutrients are available in manure than can be removed by crops. Crop uptake % refers to the portion of the manure nutrient stock that can be removed by crop production. The third row in Table 5-18 adds the capacity of vacant land that is zoned agricultural but not presently used for agriculture by assuming that this vacant land enters non-irrigated agriculture; this approximates the maximum potential crop nutrient uptake capacity for agricultural land in the watershed.

Table 5-18. Estimated mass balance between N and P available in San Jacinto River watershed dairy manure and potential N and P crop removal from San Jacinto River watershed agricultural land

	Available manure N (lbs)	N crop removal (lbs)	N Balance (lbs)	Crop uptake %	Available manure P (lbs)	P crop removal (lbs)	P Balance (lbs)	Crop uptake %
All SJ Ag land	5,019,609	3,488,129	1,531,480	69%	1,606,275	442,935	1,163,340	28%
Ag land out of GWMZ	5,019,609	1,446,618	3,572,991	29%	1,606,275	185,438	1,420,836	12%
Maximum potential ag land	5,019,609	3,708,445	3,708,445	74%	1,606,275	484,661	1,121,613	30%

Considering all 2008 watershed agricultural land and ignoring most of the manure quality and timing constraints described earlier, 69 percent of the N and 28 percent of the P contained in corral manure produced in the San Jacinto River watershed could be applied to crops at a crop removal rate, and therefore potentially used without off-site effects. Adding vacant land zoned for agriculture increases the N and P capacity to 74 percent and 30 percent, respectively. Recall that these assumed rates ignore existing N and P levels in the soil, so the estimates are probably optimistic. If application were restricted to agricultural land outside the GWMZ areas lacking assimilative capacity for TDS or nitrate, 29 percent of the manure N and 12 percent of the manure P produced in the San Jacinto River watershed could be safely applied to cropland under the assumptions used in this analysis.

In sum, unless the San Jacinto dairies can demonstrate that manure nutrients can be applied to cropland at crop removal rates without deleterious effects on groundwater TDS and nitrate levels, little capacity exists for agricultural land in the San Jacinto River watershed to safely accept dairy manure. Even if this can be demonstrated, there is not sufficient agricultural land in the watershed to accept the current load of manure nutrients. Conversations between WRCAC and the RWQCB indicate that the RWQCB will assume that all TDS and nitrate applied to cropland will eventually reach groundwater unless credible scientific evidence is provided to the contrary. Demonstrating that nitrate applied to cropland will be used by crops could be based on a relatively straightforward mass-balance calculation included in a dairy's NMP. Such a demonstration for TDS will be more complex because some TDS components are used by crops. Additional research might be necessary to show the fate and transport of individual TDS components applied to San Jacinto croplands.

Turf Production. Turfgrass production is a special case of cropland in the San Jacinto, a high-value commodity that could offer unique opportunities for exporting manure nutrients and salts from the watershed. Composted sewage sludge and other organic wastes are commonly used to amend soil for turfgrass establishment and growth in other regions. Adding manure provides fertilization and improves the quality of the soil layer that enhances turfgrass maintenance and regrowth after harvest, improving the overall quality of the product. The high gross income per acre of turfgrass sod could help finance transportation and application of manure on sod-producing areas, especially because 1,137 acres of turf production are in close proximity to dairies in the San Jacinto River watershed.

Considerable research has been done into the potential for exporting manure nutrients from watersheds in turfgrass, notably in the North Bosque River watershed in central Texas. Vietor et al. (2002) document N removals of 100–570 lb/ac/yr (112–641 kg/ha/yr) from turfgrass plots at various manure application rates, compared to 42–140 lb/ac/yr (47–157 kg/ha/yr) with only inorganic fertilization. P removals ranged from 68–236 lb/ac/yr (76–264 kg/ha/yr) with manure application, compared to 8–19 lb/ac/yr (9–21 kg/ha/yr) with inorganic fertilization. In these experiments, 46 to 77 percent of applied P and 36 to 47 percent of N were removed in a single sod harvest. Most of the nutrients were removed in the soil component of the sod; the P content in soil was 2 to 10 times greater than in plant components of sod and N contained in the soil component of sod ranged from 1.3 to 5 times greater than in the plant component. For both N and P, the quantities removed in harvested sod increased proportionally as the amounts added in manure application increased. Because turfgrass harvest removes both manure residue and vegetation, the authors suggest that a BMP for manure application to turfgrass could allow application rates of P and N above what is needed for crop growth. That would amount to exporting some unused manure nutrients with the shipped turf.

Choi (2005) confirms these results at a field scale and concludes that turfgrass sod can be used as a sustainable BMP for exporting manure nutrients out of the North Bosque River watershed and other impaired watersheds.

Munster et al. (2004) assessed the potential for such a BMP in the North Bosque River watershed as a whole. The researchers used a geospatial database to locate appropriate turf production areas and to estimate manure P exports and reduced P loading because of implementing a turfgrass-sod-manure-export BMP on a county scale. The study concludes that under optimal conditions, 436,590 lb P/yr (198,000 kg manure P/yr) could be applied to 6,531 ac (2,643 ha) of turfgrass production and 253,222 lb P/yr (114,840 kg manure P/yr) could be exported from the watershed by implementing a system using dairy manure to produce turfgrass sod. This was estimated to be the equivalent of the manure P applied from 10,032 dairy cows annually and exported from 5,808 dairy cows each year.


Turf production in the San Jacinto River watershed

Applying dairy manure to turfgrass production fields is not without potential environmental effects. Vietor et al. (2004) note that both soil test P and nitrate in soils after sod harvest increased with increased manure rate. The authors caution that P and N transport in surface runoff during sod production and after transplanting of sod needs to be evaluated and that P and N losses to ground and surface waters through leaching and subsurface drainage could occur. The authors recommend composting of manure before application to reduce odors, volatilization losses of ammonia, and high counts of pathogenic microorganisms associated with surface applications of fresh dairy manure.

Choi (2005) reports that applications of composted manure to a Texas field for two sod crops per year doubled the mass loss of total P in runoff compared to an un-manured control field and significantly increased dissolved P concentration in surface runoff. Total mass losses of TKN from the manured field were nearly 1.5 times greater than that from the control field, although the total mass of nitrate loss in surface runoff was similar on both fields. Concentrations of TKN and nitrate in runoff from the treated field were both elevated compared to the control.

Analysis of soil samples from the manured field indicate that increases of soil test P occurred after surface applications of composted manure. The author noted that despite the increased runoff losses of both N and P, the losses attributed to manure are 3.5 percent of applied manure P and 3.1 percent of applied manure N. Although Choi (2005) does not report conclusive results from groundwater sampling, note that leaching of nitrate from turf production is a potential problem, especially under irrigation. Appropriate irrigation water management practices would be required to minimize nitrate leaching.

The extent of manure application to turfgrass in the watershed is unknown. The actual potential of turfgrass production to facilitate exporting manure nutrients and salts from the San Jacinto River watershed is uncertain but likely to be relatively modest. There are 1,137 acres of turf production in the watershed, possibly enough to accept 75,000 lb P/yr (38 t P/yr) of manure (based on P) under the scenario presented by Munster et al. (2004). That translates to approximately 7,812 t/yr manure, or the manure production of about 1,900 dairy cows. Furthermore, all known turfgrass fields in the San Jacinto River watershed overlie critical GWMZs; managing both manure application and irrigation water would therefore be critical and could limit manure application. Finally, decreased construction in the economy is likely to depress the demand for turfgrass sod in the region, at least in the near term, making it unlikely that sod production could be expanded as a vehicle for manure export.

5.4.2.6 Related Cropland BMPs

Techniques for reducing sediment, nutrient, and other pollutant losses from cropland are well-developed and generally well-known. A recent analysis recommended general management principles, along with processes to select specific practices, for agricultural enterprises in the San Jacinto River watershed to reduce nutrient loads to Lake Elsinore and Canyon Lake (Tetra Tech 2008a). Another recent report assessed Best management Practices to reduce nutrient loads from agriculture in the San Jacinto Watershed (UCR 2009). The principles and some of the BMPs recommended in those reports apply to cropland associated with dairies in the San Jacinto River watershed, as well as to agricultural producers.

The following general management principles can be applied to cropland in the San Jacinto River watershed; within each principle, a producer can implement specific BMPs tailored to the specific crop(s) and operation involved:

- **Nutrient Management.** Crop nutrients should be supplied in quantities that reflect the amounts needed to produce a reasonable crop yield; the amounts already present in the soil; and the amounts contributed by all nutrient sources, including commercial fertilizers, animal manure, irrigation water, and other sources. Nutrients should be applied using rates, timing, and methods designed to minimize losses to surface water and groundwater. Effective nutrient management reduces the amounts of nutrients available on agricultural land to be washed into surface water or groundwater, while providing for adequate crop growth (see Section 5.4.2.1).
- **Irrigation Water Management.** The amount of irrigation water applied should be managed to minimize surface runoff and unwanted groundwater leaching beyond the root zone, while satisfying the moisture requirements of the crop. When making irrigation decisions, producers should consider environmental interactions and soil hazards relative to erosion potential and infiltration rates. Irrigation applications should be designed to maximize uniformity and efficiency in water delivery. Soil moisture should be assessed before all irrigations. Effective irrigation water management avoids providing excess water to move nutrients from cropland to surface and groundwater, while satisfying the moisture

requirements of the crops. The specific elements and techniques of irrigation water management vary by crop and irrigation system type, but they typically include these activities:

  - Crop water needs and soil moisture assessment
  - Irrigation system design to efficiently apply irrigation water in the amounts and locations needed
  - Tracking irrigation applications to aid in refining irrigation application timing and rates, in reconciling usage, and in calculating irrigation efficiency
  - *Tail water management* to capture and treat excess water to prevent off-site discharge of nutrients and sediments, especially from furrow irrigation

- **Erosion Control.** Tillage, planting, cultivation, and crop harvest should be conducted to minimize soil erosion by wind and water. Effective erosion control minimizes off-site movement of soil particles and associated nutrients to surface waters and helps to preserve soil productivity. Specific practices vary by crop type and field conditions, but erosion control practices usually address the following:
  - Detachment of soil particles by wind or water
  - Movement of soil particles by wind or water
  - Delivery of soil particles to waterways

Specific crops might require specific practices adapted to their production and management to accomplish nutrient management, irrigation management, and erosion control. Dairy operators should consult with their producer organizations, NRCS, and other resources to identify specific practices appropriate to their crops and operations.

5.4.3 Cost Analysis

The following sections evaluate the potential cost of BMPs readily available to San Jacinto Basin dairy operators, including hauling costs associated with manure export, manure composting, nutrient management, pond lining, and precision feeding. In most cases, the technical and engineering aspects of these best management approaches are well documented in the available literature. However, the specific costs and economic implications are broadly covered, and site-specific costs will need to be discussed with NRCS staff, local extension agents, or a knowledgeable local consultant or engineer. Applying site-specific BMPs will be highly dependent on dairy size, annual manure and wastewater production, existing practices, and the financial condition of each individual dairy. Specifically, manure hauling costs and potential revenue from compost are localized and fluctuate with demand, fuel costs, labor, and other variable costs.

This cost analysis does not evaluate watershed-scale solutions, such as constructing a regional digester, source water treatment, on-site or regional wastewater treatment, or delivering leachate to the Santa Ana Regional Industrial Line. These are longer-term, more expensive solutions that will require coordination among all San Jacinto dairy operators to accomplish and a thorough analysis of the characteristics of the wastestream that will be treated.

5.4.3.1 Manure Export

The two sections below present estimated hauling costs using a contract hauler or a cooperatively or individually owned truck trailer unit. Hauling costs are highly dependent on the volume of manure, weight, haul distance, and whether loading/offloading is required. Contract haulers were difficult to locate, and those who were contacted were unwilling to provide even general, or ballpark, hauling costs. Hauling costs using a privately owned unit were estimated according to a review of relevant literature on trucking costs and cost-per-mile to operate a medium-to-heavy duty truck. An additional consideration for either approach is the tipping fee that could be charged at the disposal site.

5.4.3.1.1 Contract Hauling

Manure removal and hauling in the San Jacinto Basin, and San Bernardino County in general, is a highly fragmented, low-margin, highly variable business, dominated by small operators that negotiate rates according to the number of loads, distance, loading/offloading requirements, fuel prices, and fixed costs. For example, one manure hauler was advertising on *Craigslist* (http://inlandempire.craigslist.org/, 11/17/09), another who was contacted refused to provide any information under suspicion that he was speaking with a competitor, and four other haulers identified from Manure Tracking Manifests had disconnected phone numbers.

Sustainable Conservation (2005) evaluated manure hauling costs as part of an overall estimate of the feasibility of co-composting municipal green waste with dairy manure in California's Central Valley. Hauling costs from that study, updated to 2009 dollars using the Bureau of Labor Statistics Consumer Price Index inflation calculator, are presented in Table 5-19.

Table 5-19. Manure delivery costs compared to distance traveled

Delivery distance (miles)	Dry manure delivery cost $/ton (approx 23 tons/load)	Moist manure delivery cost $/ton (approx 17 tons/per load)
0–15	$4.44	$6.02
16–20	$4.85	$6.57
21–25	$5.26	$7.12

Source: Sustainable Conservation 2005

Hauling costs presented in Table 5-10 can be compared to information submitted on a Dairy Manure Tracking Manifest for 2008 by a dairy in Corona, California. The dairy reported hauling 1,400 tons of manure to the Redstar Fertilizer Company, a distance of 1.9 miles. The hauler charged the dairy $15,300 for 74 *truck-trailer* loads and 107 *bob loads* resulting in an estimated per-ton hauling cost of $10.93, or $5.75/ton/mile. When contacted, the hauler refused to provide any additional information , citing it as confidential business information, regarding current hauling rates, the condition of the manure (dry or moist), or whether the invoices provided with the Manure Tracking Manifests included manure loading or offloading. Redstar Fertilizer Company invoiced the dairy approximately $6.25 per ton to receive the manure for processing, according to the Manure Tracking Manifest.

Hauling costs obtained from other Manure Tracking Manifests submitted to the Santa Ana Regional Water Quality Control Board present hauling cost on a per load basis, but here as well, information is not available as to whether the costs include loading or offloading. Per load hauling costs in 2008 ranged between $190 and $200 per load for cow manure and $50 to $100 for dirt over one-way distances between 3 and 39 miles (Ontario, California, to Perris, California). Manure offloading sites included the Chino Prison, Farmers Fertilizer, Red Star Fertilizer, IEUA's Regional Plant No. 5—Solids Handling Facility (regional digester), and agricultural fields in San Bernardino and Riverside counties.

Last, Araji and Abdo (2001) looked at hauling costs as a component of effective use of animal manure on cropland. Custom manure-hauling services in Twin Falls, Idaho, typically use trucks with a 10-ton capacity, approximately 22 cubic yards of corral manure, and an 8-foot spreader. These haulers charge $19 per truck for loading and hauling a 1-mile roundtrip and an additional

$1.50/mile/truckload for each additional mile after the first roundtrip mile (Araji and Abdo 2001). Unfortunately, however, the cost data used in the report were not dated so it was not possible to determine if the cost estimates are relevant in 2009.

5.4.3.1.2 Cooperative Hauling

An alternate approach to using a custom manure hauler would be for one or more dairy operators to purchase their own truck for hauling manure out of the basin. By sharing costs, dairy operators could avoid paying a potentially more expensive custom hauler, particularly given the distances the manure might be hauled—Blythe (156 miles one-way), Bakersfield (196 miles one-way), and the high desert area. At the time of this report's writing, at least one San Jacinto dairy operator is using his own trucks to haul manure to the Blythe area, so some actual, recent cost data are available.

While different types of trailers are on the market, a walking floor trailer is a good choice for hauling manure or compost. The trailer is loaded using a front-end loader and covered with a tarp for transport. Upon arrival at the disposal site, manure or compost is *walked off* in eight to 10 minutes. Belt trailers unload quicker (1–2 minutes) and are recommended for short runs of 5 miles or less. Because belts weigh more, compared to the walking floor, load capacity is reduced, and operating cost per mile is greater. Because San Jacinto dairies would be hauling distances greater than 5 miles, the walking-floor trailer is appropriate for this analysis.

A new 70- to 80-cubic-yard walking floor trailer costs approximately $45,000. A basic model is 45 feet long and 12 feet high, constructed with a sheet and post frame. Loads for the trailer are best applied in bulk, rather than on pallets, and the operator would need to steam clean or rinse the trailer if back-hauling manure or compost after feed. Regulations limit the gross vehicle weight to 80,000 lb, with the tractor weighing about 18,000 lbs and the trailer 14,000–16,000 lbs, leaving 56,000–58,000 lbs for the load—approximately 35 cubic yards of manure or a full load of 70 to 80 cubic yards of compost. Heavier-duty floors, for pallet loading for example, add between $2,000 and $5,000 to the cost of the trailer, and a stronger trailer with a welded frame costs around $60,000.

In addition to purchasing the trailer, the operator(s) would also need to purchase a highway truck or on-road tractor to pull the trailer. The cost of a highway truck depends on whether it is purchased new or used, features, and the truck's condition. A basic to average truck cab will cost between $80,000 and $150,000 new, $45,000 to $60,000 for a medium-used truck, or $80,000 to $150,000 for a lightly used truck.

Operating costs including fuel, tires, maintenance and repair, depreciation, and the driver's hourly cost are typically calculated on a per mile basis. Factors that influence the operating cost per mile include the reliability of the truck purchased, pavement quality, weight of the load, speed, tire quality, and other factors. Barnes and Langworthy (2003) surveyed available literature to estimate the overall per-mile costs of operating automobiles and trucks. Fuel cost is obviously a significant variable in the cost-per-mile equation. Barnes and Langworthy (2003) used a diesel price of $1.50 per gallon, or $1.76 in 2009$, resulting in a cost of $0.21 and $0.25 per mile, respectively, assuming 7 miles per gallon (mpg). Fuel costs have increased faster than the overall consumer price index, and the average cost of a gallon of diesel in California (as of 11/16/09, Energy Information Administration 2009) is $2.964. Assuming an average fuel economy of 7 mpg, the appropriate cost per mile for diesel is $0.42. Adjusting the fuel cost to reflect current prices, the cost per mile of operating a commercial truck ranges from $0.93 (without driver costs) to between $1.43 and $2.18—averaging $1.51 per mile.

Hauling manure in the San Jacinto River watershed

Thus, roundtrip operating costs to haul a load of manure/compost to Blythe would be $472 (at $1.51 per mile) or $681 (at $2.18 per mile) and a roundtrip to Bakersfield would cost between $593 and $856, respectively. That does not include the capital costs of the truck and trailer. Hauling costs presented are round trip and would be incurred regardless of whether the operator deadheads back to San Jacinto with an empty trailer or backhauls feed, dirt, or other material. Backhauling in the area, in fact, has generally occurred in the reverse order, with feed as primary commodity and manure backhauled in some cases. Given the need to remove about 90 percent of San Jacinto manure from the watershed, however, large-scale manure export would more frequently begin with the manure haul, accompanied by backhauling of feed or other commodity to avoid costs for paying a hauler to transport feed separately to the dairy. The opportunity to backhaul feed would result in cost savings whether using a cooperative truck or, potentially, a custom hauler.

The conservative assumption is applied that the cost per mile of hauling feed is similar to that of hauling manure; a fully loaded truck is expected to have the same operating cost per mile regardless of the commodity hauled (between $1.51 and $2.18 per mile), although volumes would be different. The costs do not include overhead and loading costs that would be applied by a contract feed hauler or loading costs for a cooperative truck. Backhauling feed has the potential to result in significant avoided costs, provided that an appropriate feed source is available adjacent to the end point or at a location on the return trip—either minimizes deadheading expenses. Driver costs would be higher depending on travel time from the manure/compost offloading location and the feed supplier, but they are expected to be minimal compared with the overall hauling cost. Time would also be spent steaming or washing the trailer between loads.

5.4.3.2 Composting

Composted manure is used as an amendment to potting, landscaping, and agricultural soils and can inhibit plant disease. Composting converts nutrients into forms that do not leach, kills plant seeds and pathogens, makes nutrients more available to plants, and increases plant health. A further benefit to San Jacinto dairy farmers is that composting can reduce manure volume by 50 to 60 percent, reduce moisture content, and alter consistency to a more spreadable form (Liu et al. 2003). Manure volume reductions from composting would pay dividends in reduced hauling costs.

The following sections discuss the overall applicability and economics of composting dairy manure. The information presented is based on a survey of available literature and is intended to provide a general overview of composting. Actual costs would depend on the specific attributes of each dairy operation including manure volume, available space, climate, financial resources, and associated characteristics.

5.4.3.2.1 Dairy Manure Composting Alternatives

The cost of a composting facility is largely dependent on three factors:

- The compost system chosen
- The amount and type of manure composted
- Any buildings that need to be constructed

The size and sophistication of the composting system would affect the total investment cost. Sophistication is defined in terms of efficiency (length of active composting period), monitoring systems (to measure temperature, oxygen, and leachate), odor control mechanisms, labor requirements, and the quality of buildings. The following sections describe some of the common approaches to composting, followed by a discussion of the estimated costs of each approach.

Passive Windrow or Static Pile Approach

The passive windrow, or static pile, approach is the simplest and least expensive composting method. Essentially, this method involves scraping corral manure and piling into windrows, letting time and natural processes turn it into compost. The drawbacks to this method include poor quality compost with minimal commercial value, adverse odors, and long-term space requirements for the windrows because the composting time is longest for the various methods.

The passive windrow approach might have limited applicability in the San Jacinto Basin. The active composting period is 6 to 24 months for this method but the RWQCB's dairy discharge permit prohibits storage of manure removed from corrals beyond 180 days (Order No. 01-800 Part D.11). Operators interested in the static pile approach must evaluate whether composting would be sufficiently completed within the 180-day limit imposed by the RWQCB.

Turned Windrow Approach

The turned windrow approach requires more capital and labor than the passive windrow approach; including a manure spreader and labor to regularly turn the windrows. Expenditures are still considered reasonable because most dairy operators already own some of the necessary equipment. Final product quality is high and regular turning shortens the composting period, freeing up space for new windrows.

For smaller operations (250–400 head), turned windrow composting can be accomplished with a front-end loader, a slab of concrete, and possibly a cover to meet California air quality regulations. A manure spreader is recommended to create a more uniform, higher quality product. A windrow turner can be used to reduce labor costs at larger operations. A tractor pulled windrow turner costs around $10,000, and a self-contained turner can cost upwards of $200,000.

Equipment needs for a turned windrow operation include

- Grinder/shredder ($3,500)
- Tractor or front end loader ($50,000 to $150,000)
- Windrow turner, tractor-pulled ($30,000) or self-propelled ($200,000)
- Screener ($50,000 to $180,000)

One acre can handle between 4,000 and 7,000 cubic yards of compost, depending on the size of the windrows and width of the alleys between the windrows. A concrete or asphalt pad would cost between $12 and $27 per square yard.

Aerated Static Pile

An ASP is a windrow piled over perforated PVC pipes. A fan blows air into the pile. Temperature and oxygen levels must be monitored closely to ensure a high-quality product. The ASP shortens composting time to 3 to 5 weeks, followed by 30 days of curing.

In-Vessel/Channel Composting

This approach uses mechanical devices to actively mix or aerate the compost. The devices are typically one of three types: a large rotation drum into which the feedstock is placed and turned; horizontal or vertical silos with built-in augers that mix the compost; or walled channels that are aerated from below and have a mechanized turner that moves along tracks.

In-vessel composting has the advantage of low labor requirements while producing high-quality compost. This approach, however, requires expensive equipment, skilled labor, and computerized monitoring systems. The cost of an in-vessel composting system is often beyond the means of many dairies.

Vermicomposting

Vermicomposting is a process where manure is placed in windrows and worms are added. As the worms consume the material, new feedstock is added onto one side of the windrow. The worms move to the new feedstock and leave behind the consumed manure for collection and screening. Vermicomposting is the least expensive composting method, and it produces two saleable commodities—compost and worms. The only major requirements for vermicomposting are a large amount of covered space to maintain a consistent temperature and screening equipment (but all composting methods require screening equipment to produce the highest-quality compost).

Scenic view of a San Jacinto dairy

5.4.3.2.2 Overview of Composting Costs

The British Columbia Ministry of Agriculture (1993) evaluated the primary approaches to composting manure and compared the five most common methods (Table 5-20). The same paper also presents estimated costs for each composting method (Table 5-21, 1996 Canadian dollars [CAD]), but the paper does not provide enough detail to convert 1996 CAD/metric ton to 2009 U.S. dollars (USD) per ton. An approximate currency conversion is that 1 CAD equals $0.935 USD.

Table 5-20. Comparison of the five composting methods

	Passive windrow	Turned windrow	ASP	In-vessel/ channel	Vermicomposting
General	Low-technology Low-quality	Low- to moderate-technology Moderate- to high-quality	Moderate- to high-technology Moderate- to high-quality	High-technology High-quality	Low-technology High-quality
Labor	Low	Moderate to high	Moderate	Moderate	Low
Equipment	Loader	Loader/turner	Loader, pump, aeration pipes	Extensive and expensive	Low
Land requirements	Moderate to large	Moderate to large	Low to moderate	Low	Large
Bulking agents	Required to increase porosity	Flexible	Required to increase porosity	Flexible	Flexible
Active period	6–24 months	21–40 days	21–40 days	21–35 days	Variable
Curing period	Not applicable	30+ days	30+ days	30+ days	Not applicable
Size: height width	1–4 meters 3–7 meters	1–2.8 meters 3–6 meters	3–4.5 meters Variable	Dependent on vessel size	< 1 meter variable
Aeration system	Natural convection	Mechanical turning	Forced aeration	Mechanical Turning	Natural and worm assisted
Process control	Initial mixing only	Initial mixing Turning	Initial mixing, aeration and temperature	Initial mixing, aeration, temperature, and turning	Initial mixing added feedstock
Odor	Substantial	Low	Low to moderate	Low	Substantial

Source: British Columbia Ministry of Agriculture 1996

Table 5-21. Compost production costs, 1996 CAD

Windrow composting system	Basic windrow[a]	Deluxe windrow[b]
Manure composted (tonnes)[c]	2,000	2,000
Sawdust required (tonnes)	1,360	1,360
Compost produced (tonnes)	1,800	1,800
Total investment	$37,685	$179,003
Production cost (per cubic meter)		
Low-efficiency[d]	$18.99	$36.87
High-efficiency[e]	$17.76	$29.88

Source: British Columbia Ministry of Agriculture 1996

a. Tractor and turner only

b. Tractor, turner, hard surface area and buildings for composting, curing, and storage

c. 20% dry matter

d. Active compost period is 49 days

e. Active compost period is 21 days

5.4.3.2.3 Compost Revenue

Benefits from composting include reduced hauling costs from the lesser volume compared with raw, scraped corral manure to the sale of compost to wholesale and retail buyers. Potential buyers could include municipalities, landscapers, and nurseries. In addition, depending on the proximity to municipalities and landscape contractors, the dairy might be able to collect tipping fees for comingling green waste with dairy manure. Any importation of feedstock for on-dairy composting, however, subjects the dairy to the requirements of Rule 1133.2, which specifies, among other things, using enclosed vessels with inward air flow, no measurable increase in NH_3 or VOC outside the enclosure, and venting exhaust through an emissions control system to achieve 80 percent reductions by weight of both NH_3 and VOC.

Liu et al (2003) estimated that at a transportation cost of $1.20/ton/mile and a market price of $14 per cubic yard of compost, the break-even mileage to deliver dairy manure and bedding from an 8,000-cow dairy to a centralized composting facility to vary between 25 miles for a 250-cow dairy to 2 miles for a 3,000-cow dairy.

Sustainable Conservation (2005) reported sale prices for compost, which vary according to the volume purchased and hauling distance. Finished green-waste compost in the Central Valley was selling for approximately $10 per ton (bulk) up to $30 per ton for smaller volumes. A private seller of composted dairy manure was selling composted manure for around $20 per ton at the pile with an additional delivery charge of $8 per ton for distances up to 15 miles; for more than 15 miles, delivery charges increase, but that cost was not included in the study. The study also suggests that receiving municipal green waste or manure from other dairies for co-composting could offset costs by generating tipping fees, but the increased costs from regulation under Rule 1133.2 would need to be factored into the cost analysis. Such potential benefits require other feedstock sources within a reasonable proximity that are willing to haul and pay a tipping fee.

5.4.3.3 Nutrient Management

The goal of nutrient management is to supply nutrients to cropland in quantities that correspond to the amounts needed to produce a reasonable crop yield, the amounts already present in the soil, and the amounts contributed by all nutrient sources, including commercial fertilizers, animal manure, irrigation water, and other sources. Effective nutrient management reduces the amounts of nutrients available on agricultural land to be washed into surface water or groundwater, while providing for adequate crop growth. Note that careful nutrient management can contribute to the reduction or elimination of nitrates and other salts leaching below the root zone. Nutrient management could result in reducing nutrients being applied to the land, thereby reducing the cost of production and protecting both groundwater and surface water quality. However, application of the measure could in some cases result in more nutrients applied where there has not been a balanced use of nutrients in the past. That will usually allow all the nutrients to be used more efficiently, thereby reducing the amount of nutrients that will be available for transport from the field during the non-growing season.

5.4.3.3.1 Cost Analysis

Using an NMP requires accurate information on the nutrient resources available to the producer. Management practices typically used to obtain this information include periodic soil testing for each field; soil or tissue testing during the early growth stages of the crop; and testing manure, sludge, and irrigation water if they are used. The plan might call for multiple applications of nutrients that require more than one field operation to apply the total nutrients the crop needs.

The following information on nutrient management costs was obtained from EPA's *National Management Measures for the Control of Nonpoint Source Pollution from Agriculture* (USEPA 2003). In general, most of the costs documented for nutrient management are associated with technical assistance to landowners to develop NMPs. Some costs are also involved in ongoing nutrient management activities such as soil, manure, and plant tissue testing. Technical assistance in nutrient management is typically offered by universities, farm service dealers, and independent crop consultants. Rates vary widely depending on the extent of the service and type and value of the crop. Fees can range from about $5 per acre for basic service up to $30 per acre for extensive consultation on high-value crops.

Nutrient management costs for typical Vermont dairy farms begin with a $150 fixed charge for an NMP. There is an additional $6 per acre for corn land, which includes record keeping for manure, fertilizer, and pesticide applications, soil analysis for each field, manure test, and a pre-sidedress nitrogen test (PSNT); cost for grassland is $4 per acre, which includes the same services as for corn fields except the PSNT.

Harvesting crops grown on a San Jacinto dairy

In Pennsylvania, where state law requires extensive nutrient management planning, charges for developing a plan range from $400 to $900. Specific costs vary from around $3 to $4 per acre for a *generic* plan without soil sampling or weed and insect control recommendations, up to $8 to $12 per acre for a complete plan with full scouting.

In Maryland, again subject to a recent state law requiring all farms to have NMPs, average costs across the state are about $3 per acre, which includes writing the plan, technical recommendations on fertilization and waste management, maps, and record keeping. Soil and manure testing are additional costs, at $2 to $5 per analysis.

Charges listed by an Illinois crop consultant range from $5 to $15 per acre for services including scaled maps, manure analysis, soil testing, and site specific recommendations for fertilizer and manure applications.

A Wisconsin agronomic service charges $5 to $8 per acre for nutrient management services that include farm aerial maps; identifying fields with manure spreading restrictions; soil test reports; animal inventory with manure analysis; written plans for each field specifying crop to be grown, previous crop grown, fertilizer recommendations, legume and manure credits, manure application rates, and record-keeping sheets; and regular field scouting.

In Nebraska, a crop consulting service charges $5 per acre for basic soil fertility and pest and water management, another $4 per acre for precision-farming GPS grid samples, plus a separate soil analysis charge.

In many instances, landowners can actually save money by implementing NMPs. For example, Maryland has estimated (from the more than 750 NMPs that were completed before September 30, 1990) that if plan recommendations are followed, the landowners save an average of $23 per acre per year (Maryland Department of Agriculture 1990). The average savings could be high because most plans were for farms using animal waste. In the San Jacinto River watershed, reductions of nutrient applications derived from manure or manure products can translate into additional hauling costs if less manure is recommended than is now applied. However, reduced applications of purchased inorganic fertilizers resulting from nutrient management might yield cost savings.

5.4.3.4 Pond Lining

As noted above, all storage ponds on San Jacinto dairies are unlined. If ponds were lined to prevent TDS and nitrates in dairy wastewater from penetrating through the soil profile into groundwater, dairies would have to rely on irrigation and evaporation for removing stored water (see Section 5.4.2.2.1). Some dairies might have adequate capacity for this purpose; others might need to construct additional storage (see Table 5-2).

5.4.3.4.1 Cost of Pond Liners

Liners can be used to prevent infiltration of dairy wastewater and stormwater to groundwater underlying the San Jacinto Basin. Clay or soil cement minimizes leaking while biological sealing is developed. Membrane sealing (e.g., plastic, vinyl, or rubber) is quite effective but, depending on the type can, be expensive and difficult to install. Moreover, membrane seals require extra care to prevent tearing when solids are removed during routine maintenance.

Liu et al. (2003) estimated lagoon construction costs in Washington to range between $20 and $25 per 1,000 gallons ($6,500 to $8,000 per acre-foot [AF]) for the first million gallons and $15 per $1,000 gallons ($4,900 per AF) for additional storage volume above one million gallons. The WSU estimate includes the cost of fencing, access ramps, and berm seeding. Adding compacted fill material to line the lagoon and embankment add an additional $8 per 1,000 gallons ($2,600 per AF) to the cost of construction. Installing a clay liner could cost as much as $5/yd^2 ($24,000 for a 1-acre pond); plastic liners are less expensive, in the range of $1 to 3/yd^2.

5.4.3.5 Precision Feeding

Changes in feed formulation and management (sometimes referred to as precision feeding) can decrease the P content of manure by more accurately applying published P dietary requirements, more precise ration formulation, improved grouping strategies to decrease variation within groups of animals, and reductions in wasted feed. Together, such strategies can reduce the P content of dairy manure by 25 to 40 percent (see Section 5.4.2.1.1).

5.4.3.5.1 Estimated Cost of Precision Feeding

Realized costs and benefits from precision feeding were not readily available in the literature because it is highly dependent on climate, current feed sources, and the availability of alternate feed sources. A study in the *Journal of Dairy Science* (Ghebremichael et al. 2007) modeled the economic and phosphorus-related effects of precision feeding at a farm scale. They looked at the effect of precision feeding on two dairy farms in the Cannonsville Reservoir Watershed (New York) to quantify the benefits of a precision feed management system to control P imbalance problems, maintain farm profitability, and reduce off-farm P losses. The study determined that the annual farm net return (based on long-term averages) increased by between $12 and $20 per cow; those results are equivalent to a farm-level net-return increase of between $624 and $2,040. The farm net-returns represent the money saved by avoiding purchasing vitamins and mineral P supplements at $550 per ton.

5.4.4 Recommended BMPs for San Jacinto Dairies and the San Jacinto River atershed

Management changes will be required for San Jacinto dairies to address upcoming salt offset regulations and nutrient TMDL. The management changes will likely be needed both at the individual dairy and the watershed level. Requirements to manage salts from manure and wastewater are more restrictive than nutrient reduction requirements; therefore, the salt offset issue will very likely dominate nutrient management issues at least in the near term. Few practices are effective in truly removing constituents of concern; in almost all cases, some additional management of residuals will be required. However, some technologies will be of value in changing the bulk, composition, or other characteristics of wastes to facilitate their subsequent management.

Because of such forces in play, the course of action that dairy operators choose for dairy management in the San Jacinto will depend first on broad-scale strategic decisions, and second on specific choices concerning what practices to implement in specific locations in the watershed.

Based on analysis of the issues facing San Jacinto dairies and the characteristics of practices available to address those issues, this IRDMP recommends the following practices for implementation in the San Jacinto River watershed:

Source Reduction

- Precision feeding
- Nutrient management (both dairy and other cropland)
- Phytoremediation
- Waste amendment

Manure export

- Raw manure
- Compost and/or digestion residuals

Structural

- Pond Lining
- Multi-pond treatments
- Constructed wetland
- Composting
- Cooperative/regional digester

Specialized practices

- VSEP®
- Innovative practices that can be shown to be practical and cost-effective

Stakeholders in the San Jacinto River watershed must make some overarching decisions about what course(s) they are willing to take to address the salt and the nutrient issues. Those decisions include the following:

- Are dairy operators willing to change their day-to-day manure and wastewater management?
- Are dairy operators willing to install and operate technical wastewater or manure treatment systems on their facilities?
- Do operators prefer an individual versus a cooperative or regional approach to management?
- Are dairy operators willing to enter into long-term contracts with outside entities, and what conditions would be required for those contracts to be acceptable?
- Are dairy operators willing and able to export substantial amounts of their manure from the San Jacinto River watershed?
- Do dairy operators see benefits to producing a value-added product like compost or biogas to help with manure management?
- Are dairy operators willing to consider a reduction in livestock numbers or a reduction in dairying as part of a solution to the salt offset issues?

Only after those strategic decisions are made can effective implementation of specific management practices begin. These are the practices/approaches that appear to have potential for the San Jacinto River watershed and therefore are recommended for consideration. Specific selection depends on strategic decisions to be made previously and on priorities the stakeholders set.

5.5 Integrating Recommendations at the Watershed Scale

Some of the recommended BMPs and management changes can be implemented on individual dairies, independent of what occurs on other dairies or cropland. Other practices—such as manure export, composting, and digestion—are best considered at a watershed scale because of potential cost savings and management benefits associated with centralized facilities, the requirements for ample and constant supply of feedstock at such facilities, and the simple fact that the actions (e.g., hauling) of one dairy operator influence the opportunities of other dairy operators (e.g., hauling costs and competition for suitable cropland to receive manure). The Manure Manifest System is one tool that should greatly help manure management and transport at the watershed scale.

Watershed-scale strategies and practices to address the transfer and disposition of dairy manure generated and brought into the San Jacinto River watershed must reflect relevant conditions and requirements both within and outside the watershed. All dairies in the San Jacinto River watershed are affected by the Lake Elsinore and Canyon Lake Nutrient TMDL, the requirements associated with GWMZs (Figure 4-1) and the SCAQMD air quality regulations (Figure 5-4). Each dairy is also affected by the ban on manure spreading in the Chino Basin that not only encourages the shipping of manure from the Chino Basin into the San Jacinto River watershed but also prohibits spreading of San Jacinto-based manure in the Chino Basin.

Source: SCAQMD 2009

Figure 5-4. Jurisdictional boundaries of the South Coast Air Quality Management District.

Stakeholders implementing strategies and practices must consider, for example, the potentially different requirements associated with applying manure and manure products to cropland within the Lake Elsinore and Canyon Lake watersheds where a nutrient TMDL applies, cropland outside the Santa Ana Watershed where water and air quality concerns could be different, cropland that overlies a GWMZ lacking assimilative capacity, and cropland within the San Jacinto River watershed that is not above such a GWMZ. Similar considerations apply to strategies that might incorporate a compost or digester facility, whether a smaller, on-farm facility or a larger, centralized facility. Some strategies will involve hauling, so it will be important to consider hauling distances and whether back-hauling is an option (see Section 5.4.2.1.6). Some watershed-scale strategies could use water supply selection as a tool to help meet salt offset requirements and to meet the needs of changes in crop production implemented through the IRDMP.

A wide range of factors affects setting a best strategy and set of practices to be implemented on each dairy and across the watershed, including capital outlays, potential returns on investments, operation and maintenance needs and costs, availability of infrastructure such as roads and pipelines, financial and regulatory incentives, dairy management preferences, and the financial situation of each dairy and the dairy industry. The following discussion addresses factors related to manure quantity, manure quality, manure processing, uses and transport of manure and manure products, and water sources in the context of the TMDL, TDS, nitrate, nuisance, and air quality requirements and constraints imposed on dairies, cropland, and compost facilities. The discussion does not directly address the logistics of dairy management, cropland management, or managing compost facilities or hauling operations, but it does address cost considerations to some degree and includes a set of options for the next steps that dairies in the San Jacinto River watershed need to take to address the many issues confronting them.

Strategies and Practices to Treat Raw Manure and Wastewater Before Use

As discussed in Section 5.4.2.1.6, hauling will be required to meet the Dairy Permit salt offset requirements and air quality requirements applicable to dairies in the San Jacinto River watershed. The primary challenge to dairy operators is to determine what would be hauled, where it would go, and how it would get there. To facilitate organized manure export from the San Jacinto River watershed, raw manure and wastewater can be treated to reduce the overall cost of handling, hauling, and applying manure, manure products, and wastewater. That can be done on individual dairies, but it might be more efficient and cost-effective at a watershed scale.

The cost of hauling manure and manure products is driven largely by the moisture content (which directly affects weight of material to be moved as well as the per-ton content of nutrients, and hence its value to customers) and the location of customers for the manure or manure products. Treatment of raw manure before hauling, especially treatment that reduces the moisture content of manure, can reduce the cost of hauling and provide manure products that are more appealing to potential customers outside the watershed.

On-site options to treat manure and wastewater include composting and anaerobic digestion, two processes that can also be centralized to serve multiple dairies. The compost product would have a lower moisture content than raw manure, which makes hauling less expensive per unit volume (Aldrich and Bonhotal 2006). That same research shows that composting can reduce the volume and weights of material to be hauled by 50 to 80 percent according to equivalent nitrogen values of the stabilized compost as compared to unamended, raw dairy manure. In simple terms, then, the effects of composting on hauling costs can range from cost-neutral to a reduction of 50 percent or more according to N content.

Existing air quality regulations present challenges to effective composting on an individual dairy. On-site composting of dairy manure is exempted from the requirements of Rule 1133.2 if all feedstock is generated on the dairy. A sufficient supply of appropriate feedstock to blend with the manure might not be available on the dairy, limiting the potential throughput and possibly creating a need to haul both raw manure and compost off-site. If off-dairy feedstock is brought in, the compost operation then becomes a co-composting operation subject to the requirements of Rule 1133.2, which specifies, among other things, using enclosed vessels with inward air flow, no measurable increase in NH_3 or VOC outside the enclosure, and venting exhaust through an emissions control system to achieve 80 percent reductions by weight of both NH_3 and VOC. That rule also requires that operators of both new and existing co-composting operations submit a compliance plan, source test[3] results every 2 years, and reports certifying compliance every two years. Records of operation must be kept for at least two years. Rule 223 (Large Confined Animal Facilities—1,000 or more milking cows) requires that all owners/operators that handle or store solid manure or separated solids outside the animal housing must incorporate at least two of seven mitigation measures, one of which specifies that ASPs used to compost manure removed from pens must be vented to a biofilter or other control device with at least 80 percent control efficiency and be designed, constructed, operated, and maintained in accordance with NRCS Practice Standard 317 or more recent NRCS standard. Compliance with those regulations would be comparatively easier for a large-scale regional facility, as opposed to an individual dairy. In fact, compliance with the requirements is likely to be cost-prohibitive for most individual dairies.

Management of the composting process and hauling/selling of compost products would likely be more appealing to a centralized facility rather than as an added responsibility for the dairy operator. If dairies with cropland include phytoremediation as a component of a salt-offset program, the crops

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[3] Source test protocols are to consist of testing plans to measure VOC and ammonia emissions from the composting process. When used for determining the control device efficiency requirement specified for new facilities, the measurements must consist of lb/hr measurements at the inlet and exhaust of the control device and a verification of the enclosure. When used for determining the overall emission reduction requirements as compared to the baseline emissions factors, emissions are to be reported as percent reductions for the active co-composting and curing phases in terms of pounds of emissions per ton of throughput (total raw material as received).

grown to remove salts from the soil could provide an on-farm source of feedstock to blend with manure for composting, thereby avoiding the added requirements for co-composting operations.

Centralized composting is already taking place in the San Jacinto River watershed, but the operations generally handle plants and plant waste rather than animal waste. Existing composting facilities in the area include Coachella Valley Compost Facility in Coachella and Agriscape in Lakeview (Riverside County 2009). Both Earthwise Organics Corona Plant in Corona and IEUA in Chino are listed by Riverside County as companies to contact for disposal of manure (Riverside County 2009a). Experience in the Central Valley indicates that adding manure to green waste increases the nutrient content of the compost and offers advantages regarding placing composting facilities on municipal properties instead of on agricultural lands (Hughes and Dusault 2005).

The Texas Commission on Environmental Quality's Composted Manure Incentive project resulted in the export from phosphorus-limited watersheds of 468,000 cubic yards of manure compost, equivalent to 2 million pounds of phosphorus (Texas Commission on Environmental Quality 2009). Rebates were later offered to agricultural producers, compost dealers, and private users who purchased compost from participating facilities. A Central Valley study by Sustainable Conservation indicates that co-composting of green waste with dairy manure is economically feasible if the compost raw materials and compost buyers are within a 15-mile radius of the composting site (Hughes and Dusault 2005). A circle with a 15-mile radius centered on San Jacinto is shown in Figure 5-5. Starting from the north and moving counterclockwise, such an area would reach the populated areas of Banning, Beaumont, Perris, Sun City, Winchester, Hemet, Mountain Center, and Pine Cove/Idylwild, serving a total population of approximately 250,000 including the city of San Jacinto (U.S. Census Bureau 2009). An analysis for the San Joaquin Valley concludes that the typical maximum practical hauling distance for compost is about 50 miles (San Joaquin Valley Dairy Manure Technology Feasibility Assessment Panel 2005); for the San Jacinto River watershed, that distance would reach into San Bernardino County.

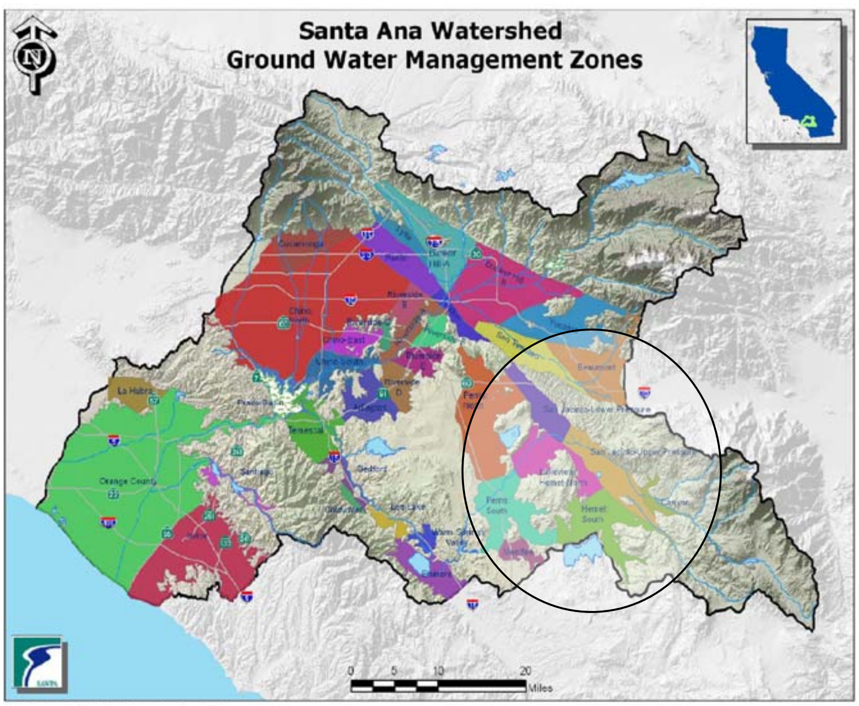

Figure 5-5. Potential market for composted manure in an approximate 15-mile radius centered near San Jacinto.

On-site digestion is another option for individual dairies. But the SCAQMD must permit anaerobic digesters, and Rule 1127 specifies numerous requirements for manure and digester management that present challenges at the individual dairy scale. The residuals from anaerobic digestion contain all the N and P of the original manure, and the solid material that accumulates in the bottoms of lagoons used in some on-farm anaerobic digesters is highly enriched in P (Section 5.4.2.2.3). While digester residuals are highly compostable, dewatering of digester solids would be required to reduce moisture content to a point where hauling cost would be lower than the cost of hauling raw dairy manure and to prepare the solids for effective composting. Such a process would be quite adaptable to centralized processing in the watershed.

A centralized digester in the Chino Basin (RP-5 SHF[4]) was considered proof that such an approach can work in the Santa Ana watershed, but the Chino Digester was closed in 2009, primarily because of changes in air quality rules. During negotiations over the exhaust system for the internal combustion engines of the Renewable Energy Efficiency Project (REEP) project, SCAQMD issued an amendment to Rule 1110.2 that changed the maximum allowed use of natural gas for such engines from a 40/60 natural gas/biogas mix to a 10/90 mix. The REEP engines were designed for the 40/60 mix and for compliance with air emissions requirements existing before the amendment. In addition to the change in mix allowed, the amendment increased the stringency of air emissions requirements. Engines that could operate on the new 10/90 mix, however, were exempted from the new air emission limits until July, 2012. Because the REEP engines were not designed to meet the new air emission limits and the digester gas supply was insufficient to continuously meet the 10/90 mix requirements, REEP was shut down. The engines using biogas for a desalter plant at the site were also shut down. The central conclusion regarding future use of the facility to process dairy manure is that the facility is *non-viable* using manure as the primary feed based on conventional economics (Black and Veatch 2009). In addition, a temporary lowering of the original manure hauling fee of $80 per load to stimulate interest was determined to be excessive relative to the value of electricity that could be generated from the manure.

The Chino Digester

The Chino Digester is not a single digester but a facility that was part of a plan including constructing several anaerobic digesters and co-generation facilities to provide treatment for collected dairy washwater (Black and Veatch 2009). Wastewater biosolids would be anaerobically digested, and the resulting biogas would be used to generate electricity through co-generation to power the facility. The first phase of the program was to construct a plug-flow manure digester to generate 500 kW of power. The modular design was intended to be easily expanded if proven to be cost-effective, but the plan also anticipated dairies moving out of the area and then using the facility for biosolids treatment. In the next phase, the plug-flow digester was modified to a partially mixed digester, generating an additional 443 kW. The third phase of the program was to construct Phase II digesters using European Technology, generating about 1,500 kW. A Renewable Energy Efficiency Project (REEP) was established in 2003 to test and research innovative, full-scale energy generation processes, using methane gas derived from local processing of food waste, dairy manure, and other organic material.

Internal combustion engines associated with the REEP project triggered regulation of air emissions by SCAQMD under Rule 1110.2.

Funding sources included grants and incentives of nearly $17 million from USDA, U.S. Department of Energy, California Energy Commission, and Western United Resources Development, Inc. Because operations ceased, $1.7 million of this cannot be claimed.

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[4] RP-5 SHF is the IEUA's Regional Water Reclamation Facility No. 5 Solids Handling Facility, referred to here simply as the Chino Digester.

In an analysis of the feasibility of clustering independent dairy operators for generation of bio-renewable energy in the Central Valley, Hurley et al. (2006) found that dairies with scrape systems such as those used in the San Jacinto River watershed are well suited for a system involving a centralized digester. Three different-sized energy outputs were considered in the analysis, with the number of milking cows required for each shown in Table 5-22. The researchers concluded that the 10-MW facility is the most feasible of the three systems from a price standpoint.

Table 5-22. Digester power output versus milk cows needed

Power output	Milking cows needed
1.5 MW	9,000–10,600
4.2 MW	20,600–27,500
10 MW	48,600–63,500

Source: Hurley et al. 2006

Approximately 27,000 milking cows are in the San Jacinto River watershed, with individual dairies ranging from about fewer than 100 to 2,100 milkers. Of the 25 dairies, 13 have between 1,000 and 1,500 milkers, and no single dairy approaches the number of milkers needed to generate 1.5 MW. The number of milkers in the San Jacinto River watershed, however, is more than twice the number (~14,000) that the Chino Digester served (Hurley et al. 2006). That facility used the manure output of 14 dairies (300 tons wet manure daily) to produce over 680,000 cubic feet of biogas per day, generating about 1.5-MW of capacity for power production.

On the basis of the feasibility analysis and operational information for the Chino Digester (Hurley et al. 2006), it appears that dairy operations in the San Jacinto River watershed could develop a centralized digester that generates about 6 MW. That could be more cost-effective than the Chino Digester[5] on the basis of the findings in the Central Valley feasibility analysis because of the greater power output. Also, hauling distances in the San Jacinto would be from 0.5 mile to about 30 miles, with most dairies within 4–5 miles if the facility was on the largest dairy (Ramona Farms in this case), consistent with the approach taken in the feasibility analysis. The state of the dairy economy and the stringent regulatory requirements, however, would continue to present challenges to developing a cost-effective regional digester.

A clear advantage of centralized facilities is that the daily management would be performed by technical staff (not by dairy operators). Dairy operators, however, would need to make changes in dairy management to provide feedstock reliably to the digester. For example, the most significant change for dairies participating in the Chino Digester project was to use a vacuum tanker truck to collect fresh manure along the feed lanes daily (Bartram and Barbour 2004). Manure had to be collected within 24 hours of being excreted, and the vacuum truck was run several times per day for each group of cows fed. The manure was transported to an *end dump* truck or nurse tank truck, which resided at the dairy. A manure hauler arrived once a day to transport the manure to the digester.

The basic regulatory requirements (Rule 223, Rule 1127, and Rule 1133.2) for both centralized digesters and centralized co-composters are the same as those for on-site digesters and co-composters. Clearly, projects of different scales pose varying construction issues (also regulated), but the technology is essentially the same for centralized versus on-site enclosed vessels. Table 5-23 summarizes the key benefits and costs of various composting and anaerobic digestion options.

[5] An analysis of 2008 income and expenses, however, shows $4,075,794 in expenses and only $1,223,289 in revenue, hardly cost-effective (Black and Veatch 2009).

Uses and Transport of Manure and Manure Products

Because of the lack of available cropland to accept manure in the San Jacinto River watershed, dairy operators should make efforts to expand the market for manure, wastewater, and manure products such as compost, biosolids, and alternative beneficial use products (Section 5.4.2.1.5). Composted manure products could be used at a variety of off-site locations, including cropland, homeowner property, and municipal sites, but the dairy community should explore potential markets. Opportunities to find additional locations for exporting manure and manure products are discussed in greater detail in Section 5.4.2.1.

One option that San Jacinto dairies should consider is developing a marketing tool or organized manure brokering service such as an Internet site to advertise to potential customers the availability of manure and composted manure. Under the proposed Manure Manifest System, the San Jacinto Basin Resource Conservation District or comparable entity would hold a substantial amount of data on manure that could be used to provide updated information regarding manure and composted manure availability, as well as the vehicle for making arrangements with potential customers. Several models for a regional manure transport/brokering system exist in areas of intensive animal agriculture, including Maryland (MDA 2009), Pennsylvania (PASBCD 2009), and Texas (TSSWCB 2005).

Manure marketing at a Santa Ana River watershed dairy

Economic Considerations

At an individual dairy or on a watershed scale, implementing new management measures would involve substantial costs; dairy operators have one principal source of revenue: milk. Minimum milk prices paid to producers in California are determined through a complex system of reference prices and formulas in which processors pay different prices for milk according to how the milk is used and payments are made to producers according to a schedule of quota, base, and overbase prices (California Department of Food and Agriculture 2008). The economic downturn beginning in October 2008 saw the average milk price drop from around $17/cwt to around $10 in May 2009 (Hirsch 2009). The breakeven price for dairy farmers is around $16 or more per cwt. At the time of writing this report, many dairies in the San Jacinto River watershed report losing as much as $100/head/month because of the economic situation.

One way to bring up milk prices is for U.S. dairy operators to collectively slash milk production, but that is difficult to do at the national scale. Cooperatives Working Together, a voluntary, producer-funded, national program designed to strengthen milk prices and bring long-term price stability to America's dairy farm families, operated two herd retirements in 2009 to reduce milk production (CWT 2009a). In the first herd retirement, 101,040 cows were slaughtered, reducing milk production by 1.96 billion pounds. In the second herd retirement, an additional 74,113 cows were slaughtered, reducing milk production by an additional 1.52 billion pounds. An independent assessment of the effect of CWT indicates that the herd retirement increased milk prices by $0.71/cwt after the first round and by $1.54/cwt after the second round (Brown 2009a, 2009b). Forty-nine California dairy farms, mostly from the Central Valley, retired their herds in the first round, and 34 more farms from the west retired their herds in the second round. Cooperatives Working Together has tentatively accepted 154 bids in the third round as of October 2009 for a total of 26,412 cows and 517 million pounds of milk, bringing the total reduction of milk production capacity to 5 billion pounds since December 2008 (CWT 2009b).

Table 5-23. Options to treat manure and wastewater before use

Options to treat manure and wastewater before use	Opportunities/benefits	Constraints/costs
Compost manure at dairy	• Exempted from Rule 1133.2 • Improved handling, lower hauling costs • Lower cost than digester • Low technology	• Performance of open-air composting is weather dependent • Little/no change to salts and nutrients • No energy collection
Co-compost manure at dairy	• Performance more reliable in closed vessel • Low technology • Improved handling, lower hauling costs	• Rule 1133.2 applies, so closed vessel required • Little/no change to salts and nutrients • Need to manage feedstock deliveries • No energy collection
On-site digestion and composting	• Cover existing lagoon • Capture methane and heat for on-farm use. Generate electricity as an option • Compost product handles better than manure • Compost costs less to haul than manure and digester solids	• More expensive than composting • Digester solids might need to be dewatered and composted. • Daily scraping needed • Little/no change to salts and nutrients • Digestion more complex than composting
Centralized Digester and Composter for Biosolids	• Electricity or natural gas production • Concurrent heat energy collection • Greenhouse gas reductions • Product handles better than manure • O&M focused in one location • Potential funding through EQIP, AgStar, or California	• Capital and O&M costs • Integration into existing energy systems • Centralized land acquisition costs • Potential particulate matter increases • Need to compost biosolids • Permit costs and regulatory oversight • More complex technology than composting • Chino model closed down; need backup plan • Still need to spread/haul compost • Little/no change to salts and nutrients
Centralized Co-Composter	• O&M focused in one location • Low technology compared to digester • Product handles better than manure and costs less to haul	• Capital and O&M costs • Permit costs and regulatory oversight • Need backup plan if fails • Little/no change to salts and nutrients • No energy collection
Centralized Dairy Waste Composter	• O&M focused in one location • Low technology compared to digester • Product handles better than manure and costs less to haul	• No advantage over co-composter from regulatory standpoint. • Capital and O&M costs • Need backup plan if fails • Little/no change to salts and nutrients • No energy collection

Clearly the actual milk prices paid to producers depend largely on supply and demand, and the formula for minimum milk prices is tied to forces beyond the boundaries of the San Jacinto River watershed. Milk prices will have a profound effect on the ability of dairy operators in the San Jacinto River watershed to invest in practices to address the environmental issues considered in this plan. But operators should assume that any actions they take to change milk production (e.g., reduce herd size) will have very little, if any, effect on milk prices.

Infrastructure

The IEUA anaerobic digester facility has access to the Santa Ana River Industrial Waste Pipeline (the so-called *Brine Line*), enabling discharge of filtrate to a facility operated by the Los Angeles County Sanitation District. Access to the same or a similar pipeline and sanitation facility would be a key consideration in deciding whether to build a centralized anaerobic digester (or a regional desalter) in the San Jacinto River watershed. Without such a pipeline, filtrate from the digester or desalter would need to be hauled by truck to a proper disposal site because there would be no way to handle the liquid on-site.

The Chino I desalter transports approximately 2 million gallons per day (mgd) of brine by a regional brine line for discharge to the ocean (IEUA 2009). If a desalter is to be constructed in the watershed, access to a similar discharge mechanism will be required. The Santa Ana Regional Interceptor (SARI) line has available capacity, but that line does not extend to the San Jacinto area. Extending the brine line is under discussion at the time of this writing; the project is expected to be quite costly, with estimates ranging up to $60 million. The availability of usable (must meet TDS requirements in basin) reclaimed water in the area is important to continuing cropland irrigation as irrigation puts a strain on groundwater sources. Without a suitable offset, producers would not be able to use reclaimed water on cropland in GWMZs that do not have assimilative capacity unless the water has a lower TDS level than the GWMZ target. Recognizing that problem, EMWD is proposing that the TDS and TIN targets be raised in the Upper Pressure San Jacinto GWMZ, increasing TDS from 320 to 500 mg/L, and increasing TIN from 1.4 to 7.0 mg/L. Current levels in the Upper Pressure GWMZ are 370 mg/L TDS and 1.7 mg/L TIN. Six dairies overlie or partially overlie the Upper Pressure San Jacinto GWMZ. As part of its proposal, EMWD pledged to develop and implement a salinity management plan, including building a desalination plant if necessary. The Hemet/San Jacinto groundwater management plan includes the Hemet/San Jacinto Integrated Recharge and Recovery Program (IRRP), a Recycled Water In-Lieu Project, the Hemet Water Filtration Plant, and forming a watermaster (EMWD 2009a). The IRRP is designed to mitigate overdraft and provide supplies to meet future water demands and enhance groundwater basins in the Hemet/San Jacinto area. The four agencies participating in the IRRP are the city of Hemet, city of San Jacinto, Lake Hemet Municipal Water District, and EMWD (EMWD 2009). EMWD is one of the largest recycled water providers in California, selling its supply to the California Department of Fish and Game, to agriculture, to golf courses for irrigation, and schools to reduce the demands for potable water. The Hemet Water Filtration Plant treats state project water at a 12-mgd plant using RO and ultraviolet to produce potable water. The watermaster is a five-member management group that has governance over the groundwater management plan.

Incentives

Improved manure and soil management practices and methane capture at individual dairies or centralized digester facilities present the potential for carbon credits to become a side benefit of improved handling of manure to achieve air quality goals. It appears unlikely that carbon credits can be derived from improved manure management, but there is a potential to achieve credits for producing renewable energy from methane generated by digesters. While renewable energy credits are always evolving, some examples include the following:

- **California Feed-in Tariffs**—a mechanism for small renewable generators to sell power to the utility at predefined terms and conditions, without contract negotiations, http://www.cpuc.ca.gov/PUC/energy/Renewables/hot/feedintariffs.htm
- **The Renewable Energy Production Incentive (REPI) program—**U.S. Department of Energy incentives for renewable energy electricity produced and sold by qualified renewable energy generation facilities, http://apps1.eere.energy.gov/repi/
- **Renewable Electricity Production Tax Credit (PTC)—**a per kWh federal tax credit applies to livestock waste digestion with minimum capacity of 150 kW, http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&re=1&ee=0

Note that renewable energy payments, carbon credits, and similar incentives can end; stakeholders must consider long-term economic viability of any enterprise if incentives disappear.

A number of state and federal programs exist to provide technical and financial assistance to dairies installing practices to address environmental issues. In 2009 USDA's Environmental Quality Incentives Program (EQIP) placed emphasis on providing accelerated financial and technical assistance to producers who are facing increasing water quality related regulatory requirements on animal feeding operations, dairies and other similar operations (NRCS 2009). In addition, the EQIP Water Quality Initiative provides financial and technical assistance to producers to voluntarily meet regulatory agency requirements for waste discharges and TMDLs. Practices offered for cost-share will help producers meet regulatory requirements and provide a natural resource conservation benefit. Approved practices include (313) Waste Storage Facility; (317) Composting Facility, (359) Waste Treatment Lagoon, (521) Pond Sealing or Lining; (634) Manure Transfer; (561) Heavy Use Area Protection-Roof Rainfall Diversion; (629) Waste Treatment; (632) Solid/Liquid Waste Separation Facility; (447) Irrigation System, Tailwater Recovery; and other appropriate practices. It is important to note that practices 313, 317 and 359 also require developing and implementing a CNMP for the entire animal feeding operation, which is consistent with the NMP required under the RWQCB dairy discharge permit for dairies applying manure to their own cropland.

EPA's AgStar program is a voluntary effort jointly sponsored by EPA, USDA, and the U.S. Department of Energy. The program encourages biogas capture and use at animal feeding operations that manage manures as liquids and slurries. AgStar provides a range of project development tools and case study information to help those who are considering implementing such technologies. A variety of products are available free of charge and can be downloaded at http://www.epa.gov/agstar/.

USDA's Rural Energy for America Program Guaranteed Loan Program (http://www.rurdev.usda.gov/rbs/busp/9006loan.htm) encourages the commercial financing of renewable energy (bioenergy, geothermal, hydrogen, solar, wind and hydro power) and energy efficiency projects. Under the program, project developers will work with local lenders, who in turn can apply to USDA Rural Development for a loan guarantee up to 85 percent of the loan amount. Loan limits are 75 percent of the project cost, with a minimum of $5,000 and a maximum of $25 million. At the time of publication, new definitions for eligibility were being determined, but borrowers must be an agricultural producer or rural small business. Agricultural producers must gain 50 percent or more of their gross income from their agricultural operations.

California incentives for renewables and efficiency permit up to 1 MW of electricity (10 MW for up to three biogas digesters) to be credited to a customer's next monthly bill at retail rates (DSIRE 2009). After 12 months, a customer could opt to have net excess generation roll over indefinitely or to have the utility pay for any net excess. Demand for net-metered generation is expanding; PG&E recently raised its cap on the aggregate capacity of net metered systems from 2.5 percent to 3.5 percent of its peak demand.

Potential for Moving and Changing Targets

Stakeholders must keep in mind that the processes involved in watershed assessment, planning, and management are iterative and that targeted actions might not result in complete success during the first or even second cycle. It is expected, however, that adjustments will be made to achieve water quality improvement. This applies to watersheds with TMDLs as well, so dairy operators need to assume that additional reductions in N and P loads to Lake Elsinore and Canyon Lake might be needed beyond those stated in the TMDL.

Rules and regulations that apply to the San Jacinto Dairies might also change over time. In fact, SCAQMD is in the process of revising Rule 1127—Emission Reductions from Livestock Waste, which was adopted on August 6, 2004. SCAQMD is exploring the possibility of mandating mitigation measures that are on the menu of options in Rule 223, such as mandating following the National Research Council's feeding guidelines. It is also looking at mandating storage and emission controls for feed and how manure is disposed of. SCAQMD is also interested in applying acidifiers to reduce ammonia emissions at the dairies, such as application after manure scraping where leftover urine and manure can cause ammonia spikes. Last, the mitigation measures listed in the proposed Rule 223 tables will apply more broadly in that smaller confined animal facilities (CAF), not just Large CAFs will be subject to the list of measures in the rule. To do this, SCAQMD is looking to use the permitting process within Rule 223 but expand on the applicability of mitigation measures for dairies in Rule 1127.

Because of the potential, or likelihood, of changes such as those occurring in the San Jacinto River watershed, the plan for dairies needs to retain some flexibility to allow for slight changes in direction or even significant tightening of environmental controls to achieve surface water, groundwater, and air quality goals and targets that could change as understanding of the problems increases over time. Whether that sort of flexibility is best provided for at the individual dairy level or at the watershed level through practices such as centralized digesters or compost facilities needs to be carefully considered and factored into planning decisions. Section 6.4 of this report contains recommendations for approaches to evaluate implementation plan performance and updating the IRDMP to reflect new goals, including those derived from regulatory revisions.

Opportunities for Pollutant Trading

Water quality trading is a market-based approach that is being used in some watersheds to achieve water quality-based requirements more efficiently and at lower cost than traditional approaches. Through water quality trading, facilities that face higher pollutant control costs to meet their regulatory obligations can purchase pollutant-reduction credits from other sources that can generate such reductions at lower cost, thus achieving the same or better overall water quality improvement (USEPA 2006).

While no trading program exists in the San Jacinto River watershed, requirements for implementing the Lake Elsinore and Canyon Lake Nutrient TMDL include developing a pollutant-trading program. When such a program is developed, dairy operators should take advantage of the opportunities that would exist under the program.

Trading typically involves a permitted facility purchasing credits from another permitted facility or from a nonpoint source such as an agricultural operation. Dairies are permitted operations, but they also have characteristics of nonpoint source agricultural operations. Because of that, dairies might have opportunities to act as credit purchasers or credit generators under a trading program.

Opportunities for trading relative to water quality requirements for production areas at dairies are limited because dairy effluent limitations do not allow discharges from dairies except as the result of a large storm event. However, if future TMDL revisions impose even more stringent water quality-based requirements on discharges from dairy production areas, the potential to trade to meet such limits might exist.

Trading opportunities are more likely for dairies that have land application areas. Such areas are subject to BMP-based effluent limitations—NMP development and implementation. It might be possible for dairies to implement practices in excess of those imposed by the permit to further reduce nutrient runoff from land application areas. The reductions could be used to generate credits for sale under a trading program. Alternatively, similar to land application areas, if more stringent water quality-based effluent limits are imposed on land application areas as a result of future TMDL revisions, dairies could also find opportunities to purchase credits to meet these requirements.

Dairy operators should be active participants in any trading program development activities in the San Jacinto River watershed to ensure that the program recognizes and accommodates trading opportunities for dairies.

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6.0 San Jacinto River Watershed IRDMP Implementation and Performance Assessment

A plan is nothing more than a stack of paper on a shelf unless it is implemented and can be adapted to changing conditions as time goes on. It will be up to watershed stakeholders—primarily dairy operators—to implement the IRDMP and assess its ongoing progress. To support that process, this section discusses some of the strategic and tactical decisions about management changes being made by stakeholders, needs for coordination in the implementation process, and a plan for long-term monitoring to track the effectiveness of IRDMP implementation.

6.1 Strategy Development

Because of the compressed schedule for completion of the IRDMP (see Section 1.6), the originally envisioned comprehensive BMP review and strategy development process was not possible. Instead, a well-attended workshop presented the opportunity for an abbreviated BMP review and initial selection process. In October 2009, WRCAC and the SJBRCD hosted a workshop in the San Jacinto River watershed titled *Dairy Waste Technologies & Management Practices.* The goal of the workshop was to help dairy operators identify and make choices about strategies and practices to support regulatory compliance and future sustainability of the dairy industry in the San Jacinto River watershed. Some 20 people attended the workshop from the San Jacinto dairy community, along with representatives from industry groups, the RWQCB, and WRCAC. The results of the workshop are summarized in Appendix J.

To build on the results of the workshop, the San Jacinto dairies, in coordination with SJBRCD and WRCAC, should complete a second phase of strategy development early in 2010. That process should include thoughtful consideration of the on-farm and regional options and cost information presented in Section 5.0, along with the strategy-development considerations laid out in Section 6.0. Section 7.0 presents specific suggestions for the next steps.

6.1.1 Strategic Considerations for IRDMP Implementation

At the October 2009 workshop, participants discussed some major strategic questions that must be answered before implementation of the IRDMP can take shape.

1. **Are San Jacinto dairy operators willing to consider new manure/wastewater treatment operations on their own dairies or as a cooperative or regional enterprise? If that means a change to their current manure scraping/hauling and wastewater management to accommodate new treatment systems?**

   Participating dairy operators appeared to be willing to consider new waste treatment operations, both on their own facilities and in cooperation with their neighbors. They also expressed willingness to change their manure scraping and wastewater management practices to support new treatment systems.

2. **Are San Jacinto dairy operators willing to enter into long-term contracts for hauling, back-hauling, regional composters, or regional digesters or other facilities? What conditions would be required by the dairies in such contracts?**

   Participating dairy operators were not generally reluctant to enter into contracts for these aspects of waste management. However, the duration of such a commitment is an issue for many. Prevailing opinion seemed to be that contracts of up to 5 years were probably acceptable, but longer contract periods were not appealing, in part because of uncertainties in the economy and the dairy industry. Considerable discussion ensued about the requirements of a regional digester for some assurance of a continuous, ample supply of feedstock and therefore the need for a reasonably long-term commitment from dairies.

3. **Are San Jacinto dairy operators willing to consider cooperation or partnership with other dairies in the San Jacinto and/or from adjacent regions for a common approach, e.g., collaborating with Chino dairy operators and other businesses that produce potential digester/composter feedstock to collectively solve their waste management problems in the Santa Ana watershed?**

   Participants appeared open to partnering or cooperating with other San Jacinto dairies, but they were not enthusiastic about regional cooperation. The prevailing feeling was that San Jacinto dairies have been taking on the problems from other dairies for years without getting much in return. An important exception to this feeling is that San Jacinto dairy operators would be willing to absorb manure from outside the area to provide adequate feedstock to a digester or composter *if the facility had available capacity.*

4. **Are there any benefits to hauling a finished product such as composted or digested manure versus hauling untreated manure?**

   Participants did not express a strong preference for a specific finished product, but the idea of bulk reduction from either composting or digestion was the subject of much discussion. It was clear that bulk reduction likely will be a key ingredient to manure hauling operations.

Scenic view in the San Jacinto River watershed

5. **What incentives do San Jacinto dairies need to address the water quality and air quality requirements they face? How much do San Jacinto dairies know about and use available cost-share incentives, e.g., NRCS?**

   Incentive programs were not discussed specifically, but there was considerable discussion of various tax credits and tax incentives that would support green energy derived from manure digesters and the importance of such an income stream to dairy operators.

6. **Are San Jacinto dairy operators willing to consider a reduction in cow numbers or a reduction in dairying in response to the salt offset issues?**

   While many dairymen commented that this is happening by itself because of the economy, there was not much enthusiasm for such a reduction as a voluntary measure.

In sum, San Jacinto River watershed dairy operators appear to be ready and willing to engage in both individual and community efforts to address the challenges facing them. Cost is a major factor, of course, and manure composting and digestion for biogas are particularly attractive options because of the potential for income to offset the costs of new practices. Dairy operators are concerned about the economic sustainability of their industry in the future, but they remain strongly committed to dairying.

6.1.2 Priority Practices for Implementation

The discussion of candidate BMPs in Section 5.4 assesses the applicability of the practices to various types of dairy operations in the San Jacinto River watershed. However, watershed stakeholders are not yet ready to commit to installing specific practices at specific locations. At the October 2009 workshop, the candidate BMPs were defined and described, and participants had the opportunity to ask questions and make comments about each of the available practices.

An important theme of that discussion was the fact that few of the candidate practices available to San Jacinto diaries have the potential to actually eliminate nutrients or salts, although many practices exist that can reduce the bulk, change the form, or improve the handling of diary wastes. Because of the probable necessity to engage in extensive, systematic manure export from the San Jacinto River watershed to comply with salt offset requirements, considerable discussion took place about manure export and how individual dairy practices could be adapted to support manure export.

The results of the discussion were as follows:

- Current dairy scrape and haul schedules are flexible, and dairy operators are willing to make adjustments.
- Some San Jacinto dairies handle their own scraping and hauling, while many contract out for the entire operation from scraping, to hauling, to ultimate disposal.
- Some San Jacinto dairy operators buy their hay from the Blythe area, others import hay from as far as Utah and Nevada.
- Back-hauling manure in hay and other commodity trucks is recognized as a viable practice; one San Jacinto dairyman is importing silage and back-hauling manure.
- The issue of composting is intimately related to manure export, because some destinations will accept only composted manure.
- Dairy operators are already paying as much as they can pay for manure disposal. There is a strong belief that dairy manure is a valuable product, and there is a need to make it valuable.

> There is little willingness to pay more for manure hauling except to save on a tipping fee, in which case, it is feasible to haul farther. This is true even if composting.

Thus, the idea of organized manure export is an acceptable option to San Jacinto dairy operators, as long as the costs are feasible.

Following the discussion of the BMPs, participants voted on their preferences, based on whether they thought the practices would work on their dairy, would help solve salt or nutrient problems and meet regulatory requirements, and would be something they would consider implementing on their dairy. Participants expressed their preferences by anonymously casting multiple votes among an array of available BMPs. Results of the preference voting are shown in Figure 6-1. Clearly, composting, manure-to-diesel conversion, and manure digestion were the most popular practices. Manure export, wash water minimization, chemical treatment of wastewater, and a regional desalter were in the second tier, and most other BMPs found considerably less support. While the appeal of a BMP to the dairy operator is one (if not *the*) major criterion for selection, it must be noted that decisions on implementation must be tempered by other knowledge. For example, while the concept of converting manure to diesel fuel is undeniably appealing, that process is a long way from reality. Other options—such as manure digestion for energy—are technically practical today, but consideration of such practices must include technical feasibility and issues like long-term viability, problems with disposal of residuals, and longevity of current economic incentives.

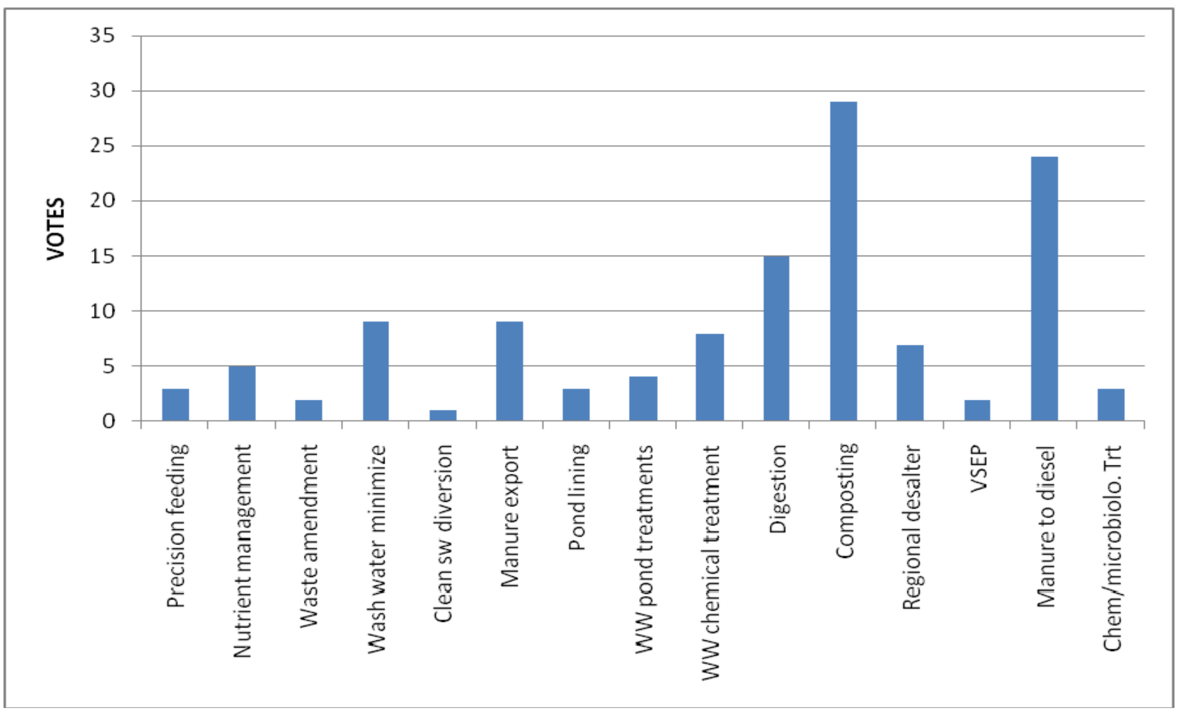


Figure 6-1 Results of workshop participants' preference voting for BMP options.

6.2 Institutional Structure for Sustainable Implementation

Leadership and effective partnerships are the keys to successful implementation of the IRDMP. While the IRDMP provides the road map for implementation, individual dairy operators, other watershed stakeholders, and in particular the institutions active in the watershed need to dedicate human and financial resources to support the various implementation activities.

WRCAC is uniquely poised to serve as the focal point for implementing the IRDMP. WRCAC was formed as a partnership to proactively represent dairy and agricultural interests in addressing environmental and regulatory issues in the San Jacinto River watershed. In collaboration with the SJBRCD, WRCAC has led the development of the IRDMP and guided related projects including water quality monitoring in the Mystic Lake area, developing a voluntary TMDL implementation strategy, preparing guidance for management practices to reduce nutrient loads from agricultural operations, and updating agricultural land use and GIS mapping in the San Jacinto River watershed.

WRCAC's participating members represent interests and capabilities that are important in implementing the IRDMP:

- San Jacinto dairy operators
- San Jacinto agricultural operators
- Milk Producers Council
- Eastern Municipal Water District
- Elsinore Valley Municipal Water District
- San Jacinto Basin Resource Conservation District
- USDA-NRCS
- USDA-ARS
- Western United Dairymen
- Regional Water Quality Control Board

With a track record of obtaining and managing grant money, a set of effective bylaws, a regular meeting schedule, and an active membership, the WRCAC has the means to lead and coordinate the IRDMP implementation effort. Note, however, that the most important players in implementing the IRDMP are the dairy operators of the San Jacinto River watershed themselves; WRCAC is a means to channel their collective voice.

In addition to assembling and coordinating an array of partners within WRCAC, the organization itself is also a participant in a number of other partnerships important to the watershed. Other regional organizations critical for successful implementation of the IRDMP include the following:

- **The Lake Elsinore and Canyon Lake TMDL Task Force** is an oversight organization charged with implementing the nutrient TMDL, with membership including responsible agencies and dischargers in the Lake Elsinore/Canyon Lake watershed led by SAWPA and LESJWA. The TMDL task force has allocated the costs of compliance with the TMDL among the various point and nonpoint nutrient sources in the watershed on the basis of the TMDL load allocations. WRCAC has been instrumental in organizing dairy and agricultural operators in the San Jacinto River watershed to ensure that the groups have met their financial obligations for TMDL compliance. Because of the effect of the TMDL on dairies in the San Jacinto River watershed, the effects of dairies and the IRDMP on nutrient loads to the impaired waterbodies, and the task force's responsibility for long-term TMDL implementation structure, cost-sharing formula and funding sources, it is essential that the task force be involved in the IRDMP implementation effort. The task force also conducts monitoring and modeling efforts in the San Jacinto River watershed that are relevant to assessing the long-term effectiveness of the IRDMP.
- **The Eastern Municipal Water District** provides domestic and agricultural water, wastewater collection and treatment service, and recycled water in the San Jacinto River watershed and has a key role to play in managing the quantity and quality of water delivered to dairies, particularly with respect to TDS and nitrate issues. Opportunities might exist for dairies to cooperate with EMWD on matters such as recycled water supply, TDS limits in GWMZs, a

regional desalter, and future connections to a brine line. EMWD also operates an extensive groundwater monitoring network that includes stations in the San Jacinto River watershed. Access to such data is critical to assessing future groundwater quality improvements as a result of salt offset measures.

- **The Santa Ana Regional Water Quality Control Board** is the lead regulatory agency for water quality concerns in the watershed and enforces the General Dairy Permit and the groundwater quality objectives that drive many of the requirements facing San Jacinto dairy operators. The RWQCB has been a cooperative partner in addressing many of the issues facing the San Jacinto River watershed, and its involvement in the IRDMP implementation is crucial. Most notably, the RWQCB's approval is required for the salt offset program that will allow continued application of dairy manure or wastewater to cropland in the San Jacinto River watershed. In addition, the RWQCB will implement and enforce the proposed Conditional Waiver of Waste Discharge Requirements for agricultural operators in the watershed. Those requirements have the potential to dramatically change the amount of dairy-generated manure that can be applied at non-dairy agricultural operations in the watershed.
- **The Santa Ana Watershed Association** develops, coordinates, and implements natural resource programs that support a sustainable ecosystem and social benefits in the largest coastal river system in Southern California. While focused on the larger Santa Ana Watershed, SAWA has a clear stake in environmental improvements in the San Jacinto River watershed.
- **The USDA-NRCS** is the principal agency of the USDA that provides technical and financial assistance to private landowners to conserve soil, water, and other natural resources. The NRCS is a critical source of both technical information and service on management practices to reduce soil and water pollution and cost-share programs to support implementation of conservation practices.
- There is a distance no less than one-quarter mile from all public schools in session during the time in which manure is to be applied and incorporated.

Each of these agencies and organizations has an important role to play in implementing the IRDMP. As noted above, WRCAC has a key role to play in organizing and coordinating these stakeholders' actions.

6.3 Coordination with State and Federal Agencies for Implementation

With so many players involved (the San Jacinto IRWMP alone had more than 40 participating agencies and organizations), coordination is obviously important. As noted above, because of its membership and activity, WRCAC is uniquely situated to effectively coordinate a large number of stakeholders in the San Jacinto River watershed. Implementing specific practices in specific locations, however, will require an additional measure of coordination and collaboration.

One especially critical area is coordination on permit compliance. The RWQCB has permitting authority over San Jacinto dairies and could have additional authority over crop producers under the proposed CWAD for agricultural operators. As discussed elsewhere in this plan, data from the dairy permit reporting system is absolutely essential for implementing important provisions of the IRDMP like the Manure Manifest System, as well as for providing data for long-term assessment of the effect of the IRDMP on the management of dairy wastes in the watershed.

WRCAC should also consider coordinating with RWQCB to develop an NMP template or more specific technical standards for nutrient management, or both. These tools could be incorporated into future revisions of the dairy discharge permit as well as the CWAD to ensure that NMPs for dairies and agricultural operations include application rates for all nutrient sources that are protective of groundwater and surface water quality.

Regulation and permitting are also issues for several BMPs that could be implemented in the San Jacinto River watershed. In particular, SCAQMD rules apply to manure and composting operations:

- Rule 223: Emission Reduction Permits for Large Confined Animal Facilities
- Rule 403: Fugitive Dust
- Rule 1127: Emission Reductions from Livestock Waste
- Rule 1133.2: Emission Reductions from Co-Composting Operations

It is critical that regulatory requirements enforced by state agencies such as the RWQCB and SCAQMD be coordinated so that individual dairy operators are not caught in the middle of jurisdictional conflicts. Considering the strong influence and role of the RWQCB in San Jacinto River watershed dairy issues and its continuing collaboration with WRCAC, it is reasonable to suggest that the RWQCB take the lead in coordinating regulatory and permit issues that apply to practices implemented under the IRDMP. This is especially important for watershed-scale practices such as regional digesters or composting enterprises.

A second issue requiring coordination is funding. Although increasingly scarce, numerous sources of state and federal funds are still available to landowners for implementing conservation practices and to organizations to work on environmental issues. Because of their experience and track record in securing and managing external funding sources, the WRCAC is a logical body to take responsibility for coordination of funding for implementation.

Potential funding mechanisms for further development and implementation of the IRDMP include the following:

- Clean Water Act section 319(h) funding
- Propositions 40 and 50
- Supplemental Environmental Projects
- EPA Targeted Watershed Grants
- Other sources of funding from local municipalities and local, state and federal agencies as they arise

San Jacinto River watershed stakeholders

Funding sources available for implementing management practices on individual dairies include the following:

- EQIP (Cost-share funding from USDA-NRCS to implement eligible conservation practices): http://www.nrcs.usda.gov/PROGRAMS/EQIP/index.html#prog
- CLEANmp (EPA funding for livestock facility assessment and NMP development): http://www.erc-env.org/CLEANMP.htm
- Pollution Control Loan Program (Low-cost loans from U.S. Small Business Administration for planning, designing, or installing a pollution control facility; available to dairies with annual receipts less than $750,000): http://www.sba.gov/financing/loanprog/pollution.html

6.4 Mechanisms for Evaluating Implementation Plan Performance and Updating the IRDMP

Evaluation of progress and effectiveness is an essential part of the IRDMP. Any plan of this magnitude should have mechanisms for evaluating plan performance and for supporting long-term adaptive management (USEPA 2008).

The goal of the IRDMP is to help dairy operations in the San Jacinto River watershed implement management practices necessary to meet regulatory requirements and help solve groundwater, surface water, air quality, and salts problems in the watershed, while maintaining the long-term sustainability of the dairy industry in the area. Achieving this goal depends largely on technology-based management and control of manure and wastewater generated at the dairies. It is expected that implementing selected strategies and management measures (BMPs) will reduce the quantities of air and water pollutants delivered from dairies, ultimately resulting in improvements in air and water quality. Long-term monitoring is needed to document the implementation of new management strategies and practices, to quantify pollutant load reductions achieved by these actions, and to assess changes in air and water quality in the watershed. By tracking meaningful indicators of progress, those implementing the IRDMP will have information to support decisions to either remain on course or make changes in the IRDMP.

Monitoring of all sources on all dairies, all pollutant pathways, and the condition of the air, surface water, and groundwater throughout the watershed is unaffordable and impractical. Therefore, it is important to create a strategic monitoring program that provides the best information possible about key sources, pollutant pathways, and air and water quality conditions within a reasonable budget and level of effort. Moreover, because there will be an inevitable lag between action and response, it is important to monitor critical, intermediate indicators of progress and endpoint outcomes. Such information will enable dairies to assess and document their progress and to identify areas needing attention as they adapt the IRDMP to achieve its overall goal.

6.4.1 Plan Performance Measures and Objectives

Those responsible for implementing the IRDMP need to select performance measures, or indicators, to be used to track progress toward objectives. Indicators are direct or indirect measurements of some valued component or quality of a system. Good indicators can be useful for assessing and communicating the status and trends of land use, pollutant source control, and water quality. Indicators should be quantitative to allow measurement of the problems and progress toward solving them (USEPA 2008).

Criteria for indicators

- **Validity**
  - Related to goals and objectives
  - Appropriate to geographic and temporal scales
- **Clarity**
  - Simple and direct
  - Accepted by stakeholders
  - Consistent methods over time
- **Practicality**
  - Adequate data available for immediate use
  - Few constraints on data collection
- **Clear Direction**
  - Clear implications for action depending on whether the change is good or bad

Source: USEPA 2008

Primary performance measures for the IRDMP should include indicators that address the extent to which the plan is implemented, the effectiveness of specific practices installed under the plan, and the overall effect of the plan on achieving water quality and air quality goals. Other programmatic indicators might also be of interest, including tracking and documenting progress made in performing special studies (e.g., assessing CNMP performance when lagoon water is applied to cropland), creating and implementing administrative tools (e.g., manure manifest program), and identifying BMPs that will enable CAFOs to achieve environmental goals (e.g., as accomplished in this IRDMP). The financial condition of dairies in the San Jacinto River watershed is of primary concern, and stakeholders might wish to include an indicator of dairy financial health as part of the approach for monitoring IRDMP performance. This monitoring plan, however, focuses on indicators related to BMP implementation and environmental response.

The monitoring plan addresses three principal objectives:

1. Track implementation of the IRDMP to demonstrate compliance with regulatory requirements and to detect changes in application and management of dairy manure and process wastewater
2. Measure the effectiveness of individual management practices on dairies and lands receiving dairy manure or process wastewater
3. Monitor water quality in selected receiving waters to detect changes as a result of implementing the IRDMP and to fill information gaps

Tracking the progress of the IRDMP will document immediate indicators of actions taken to solve the water quality problems associated with dairies in the San Jacinto River watershed. Measuring the effectiveness of management practices adopted on San Jacinto dairies will provide direct evidence of changes in pollutant generation and delivery to the watershed. Finally, monitoring of water quality in surface and groundwaters of the San Jacinto River watershed will reveal the overall progress of the IRDMP in solving groundwater, surface water, and salts problems in the watershed, as well as filling information gaps to help refine the IRDMP to more efficiently achieve its overall goals. A combination of monitoring that addresses both near-source (i.e., dairy- or BMP-specific monitoring) and receiving waters (surface and ground) is needed to develop an understanding of the relationship between the implementation of strategies/BMPs and the anticipated reduction of pollutant loads and improvements in water quality. Specific indicators recommended for these three monitoring objectives are discussed in the following sections.

Although regulations require dairies and related businesses (e.g., composting) to implement practices to protect air quality (see text box), no mandate is in place for dairies to perform air quality monitoring to assess the performance of these practices. The principal indicators of concern under those regulations are NH_3, VOCs, and fine particulate matter less than 10 microns (PM_{10}); ammonia is a PM_{10} precursor and VOCs are ozone precursors (Krause and Stevens 2004). SCAQMD monitors air quality in Perris and Lake Elsinore. While it is unlikely that air quality data collected at those locations can be related directly to emissions from dairies and lands receiving dairy manure or wastewater, let alone changes in the emissions, SCAQMD appears to be the best source for ambient air quality data related to implementing the rules. No additional air quality monitoring is recommended in this plan because both the cost and technical requirements are generally beyond the reach of IRDMP stakeholders. This plan does, however, include recommendations for tracking various indicators of compliance and progress toward reducing air quality effects from dairies. Rule 1127, for example, requires dairy farms and related operations (e.g., heifer and calf farms) with 50 or more head to implement a number of practices from a suite of options, including when to scrape manure from a corral and paving feedlanes. Rule 223 requires that confined animal facilities with 1,000 or more milk-producing dairy cows implement specific mitigation measures, also selected from a suite of options, including such things as corral cleaning frequency and manure depth management,

AIR QUALITY

SCAQMD Rules 223 and 1127 apply to San Jacinto dairies (SCAQMD 2009). The purpose of those rules is to reduce ammonia (NH_3), VOCs, and PM_{10} (fine particulate matter) emissions from livestock waste on CAFOs. SCAQMD conducts air quality monitoring using a network of 35 permanent, ambient air quality monitors spread over an area that includes Orange County and the non-desert portions of Los Angeles, Riverside, and San Bernardino counties (Bermudez and Fine 2009). Some of these sites monitor air pollutants in Perris and Lake Elsinore. Pollutants measured at Lake Elsinore are CO, NO_2, O_3, $PM_{2.5}$, and PM_{10}, while O_3 and PM_{10} are measured at Perris.

cleaning feed aprons, corral drainage maintenance, covering dry manure piles, composting with aerated static piles, and digesters.

EMWD conducts an active groundwater monitoring program in two management areas that overlap the San Jacinto River watershed: the West San Jacinto Groundwater Basin Management Area and the Hemet/San Jacinto Water Management Area (EWMD 2008, 2009). The EMWD programs include semiannual monitoring of groundwater levels, metering groundwater extraction, and annual groundwater quality sampling (major cations and anions, nitrogen, metals, conductance, and TDS) from several hundred private, public, and agricultural wells in the region. No additional watershed-scale groundwater monitoring is proposed for the IRDMP. This plan includes recommendations for tracking indicators of progress toward reducing groundwater effects from dairies; site-specific groundwater monitoring might be appropriate for evaluating the performance of specific BMPs (see below).

6.4.2 Long-term Monitoring Plan

This recommended monitoring plan is based on an assessment of data available and considering related, ongoing monitoring activities that could provide an efficient means of obtaining the data needed to assess the effectiveness of the IRDMP. This section discusses performance measures and data needs to meet the monitoring plan objectives, describes existing monitoring and tracking efforts that can contribute to the IRDMP performance assessment, and recommends additional efforts to supplement existing activities.

The long-term monitoring plan calls for three main elements corresponding to the objectives discussed above: IRDMP implementation, BMP effectiveness, and watershed surface water quality.

6.4.2.1 Objective 1: IRDMP Implementation

Tracking implementation activities under the IRDMP will focus on individual dairies, on dairy-related cropland, and on activities at the watershed scale.

Indicators

Key indicators (and relevant watershed issues) for this objective include the following:

- **Dairy operational data, including number and type of animals and quantities of manure and wastewater generated on watershed dairies (surface water, groundwater, and air quality).** Accurate information on the quantities of pollutants to be managed in the watershed is essential, and the quantities could change with changing the dairy economy over time.
- **Estimates of dairy-derived salt application to watershed lands (groundwater).** Accurate information on application quantities and locations will allow separate estimates for inputs to land on-dairy versus off-dairy, and over GWMZ versus not over GWMZ, as well as assessing changes from salt-offset efforts.
- **Estimates of field, farm, and watershed-scale nutrient balances (surface and groundwater).** The nutrient balance will yield estimates of net over- or under-application.
- **Inventory of practices implemented to address groundwater, surface water, and air quality concerns.** The inventory should include a summary of specific mitigation measures implemented in accordance with Rules1127 and 223. Units will vary, but they should include acreage and number of animals served by the practices.

Data Needs

Core data needs for tracking the IRDMP implementation are summarized in Table 6-1. The rationale for tracking the variables, or indicators, describes their relationship to the key indicators listed above.

Table 6-1. Data needs for tracking IRDMP implementation

Source	Monitoring variables	Rationale
All land in watershed	• Land use, acreage, location	Changes in cropland acreage will affect manure hauling options. Aids interpretation of watershed water quality data under Objective 3 because changes in land use will contribute to changes in water quality.
Land receiving manure and process wastewater	• Location, land use, crops receiving manure or wastewater (acreages, acreage overlying GWMZ, rotations and dates, soil test results, fertilizer applied, crop nutrient needs, yields); • Manure or wastewater application (dates, amount, application methods, nutrient and salt content, % moisture, sources); and • Fertilizer application (N, P and K rates and dates)	Documents hauling from San Jacinto dairies, as well as manure or wastewater applications from other sources. Allows estimation of salt application and nutrient balance calculations to indicate compliance with nutrient management goals. Application method (e.g., immediate incorporation of manure on land over GWMZ with nitrate and TDS assimilative capacity) helps document air quality protection achieved.
Dairies	• Name and location, acreage, number of animals and types, manure and wastewater production (amount, nutrient and salt content, % moisture) • Cropland receiving manure or wastewater (acreage, acreage overlying GWMZ, rotations and dates, soil test results, fertilizer applied, crop nutrient needs, yields) • Manure applied on-site (dates, amount, application methods, nutrient and salt content, % moisture) • Wastewater applied on-site (dates, rate, nutrient and salt content) • Manure and wastewater removed from site (dates, amount, salt and nutrient content, % moisture, destination) • Water consumption by dairy (private and EMWD well amounts and TDS/nitrate content) • Water use by dairy (cropland irrigation, storage, stock watering, cleaning, other) • Frequency and volume of discharges of process wastewater or stormwater runoff from manured or production areas • TDS and nitrate offsets applied (amount, dates, locations) • Frequency and duration of direct contact between animals and waters of the United States • Existence of approved EWMP or approved NMP implemented as part of the emission mitigation plan under Rule 223. • Other practices implemented specifically for compliance with Rule 223 and Rule 1127	Documents land application and hauling of manure and wastewater by San Jacinto dairies. Allows estimation of salt and nutrient application on dairy and salt and nutrient export from dairy to locations in and outside watershed. Allows mass balance estimation for manure generation, application or storage on farm, and hauling within and outside San Jacinto watershed. Manure application method and practices implemented under Rules 223 and 1127 contribute to documenting air quality protection achieved. Allows water balance calculations and estimating salt and nitrate mass balances from water use.

Table 6-1. Data needs for tracking IRDMP implementation (cont.)

Source	Monitoring variables	Rationale
Other animal operations	• Location, acreage, number of animals and types, crops (types, acreage, rotations and dates, manure/wastewater and fertilizer applications, crop nutrient needs, yields) • Manure (amount generated, nutrient content, % moisture) • Process wastewater (amount generated, nutrient content) • Manure and wastewater management practices • Cropland management practices	Information on other animal operations is needed to interpret watershed monitoring data collected under Objective 3. TDS and GWMZ information not tracked because groundwater monitoring is not performed. It might not be possible to collect all data from non-dairy operations.

Existing Monitoring and Available Data

Much of the data included in Table 6-1 should be obtainable from records and annual reports required under the General Permit (Order No. R8-2007-001) each January 15th, as illustrated in Appendix K. Data from annual reports, EWMPs, and NMPs for dairies should be obtained directly from documents on file at the RWQCB. It is important to note, however, that cooperating dairies will need to provide this information in a consistent format and at a level of detail suitable for long-term tracking objectives. In some cases, improvement in the RWQCB's review and oversight would help improve the quality and reliability of the information reported by dairies under their permits.

NMPs have the potential to provide much of the information needed to estimate mass balances for nutrients, an important piece of data for demonstrating the extent to which dairies have implemented the IRDMP. However NMPs are required only of dairies that apply manure or wastewater to their own cropland under the General Permit, and the land covered by this provision represents a relatively small portion of the land receiving dairy manure in the watershed. For sufficient NMP information to be available to interpret watershed-scale water quality information, similar data are needed from others in the watershed who apply animal waste or fertilizer to their lands. It is possible that the forthcoming *Conditional Waiver of Waste Discharge Requirements* could require that all operators of irrigated or dry-farmed land, and of other agricultural or livestock operations not already regulated by the RWQCB implement NMPs, but this has not yet happened. Because the specific details of NMPs differ across farms, it is important to track—in addition to whether a farm/dairy has an approved NMP—the actual nutrient application rate and methods, manure and soil test results, crop rotations, and crop yields to better characterize the NMPs for relationship to water quality data. If the RWQCB adopted a specific NMP template as part of the dairy permit, it would help to generate reliable and complete data from dairies and others adopting NMPs. An NMP template or more specific technical standards for nutrient management could also help to ensure application of manure and other nutrient sources at rates that are protective of groundwater and surface water quality.

In addition to reporting under the General Permit, Rule 223 requires that dairies with 1,000 or more milk-producing cows submit to SCAQMD annual compliance plans and maintain records of monthly animal populations. The annual compliance plans must include identification of the control measures to be implemented as part of the CAFO's emissions mitigation plan. Record-keeping and reporting requirements under Rule 1127 for dairies and related operations with 50 or more head include annual reports that include information on animal population, the amount of manure transported to agricultural lands and manure processing operations within the jurisdiction of SCAQMD, and the amount of manure transported outside SCAQMD's jurisdiction. The SCAQMD is an area of 10,750 mi^2 and encompasses most of Los Angeles, San Bernardino, and Riverside counties and all of Orange County (Figure 5-3). To the east, the SCAQMD extends about 25 miles east of Desert Center, but it does not extend to the city of Blythe.

Record-keeping requirements for dairy operators under Rule 1127 include all manure manifests, tipping fee invoices, manure moisture test records, corral clearing records, and stockpile removal records, including date(s) of removal, hauler (if applicable), and manure destination. While not requiring reporting by dairies, haulers, or those receiving manure or process wastewater, Riverside County Ordinance No. 427 does specify that the Riverside County Agricultural Commissioner must maintain for public inspection a list of approved exempt sites that can receive manure in the unincorporated areas of the county. That list includes the approval date, site location, dates of manure application, and the expiration date for each exemption, all useful information for tracking application of manure from San Jacinto dairies and other sources.

Known Gaps

Much of the information identified in Table 6-1 that should be obtainable via General Permit reporting is of uneven quality and reliability, particularly when considering the needs for tracking information under this objective. Specifically, NMP data are not consistently reported. That is a major problem when considering the task of developing mass balance estimates for manure, nutrients, and salts.


San Jacinto Wildlife Area

Information on salt content of manure and wastewater generated on San Jacinto dairies is not systematically collected, nor are quantities of wastewater generated tracked beyond estimates contained in facility EWMPs. The recommendations in Section 5.1.5 for tracking quantity and quality of dairy manure and wastewater for estimating salt load through water metering and for regular manure and wastewater sampling and analysis should be implemented to fill these gaps and to track quantitative progress in salt offset efforts.

Information regarding NMPs is likely to not be broadly available because NMPs are required only of dairies that apply manure or wastewater to their own cropland under the dairy discharge permit. This would greatly compromise the ability to look at nutrient mass balance at the watershed scale, a valuable tool for documenting progress in meeting implementation goals and for purposes of interpreting water quality data. This issue could be addressed either via the forthcoming *Conditional Waiver of Waste Discharge Requirements* or through a negotiated agreement among all in the watershed who apply nutrients to cropland.

Recommendations

Improvement in the RWQCB's review and oversight would help improve the quality and reliability of the information reported by dairies under their permits. Its adoption of a specific NMP template as part of the dairy permit would help to generate reliable and complete data from dairies and others adopting NMPs.

NMP data and other practice and crop information specified in Table 6-1 that are not available through those programs described above could be obtained by dairy self-reporting, perhaps facilitated by the RWQCB annual reporting process, from the Riverside County Cooperative Extension Service, by surveys administered through the WRCAC, or by other means.

When the recommended Manure Manifest System is implemented, a substantial amount of the data identified in Table 6-1 should be obtainable from a single source, the SJBRCD. Specifically, the SJBRCD should be able to provide the following (Tetra Tech 2008a):

Dairies

- Facility name and location
- Number of milking cows, dry cows, heifers, calves
- Number and type of other animals
- Manure amount
- Nutrient and dry matter analyses of manure
- Frequency of nutrient and dry matter analyses
- Total facility acreage
- Corral acreage
- Crops, acreage, and number of plantings per year
- Status of NMP
- Containment pond capacity
- Wastewater disposal/pasture acreage
- Estimated frequency or timeline for manure/wastewater removal
- Dates, manure quantity, and condition (wet/dry/composted) of manure transfers

Landowners receiving manure

- Location
- Acreage of land available for manure/wastewater application
- Current crops and acreage
- Crop rotation
- Number of plantings per year
- Crop history and associated acreage
- Status of NMP
- Soil information
- GWMZ
- Soil sampling results
- GIS-based field maps
- Date, areas, and methods for application of manure/wastewater

Under the proposed Manure Manifest System, haulers would confirm the transfer dates, manure quantity, manure condition, and source and destination of manure or wastewater. Essentially, all above information would be updated annually, and site visits would confirm basic information about CAFOs and land application sites, providing some degree of quality assurance/quality control. Site visits would also be used to collect additional data, including potential drainage and runoff effects. While most of the dairy information listed above is already available in facility EWMPs and annual reports to the RWQCB, the Manure Manifest System would provide a convenient and up-to-date source of information. Several important pieces of information that are not routinely reported—

manure analysis on smaller dairies and detailed data on all manure transfers—would be collected by the Manure Manifest System.

In addition, the monitoring plan for the Lake Elsinore and Canyon Lake Nutrient TMDL includes two special studies that could provide some very useful data for Objective 1 if funding is available (LESJWA 2006). An assessment of agricultural/fertilizer application and spatial variability of crop types in the watershed would include the following components:

- Spatial inventory (GIS) of crop distributions in the watershed; if crops are rotated throughout the year, each crop and associated season would be included in the inventory.
- Estimates of seasonal nutrient application rates for each crop type. For both fertilizer and manure, content will be assessed to determine quantities of nitrogen and phosphorus. If management of specific farms varies significantly for identical crop types, nutrient application rates will be estimated and catalogued separately for each farm so that spatial variability in the watershed will be representative of such conditions.
- Estimates of agronomic rates associated with each crop type for both nitrogen and phosphorus.

Second, the EMWD plans to update its previous land use data set to current conditions. Once collected, these data can be used to update the previously developed watershed model to assess changes in pollutant transport and effects on Canyon Lake and Lake Elsinore.

Finally, in addition to the pollutant source and disposition inventory data discussed above, the implementation of specific BMPs on individual dairies or groups of dairies should be tracked and documented. The following information about each case of BMP implementation should be recorded annually:

- BMP name/process
- Facility/facilities served
- Manure or wastewater quantity treated/land area served
- Date completed/operational
- Design parameters, e.g., capacity, inputs/outputs, rates
- Operation and maintenance activities needed, scheduled, and completed
- Other relevant information

In some cases, BMP installation would be reflected in updated EWMPs filed with the RWQCB. Other BMP tracking could be largely self-reported because it would be in each dairy's interest to take credit for its contributions to solving the problems facing the dairy industry in the watershed. Individual dairy BMP installation data should be collected and reported annually for the entire San Jacinto River watershed.

> Collecting data on IRDMP implementation will track progress made toward managing the sources and disposition of nutrients and salts in the San Jacinto watershed. Information from animal inventories, dairy facility infrastructure, manure and wastewater disposition, and nutrient management on dairy-associated cropland will confirm changes in pollutant generation patterns in the watershed resulting from the IRDMP. Data on BMPs implemented will document concrete efforts taken to control pollutants from dairies and, when combined with results of individual BMP monitoring, will help estimate actual pollutant reductions by dairies in the watershed.

6.4.2.2 Objective 2: BMP Effectiveness

Indicators

Indicators appropriate for this objective could include

- Pollutant removal
- Percent and absolute change in concentration or load

Data Needs

It is difficult to identify data needs and set out specific protocols for monitoring of individual management practices before it is known what practices are installed and where. However, some guidelines and principles can be provided.

Existing Monitoring and Available Data

Although two completed BMP monitoring studies (VSEP and CNMP/lagoon wastewater, see Section 3.2) have provided data on BMP effectiveness, no ongoing BMP monitoring activity within the San Jacinto River watershed can contribute to this objective, so this will be a new effort.

Known Gaps

No ongoing BMP monitoring or identification of specific BMPs can be relied on to achieve watershed goals. Without identifying these BMPs and the schedule and locations for their implementation, specific monitoring recommendations cannot be made.

Recommendations

In general, at least one instance of each significant BMP implemented in the San Jacinto (e.g., precision feeding, wastewater treatment system, digester) should be monitored to document its effectiveness in reducing nutrient and salt pollutants. The design of BMP effectiveness monitoring will vary fundamentally with the type of practice:

1. **Source reduction practices.** To monitor the effectiveness of source reduction practices such as precision feeding or manure amendment, comparison of treated (e.g., where precision feeding is implemented) and control (e.g., where conventional feeding is practiced) dairies is an appropriate design. On the selected treatment and control dairies, collect data on the quantity of feeds imported and the quantity of manure generated. Sample and analyze P, N, and salts in feeds and manure monthly for 12 months. Each month and annually, compare the mass of P, N, and salts imported in feed and excreted in manure for the treated and the control dairies. The difference in nutrient and salt mass inputs and outputs between the two dairies (tested with appropriate statistics) will provide data on the effectiveness of the practice.
2. **Wastewater/manure treatment practices.** To assess the effectiveness of treatment BMPs such as digestion, constructed wetlands, or composting, an input/output design is recommended. For a specific BMP, identify locations to sample (for quality and quantity) inputs and outputs from the BMP. For a digester, that would involve measuring the quantity and the nutrient and salt concentrations of the manure feedstock and making comparable measurements of the residuals after digestion. If the residuals from digestion or desalting are managed through disposal or export, this component should be tracked in a mass-balance approach similar to manure export, as discussed below. Appropriate variables would include total P, soluble P, all forms of N, TDS, and % dry matter. Note that it is important to measure not just the concentration of these

constituents, but also the quantity of the parent material so that the mass of constituents is known. Appropriate sampling frequency would depend on the BMP. A single sampling before and after digestion or composting might suffice, whereas weekly or monthly sampling of a wetland treatment system might be necessary to capture important seasonal or temporal variations. In a flow-through situation like a wetland or pond treatment system, sampling frequency should also consider the time required to move through the system so that the same water mass is sampled going in and going out. Outputs can be compared to inputs as percent reduction; actual output concentrations and loads must also be evaluated to assess the level of treatment accomplished by the BMP. For a wetland or other system where plants or other organisms perform part of the treatment function, it would be important to allow the system to fully develop (perhaps for a full year) before evaluating effectiveness and to track performance indicators such as vegetation growth, water level, and sediment accumulation.

3. **Manure export.** Monitoring manure export effectiveness would focus on tracking the export of manure from individual dairies and from the San Jacinto River watershed. Manure production data are available from individual dairy records and from RWQCB annual reports. Data on manure hauling and destinations can be collected from individual dairy records and from the Manure Manifest System. To track the effectiveness of manure export, the mass of manure produced can be compared with the mass of manure and manure products (e.g., composted manure) shipped outside the watershed. That information can be supplemented by manure and manure product nutrient and salt analysis data to calculate the mass of P, N, and salts effectively exported from the watershed.

BMP effectiveness monitoring should focus on the constituents the practice is designed to treat. Evaluation of the effectiveness of precision feeding, for example, should focus on concentrations of soluble and total P and total N in feed and animal waste. Assessment of manure amendment to immobilize P and N should measure soluble and total P, ammonia-N, and total N concentrations in the manure. Treatment effectiveness of dairy wastewater treatments such as VSEP should document changes in TDS and conductivity. Performance of wastewater lagoon treatments such as multiple ponds or constructed wetlands should be tested by measuring concentrations and loads of total and soluble P, ammonia-N, nitrate-N, and total N, TDS, and conductivity.

Crop monitoring for the CNMP Pilot Project

Sample type, location, and frequency will depend on the specific BMPs monitored. Monthly grab samples would probably be sufficient to document changes in wastewater and manure quality in response to precision feeding; weekly grab samples would likely be necessary to evaluate wastewater and manure treatment practices, at least initially. Some BMPs, such as pond treatments or constructed wetlands, might require more frequent sampling (e.g., storm event sampling) if they are subject to weather influences. Note that for input/output monitoring of treatment practices, some adjustment of sampling frequency and schedules would be necessary to account for time of travel of water through the treatment system.

In general, most BMPs should be monitored for at least one full year to assess performance through a full seasonal cycle. For practices that require time to fully develop, e.g., a constructed wetland, longer-term monitoring would likely be required as the practice matures. While BMP effectiveness monitoring can be used to assess actual versus expected performance of BMPs, short-term monitoring results generally should not be used to justify changing BMPs unless the results are dramatic and easily interpretable.

For watershed-scale practices such as a regional digester, composter, or systematic manure export, monitoring would probably focus on analysis of feedstock and product for moisture content, percent dry matter, soluble and total P, ammonia-N, organic-N, nitrate-N, total-N, and chloride. At least monthly grab sampling over a full seasonal cycle is recommended.

Documenting the effectiveness of individual BMPs through monitoring will provide credible, site-specific evidence of pollutant-reduction results from implementing the IRDMP by San Jacinto dairy operators. When combined with watershed-wide BMP inventory information, the resulting data would support reasonable estimates of the effects of the IRDMP on reducing real watershed pollutant loads.

It is impossible to address all the technical considerations required for good BMP monitoring in this plan. For additional information and guidance, see these sources:

- USDA (U.S. Department of Agriculture). 1996. *National handbook of water quality monitoring, part 600 national water quality handbook.* U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC. ftp://ftp.wcc.nrcs.usda.gov/downloads/wqam/wqm1.pdf
- USEPA (U.S. Environmental Protection Agency). 1997. *Monitoring Guidance for Determining Effectiveness of Nonpoint Source Controls, Final.* EPA/841-B-96-004. September 1997. Available through the National Service Center for Environmental Publications at (800) 490-9198.
- Law, N.L., L. Fraley-McNeal, K. Cappiella, and R.Pitt. 2008. *Monitoring to Demonstrate Environmental Results: Guidance to Develop Local Stormwater Monitoring Studies Using Six Example Study Designs* (Study Design 3). Prepared for the Center for Watershed Protection, Ellicott City, MD.

6.4.2.3 Objective 3: Watershed Water Quality

Indicators

Appropriate indicators (and relevant watershed issues) for this objective include the following:

- Surface water nutrient and TDS loads (TMDL, groundwater, information gaps)
- Surface water bacteria and BOD concentrations and loads as indicators of manure runoff
- Stream and ditch water chemistry (information gaps)
- Mystic Lake nutrient and TDS loads, both inflow and outflow (TMDL, groundwater, information gaps)
- Mystic Lake nutrient and TDS concentrations (groundwater, TMDL, information gaps)
- Mystic Lake water chemistry (information gaps)

Basic water chemistry for Mystic Lake, streams, and ditches will help fill information gaps regarding the flow and transport of pollutants in the Gap Area described below.

Data Needs

Data needed to apply the indicators for this monitoring objective are summarized in Table 6-2 for surface water and Table 6-3 for Mystic Lake. In addition to the water quality data identified in these two tables, it is important to track the land use and land treatment data listed in Table 6-1 at the watershed scale to aid interpretation of the water quality data.

Table 6-2. Runoff and stream or ditch water monitoring variables and rationale

Monitoring variables	Rationale	Comments
TSS, total organic carbon, pH, temperature, dissolved oxygen, BOD	Standard water chemistry data	Section 303(d) list includes low dissolved oxygen in Lake Elsinore
Total coliform, fecal coliform, and *E. coli*	Dairy wastes are sources of bacteria	Section 303(d) list includes high bacteria in Canyon Lake
TDS and conductivity	Concerns of TDS loading from dairies[a]	TDS not monitored in Phase 1 or Phase 2 of TMDL monitoring
Total P, soluble P, ammonia N, TKN	Measurement of nutrient loads associated with dairies	Lake Elsinore and Canyon Lake nutrient TMDL
Nitrate N	Concerns of NO_3-N loading from dairies	Lake Elsinore and Canyon Lake nutrient TMDL

a. Although TDS loading is limited only by groundwater objectives, by tracking TDS in surface water, some gaps in understanding regarding sources and transport of TDS can be addressed. Given local hydrologic conditions, much of the surface water simply percolates into the soil profile without moving on to the lakes.

Table 6-3. Mystic Lake monitoring variables and rationale

Monitoring variables	Rationale	Comments
Depth, pH, temperature, conductivity, dissolved oxygen, TSS, total organic carbon	Standard limnological data	Section 303(d) list includes low dissolved oxygen in Lake Elsinore
Total coliform, fecal coliform, and *E. coli*	Section 303(d) list includes high bacteria in Canyon Lake	Not monitored in Phase 1 at Lake Elsinore and Canyon Lake
TDS	Concerns of TDS loading from watershed	Not monitored in 2008 or in Phase 1 at Lake Elsinore and Canyon Lake
Total P, soluble P, nitrate N, ammonia N, TKN	Responds to incoming watershed nutrient loads	Source of nutrient loads to L. Elsinore and Canyon Lake in wet scenario
Nitrate N	Concerns of NO_3-N loading from watershed	Source of nutrient loads to L. Elsinore and Canyon Lake in wet scenario

Existing Monitoring and Available Data

Modeling

The design of any watershed monitoring effort requires an understanding of watershed hydrology and pollutant sources. Modeling performed to develop the nutrient TMDL for Lake Elsinore and Canyon Lake sheds considerable light on the hydrology and pollutant sources of the San Jacinto River watershed (Tetra Tech 2003). For example, results have identified areas that are significantly affected by dairies and dairy manure or wastewater. Such areas are important to assessing IRDMP performance because they hold the greatest potential for documenting water quality changes because of changes in managing dairies and their manure or wastewater. This modeling is summarized in Figure 6-2 and in Appendix L. At the time of writing this report, an update of the TMDL modeling is underway. Readers should consult the revised modeling results when they become available.

Mystic Lake is clearly a very important waterbody in the San Jacinto River watershed, particularly with regard to the IRDMP. Scenario 1 modeling results indicate the need to monitor the discharge from Mystic Lake with storm-event monitoring to capture the wet season. Mystic Lake water quality will reflect to some degree the effect of dairy and manure/wastewater management because it receives all the flow from zones 7–9 (see Figure 6-2), including surface runoff that flows over agricultural and dairy operations because of failure of the earthen structures within the San Jacinto River *Gap Area* (Tetra Tech 2007). A feasibility study was performed to assess the effectiveness and viability of better managing the flood flows through improvement of the river reach in this area (Figure 6-3), and any actions taken in response to the study will have potential effects on both Mystic Lake and San Jacinto River water quality. For that reason, it is important to monitor both Mystic Lake and the San Jacinto River, preferably upstream and downstream of the Gap Area.

The accumulation of N and P from cropland and dairies along the pathway from zone 9 to zone 7 indicates a potential for upstream-downstream monitoring to demonstrate the impact of the San Jacinto dairies and associated cropland on N and P loads. Based on modeling, the contributions of N and P from both forest and septic systems in these zones are significant, however, and cannot be ignored (Tetra Tech 2003). Forest inputs should occur largely upstream of the dairies, so could be factored out to some degree by measuring flow and taking samples at a site downstream from the major forested area and upstream of the major dairy areas (e.g., Zone 9 outflow).

San Jacinto River watershed cropland

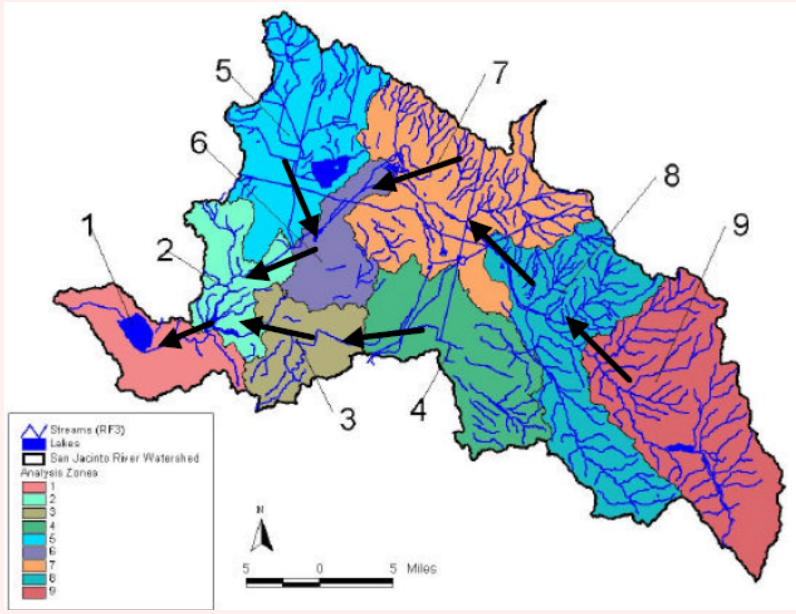


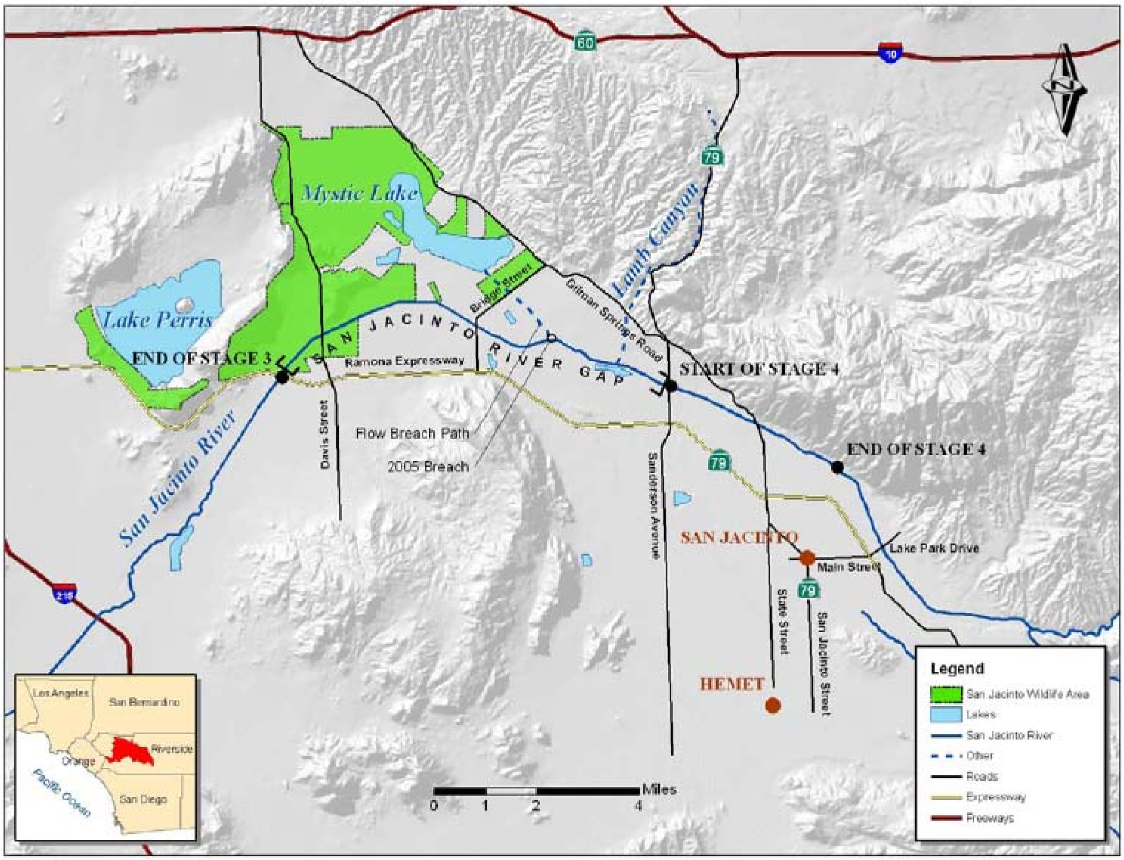
Figure 6-2 San Jacinto River watershed modeling.

Although some of the assumptions and data used are out of date, modeling performed to develop the nutrient TMDL for Lake Elsinore and Canyon Lake (Tetra Tech 2003) provides important context on the hydrology and pollutant sources of the San Jacinto River watershed that is useful to guide a monitoring program. Under this modeling effort, the San Jacinto River watershed was divided into nine modeling zones to examine N and P loading sources to Lake Elsinore and Canyon Lake under three different hydrologic scenarios:

- Scenario 1: Mystic Lake and Canyon Lake overflowed (wet year)
- Scenario 2: Canyon Lake overflowed, but Mystic Lake did not (moderately wet year)
- Scenario 3: Neither Mystic Lake nor Canyon Lake overflowed (dry year)

San Jacinto dairies are primarily in zones 3, 6, and 7 in the middle region of the watershed. Modeling results clearly indicate that dairies contribute more to the export of N from Mystic Lake than does cropland in wet years (Scenario 1), whereas cropland contributes much more of the P export from Mystic Lake. Zone 5 cropland contributes so much more N than zone 5 dairies under Scenario 1, that the zone 6 N load has a greater cropland than dairy contribution despite the larger dairy versus cropland contribution from zone 7. Cropland is a bigger contributor than dairies to both N and P in zones 4 and 3 under Scenario 1. Under drier conditions (scenarios 2 and 3), neither cropland nor dairies contribute much N or P through zone 6, while cropland contributes about twice as much N and 8-10 times as much P as dairies to the relatively small loads from zone 3.

The general pattern for dairy N and P under scenario 1 indicates an accumulation from zone 8 to zone 7, followed by a slight decrease through zone 6, with little contribution from zone 5. The dairy N load from zone 6 represents about 80 percent of the total dairy N load to Canyon Lake, while the dairy N load from Mystic Lake equals 103 percent of the dairy N load to Canyon Lake. Dairy N contributions increase substantially from zone 4 to zone 3, increasing again within zone 2. Under scenarios 2 and 3, very little dairy N and essentially no dairy P passes through zone 6, with zone 3 having the greatest, though relatively small, accumulation of dairy N and P.



Source: Tetra Tech 2007

Figure 6-3. San Jacinto River gap area.

The Gap Area

The Gap Area is an approximately 4.4-mile-long rural area within the 100-year floodplain of the San Jacinto River composed mostly of dairy farming to the south and southeast and Mystic Lake and the San Jacinto Wildlife Area to the north and northwest (Figure 6-3). A channel/levee system constructed beginning in the early 20th century diverted flood flows away from the Mystic Lake depression and toward the better defined river channel below the Ramona Expressway (Tetra Tech 2007). This diversion channel is typically shown as the San Jacinto River on most maps today. Typically, in wetter storm seasons, the river breaks through the levees of the diversion channel and begins to fill Mystic Lake and, in extreme years, the rest of the floodplain. However, managing ephemeral flows in the river during moderate years has become problematic, and the channel is plagued by sediment buildup and vegetative growth. Consequently, smaller flow events have caused failure of the diversion channel levees, and damage to the agricultural properties has become more frequent, increasing nutrient loads in the flow reaching Mystic Lake.

Modeling results also indicate that grab sampling in Zone 3 during runoff events might be appropriate to assess the effect of the IRDMP on pollutant loads there. Scenarios 2 and 3 results show that dairies and cropland in Zone 3 are larger contributors of N and P to Canyon Lake than dairies and cropland in Zone 6 but that the overall dairy loads to Canyon Lake are much lower than under Scenario 1.

TMDL Monitoring

The adopted Lake Elsinore and Canyon Lake TMDL Amendment (RWQCB 2004) requires stakeholders to prepare and implement a Nutrient Monitoring Program to include the following:

1. A watershed-wide monitoring program to determine compliance with interim or final N and P allocations; compliance with the N and P TMDL, including the LAs and WLAs

2. A Lake Elsinore nutrient monitoring program to determine compliance with interim and final N, P, chlorophyll *a*, and dissolved oxygen numeric targets
3. Canyon Lake nutrient monitoring program to determine compliance with interim and final N, P, chlorophyll *a*, and dissolved oxygen numeric targets
4. An annual report summarizing the data collected for the year and evaluating compliance with the TMDL

The approved plan includes monitoring in three phases to accommodate budgetary and staffing considerations and to account for significant gaps in information required to understand in-lake and watershed processes (LESJWA 2006). The three phases are described below.

Phase 1—Intensive Lake Study

Phase 1 focuses on data issues regarding in-lake processes and on relating external pollutant loading to in-lake response and associated nutrient concentrations compared to numeric water quality targets. Phase 1 was scheduled to occur over a 2- to 3-year period, depending on the completion of in-lake studies and the amount of data collected:

a. Continuing trend monitoring in Lake Elsinore and Canyon Lake
b. Watershed monitoring at four stations to determine lake inputs and compliance with load allocations
c. Extreme wet-weather monitoring for one event at 15 stations to verify hydrologic and pollutant transport processes in the model for the Mystic Lake area (if funding allows)
d. Continuing sediment nutrient flux and oxygen demand studies in Lake Elsinore and Canyon Lake
e. Monitoring dry-weather runoff flows and water quality
f. Studies on benefits of in-lake projects, reevaluating nutrient targets, and benefits of carp removal from Lake Elsinore

The results of Phase 1 monitoring will be used for the triennial review, including verification of LAs, and possible revision of the nutrient TMDL. After LAs are determined for each lake, more intensive monitoring in the watershed will be conducted in Phase 2.

Phase 2—Intensive Watershed Study

Phase 2 includes compliance monitoring and additional monitoring stations to address key data gaps needed in understanding external nutrient source contributions from the watershed:

a. Intensive watershed monitoring at 13 stations
b. Continuing trend monitoring in Lake Elsinore and Canyon Lake
c. Bathymetric survey of Mystic Lake and developing inflow and stage-outflow relationships
d. Mystic Lake in-lake water quality monitoring
e. Assessing agricultural/fertilizer application and spatial variability of crop types in the watershed
f. Updating the land use database

Completion of Phase 2 of the approved monitoring program will enable the prediction of more reliable internal and external watershed loading by updating historical models.

Phase 3—Compliance Monitoring

Phase 3, or the compliance monitoring phase, is proposed to begin after the intensive data collection efforts of Phases 1 and 2 are complete. It is proposed that this monitoring phase consist of an agreed upon base level of in-lake and watershed compliance monitoring determined after many of the data gaps have been addressed.

The TMDL task force is implementing Phase 1 of this approach, which includes watershed monitoring at TMDL stations 741, 745, 759, and 841 (Figure 6-4). Phase 1 calls for watershed sampling across the hydrograph of three storms per year. Continuous flow is measured at all four TMDL stations. Sampling to be performed at these sites is summarized in Table 6-4. Although not explicitly stated in monitoring plans, pH, turbidity, and TDS analyses were reported for some samples collected recently.

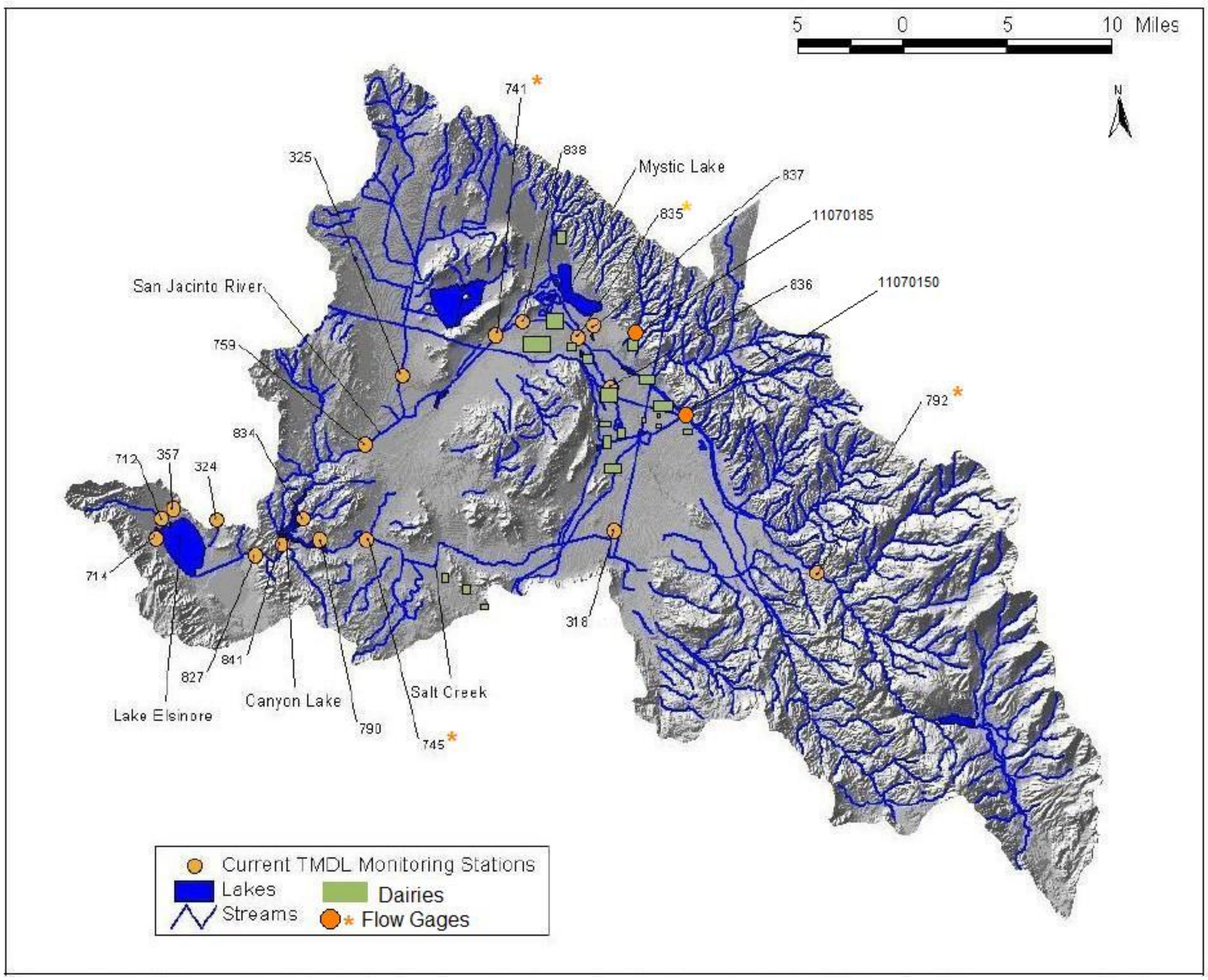


Figure 6-4. Location of dairies, TMDL monitoring stations, and flow gage stations.

Table 6-4. Phase 1 Watershed monitoring for nutrient TMDL (relevant to the IRDMP).

Stations	Sampling frequency	Laboratory analysis		
741 745	Eight samples across the hydrograph of three storms per year	Ammonia N Nitrite N Nitrate N Total N Soluble P	Total P BOD COD TSS Turbidity	pH Total hardness TDS Calcium Magnesium

Phase 1 watershed sampling from July 2006 through June 2007 produced no data because no runoff events occurred (LECLNTTF 2007). For the July 2007–June 2008 period, two storms were sampled, but no significant flows at sampling at station 741 occurred (LECLNTTF 2009a). Most recently, the July 2008–June 2009 monitoring period provided only two storm events. As in 2007–2008, no samples were collected at station 741 because no significant flows were observed (LECLNTTF 2009b). Although prior data had suggested that station 792 (San Jacinto River at Cranston Guard Station) might serve as a useful upstream station for an upstream-downstream study along the San Jacinto River upstream of Mystic Lake, that station has been removed because of the continual observance of low to no flow at the downstream location of Ramona Expressway (LECLNTTF 2009b).

Table 6-5 summarizes the six gaging stations identified through the process of developing the approved TMDL monitoring plan that could be useful for Objective 3 monitoring (Tetra Tech 2005; LESJWA 2006). With the exception of station 11070185 (Lamb Canyon Victory Ranch near San Jacinto), which is to be used only for the extreme wet-weather event, all stations will be monitored for water quality and flow in Phase 2 of the TMDL monitoring program. It is not known if station 792 will remain shut-down in Phase 2.

Table 6-5. Sampling station descriptions

TMDL station ID	USGS gage ID	Location	Monitoring phasesa	Affiliated agency	Period of record
792	11069500	San Jacinto River at Cranston Guard Station	E,2	USGS	10/1/1920–9/30/1991; 10/1/1996–present
745	11070465	Salt Creek at Murrieta Road	1, E, 2	USGS	10/1/1969–9/30/1978; 8/25/2000-present
741	11070210	San Jacinto River at Ramona Expressway	1, E, 2	USGS	8/23/2000–present
835	N/A	San Jacinto River at Bridge Street	2	Not Specified	New
N/A	11070150	San Jacinto River at State Street	E, 2	USGS, EMWD, RCFC	10/1/1996–present
N/A	11070185	Lamb Canyon Victory Ranch near San Jacinto	E	USGS, EMWD	1/26/1997–present

Source: LESJWA 2006

a. 1 = Phase 1, E = Extreme Wet Weather Event on Phase 1, 2 = Phase 2 of nutrient TMDL monitoring plan (LESJWA 2006).

Phase 3 TMDL monitoring is not described beyond consisting of an agreed upon base level of both lake and watershed monitoring (LESJWA 2006).

Additional Monitoring

As part of developing the IRDMP, WRCAC performed additional monitoring in 2007–2008 to provide data on pollutant loads in the watershed and to fill gaps in data needed for nutrient TMDL modeling and planning (Tetra Tech 2008b). (The final report describing the results of that monitoring is included as Appendix B.) Monthly sampling was conducted at two stations on Mystic Lake, while flow monitoring and water quality sampling of one storm event over each storm season (September 1 to April 30) was conducted at three locations in the San Jacinto River watershed (Figure 6-5, Table 6-6). Monitoring data from 2008 suggests that monthly[1] grab sampling at a single lake station (ML2) is adequately representative of water quality in the lake. A single lake station with samples collected at 3-foot intervals (for most parameters) was also recommended for Phase 2 monitoring of Mystic Lake in the *Lake Elsinore and Canyon Lake Nutrient TMDL Monitoring Plan* (LESJWA 2006).

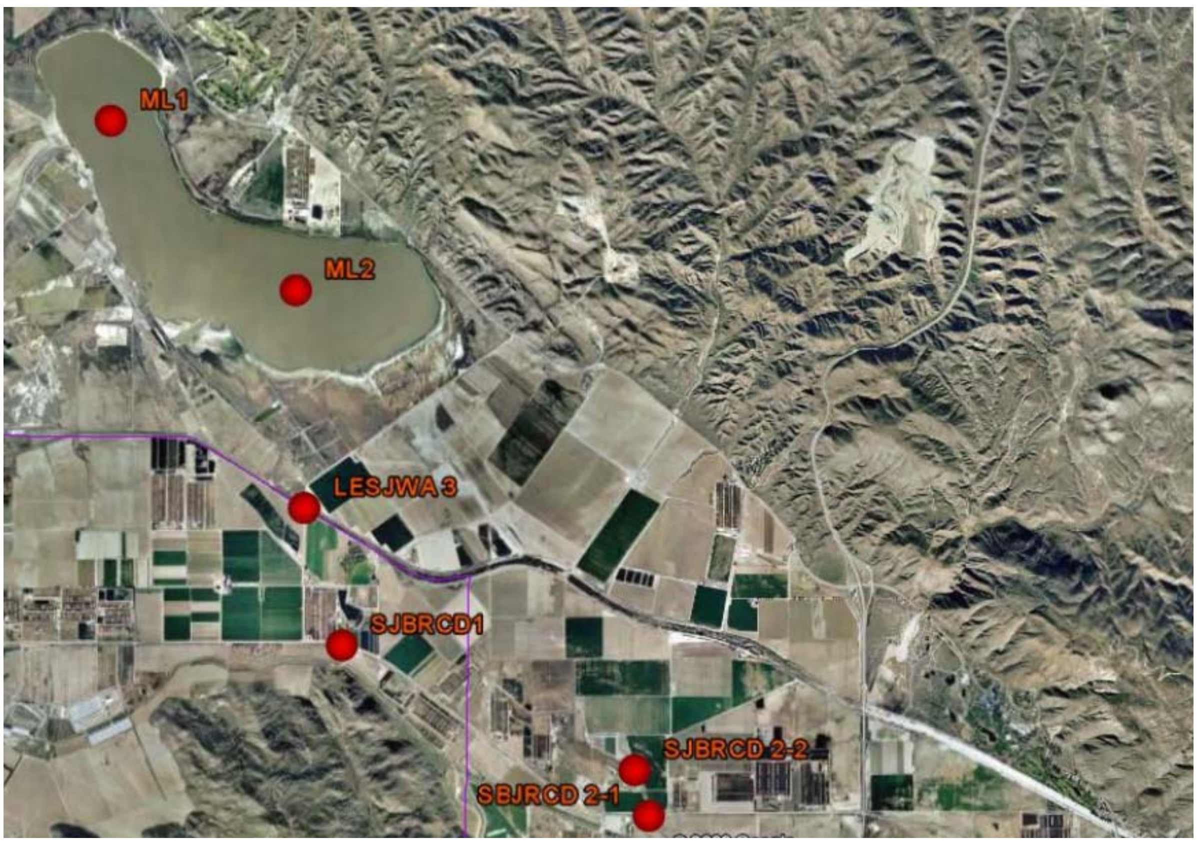


Figure 6-5. Location of 2008 monitoring sites.

The 2008 monitoring of stream and channel stations described in Table 6-6 was not entirely successful in documenting pollutant loads. Station SJBRCD2-1 was abandoned and replaced by SJBRCD2-2 because of flow measurement issues, and the flow sensor at SJBRCD1 had to be repositioned to permit more accurate low-flow measurement. It was soon discovered that the city of San Jacinto had diverted some of the flows from the SJBRCD2-2 channel for erosion control purposes, and discussions were initiated with the city to determine if and how that situation could be

1 Phase 1 Nutrient TMDL monitoring at Lake Elsinore and Canyon Lake is performed monthly October–May and biweekly June–September (LESJWA 2006).

rectified. Discussions led to agreement that construction would be completed and the flow pattern settled by January 2009. Monitoring was slated to begin again after construction, but state budget issues caused a delay, and monitoring did not occur.

Known Gaps

Very little data have been generated to date at the stream and channel monitoring sites in Table 6-6, so little is known about flows, water quality, and the utility of these stations for long-term monitoring under this objective. The following are specific concerns:

- Sampling has occurred at only about 2 events per year so far
- Monitoring was discontinued in 2009 at the upstream station 792
- Flow is not measured at all stations
- The variables analyzed are inconsistent among sites

Table 6-6. Description of the IRDMP monitoring sites for 2007–2008

Site name	Location (Long/Lat)	Station type	Type of sampling
ML1	North end of Mystic Lake	Lake	Grab
ML2	South end of Mystic Lake	Lake	Grab
SJBRCD 1	Ramona Expressway near Bridge Street, Te Velde property	Culvert under bridge crossing	Continuous-flow monitoring and time-weighted grabs
SJBRCD 2-1	Ramona Expressway east of Warren Road, Bert Lauda property	Culvert under bridge crossing	Continuous-flow monitoring and time-weighted grabs
SJBRCD 2-2	Near Ramona Expressway and Warren Road 0.5 km N of SJBRCD2-1	Agricultural irrigation ditch	Continuous-flow monitoring and time-weighted grabs
LESJWA 3	San Jacinto River at Bridge Street	Culvert under bridge crossing	Continuous-flow monitoring and time-weighted grabs

Recommendations

Reconnaissance should be performed at all stations recommended here before monitoring begins to ensure that they are still viable and representative of the pollutants and pollutant sources described in this plan. Land use changes, channel alterations, and flow management all have the potential to create a situation where the recommended stations are no longer suitable for the stated objectives. It might be feasible and advisable to establish new monitoring stations in the vicinity of those described below to provide better opportunities for flow measurement, data collection, and attribution of water quality data to the dairies and cropland that are the subject of the IRDMP. If new stations are developed, it is absolutely essential to avoid issues of submergence or back-water at culvert outlets and similar issues that were problematic at several stations during the previous monitoring cycle. Conducting a synoptic survey during a significant runoff event would be a good first step before making final decisions about the monitoring locations to use to address Objective 3 of the long-term monitoring plan.

Mystic Lake

Mystic Lake should continue to be monitored monthly (or monthly October–May and biweekly June–September) at a single station, ML2. Monitoring variables should include depth, pH, temperature, conductivity, dissolved oxygen, total suspended solids, total P, soluble P, nitrate N, ammonia N, TKN, total organic carbon, total coliform, fecal coliform, and *E. coli*. Nitrite analysis should be discontinued because all previous results have been below detection limits. TDS should be added to the constituents analyzed because of salinity concerns in the watershed. With those changes, monitoring of Mystic Lake would address the lake indicators identified earlier in this section (6.4.2.3) and satisfy the data needs identified in Table 6-3.

Mystic Lake

In addition to monitoring in Mystic Lake, the long-term plan should include monitoring in streams and channels to assess watershed-scale effects of the IRDMP and to help fill data gaps associated with pollutant sources and transport. The following recommendations would address the non-lake surface water indicators in this section (6.4.2.3) and satisfy the data needs in Table 6-2. Monitoring at all these locations is not necessary to provide an indication of IRDMP progress and its effects on San Jacinto River watershed water quality, but the recommendations would support a reasonably comprehensive assessment of progress that would feed directly into the adaptive management process described in Section 6.4.4 to provide a solid basis for moving forward with the IRDMP, including making any adjustments needed to enhance progress.

It would be beneficial to seek consistency with the watershed monitoring in Phase 1 and Phase 2 (and most likely Phase 3) of the nutrient TMDL monitoring plan by recommending that at least eight samples be collected throughout the hydrograph of three storms per year at each stream or channel station (LESJWA 2006), but given the lack of data for the stream and channel sites in Table 6-6, a slight redirection of this part of the watershed monitoring effort would not create significant problems for the long-term data record. As such, it is recommended that all stream and channel monitoring be performed for all storm events using time-interval automated or grab sampling for the variables identified in Table 6-2. Field measurements of pH, temperature, dissolved oxygen, and conductivity should be made at least twice (or once every 8 hours) throughout the hydrograph, and at least two samples should be collected (or once every 8 hours) during the event for analysis of BOD, total coliform, fecal coliform, and *E. coli* bacteria. A recording precipitation gage should be in the Gap Area to collect continuous local precipitation data in support of this monitoring effort because the five rain gages used for the nutrient TMDL monitoring effort are all at least 5 miles from the central dairy region of the San Jacinto River watershed (LECLNTTF 2009).

Watershed Response to Changes on Dairies and Cropland in Zones 8 and 7

Modeling results indicate considerable input of nutrients to Mystic Lake from zones 8 and 7, so it would be useful to track water quality in zone 9 (upstream of the dairies and cropland) and in zone 7 upstream of Mystic Lake to measure the contributions and attempt to detect any changes resulting from IRDMP implementation. One approach would be to simply monitor at station 741 (Table 6-7) to measure the cumulative effect of sources in zones 9, 8, and 7, including Mystic Lake, but that would provide little information specific to the upstream dairies and cropland, especially any changes made on them in response to the IRDMP.

An approach using station 792 (Table 6-7) as an upstream station and either station 11070150 or station 835 as a downstream station might be suitable for tracking the aggregate influence of dairies in Zones 8 and 7 depending on the potential for contributions from other sources (e.g., urban, septic systems) to confound data interpretation. Modeling results indicate that the likely effect of forest and septic systems on N and P loads is significant for all three scenarios, so location of septic systems is essential to accounting for their influence on observed water quality data. The location of station 835, which appears to coincide with LESJWA 3 in Table 6-6, could be problematic over the long term because it is within the Gap Area and could be affected by stream improvements made in response to the Gap feasibility study. For that reason, station 11070150 might be a better downstream station despite its location upstream of much of the dairy activity in zone 7.

Watershed Response to Changes on Dairies and Cropland in Zone 3

Modeling also indicates a significant contribution of N and P from dairies and cropland in zone 3, particularly under Scenario 1, but also under Scenario 2 and Scenario 3. Monitoring at station 745 (Table 6-7) should provide a useful measure of the cumulative effects of dairies and cropland in zone 3.

Focused Monitoring on Dairies and Cropland within Gap Area

The stream and channel monitoring locations in Table 6-6 are well-suited to the needs of the IRDMP because they are generally more tightly focused on dairies and cropland. Regardless of the problems in 2008–2009, the locations of SJBRCD 1 and LESJWA 3 make these sites good candidates for continued monitoring to provide data on pollutant loads in the watershed and to fill gaps in data needed for nutrient TMDL modeling. It might also be possible to incorporate the upstream-downstream approach on the SJBRCD 1 ditch to isolate a specific dairy for the purpose of measuring BMP effectiveness under Objective 2; if that were done, it would be necessary to add a new ditch site for the upstream-downstream study. A potential problem with SJBRCD 1 is that it could be affected by river reach improvements in the Gap Area, but that station probably would not be needed for more than a few years if used to either fill data gaps for TMDL modeling or for an upstream-downstream BMP evaluation under Objective 2.

San Jacinto dairy cows

Watershed Response to Flood Management Improvements in Gap Area

It appears that the effects of flood management improvements in the Gap Area could be measured with a combination of stations ML2, 11070150, and 741. ML2 would provide an indication of significant effect on Mystic Lake, while changes in conditions at and in the relationship of conditions between station 11070150 and station 741 could provide an indication of effects on the San Jacinto River.

Table 6-7 summarizes the seven stations described above that should be considered for long-term, watershed-scale monitoring in support of monitoring Objective 3.

Table 6-7. Potential monitoring sites for long-term assessment of IRDMP performance

Site name	Location	Station type	Purpose	Type of sampling
ML2	South end of Mystic Lake	Lake	Quality of receiving waterbody; potential load to Canyon Lake	Grab
SJBRCD 1	Ramona Expy near Bridge Street, Te Velde property	Culvert under bridge crossing	Captures runoff flow from a watershed dominated by dairy land use	Continuous -flow monitoring and time-weighted automated or grabs
LESJWA 3 835	San Jacinto Road at Bridge Street	Culvert under bridge crossing	Captures runoff from a watershed dominated by urban and crop agriculture land uses	
792	San Jacinto Road at Cranston Guard Station	Stream	Effect of San Jacinto dairies and associated cropland and IRDMP on N and P loads; upstream/forestland drainage	
745	Salt Creek at Murrieta Road	Stream	Effect of dairies/cropland, IRDMP downstream of Zone 3	
741	San Jacinto Road at Ramona Expressway	Stream	Quality of inflows to Mystic Lake; downstream of Gap Area	
11070150	San Jacinto Road at State Street	Stream	Quality of inflows to Mystic Lake; upstream of Gap Area/downstream of dairies	

Land use and management data collected in support of Objective 1 need to be summarized at the watershed scale to support Objective 3. Data from the Manure Manifest and Salt Offset programs should be compiled and assessed annually, and the variables in Table 6-1 should be tracked to the extent possible annually and summarized for the drainage area above each monitoring station. Annual information on total manure import and export from the San Jacinto River watershed, salt budgets, and land use and land cover changes are critical to obtain at the watershed scale and for each monitored subwatershed. Using the 2008 AIS land use map as a baseline, annual updates from satellite imagery or aerial photography could serve to track important changes in the extent of dairy and cropland activity, growth of urban land, and other changes that could affect water and air quality in the San Jacinto River watershed.

6.4.2.4 Cost Considerations

Ideally, dairies should assess IRDMP performance out at three scales in accordance with Objectives 1–3, but the extent of data gathering and water quality monitoring can be adjusted to reflect budget limitations. Monitoring of some form is needed to address Objectives 1 and 3 because of regulatory requirements, but monitoring for Objective 2 is not required and could be scaled back or dropped if necessary. It must be kept in mind, however, that for assessing long-term IRDMP effectiveness, it is essential that whatever monitoring activities are chosen be carried out at the same locations, with the same frequencies and sampling methods, and the same variables and laboratory methods throughout the desired monitoring period. Because of that, monitoring choices need to be governed to a large degree by the period needed to gather meaningful results and the probable funding levels over that period.

Several approaches are available to reduce monitoring costs without entirely compromising the long-term monitoring objectives. For example, because the emphasis of the IRDMP is on nutrients and TDS, it is possible to reduce costs by dropping all other monitoring variables (e.g., fecal coliform, dissolved oxygen, BOD, temperature, TSS) without compromising the ability of the monitoring to track progress against nutrient and TDS targets or goals. Zone 3, as described in the Lake Elsinore/Canyon Lake Nutrient TMDL model (see Figure 6-2) is a lesser contributor of dairy and cropland nutrients to Canyon Lake and Lake Elsinore than are Zones 7 and 6, so monitoring in Zone 3 is less important to documenting the success of the IRDMP. If budget constraints limit the number of stations that can be monitored, a simplified monitoring design for Objective 2 and Objective 3 could rely solely on stations 741, ML2, 745, and SJBRCD 1 to give a rough indication of IRDMP progress. Another option to cut costs would be to monitor in alternate years instead of annually. That, of course, would significantly increase the time needed to measure any changes resulting from IRDMP implementation.

Reliance on monitoring conducted in compliance with the nutrient TMDL could reduce monitoring costs considerably while still providing some measure of IRDMP assessment (Objective 3), but doing so would not address the assessment of individual BMP performance (Objective 2). In addition, monitoring a predetermined number of storms each year (i.e., three storms for TMDL monitoring) does not guarantee a representative database from which to draw conclusions regarding IRDMP achievements. Rather, such a design has the potential to bias sampling toward the first half of a monitoring year, a problem avoided by monitoring every storm event.

Monitoring changes in water quality in surface waters of the San Jacinto River watershed would document the effects of the IRDMP on impairments and threats to water quality that face watershed stakeholders. To the extent possible, long-term watershed monitoring should rely on programs already in place such as those being conducted for TMDL compliance, coupled with continuing the supplementary monitoring initiated by the IRDMP in 2008. Land use and management data collected in support of Objective 1 and results of BMP monitoring for Objective 2 should be integrated into watershed-scale monitoring. Cooperation among monitoring efforts conducted by all organizations active in and around the San Jacinto River watershed would improve the cost-effectiveness of efforts to assess and manage long-term performance of the IRDMP.

6.4.2.5 Data Management, Analysis, and Reporting

Because the proposed monitoring program combines numerous activities at different scales and locations, a single organization and a single individual within that organization should be given the responsibility to oversee, coordinate, analyze, and report the data relevant to the long-term assessment of IRDMP implementation. Data from all sources should be managed together in a single platform (e.g., a spreadsheet or database system). The person responsible for data management should check for basic errors in data at the time of entry into the data management system, and they should examine it (e.g., plot, summarize it) frequently to detect any problems in data collection.

The recommended Manure Manifest System provides for an Information Technology/GIS Specialist who could be responsible for managing land use/land treatment data for the long-term monitoring effort. A GIS framework would enhance capabilities for generating land use/land treatment data summaries appropriate for analyses incorporating water quality data.

Analysis of monitoring data would vary with the type of data. IRDMP implementation data should be tabulated and summarized annually to provide a snapshot of dairy management status and to provide summary statistics on the implementation and operation of treatment measures. Mass balance of manure nutrients and salts should be recalculated annually. Trends over time in soil nutrient levels should be tracked. Land use (acres and percent) and land use change should be tabulated and mapped annually. Data on BMP effectiveness should focus on appropriate statistical comparison of input/output concentrations/loads, along with percent reduction in variables monitored. Note that determination of percent reduction is not the only measure of BMP effectiveness; actual output concentrations or loads should also be reported.

Data should be reported annually at a minimum in a comprehensive San Jacinto IRDMP monitoring report. Some efforts—such as rainy-season event monitoring or episodic dairy BMP monitoring—could require more frequent reporting. Ongoing monitoring activities should be reported more frequently at regular WRCAC meetings to minimize data gaps and facilitate adaptive management of both the IRDMP implementation and the long-term monitoring effort. Problems associated with the quality of monitoring data are best identified and addressed via periodic site inspections, routine equipment maintenance, and frequent data analysis in accordance with an approved quality assurance plan.

6.4.3 Summary of Recommended Long-Term Monitoring Plan

Key recommendations for the long-term monitoring plan include the following:

- Annually tracking implementation activities of the IRDMP using information from an enhanced General Permit reporting procedure; adopting a specific template for nutrient management plans; gathering data via the proposed Manure Manifest System; and collecting other information via self-reporting, WRCAC surveys, or other cooperative efforts
- Short-term (generally 1–2 years) BMP effectiveness monitoring of each significant BMP implemented by dairies in the San Jacinto River watershed
- Monthly monitoring at one site on Mystic Lake
- Monitoring every storm event at seven stream and ditch sites in those areas where water quality is primarily affected by dairies and cropland
- Centralized data management, analysis, and reporting
- Frequent analysis and reporting of water quality data, and annually reporting all data

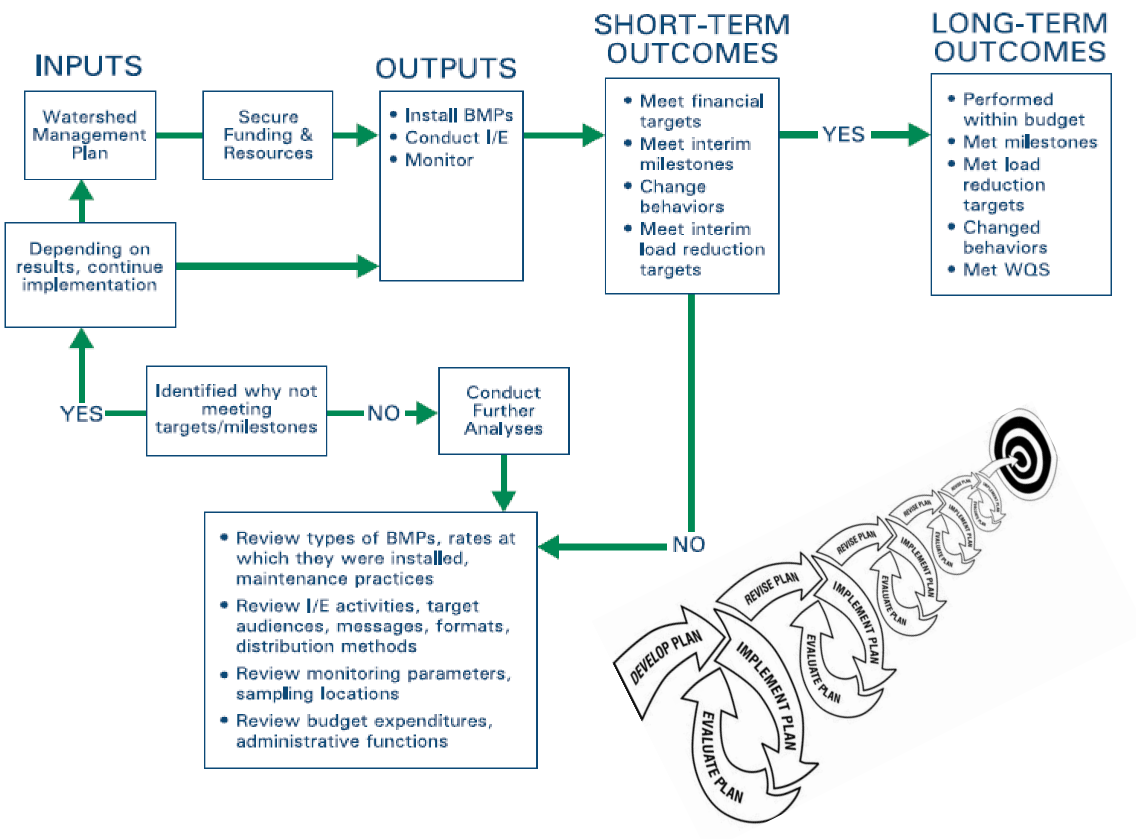
6.4.4 Adaptive Management Process for Plan Assessment and Updates

In general, all watershed planning efforts follow a similar path from identifying the problems to implementing actions to achieve the established goals. The basic planning process includes the following steps (USEPA 2008):

1. Build partnerships
2. Characterize the watershed to identify problems
3. Set goals and identify solutions
4. Design an implementation program
5. Implement the watershed plan
6. Measure progress and make adjustments

With the completion of the IRDMP, San Jacinto River watershed stakeholders have made significant progress on Steps 1–4.

The adaptive management approach is not linear but circular, allowing stakeholders to integrate results back into their program. Information should be reviewed at least annually, with monitoring data reviewed more frequently to identify problems before they grow beyond repair. Figure 6-6 illustrates how the adaptive management approach feeds back into a program using information gathered from monitoring and management tracking. As part of IRDMP evaluation efforts, it would be important to periodically review the activities included in the work plan, many of which are triggered by regulatory requirements, and the monitoring results to determine whether satisfactory progress has been made toward achieving plan goals. Additional details regarding work plan tracking and analysis of monitoring data are in EPA's watershed planning guide (USEPA 2008).



Note: I/E = Information/Education

Figure 6-6. Adaptive management approach.

If analysis of available information indicates that implementation milestones or interim targets for load reductions and other goals have not been met, it is important to identify the reasons for this inadequate progress before taking action. The reasons for that can be many, including lag time, insufficient implementation levels to cause measurable change, weather conditions, or the influence of other sources not addressed by the IRDMP.

It is often the case that minor adjustments in the types and location of BMPs implemented will result in improved pollution control, but in some cases it might be necessary to consider revising the overall plan—in this case the IRDMP. Such a major change should be considered only after all other possibilities for explaining a failure to achieve targets and goals are ruled out.

Effective operation of a well-designed monitoring program will help avoid drawing incorrect conclusions about the progress of the IRDMP. Precipitation patterns in the San Jacinto River watershed can be highly variable as evidenced by data collection efforts in 2007 and 2008. Dry years followed by wet years can result in data sets that show increased pollutant concentrations and loads regardless of the efforts made to control pollutant sources. Conversely, what might appear to be a success in reducing pollutant loads could be simply an apparent improvement resulting from a few dry years following wet years or animal operations or other pollutant sources going out of business and ceasing pollutant-generating activities. It is essential that such factors be tracked to help interpret water quality data. That is the central reason for performing long-term monitoring to assess the performance of the IRDMP.

In conducting watershed water quality monitoring programs, a great deal of attention is usually given to matters of flow measurement, sample collection, chemical analysis, and the like—and rightly so. However, it is also common that inadequate attention is given to what is happening on the land, which represents the cause to the effects monitored in the water. That is the reason for the dairy- and land-based indicators listed in Table 6-1. Whereas a simple inventory of practices implemented on the dairies and lands receiving manure and process wastewater might indicate full implementation in accordance with the IRDMP, a closer inspection might reveal that practices are not implemented or maintained in complete accordance with design requirements or regulations or that the standards and specifications are inadequate to address the identified problems. It could be necessary to reduce manure and nutrient applications further or implement additional measures to reduce pollutant delivery off-site. Collecting both water quality and land-based data makes that type of adjustment possible, but it would not be possible if the variables identified in Table 6-1 are not tracked.

Note that activities beyond the scope of the IRDMP (e.g., the diversion of flow by the city of San Jacinto, cropping patterns, urbanization) are likely to influence observed water quality in ways that have nothing to do with the problems being addressed by the IRDMP. Therefore, it is essential to coordinate monitoring of both land and water with others in the watershed to acquire the information necessary to explain such events. Cooperation among watershed stakeholders will also improve the cost-effectiveness of the monitoring effort.

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7.0 Conclusions and Next Steps

Time is of the essence. Completing the IRDMP is only the beginning of the real work—implementation. Strategies, projects, and ideas contained in any plan require concrete actions by individuals to make them happen, and actions to achieve the goals of the IRDMP need to happen soon. The September 2012 salt-offset deadline is just around the corner, especially given the complexities associated with implementing some of the elements of the IRDMP. Permits for such things as regional digesters or compost facilities will take time to obtain, typically more time than predicted. The interrelationship of IRDMP plan elements with those of ongoing efforts like the TMDL and the San Jacinto River watershed and Santa Ana River watershed plans presents great opportunities for collaboration but also means greater inertia to overcome every step of the way. In addition, their dependence on landowners within and outside the San Jacinto River watershed for such things as providing land to receive manure and becoming customers for compost and other products means that San Jacinto dairy farmers do not control their own destinies. That unpleasant fact makes it extremely important that plan implementation be given much more attention and energy than the high level already devoted to plan development.

The task is difficult. The challenge of maintaining a profitable dairy business while meeting environmental obligations is a daunting one. Although the IRDMP explores many potentially productive avenues, there is no silver bullet. There are simply too many nutrients and salts in the San Jacinto River watershed for the land and water to safely absorb, and few practices exist to make these potential pollutants go away. Options like manure digestion might be able to produce renewable energy and offer significant financial incentives, but they present major permitting challenges and in the end, do little to reduce the quantity of nutrients and salts in the watershed. Other practices like direct production of biodiesel from manure and wastewater are immensely appealing but are not yet practical realities. In light of those challenges, San Jacinto dairy operators might appear to be the underdogs, but underdogs can win. The IRDMP identifies ways in which San Jacinto River watershed dairy operators can meet their environmental obligations while maintaining profitable businesses.

Scenic view in San Jacinto River watershed

Cooperation is required. Implementing the IRDMP will require detailed work plans for individual dairies and at the watershed level. Elements of the IRDMP effort will require cooperation with other interests in the watershed, such as crop producers and water supply districts. Dairy operators will be challenged to remain financially viable while addressing the many demands facing them to protect air and water quality in the watershed. Even fiercely independent dairy operators will need to work together to keep their businesses viable in the San Jacinto River watershed. The challenge is significant, but if dairy operators roll up their sleeves together, assume some risk that in many cases will be uncomfortable, combine forces with other groups in the San Jacinto River watershed, and keep their eyes on the goal, they can meet the challenge successfully.

Go public. San Jacinto dairy operators are to be congratulated for completing the collaborative effort that is the IRDMP. An important next step in the process is to take the plan public. Make sure that residents of the San Jacinto River watershed and other stakeholders fully understand that

- San Jacinto dairies face serious challenges on water and air quality requirements
- The dairies are suffering financially from depressed milk prices
- The dairies are committed to succeed financially and do their part to solve the pressing environmental problems in the San Jacinto River watershed
- The dairies have developed a serious plan to achieve the goals
- The dairies have manure and manure products that they need to export from the watershed to meet those goals while still providing high-quality dairy products in the watershed

San Jacinto cow

Other ideas for increasing public awareness of plans such as the IRDMP are in EPA's watershed planning handbook (USEPA 2008).

7.1 Take Immediate Actions

7.1.1 Mobilize the Leaders

WRCAC is well-suited to lead the organizational structure necessary for the IRDMP implementation effort. At this beginning stage, it is essential to assess the various skills and capabilities of WRCAC members and dairy operators to determine who is best equipped to handle specific tasks identified in the IRDMP and the work plans that should follow. As noted above, there is no time to delay, so those involved should hold frank discussions to identify the participants who are best able to address such tasks as the following:

- Seeking potential locations for land application of manure and manure products in the Imperial Valley, the Palo Verde Valley, and elsewhere
- Exploring the true potential for alternative beneficial use products, including identifying potential investors and entrepreneurs
- Negotiating with regulators to expedite the permit process where needed to facilitate project implementation

- Negotiating grants and other financial incentives to support monitoring and implementation of high-cost practices
- Negotiating contracts with haulers that benefit all dairy operators in the watershed
- Communicating with the public and press
- Assessing the technical merits of options for addressing the water quality and air quality requirements
- Assessing the financial aspects of the options and developing work plans
- Ensuring that the needed technical assistance is available for designing and installing practices
- Ensuring that training on operation and maintenance of practices, the Manure Manifest System, and tracking practice implementation is available for dairy operators

WRCAC leaders and their consultant

Specific individuals should be assigned to these tasks, and it is essential that those assigned are both capable and committed.

7.1.2 Develop a 2010–2012 Work Plan

San Jacinto dairy operators must make some big decisions up front—decisions that will dictate many of the details to follow. Work plans are needed that address both watershed-scale and individual dairy actions.

Part of the challenge in implementing the IRDMP is deciding which actions are watershed-wide and dairy industry-wide actions versus those actions that are for individual dairies. Some actions will need to be decided upon simultaneously from both the industry-wide and dairy-specific perspectives, so constant communication is essential to successfully coordinate implementation activities. Clear and detailed planning is also critical to success.

Work plans are needed to address the specific tasks both at the watershed scale and at individual dairies. Such work plans should translate the options contained in the IRDMP into specific, actionable items with appropriate deadlines that make it possible to achieve the IRDMP goals on schedule. Good work plans can also serve as templates for preparing grant applications to ease the financial burden on the dairies (USEPA 2008).

A San Jacinto dairy

Because most of the options recommended in the IRDMP involve business decisions by the dairies, dairy operators should consider addressing should address the following key elements in dairy-specific work plans; some of these elements might already exist in a dairy's business plan (Entrepreneur 2009):

- Business description
- Market strategies
- Competitive analysis
- Design and development plan
- Operations and management plans
- Financial components

A market analysis is essential to determine which practices should be implemented on individual dairies or as central facilities. For example, there is no point to building a high-cost central digester if there is no market for the biogas or electricity that would be generated. Similarly, production of high-quality compost or *CowPots* makes sense only if a customer base is identified. Hauling will not solve the manure problem in the San Jacinto River watershed unless a suitable customer base is identified first and the preferred composition of the manure or manure product is specified. Define the target markets for the San Jacinto dairies on the basis of geography (e.g., Blythe, Imperial Valley or other potential hauling locations), customer attributes (e.g., farms with back-hauling potential), or product-oriented considerations (e.g., customers needing high-quality compost).

7.1.3 Design a Manure Export System

Because it is nonstructural and does not require major capital investment, manure export is the first option that San Jacinto dairy operators should approach. A system developed now for raw manure could easily be adapted or expanded to ship manure products like compost. Important steps in this process include the following:

Manure hauling at a San Jacinto dairy

- Implement the Manure Manifest System
- Identify specific manure receiving areas outside the San Jacinto River watershed
- Conduct a market analysis for manure or compost in potential receiving areas
- Evaluate logistical issues such as labor and equipment needs and manure/compost quality requirements
- Develop a promotion and marketing plan to support distribution in the receiving areas
- Set up a Web-based manure trading/brokering system
- Explore business/contractual arrangement among dairy operators and between dairy operators and haulers/brokers to manage the system

7.1.4 Explore New Beneficial Use Products

Conduct a market analysis for potential beneficial use manure products, beginning with an effort to define the market size, structure, growth prospects, trends, and sales potential (Entrepreneur 2009). The next step is to define the target market for such products. Then, determine the total feasible market—the part of the market that can be captured by San Jacinto dairies. Other steps along the way include a market share analysis and assessing the best way to position the business to capture that market. San Jacinto dairy operators analyzing markets for beneficial use products should address the following strategic questions:

- How are your competitors positioning themselves?
- What specific attributes does your product have that your competitors' don't?
- What customer needs does your product fulfill?

A market analysis will also help establish pricing—an essential ingredient in determining the overall budget for the business and a key factor in the success of the business. The first basic rule of pricing is that prices must cover all costs, so a reasonable cost analysis is essential to the survival of San Jacinto dairies. Failure to base capital investments on sound financial analysis can be fatal to a business.

Business decisions made by San Jacinto dairies should also consider distribution, the entire process of moving the product from the dairy to the end user. The type of distribution network dairies choose will depend on the industry and the size of the market, and some of the more common distribution channels relevant to San Jacinto dairies include the following (Entrepreneur 2009):

- Direct sales
- Wholesale distributors
- Brokers

San Jacinto calf

Developing a promotion plan to sell the manure products is also needed. Analyzing sales potential, identifying and analyzing the competition, formulating a set of procedures for implementing the plan, scheduling, budget development, and obtaining the right mix of personnel are to be considered in making business decisions as are an assessment of risk in developing the product and identifying ways to address each risk. Showcasing the efforts of San Jacinto dairies to solve environmental problems while providing renewable products should be a key element of a promotion effort.

7.2 Plan for the Next Phase

7.2.1 Use Early Experience to Guide Choices

The work plans and early results should form the basis for deciding on the best technologies to implement that meet the environmental requirements imposed on San Jacinto dairies while also providing the products desired by the market. For example, market analysis could indicate that raw manure is in far less demand than composted manure, so on-farm composting or a centralized compost facility might be the best option for the dairies. Having decided on the principal practice to be used to solve the manure problem and taking advantage of the organizational structure described above, dairies could then address hauling options and build individual dairy plans that best support the composting operation.

7.2.2 Maintain Momentum

WRCAC should facilitate and guide the collective effort of dairies to follow through on necessary implementation actions through frequent communication and helping to manage incentives and opportunities. In addition, WRCAC should broadly advertise important actions that the San Jacinto dairies have taken. That will ensure that proper credit is given and to demonstrate a willingness and ability to get things done to achieve environmental objectives. Maintaining momentum will be important to meeting deadlines in the IRDMP and associated work plans, and every tool in the toolbox should be used to keep things moving.

Implementing the IRDMP is a tremendous challenge for San Jacinto dairies. However, through careful business planning, crafting meaningful and efficient work plans, astute management of the skills and strengths of the various participants in the process, open and effective internal and external communication, and fast action, San Jacinto dairies can achieve the goals of this ambitious plan.

Aerial view of dairies in the San Jacinto River watershed

References

Entrepreneur. 2009. *How to create a business plan*. <http://www.entrepreneur.com/startingabusiness/businessplans/article38308-7.html>. Accessed November 22, 2009.

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