Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area and a Portion of San Joaquin County

October 2007

BOYLE 1120 West "I" Street, Suite C Los Banos, California 93635

Table of Contents

References

Tables

Figures

ABBREVIATIONS

AB 3030	Groundwater Management Act, Assembly Bill 3030
BMPs	Best Management Practices
CAS	California Aquifer Susceptibility (CAS) Assessment
CVP	Central Valley Project
CVPSA	Central Valley Project Service Area
DHS	Department of Health Services
DMC	Delta-Mendota Canal
DPWD	Del Puerto Water District
DTSC	Department of Toxic Substances Control
DWR	California Department of Water Resources
DWSAP	California's Drinking Water Source Assessment and Protection Program
EHD	San Joaquin County Environmental Health Department
GAMA	Groundwater Ambient Monitoring and Assessment Program
GMA	Groundwater Management Area
GMP	Groundwater Management Plan
HR	Hydrologic Regions
Los Banos	City of Los Banos
MCL	Maximum Contaminant Level
mg/L	Milligrams Per Liter
MOU	Memorandum of Understanding
NSGMP	Northern Subbasin Groundwater Management Plan
Ordinance	Groundwater Export Ordinance, San Joaquin County
PAs	Participating Agencies
Patterson	City of Patterson
QA/QC	Quality Assurance/Quality Control
RWQCB	Regional Water Quality Control Board
SB 1938	Senate Bill 1938
SDWA	Safe Drinking Water Act
Semitropic	Semitropic Water Banking Project

SJC	San Joaquin County
SJCFCWCD	San Joaquin County Flood Control and Water Conservation District
SJV	San Joaquin Valley
SLDMWA	San Luis & Delta-Mendota Water Authority
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
Tracy	City of Tracy
μg/L	Micrograms Per Litter
USGS	U.S. Geological Survey
UST	Underground Storage Tanks Program
UWMP	Urban Water Management Plan
WPP	Wellhead Protection Program
WRCC	Western Regional Climate Center

Section 1 Introduction

The Groundwater Management Act, Assembly Bill 3030 (AB 3030), signed into law in 1992, establishes provisions to allow local water agencies to develop and implement groundwater management plans. The Act provides a systematic procedure for existing local agencies to develop these plans. Amendments to the Water Code Section 10750 et seq., made in 2002, enacted through the passage of Senate Bill 1938 (SB 1938) (Stats 2002, Ch 603), require AB 3030 groundwater management plans to contain specific plan components in order to receive state funding for water projects.

The Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area and a Portion of San Joaquin County (GMP) is part of the ongoing efforts by the San Luis and Delta-Mendota Water Authority (SLDMWA) and their Participating Agencies (PAs) to manage their limited water resources in the region. It will benefit the residents of the Groundwater Management Area (GMA) that rely on the groundwater resource as a part of their water supply. This GMP provides a mechanism to bridge gaps and interface in local PAs' programs to support comprehensive regional water resources management in the GMA.

The PAs of the SLDMWA, located in the northern Delta-Mendota Canal (DMC) service area, entered into an agreement under the SLDMWA umbrella to jointly fund the preparation of a coordinated regional plan. The area in the southwestern portion of San Joaquin County is being represented by the San Joaquin County Flood Control and Water Conservation District (SJCFCWCD), which entered into a memorandum of understanding with the SLDMWA such that the GMP could cover this portion of San Joaquin County.

The water needed is obtained from three sources for agricultural, municipal, and industrial uses within the GMA. The first source is imported surface water diverted from the DMC under the Central Valley Project (CVP). The DMC provides water for urban use in the City of Tracy (Tracy) and for agricultural production. During drought conditions, supplies from the CVP surface water are limited, which requires many water users to pump groundwater to meet water demand. Surface water supplies diverted south of the Sacramento-San Joaquin Delta are further limited by restrictions in water export set in place to protect endangered species that depend on adequate water conditions within the Delta.

The second source is local surface water supply diverted from the San Joaquin River for agricultural use. Several of the PAs possess water rights to divert water from the river.

The third source is groundwater, which is used for municipal and industrial purposes, for rural domestic needs, and for agricultural production where the surface water supplies are either not available or are insufficient to meet the crop demand. Communities that rely on groundwater for their water supply have experienced water quality deterioration over time, while regulations governing domestic water quality become stricter. This combination has made it increasingly difficult for these communities to find viable groundwater supplies and has raised serious concerns about the sustainability of groundwater resources to meet domestic demands without expensive treatment. As an example, Tracy uses treated surface water to blend with high salinity groundwater to provide potable domestic water for the community.

Proper management of groundwater requires knowledge of the storage, distribution, depletion, and replenishment of the groundwater resource as well as various other local and regional geologic and hydrologic factors. Without such knowledge, the effect of current and future activities on groundwater resources cannot be adequately predicted.

SLDMWA would be responsible under this plan to monitor the regional groundwater conditions within the basin, although water level and water quality monitoring would be conducted by other agencies (the PAs, California Department of Water Resources (DWR), United States Geological Survey (USGS), Counties and Cities). SLDMWA would collect these data from the various agencies in order to evaluate the general condition of the groundwater basin and to evaluate and promote projects that appear to provide effective and efficient utilization and protection of groundwater resources.

As the PAs have very different motivations with regard to groundwater management, it will be very difficult to develop or implement a single set of groundwater management programs that suit the needs of the group as a whole. Rather, it would be more efficient, and programs would be better focused, if they were undertaken by each individual agency or group of agencies depending on their specific needs. The PAs can also prepare their own GMP. The regional plan would be prepared to facilitate coordinated regional management of groundwater resources. Each PA would independently adopt the whole plan or portions of it. Implementation of this GMP will provide the means for collection of the necessary groundwater monitoring data needed to assess the impacts of activities that affect the groundwater basin such that sustained use of groundwater can be optimized without adverse impacts to the water quality and yield. Sustainability is the basic goal of groundwater management.

The PAs within the GMA have been involved in and will continue to reserve operational flexibility to engage in transfers of water supplies to qualified purchasers. Circumstances occur where shortages of water have the potential to create hardship in other areas of the region or state, which have access to federal water project facilities, and the PAs may have a water supply surplus that can help alleviate the hardship.

Prior to undertaking any water transfer program, the PAs will evaluate the economic and environmental impacts of the program. The evaluation may include, but is not limited to, an assessment of water management practices, groundwater storage capacity, and conjunctive use with surface water supplies. These transfer programs may be undertaken to assist other areas in need of water and to benefit the PAs and their consumers, as long as such programs do not:

- Result in conditions of overdraft or otherwise fail to comply with provisions of California Water Code Section 1745.10;
- Result in unmitigated adverse impacts upon landowners affected by the program.

This plan characterizes the groundwater basin, summarizes the existing groundwater management activities in the GMA, identifies management objectives, develops the relative elements of the GMP, and provides recommendations for project implementation.

Section 2
The Groundwater Management Area

The DWR Bulletin 118 Update 2003, for planning purposes, divides California into 10 hydrologic regions (HRs) that generally correspond to the State's major drainage areas (DWR, 2003). HR boundaries are shown in Figure 1. The San Joaquin River HR is further divided into subbasins largely based on political considerations for groundwater management purposes (Figure 2). The area included in this GMP is part of the Tracy and Delta-Mendota Subbasins of the San Joaquin River HR and covers portions of Merced, Stanislaus and San Joaquin Counties. The GMA is bounded on the north by Old River, on the south by the southern boundary of the Del Puerto Water District, on the west by the Coast Ranges, and on the east by the San Joaquin River. The GMA encompasses approximately173,000 acres. Figure 3 shows the boundaries of the GMA.

The GMA includes the following agricultural water supply districts: Banta-Carbona Irrigation District, Westside Irrigation District, West Stanislaus Irrigation District, Patterson Irrigation District, Del Puerto Water District, and the Central Valley Project Service Area (CVPSA) within the Byron-Bethany Irrigation District. Non-district lands within San Joaquin County are included in the plan and are represented by the San Joaquin Flood Control and Water Conservation District. The GMA also contains Tracy and the City of Patterson (Patterson) as well as several unincorporated communities. Tracy is the only city participating at this time.

Del Puerto Water District includes the former Davis, Foothill, Mustang, Orestimba, Hospital, Kern Canon, Quinto, Romero, Salado, and Sunflower Water Districts. These district boundaries continue to be recognized within Del Puerto Water District in the management of water transfers. A list of the current PAs involved in the GMP is given in Table 1.

Table 1
List of Agencies Participating in the Groundwater Management

Water or Irrigation District:

- Banta Carbona Irrigation District
- Byron-Bethany Irrigation District (only the CVPSA)
- Del Puerto Water District
- Patterson Irrigation District
- West Stanislaus Irrigation District
- Westside Irrigation District

Cities:

- City of Tracy

Non-District Lands:

San Joaquin County West of the San Joaquin River

Section 3
Characteristics of the GMA

3.1 Land Use and Groundwater Beneficial Use

Most of the land in the San Joaquin Valley is utilized for agricultural crop production. Major agricultural activities include the operation of dairies, and the production of cotton, alfalfa, corn, grapes, walnuts, almonds and oranges. A number of small rural communities, as well as some large municipalities exist within the San Joaquin Valley. The largest of these communities, Fresno, has a population of nearly a half of a million people. The majority of communities have populations of less than 100,000 people, and many have less than 10,000. Other notable large municipalities in the San Joaquin Valley include Stockton, Modesto, and Bakersfield. The southern end of the San Joaquin Valley also has a large oil production industry, and numerous oil/gas fields are located through out the San Joaquin Valley.

Within the GMA in the sourthern end of the valley, the majority of the current land use is agricultural, with irrigated crops, dairies and rangeland. There are two municipalities within the GMA, the cities of Tracy and Patterson. Tracy is a municipality with a population of about 80,000 people, and Patterson has a population of about 19,000 people. There are also some smaller unincorporated communities within the GMA.

The beneficial uses of groundwater in the GMA are predominantly for agriculture and related industry, domestic potable water, and other municipal uses. Groundwater is generally used conjunctively to supplement surface water supplies that support the water needs in the GMA.

3.2 Topography and Structure

The San Joaquin Valley is the southern portion of the Great Valley Geomorphic Province in central California. The San Joaquin Valley is a structural trough up to 200 miles long and 45 to 70 miles wide. It conjoins the northern portion of the Great Valley Geomorphic Province, the Sacramento Valley, at the confluence of the Sacramento and San Joaquin Rivers ("the Delta"). The Great Valley opens to the San Francisco Bay west of this Delta.

The San Joaquin Valley is bounded by the Sierra Nevada Mountains to the east, the Coast Range Mountains to the west, and the Tehachapi Mountains to the south. It is a broad, fault bounded, northwest trending, asymmetric topographic and structural trough, with axis of the valley offset nearer the western margin. The topographic slope along the axis declines gently, generally towards the north-northwest.

Within the GMA, the land surface generally slopes easterly to northeasterly from the base of the Coast Range Mountains, near the western boundary, towards the trough of the valley and the San Joaquin River, along the eastern boundary. Small ephemeral streams drain from the Coast Range Mountains typically trending northeasterly toward the trough of the valley. The natural land surface is relatively flat to slightly undulating. However, agricultural practices have modified many topographic features to provide suitable conditions for crop production. The land surface elevation in the GMA ranges from about 60-feet above mean sea level in the southwest to about sea level in the north. Major man-made features include Interstate Highway 5, the California Aqueduct, the DMC, and a number of smaller canals used for water supply distribution and drainage.

3.3 Climate

The San Joaquin Valley has a more continental climate than much of the more populous coastal areas, with relatively warm summers and cooler winters. The mean annual high temperatures in the valley range from about 73° Fahrenheit (°f) to 79°f, and the mean annual lows range from about 48°f to 50°f.

Due to some rain shadow effects from the Coast Range Mountains and the lower elevations of the valley floor, the valley experiences relatively little rainfall, typically less than 12 inches. Some areas of the southern San Joaquin Valley experience desert conditions due to the very low seasonal precipitation. Rainfall occurs typically between late fall and early spring, with dry summers. Mean annual rainfall amounts range from 5 to 13 inches per year on the valley floor.

The range of typical climatic conditions experienced within the GMA can vary. Two representative weather stations, with long documented histories, have been chosen to demonstrate the range of climatic conditions within the GMA. The City of Los Banos (Los Banos) lies within 10 nukes of the southern boundary of the GMA, and Tracy lies within the GMA near the northern boundary. The recent climatic history recorded for each location is presented below:

- Los Banos:

  Between 1948 and 2005, the average monthly high temperature of 96.2 °f was in July, and the average monthly low temperature of 36.1°f was in December (WRCC, 2006). Los Banos averages about 96 days per year above 90°f, and 28 days below 32°f. The hottest day on record was 114°f on June 30, 1950, and the coldest was 14°f on January 11, 1949.

  Between 1948 and 2005, the average annual rainfall was 9.43 inches. The highest annual rainfall was 21.80 inches in 1998, and the lowest annual rainfall was 5.24 inches in 1989. The maximum-recorded rainfall over a 24-hour period was 2.25 inches on September 30, 1983. Annually, Los Banos experiences, on average, about 48 days with precipitation greater than 0.01 inches, 26 days with precipitation greater than 0.10 inches, 5 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

- Tracy:

  Between 1955 and 2005, the average monthly high temperature of 92.6°f was in July, and the average monthly low temperature of 38.2°f was in January (WRCC, 2006). Tracy averages about 74 days per year above 90°f, and 18 days below 32°f. The hottest day on record was 112°f on June 16, 1961, and the coldest was 17°f on December 26, 1990.

  Between 1955 and 2005, the average annual rainfall was 12.26 inches. The highest annual rainfall was 27.48 inches in 1983, and the lowest annual rainfall was 5.44 inches in 1976. The maximum recorded rainfall over a 24-hour period was 2.80 inches on January 4, 1982. On average, annually, Tracy experiences about 55 days with precipitation greater than 0.01 inches, 31 days with precipitation greater than 0.10 inches, 7 days with precipitation greater than 0.50 inches, and 1 day with precipitation greater than 1.0 inch.

Table 2
Summary of Climatic Data for Los Banos and Tracy

		Los Banos	Tracy
Average Monthly High-Temperature	°f	96.2	92.6
Average Monthly Low Temperature	°f	36.1	38.2
Hottest Recorded High Temperature	°f	114	112
Coldest Recorded Low Temperature	°f	14	17
Average Number of Days Above 90°f		96	74
Average number of Days Below 32°f		28	18
Average Annual Rainfall	Inch	9.43	12.26
Highest Annual Rainfall	Inch	21.80	27.48
Lowest Annual Rainfall	Inch	5.24	5.44
Maximum 24-hour Rainfall	Inch	2.25	2.80

3.4 Geology

The geologic materials that fill the San Joaquin Valley are comprised of mostly unconsolidated alluvial and lacustrine sediments, Holocene to Jurassic in age, derived from parent materials of the Coast Range and the Sierra Nevada Mountains, these sediments are overlying older marine sediments. The Valley fill reaches a thickness of about 28,000-feet in the southwestern corner (Page, 1986). Continental deposits shed from the surrounding mountains form an alluvial wedge that thickens from the valley margins toward the axis of the structural trough. This depositional axis is below to slightly west of the series of rivers, lakes, sloughs, and marshes, which mark the current and historic axis of surface drainage in the San Joaquin Valley (DWR, 2003). Major faults run parallel to the western boundary of the GMA, along the east side of the Coast Range Mountains. In particular, the Greenville and Ortigalita faults lie within about 10 to 20 kilometers of the western boundary.

The water bearing geologic formations within the GMA typically are comprised of continental deposits of Late Tertiary to Quaternary age. These deposits include the Tulare Formation, older alluvium, flood basin deposits, terrace deposits, and younger alluvium. The cumulative thickness of these deposits ranges from a few hundred feet near the Coast Range foothills west of the GMA to about 3,000 feet along the trough of the valley east of the GMA (DWR, 2003).

The Tulare Formation is composed of beds, lenses, and tongues of clay, sand, and gravel that have been alternately deposited in oxidizing and reducing environments (Hotchkiss, 1972). The Tulare Formation dips eastward from the Coast Range in the west towards the trough of the valley. The total thickness of the Tulare Formation is about 1,400 feet (DWR, 2006). The Corcoran Clay occurs near the top of the Tulare Formation and confines the underlying fresh water deposits.

3.4.1 Confined Aquifer

The confined zone underlying the clay stratum extends downward from the base of the Corcoran Clay to the base of fresh water (Page, 1971). Sierran Sand and Coast Range alluvium interfinger in a similar fashion as those of the semi-confined zone, except that Sierran sediments extend further to the west in the confined zone (Dubrovsky et al., 1991).

3.4.2 Corcoran Clay Layer

The Pleistocene layer known as the Corcoran Clay layer, or E-clay, is continuous across much of the central and northern portions of the valley, near the trough of the valley. This layer is comprised of fine-grained lacustrine and marsh deposits that divide the aquifer system vertically into an upper semiconfined zone and a lower confined zone (Davis and DeWiest, 1966). Because of this, the underlying aquifer is typically designated the confined aquifer or zone in the regions where the Corcoran Clay occurs. The Corcoran Clay member of the formation underlies the basin at depths ranging from about 100 to 500 feet and acts as a confining bed (DWR 1981). The unconsolidated sediments of the valley floor taper toward the Coast Ranges, and the Corcoran Clay becomes discontinuous along the west margin of the valley, near the western limits of the GMA. Other, less-extensive, younger, continuous fine-grained lacustrine layers also exist at depths shallower than the Corcoran Clay. However, these other lacustrine layers do not appear to extend into the GMA.

3.4.3 Semiconfined Aquifer

In the area of the GMA, overlying the Corcoran Clay is the semiconfined zone. It is comprised of sediments derived from the Coast Ranges on the west interfingered to the east with sediments derived from the Sierra Nevada. These sediments comprise the older alluvium, younger alluvium and terrace deposit layers. The Coast Ranges and Sierran sediments differ in their hydrogeologic characteristics. The Coast Range sediments consist of beds, lenses, and tongues of clay, sand, and gravel, and form most of the sedimentary material deposited west of the San Joaquin River (Hotchkiss, 1972). Although there are no distinct continuous aquifers or aquitards within the Coast Range alluvium, the term "semiconfined" is used to emphasize the cumulative effect of the vertically distributed fine-grained materials. The Sierran sediment that interfingers with the Coast Range alluvium is well sorted, medium to coarse-grained micaceous sand derived from the Sierra Nevada. The uppermost expression of the interface between the Coast Ranges and Sierran deposits is close to the eastern boundary of the GMA.

Across much of the San Joaquin Basin, a layer of older alluvium consisting of loosely to moderately compacted sand, silt and gravel deposited in alluvial fans during the Pliocene and Pleistocene ages overlies the Tulare Formation. The older alluvium is widely exposed between the Coast Range foothills and the Delta. The thickness of the older alluvium is up to about 150 feet. It is moderately to locally highly permeable.

A layer of younger alluvium overlies the layer of older alluvium. This layer includes sediments deposited in the channels of active streams as well as overbank deposits and terraces of those streams. They consist of unconsolidated silt, fine to medium grained sand, and gravel. Sand and gravel zones in the younger alluvium are highly permeable and, where saturated, yield significant quantities of water to wells. The thickness of the younger alluvium near Tracy is less than 100 feet (DWR, 2006). Further south terrace deposits of Pleistocene age lie up to several feet higher than present streambeds. They are composed of yellow, tan, and light-to-dark brown silt, sand, and gravel with a matrix that varies from sand to clay (Hotchkiss 1971). The water table generally lies below the bottom of the terrace deposits.

In the northern portion of the GMA, flood basin deposits occur (DWR, 2006). They are the distal equivalents of the Tulare Formation and older and younger alluvial units and consist primarily of silts and clays. Occasional interbeds of gravel occur along the present waterways. Because of their fine-grained nature, the flood basin deposits have low permeability and generally yield low quantities of water to wells. The flood basin deposits are generally composed of light-to-dark brown and gray clay, silt, sand, and organic materials with locally high concentrations of salts and alkali. Occasional zones of fresh water are found in the basin deposits, but they generally contain poor quality groundwater. The maximum thickness of the flood basin deposits is about 1,400 feet.

3.5 Hydrology

The following sections discuss the surface and groundwater hydrology of the area. Hydrologically, the GMA has inflow from outside bringing water supplies into the area. Inflows include diversions into the GMA from the San Joaquin River, the streams and channels conveying storm runoff from the east side of the Coast Range Mountains, the network of canals conveying surface water south from the Delta, subsurface groundwater flowing in from the southwest, and precipitation. Outflows from the GMA include surface runoff to the San Joaquin River, groundwater flow moving towards the trough of the valley and exiting the GMA, groundwater discharged to the San Joaquin River system, evaporation, canals and drainage ways conveying water outside the GMA, and crop and phreatophyte evapotranspiration.

3.5.1 Surface Hydrology

Streams flowing from the Sierra Nevada and Coast Range mountains that drain into the northern two-thirds of the San Joaquin Valley empty into the San Joaquin River and drain northward to join the Delta. Historically, the rivers and streams in the southern one-third of the San Joaquin Valley had no natural drainage connecting to the ocean, but rather drained into Tulare and Buena Vista Lakes. Seasonal flooding would occur along these rivers and streams in spring as rainfall and snowmelt from the mountains drained to the valley floor. A number of dams placed along the major watercourses, particularly in the Sierra Nevada Mountains, have alleviated the flooding. The majority of the runoff that drains into the San Joaquin River is derived from the rainfall and snowmelt from the western side of the Sierra Nevada Mountains. These rivers typically drain southwest to west out of the Sierra Nevada Mountains, turning north at the trough of the valley floor, where the San Joaquin River is located.

The ephemeral streams of the eastern side of the Coast Range Mountains typically drain east to northeast out of the mountains towards the trough of the valley floor. Many of these streams only flow during torrential winter storms and for very short periods following. In the past, many of these ephemeral streams would drain out onto the valley into wetlands and infiltrate before reaching the San Joaquin River. This infiltrated water would supply base flow for the San Joaquin River and recharge groundwater. Many of these ephemeral streams have been transected by canals and highways, their drainage courses diverted, and agriculture reclaimed and drained much of the wetlands and lakes. Much of the surface hydrology of the San Joaquin Valley is controlled by man-made structures and practices. Surface waters in the San Joaquin Valley are frequently conveyed into and out of the valley by a network of large canals that supply users' needs in areas far from the natural source. Large man-made reservoirs are used to retain and store runoff from the mountains and temporary surface water being conveyed to other locations.

Consistent with most of the San Joaquin Valley, within the GMA, much of the surface hydrology is governed by the man-made structures, agricultural practices, and urbanization. A notable few ephemeral streams convey water into the GMA from the east side of the Coast Range Mountains. These streams include: Corral Hollow Creek, Lone Tree Creek, Hospital Creek, Ingram Creek, Del Puerto Creek, Crow Creek, Salado Creek, Orestimba Creek, and Garzas Creek. North of Tracy, a network of sloughs and river channels intertwine as the San Joaquin River system and nearby streams form a large flat low lying Delta system that drains the San Joaquin Valley. Some areas within the GMA are relatively flat, and groundwater can be seasonally shallow. These conditions may create seasonal wetlands where the drainage has not been modified. The San Joaquin River flows along the eastern boundary of the GMA and is a major source of water to the GMA.

Besides the natural water conveyance systems, some major canals convey water from the Delta, to and through the GMA. These canals include the California Aqueduct and the DMC. Other smaller canals in the network convey surface water supplies to the users and drain runoff from areas within the GMA. The DMC is a major water supply source to the GMA.

3.5.2 Subsurface Hydrology

Groundwater in the region occurs in three water-bearing zones (DWR, 2006). These include the lower zone, which contains confined fresh water in the lower section of the Tulare Formation, an upper zone which contains confined, semi-confined, and unconfined water in the upper section of the Tulare Formation and younger deposits, and a shallow zone which contains semi-confined and unconfined water to within about 25 feet of the land surface.

Agricultural irrigation in the GMA provides most of the recharge water of the semiconfined zone through seepage losses occurring in irrigation water conveyance channels and by deep percolation of applied water. Other sources of recharge include seepage from creeks and rainfall. Occasional recharge from the creeks that enter the GMA from the Coast Ranges to the west is relatively small compared to the other sources (KJC, 1990). Recharge to the lower confined zone occurs primarily by infiltration downward from the unconfined zone through the Corcoran Clay. Groundwater pumping from below the Corcoran Clay in the GMA is likely to increase percolation through the clay layer.

Historically, groundwater flow was northwestward parallel to the San Joaquin River (Hotchkiss and Balding, 1971). More recent data shows flow tending northeastward, toward the San Joaquin River (DWR 2003). The groundwater flow direction towards the San Joaquin River typically causes subsurface outflow laterally along the eastern boundary of the GMA. The hydraulic gradients west of the San Joaquin River are generally steeper than those east of the river (Phillips, et al., 1991). Typically, notwithstanding local influences, the water table west of the San Joaquin River can be thought of as a subdued replica of the ground surface topography, sloping gently toward the river from the Coast Ranges.

The previous GMP (Stoddard & Associates, 1996) indicated that the average groundwater levels from 1986 through 1993 have declined in the subbasins, but from 1993 through 1994, water levels rose throughout the study area, demonstrating recovery in the groundwater storage system. That report concluded that the study area was in a hydrologically balanced condition over the study period.

As a part of this planning effort, changes in groundwater levels were examined over the 1993 to 2004 period.

From 1993 through 1998, the groundwater levels continued to rise throughout most of the GMA (Figure 4). This pattern reversed during the 1998 to 2004 period (Figure 5). Figure 6 shows lines of equal change of groundwater levels for selected wells from 1993 through 2004. The influence of Tracy on the groundwater levels in the vicinity can be observed. The northern part of the subbasin (From Tracy to Westley) shows a depression in groundwater levels up to 5 feet below the surrounding levels. This depression could be a developing overdraft condition in that area. The exception for the overdraft condition is the area west of Vernalis where groundwater levels rose during the time period, indicating recharge in the area exceeded use. No overdraft condition appears to be occurring in this area. From Westley through the southern border of the GMA, water levels slightly rose on the east (along CA-33), and appreciably dropped on the west (along I-5). During this period, the water levels underlying the vicinity of Patterson appeared to have minimal change. This appears to indicate equilibrium between recharge and use during the period.

Figure 7 shows lines of equal elevation of groundwater for selected wells during the spring of 2004 and the direction of groundwater flow throughout the study area. The flow direction arrows show groundwater in the study area generally flows northeast towards the San Joaquin River.

The DWR groundwater database utilized different wells for water level measurements between 1993 and 2004 for the central part of the GMA (West Stanislaus ID and Patterson WD). For this reason, it is difficult to establish the groundwater level change for the period analyzed in this study. Data from close by monitoring wells was used when there was no other information available.

3.6 Groundwater Quality

The USGS, between March and July 1985, analyzed water samples from 44 wells in the northern part of western San Joaquin Valley (Dubrovsky, et al., 1991). Their objective was to assess the geochemical relations and distribution of major ions and selected trace element concentrations in groundwater of the area. Their results indicate a relatively better quality of water in the confined zone than in the semiconfined zone. These results were supportive of those of Hotchkiss and Balding (1971). Concentrations of selected constituents reported by USGS (Dubrovsky, et al., 1991) in both zones are provided in Table 3. It was concluded that the areal and vertical distributions of groundwater of varying quality has been affected by different agricultural and natural sources of recharge, and the sources and geochemical nature of the sediments are products of a depositional environment.

Table 3
Chemical Analysis of Selected Constituents in Groundwater

State Well No.	Sampling Date	Sulfate	Upper Zone TDS (mg/L)	N	Boron	As (µg/L)	Se
2S/5E-13P1	3/28/85	320	1400	9.1	2.20	<1	4
3S/6E-07E1	3/11/85	230	1100	6.4	1.60	1	2
4S/7E-33B1	3/12/85	370	1400	0.1	0.90	3	10
5S/7E-01M2	5/01/85	120	750	18.0	0.58	<1	2
5S/8E-22C1	4/30/85	1200	2400	0.9	2.20	3	13
6S/8E-04P1	5/16/85	540	1300	15.0	0.51	<1	4
7S/8E-13N1	3/26/85	300	1900	11.0	0.64	<1	<1
8S/8E-01H1	3/27/85	120	750	11.0	0.48	<1	2

State Well No.	Sampling Date	Sulfate	Lower Zone TDS (mg/L)	N	Boron	As (µg/L)	Se
2S/5E-21D1	3/27/85	220	650	2.3	1.30	1	3
2S/6E-20L2	5/21/85	140	510	<0.1	0.57	5	<1
3S/5E-20A2	3/28/85	330	920	1.4	3.00	<1	2
3S/6E-26Q1	3/12/85	120	710	5.6	0.79	<1	1
4S/6E-09M1	3/13/85	44	340	9.1	0.43	<1	2
4S/7E-36Q3	3/13/85	120	690	8.3	0.59	<1	1
5S/7E-27B1	5/16/85	190	760	16.0	1.20	1	5
5S/8E-32K3	4/30/85	530	1000	4.0	0.67	1	11
6S/7E-01R1	5/16/85	630	1300	9.6	0.86	1	6
6S/8E-03R2	5/16/85	360	820	6.4	0.41	2	8
7S/8E-27Q1	5/13/85	56	650	10.0	0.47	<1	<1

3.6.1 Hydrochemical Facies

Chemical analyses of groundwater from the semiconfined zone shows considerable variation in water type and concentration of dissolved solids (Hotchkiss and Balding, 1971). In general, the chemical character of the water in the upper water bearing zone (except near Patterson and Crows Landing) is a transitional type, i.e., groundwater in which no single anion or cation reacting value amounts to 50 percent or more of the total reacting values. The transitional type groundwater in the GMA occurs in many combinations.

Groundwater near Tracy is very hard. Northwest of Tracy, in the vicinity of the Tracy pumping station, groundwater is a chloride type. The sodium chloride type groundwater in the area northwest of Tracy is probably due to infiltration of water from Old River. Old River water varies from transitional chloride bicarbonate to sodium chloride type (Hotchkiss and Balding, 1971).

Sulfate type groundwater occurs in areas located west of Patterson and Crows Landing. Near Patterson, groundwater is sodium magnesium sulfate type to the west and sodium calcium sulfate type to the east. Waring (1915) mentioned some small sulfur springs on Crow and Orestimba Creeks, indicative of sulfate bearing deposits that are probably responsible for the sulfate groundwater type in the area near Patterson (Hotchkiss and Balding, 1971).

3.6.2 Dissolved Solids

Results of the USGS sampling study showed that in the semi-confined zone the total dissolved solids (TDS) concentration ranges from 750 to 2,400 mg/L. Areal distribution of the data shows a high TDS concentration (>1,500 mg/L) in groundwater in the semiconfined zone measured near Patterson and west of Newman, and low concentration (<1,000 mg/L) is reported near the community of Westley. The TDS concentration in water in the confined zone generally ranged between 500 and 1,000 mg/L. Although high TDS concentrations (>1,000 mg/L) in water in the confined zone have been reported southwest of Patterson by the USGS, Patterson has reported TDS concentrations between 600 and 1,000 mg/L (Patterson, 2004). Low TDS concentrations (<500 mg/L) have been measured west of Vernalis. The distribution of TDS in groundwater in the two zones has shown little similarity.

3.6.3 Sulfate

Sulfate concentrations vary greatly in both water-bearing zones, but areal distribution is similar in both zones. Highest sulfate concentration in groundwater (>500 mg/L) is measured in an area centered near Crows Landing and Patterson. A similar area of high sulfate concentration was also reported by Hotchkiss and Balding (1971) and is likely related to the Coast Range streams that recharge this area (Hotchkiss and Balding, 1971). Smaller sulfate concentrations were reported in 2004 by Patterson, which detected concentrations in a range between 190 and 380 mg/L (Patterson, 2004). In 2004, Tracy reported groundwater sulfate concentrations between 160 and 330 mg/L (Tracy, 2004). The lowest concentrations of sulfate in groundwater (<100 mg/L) were measured in an area south of Vernalis. The similarity of sulfate concentrations in both zones in the GMA could result from the presence of similar sulfate concentrations in the streams that were the major source of recharge under natural conditions over a long period of time. In addition, mixing of groundwater between the two water bearing zones occurs due to wells that are screened in both the upper and lower zone.

3.6.4 Boron

Concentrations of boron in groundwater range from 0.48 to 2.2 mg/L in the semiconfined zone and from 0.41 to 3.0 mg/L in the confined zone. Areal distribution of boron in the semiconfined zone shows high concentrations (>0.75 mg/L) near Tracy and northeast of Crows Landing near Patterson. The areal distribution of boron in the confined zone shows high boron concentrations (>0.75 mg/L) near Tracy, Vernalis and west of Patterson. This agrees with the results presented by Tracy (Tracy, 2004). The U.S. Environmental Protection Agency (EPA) suggested criterion for boron concentration in water used for long-term irrigation of sensitive crops is 0.75 mg/L. This limit was exceeded in four samples in the semiconfined zone and five samples in the confined zone (Table 2).

3.6.5 Arsenic

Recently, the federal primary drinking water standard maximum contaminant level (MCL) for arsenic was lowered from 50 µg/L to 10 µg/L. This change became effective for all states as of January 23, 2006 (DHS, 2006). Currently, the California standard is consistent with the federal standard. Arsenic is typically derived by dissolution of igneous parent materials, and released from iron and manganese oxides when pH declines. Based on the USGS study, arsenic concentrations in the groundwater samples from the semi-confined aquifer in the GMA vicinity ranged between 1 and 38 µg/L, which at that time were below the MCL (Dubrovsky, et al, 1991). Based on the USGS study, arsenic concentrations in the groundwater samples from the confined aquifer in the region ranged between 1 and 18 µg/L. Within the GMA the highest reported arsenic concentrations were 3 µg/L and 5 µg/L, respectively. In both aquifers, arsenic concentrations were reported that exceeded the current MCL in the vicinity of the GMA, but none within the GMA. The arsenic distribution between the groundwater in the semi-confined and confined aquifers showed little difference. However, the areal distribution showed an increase in arsenic concentrations in the GMA toward the southeast. The concentrations increased in the Sierran sediments. The increase is probably related to the higher proportion of Sierra sediments in the profile towards the southeast. In their respective water quality reports, Tracy reported arsenic concentrations as high as 3 µg/L, and Patterson reported arsenic concentrations as high as 6 µg/L, which are below the current MCL (Tracy, 2004; Patterson, 2004).

3.6.6 Selenium

Selenium concentrations in the GMA groundwater range from a less than detectable limit of 1 µg/L to 13 µg/L (Table 3). The current MCL for selenium in drinking water is 50 µg/L. The selenium MCL concentration was equaled or exceeded in two samples from the unconfined zone and in one sample from the confined zone. The concentration and areal distribution of selenium were similar in both zones. Selenium concentrations are relatively high (10 µg/L) in a narrow area of both zones between Patterson and Crows Landing. Lower concentrations (between 3 and 8 µg/L) were reported in 2004 by Patterson (Patterson, 2004). In the Tracy and Vernalis area, the selenium concentrations range between 1 µg/L to 5 µg/L. The USGS (Dubrovsky, et al., 1991) study concluded that selenium was transported to the area under natural conditions by runoff from the Coast Range.

3.6.7 Nitrate

The MCL for nitrate in drinking water is 45 mg/L. The USGS (Dubrovsky, et al., 1991) sampling study indicated that no well water in the GMA exceeds the MCL for nitrate. This agrees with the results presented by Tracy (Tracy, 2004) and Patterson (Patterson, 2004). However, Dubrovsky et al (1991) mentioned that there were reports of nitrate MCL exceedence in shallow domestic wells. In general, higher nitrate concentrations in groundwater exist along the west side of the GMA and in the Westley area. The areas along the San Joaquin River have lower nitrate concentrations (Hotchkiss and Balding, 1971).

3.6.8 Trace Elements

The Deverel et al. (1984) study (reported by Dubrovsky, et al., 1991) states that the shallow groundwater, near the top of the semiconfined zone and less than 30-feet below the land surface, generally has higher trace element concentrations than the deeper zones. This study indicates that the higher trace element concentrations in the shallow groundwater might correlate with the generally higher TDS concentrations in the shallow groundwater. The higher concentrations probably result from leaching of soil salts and evaporative concentration of shallow groundwater near the land surface.

Because of the high variability of groundwater quality in the GMA, focused groundwater supply investigations are necessary to determine if groundwater is suitable for the intended use. Additionally, management practices must be designed to maintain or improve groundwater quality to meet the differing needs of the users within the GMA.

Section 4
Management Objectives

As it was stated before, typically, this regional program will rely on the PAs to develop the specific programs and projects to meet management objectives that address local groundwater concerns while considering regional interests.

There are general objectives that should be considered for management of groundwater resources within the GMA:

- Assure an affordable groundwater supply for the long term needs of the users.
- Prevent long-term depletion of groundwater resources, and maintain adequate groundwater supplies for all users.
- Maintain groundwater quality to meet the long-term needs of users.
- Attempt to reduce or prevent inelastic land subsidence due to groundwater overdraft.

Section 5
Program Components Relating to Management

During recent years, there have been several groundwater management activities undertaken by various agencies and individuals in the GMA to protect the groundwater resources. Previous activities within the GMA are detailed by Stoddard & Associates (1996). The following activities can be mentioned as examples of the PAs actions:

In 1996, the PAs included in the Northern Subbasin Groundwater Management Area under the leadership of the SLDMWA, developed the Northern Subbasin Groundwater Management Plan (NSGMP) under AB 3030 (Stoddard & Associates, 1996). The implementation of this plan provided the means for collection of the necessary monitoring data needed to assess the impact of activities that affect the groundwater basin such that sustained use of groundwater could be optimized without adverse impacts to the water quality and yield.

A Groundwater Monitoring Program was prepared in 1999 as the first step in the implementation of the NSGMP (Stoddard & Associates, 1999). This program was designed to utilize existing agricultural and public water supply wells to monitor regional changes in groundwater quantity and quality in the semiconfined and the confined zones. The program outlined networks of wells for water level and water quality monitoring, proposed monitoring frequencies for each network, and proposed new monitoring well locations for future inclusion in the networks. Maps depicting the location of wells in each network were presented and relevant construction data were tabulated. To date, the monitoring program has not initiated groundwater quality measurements. Under this program, the groundwater levels are measured twice a year.

In June 2000, San Joaquin County adopted the Groundwater Export Ordinance to prevent the deliberate export of groundwater for use outside of the County and placed conditions on the extraction of banked groundwater by out-of-County partners without a permit. Under the Ordinance, the County seeks to foster prudent water management practices to avoid significant adverse overdraft and related environmental, social, and economic impacts.

The SJCFCWCD developed the San Joaquin County Water Management Plan, which was adopted in 2002. This plan addresses overdraft conditions, prevents further degradations of groundwater quality due to saline water intrusion, increases water supply reliability, meets the projected year 2030 county water demand, identifies viable water supply and recharge options, and identifies the institutional structure to implement the options (Camp Dresser and McKee, 2001).

The passage of SB 1938 requires a GMP to include components relating to the management of groundwater levels, groundwater quality, inelastic land surface subsidence and changes in surface flow and water quality that directly affect groundwater levels or quality, or are caused by groundwater pumping.

Establishing effective working relationships with the various state agencies and federal agencies is essential for water resources management to be efficient and effective. The PAs value the information and guidance provided by these agencies. The PAs should collaborate with the appropriate state and federal agencies in well data collection, studies and findings, and in establishing effective communication and data transfer strategies.

The following sections discuss how these components are included in the GMP, identify elements to be included in potential programs, and briefly describe the related activities within the GMA.

5.1 Components Relating to Groundwater Level Management

5.1.1 Reduction of Groundwater Use by Development of New Surface Water Supplies

Agencies buy water from out-of-basin sellers to supplement their supplies.

Activities within the GMA: Tracy is participating with the cities of Manteca, Lathrop, Escalon and the South San Joaquin Irrigation District in the South County Surface Water Supply Project (SCSWSP), to bring high quality Sierra Nevada water from the Stanislaus River to cities for their urban use. The intent of the project is to reduce the reliance on groundwater and to satisfy future urban demand increases. A water treatment plant on the Stanislaus River uses water that the irrigation district has conserved from improvements in irrigation practices and water efficiencies. Water is taken from Woodward Reservoir, treated to drinking standards, and conveyed to the cities. Water deliveries commenced in July 2005.

5.1.2 Increase Use of Available Surface Water Supplies

There are some in-basin water transfers and purchases from agencies to others with limited water rights overlying areas having more depressed groundwater levels.

Activities within the GMA: Surface water purchases by Tracy from West Side ID and Banta Carbona ID, and the use of Byron-Bethany ID CVP water supply for municipal and industrial purposes.

5.1.3 Development of Overdraft Mitigation Programs

According to the DWR definition, overdraft occurs when continuation of present water management practices would probably result in significant adverse overdraft related impact upon environmental, social, or economic conditions at a local, regional, or state level. Long-term depletion of storage can cause several problems, including land subsidence, degradation of groundwater quality, and increased pumping costs.

Although overdraft of the entire basin is not occurring, conditions of localized overdraft could happen, since areas of extraction do not typically coincide with areas of recharge. One portion of the GMA can experience an increase in groundwater storage while another shows a continual decrease. Such localized overdraft can cause the same adverse impact as basin-wide overdraft, except on a smaller scale. Monitoring of groundwater levels and water quality is necessary to identify areas where localized overdraft is occurring, and to evaluate its effect. The monitoring will allow the overdraft to be quantified, which is needed to evaluate means to control or reverse the overdraft. Curtailing local overdraft usually requires increasing or redistribution of basin surface water supplies or reducing the amount of groundwater pumped.

The prerequisite to implementation of an overdraft mitigation program is to monitor groundwater levels. Once groundwater trends are known, a responsive overdraft investigation program should be developed around the following components:

- Identify areas of overdraft.
- Determine the potential for significant adverse impact due to the overdraft.
- Formulate a plan to mitigate the impact and a strategy for plan implementation.

Activities within the GMA: The programs described in 5.1.1 and 5.1.2 above.

5.1.4 Development of Conjunctive Use Programs and Projects

Conjunctive use of groundwater and surface water typically occurs when the surface water supply varies from year to year and is insufficient at times to meet an area's demand. In some years, the surface water supply is greater than the water demand; and in other years, the surface water supply cannot meet the entire water demand. In the years when water is plentiful, water available above the demand is utilized to recharge the groundwater aquifer. Recharge can occur either directly by operation of recharge facilities or injection wells, or indirectly, by applying surface water where available to areas to avoid the use of groundwater. In effect, the groundwater basin is utilized as a storage reservoir, and water is placed in the reservoir during wet periods and withdrawn from the reservoir during dry periods.

There are opportunities for conjunctive use in the study area that could increase overall water supply yield; however, each must be evaluated in terms of available water supply, basin geology, available storage capacity, pumping zones, and recharge potential to determine yield, costs, and potential adverse impacts. In the GMA, pumping takes place primarily from the confined zone, while unoccupied aquifer storage is available only in the unconfined zone. Based on the basin characteristics, water supply sources, and current groundwater usage, potential conjunctive use opportunities should focus on the following:

- Identifying areas of local overdraft and evaluating the viability of a recharge program using direct recharge.
- Evaluating the availability of additional surface water supplies, which could be utilized in conjunctive use programs either directly or via exchange of CVP supplies.
- Optimizing the overall groundwater yields during dry periods through sound basin management

In recent history in the GMA, conjunctive use has been practiced in an unmanaged fashion. When full CVP water supplies are being received, relatively little pumping occurs. During the water short periods of 1976-1977 and 1989-1992, water was withdrawn from the aquifer to make up for the deficits in surface water supply.

Activities within the GMA:

a. Patterson Irrigation District pumps groundwater on an as needed basis. The District has focused its efforts on improving surface water delivery and pumping efficiencies by recycling surface drainage as opposed to limiting canal seepage. Deep percolation of irrigation water and distribution system seepage/losses, enter the groundwater aquifer and is either stored there or is lost as base flow into the San Joaquin River. The stored groundwater supply is available to the District during drought conditions. Such recharge is important to the District to recharge the groundwater supply (Patterson ID, 2005).

b. DWR has implemented, through its Conjunctive Water Management Program (CWMP), several integrated programs to improve the management of groundwater resources in California. The program emphasis is on forming partnerships with local agencies and stakeholders to share technical data and costs for planning and developing locally controlled and managed conjunctive water use projects. DWR and SJCFCWCD entered into a Memorandum of Understanding to cooperatively develop a CWMP, establish an advisory committee representative of all water stakeholders, and complete a basin management evaluation (DWR, 2006).

c. Tracy is evaluating the use of the Tracy groundwater basin for water storage, as a way to increase the reliability of the City's water supply during droughts or reduction in surface water imports. This consists of injecting surface water treated to drinking water standards into the aquifer via deep wells during times of surplus water and recovery of that potable water from the aquifer to optimize water quality and meet seasonal peak demands during droughts or when emergency or disaster scenarios preclude the use of imported water supplies. Tracy anticipates that, under this Aquifer Storage and Recovery (ASR) program, approximately 3,000 acre-feet (af) of high-quality groundwater would be available in drought years, thereby increasing the reliability of Tracy's water supply and closing the potential future gap between supply and demand during drought or emergency conditions (EKI, 2005).

d. Tracy is also studying the possibility of procuring surface water storage to increase water supply reliability. Tracy is evaluating the potential to buy water storage capacity in the Semitropic Water Banking Project (Semitropic) in Kern County. In order to store water in Semitropic, Tracy would not withdraw a portion of its CVP water from the DMC, such that this water would move through the DMC and California Aqueduct systems for delivery to Semitropic. During a drought, Semitropic would pump the stored water into the California Aqueduct and a like amount of water would be made available to Tracy to pump from the DMC. Tracy is currently in negotiations with Semitropic to purchase up to 10,500 af of storage volume. If this storage were secured, it would provide Tracy with up to 3,500 af of water annually for three years during water short periods (EKI, 2005).

5.1.5 Development of Agricultural and Urban Incentive Based Conservation and Demand Management Programs

Reduction of demand, either urban or agricultural, should be an important component of the long-term planning and management of water resources. It reduces the need for new water supply projects, often at relatively low cost, and assists in making prudent use of the available supplies.

The experience of active urban water conservation programs in California is that the potential for water savings are initially about 10 to 20 percent of the volume of water used. Such programs typically include distribution system leak-reduction programs, household metering, tiered pricing to discourage high use, education of children and the public and market-enforced transition to water-saving household plumbing devices.

The greatest potential for agricultural water conservation relies mainly on the use of more efficient irrigation technologies. Increasing irrigation efficiency decreases the amount of water that is lost to the system or leaves the site through surface water runoff or deep percolation to groundwater.

From the hydrologic system perspective, the water conservation efforts must be planned locally, taking into account groundwater levels, groundwater quality, and groundwater supply.

Activities within the GMA:

a. Tracy developed a Water Conservation Plan in 2000. The conservation efforts include implementation of the California Urban Water Conservation Council's (CUWCC) 14 Best Management Practices (BMPs). The BMPs include residential water surveys, system water audits and leak detection, water pricing to encourage conservation, waste prohibitions, public information, landscape guidelines, etc.

b. An update of the Urban Water Management Plan (UWMP) for Tracy was prepared in 2005 to fulfill the UWMP Act requirements. This UWMP describes how Tracy intends to manage its current and future water resources and demands to continue to provide its customers with an adequate and reliable water supply. This updated UWMP reflects changes to the Tracy's water supply portfolio and water demands since 2000 (EKI, 2005).

c. Many of the PAs have completed agricultural water conservation plans and periodically update the plans pursuant to the Central Valley Project Improvement Act. In these plans, water conservation practices have been identified and instituted to maximize beneficial use of the water supply. Practices include better irrigation management, physical improvements, and institutional adjustments. Irrigation management practices include on-farm water management and district water accounting, use of efficient irrigation methods, and on-farm irrigation system evaluations. Physical improvements include lining of canals, replacement of unlined ditches with pipeline conveyance systems, and improvement of on-farm irrigation and drainage technology. Institutional adjustments include improvements in communication and cooperative work among districts, water users, and state and federal agencies, increased conjunctive use of groundwater and surface water, and facilitating the financing of on-farm capital improvements. Other practices that have been instituted include installation of flow measuring devices, modification of distribution facilities to increase the flexibility of water deliveries, and changes in the water fee structure to provide incentive for more efficient use of water.

   The water conservation plans have helped the districts identify the opportunities for better irrigation water utilization.

5.1.6 Replenishment of Groundwater Extracted by Water Producers

The hydrologic balance included in the previous GMP, suggests that lowering the groundwater levels increases sustainable yield, since subsurface outflow is reduced which counteracts the water extracted. More data and analysis is needed to confirm this finding and to determine the level of pumping that can be sustained without overdraft. As urban areas develop and there is a corresponding shift from surface water use to groundwater use, groundwater use increases and aquifer recharge decreases. Judging by the water resources balance, the GMA should be able to absorb the increased extraction to supply urban demand and maintain a balance notwithstanding large changes in surface water delivery, the potential for localized overdraft caused by concentrated pumping, and water quality limitations. It appears that the natural response of the aquifer to limited increases in pumping will provide for replenishment.

5.2 Components Relating to Groundwater Quality Management

5.2.1 Regulation of the Migration of Contaminated Groundwater

Contaminants addressed in this section are those that result from improper application, storage or disposal of petroleum products, solvents, pesticides, fertilizers and other chemicals used by industry, and are distinguished from salinity degradation. The SLDMWA's role in protecting groundwater from contamination by point sources will be supporting the Regional Water Quality Control Board (RWQCB), whose primary responsibility is enforcing water quality regulations, in the respective counties. The SLDMWA will help develop a better understanding of the regional hydrogeology of the GMA, the vertical and lateral groundwater flow directions, and groundwater quality based on the various groundwater monitoring activities supporting this program. The PAs shall make the appropriate regulatory agencies aware of changes in groundwater quality, which may indicate that new sources of contamination or changes in existing plumes of contamination are occurring.

Activities within the GMA:

a. The San Joaquin County Environmental Health Department (SJCEHD) carries out different management programs. The purpose of the "Underground Injection Control" program is to protect public health and the environment from exposure to contaminants that may exist in shallow underground injection wells, such as dry wells, seepage pits, sumps, etc. These injection wells could transport contaminants to soil and groundwater. The primary focus is on protection of groundwater from contamination. Activities include identifying, mapping, inspecting and remediating potential or existing contaminant sources. The SJCEHD also permits and inspects well installation and destruction to minimize the potential for the wells to adversely impact groundwater.

b. The "Underground Storage Tanks (UST)" program was developed by SJCEHD to protect public health and the environment from exposure to hazardous materials stored in USTs. The primary focus is on protection of groundwater from contamination. Activities include inspection, permitting, monitoring, repair, installation and removal of USTs. UST sites with identified contamination are referred to the SJCEHD Site Mitigation Unit for cleanup oversight.

c. SJCEHD is also responsible for a "Site Mitigation Database". This contains information about all the known hazardous material contamination sites within San Joaquin County. The database was established in 1993, although it includes information as far back as 1985. It is available to the public.

d. The Stanislaus County Department of Environmental Resources, Hazardous Material Division has an UST program. The goal of the program is to protect public health, the environment and groundwater. UST inspectors make certain that businesses and facilities with ongoing UST operations are properly permitted and meet the monitoring requirements applicable to their type of equipment. The UST Program and the Site Assessment and Mitigation Program oversee UST removal and soil clean-up activities. The primary function of the Site Assessment and Mitigation Program in UST removal activities is to provide regulatory oversight for the site assessment and mitigation of properties where unauthorized releases from UST systems have occurred.

e. The State Water Resources Control Board (SWRCB) developed a UST program which purposes are to protect public health and safety and the environment from releases of petroleum and other hazardous substances from tanks. By 2005, there were approximately 2,650 open UST cases in the Central Valley Region. There are four program elements: leak prevention program (requirements for tank installation, construction, testing, leak detection, spill containment and overfill protection), cleanup of leaking tanks, enforcement, and tank tester licensing. In addition, there is a database and geographic information system (GIS), Geo Tracker, which provides online access to environmental data (http://www.geotracker.waterboards.ca.gov/). It tracks regulatory data about underground fuel tanks and public drinking water wells, as well as other types of sites, such as above ground storage tanks and site cleanup cases (SWRCB, 2006).

5.2.2 Development of Saline Water Intrusion Control Programs

Groundwater quality within an aquifer can be permanently degraded if saline groundwater migrates into the aquifer. Such degradation has the potential to render the groundwater unsuitable for some uses, particularly potable water use, if not treated. Desalination treatment systems are very expensive. In the GMA, saline water intrusion does not occur from an ocean or saltwater body; instead, it results from: naturally occurring salts present in the soil, salts imported with surface water, and other activities on the land surface.

When water is applied for irrigation purposes, plants consume the water for plant growth leaving excess salts in the soil profile. Water is applied to crops in amounts in excess of the crop consumptive use requirement, so there is sufficient water to migrate downward and carry these salts beyond the crop root zone. This water also carries naturally occurring salts that are dissolved from the soil profile. Chemical fertilizers used in agricultural production, and percolation of effluent from waste treatment facilities also contributes salts to the groundwater basin. Without a means to remove the accumulated salts, the salts remain in the basin and ultimately increase the salinity of the groundwater.

Due to the nature of the processes, shallower groundwater is the first to degrade and a vertical water quality gradient is established, with the poorer quality water in the upper zones and the better quality water in the deeper zones. In the GMA, the best quality water typically occurs in the confined zone just below the Corcoran Clay.

While it is recognized that there is slow groundwater quality degradation occurring due to the regional downward movement of surface salts, upwelling of deep saline groundwater may also be occurring. Both downward and upward migration may be accelerated due to increased groundwater pumping. During the 1976-1977 and 1986-1992 drought periods there were substantial increases in groundwater pumping that may have caused accelerated water quality degradation (Stoddard & Associates, 1996).

To maximize the sustainability of the groundwater basin, knowledge of the various water quality zones and groundwater flow patterns is necessary. Once this information is gained, groundwater management techniques can be evaluated to protect zones of high water quality so that the beneficial uses are protected. A program to minimize water quality deterioration due to saline water intrusion should contain the following elements:

- Analysis of groundwater data obtained from different Agencies.
- Identify areas where water quality monitoring and the groundwater flow patterns suggest a high probability of water quality degradation.
- Identify zones of marginal quality water, which can be used in conjunction by blending with surface water to increase water supply to reduce migration of saline water.

- Identify water management measures that may be employed to minimize the degradation.
- Cooperate in programs aimed at providing a way to export salts out of the GMA via some type of drainage program to export salts to provide a balance with imported salts.

Activities within the GMA: currently there are no related programs within the GMA.

5.2.3 Identification and Management of Wellhead Protection Areas and Recharge Areas

The Federal Wellhead Protection Program established by Section 1428 of the Safe Drinking Water Act (SDWA) Amendments of 1986 was designed to protect groundwater resources of public drinking water from contamination, and to minimize the need for costly treatment to meet drinking water standards. A Wellhead Protection Area, as defined by the 1986 Amendments, is *"the surface and subsurface area surrounding a water well or well field supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water or well field."*

The California's Drinking Water Source Assessment and Protection (DWSAP) Program has been prepared in response to the 1996 reauthorization of the federal SDWA, which included an amendment requiring states to develop a program to assess sources of drinking water and encourages states to establish protection programs. The Department of Health Services (DHS) Division of Drinking Water and Environmental Management is the lead agency for development of the DWSAP Program and its implementation. Since California has not developed a wellhead protection program, the groundwater portion of the DWSAP will serve as the State's wellhead protection program (DHS, 1999).

According to the California Water Plan Update 2005 (DWR, 2005), recharge area protection includes keeping groundwater recharge areas from being paved over or otherwise developed and guarding the recharge areas so they do not become contaminated. Protection of recharge areas, whether natural or man-made, is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. Existing and potential recharge areas must be protected so that they remain functional and they are not contaminated with chemical or microbial constituents. Zoning can play a major role in recharge area protection by regulating land-use practices so that existing recharge sites are retained as recharge areas.

In the GMA the primary source of recharge is from percolation of excess irrigation water. Incidental recharge sources include seepage losses from canals and ditches and from the westside streams that flow intermittently during the rainfall season. To protect recharge areas, the PAs should review applications for Waste Discharge Permits within and adjoining their boundaries that have the potential to degrade groundwater. Such waste disposal systems include disposal of dairy wastes, disposal of industrial wastes, sewage treatment plant effluent disposal, and solid waste disposal. Environmental documents for such facilities and Tentative Waste Discharge Permits issued by the RWQCB should be closely reviewed such that appropriate monitoring and mitigation measures are developed to preclude the possibility of migration of pollutants from the disposal sites. PAs should be on the lookout for existing and proposed land use activities that have the potential to degrade groundwater, so that appropriate action can be taken.

Activities within the GMA: Through programs administered by RWQCB, the California Integrated Waste Management Board (CIWMB) and the Department of Toxic Substances Control, the State of California regulates waste disposal. The PAs will rely on continued regulation by the State; however, the

PAs will assist the State by identifying areas that are threatened or are the most susceptible to groundwater contamination.

5.2.4 Administration of Well Abandonment and Well Destruction Program

State regulations require that all unused wells be properly abandoned or destroyed so that they do not act as conduits for mixing of groundwater of differing quality. Non-pumped wells are a much greater threat than pumped wells, since pumping normally quickly removes contaminants that may have migrated during idle periods. In gravel packed wells, the gravel pack as well as the casing itself can act as a conduit for mixing and potential contamination.

Permits are required from the applicable county or city for abandonment of wells within their jurisdiction. For public water supply wells, additional requirements may be prescribed by the DHS. Permit fees are normally required.

Activities within the GMA: The PAs rely on continued administration of the well abandonment and destruction program by the permitting agencies. The PAs' role in well abandonment and destruction is to provide available groundwater data, assist in identifying locations of operating and abandoned wells, and advise well owners why proper well destruction is important for protection of water quality.

5.2.5 Well Construction

Improperly constructed wells can establish pathways for pollutants to enter from surface drainage and can cause mixing of water between aquifers of differing quality. Sections 13700 through 13806 of the California Water Code require proper construction of wells. The standards of well construction are specified in DWR Bulletins 74-81 and 74-90.

The counties and cities within the GMA have the fiduciary responsibility to enforce well construction standards. Well construction permits are required to drill a new well or to modify an existing well. Well Driller's Reports must be filed with the DWR and the respective counties.

The environmental health divisions of the respective counties maintain records on wells and groundwater quality because of their responsibility to enforce standards for construction and abandonment of wells, and for issuance of drinking water permits for small community water supply systems. These data are publicly available and should be collected to incorporate into regional monitoring. It should be supplemented with data on water levels and groundwater quality collected by other agencies to identify locations susceptible to intermixing of aquifer zones of varying water quality. The information should be used to establish specifications for well construction and destruction to optimize well water quality and minimize mixing of water between zones of varying water quality.

A better understanding of the subsurface geology and water quality is needed to define the confining beds between aquifer zones of differing water quality. Site-specific hydrogeologic investigations should be conducted to support well designs and should be submitted with the proposed well designs to obtain the well drilling permit.

Activities within the GMA: Merced and Stanislaus Counties have adopted the DWR standards. San Joaquin County has developed its own standards to better protect against migration of contaminants. The authority over well construction remains with the respective counties and cities. The PAs should request that the counties supply them with copies of well permits, logs, and studies to assist in their groundwater management activities.

5.2.6 Review of Land Use Plans to Assess Risk of Groundwater Contamination

Land use planning is used by counties and cities for regulation of land uses within their boundary or sphere of influence to create a quality of life and to achieve compatibility between man's activities and the environment. It is a very effective method to mitigate impacts of changes in land use on groundwater quantity and quality.

Policies set forth in county general plans, city general plans, and community specific plans that affect groundwater may include:

- Regulating growth in groundwater recharge areas to protect water quality.
- Monitoring water quality and groundwater levels.
- Providing planning for proper disposal of solid waste, sanitary waste and storm runoff, and hazardous wastes generated by the community.
- Matching projected growth in water consumption to available water supplies.
- Mitigating the impacts of reduction in surface water supply resulting from conversion of land from agricultural use to urban use.

To achieve the common goals between the various land use plans and this GMP, close coordination between agencies is needed. During periodic land use plan preparation and updates, cities or counties should consult with the appropriate PAs to avail themselves of the latest information on hydrogeologic conditions that may be affected by proposed activities, so that appropriate mitigation measures can be included in the plans to avoid significant adverse impacts to the groundwater basin. Proposed land use plans and supporting environmental documentation should be reviewed and commented upon by the PAs.

5.2.7 Construction and Operation of Groundwater Management Facilities

Groundwater management plans can include projects that protect the quality of groundwater and assures that the quantity of groundwater in storage is managed to meet long-term demand. The facilities that can aid in efficient management of groundwater resources include groundwater contamination clean-up projects, groundwater recharge projects, water recycling projects, and groundwater extraction projects. As knowledge is gained through implementation of the GMP components, specific projects may be identified and evaluated. The individual PAs are responsible for the development and implementation of those projects.

5.3 Components Relating to Inelastic Land Surface Subsidence

Reducing the amount of groundwater in storage by pumping could cause the dewatering of fine-grained geological formations, potentially resulting in land subsidence and a reduction in the storage capacity of the aquifer.

The management of the land subsidence would include monitoring and prevention programs. Management of land surface subsidence should contain the following elements:

- Establish a subsidence monitoring program. Benchmarks should be established at well locations, so it would be possible to relate the subsidence to groundwater extraction.
- Identify areas where monitoring suggest land subsidence.
- Identify management measures that may be employed to minimize the subsidence.

Activities within the GMA: Tracy established a subsidence-monitoring program in 2003. Benchmarks were established at each of the City's monitoring wells. An annual benchmark survey is performed in the spring of each year by using the Global Positioning System (GPS). The results of the Monitoring Program are presented in semiannual reports.

5.4 Components Relating to Surface Water Quality and Flow

SB 1938 requires the inclusion of components relating to the management of changes in surface flow and water quality that directly affect groundwater levels or quality, or are caused by groundwater pumping. Specific actions may include:

- Use of surface water supplies when available in a recharge program or conjunctive use program that is sensitive to downstream users and the environment;
- Avoidance or mitigation of projects that detrimentally affect surface water quality and flow;
- Increase understanding of the interaction between surface water quality and groundwater quality through the GMA monitoring programs.

Activities within the GMA: The current and planned actions within the GMA related to recharge and conjunctive use are detailed in previous sections.

Section 6
Groundwater Monitoring Program and Monitoring Protocols

6.1 Groundwater Monitoring Program

The purposes of a groundwater monitoring program are to identify areas of overdraft, provide information that will allow computation of changes in groundwater storage to determine net recharge or depletion, and identify the areas and extent of water quality degradation for potential mitigation. Groundwater level monitoring is essential to understand the impact on aquifer storage due to changes in water inflow and outflow components and in pumping activities. Mapping of groundwater levels depicts the direction of groundwater movement and the hydraulic gradient necessary for quantifying groundwater inflow and outflow to the GMA. Monitoring and mapping should be done independently in the unconfined and confined zones.

The monitoring program for this plan would rely on data collected by agencies like DWR, USGS, DHS, SLDMWA, PAs, Counties, and Cities. Groundwater levels and groundwater quality data would be reviewed individually or as a group during the PAs meetings, and the PAs would decide if additional monitoring programs are necessary to supplement information for areas where existing data indicates possible overdraft or water quality issues.

The agencies that collect groundwater data for this area are the following:

- DWR

  The DWR measures groundwater levels in monitoring wells, and develops databases for groundwater levels. Statewide groundwater level data are available for download at the Department's Groundwater Level Database website (http://wdl.water.ca.gov/). This site provides a graphical interface that allows selection of individual wells from a local area map. Data can also be retrieved by specifying the groundwater basin or township of interest. A selected well will return a groundwater level hydrograph and data table including the depth to water below reference point, elevation of water surface and depth to water below land surface. This site maintains groundwater level information for nearly 18,000 wells within the San Joaquin District boundary and about 60,000 wells statewide.

- USGS

  The USGS Ground-Water Data for the Nation database (http://waterdata.usgs.gov/nwis/gw) contains groundwater site inventory, groundwater level data, and water quality data. The groundwater site inventory consists of more than 850,000 records of wells, springs, test holes, tunnels, drains, and excavations in the United States. Available site descriptive information includes well location information such as latitude and longitude, well depth, and aquifer. The USGS annually monitors groundwater levels in thousands of wells in the United States. Groundwater level data are collected and stored either as discrete groundwater level measurements or as continuous record. The data available for this GMA is not updated.

- SWRCB – USGS – Lawrence Livermore National Laboratory (LLNL)

  The SWRCB is collaborating with the USGS and the LLNL to implement the Groundwater Ambient Monitoring and Assessment Program (GAMA). Statewide, the GAMA Program was developed in response to the Groundwater Quality Monitoring Act of 2001 (Water Code sec.10780-10782.3). The goals are to improve statewide groundwater monitoring, and facilitate the availability of information about groundwater quality to the public. The data collected will provide an early indication of potential water quality problems. It will also be used to identify the natural and human factors affecting groundwater quality. Prior to 2003, the GAMA Program conducted the California Aquifer Susceptibility (CAS) Assessment. The CAS Assessment addressed the relative susceptibility to contamination of public wells. This effort was the foundation for the GAMA Program. The GAMA Program also addresses the quality of private/domestic drinking water wells through the Voluntary Domestic Well Assessment Project.

  The groundwater basins in California were ranked in groups of sampling priority on the basis of the number of public wells, groundwater usage, and potential sources of groundwater contamination in each basin. Three types of water quality assessments will be conducted for each unit:

    a. The assessment of current groundwater quality.

    b. The detection of changes in water quality.

    c. The assessment of natural and human factors that affect groundwater quality.

  To facilitate a statewide, comprehensive groundwater quality-monitoring and assessment program most efficiently, uniform and consistent study-design and data-collection protocols are being applied to the entire state. The GAMA Program monitors groundwater for a broad suite of chemicals at very low detection limits, including exotic chemicals such as wastewater chemicals and pharmaceuticals. Monitoring and assessments for priority groundwater basins are to be completed every ten years, with trend monitoring every 3 years. The sampling for the Western San Joaquin Valley Unit will be performed during Fall 2007. The Report for the Northern San Joaquin Valley Unit can be found at http://pubs.usgs.gov/ds/2006/196/ds_196.dpf. More information about this program is available at http://www.swrcb.ca.gov/gama/ or http://ca.water.usgs.gov/gama/.

- DHS - Division of Drinking Water and Environmental Management

  Every public water system in the State has to have the analyzing laboratory enter the results of chemical monitoring to the Drinking Water Program, a water quality monitoring database. A CD containing the database can be purchased from the Monitoring and Evaluation Unit (Contact: Steve Book, Phone: 916-449-5566; sbook@dhs.ca.gov). For security reasons, DHS does not provide the coordinates of each well included in the database. However, a lot of general vicinity locational information is easy to deduce from names of the water systems.

- SLDMWA

  The PAs cooperatively developed a comprehensive groundwater level and quality monitoring plan for the GMA (Stoddard & Associates, 1999). Currently, only the groundwater levels are monitored twice a year in accordance to the plan. Other elements of the plan have not yet been implemented though implementation of additional elements may occur in the future. (Contact: Joe Martin, Phone: 209-832-6241; joe.martin@sldmwa.org.)

- San Joaquin County

  The San Joaquin County Groundwater Data Center (GDC) is a countywide centralized groundwater information medium that provides access to groundwater data collected and shared by agencies throughout San Joaquin County. The county groundwater level monitoring program includes semi-annual measurements of over 550 wells, of which approximately 300 are measured by County Staff. The data collected is stored electronically in a database for further analysis. Over the internet, water interests are able to access historic groundwater data at: http://www.sjmap.org/groundwater/.

- Stanislaus County

  The County has groundwater quality information available from the Public Water System database. An appointment is necessary to gather that information. At this time, there is no groundwater level information available. (Contact: Tom Wolf, Phone: 209-525-6756)

- City of Tracy

  Tracy developed a Mitigation Monitoring Program in 2001. The monitoring network consists of eight active production wells, four nested monitoring wells, and 18 clustered monitoring wells. Because of the design of the monitoring wells, data from those wells are considered representative of individual aquifer conditions and are generally of higher quality than the data obtained from production wells. Groundwater levels are obtained monthly, and water quality is collected quarterly. This Program also includes a subsidence survey. The annual benchmark survey is performed in the spring of each year. The results of the Monitoring Program are presented in semiannual reports (GEI Consultants, 2005). (Contact: Steve Bayley, Phone: 209-831-4420; steve.bayley@ci.tracy.ca.us.)

6.2 Monitoring Protocols

SB 1938 requires the adoption of monitoring protocols in order to collect the groundwater data in a systematic and consistent manner. For this GMP, monitoring protocols would be defined based on goals of particular programs.

With the responsibility for the perform of the monitoring on each of the PAs, the Authority is in the process of coordinating the activities of the PAs, including development of standardized collection techniques for groundwater level monitoring, groundwater quality sample collection, preparation, chain-of-custody, laboratory procedures and methods, and data validation procedures in an established QA/QC program for the PAs.

The Authority, through consultation with the PAs, will develop a framework for analysis of data and dissemination of the results.

Section 7
Implementation of the Groundwater Management Plan

GMP implementation involves development of programs through cooperative efforts of the PAs. Implementation of some aspects of the plan may require considerable expenditures and formulas must be developed to allocate costs amongst the PAs. Implementation of regional groundwater management plans is ultimately less costly than implementation of plans by individual agencies, but the implementation strategy is complicated since the PAs have varied reliance on the groundwater resource. The priorities for implementation of the various elements of the GMP will vary from PA to PA. The potential benefits of regional planning within a common groundwater basin or subbasin far outweigh the difficulties of plan implementation. The cooperation of agencies increases the opportunities for water resource management.

In the GMA, the PAs can be generally separated into four categories:

a. Urban water users that currently rely exclusively or primarily on groundwater.

b. Agricultural water users who rely solely on groundwater for water supply.

c. Agricultural water users that rely on groundwater for supplemental supply.

d. Agricultural water users with sufficient surface water supply, with groundwater used only for incidental purposes.

Depending on the category, a PA will be willing to invest an appropriate amount of time, effort, and dollars in groundwater management and make the investment in those management elements that affect it the most. It cannot be expected that all agencies will invest equally in all the elements of the GMP. Hence, an implementation strategy must provide flexibility in the level of agency participation in each element of the plan. For instance, urban agencies and agricultural agencies that rely solely on groundwater supplies may be much more prone to invest in controlling saline water intrusion and localized overdraft; whereas, urban agencies may be the only ones interested in wellhead protection or controlling migration of contaminated groundwater. Participating in conjunctive use operations is obviously desirable for those PAs with water supply deficits, but may also be attractive to those with surplus surface supplies that can be used for recharge purposes.

With consideration given to the reliance upon groundwater by the PAs and the varying importance of the groundwater management elements, the recommended implementation strategy is as follows:

a. After public review and consideration of comments received, the final plan should be adopted by each agency.

b. The SLDMWA will coordinate plan implementation among the PAs.

c. A plan implementation committee made up of representatives of each PA will meet twice a year to review particular projects being implemented or considered by the PAs, and coordinate these projects under the regional GMP. The groundwater level and quality data, collected and analyzed, would be reviewed with the group at these meetings.

d. With consideration given to the identified problem areas, the committee shall establish a priority list for management actions.

e. Management activity groups will be formed of those participating agencies interested in implementing certain elements of the groundwater management plan to identify specific management actions, develop budgets, and apportion costs.

f. Once a year, the PAs would submit a report to the SLDMWA summarizing their programs under each plan component for consideration by the PAs and for coordination purposes.

g. An annual summary would be prepared to report the current state of the basin and describe the management activity that has taken place for each plan element. It would be used to keep PAs and the SLDMWA abreast of the group's activities.

This implementation strategy is expected to be refined as necessary by the management committee.

REFERENCES

California Department of Water Resources. 2003. "California's Groundwater". Bulletin 118, Sacramento, California.

California Department of Water Resources. 2005. "California Water Plan Update 2005". Sacramento, California.

California Department of Water Resources. 2006. "Conjunctive Water Management Branch Partners - San Joaquin County" http://www.groundwater.water.ca.gov/ cwm/conjuse/sanjoaq_index.cfm

Camp, Dresser & McKee. 2001. "Water Management Plan. Phase 1- Planning, Analysis and Strategy". Report submitted to San Joaquin County, Flood Control and Water Conservation District, California.

City of Patterson. 2004. "Consumer Confidence Report 2004." Patterson, California.

City of Tracy. 2004. "2004 Water Quality Report." Tracy, California.

Davis, S. N. and R. J. M. DeWiest. 1966. "Hydrogeology." New York, John Wiley.

Department of Health Services. 1999. "Drinking Water Source Assessment and Protection (DWSAP) Program." http://www.dhs.ca.gov/ps/ddwem/dwsap/DWSAP_document.PDF

Department of Health Services. 2006. "Arsenic in Drinking Water: California MCL Status." http://www.dhs.ca.gov/ps/ddwem/chemicals/arsenic/newmcl.htm

Dubrovsky, N. M., J. M. Neil, M. C. Welker, and K. D. Evenson. 1991. "Geotechnical Relation and Distribution of Selected Trace Elements in Groundwater of Northern Part of the Western San Joaquin Valley, California." United States Geological Survey Open File Report 90-108.

Erler & Kalinowski. 2005. "City of Tracy Urban Water Management Plan". Report submitted to the City of Tracy, California.

GEI Consultants. 2005. "Mitigation Monitoring Report – November 2004 Trough April 2005". Report submitted to City of Tracy, California.

Hotchkiss, W. R. and G. O. Balding. 1971. "Geology, Hydrology and Water Quality of the Tracy-Dos Palos Area." Open File Report, United States Geological Survey, Menlo Park, California.

Hotchkiss, W. R. 1972. "Generalized Subsurface Geology of the Water-Bearing Deposits, Northern San Joaquin Valley, California." Open File Report, United States Geological Survey, Menlo Park, California.

Kennedy/Jenks/Chelton. 1990. "Tracy Area Groundwater Yield Evaluation". Report submitted to City of Tracy, California.

Page. 1971. "Base of Fresh Groundwater in the San Joaquin Valley, California." United States Geological Survey Open File Report.

Patterson Irrigation District. 2005. "Water Conservation Plan – 5 Years Update". Patterson, California.

Phillips, S. P., Sherrill Beard and R. J. Gilliom. 1991. "Quantity and Quality of Groundwater Inflow to the San Joaquin River, California." United States Geological Survey Water Resources Investigative Report 91-4019.

Schuette, J., D. Weaver, J. Troiano, M. Pepple, and J. Dias. 2003. "Sampling for Pesticide Residues in California Water Wells, 2003 Well Inventory Database, Cumulative Report 1986-2003". California Department of Pesticide Regulation, Document EH03-08.

Stoddard & Associates. 1996. "Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area and a Portion of San Joaquin County." Report submitted to San Luis & Delta-Mendota Water Authority, Los Banos, California.

Stoddard & Associates. 1999. "Regional Groundwater Monitoring Program for the Northern Subbasin Groundwater Management Area." Report submitted to San Luis & Delta-Mendota Water Authority, Los Banos, California.

State Water Resources Control Board. 2006. "Underground Storage Tank Program". http://www.swrcb.ca.gov/cwphome/ust/

United States Geological Survey. 2007. "USGS Ground-Water Data for the Nation". http://waterdata.usgs.gov/nwis/gw

Waring, G.A. 1915. "Springs of California." United States Geological Survey, Water Supply Paper 338.

Western Regional Climate Center. 2006. "Historical Climate Information". http://www.wrcc.dri.edu/CLIMATEDATA.htm

FIGURES

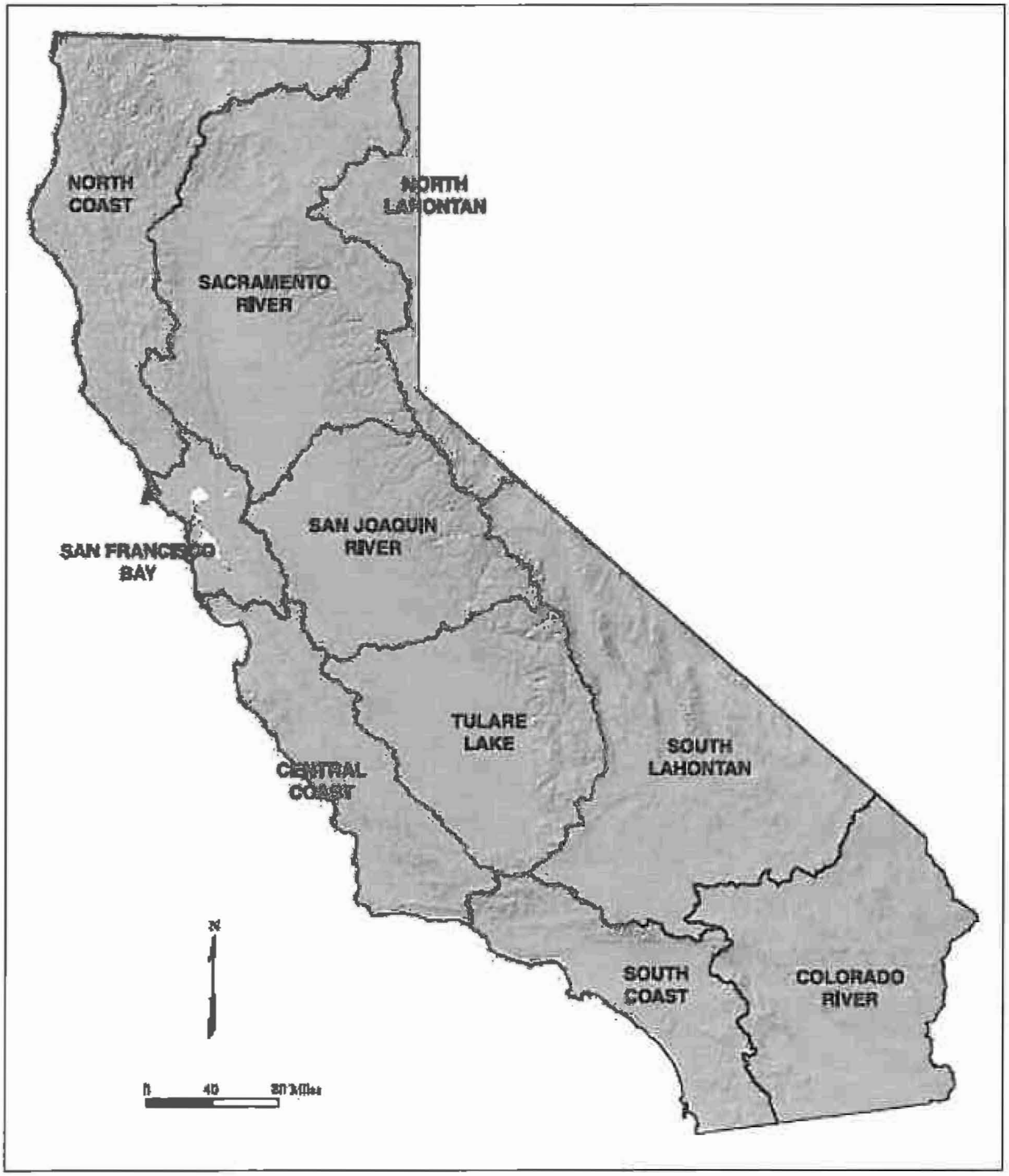


Figure 1

Hydrologic Regions, California

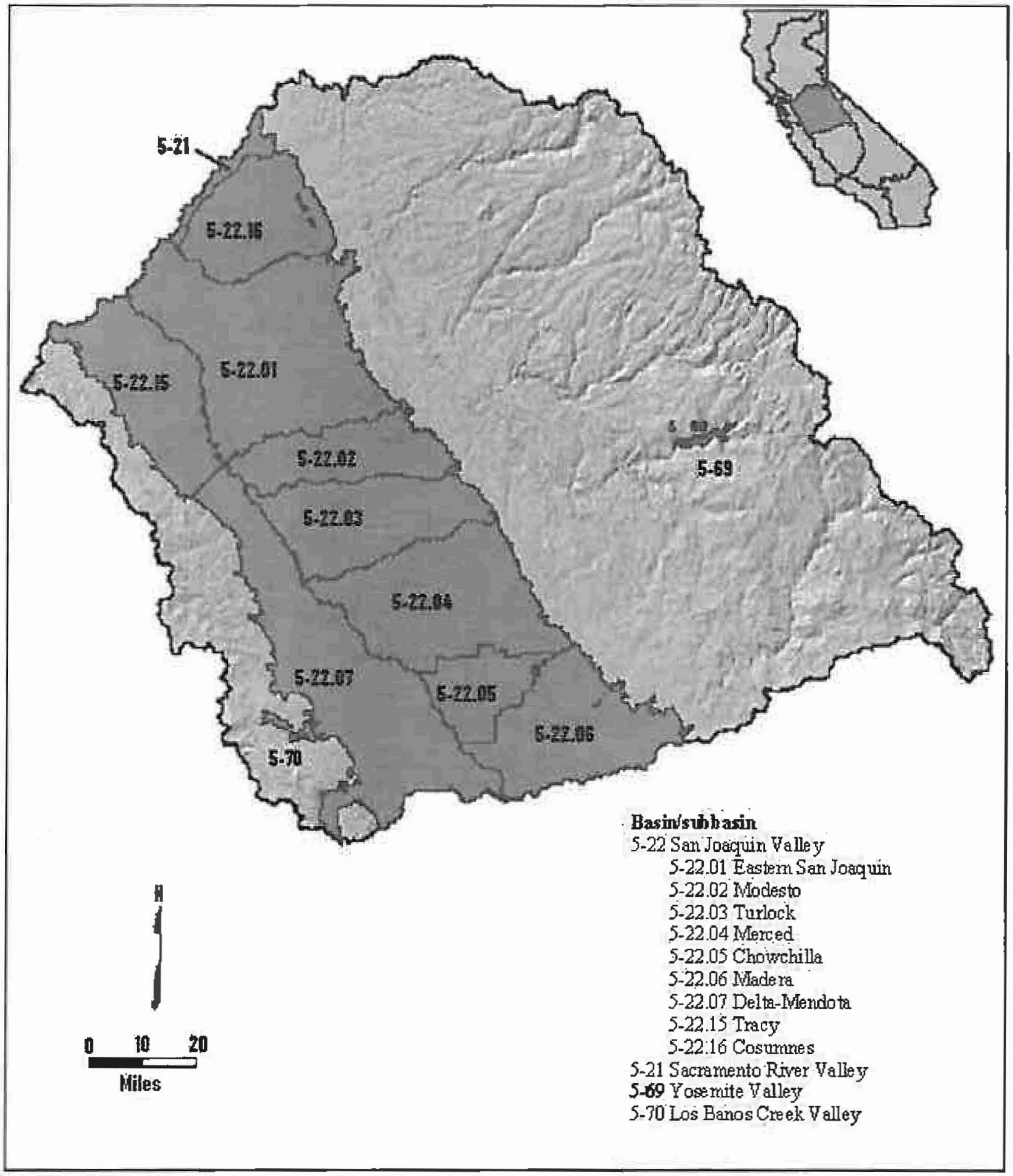


Figure 2

Subbasins of the San Joaquin River Hydrologic Region

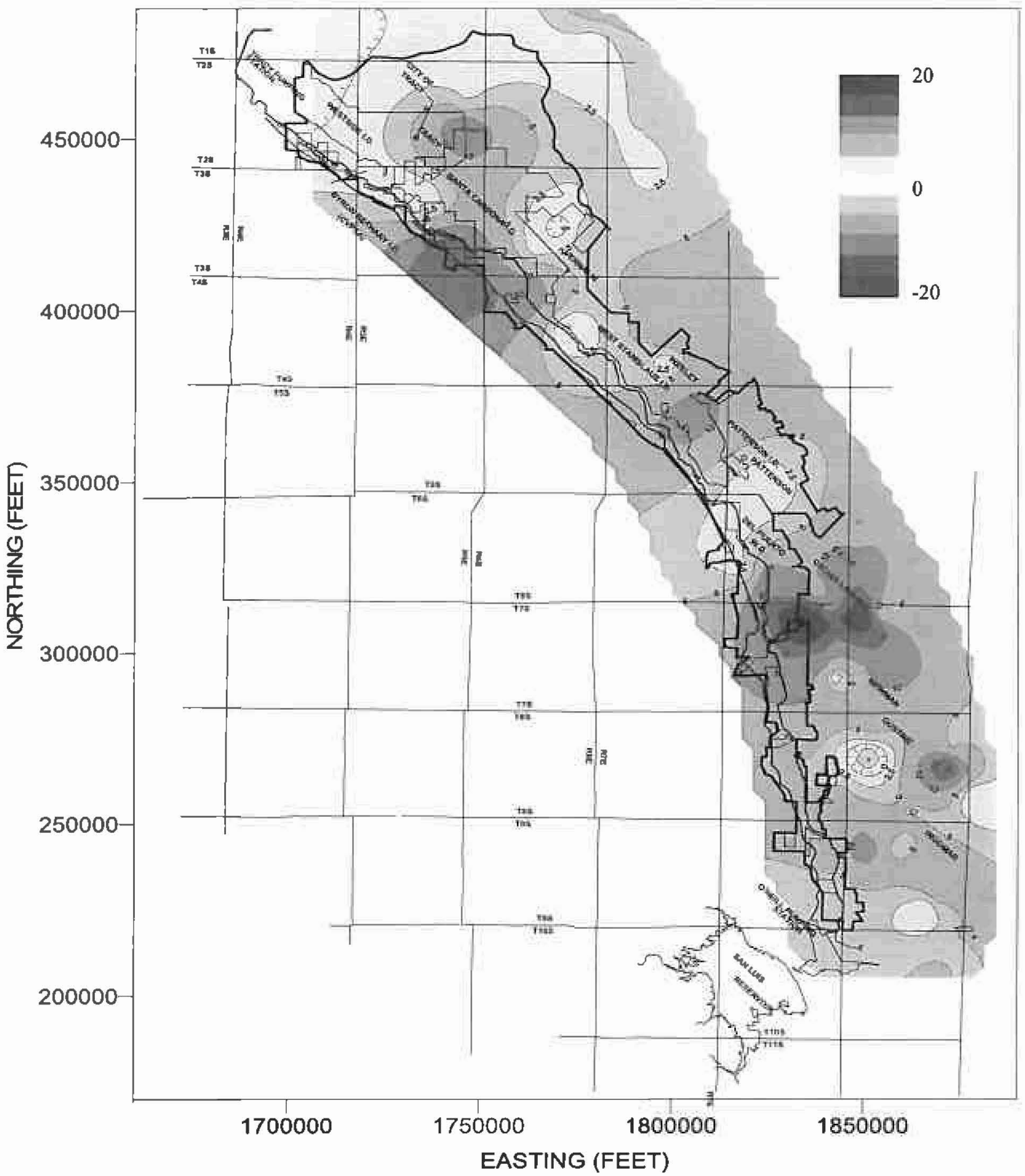


Figure 4

Unconfined Groundwater Level Change (feet), Spring 1993 to Spring 1998

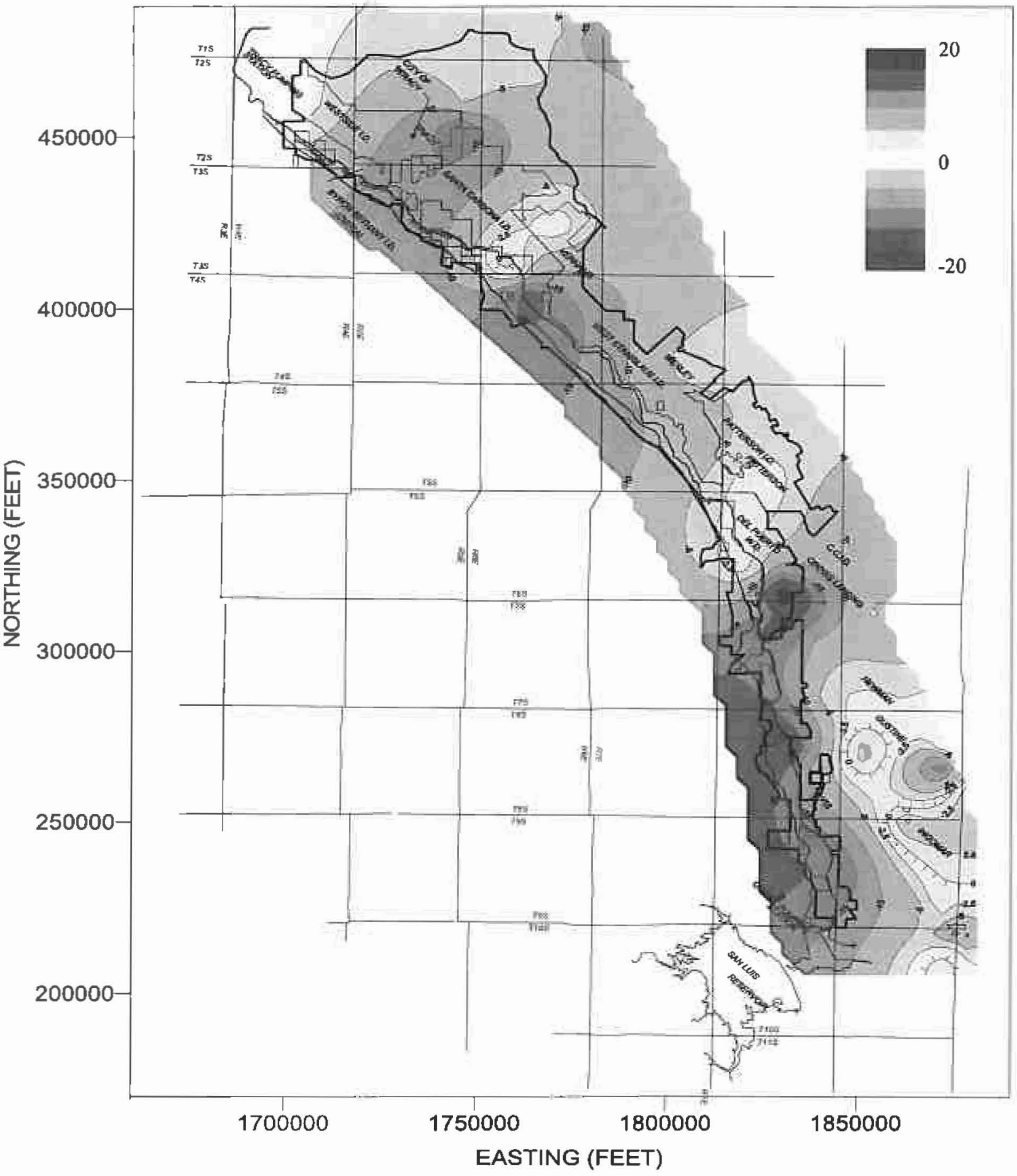


Figure 5

Unconfined Groundwater Level Change (feet), Spring 1998 to Spring 2004

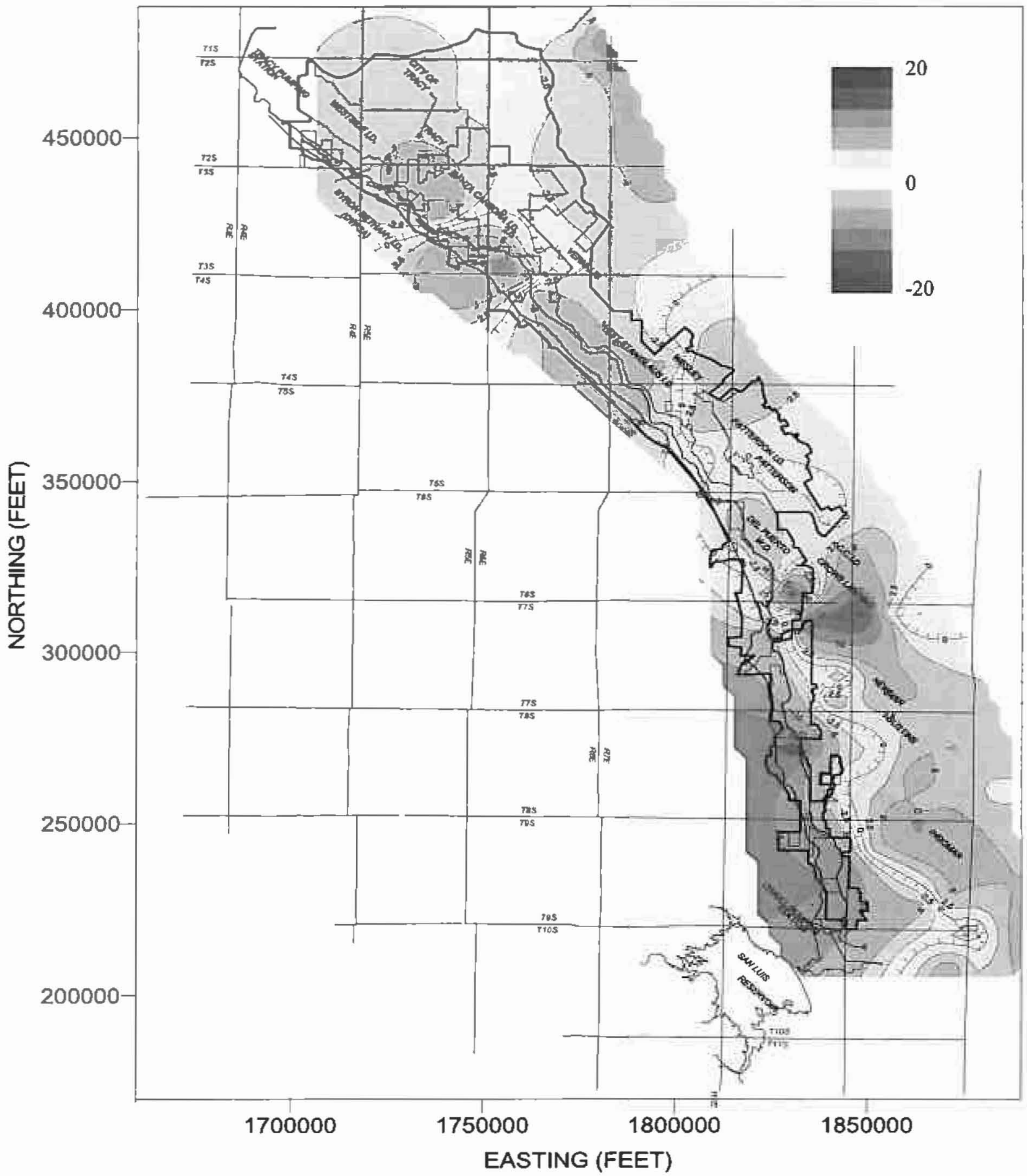


Figure 6

Unconfined Groundwater Level Change (feet), Spring 1993 to Spring 2004

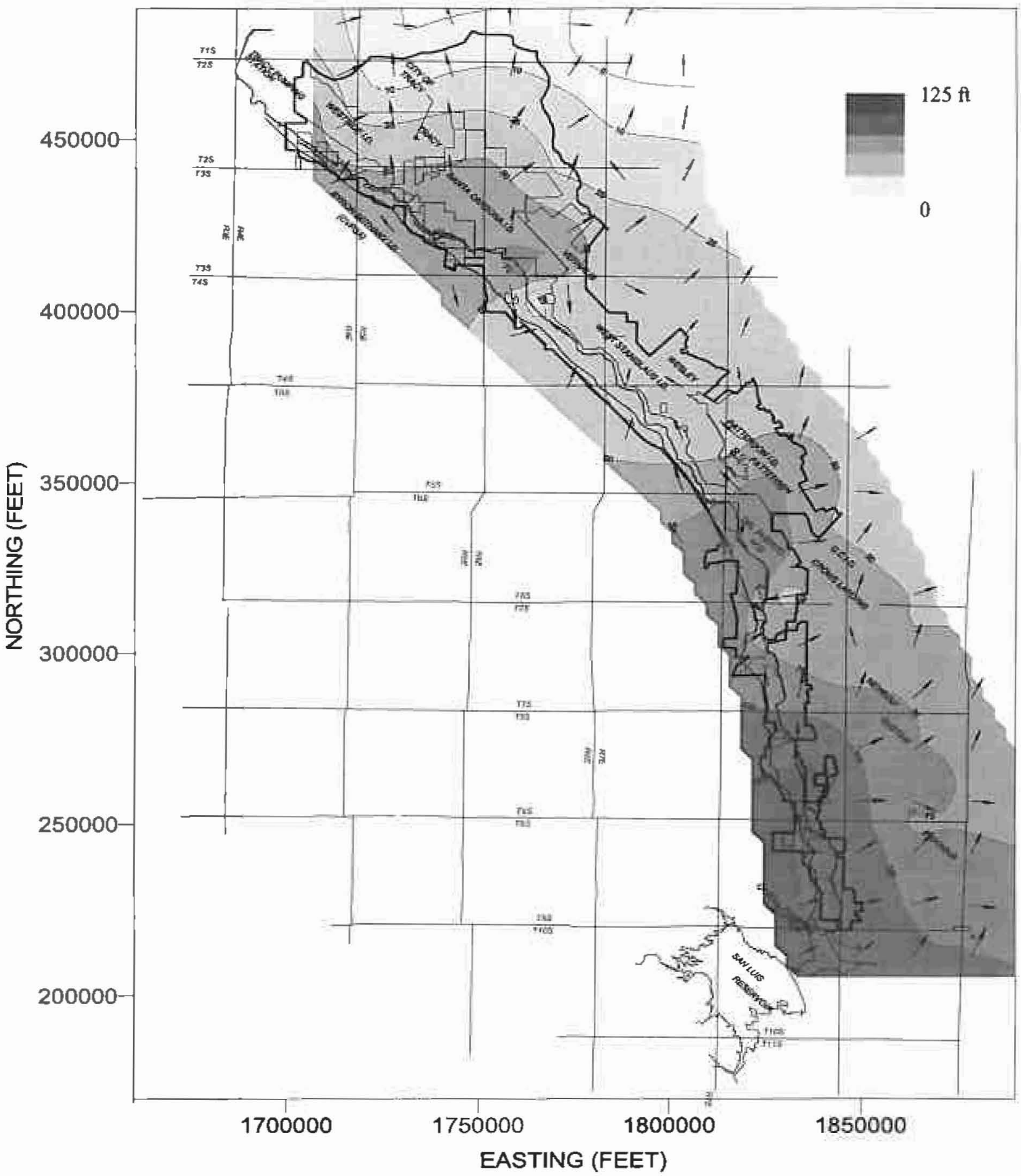


Figure 7

Unconfined Groundwater Level (feet above Mean Sea Level), Spring 2004

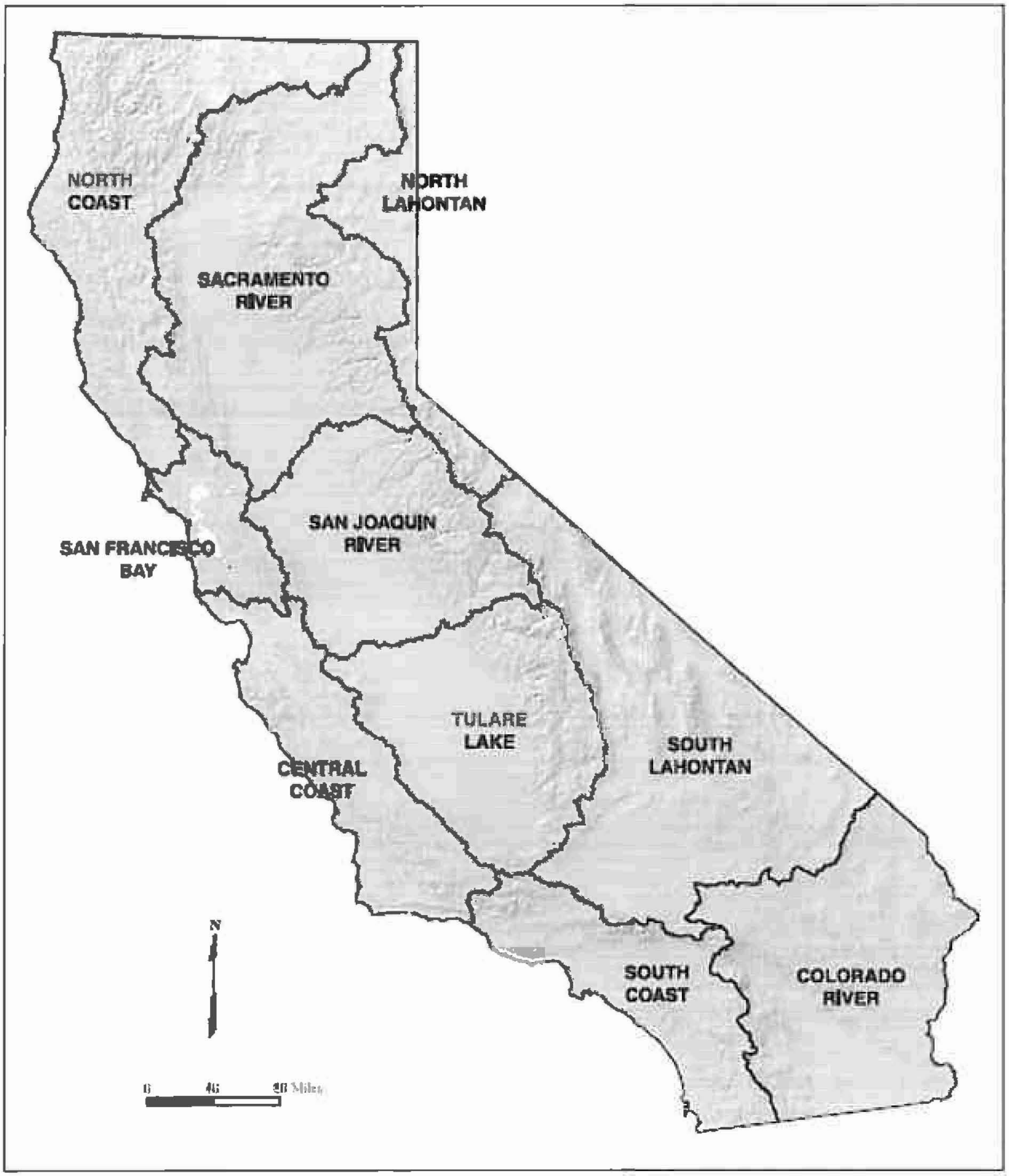


Figure 1. Hydrologic Regions, California (DWR, 2003)

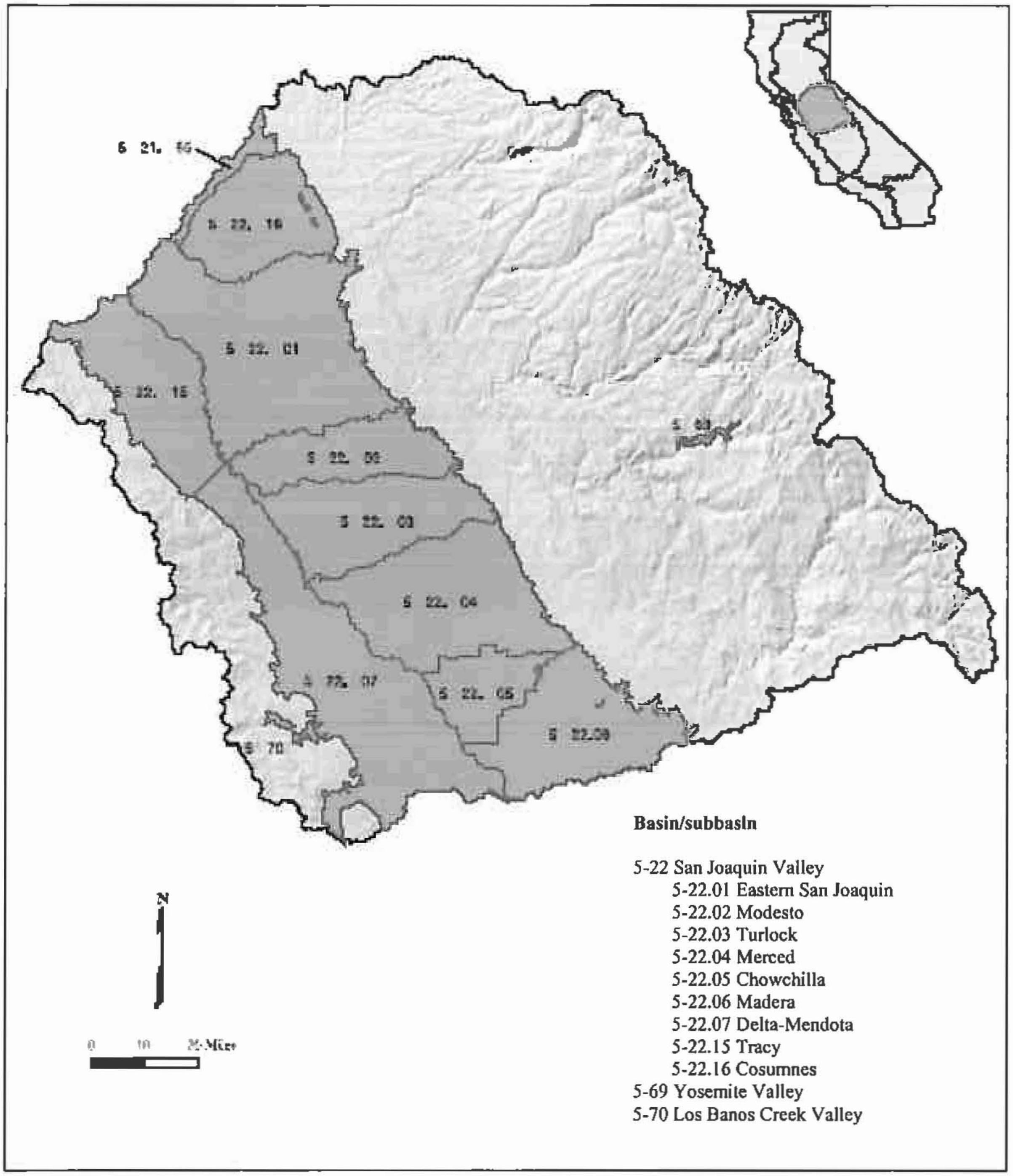
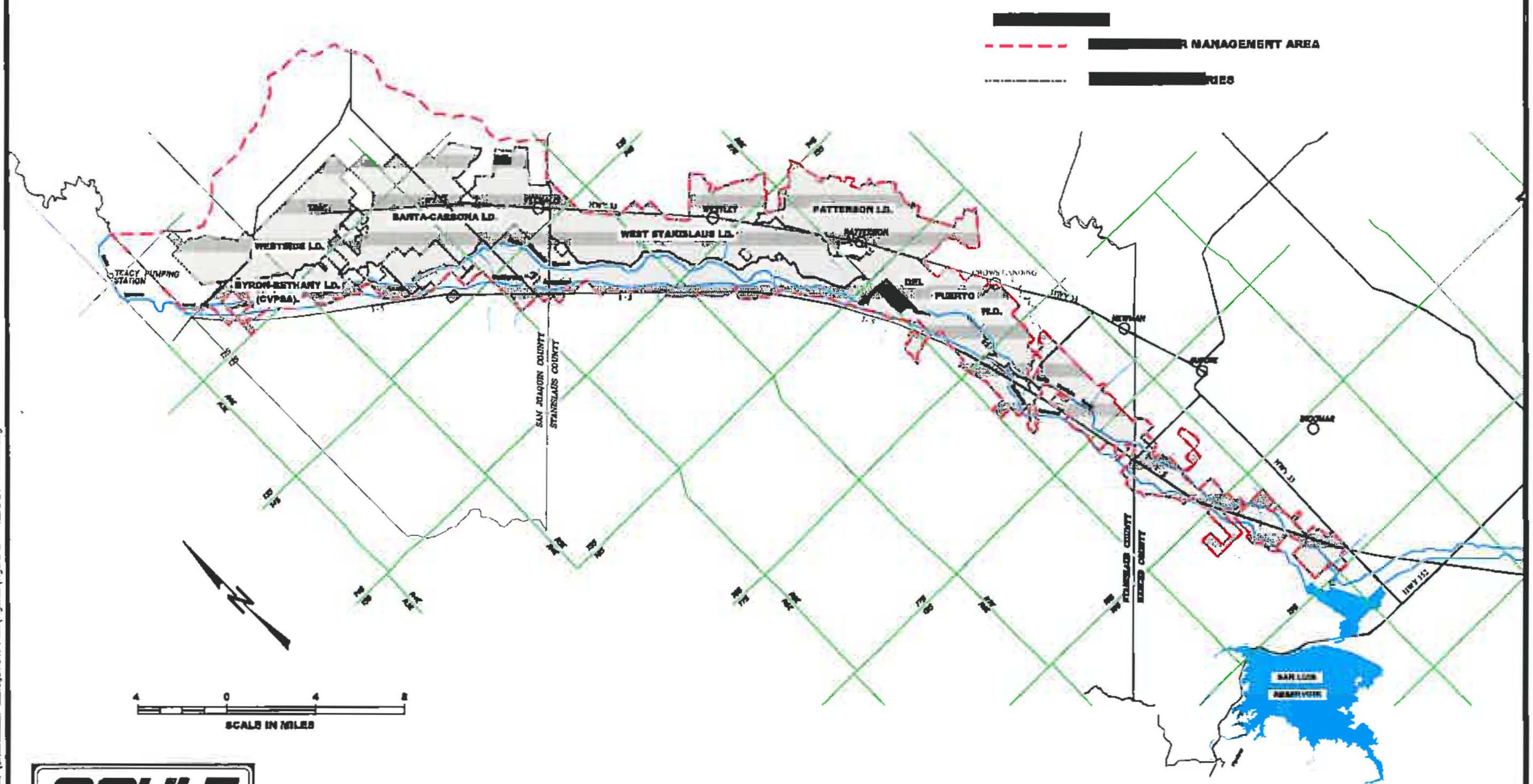


Figure 2. Basins and Subbasins of the San Joaquin River Hydrologic Region (DWR, 2003)



BOYLE ENGINEERING CORPORATION
WWW.BOYLEENGINEERING.COM

Oct 25, 2007 - 11:56am

FIGURE 3. BOUNDARY OF THE GROUNDWATER MANAGEMENT AREA
GROUNDWATER MANAGEMENT PLAN
NORTHERN AGENCIES IN THE DELTA-MENDOTA SERVICE AREA AND PORTIONS OF SAN JOAQUIN COUNTY
SAN LUIS AND DELTA-MENDOTA WATER AUTHORITY

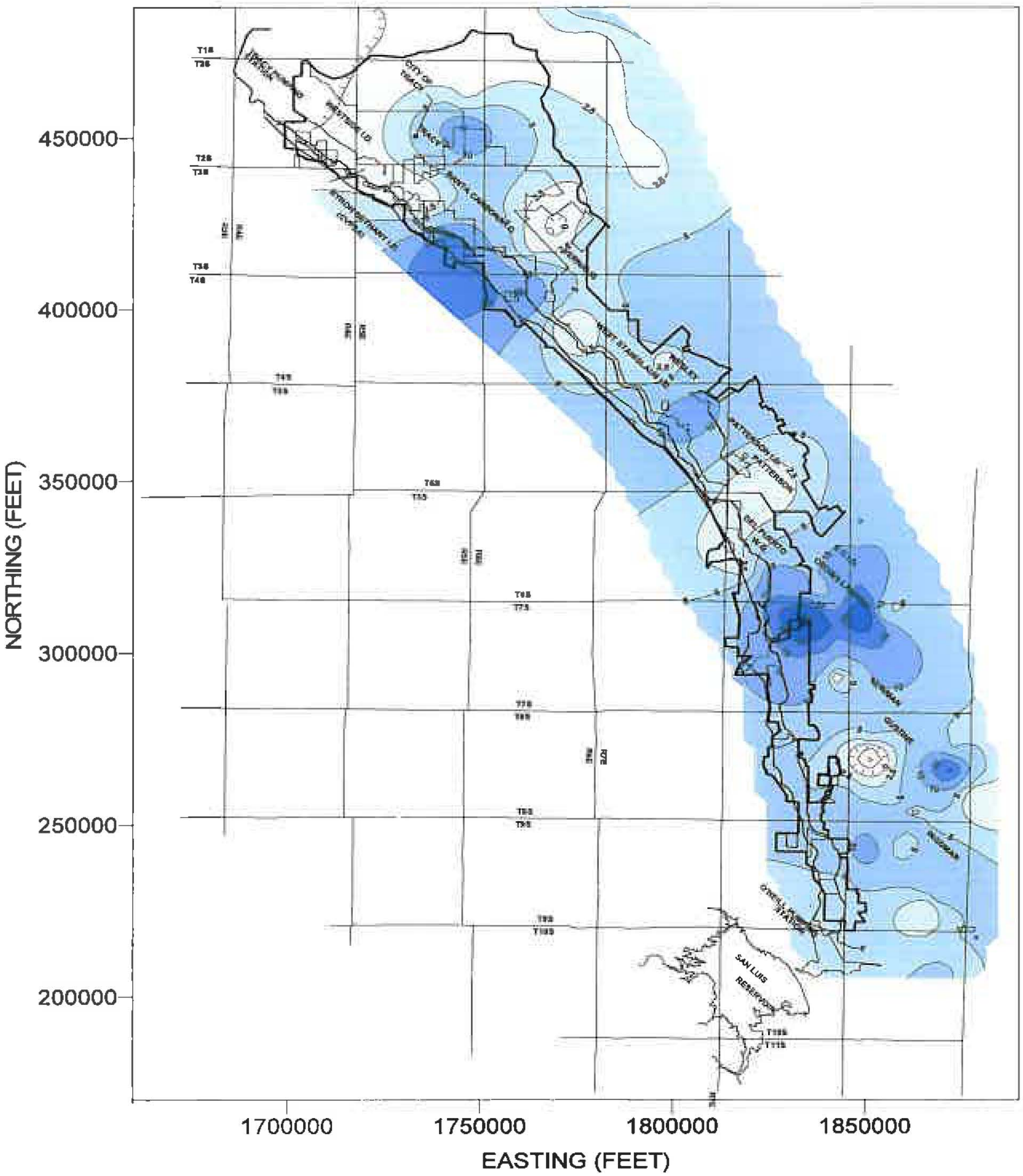


Figure 4. Unconfined Groundwater Level Change (feet), Spring 1993 to Spring 1998

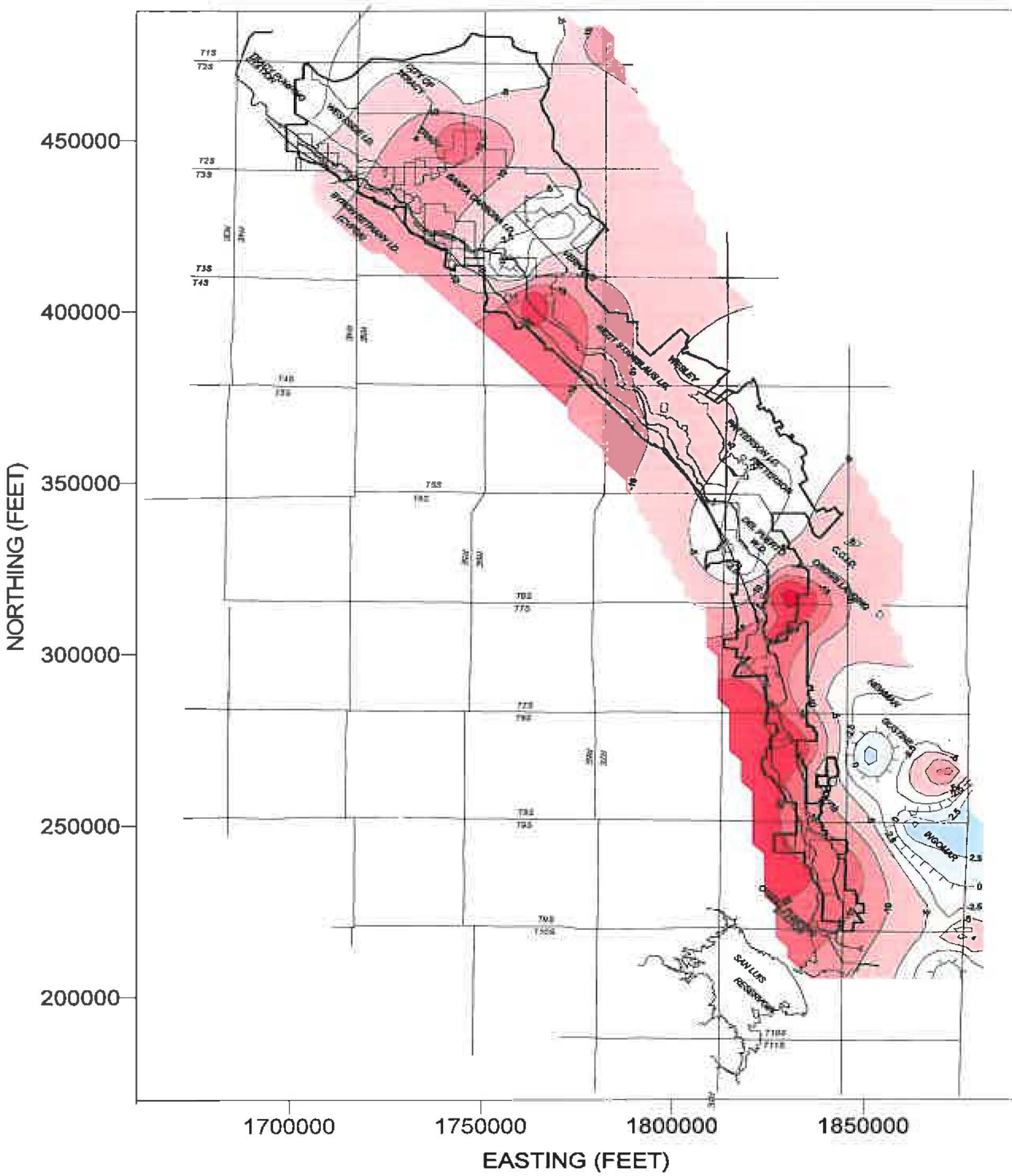


Figure 5. Unconfined Groundwater Level Change (feet), Spring 1998 to Spring 2004

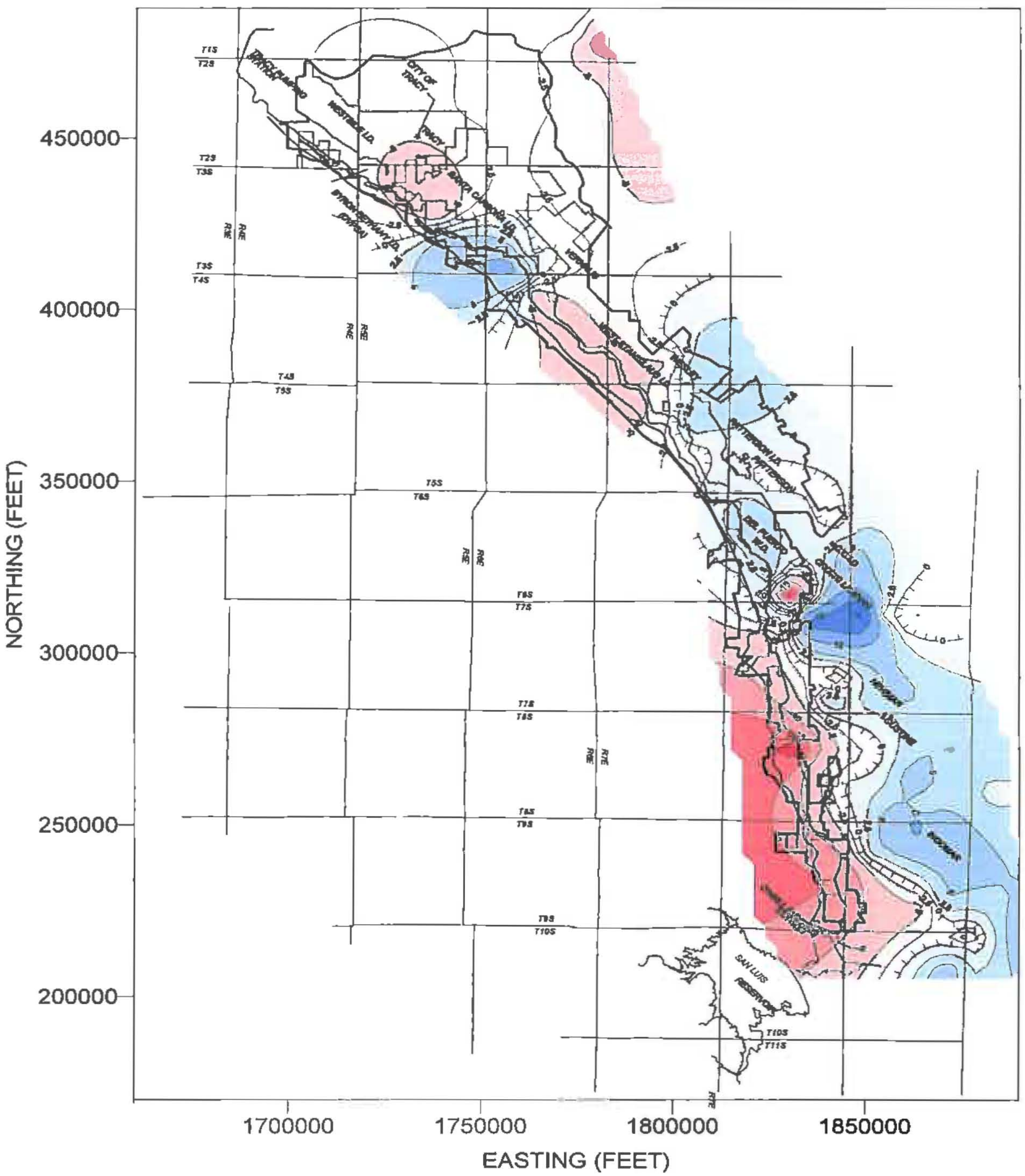


Figure 6. Unconfined Groundwater Level Change (feet), Spring 1993 to Spring 2004

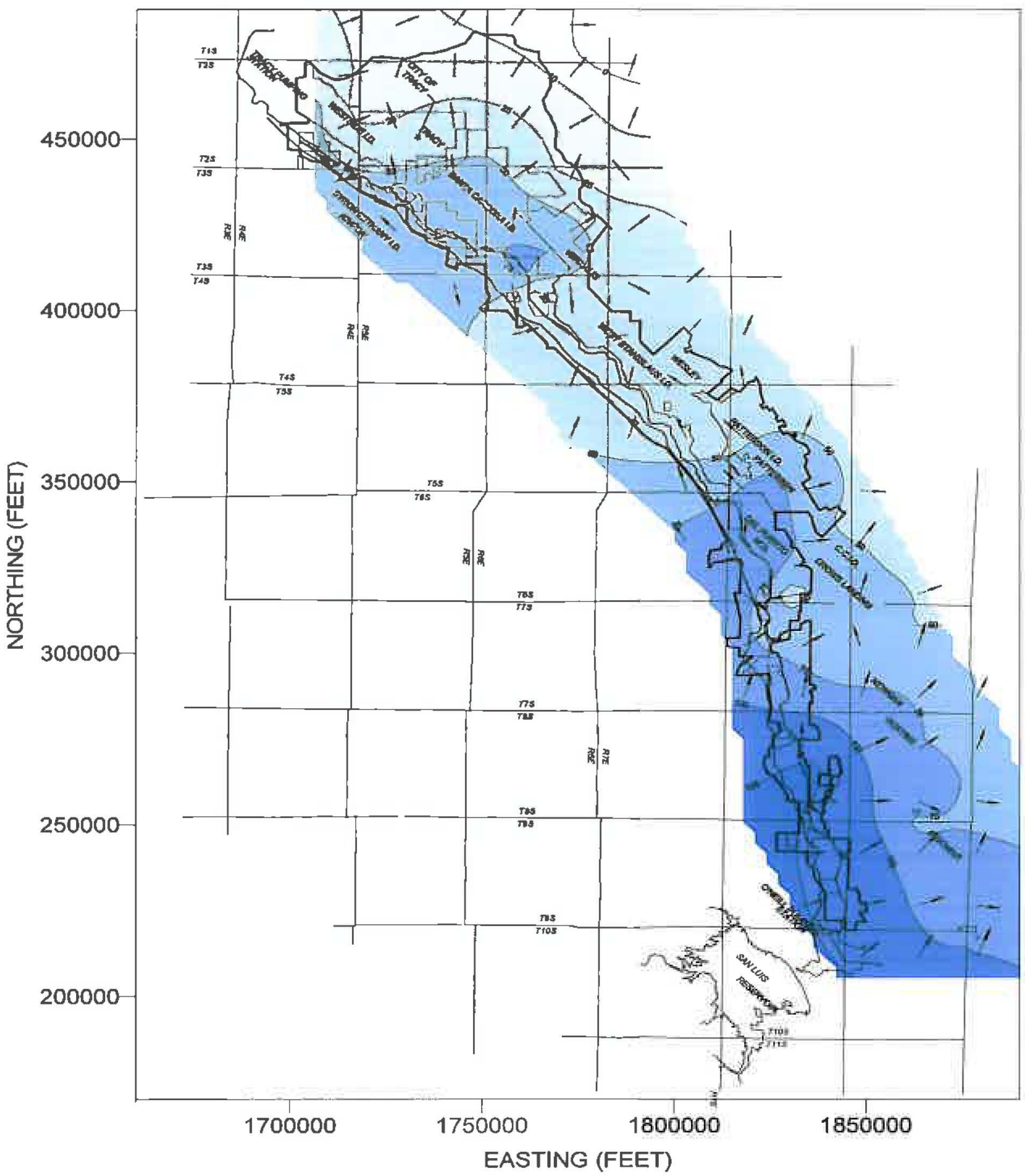


Figure 7. Unconfined Groundwater Level (feet above mean sea level), Spring 2004.

Camp, Dresser & McKee. 2001. "Water Mangement Plan. Phase 1- Planning, Analysis and Strategy". Report submmited to San Joaquin County, Flood Control and Water Conservation District, California.

City of Patterson. 2004. "Consumer Confidence Report 2004." Patterson, California.

City of Tracy. 2004. "2004 Water Quality Report." Tracy, California.

Davis, S. N. and R. J. M. DeWiest. 1966. "Hydrogeology." NewYork, John Wiley.

Department of Health Services. 1999. "Drinking Water Source Assessment and Protection (DWSAP) Program." http://www.dhs.ca.gov/ps/ddwem/dwsap/DWSAP_document.PDF

Department of Health Services. 2006. "Arsenic in Drinking Water: California MCL Status." http://www.dhs.ca.gov/ps/ddwem/chemicals/arsenic/newmcl.htm

Dubrovsky, N. M., J. M. Neil, M. C. Welker, and K. D. Evenson. 1991. "Geotechnical Relation and Distribution of Selected Trace Elements in Groundwater of Northern Part of the Western San Joaquin Valley, California." United States Geological Survey Open File Report 90-108.

California Department of Water Resources. 2003. "California's Groundwater". Bulletin 118, Sacramento, California.

California Department of Water Resources. 2005. "California Water Plan Update 2005". Sacramento, California.

California Department of Water Resources. 2006. "Conjunctive Water Management Branch Partners - San Joaquin County" http://www.groundwater.water.ca.gov/cwm/conjuse/sanjoaq_index.cfm

Erler & Kalinowski. 2005. "City of Tracy Urban Water Management Plan". Report submmited to the City of Tracy, California.

GEI Consultants. 2005. "Mitigation Monitoring Report – November 2004 Trough April 2005". Report submmited to City of Tracy, California.

Hotchkiss, W. R. and G. O. Balding. 1971. "Geology, Hydrology and Water Quality of the Tracy-Dos Palos Area." Open File Report, United States Geological Survey, Menlo Park, California.

Hotchkiss, W. R. 1972. "Generalized Subsurface Geology of the Water-Bearing Deposits, Northern San Joaquin Valley, California." Open File Report, United States Geological Survey, Menlo Park, California.

Kennedy/Jenks/Chelton. 1990. "Tracy Area Groundwater Yield Evaluation". Report submmited to City of Tracy, California.

Page. 1971. "Base of Fresh Groundwater in the San Joaquin Valley, California." United States Geological Survey Open File Report.

Patterson Irrigation District. 2005. "Water Conservation Plan – 5 Years Update". Patterson, California.

Phillips, S. P., Sherrill Beard and R. J. Gilliom. 1991. "Quantity and Quality of Groundwater Inflow to the San Joaquin River, California." United States Geological Survey Water Resources Investigative Report 91-4019.

Schuette, J., D. Weaver, J. Troiano, M. Pepple, and J. Dias. 2003. "Sampling for Pesticide Residues in California Water Wells, 2003 Well Inventory Database, Cumulative Report 1986-2003". Caifornia Department of Pesticide Regulation, Document EH03-08.

Stoddard & Associates. 1996. "Groundwater Management Plan for the Northern Agencies in the Delta-Mendota Canal Service Area and a Portion of San Joaquin County." Report submitted to San Luis & Delta-Mendota Water Authority, Los Banos, California.

Stoddard & Associates. 1999. "Regional Groundwater Monitoring Program for the Northern Subbasin Groundwater Management Area." Report submitted to San Luis & Delta-Mendota Water Authority, Los Banos, California.

State Water Resources Control Board. 2006. "Underground Storage Tank Program". http://www.swrcb.ca.gov/cwphome/ust/

Waring, G.A. 1915. "Springs of California." United States Geological Survey, Water Supply Paper 338.

Western Regional Climate Center. 2006. "Historical Climate Information". http://www.wrcc.dri.edu/CLIMATEDATA.html

AB 3030	Groundwater Management Act, Assembly Bill 3030
BMPs	Best Management Practices
CAS	California Aquifer Susceptibility (CAS) Assessment
CVP	Central Valley Project
CVPSA	Central Valley Project Service Area
DHS	Department of Health Services
DMC	Delta-Mendota Canal
DPWD	Del Puerto Water District
DTSC	Department of Toxic Substances Control
DWR	California Department of Water Resources
DWSAP	California's Drinking Water Source Assessment and Protection Program
EHD	San Joaquin County Environmental Health Department
GAMA	Groundwater Ambient Monitoring and Assessment Program
GMA	Groundwater Management Area
GMP	Groundwater Management Plan
HR	Hydrologic Regions
Los Banos	City of Los Banos
MCL	Maximum Contaminant Level
mg/L	Milligrams Per Liter
MOU	Memorandum of Understanding
NSGMP	Northern Subbasin Groundwater Management Plan
Ordinance	Groundwater Export Ordinance, San Joaquin County
PAs	Participating Agencies
Patterson	City of Patterson
RWQCB	Regional Water Quality Control Board
SB 1938	Senate Bill 1938
SDWA	Safe Drinking Water Act
Semitropic	Semitropic Water Banking Project
SJC	San Joaquin County
SJCFCWCD	San Joaquin County Flood Control and Water Conservation District
SJV	San Joaquin Valley
SLDMWA	San Luis & Delta-Mendota Water Authority

SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
Tracy	City of Tracy
μg/L	Micrograms Per Litter
USGS	U.S. Geological Survey
UST	Underground Storage Tanks Program
UWMP	Urban Water Management Plan
WPP	Wellhead Protection Program
WRCC	Western Regional Climate Center

Frances Mizuno

From: Mariana Pascuet [mpascuet@BoyleEngineering.com]
Sent: Tuesday, June 26, 2007 10:53 AM
To: Frances Mizuno
Subject: FW: Groundwater Management Plan
Attachments: SLDMWA-GMP-SEC.DOC

AB 3030 Procedures

Citations refer to relevant sections in the California Water Code.

Procedures

1. The local agency must publish notice of a public hearing. Section 10753.2 (a)
2. Conduct a hearing on whether to adopt a groundwater management plan. Section 10753.2 (a)
3. The local agency may adopt a resolution of intention to adopt a groundwater management plan. Section 10753.2 (b)
4. They must publish the resolution of intention. Section 10753.3
5. They must prepare a groundwater management plan within 2 years. Section 10753.4
6. If not, return to step 1. Section 10753.4
7. They must hold a 2d public hearing after the plan is prepared. Section 10753.5 (a)
8. Consider protests. Section 10753.5 (b)
9. A majority protest consists of more than 50% of the assessed value of the land within the agency. Section 10753.6 (c) (1)
10. If a majority protest exists, the plan shall not be adopted. Section 10753.6 (c) (2)
11. No new plan for the same area may be considered for 1 year. Section 10753.6 (c) (2)
12. If there is no majority protest, the groundwater management plan may be adopted within 35 days after the 2d public hearing. Section 10753.6 (c) (3)
13. The local agency shall adopt rules and regulations for implementation and enforcement of the plan. Section 10753.8
14. They have the authority of a water replenishment district ($60220 et seq and $60300 et seq) to fix and assess fees and assessments for groundwater management. Section 10754
15. The local agency may impose equitable annual fees and assessments for groundwater management based on the amount of groundwater extracted to pay for costs of replenishment water, administration and operation, and capital facilities necessary to implement the groundwater management plan. Section 10754.2
16. They shall hold an election in the manner prescribed for the local agency and will be authorized to assess fees only if a majority vote is in favor. Section 10754.3
17. Local agencies in the same basin that adopt groundwater management plans must meet at least annually to coordinate. Section 10755.3
    http://www.groundwater.water.ca.gov/water_laws/ab3030_gma/index.cfm