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MEMORANDUM OF UNDERSTANDING
BETWEEN THE DEPARTMENT OF WATER RESOURCES
AND
SAN JOAQUIN COUNTY
FLOOD CONTROL AND WATER CONSERVATION DISTRICT

This Memorandum of Understanding is entered into this ____ day of APR 04 2000, 2000, by and between the California Department of Water Resources and the San Joaquin County Flood Control and Water Conservation District.

WHEREAS, groundwater in San Joaquin County has been and will remain a significant source of the water for the people, environment and agribusiness of San Joaquin County and provides an invaluable contribution to the local economy and public well being; and

WHEREAS, a goal of the San Joaquin County Flood Control and Water Conservation District (District) is to increase the availability and reliability of local groundwater and surface water resources within the County; and

WHEREAS, the District has an interest in the management of its groundwater resources; and

WHEREAS, the District and the Department of Water Resources (DWR) recognize that there is potential for conjunctive management of ground and surface water resources, and are willing to explore the possibility of increasing the availability of dry-year supplies through regional conjunctive use efforts; and

WHEREAS, the diversion of surface water to serve agriculture has contributed to groundwater recharge in San Joaquin County, and the conjunctive management and use of surface water and ground water for agriculture and urban areas currently relying solely on groundwater should be encouraged to further contribute to the recharge of the groundwater resources in San Joaquin County; and

WHEREAS, the Legislature has determined that the conjunctive management of surface water and groundwater is an effective way to improve the reliability of water supplies for all sectors of the State; and

WHEREAS, the DWR seeks to facilitate and support local surface water and groundwater management efforts, particularly those that could increase dry-year water supplies, while providing management and protections for the basin water resources; and

WHEREAS, cooperation, open communication, and consensus building among San Joaquin County stakeholders are recognized prerequisites before deciding on any preferred action; and

WHEREAS, the District and the DWR have determined that studying the development of a conjunctive water management program is necessary.

NOW, THEREFORE, the District and DWR agree to the following principles:

The District and the DWR will work cooperatively in examining and enhancing ongoing, and exploring new conjunctive water management program initiatives, identifying potentially feasible initiatives, programs, or projects that manage the dependable yield of the basin along with enhanced surface water supplies. An initial review of possible programs or projects shall be undertaken with the objective of identifying initiatives that provide water supply benefits and are technically, environmentally, economically, institutionally, socially, and legally feasible. Appendix A is an outline of work of specific tasks to be performed as part of this initial review.

The District, in concurrence with DWR, will establish an Advisory Committee that will include representation by all water interests within the County and DWR. The purpose of the Advisory Committee will be to provide technical and policy direction regarding management of the groundwater resources in the County and viability of conjunctive water management initiatives that could be pursued within the County.

This MEMORANDUM OF UNDERSTANDING and the Advisory Committee are a part of the first phase of a three-phase process. Any project identified by the Advisory Committee proceeding toward implementation will be pursued by the project beneficiaries and addressed in future phases. Project-specific feasibility reports, with environmental documentation and permits, will be addressed in future phases, under separate agreements with the implementing agency and the Department of Water Resources; therefore, the Advisory Committee will not participate in any specific project unless requested by the project participants.

This MEMORANDUM OF UNDERSTANDING does not diminish the County's support for ongoing cooperative efforts, such as the East San Joaquin Parties Water Authority, the Farmington Groundwater Recharge and Wetlands Feasibility Study, and the County Advisory Water Commission.

Within six months following the signing of this MEMORANDUM OF UNDERSTANDING, the District and DWR will complete and submit to the Advisory Committee for its review a progress report.

This MEMORANDUM OF UNDERSTANDING may be executed in any number of counterparts, and upon execution by all parties, each executed counterpart shall have the same force and effect as an original document and as if all parties had signed the same document.

IN WITNESS WHEREOF, the parties hereto have executed this MEMORANDUM OF UNDERSTANDING on the date first above written.

ATTEST: LOIS M. SAHYOUN
Clerk of the Board of Supervisors of the County of San Joaquin, State of California

By Caroline Junco
Deputy Clerk

(SEAL)

COUNTY OF SAN JOAQUIN, a political subdivision of the State of California

By
EDWARD A. SIMAS, Chairman
of the Board of Supervisors

"COUNTY"

APPROVED AS TO FORM:
TERRENCE R. DERMODY
County Counsel

By Dee Anne Watkins
DEEANNE WATKINS
Deputy County Counsel

RECOMMENDED FOR APPROVAL:

Henry M. Hirata
HENRY M. HIRATA
Director of Public Works

Approved as to legal form and sufficiency:

Asst. Chief Counsel, DWR

By Naser Bateni
NASER BATENI, Chief
Integrated Storage Investigations Program
"DEPARTMENT OF WATER RESOURCES"

APPENDIX A

PHASE I: OUTLINE OF WORK
San Joaquin County Conjunctive Water Management Program

Purpose

The District and the DWR will work cooperatively to formulate a conjunctive water management program, identifying potentially feasible initiatives, programs, or projects that would effectively manage the surface water and groundwater resources in conjunction within San Joaquin County. The District, in cooperation with DWR, will assume administrative responsibilities for coordination of the program and Advisory Committee activities with San Joaquin County water interests. All program activities will be jointly agreed to by the District and DWR prior to proceeding.

Phase I Tasks

1. Establish an Advisory Committee that includes representation by all water interests within the County, to provide technical and policy direction regarding viable conjunctive water management programs.

2. Provide input to the District's current groundwater/surface water management planning process.

3. Identify potential conjunctive water management projects in the Basin that help address local water supply issues and needs while concurrently helping improve the State's overall dry year water supply reliability, consistent with the San Joaquin County Groundwater Export Ordinance.

4. As part of the programmatic feasibility evaluation process, conduct a preliminary environmental review, identifying the impacts of potential projects or programs, including possible third party impacts, and possible measures that could avoid or mitigate the impacts.

5. As part of the programmatic feasibility evaluation process, outline Basin conjunctive water management principles and operating criteria.

6. Draft a programmatic basin management evaluation, identifying specific conjunctive water management project and program options for the Basin, and recommending an action plan for Phase II.

Phase II and III activities, which include preparation of project-specific feasibility reports, with environmental documentation and permits, working together to implement specific conjunctive management projects; and supporting County efforts to obtain financial assistance for the development of conjunctive management programs, which will be addressed under future, separate agreements.

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USGS
science for a changing world

Open File Report 2006-1309
Prepared in cooperation with Northeastern San Joaquin Groundwater Banking Authority and California Department of Water Resources

Sources of High-Chloride Water to Wells, Eastern San Joaquin Ground-Water Subbasin, California

By John A. Izbicki, Loren F. Metzger, Kelly R. McPherson, Rhett R. Everett, and George L. Bennett V

Introduction

As a result of pumping and subsequent declines in water levels, chloride concentrations have increased in water from wells in the Eastern San Joaquin Ground-Water Subbasin, about 80 miles east of San Francisco (Montgomery Watson, Inc., 2000). Water from a number of public-supply, agricultural, and domestic wells in the western part of the subbasin adjacent to the San Joaquin Delta exceeds the U.S. Environmental Protection Agency Secondary Maximum Contaminant Level (SMCL) for chloride of 250 milligrams per liter (mg/L) (fig. 1) (*link to animation showing chloride concentrations in water from wells, 1984 to 2004*). Some of these wells have been removed from service. High-chloride water from delta surface water, delta sediments, saline aquifers that underlie freshwater aquifers, and irrigation return are possible sources of high-chloride water to wells (fig. 2). It is possible that different sources contribute high-chloride water to wells in different parts of the subbasin or even to different depths within the same well.

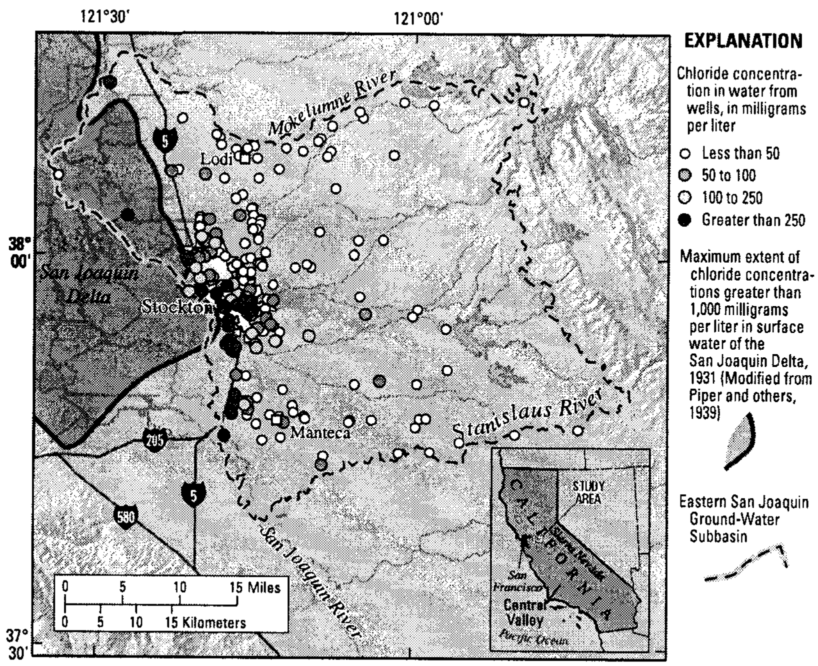

Figure 1. Chloride concentrations in water from wells in the Eastern San Joaquin Ground-Water Subbasin, California, 1984–2004.

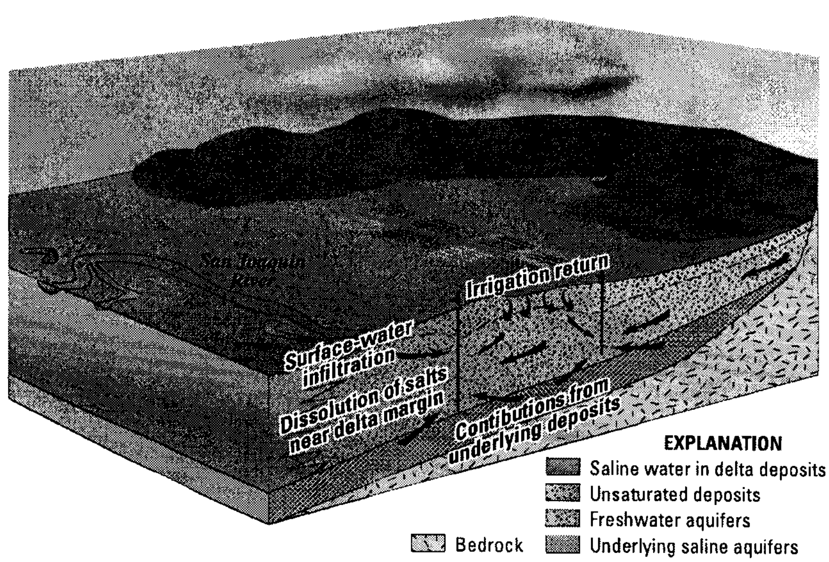

Figure 2. Sources of high-chloride water to wells, Eastern San Joaquin Ground-Water Subbasin, California.

Hydrogeology

The study area is the Eastern San Joaquin Ground-Water Subbasin near Stockton, California. The ground-water subbasin is about 1,100 square miles (California Department of Water Resources, 2006) and is part of the larger San Joaquin Ground-Water Basin that forms the southern half of the Central Valley of California. The climate of the area is characterized by hot, dry summers and cool, moist winters. Average annual precipitation ranges from about 10 to 18 inches (Soil Conservation Service, 1992). Precipitation is greater in the Sierra Nevada to the east of the study area. Runoff from those mountains, primarily as snowmelt, sustains flows in rivers and streams that cross the study area. The largest of these, the Mokelumne and Stanislaus Rivers, bound the study area to the north and south, respectively. The San Joaquin River, which drains the San Joaquin Valley to the south, bounds the study area to the west, and the foothills of the Sierra Nevada bound the study area to the east (fig. 1).

The study area is underlain by several thousand feet of consolidated, partly-consolidated, and unconsolidated sedimentary deposits (California Department of Water Resources, 1967). Volcanic deposits about 1,000 feet (ft) below land surface in the Stockton area, and at shallower depths to the east, separate overlying deposits from underlying marine deposits. Although they contain freshwater near the mountain front, the marine deposits contain saline water in most parts of the study area. The marine deposits have been explored for oil and gas and for the potential storage of waste. The overlying deposits can be divided into alluvial-fan deposits eroded from the Sierra Nevada, and delta deposits along the San Joaquin River. The alluvial-fan deposits are pumped extensively for water supply.

Under predevelopment conditions prior to the onset of ground-water pumping, ground-water movement in the alluvial-fan deposits was from the front of the Sierra Nevada to ground-water discharge areas near the San Joaquin Delta. Ground-water discharge to springs and seeps in this area was fresh and low in dissolved solids (Mendenhall, 1908). Surface water also infiltrated from the upstream reaches of rivers and streams into underlying alluvial deposits and ground water discharged along the downstream reaches of these streams (Piper and others, 1939). Regional ground-water movement in the San Joaquin Valley under predevelopment conditions was from south to north along the axis of the valley, with regional ground-water discharge to the delta. In a large part of the study area, ground water in deep wells completed below the volcanic deposits flowed to land surface under artesian conditions. Water from most of these deep artesian wells was saline (Mendenhall, 1908) and not used for agricultural or public supply. Saline water extracted from deep wells, especially those used for natural gas production, was "allowed to waste" (Mendenhall, 1908), or in the Stockton area was used for recreational swimming pools because of its warm temperature (fig. 3).

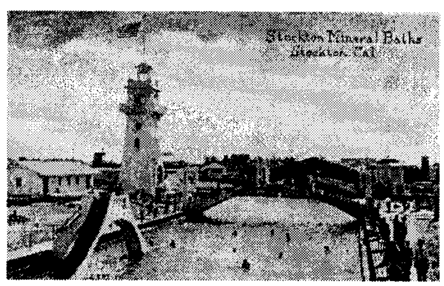

Figure 3. Recreational pools developed from saline ground water discharge in the San Joaquin Ground-Water Subbasin, Stockton, California, circa 1910. (Photograph courtesy of the Stockton Record.)

In 2000, the study area had a population of about 580,000 (CDM, Inc., 2001), and population is expected to increase to more than 1.2 million by 2040 (CDM Inc., 2001). Ground-water recharge is about 900,000 acre-feet per year (acre-ft/yr), and pumping exceeds recharge by 150,000 acre-ft/yr. Water levels in parts of the subbasin declined to below sea level in the early 1950's (California Department of Water Resources, 1967). The pumping depression expanded and shifted eastward in recent years *(link to animation showing changes in water-level contours, 1974 to 1999)*, and water levels in parts of the basin were declining at rates as high as 2 feet per year (Northeastern San Joaquin County Groundwater Banking Authority, 2004). Within the pumping depression, ground water flowed from recharge areas near the mountain front, from major streams and rivers, and from the San Joaquin Delta toward pumping wells.

Purpose and Scope

The purpose of this report is to illustrate the types of data collected, and to present preliminary (2006) results from an ongoing study of the source of high-chloride water to wells in the Eastern San Joaquin Ground-Water Subbasin. The scope of the study includes test-drilling, geophysical logging, and identification of the source of high-chloride water to wells using geochemical techniques. The study couples a basin-wide areal assessment of water quality with more detailed geologic, geophysical, and geochemical data collection along geologic sections in the area affected by declining water levels and increasing chloride concentrations (fig. 4). Although beyond the scope of this preliminary report, extrapolation of data along the cross-sections is intended to extend detailed data collected from multiple-well monitoring sites and from large-capacity wells to other wells along the geologic sections. This approach will aid in the development and a more complete understanding of how the spatial and vertical distribution of subsurface geology, hydrology, and geochemistry combine to influence the movement of high-chloride water to wells.

Test Drilling and Well Installation

Test drilling and well installation was done to obtain samples of geologic materials, lithologic and geophysical logs, and to install wells for use as measuring points for water-level and water-quality data collection. Between May and October 2005, three multiple-well sites—each containing three to

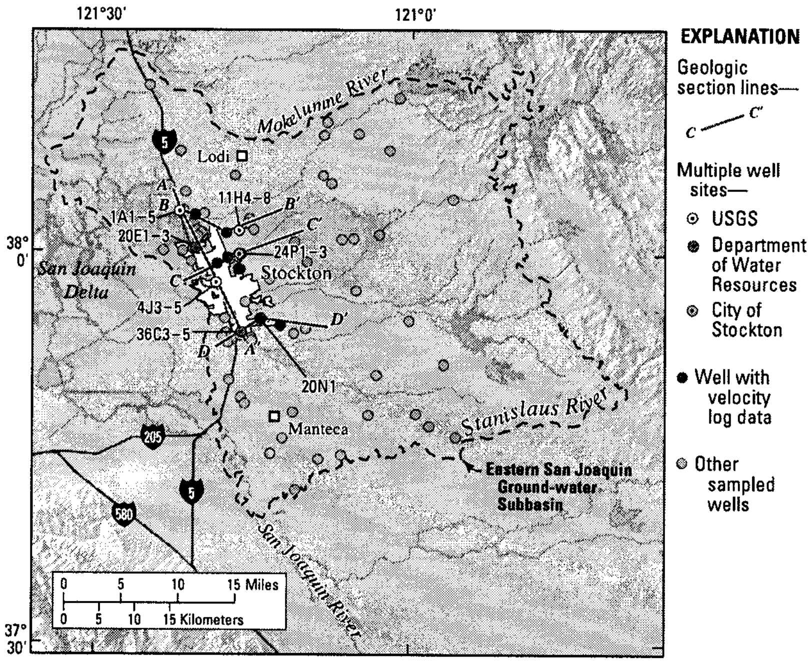

Figure 4. Location of selected wells and geologic sections, Eastern San Joaquin Ground-Water Subbasin, California.

respectively (fig. 5). Data from the wells at this site and from monitoring wells at other multiple-well sites will be used to evaluate the chemical and isotopic composition of potential sources of high-chloride water to these wells.

The two other multiple-well sites 1N/6E-4J3–5 and 2N/6E-11H4–8 (fig. 4) were drilled to depths of 600 and 643 ft below land surface, respectively. In January 2006, chloride concentrations in water from sites -4J3–5 near the San Joaquin Delta ranged from 120 to 510 mg/L, with the highest concentration in well -4J4 that was completed between 360 and 340 ft below land surface. In May 2005, chloride concentrations in water from sites -11H4–8, near ground-water recharge ponds east of the delta, were between 9.9 and 3.4 mg/L.

five 2-inch diameter monitoring wells with PVC casings installed at different depths, were completed. Data from these sites were supplemented with data from multiple-well sites installed previously at two locations by the California Department of Water Resources (2003), and at an additional location by the City of Stockton (fig. 4).

Geophysical logs and well-construction data for multiple-well site 2N/5E-1A1–5, installed near the eastern edge of the San Joaquin Delta, are shown in figure 5. This site was selected because two wells less than one-half mile east of this site were removed from service as a result of high-chloride concentrations. Water levels at this multiple-well site ranged from about 13 to 27 ft below land surface in May 2005, and depth to water increased with well depth. The site is located in what would have been a ground-water discharge area under predevelopment conditions, and the increase in depth to water with well depth is probably the result of regional ground-water pumping. In May 2005, chloride concentrations at this site ranged from 550 to 1,800 milligrams per liter (mg/L). At that time, the shallowest and deepest wells had chloride concentrations of 1,800 and 1,700 mg/L,

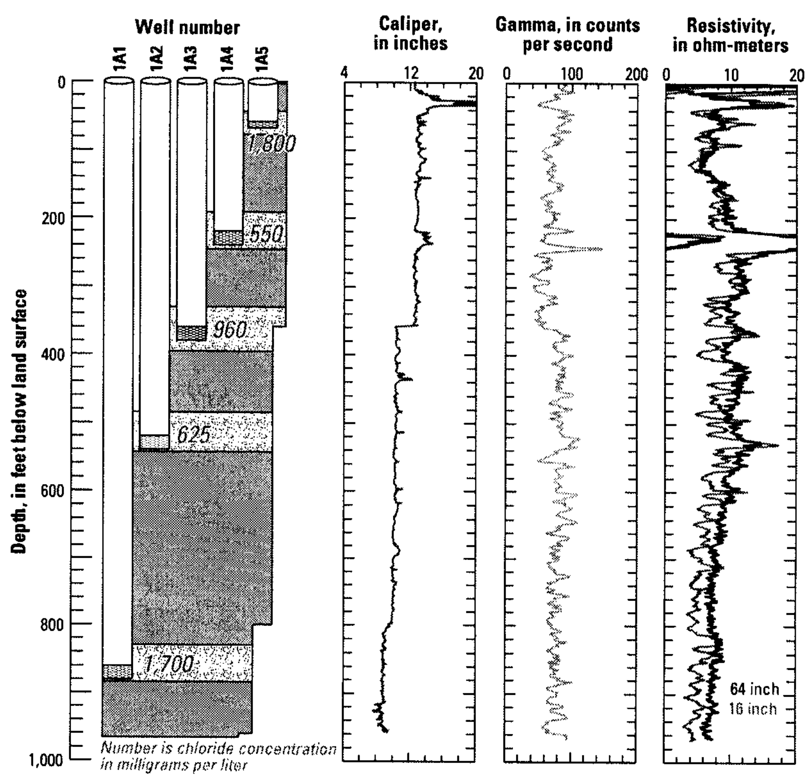

Figure 5. Selected geophysical logs and well-construction data for multiple-well site, 2N/5E-1A1–5, Eastern San Joaquin Ground-Water Subbasin near Stockton, California, May 2005.

Borehole Geophysical Data

In addition to geophysical logs collected during test drilling, two types of borehole geophysical data were collected as part of this study. Electromagnetic (EM) logs were collected from selected multiple-well sites to evaluate changing water quality at depth. Fluid-velocity logs were collected under pumping conditions from selected public supply wells to determine the depth at which water enters those wells. Velocity logs were coupled with depth-dependent water-quality data, also collected under pumping conditions, to determine the quality of water entering the well at different depths.

Electromagnetic logs

Only a limited number of wells screened over selected intervals can be installed at multiple-well monitoring sites. As a consequence, changes in water quality are not measured directly through much of the aquifer thickness. To address this issue, the deepest well at multiple-well sites was used as access tubes for repeated measurement of electromagnetic resistivity through the entire aquifer thickness penetrated by the well. EM logs collected through the PVC casings of monitoring wells are sensitive to the lithology of the deposits and to the resistivity of the pore fluids within the deposits (McNeill and others, 1990). Because the lithology remains constant with time, repeated EM logs differ only if the fluid resistivity changes as a result of the movement of water of differing quality at depth (Williams and others, 1993). The radius of the material measured by the logging tool is between 10 and 50 inches, and as a result the tool is relatively insensitive to borehole fill material adjacent to the well (McNeill and others, 1990). These properties make EM resistivity a suitable tool for identifying changes in water quality, particularily changes in salinity, at locations from which ground-water samples cannot be collected directly.

EM resistivity values at corresponding depths from logs collected within well 2N/6E-20E1 in June 2004 and January 2006 are shown in figure 6. In the time between collection of the two logs, EM resistivity values decreased in a narrow interval between 400 and 402 ft below land surface (fig. 6). The January 2006 values, between 400 and 402 ft, were among the lowest collected from the well. Because the lithology has not changed, decreased EM resistivity at this depth may be the result of decreased fluid resistivity (increased fluid conductivity) resulting from increased salinity between the two logging dates. Horizontal movement of poor-quality water through thin, permeable zones that are either areally extensive, or well-connected hydraulically, commonly occurs in coastal California aquifers (Nishikawa, 1997). Given this scenario, the three monitoring wells at this site (screened from 472 to 507, 289 to 319, and 189 to 209 ft below land surface, respectively) would not have detected changes in water quality that caused changes in EM resistivity observed near 400 ft.

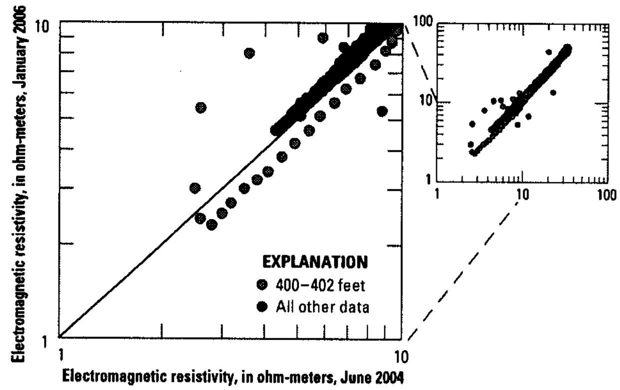

Figure 6. Comparison of electromagnetic resistivity values collected in well 2N/6E-20E1, Eastern San Joaquin Ground Water Subbasin near Stockton, California.

Decreases in EM resistivity consistent with increasing chloride concentrations also were observed between 40 and 45 ft below land surface in EM logs collected from well 1N/6E-36C3 between June 2004 and January 2006. Previous work (California Department of Water Resources, 1967) indicated the presence of poor-quality water near the water-table in this part of the study area and suggested that this shallow ground water may have been the source of high-chloride water in some production wells.

Additional EM logging at these sites would be required to determine if EM resistivity values will continue to decrease through time. Additional data collection, possibly including the installation of new wells, may be required to determine if changes in EM resistivity are the result of changes in water quality or the result of some other cause.

Fluid-velocity logs and depth-dependent water-quality sample collection

Fluid-velocity logs from unpumped and pumped wells were collected using an EM flowmeter. The EM flowmeter measures uphole or downhole velocities according to Faraday's Law, where the voltage generated by the movement of charged ions in water flowing through an induced magnetic field is proportional to the velocity of water flowing through the field. The tool has a range from 0.3 to 260 feet per minute, and is suitable for both the low velocities in unpumped wells and the high velocities in pumped wells (Newhouse and others, 2005). Fluid resistivity and fluid temperature data collected during logging were used to constrain interpretations of fluid-velocity logs.

Fluid-velocity logs from pumped wells were coupled with water-quality samples collected under pumping conditions from selected depths within the well. Sample depths were selected on the basis of measured velocity logs, lithologic logs, geophysical logs, and well-construction data. The samples were collected using a commercially available, small-diameter gas-displacement pump (Izbicki, 2004). Water samples collected using this method are mixtures of water that entered the well from different depths. However, when coupled with velocity log data,

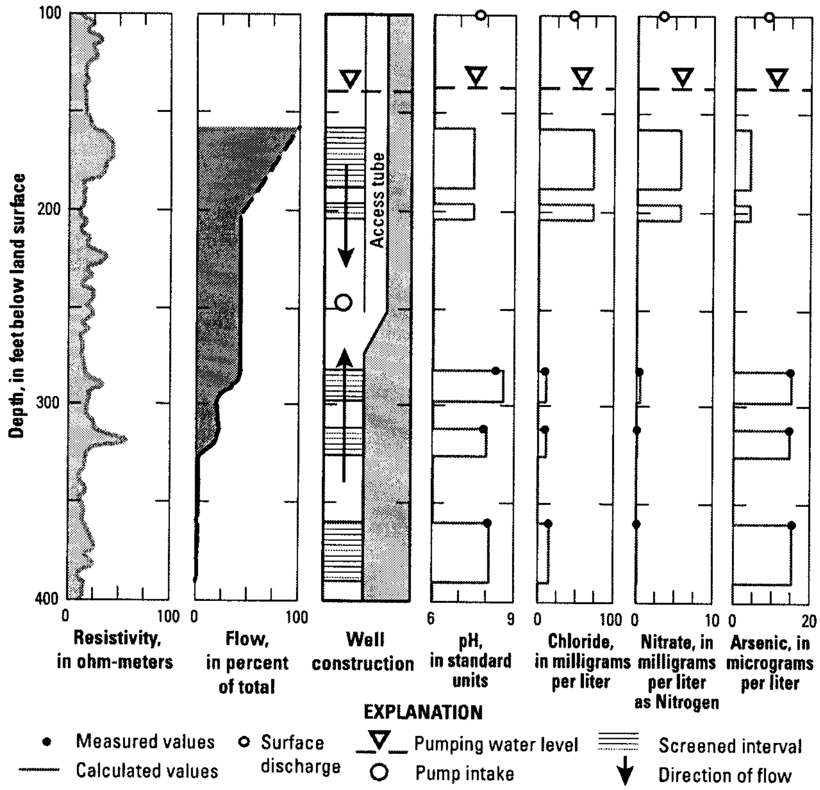

Figure 7. Fluid velocity and depth-dependent water-quality data from well 1N/7E-20N1, Eastern San Joaquin Ground-Water Subbasin, California, August 2004.

depth-dependent water-quality data can be used to estimate the quality of water entering a well from selected depths in an aquifer (Izbicki, 2004).

Fluid-velocity logs from well 1N/7E-20N1 show that slightly more than one-half of the water entered well -20N1 through the two upper screens located 158 to 204 ft below land surface (fig. 7). Most of the remaining water entered the well through screens at 282 to 298 and 312 to 326 ft below land surface. Only a small amount of water entered the well through the deepest screen 360 to 390 ft below land surface (fig. 7). In well -20N1, the higher yielding upper zones correspond to electrically resistive sand and gravel units indicated on the electric log (fig.7). Where present in other wells, this high-resistivity zone also contributes large amounts of water to wells. The small amount of yield from the deepest screen was unexpected on the basis of lithologic and geophysical logs, and may reflect increased consolidation and decreased hydraulic conductivity of alluvial deposits with depth.

Depth-dependent water-quality samples collected within well -20N1 under pumping conditions reflect the vertical distribution of water-quality within the aquifer (fig. 7). Chloride and nitrate concentrations are higher in water entering from the upper well screens than the deeper well screens. In contrast, pH and arsenic concentrations were higher in water entering from the deeper parts of the well. Arsenic concentrations in the deeper parts of well -20N1 were as high as 15 micrograms per liter (μg/L). Mixing of water having lower arsenic concentrations from shallower depths within the well caused water discharge at the surface to approach the Maximum Contaminant Level (MCL) for arsenic of 10 μg/L (U.S. Environmental Protection Agency, 2006). Changes in well drilling and construction practices could exclude zones having high concentrations of constituents such as chloride, nitrate, or arsenic from newly installed wells, and modifications in well design could exclude zones contributing poor-quality water to existing wells—thereby improving the quality of water from those wells.

By January 2006, fluid velocity logs coupled with depth-dependent water-quality data had been collected from eight wells that are distributed along the sections shown in figure 4. Data from these wells will be used with geochemical data collected from the surface discharge of wells throughout the study area to determine the sources of high-chloride water to wells.

Sources of High-Chloride Water to Wells

Prior to the construction of reservoirs on rivers tributary to the San Joaquin Delta, water having chloride concentrations as high as 1,000 mg/L intruded the delta during low-flow periods (Piper and others, 1939) (fig. 1). Under present-day (2006) conditions, surface flows are managed to protect freshwater resources in the delta and to prevent the inland movement of seawater. However, high-chloride water may originate from water trapped in delta sediments during their deposition—constituents dissolved within this water may retain a chemical composition consistent with a seawater origin. High-chloride water also may originate from soluble salts emplaced in sediments from ground-water discharge along the delta margin—constituents dissolved within this water would have a chemical composition different from seawater. It is likely that water from deeper aquifers that underlie freshwater aquifers pumped for supply also has markedly different chemical composition and may contribute high-chloride water to wells in different parts of the subbasin. In addition, irrigation return may increase chloride concentrations near the water table. To further complicate the issue, multiple sources of high-chloride water may occur at different depths within the same well. Water from wells was sampled and analyzed for major-ions, selected minor ions, and its isotopic (oxygen-18

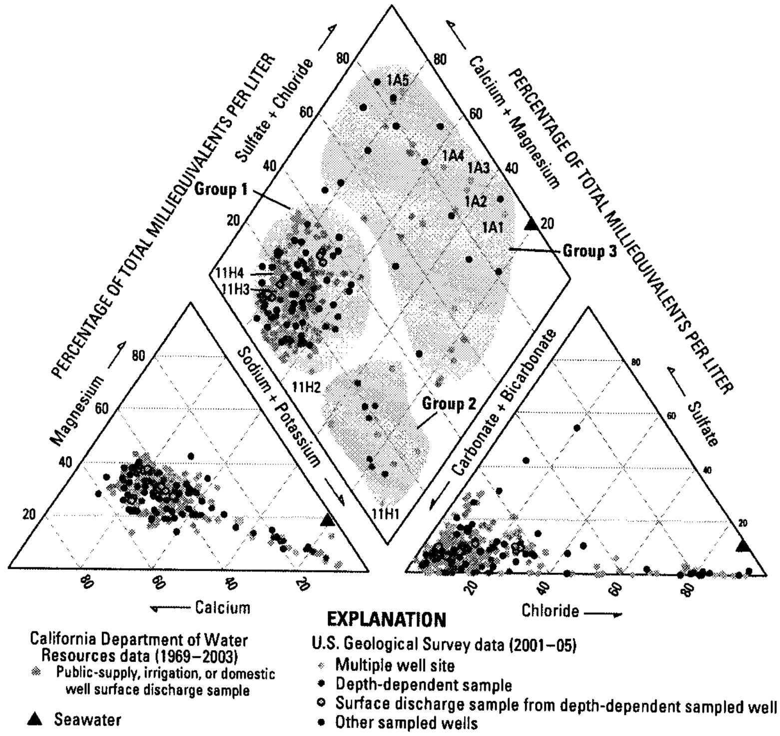

Figure 8. Major-ion chemistry of water from selected wells in the Eastern San Joaquin Ground-Water Subbasin, California, 2004–2005.

and deuterium) composition, to determine the composition of fresh and high-chloride waters in the study area and the sources of high-chloride water to wells.

Major-Ion Composition of Water from Wells

The major-ion composition of 100 water samples from 76 public-supply, irrigation, domestic, and observation wells collected as part of this study between May 2004 and January 2006, and 245 historical samples from 42 wells were evaluated using a trilinear diagram (fig. 8). A trilinear diagram shows the proportions of the major cations (calcium, magnesium, and sodium plus potassium) and the major anions (carbonate plus bicarbonate, sulfate, and chloride) on a charge-equivalent basis (Hem, 1985). Cations are plotted on the lower left triangle, anions on the lower right triangle, and the central diamond integrates the data.

On the basis of their distribution within the trilinear diagram, data were separated into three groups having different chemical compositions. Group 1 represents the majority of sampled wells. Group 2 consists of depth-dependent samples from deeper depths within sampled public-supply wells, and samples from deeper observation wells at multiple-well sites. The composition of water from deeper aquifers represented by these samples is not apparent in historical data collected from the surface discharge of wells; because ground water from deeper depths mixes within the wells with ground water from shallow depths during pumping, thereby masking the composition of the deeper ground water. As a result of mixing within the well during pumping, samples from the surface discharge public-supply wells plot within Group 1 even though deeper samples from the same well plot within Group 2. All samples within Groups 1 and 2 had chloride concentrations of less than 100 mg/L. In contrast, all but two samples within Group 3 were from wells that had chloride concentrations greater than 100 mg/L. This group included several public-supply wells that are no longer in use due to chloride concentrations that were greater than the Secondary Maximum Contaminant Level (SMCL) of 250 mg/L (U.S. Environmental Protection Agency, 2006). The major-ion composition of water from wells did not trend consistently toward the composition of seawater as chloride concentrations increased.

Minor-Ion Composition of Water from Wells

Certain minor ions in water, such as bromide, iodide, barium, and boron are present naturally in high-chloride water from different sources, and have been used to determine the origin of high-chloride water to wells (Piper and Garrett, 1953; Izbicki and others, 2005). Analysis of this combination of minor ions is especially effective because their differing abundances, chemical properties, and biological reactivity can produce a wide range of compositions, relative to chloride concentrations; these compositions reflect different geology, source-water composition, and aquifer chemistry. Of the four minor ions analyzed in this study, iodide commonly has the largest range in environmental compositions, relative to chloride and is commonly very useful in determining the source of high-chloride water to wells.

Iodide is depleted in seawater through uptake by marine organisms (Izbicki and others, 2005). As these organisms die, are buried, and decay, water within marine deposits may become enriched in iodide. In the plot of chloride-to-iodide ratio as a function of chloride (fig. 9), data are bimodally distributed and reflect contributions of high-chloride water from at least two sources. The chloride-to-iodide ratio from some wells follows a seawater mixing line with increasing chloride concentrations, and reflects high-chloride seawater minimally altered by contact with aquifer material.
Water from most observation wells and from depth-dependent samples collected within the deeper parts of public-supply wells plotted to the right of the seawater mixing line. The iodide-enriched composition of water from these wells is similar to that of water from marine rocks and oil-field brine sampled elsewhere in

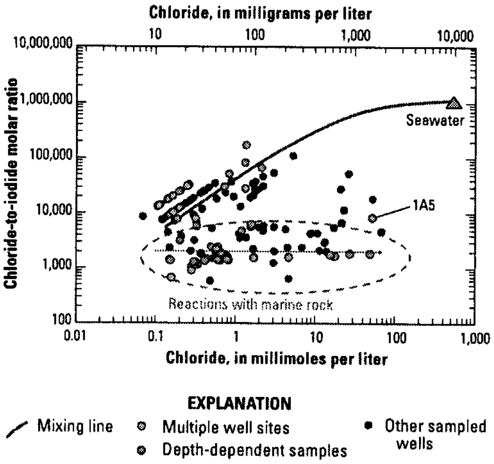

Figure 9. Chloride-to-bromide and chloride-to-iodide ratios as a function of chloride concentration in water from selected wells in the Eastern San Joaquin Ground-Water Subbasin, California, 2004–2005.

California (Piper and Garrett, 1953; Izbicki and others, 2005). Several wells having high-chloride water, including the shallow observation well -1A5 at the Oak Grove Park multiple-well site, have chloride-to-iodide ratios intermediate between compositions expected from seawater mixing and from deep brines. Water from these wells may be complex mixtures of high-chloride water from multiple sources, or the water may have reacted with aquifer materials to remove iodide from the solution.

Oxygen-18 and Deuterium Composition of Water from Wells

Oxygen-18 and deuterium are naturally occurring stable isotopes of oxygen and hydrogen, respectively. Oxygen-18 ($\delta^{18}O$) and deuterium (δD) abundances are expressed as ratios, in delta notation as per mil (parts per thousand) differences, relative to the standard known as Vienna Standard Mean Ocean Water (VSMOW). By convention, the value of VSMOW is 0 per mil. Negative per mil values have more of the lighter isotope than VSMOW (Craig, 1961), and highly negative per mil values have more of the lighter isotope than less negative values.

Most of the world's precipitation originates from the evaporation of seawater. As a result, the $\delta^{18}O$ and δD composition of precipitation throughout the world is correlated linearly and distributed along a line known as the global meteoric water line (Craig, 1961). In many areas, water samples plot along a line slightly below the global meteoric water line that is known as the local meteoric water line. The $\delta^{18}O$ and δD composition of a water sample, relative to the global meteoric water line and relative to the composition of water from other areas, provides a record of the source and evaporative history of the water, and can be used as a tracer of the movement of the water. Differences in the $\delta^{18}O$ and δD composition of water from the global meteoric water line may result from differences in the temperature of condensation of precipitation that recharged the ground water. These differences may result from condensation at different altitudes, from seasonal or short-term climatic changes, or from long-term climatic changes such as those that occurred at the end of the Pleistocene Epoch. Partial evaporation of a water sample shifts the $\delta^{18}O$ and δD composition to the right of the global meteoric water line along an evaporative trend line (International Atomic Energy Agency, 1981).

The $\delta^{18}O$ and δD composition of water from wells in the study area ranged from –6.3 to –11.2 per mil and –48 to –81 per mil with a median composition of –8.4 and –60 per mil, respectively (fig. 10). Most samples plot parallel to, but below, the global meteoric water line.

The more negative values are from shallow wells, typically about 100 ft deep, along the Mokelumne and Stanislaus Rivers (fig. 10). These rivers drain the higher altitudes of the Sierra Nevada to the east of the study area, and water from these wells probably originated as precipitation at cooler temperatures associated with higher altitudes instead of precipitation at warmer temperatures associated with lower altitudes. There was no consistent trend toward increasingly negative values from deeper wells at multiple-well sites installed as part of this study. However, δD values between –70 and –68 per mil were obtained from shallower wells at a multiple-well site 2N/6E-11H4–8 near ground-water

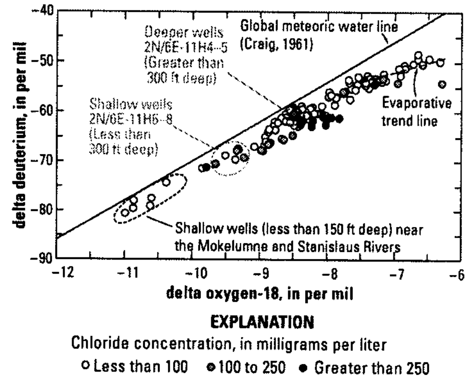

Figure 10. Oxygen-18 and delta deuterium composition of water from selected wells in the Eastern San Joaquin Ground-Water Subbasin, California, 2004–2005.

recharge ponds. These data are consistent with movement of recharge water from the ponds (that originated from reservoirs in the Sierra Nevada) to depths as great as 300 ft.

The less negative samples plot to the right of the local meteoric water line along an evaporative trend line (fig. 10). Although most high-chloride water plots to the right of the meteoric water line, chloride concentrations do not consistently increase with the evaporative shift in $\delta^{18}O$ and δD isotopic composition. These data suggest that the high-chloride concentrations are the result of processes other than evaporative concentration of ground water, and are consistent with high-chloride water mobilized from delta sediments or deeper deposits.

Summary

Water levels are declining and chloride concentrations are increasing in water from wells in the Eastern San Joaquin Ground-Water Subbasin near Stockton, California, as a result of pumping in excess of recharge. A study approach that utilizes a combination of data collection activities including (1) drilling and monitoring well installation, (2) borehole geophysical data collection from monitoring wells and large-capacity pumping wells, and (3) geochemical data collection was developed to evaluate the areal and vertical distribution of chloride within freshwater aquifers and to determine the sources of high-chloride water to wells. The study couples a basin-wide areal assessment of water quality with detailed geologic, geophysical, and geochemical data collected along geologic sections in the area affected by declining water levels and increasing chloride concentrations.

Preliminary results show that water from multiple-well site 2N/5E-1A1–5 near the San Joaquin River Delta had chloride concentrations as high as 1,800 mg/L. High chloride concentrations were present at this site to almost 1,000 ft below land surface. EM logs collected from well 2N/6E-20E1 north of Stockton showed decreased EM resistivity. EM logs collected in well 1N/6E-36C3 south of Stockton, showed decreases in EM resistivity at shallower depths between 40 and 45 ft below land surface. High-chloride water from shallow depths has been observed in production wells in this part of the study area. Additional EM logging at these sites would be required to determine if EM resistivity values continue to decrease through time and if decreasing resistivity is the result if increasing salinity.

Water-quality in the study area changes with depth, and the major-ion composition of water from deeper aquifers is obscured by mixing within wells during pumping. As a consequence, the composition of water from deeper deposits penetrated by wells is not apparent in historical data collected primarily from the surface discharge of wells. Changes in the iodide composition of water from wells with elevated chloride concentrations are consistent with a marine origin of the chloride dissolved in water from wells. Entrainment of seawater in delta deposits may have occurred during deposition of delta sediments. Subsequent mobilization of this entrained water may have occurred as a result of ground-water pumping. High-chloride water in deeper parts of the aquifer is enriched in iodide, relative to seawater compositions and also contributes to increasing chloride concentrations in water from some wells. Such enrichment is common in deeper ground water from oil- and gas-producing regions in California (Piper and Garrett, 1953; Izbicki and others, 2005). Shifts in the $\delta^{18}O$ and δD composition of water from some shallower wells are consistent with partial evaporation of water and irrigation return water. However, increases in chloride concentrations from evaporation of irrigation water are small compared to chloride inputs from the delta and underlying deposits.

Acknowledgements

This study was funded by the Northeastern San Joaquin Groundwater Banking Authority and the California Department of Water Resources in cooperation with the U.S. Geological Survey. The authors thank the County of San Joaquin, the California Department of Water Resources, and the California State Water Resources Control Board Ground-Water Ambient Monitoring and Assessment (GAMA) Study for their assistance with sample collection and analyses. The authors also thank the local water agencies for the support, and access to wells during this study—especially Brandon Nakagawa of the San Joaquin County Public Works Department, Anthony Tovar of the City of Stockton Municipal Utilities Department, and Eric Mar of the California Water Service Company.

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Eastern San Joaquin Groundwater Basin Groundwater Management Plan

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Copies of the Groundwater Management Plan may be purchased for $50 from:
San Joaquin County Department of Public Works
P.O. Box 1810
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Make checks payable to: San Joaquin County Department of Public Works

Foreword

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The American West and particularly the State of California is faced with the critical challenge of sustainable development and equitable management of increasingly scarce water resources. The entirety of this concern is framed by greater competition between regional powers for limited surface supplies from major rivers and heightened attention regarding the future use and control of groundwater by overlying landowners, appropriative agencies and the State. Consequently, the Northeastern San Joaquin County Groundwater Banking Authority Joint Exercise of Powers Agreement was established in 2001 to provide a consensus-based forum for local water interests with historically diverse viewpoints regarding the exploitation of groundwater resources in the Eastern San Joaquin Groundwater Basin. Members agreed to work cooperatively with unanimity toward achieving water resource planning objectives and to speak with one regional voice. This Groundwater Management Plan is the result of this inexorable collaborative effort, which was single-minded in its effort to reinforce local control and provide direction for the sustainable development of this vital resource for the future social, economic and environmental viability of San Joaquin County.

Mel Lytle, Ph.D.
Water Resource Coordinator

Acknowledgements

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This Groundwater Management Plan (GMP) is a product of the commitment that the Groundwater Banking Authority (GBA) members together with many other interested agencies made to sustain and enhance the groundwater resources of the Eastern San Joaquin Basin. The GBA extends thanks to staff consultants from HDR, Schlumberger Water Services and Camp Dresser & McKee Inc. in the preparation of materials, modeling information and technical review of the GMP. In addition, special thanks are given for grant funding, information and services provided by the California Department of Water Resources, the Center for Collaborative Policy and the U.S. Geological Survey.

Finally, the GBA would like to thank staff, the Department of Public Works and the GBA Coordinating Committee and Plan Group members in guiding the preparation and technical review of the GMP. Significant funding for this work was provided by GBA member contributions and the San Joaquin County Flood Control and Water Conservation District Water Investigation Zone No. 2. A special benefit assessment supported by the taxpayers of San Joaquin County.

Northeastern San Joaquin County Groundwater Banking Authority

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List of Abbreviations

AB – Assembly Bill
ACWA – Association of California Water Agencies
ADAPS - Automatic Data Acquisition and Processing System
af – Acre-foot
ASR – Aquifer Storage and Recovery
Authority – Northeastern San Joaquin County Groundwater Banking Authority
BMP – Best Management Practice
Cal Water – California Water Service Company
CCWD – Calaveras County Water District
CDWA – Central Delta Water Agency
CERCLA – Comprehensive Environmental Response, Compensation and Liability Act
cfs – Cubic Feet per Second
CSJWCD – Central San Joaquin Water Conservation District
CVP – Central Valley Project
CVPIA – Central Valley Project Improvement Act
DMM – Demand Management Measure
DO – Dissolved Oxygen
DWR – California Department of Water Resources
EBMUD – East Bay Municipal Utility District
EC – Electrical Conductivity
EDF – Environmental Defense Fund
EIR – Environmental Impact Report
EIS – Environmental Impact Statement
ESJGB – Eastern San Joaquin Groundwater Basin
ESJPWA – East San Joaquin Parties Water Authority
FERC – Federal Energy Regulatory Commission
FSC – Folsom South Canal
FRWP – Freeport Regional Water Authority
GBA – Groundwater Banking Authority
GIS – Geographic Information System
GMP – Groundwater Management Plan
GOES – Geostationary Observational Environmental System
JPA – Joint Powers Agreement
MARS – Mokelumne Aquifer Recharge & Storage
mg/L – Milligrams per Liter
MGD – Million Gallons per Day
MORE WATER – Mokelumne Regional Water Storage and Conjunctive Use Project
MO – Management Objective
MOU – Memorandum of Understanding
MRWPA – Mokelumne River Water and Power Authority
MSL – Mean Sea Level
MW – Megawatts
NSJWCD – North San Joaquin Water Conservation District
OID – Oakdale Irrigation District
RWQCB – Regional Water Quality Control Board
SARA – Superfund Amendments and Reauthorization Act
SAWS – Stockton Area Water Suppliers
SB – Senate Bill
SCADA – Supervisory Control and Data Acquisition

SDWA – South Delta Water Agency
SEWD – Stockton East Water District
SJCOG – San Joaquin Council of Governments
SSJID – South San Joaquin Irrigation District
SWP – State Water Project
SWRCB – State Water Resources Control Board
TDS – Total Dissolved Solids
TMDL – Total Maximum Daily Load
USACE – United States Army Corps of Engineers
USBR – United States Bureau of Reclamation
USGS – United States Geological Survey
WHPA – Wellhead Protection Area
WID – Woodbridge Irrigation District

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Executive Summary

ES-1 Background

Independently, agencies in Eastern San Joaquin County have found it difficult to wield the political and financial power necessary to mitigate conditions of critical groundwater overdraft. County interests have come to realize that a regional consensus based approach to water resources planning and conjunctive water management increases the chance for successfully implementing groundwater management actions that are equitable, affordable, and provide far reaching benefits locally, regionally, and Statewide.

Organized in 2001, the Northeastern San Joaquin County Groundwater Banking Authority (Authority) employs the consensus based approach in its goal to develop "...locally supported groundwater banking projects that improve water supply reliability in Northeastern San Joaquin County...and provide benefits to project participants and San Joaquin County as a whole." Collaboration amongst the Authority member agencies has strengthened the potential for broad public support for groundwater management activities as well as the ability to leverage local, State, and federal funds. The Groundwater Management Plan for Eastern San Joaquin County (Plan) is a continuation of the collaborative effort to effectively manage the Eastern San Joaquin Groundwater Basin (Basin). Table ES-1 lists the member agencies of the Authority.

Table ES-1 Member Agencies of the Northeastern San Joaquin County Groundwater Banking Authority
City of Stockton
City of Lodi
Woodbridge Irrigation District
North San Joaquin Water Conservation District
Central San Joaquin Water Conservation District
Stockton East Water District
Central Delta Water Agency
South Delta Water Agency
San Joaquin County Flood Control and Water Conservation District
California Water Service Company*
San Joaquin Farm Bureau Federation*
* Associate Members

ES-2 Purpose and Objectives

The purpose of the Groundwater Management Plan is to review, enhance, assess, and coordinate existing groundwater management policies and programs in Eastern San Joaquin County and to develop new policies and programs to ensure the long-term sustainability of groundwater resources in Eastern San Joaquin County. To better define the supporting values included with this Plan's purpose, the Authority has listed the following mission values centered on the development of the Plan as outlined in Table ES-2.

Table ES-2 Groundwater Management Plan Mission Values for Success		
Be implemented in an equitable manner	Maintain or enhance the local economy	Protect groundwater and surface water quality
Be affordable	Minimize adverse impacts to entities within the County	Provide more reliable water supplies

Exhibit multiple benefits to local land owners and other participating agencies	Maintain overlying landowner and Local Agency control of the Groundwater Basin	Restore and maintain groundwater resources
Minimize adverse impacts to the environment	Protect the rights of overlying land owners	Increase amount of water put to beneficial use within San Joaquin County

In order to meet the purpose of the Plan and ensure the long-term sustainability of the Basin, the Authority created the following Plan objectives:

1. Maintain long-term sustainability of the Basin through the development of management objectives, practices and conjunctive use projects to benefit the social, economic and environmental viability of Eastern San Joaquin County.
2. Prevent further saline intrusion and degradation of groundwater quality throughout the Basin.
3. Increase understanding of Basin dynamics through the development of a sound research program to monitor, evaluate, and predict Basin conditions.
4. Maintain local control of the groundwater Basin through the responsible management of groundwater resources by overlying cities, counties, water districts, agencies, and landowners.
5. Formulate rational and attainable Basin management objectives to comply with SB 1938 and retain State funding eligibility.
6. Formulate voluntary policies, practices and incentive programs to meet established Basin management objectives.
7. Formulate appropriate financing strategies for the implementation of the Plan.

ES-3 Groundwater Management Area

San Joaquin County overlies the Eastern San Joaquin, Cosumnes, and Tracy Sub-basins of the greater San Joaquin Valley Groundwater Basin. For the purposes of the Plan, the Eastern San Joaquin County Groundwater Management Area (GMA) is defined as the portion of San Joaquin County overlying the Eastern San Joaquin and Cosumnes Sub-Basins. Within the GMA, the member agencies of the Authority will implement the Plan within their respective boundaries. To ensure that every parcel in the GMA is represented, all unorganized areas will be included in the San Joaquin County Flood Control and Water Conservation District. Figure ES-1 depicts the member Agencies of the Authority and their respective boundaries within the GMA.

ES-4 Agency Participation

The physical boundaries of the Eastern San Joaquin and Cosumnes Sub-Basins extend beyond the political boundaries of San Joaquin County. Portions of Calaveras and Stanislaus Counties overlie the eastern fringes of the Basin. Recognizing the need for increased coordination between agencies outside of the GMA, the Authority invited a variety of interest groups from the business, environmental, agricultural, and political communities to participate in the development of the Plan. The Authority values the consensus based approach to groundwater management and strives to coordinate, integrate, and mutually benefit from the groundwater management efforts of its member agencies and those with vested interest in the social, economic, and environmental viability of Eastern San Joaquin County.

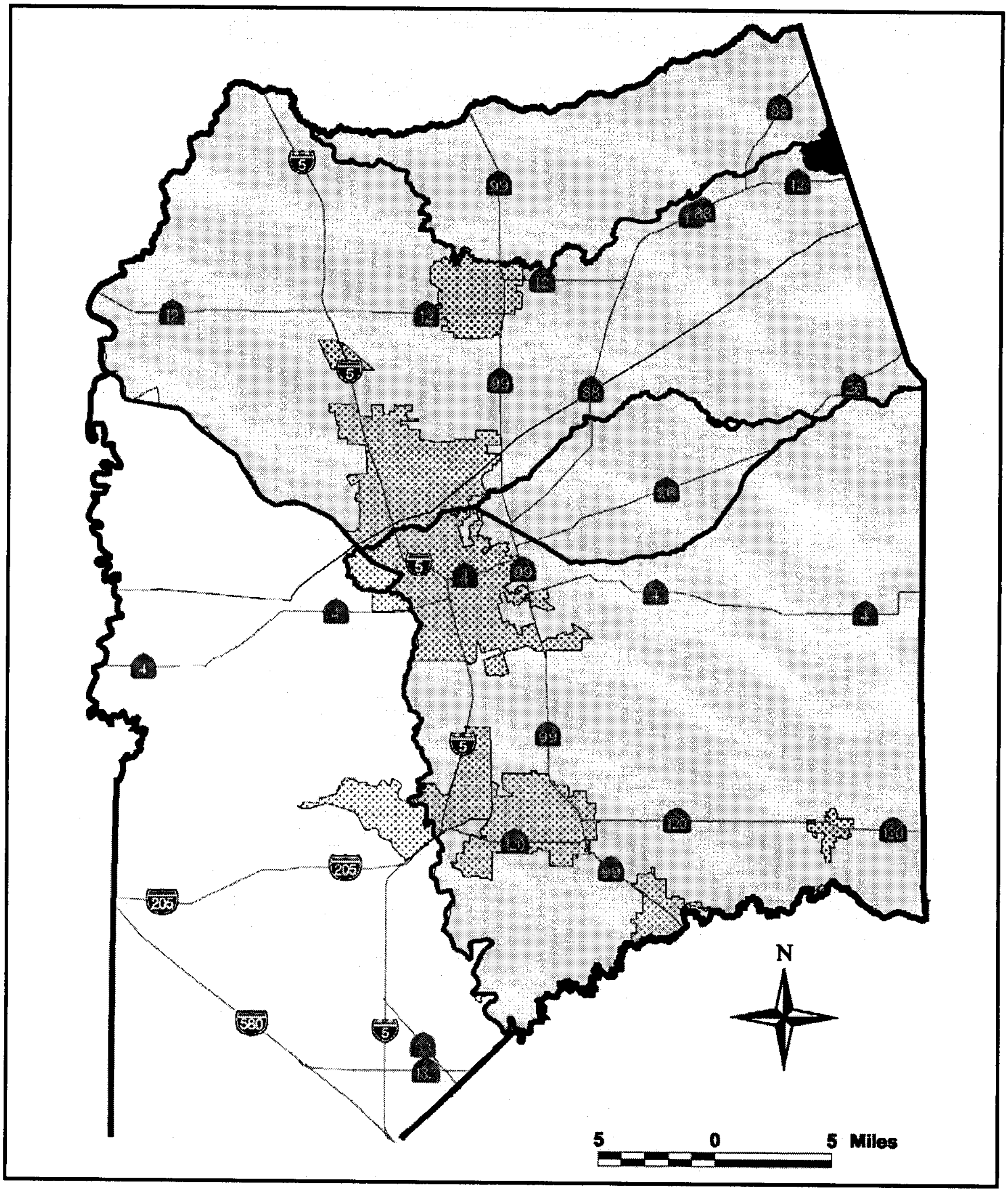

Figure ES-1 Groundwater Management Area
Source: California Spatial Information Library at http://www.gis.ca.gov/

Throughout the planning process, the Authority's Coordinating Committee, a technical sub-group of the Authority, convened every 4th Wednesday of the Month to formulate the Plan. Key discussion points and decisions were debated and finalized by the Coordinating Committee and incorporated into the Plan by Authority Staff. Draft sections of the Plan were also presented to and commented on by the Coordinating Committee. The Authority Board of Directors was regularly updated on the activities of the Plan at their regular meetings on the 2nd Wednesday of the month. For the purpose of providing an atmosphere conducive to broad-based consensus building and compromise, Authority Coordinating Committee meetings were facilitated through the California Center for Collaborative Policy.

Attendees of these meetings include representatives from over 40 agencies and interest groups. Table ES-3 is a list of meeting attendees and agencies contributing to the plan.

Table ES-3 Groundwater Management Planning Participants

Local Participants & Agencies	
Anders Christensen	Woodbridge Irrigation District
Cary Keaton	City of Lathrop
Dante Nomellini	Central Delta Water Agency
Dave Kamper	South San Joaquin Irrigation District
Ed Formosa	City of Stockton Municipal Utilities Department
Ed Steffani	North San Joaquin Water Conservation District
Gary Giovanetti	Stockton City Council
Joe Petersen	San Joaquin Farm Bureau Federation
John Herrick	South Delta Water Agency
Keith Conarroe	City of Manteca
Kevin Kauffman	Stockton East Water District
Larry Diamond	Calaveras County Water District
Loralee McGaughey	Stockton East Water District
Mark Lindseth	City of Lodi
Mark Madison	City of Stockton Municipal Utilities Department
Mel Lytle	San Joaquin County Public Works
Melvin Panizza	Stockton East Water District
Michael McGrew	San Joaquin County Counsel
Paul Risso	California Water Service Company
Ray Borges	San Joaquin County Environmental Health
Reid Roberts	Central San Joaquin Water Conservation District
Richard Prima	City of Lodi
Steve Stroud	South San Joaquin Irrigation District
Teresa Tanaka	Linden County Water District
T.R. Flinn	San Joaquin County Public Works
Tom Gau	San Joaquin County Public Works
State Participants & Agencies	
Ann Jordan	Office of State Senator Charles Poochigan
Mary Bava	Office of Assemblyperson Barbara Matthews
Tim Parker	Department of Water Resources
Federal Participants & Agencies	
David Simpson	Natural Resource Conservation Service
Eric Reichard	US Geologic Survey

John Izbicki	US Geologic Survey
Patrick Dwyer	US Army Corps of Engineers
	Other Participants & Agencies
Barbara Williams	Sierra Club
Carolyn Ratto	California Center for Collaborative Policy
David Beard	Great Valley Center
Gerald Schwartz	East Bay Municipal Utility District
Gina Veronesc	Camp, Dresser, & McKee
James Cornellius	Calaveras County Water District
James Moore	Galt Economic Development Task Force
John Aud	Stanislaus County
Larry Diamond	Calaveras County Water District
Mark Williamson	Saracino-Kirby-Snow
Robert Vince	Camp, Dresser, & McKee
Ron Addington	Business Council, Inc.

The Authority will continue to seek the input of its neighbors and interest groups during the implementation of the Groundwater Management Plan and any future planning efforts.

ES-5 Consistency with Water Code Section 10750 *et. seq.*

Groundwater management is the planned and coordinated effort of sustaining or improving the health of the underlying basin in order to meet future water supply needs. With the passage of Assembly Bill (AB) 3030 in 1992, local water agencies were provided a systematic way of formulating groundwater management plans and granted the Authority to implement those plans through fees and assessments. AB 3030 also encourages coordination between local entities through joint power authorities or memorandums of understanding.

In 2002, the passage of Senate Bill (SB) 1938 further emphasized the need for groundwater management in California. SB 1938 requires AB 3030 groundwater management plans to contain specific plan components in order to receive state funding for water projects. Table ES-4 illustrates the recommended components of a groundwater management plan as outlined in AB 3030 and the required sections under SB 1938. Table ES-4 also indexes the sections of this Plan where the recommended or required AB 3030/SB 1938 components are addressed.

ES-6 Eastern San Joaquin County Hydrogeology

Current and historical groundwater pumping rates exceed the sustainable yield of the underlying groundwater Basin on an average annual basis. Historic groundwater level trends as seen by well hydrographs throughout the Basin illustrate the following trends:

1. In the central portion of the Basin, the groundwater table dropped continuously from the 1950s to the early 1980s. Inclines during the early 1980s are attributed to extreme wet years of heavy rainfall.

2. In the northern part of the Basin, groundwater levels declined into the early 1990s.

3. Beginning in the early 1980s, a distinct drawdown and recovery cycle appears be driven by climatic conditions more than long-term changes in groundwater use.

4. Groundwater levels in the early 1990s had declined to the point where a number of wells throughout the Basin could not be operated. The severity of the situation forced many pumpers to construct new deeper wells.

Table ES-4 Components of a Groundwater Management Plan

Plan Component	Recommended by AB 3030	Required by SB 1938	Plan Sections
Control of saline water intrusion	X		2, 3, 4, 5, 8
Management of wellhead protection and recharge areas	X		4
Regulation of contaminated groundwater	X		4
The administration of a well abandonment	X		4
Elimination of groundwater overdraft	X		2, 3, 4, 5, 8
Replenishment of groundwater	X		2, 3, 4, 8
Groundwater monitoring	X	X	5
Operation of a conjunctive water management system	X		3, 8
Well construction standards	X		4
Financing groundwater management projects	X		6, 7
The development of groundwater management partnerships	X		1, 4, 7, 8
Coordination of land use planning and groundwater management	X		4
Description of participation by interested parties		X	1, 7
Plan to involve agencies overlying the basin		X	1, 7
Basin Management Objectives		X	3
Basin management entity and area map		X	1

Sources: California Department of Water Resources Division of Planning and Local Assistance http://wwwdpla.water.ca.gov/cgi-bin/supply/gw/management/hq/ab3030/main.pl

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Figures ES-2 and Figure ES-3 depict the Fall 1993 and Spring 1998 groundwater level contours respectively. The Fall 1993 contour represents the lowest groundwater level contours recorded in the Basin historic record. The Spring 1998 contour represents the recovery of the Basin following years of above average and severe precipitation.

The result of long-term groundwater overdraft is two fold: significant decline in groundwater levels and increased accretions from area waterways. Although increased accretions to the groundwater basin from high quality surface water sources are desirable, accretions in the western fringes of the Basin from the Lower San Joaquin River and older marine geologic formations are generally undesirable primarily due to elevated salt levels. Based on a simplified groundwater balance, as shown in Table ES-5, the net groundwater overdraft is estimated to be approximately 160,000 af/yr.

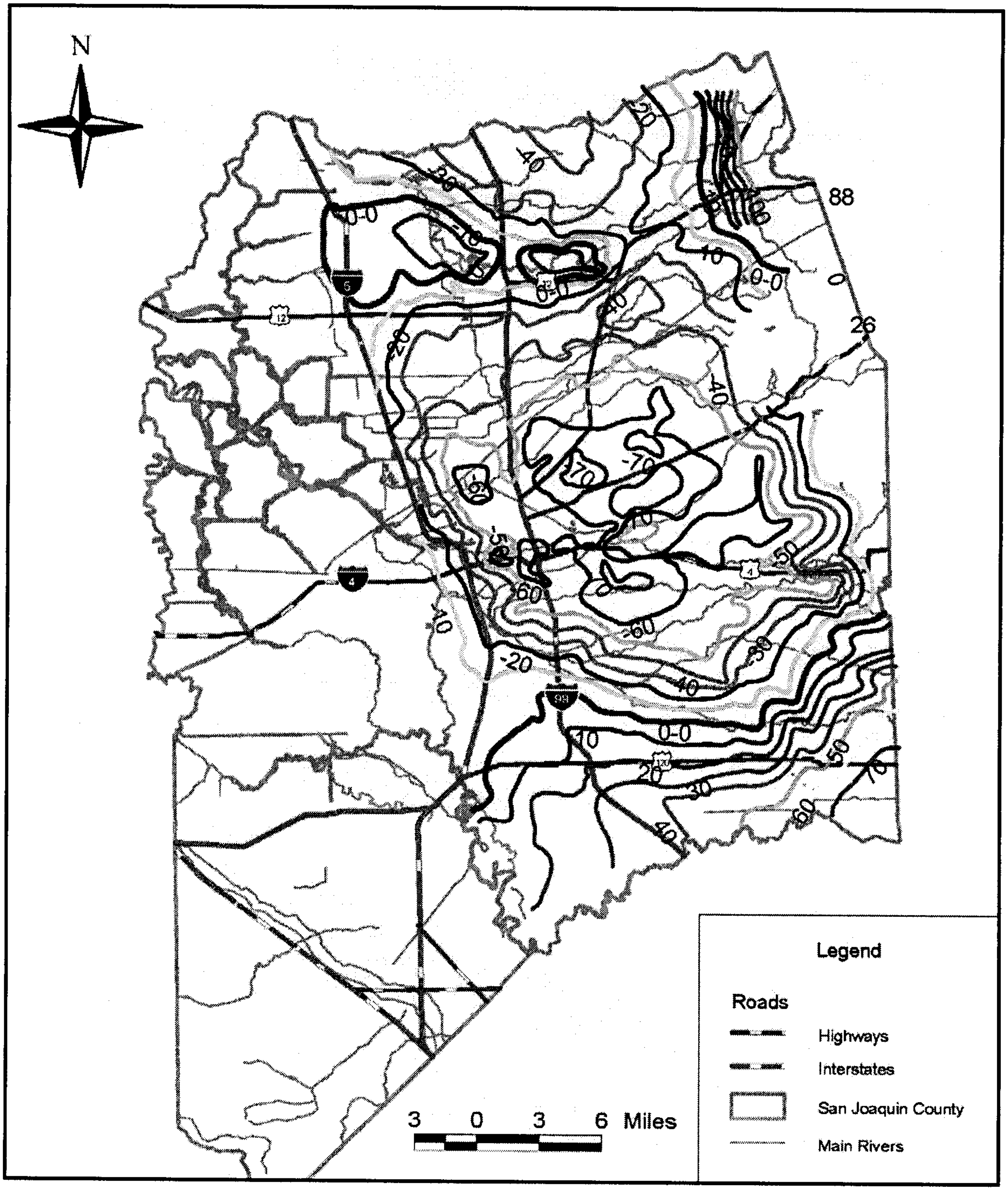

Figure ES-2 Fall 1993 Groundwater Contours
Source: Camp Dresser & McKee Inc.

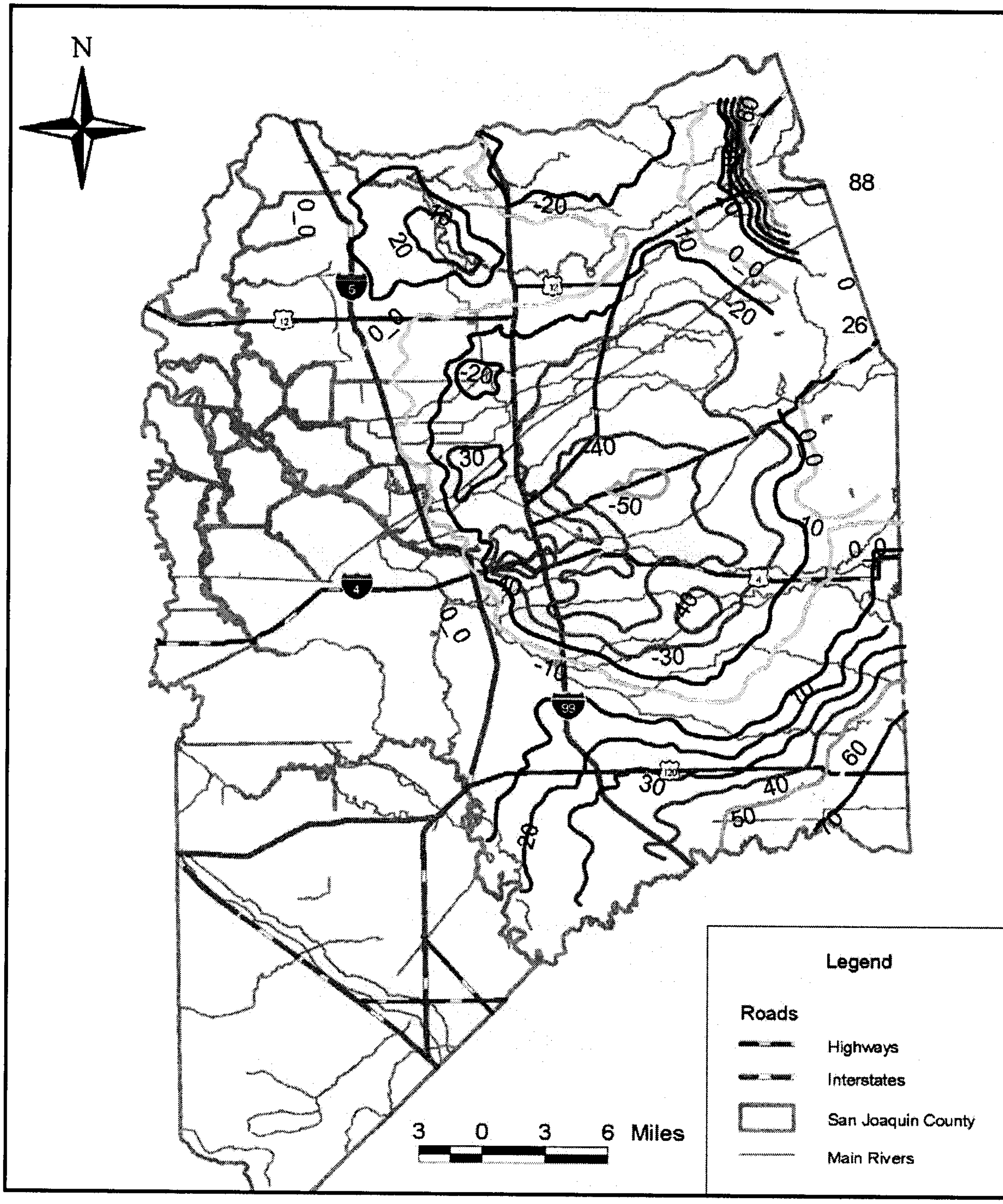

Figure ES-3 Spring 1998 Groundwater Contours
Source: Camp Dresser & McKee Inc.

Table ES-5 Simplified Groundwater Balance for Eastern San Joaquin County		
Groundwater Flow Component	**Average Value**	**Explanation**
	Inflows (af)	
Deep Percolation/Recharge	608,400	Net infiltration from rainfall, irrigation, canal leakage etc.
Gain from Streams	198,170	Net inflow from streams to groundwater system
Lateral Inflow	98,000	Net of subsurface inflows and outflows.
Total Inflows	**904,577**	
	Outflows (af)	
Groundwater Pumping	867,600	Net agricultural, municipal and industrial pumping
Loss to Streams	108,898	Net outflow from groundwater system to streams
Lateral Outflow	35,300	Subsurface Outflows
Total Outflows	**1,011,815**	
	Groundwater Overdraft (af)	
Mined Aquifer Storage	107,238	Total Inflows minus Total Outflows
Estimated Saline Intrusion	42,000	Lateral Saline Intrusion into the Stockton Area
Total Estimated Overdraft	**150,700**	Sum of Mined Aquifer Storage and Saline Intrusion
Source: San Joaquin County Water Management Plan Volume I		

Groundwater flow in the Basin now converges on the depression with relatively steep groundwater gradients eastward from the Delta toward the cone of depression as depicted in Figures ES-2 and ES-3. The eastward flow from the Delta area is significant because of the typically poorer quality water now moving eastward in the Stockton area. Increased lateral inflow from the west is undesirable, as this water is typically higher in TDS and chloride levels and causes the degradation of water quality in the Basin. Figure ES-4 illustrates the approximate location of the 300 mg/L isochlor as measured in 2000. Projections indicate that the rate of eastward migration of the saline front is approximately 150 to 250 feet per year. Figure ES-4 also depicts the projected 2030 location of the 300 mg/L isochlor under no-action conditions.

Degradation of water quality due to TDS or chloride contamination threatens the long-term sustainability of a very important water resource for San Joaquin County, since water high in TDS and/or chloride is unusable for either urban drinking water needs or for irrigating crops. Damage to the aquifer system could for all practical purposes be irreversible due to saline water intrusion, withdrawal of groundwater from storage, and potentially subsidence and aquifer consolidation. The saline intrusion problem is not well understood by the Authority. Further studies and monitoring methods are necessary to ensure the problem is addressed and monitored adequately. The Plan further defines the groundwater science and monitoring investigations geared towards both saline intrusion and general Basin understanding.

A no-action or baseline simulation was conducted to predict how current groundwater and surface management practices would impact the groundwater basin in 2030. Groundwater modeling has shown that unless there is a change in how groundwater is used or managed,

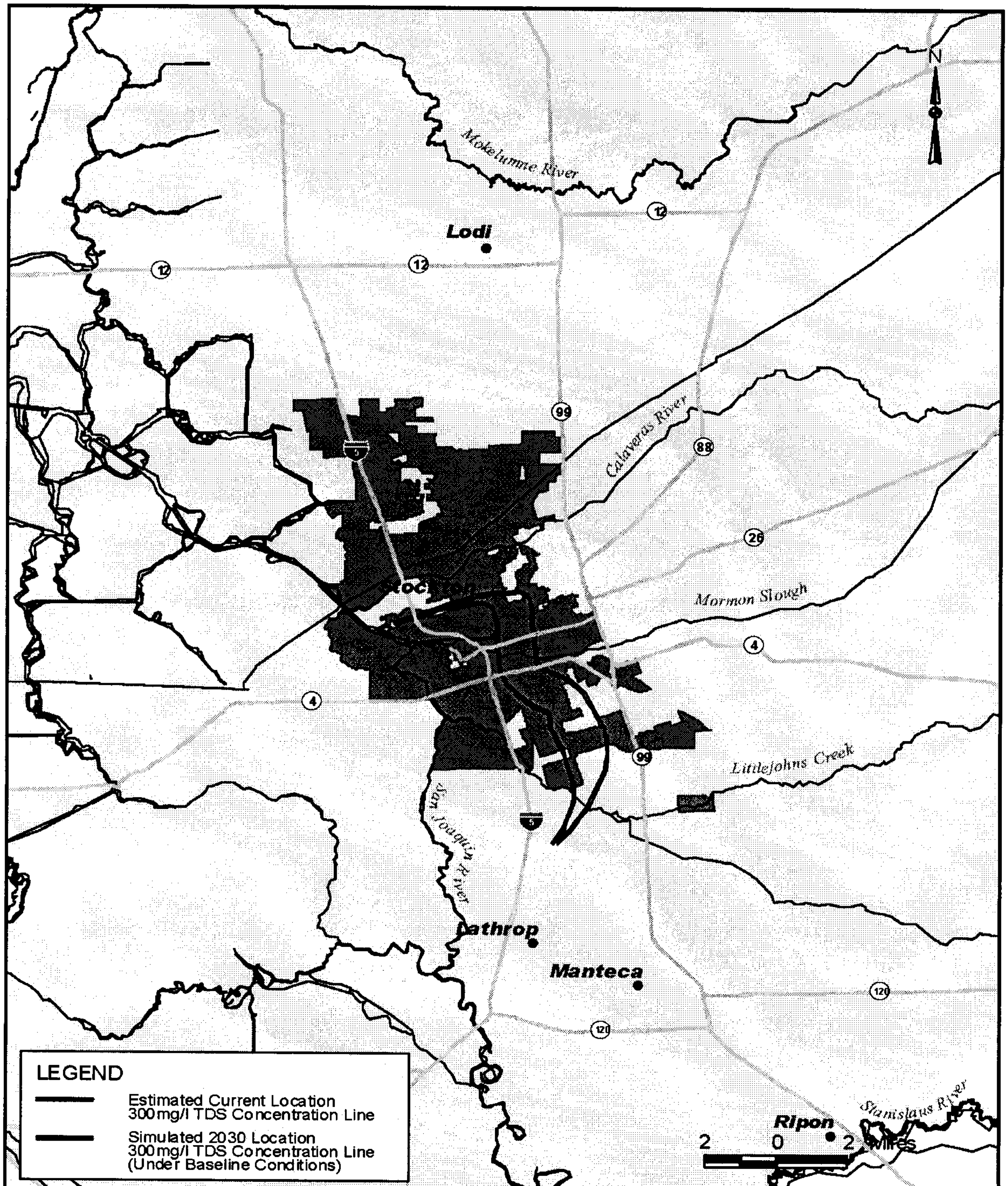

Figure ES-4 Estimated 2000 and 2030 Projected Saline Front
Source: Camp Dresser & McKee, Inc.

levels will continue to decline and storage will continue to be reduced. Figure ES-5 shows the corresponding simulated groundwater table for the year 2030 under baseline conditions. A large portion of the Basin is shown to have groundwater levels 60 to 80 feet below sea level.

Further exacerbating the groundwater conditions, as already mentioned, is the lateral inflow of higher salinity water from the west, which could render parts of the aquifer unusable. Figure ES-4 illustrates the approximate location of the 300 mg/L chloride concentration contour as of 1996 as well as the projected 2030 contour. Groundwater modeling has indicated that the rate of eastward movement of this line is approximately 150 to 250 feet per year. Figure ES-4 also shows the projected location of the 300 mg/L chloride concentration line by the year 2030 under baseline conditions.

ES-7 Basin Management Objectives

SB 1938, created in 2002, requires that agencies that elect to, "Prepare and implement a groundwater management plan that includes basin management objectives for the groundwater basin that is subject to the plan. The plan shall include components relating to the monitoring and management of groundwater levels within the groundwater basin, groundwater quality degradation, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin." In addition, local agencies that do not adopt or participate in a plan fulfilling the requirements of SB 1938 shall not be eligible for State funding intended for groundwater projects. The Authority has developed the following qualitative Basin Management Objectives (MO) for the GMA.

Management Objective #1: Groundwater Levels

Maintain or enhance groundwater elevations to meet the long-term needs of groundwater users within the Groundwater Management Area.

Management Objective #2: Water Quality

Maintain or enhance groundwater quality underlying the Basin to meet the long-term needs of groundwater users within the Groundwater Management Area.

Management Objective #3: Surface Water Quality

Minimize impacts to surface water quality and flow due to continued Basin overdraft and planned conjunctive use.

Management Objective #4: Water Quality

Prevent inelastic land subsidence in Eastern San Joaquin County due to continued groundwater overdraft.

ES-8 Groundwater Management Options

Groundwater management tools available to the Authority are explored in the Plan. In order to successfully implement a conjunctive use program that will meet the goals of this Plan, the Authority must first identify and develop a list of water management options. An option, in the context of this Plan, is the method, program or policy suitable for the broader conjunctive use program for Eastern San Joaquin County. The Plan explores the concepts for the acquisition of new and maximization of existing surface water supplies, groundwater recharge techniques, and other options dealing with demand management and water reuse. Table ES-6 lists the groundwater management options explored in the Plan.

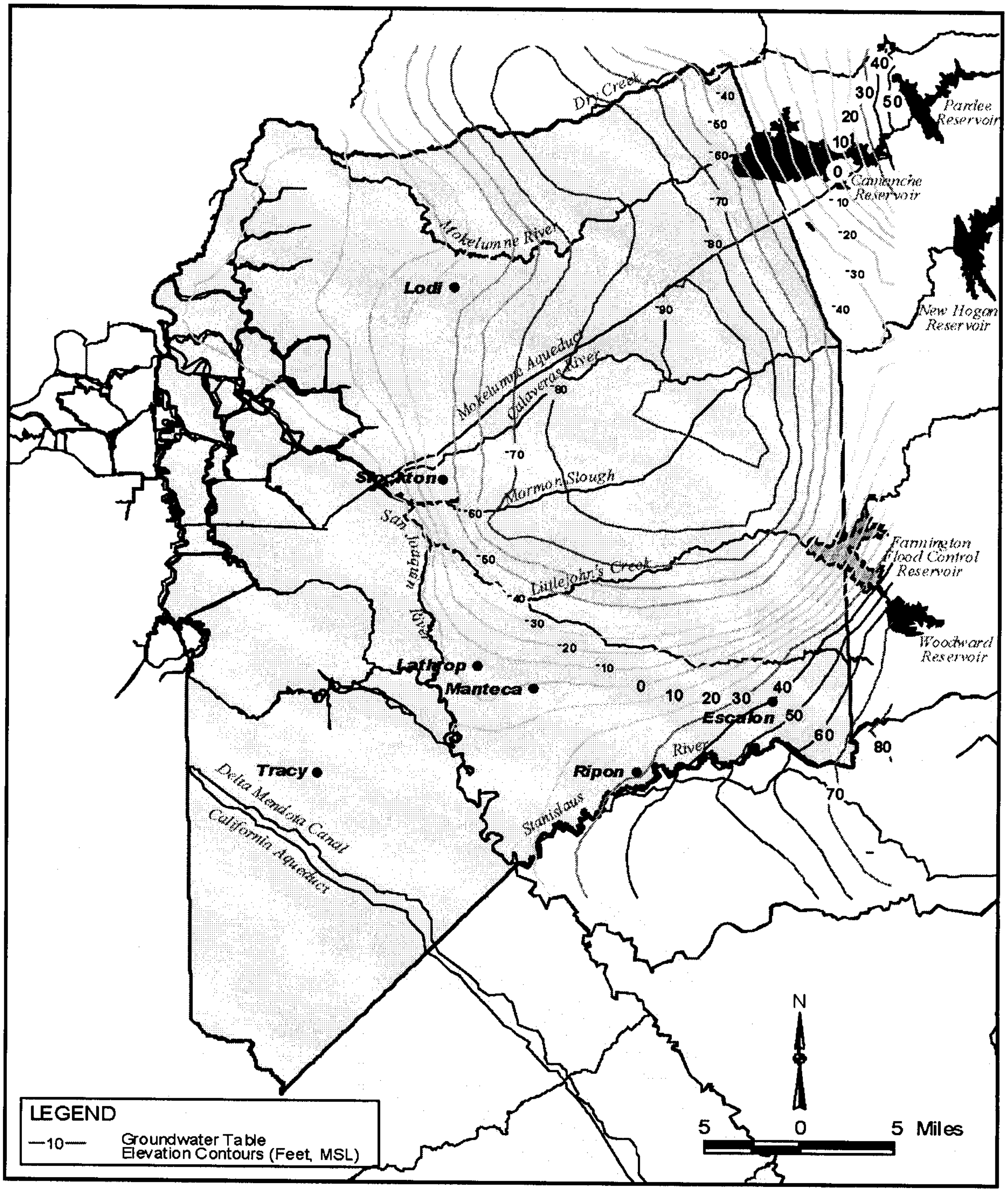

Figure ES-5 Simulated Groundwater Levels Under Baseline Conditions
Source: Camp Dresser & McKee Inc.

Table ES-6 Groundwater Option Comparisons

Option Type	Recharge Method	Improvement Costs ($/af)	Infrastructure Requirements	Land Requirements	Effectiveness	Operation/ Maintenance
Surface Supply Options	Wet Year Flows	~$500	On or off-stream regulating reservoir	Extreme for new reservoir	Very effective based on reservoir size and frequency	Very high requirements
	Water Transfers - Out of Basin	$200-400	Conveyance and storage	Potentially land intensive	Effective based on quantity of water and agreement duration	Varies with infrastructure requirements and year to year availability
	Area of Origin Priority	$0-$350	Use of existing or new infrastructure	Potentially land intensive	Very effective	Varies with infrastructure requirements
	Reservoir Re-operation	~$100	Use of existing infrastructure and storage	Minimal	Less effective	Minimal based on existing facilities
	Water Transfers - In Basin	~$100-$200	Minor conveyance	Minimal	Less effective	Varies with infrastructure requirements and year to year availability
Groundwater Recharge Options	Field Flooding	$50 - $100	Uses Existing Infrastructure	Uses seasonally fallow areas	Somewhat effective only available seasonally	Significant effort
	Spreading Basin/ Recharge Pond	$100 - $150	New Infrastructure	Requires relatively large dedicated areas	Potentially effective, requires detailed field testing	Significant effort
	Recharge Pit	$400 - $450	New Infrastructure	Requires dedicated areas	Potentially effective, requires detailed field testing	Significant effort
	Leaky Canal	Varies	New Infrastructure	Land intensive	Potentially effective, conveyance benefits	Significant effort
	Injection Wells	$150 - $200	New Infrastructure	Requires dedicated areas	Potentially effective, requires extensive well field	Significant effort
	Agricultural In-lieu	$200 - $250	New / Or Existing Infrastructure	Existing Land Use	Very effective based on quantity of water	Additional effort required by owner and district
	Urban In-lieu	~$250-$400	New / Or Existing Infrastructure	Existing Land Use	Very effective based on quantity of water	Requires treatment plant O&M costs
	Regional Groundwater Banking	$200-$300	New / Or Existing Infrastructure	Potentially land intensive	Very effective, financial assistance through third party	Significant effort
Other Options	Water Reclamation	$300-$500	Retrofit of existing facilities	Minimal	Less effective due to treatment costs and public perception	Requires treatment plant O&M costs
	Agricultural Water Conservation	$200-$250	New Infrastructure	Minimal	Potentially effective	Significant effort
	Urban Water Conservation	$200-$250	New Infrastructure	Minimal	Potentially effective	Minimal
	Crop Rotation/Land Fallowing	~$50	None	Potentially land intensive	Potentially effective if mitigated	Minimal

Source: San Joaquin County Water Management Plan Volume I
Farmington Groundwater Recharge and Seasonal Habitat Study

ES-9 Groundwater Contamination

Groundwater contamination and the continued degradation of groundwater quality is a global threat to all groundwater users. The Authority recognizes that the long-term sustainability of the underlying Basin cannot be accomplished without adequate groundwater quality protection, contamination prevention, and remediation programs. The Authority has discussed the issue of managing groundwater protection and contamination programs in Eastern San Joaquin County. A major concern of the Authority is that undertaking regulatory oversight will only duplicate the existing efforts of other regulatory agencies while financially burdening the community beyond its abilities. Increased coordination with regulatory agencies and a concerted effort to ensure its activities do not degrade water quality is potentially less resource intensive for the Authority and a more efficient method of protecting groundwater quality throughout the Basin. The Authority will continue to lead the pursuit against saline groundwater intrusion.

The following policies reflect the Authority's desire to address groundwater contamination and groundwater quality degradation:

1. Coordinate with local, State, and Federal agencies to ensure the underlying Basin is adequately protected against groundwater contamination and to ensure all contaminated sites are documented and mitigated by the responsible parties.

2. Continue to manage efforts to combat saline groundwater intrusion.

3. Strive to improve groundwater quality when technically and economically feasible. Authority actions degrading groundwater quality are not acceptable.

4. Require recharge projects to identify and evaluate impacts to groundwater quality and the potential for mobilization of soil and source water contaminants.

5. Consider current and future water quality standards in the planning and design of projects identified in this Plan.

ES-10 Groundwater Monitoring and Science Program

Since 1971, the San Joaquin County Flood Control and Water Conservation District (County) initiated the collection and management of groundwater data and the production of semi-annual groundwater reports. Currently, the County is undertaking the development of a Web-based interactive tool in order to make groundwater data collected over the years available to the public over the internet. The tool has been coined the San Joaquin County Groundwater Data Center (GDC). The GDC would become the repository for groundwater data and would facilitate groundwater analysis essential to the groundwater management objectives of San Joaquin County. The GDC is not only a technical tool, but also a public outreach tool as well. Through the internet, water users including County and agency staff, industry professionals, decision makers, and the general public will have access to groundwater data and historic semi-annual reports.

The overall goals and objectives of the GDC are:

1. Create and maintain a working groundwater database for San Joaquin County.
2. Develop the tools necessary to analyze groundwater data.
3. Make groundwater information available to decision makers, agency staff, and the general public through the internet.

4. Create an efficient and enforceable QA/QC plan.
5. Utilize the proven and supported technologies in groundwater monitoring, database management, and Geographic Information Systems (GIS).

The Authority and its member agencies are co-participants with the United States Geological Survey (USGS) and California Department of Water Resources (DWR) for the Groundwater Recharge and Distribution of High-Chloride Groundwater from Wells Study (Study). The purpose of the study is to quantify the source, aerial extent, and vertical distribution of high-chloride groundwater and the sources, distribution, and rates of recharge to aquifers along selected flow paths in Eastern San Joaquin County. The information gained from the Study will answer many questions with respect to future water levels, water quality, and storage potential under current and future management of the Basin. The total cost of the study is $2,579,350. The proposed USGS contribution will be $625,000 over 5 fiscal years as well as an additional $625,000 from the DWR over the first 3 fiscal years. Member agencies within the Authority will contribute the remaining $1,322,350 over next 5 fiscal years.

In order to ensure that groundwater data is collected in a systematic and consistent manner, the Authority has adopted the Groundwater Monitoring Program Quality Assurance/Quality Control (QA/QC) Plan, prepared by MWH in 1998. The QA/QC Plan addresses the following items: monitoring and sampling preparations, sample collection procedures, chain-of-custody procedures, sample transport, laboratory procedures and methods, and data validation and reporting. The QA/QC Plan can be obtained at the San Joaquin County Department of Public Works Stormwater Management Division. A revised QA/QC plan proposed as part of the GDC is expected to be completed by the Spring of 2005 ad subsequently adopted by the Authority Board.

ES-11 Financing Options

The development of new water supplies and the necessary infrastructure is a major financial undertaking. It is absolutely necessary for the Authority and its member agencies to leverage as much support for outside funding. The Plan provides a general overview of the potential funding sources, programs, and project partnerships available to the Authority from federal, State, and local sources.

ES-12 Plan Governance

Water interests in San Joaquin County have historically been fragmented, but have realized that projects developed in a collaborative process have the potential to exhibit greater and more far reaching benefits to all involved parties while increasing its implementability and fundability. Implementation of the water management options can best be achieved by continuing to work in a collaborative fashion to develop a broad base of political and financial support. The Authority has explored numerous options concerning the appropriate organization and powers needed to implement the plan and the best management framework that addresses the concerns of the Authority member agencies. Although no changes have been formally proposed to the powers and governance structure, the Authority could consider revisions in the future.

The Authority has served as a regional planning body and a forum for member agencies to share their groundwater management efforts and ensure that those efforts do not detrimentally affect other member agencies. In order to avoid potential conflicts between Basin stakeholders, the Authority employs the following policies:

- **Expanded Membership:** The membership in the Authority is diverse as are the challenges facing water Eastern San Joaquin County. In 2001, the Central Delta Water Agency and the South Delta Water Agency became full contributing and voting member agencies to the Authority. Associate membership (ex-officio) was also extended to the California Water Service and the San Joaquin Farm Bureau Federation as their input and support is essential to the success of the Authority. Other members have been contemplated such as SSJID, OID, City of Lathrop, Manteca, Escalon, and Ripon, Calaveras County Water District, Stanislaus County, DWR, Freeport Regional Water Authority, and EBMUD.

- **Continued Use of the Authority as a Forum:** As the Authority looks to implement the Plan, the member agencies will move the outlined projects through the planning, permitting, and design stages and ultimately to construction. In a forum, implementing member agencies will be able to quantify the benefits of its projects to stakeholders and receive comments and suggestions before disputes arise.

- **Continued Facilitation by the California Center for Collaborative Policy:** The California Center for Collaborative Policy (Center) has been an integral part to the success of the Authority's consensus based process. The Center's presence has maintained an atmosphere conducive to openness, compromise, and agreement. It is expected that the Center will continue to facilitate Authority meetings and throughout the implementation of the Plan.

ES-13 Integrated Conjunctive Use Program

The Integrated Regional Conjunctive Use Program is the key element in fulfilling the purpose of the Plan to ensure the sustainability of Groundwater resources in Eastern San Joaquin County. The Program is an inventory of viable options available to stakeholders in Eastern San Joaquin County as described by major supply elements, major surface storage and conveyance elements, and groundwater recharge components. Supply elements are grouped by river system and are a combination of reallocations, new water, and transfers. Entitlements to water are supported by legal claims based on existing water right permits, water service contracts and agreements, and pending water right applications. Major surface storage and conveyance elements are considered existing or proposed regional infrastructure intended for the capture and delivery of substantial amounts of water when available. Groundwater recharge components include groundwater recharge infrastructure improvements programs, drinking water treatment facilities, and incentive based agency conjunctive use programs. Table ES-7 describes each of the Integrated Conjunctive Use Program components.

The opportunity for groundwater banking partnerships in Eastern San Joaquin County is considered a viable alternative that creates new water. Groundwater banking is supported regionally and Statewide as an alternative means to new highly-contentious on-stream reservoirs and costly desalinization plants. The underlying Basin has the potential to store over 1 million acre-feet in close proximity to the Delta. The opportunities possible are a logical match for regional and Statewide interests to look to the Authority for groundwater banking opportunities. It is paramount to the Authority that banking rates, extraction rates, and quantities remain under local control.

Table ES-7 Integrated Conjunctive Use Program Elements

Supply Source	Water Rights and Contracts	Storage/Conveyance	GW Recharge
American River	• 350 cfs diversion at Freeport from Dec. 1 to June 30 • Currently limited to 155 cfs by EBMUD's pipeline • (Average Annual Yield = 44,000 af)	• Proposed Duck Creek Reservoir • SJC Freeport Interconnect • Alliance Canal • Freeport Regional Water Project	• Farmington Program • GW Recharge and Conjunctive Use • ASR Wells • Third Party Banking and Conjunctive Use Partnerships
Mokelumne River	• 1000 cfs diversion to storage Dec. 1. to June 30 • 620 cfs direct diversion • (Average Annual Yield = 60,000 - 100,000 af) • 39,000 to 60,000 af to WID • 20,000 af to NSJWCD subject to others • (Average Annual Yield = 11,000 af)	• MORE WATER Project Tunnel and Pipeline • MORE WATER Project Lower River Diversions • Woodbridge Dam Replacement and Existing Canal System • Existing South System and North System Rehabilitation • NSJWCD - Bear Creek, Pixely Slough, Paddy Creek, Gill Creek • Alliance Canal	• Proposed Duck Creek • Lodi Recharge or use of 6,000 af transfer • Farmington Program • In-lieu and direct recharge by Districts • Third Party Banking and Conjunctive Use Partnerships • ASR Wells
Calaveras River	• 100,000 af 56.5% to SEWD and 43.5% to CCWD • By agreement, SEWD is allowed to utilize CCWD unused supply • 13,000 ac-ft riparian demand	• Peters Pipeline • Mormon Slough • Alliance Canal • South Gulch Reservoir	• Farmington Program • Treatment Plan Expansion - Urban In-lieu • In-lieu and direct recharge • SJAFCA and Other Storm Water Detention Ponds • Third Party Banking and Conjunctive Use Partnerships
Stanislaus River	• 155,000 af contract to SEWD/CSJWCD • 75,000 af interim to SEWD • 49,000 af firm and <31,000 ac-ft interim to CSJWCD • 320,000 af (In San Joaquin County) • 34,000 af (South County Project In-basin delivery) • 30,000 af transfer to SEWD	• Peters Pipeline • CSJWCD - Lone Tree, Duck Creek, Temple Creek, Littlejohns Creek • Alliance Canal • South County Water Supply Project	• Farmington Program • Treatment Plant Expansion • Lathrop, Manteca, and Escalon In-lieu • In-lieu and direct recharge • SJAFCA and Other Storm Water Detention Ponds • Third Party Banking and Conjunctive Use Partnerships
Littlejohns Creek and Rock Creek	• 250,000 af Dec. 1 to April 30 • 60,000 af direct diversion • 190,000 af to storage • (Average Annual Yield = 15,000 af)	• Farmington Canal • CSJWCD - Lone Tree, Duck Creek, Temple Creek, Littlejohns Creek • Alliance Canal • Farmington Canal to South Gulch • Lyons Dam Project	• Farmington Program • CSJWCD Surface Water Incentive Program • In-lieu and direct recharge by Districts • Third Party Banking and Conjunctive Use Partnerships • SJAFCA and SJCOG Storm Water Detention Ponds
Delta	• City of Stockton Delta Water Supply Project • Initially 20,000 af increasing to 125,900 af in 2050 • (Average Annual Yield = 60,000 af)	• Pipeline and Treatment Facility	• Stockton In-lieu and ASR Wells • Third Party Banking and Conjunctive Use Partnerships • Farmington Program

The San Joaquin Groundwater Export Ordinance (Export Ordinance) is purposefully and notoriously stringent in order to protect local groundwater users from groundwater exports. San Joaquin County Board of Supervisors has continually stated that they are willing to amend the Export Ordinance should a project be proposed that can demonstrate local benefits with minimal risk to losing local control of the Basin.

Banking partnerships could provide the Authority with capital to fund portions of Integrated Conjunctive Use Program envisioned above. Conceptually, the Authority could employ various arrangements for the ranging from water storage agreements, surface water transfers/groundwater substitution, and a 'two for one' storage/extraction concept. Potential partners that have shown interest are EBMUD, Metropolitan Water District of Southern California, DWR, CALFED Environmental Water Account, and the City of Tracy. Entities have purchased raw water from other groundwater banks throughout the State at rates upwards of $420/af.

ES-14 Plan Implementation

The Authority is committed to adopting a Plan implementation strategy that is adaptive and incentive driven. This Plan is the first step in the development of a regional document that details how the groundwater basin will be managed and initiates the process that will ultimately define the guidelines and conditions that water districts and others will follow to achieve basin management objectives. Following the adoption of this Plan, the Authority and its members will work to implement the management objectives. The objectives coupled with regular groundwater monitoring and the development of basin operations criteria will establish a framework and the foundational information for future groundwater banking and recharge project operations in the Basin.

To encourage the continued implementation of the Plan, the Authority will complete a periodic assessment of the progress, direction and recommendations regarding Plan objectives. Basin conditions are currently measured by groundwater level and quality monitoring on a semi-annual basis. This assessment activity will be coupled with the annual review of Plan implementation activities and project development in the basin.

To ensure that the Authority is constantly striving to better manage groundwater resources, the following actions will be undertaken:

1. An annual report by March 1st of each year that outlines the accomplishments of the previous year's groundwater management efforts and report the current state of the Basin,

2. A review of the political, institutional, social, or economic factors affecting groundwater management, and

3. Based on the information gained in the above actions, recommendations for any required amendments to the Plan.

ES-15 Future Activities

The adoption of the Plan is merely the beginning of a series of actions the Authority will undertake to help meet future basin demands. As such, many of the identified actions will likely evolve as the Authority takes a more active approach to manage the Basin and meet the outlined objectives. Many additional actions will also be identified in the annual summary report described above. The Plan is therefore intended to be an iterative document, and it will be important to evaluate all of the actions and objectives over time to determine how well they are meeting the overall goal of the plan. The Authority plans to evaluate this entire plan within five years of adoption. In the immediate future, the Authority and its member agencies will undertake the following planned activities described below subsequent to the adoption of the Plan.

Integrated Conjunctive Use Program CEQA Review

The California Environmental Quality Act (CEQA) allows agencies to prepare a Programmatic Environmental Impact Report (EIR) for a proposed course of action. The Integrated Conjunctive Use Program is a grouping of stand alone projects that could have very different specific environmental impacts, but would also have to address many of the same global environmental impacts requiring disclosure under CEQA. The Program EIR will support the implementation of future site-specific projects by:

- Allowing proper consideration of broader scale impacts, alternatives, and mitigation criteria that would extremely difficult in individual site-specific project level EIR.
- Focusing on cumulative impacts and growth inducing impacts with the implementation of the Conjunctive Use Program.
- Addressing policy, design, and management issues at the program level rather than repeatedly considering them at the project level.
- Considering broad policy alternatives and programmatic mitigation measures at an early stage in the development of the Conjunctive Use Program when policy flexibility is greatest.
- Conserving resources and promoting consistency by encouraging the reuse of data.
- Providing the basis for National Environmental Policy Act (NEPA) review and Federal permitting approval processes should federal interest be established in the Conjunctive Use Program or any of the Program elements.

The Program EIR would also include a healthy technical appendix that would speak to the feasibility of specific project in the Conjunctive Use Program, demand management measures, and other policy alternatives. The Program EIR will also analyze the potential environmental effects of the Basin Management Objectives, assumptions and technical methods, policy alternatives to achieving identified objectives, broad-scale impacts, and establish mitigation criteria for the overall Plan. The Program EIR effort is expected to begin in 2005 and continue for 18 to 24 months

Basin Operations Criteria

Originally tied to the development of Basin Management Objectives, Basin Operations Criteria would set quantitative target groundwater levels and descriptive basin condition levels. Basin Operations Criteria could potentially consist of a series of groundwater levels that would correspond to basin condition levels (similar to the US EPA Air Quality Index and the US Department of Homeland Security Advisory System) to indicate the effectiveness of groundwater recharge programs and also potentially when and how much groundwater could be exported. The development of Basin Operations Criteria is a collaborative process that will be undertaken by the Authority immediately following the adoption of the Plan and is expected to be completed by summer 2005. Basin Operations Criteria developed with the framework of the Authority could ultimately provide the basis for a revised Export Ordinance and a new Groundwater Management Ordinance.

A G R E E M E N T

THIS AGREEMENT, made and entered into this 11th day of October, 1963, by and between EAST BAY MUNICIPAL UTILITY DISTRICT, a municipal utility district of the State of California, hereinafter referred to as "EAST BAY", and NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT, a water conservation district of the State of California, hereinafter referred to as "NORTH SAN JOAQUIN",

WITNESSETH:

WHEREAS, EAST BAY is the owner and operator of Pardee Reservoir on the Mokelumne River in Amador and Calaveras Counties, California, and is constructing Camanche Reservoir on said river below Pardee Reservoir and will operate said reservoirs for the appropriation of the water of said river under EAST BAY'S Permits from the State of California;

WHEREAS, NORTH SAN JOAQUIN intends to temporarily appropriate water of the Mokelumne River;

WHEREAS, upon completion of the proposed Folsom South Canal by the U. S. Bureau of Reclamation, NORTH SAN JOAQUIN proposes to obtain its required supplemental supply of water by the use of American River water from said Folsom South Canal under contract with the Bureau of Reclamation, and thereupon NORTH SAN JOAQUIN plans to abandon its appropriation of water from the Mokelumne River; and

WHEREAS, from time to time and pending the time when NORTH SAN JOAQUIN will obtain its required supply of supplemental water from the Folsom South Canal, there may be available in said Pardee Reservoir or said Camanche Reservoir, when completed, or in both said reservoirs, space for the storage of Mokelumne River water which could be temporarily appropriated by NORTH SAN JOAQUIN;

NOW, THEREFORE, in consideration of the mutual covenants and agreements hereinafter stated, the parties hereto agree as follows:

1. Subject to the provisions of this Agreement, EAST BAY shall, during the life of this Agreement, collect and store for the account of NORTH SAN JOAQUIN, in such space as may be available for that purpose in EAST BAY'S Pardee Reservoir or Camanche Reservoir, when completed, or in both said reservoirs, not to exceed 20,000 acre feet of water from the Mokelumne River which NORTH SAN JOAQUIN may be entitled to divert and store under the terms of Permit 10477 during each storage season, said season to consist of the period commencing on December 1st of each calendar year and ending on July 1st of the succeeding calendar year.

2. EAST BAY shall keep full and complete records of the quantities of water stored for the account of NORTH SAN JOAQUIN as aforesaid, and shall notify NORTH SAN JOAQUIN in writing on or before the 15th day of each calendar month during the period commencing on March 1st and ending on October 31st of each calendar year of the quantity of water so stored for and available for release to NORTH SAN JOAQUIN during the succeeding calendar month.

3. NORTH SAN JOAQUIN shall notify and direct EAST BAY in writing on or before the 24th day of each calendar month during the period commencing on March 1st and ending on October 31st of each year of the quantity of water to be released during the succeeding calendar month by EAST BAY from water collected and stored for the account of NORTH SAN JOAQUIN as aforesaid, and of the uniform rate at which such release is

to be made by EAST BAY during said succeeding calendar month. Said uniform rate shall not exceed 100 cubic feet per second and the total quantity to be so released shall not exceed the total quantity to be collected and stored as provided in Paragraph 1 above.

4. Subject to the provisions of this Agreement, EAST BAY shall release from said reservoir or reservoirs such quantity of water and at such a uniform rate as has been directed to be released by NORTH SAN JOAQUIN as provided in Paragraph 3 above. Each such release shall be made by EAST BAY into the natural channel of the Mokelumne River at a point immediately downstream from said Camanche Dam. In any calendar month upon the written request of NORTH SAN JOAQUIN, EAST BAY shall change the rate of release of such water from the rate previously established in the manner provided in Paragraph 3 above; provided, however, that such written request shall be delivered to EAST BAY at least eight days prior to the date the change of rate of release is desired by NORTH SAN JOAQUIN, that not more than one such request shall be made by NORTH SAN JOAQUIN in any one calendar month, and that the changed rate of release shall be subject to the limitations otherwise provided in this Agreement relative to release of water for use by NORTH SAN JOAQUIN. The parties hereto may also mutually agree from time to time as to other changes in the rates of release of such water.

5. NORTH SAN JOAQUIN shall accept for its use at the point of release specified in Paragraph 4 above, and shall compensate EAST BAY in the manner hereinafter provided for, all such water released at said point. NORTH SAN JOAQUIN shall assume full responsibility that the water so released by EAST BAY at said point of release reaches the pumps or other diversion facilities of NORTH SAN JOAQUIN.

6. NORTH SAN JOAQUIN shall pay monthly to EAST BAY at its offices at 2130 Adeline Street, Oakland, California, the sum of TWO DOLLARS ($2.00) for each acre foot of water released for NORTH SAN JOAQUIN during the preceding calendar month, pursuant to the provisions of this Agreement, to compensate EAST BAY for the use of its reservoirs. Statements covering such water shall be rendered by EAST BAY monthly and each such statement shall be paid as aforesaid by NORTH SAN JOAQUIN within thirty days after it is so rendered.

7. NORTH SAN JOAQUIN shall install and maintain an accurate measuring device, satisfactory to EAST BAY, in the diversion facility or facilities of NORTH SAN JOAQUIN at its point or points of diversion of water from the Mokelumne River in order to measure continuously the quantity of water so diverted by it, and shall furnish to EAST BAY monthly, or otherwise upon reasonable request, a full and complete record of such diversions. The original cost of acquiring and installing the measuring device shall be immediately credited against water charges due to EAST BAY under the agreement until said credit is exhausted. Subsequent maintenance and operation costs of the device shall be borne by NORTH SAN JOAQUIN.

8. EAST BAY shall, in its sole judgment and discretion, determine whether space is available in said reservoirs for the collection and storage of water for NORTH SAN JOAQUIN, and whether the flow of the Mokelumne River into said reservoirs is sufficient in quantity from time to time to entitle NORTH SAN JOAQUIN to store water under the provisions of Permit 10477 and this Agreement.

9. EAST BAY shall be released from all liability under this Agreement to collect, store or release water for NORTH SAN JOAQUIN hereunder, if hindered or prevented from so doing

by acts of God, accident, fire, flood, suits, proceedings, judgments, decrees, or orders of courts or governmental agencies, or by any other cause beyond the control of EAST BAY.

10. EAST BAY shall at no time be required hereunder to release water for NORTH SAN JOAQUIN in excess of the amount collected and stored for NORTH SAN JOAQUIN during the preceding storage season, as defined in Paragraph 1 above, or to release water hereunder after November 30th following the end of said storage season, or to release water hereunder which has been collected and stored during a prior storage season.

11. NORTH SAN JOAQUIN, as a result of State Water Rights Board Decision D858, July 3, 1956, is entitled to temporarily appropriate, in accordance with Section 1462 of the California Water Code and its Permit 10477, certain excess over and above the quantity applied to beneficial use from time to time by EAST BAY. This Agreement shall at all times be subordinate to prior rights of EAST BAY to divert from the Mokelumne River and to store in its present and prospective reservoirs such quantities of water from time to time as are necessary for present or prospective use of EAST BAY and its consumers or in the proper operation of its facilities to supply such use. This Agreement does not, and is not intended to, in any manner affect the right of either party hereto to divert water from the Mokelumne River not stored under the terms of this Agreement and which the respective parties are entitled to divert and use under, pursuant and subject to existing permits, state and federal laws and the rules and regulations of governmental agencies.

12. Promptly upon execution of this Agreement NORTH SAN JOAQUIN will prepare, cause to be filed and processed with the State Water Rights Board, a petition to change the point of diversion under its Permit 10477 to allow NORTH SAN JOAQUIN

to store in Camanche and/or Pardee Reservoirs of EAST BAY, instead of in the Mehrton Reservoir described in NORTH SAN JOAQUIN'S Application 12842, waters which are subject to appropriation by NORTH SAN JOAQUIN under its Permit 10477. EAST BAY shall not be obligated to store or release any water hereunder to NORTH SAN JOAQUIN until Permit 10477 is amended by the State Water Rights Board in the particulars aforesaid.

13. This agreement shall also be subordinate to the prior or vested rights of third parties or persons to the use of water from the Mokelumne River.

14. This agreement shall become effective on the date hereof and shall continue thereafter until such time as NORTH SAN JOAQUIN could receive, or commences to receive, its supplemental supply of water from Folsom South Canal, or until such time as EAST BAY determines that its increasing needs for water of the Mokelumne River do not permit the further collection and storage of water hereunder for NORTH SAN JOAQUIN, and may be terminated upon the happening of any of said occurrences by at least twelve months' advance written notice given by either party to the other. Unless so terminated this Agreement shall continue in effect thereafter until terminated at any time by at least twelve months' written notice given by either party to the other.

15. NORTH SAN JOAQUIN hereby waives and releases EAST BAY from any liability of EAST BAY to compensate NORTH SAN JOAQUIN under Section 1463 of the Water Code of the State of California, or any amendments thereof, for any facilities provided by NORTH SAN JOAQUIN to take, convey or store water collected, stored or released by EAST BAY under this Agreement.

16. NORTH SAN JOAQUIN agrees to indemnify and hold EAST BAY harmless from and against any and all costs, claims,

judgments, demands, actions, suits or any other liability arising out of or in connection with the release of water by EAST BAY under this Agreement, except acts of negligence and wilful misconduct on the part of authorized agents and employees of EAST BAY.

17. Neither this Agreement nor any of the rights of the parties hereunder shall be assigned or transferred by either of the parties without the prior written approval of the other party.

18. Any notices or communications required to be given or served hereunder by one party to the other shall be deemed to be properly given or served if sent by United States mail with postage prepaid; if to EAST BAY, addressed to its General Manager, 2130 Adeline Street, Oakland, California; and if to NORTH SAN JOAQUIN, addressed to 228-230 West Pine Street, Lodi, California.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement, in duplicate, the day and year hereinabove first written, by their respective officers thereunto authorized by resolution of the respective Boards of Directors of said parties.

EAST BAY MUNICIPAL UTILITY DISTRICT

By [signature]
President

By [signature: John F. Plumb]
ASSISTANT Secretary

NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT,

By [signature: Robert L. Carter]
President

By [signature]
Secretary

SUPPLEMENTARY AGREEMENT

This Supplementary Agreement, made this 27th day of May, 1969, between EAST BAY MUNICIPAL UTILITY DISTRICT, a public corporation of the State of California, hereinafter called "EAST BAY", and the NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT, a water conservation district of the State of California, hereinafter referred to as "NORTH SAN JOAQUIN".

W I T N E S S E T H:

WHEREAS, the parties have heretofore entered into an agreement dated October 11, 1963, hereinafter referred to as the 1963 agreement, relative to the storage and release of water of the Mokelumne River by EAST BAY for subsequent diversion and use by NORTH SAN JOAQUIN, and

WHEREAS, practical difficulties have arisen in carrying out the procedure set forth in the 1963 agreement for scheduling and ordering the release of water from EAST BAY reservoirs for use by NORTH SAN JOAQUIN, and the parties hereto desire to establish a more workable arrangement for releasing water without in any way altering the fundamental objectives of the 1963 agreement or the respective rights and obligations of the parties determined thereby, and

WHEREAS, EAST BAY and NORTH SAN JOAQUIN desire to supplement and modify said 1963 agreement in the particulars hereinafter set forth,

NOW, THEREFORE, in consideration of the mutual covenants and agreements hereinafter stated, the parties hereto agree as follows:

1. The written agreement between EAST BAY and NORTH SAN JOAQUIN dated October 11, 1963 is not canceled or superseded by this Supplementary Agreement but shall remain in full force and effect between the parties except as herein modified or supplemented. In the event that this Supplementary Agreement is later terminated in whole or in part for any reason, the 1963 agreement insofar as it is affected by this Supplementary Agreement or by the part of the latter so terminated shall be restored to the effective status it occupied prior to the execution of this Supplementary Agreement.

2. Paragraph 2 of the 1963 agreement is amended to read as follows: EAST BAY shall keep full and complete records of the quantities of water stored in its reservoirs for the account of NORTH SAN JOAQUIN, and upon request at any reasonable time shall inform NORTH SAN JOAQUIN of the quantity of water so stored.

3. Paragraph 3 of the 1963 agreement is amended to read as follows: NORTH SAN JOAQUIN hereby directs EAST BAY to release water collected and stored by it for use by NORTH SAN JOAQUIN in accordance with the following procedure:

a. On or before January 15 of each year, EAST BAY shall furnish in writing to NORTH SAN JOAQUIN a tabulation of the total annual and monthly quantities in acre-feet of water diverted from the Mokelumne River by NORTH SAN JOAQUIN during the preceding calendar year.

b. On or before February 15 of each year, NORTH SAN JOAQUIN shall notify EAST BAY of the quantity of water in acre-feet which it wishes to divert each month during the remainder of the calendar year, and shall request EAST BAY to store a sufficient quantity of water in its reservoirs for later release to satisfy the requirements of NORTH SAN JOAQUIN at times when the flow of the Mokelumne River is insufficient to satisfy them by direct diversion from said flow without interference with the rights of others. If by March 1 NORTH SAN JOAQUIN fails to so notify and request EAST BAY, EAST BAY shall act upon the assumption, until notified to the contrary, that it is the intention of NORTH SAN JOAQUIN to divert each month during the remainder of the calendar year the same quantities of water which were diverted by it during the corresponding month of the preceding calendar year. All releases of water from storage by EAST BAY shall be at a uniform rate during the month, except as otherwise arranged pursuant to the provisions of Paragraph 4. Said uniform rate shall not exceed 100 cubic feet of water per second and the total quantity to be so released from storage by EAST BAY shall not exceed the total quantity to be collected and stored as provided in Paragraph 1.

c. The quantity of water to be released by EAST BAY each month from storage, for which EAST BAY is to be compensated pursuant to the provisions of Paragraphs 5 and 6 hereof, shall be deemed to be the quantity of water actually diverted by NORTH SAN JOAQUIN during said month, multiplied by the percentage set forth in the following tabulation for the particular month and for the applicable streamflow condition.

PERCENTAGE OF ACTUAL TOTAL NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT DIVERSION TO BE CONSIDERED AS STORED WATER TO BE PAID FOR

STREAMFLOW CONDITION	MAR 31 OR PRIOR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV 1 OR AFTER
39% or below	97	100	100	100	100	100	100	68	70
40- 59	60	97	100	100	100	100	100	68	19
60- 79	14	88	52	53	100	100	98	40	5
80- 99	2	48	33	18	100	100	98	26	0
100-119	0	16	8	0	100	100	95	19	0
120-139	0	0	0	0	82	100	88	14	0
140-159	0	0	0	0	55	99	81	10	0
160% or above	0	0	0	0	10	95	71	5	0

d. The applicable streamflow condition referred to in sub-paragraph c. above shall be the percentage of unimpaired normal runoff of the Mokelumne River at Mokelumne Hill (inflow to Pardee Reservoir) for the period of April through July, as of the most recent forecast published by the State of California, Department of Water Resources. During the month of August of each year, EAST BAY shall prepare an estimate of the actual streamflow condition for that year, based on available U. S. Geological Survey records and other data available to EAST BAY, and if this estimate differs from the forecasts of the State of California to such an extent that the charges for water would be affected, EAST BAY, in rendering statements of charges for water pursuant to paragraph 6, shall make an appropriate adjustment of water charges for the year in accordance with said estimate. In the event that such an adjustment shows there has been an overpayment by NORTH SAN JOAQUIN for water furnished during the period for which the adjustment was made, EAST BAY shall promptly refund to NORTH SAN JOAQUIN the amount of said overpayment. In the event that such an adjustment shows there has been an underpayment by NORTH SAN JOAQUIN for water furnished during the period for which the adjustment was made, NORTH SAN JOAQUIN shall promptly remit the amount of said underpayment.

4. The water charges heretofore rendered by EAST BAY for service in calendar years 1967 and 1968 shall be recalculated and statements to NORTH SAN JOAQUIN resubmitted on the basis of the method prescribed in this Supplementary Agreement.

IN WITNESS WHEREOF, the parties hereto have executed this Supplementary Agreement, in duplicate, the day and year hereinabove first written, by their respective officers thereunto authorized by resolution of the respective Boards of Directors of said parties.

EAST BAY MUNICIPAL UTILITY DISTRICT

By [signature]
President

By [signature]
ASSISTANT Secretary

NORTH SAN JOAQUIN WATER CONSERVATION DISTRICT

By [signature: Robert L. Carter]
President

By [signature]
Secretary