GROUNDWATER AND SURFACE WATER INTERACTION (GSWI) STUDY FOR UPPER SANTA CLARA RIVER CHLORIDE TMDL

STAFF REPORT

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD - LOS ANGELES REGION

September 16, 2008

Executive Summary

The Upper Santa Clara River (USCR) Chloride Total Maximum Daily Load (TMDL) became effective on May 5, 2005. The TMDL includes special studies to determine the chloride threshold for salt-sensitive crops and the chloride loading from surface water to underlying groundwater basins. The TMDL also includes Los Angeles Regional Water Quality Control Board (Regional Board) reconsideration of the TMDL schedule 12 months after the TMDL effective date based on results of the special studies. This Staff Report summarizes background information on chloride issues and the modeling results of TMDL-related activities in the USCR. It provides four compliance options for the TMDL Implementation Plan for Regional Board consideration and staff's recommended alternative.

The results of the Groundwater Surface Water Interaction (GSWI) study were used to initiate appropriate implementation activities for the TMDL. Based on the modeling results as provided in the reports of Task 2B-1 and Task 2B-2 of the GSWI Study, Staff finds that none of the simulated chloride concentrations derived from the proposed compliance options result in chloride concentrations less than the existing WQO of 100 mg/L in surface water at all times over 24-year simulation periods (2007-2030) and at all locations in Reaches 4B, 5 and 6. All of the predicted chloride concentrations in groundwater for all compliance options consistently met the existing WQO of 200 mg/L in groundwater of the Piru Basin except the area between Blue Cut and SCR-RF monitoring locations.

Staff finds that the predicted high chloride concentrations of 350 mg/L or greater exist in the alluvial groundwater with a thickness of 50-100 ft in the areas between Blue Cut and SCR-RF during drought periods for all proposed compliance options. The high chloride concentration in this area will migrate downstream through the pumping activity in the proposed extraction well locations for the Alternative Water Resource Management (AWRM) compliance option and will affect the chloride concentration of the mixed water with RO and then will affect the chloride concentration in SCR in Reach 4A.

Staff finds that the AWRM compliance option can produce better chloride concentration than other proposed compliance options during drought periods and the salt export capability of the AWRM compliance option will help achieve to substantially reduce the amount of chloride loading from salt-water intrusion in the Oxnard Plain.

Staff finds that the Advanced Treatment and Brine Disposal Compliance Option can not result in full attainment of the 100 mg/L WQO for the USCR at Blue Cut at all times and in all locations of the receiving water. In addition, other compliance options like conveying all recycled water discharges from the Valencia and Saugus WRPs to the ocean outfall (Zero Discharge Compliance Option), limiting discharges from the WRPs and conveying the balance of WRPs recycled water discharges to ocean outfall (Minimal Discharge Compliance Option), and moving the discharge location of WRPs to the beginning of Reach 7 near Lang gauge (Alternative WRP Discharge Location

Compliance Option) are also not likely to achieve attainment of the existing 100 mg/L WQO at all times and all locations.

Staff notes that an alternative compliance option is required to achieve the site specific objectives (SSOs) when the original proposed compliance options were not able to achieve the existing WQO of 100 mg/L. Staff also notes that the SSOs shall be carefully evaluated based on the GSWI model results of different averaging periods to ensure they are fully protective of the agricultural beneficial uses in the study area.

Staff finds that the predicted chloride concentrations in both groundwater and surface water at Blue Cut were generally related to concentrations of chloride in the discharges to the SCR from the Saugus and Valencia WRPs.

Staff find that the GSWI model has been adequately calibrated by 88 groundwater level, 50 groundwater chloride, 6 streamflow, and 12 surface-water quality target locations that are spatially distributed throughout the GSWI domain and it has been considered as an appropriate model for groundwater and surface water interaction modeling purposes.

According to the modeling results, Staff recommends the AWRM compliance alternative. Staff finds that the remaining compliance options of advanced treatment and brine disposal alternatives will not result in full attainment of the 100 mg/L WQO for the SCR. Staff finds that the AWRM compliance alternative will result in timely attainment of the revised WQOs and reduce the chloride load to the USCR and underlying groundwater basins during the TMDL implementation period. Staff further finds that the AWRM will help provide enough mass loading to protect the SCR downstream from sea water intrusion.

Table of Contents

List of Acronyms

AGR – Agricultural Supply Beneficial Use
AWQC – Ambient Water Quality Criteria
AWRM – Alternative Water Resource Management
cfs – cubic feet per second
CLWA – Castaic Lake Water Agency
DWR – California Department of Water Resources
EIR – Environmental Impact Report
ESA – Extended Study Alternatives
ESP – Endangered Species Protection
GWR – Groundwater Recharge Beneficial Use
GSWI – Groundwater and Surface Water Interaction
GSWIM – Groundwater and Surface Water Interaction Model
LRE – Literature Review and Evaluation
MGD – million gallons per day
mg/L – milligrams per liter
MODHMS - Modular Hydrogelogical Model System
NPDES – National Pollutant Discharge Elimination System
OAL – Office of Administrative Law
ppd – pounds per day
RARE – Rare and Endangered Species Habitat Beneficial Use
RO – Reverse Osmosis
SCV – Santa Clarita Valley
SCVSD – Santa Clarita Valley Sanitation District of Los Angeles County
SCVJSS – Santa Clarita Valley Joint Sewerage System
SRWS – Self-Regenerating Water Softener
SSO- Site Specific Objective
SWP – State Water Project
SWRCB – State Water Resources Control Board
TAC – Technical Advisory Committee
TAP – Technical Advisory Panel
TDS – Total Dissolved Solids
TMDL – Total Maximum Daily Load
USACE – United States Army Corps of Engineers
USBR – United States Bureau of Reclamation
USCR – Upper Santa Clara River
USEPA – United States Environmental Protection Agency
USGS – United States Geological Survey
UWCD – United Water Conservation District
VCPWA – Ventura County Public Works Agency
VWC – Valencia Water Company
WARMF – Watershed Analysis Risk Management Framework
WLA – Waste Load Allocation
WQO – Water Quality Objective
WRP – Water Reclamation Plant

1. Introduction

The Los Angeles Regional Water Quality Control Board (Regional Board) adopted a total maximum daily load (TMDL) to address chloride impairments of the Upper Santa Clara River (USCR) on July 10, 2003 (Resolution 03-008). On May 6, 2004, the Regional Board amended the USCR chloride TMDL to revise the interim waste load allocations (WLAs) and implementation schedule (Resolution 04-004). The amended TMDL was approved by the State Water Resources Control Board (State Board), Office of Administrative Law (OAL) and United States Environmental Protection Agency (USEPA), and became effective on May 4, 2005.

The Santa Clarita Valley Sanitation District of Los Angeles County (SCVSD), along with their consultant team, CH2M HILL and HydroGeoLogic, Inc. (HGL) (CH2M HILL-HGL), and with input from the Regional Board, have developed a numerical model for a portion of the Santa Clara River (SCR) watershed, called the Groundwater Surface Water Interaction (GSWI) model. The overall purpose of the GSWI Study is to evaluate the fate and transport of chloride and total dissolved solids (TDS) in surface water and the groundwater basins underlying Reaches 4A and 4B, 5, 6, and 7 (as designated by the Regional Board) of the SCR in accordance with the chloride total maximum daily load (TMDL) collaborative process. This numerical model is a tool to improve the understanding of the interaction between surface water and groundwater and the linkage between surface-water quality and groundwater quality with respect to chloride and TDS.

The GSWI Study includes the following tasks:

- **Task 1A – Evaluate Existing Models, Literature, and Data** – Compile and evaluate available information from which to develop GSWIM. (CH2M HILL-HGL, 2006a).
- **Task 1B – Conduct Additional Studies/Monitoring and Enhance Monitoring Network, as Necessary** – Address data gaps identified in Task 1A and subsequent tasks.
- **Task 2A – Conceptual Model Development** – Use the information compiled in Tasks 1A and 1B to develop physical descriptions of the study area and processes governing the sources, fate, and transport of chloride and TDS (CH2M HILL-HGL,2006b).
- **Task 2B – Numerical Model Development and Calibration** – Develop a numerical model, initially based on the conceptual model described in the Task 2A report, calibrate numerical model to accurately represent both surface water and groundwater quality, and to simulate the historical water levels, flows, and concentrations and movement of chloride in surface water and groundwater in the study area from calendar years (CY) 1975 through 2005. Use the model to simulate potential chloride impacts from CYs 2007 through 2030 according to future water use and treatment assumptions. (CH2M HILL-HGL, 2008).

- **Task 3 – Public Review Strategy** – Ensure that GSWI Study information and analyses are made available to stakeholders in the SCR watershed (CH2M HILL-HGL, 2007b).
- **Task 4 – Reporting, Presentations, and Documentation** – Document and present information, analyses, and results of the GSWI Study and get appropriate input from the GSWI Technical Working Group, GSWI Modeling Subcommittee, GSWI Technical Advisory Panel, and other project stakeholders. Separate reports have been and will be prepared for Tasks 1A, 1B, 2A, 2B, and 3. A final summary report that addresses all tasks will be submitted at the end of the study.

GSWI determined the interaction between surface water and groundwater and the linkage between surface water quality and groundwater quality with respect to chloride and TDS. The model assessed the assimilative capacity of the surface water and groundwater system(s) within Reaches 5 and 6 (in Santa Clarita), and in Piru Basin (a portion of Reach 4) in relation to existing Basin Plan WQOs for groundwater and surface water. Modeling the groundwater-surface water interactions determined the gradient of chloride concentrations from the Saugus and Valencia WRPs outfalls to downstream receiving water stations and assessed the impacts that the WRPs may have on underlying groundwater in the USCR.

Based on these studies, the Regional Board will consider whether revisions to the chloride water quality objectives (WQOs) or TMDL schedule, or establishment of a site-specific objective (SSO) are warranted.

This Staff Report provides staff's review of the GSWI study report, staff's findings about the model results of all proposed compliance options and staff's recommendation for the TMDL implementation plan.

In combination with the results of the other TMDL studies, the GSWI provided compliance information to assist the Regional Board in consideration of a site-specific chloride objective for the USCR that is protective of surface and groundwater resources.

This Staff Report is organized under seven headings: Background, Technical Advisory Panel, Model Selection and The Model Selected, Data Gaps and Additional Sampling Data, Key Issues, Model Setup and Model Calibration, Potential Compliance Options and Model Results. Background provides a description of the Santa Clara River watershed, an overview of chloride issues in the USCR, and a brief summary of regulatory history. The remaining Sections include the description of the Technical Advisory Panel, model selection and the model selected for the GSWI Study, data gaps and additional data required for the model, and potential compliance options simulated by the model and the model results. Finally, Staff provides the findings of the model results for all proposed compliance options and recommends a compliance option for the Regional Board's consideration for the USCR Chloride TMDL implementation plan.

2. Background

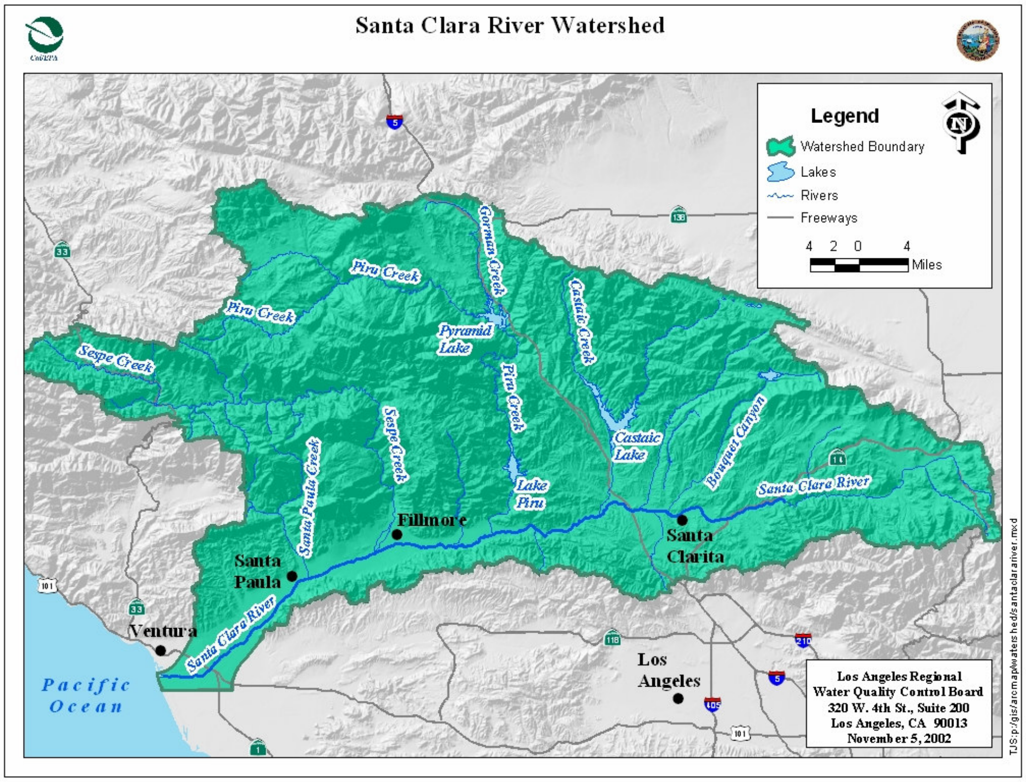
This section provides background information on chloride issues in the USCR watershed.

2.1. Environmental Setting

The Santa Clara River is the largest river system in Southern California that remains in a relatively natural state. The river originates on the northern slope of the San Gabriel Mountains in Los Angeles County, traverses Ventura County, and flows into the Pacific Ocean between the cities of San Buenaventura (Ventura) and Oxnard. Municipalities within the watershed include Santa Clarita, Newhall, Fillmore, Santa Paula, and Ventura.

Extensive patches of high quality riparian habitat exist along the length of the river and its tributaries. Two endangered fish, the unarmored stickleback and the steelhead trout, are resident in the river. One of the Santa Clara River's largest tributaries, Sespe Creek, is designated a wild trout stream by the state of California and a wild and scenic river by the United States Forest Service. Piru and Santa Paula Creeks, tributaries to the Santa Clara River, also support steelhead habitat. In addition, the river serves as an important wildlife corridor. The Santa Clara River drains to the Pacific Ocean through a lagoon that supports a large variety of wildlife.

The predominant land uses in the Santa Clara River watershed include agriculture, open space, and residential uses. Revenue from the agricultural industry within the Santa Clara River watershed is estimated at over $700 million annually. Residential use is increasing rapidly both in the upper and lower watershed. The population within the Santa Clarita Valley alone is expected to grow from 187,172 in 1998 (Santa Clarita Magazine, DDS Marketing) to more than 350,000 by 2025 (Santa Clarita Community Profile, SCAG).



The upper reaches of the Santa Clara River include Reaches 5 and 6, which are located upstream of the Blue Cut gauging station that lies west of the Los Angeles - Ventura County line between the Cities of Fillmore and Santa Clarita. The upper boundary extends to Bouquet Canyon, upstream of the City of Santa Clarita. Two major point sources, the Saugus and Valencia WRPs, discharge to the USCR.

2.2. Beneficial Uses and WQOs

Key beneficial uses and WQOs for the USCR are described in the Basin Plan and include agricultural supply (AGR), groundwater recharge (GWR) and rare and endangered species habitat (RARE). A full description of each of these beneficial uses is included in the Basin Plan. AGR is designated as existing or potential for all reaches of the Santa Clara River, including the USCR, except the headwaters. GWR is designated as an existing or potential beneficial use for the entire Santa Clara River. RARE is an existing and potential designated beneficial use for the upper reaches included in this TMDL. Two types of endangered and rare aquatic species are known to reside in the watershed: steelhead trout and unarmored three-spine stickleback.

The WQO for chloride in Reaches 5 and 6 of the Santa Clara River is 100 milligrams per liter (mg/L). The groundwater quality objectives for the Santa Clara – Piru Creek area are: 200 mg/L chloride in the Upper area (above Lake Piru), 200 mg/L in the Lower area east of Piru Creek, and 100 mg/L west of Piru Creek. The existing surface water WQO is within the guideline concentration range established by the LRE.

2.3. Regulatory History

The Regional Board adopted five resolutions that regulated chloride in the USCR, starting with Resolution 75-21 in 1975, which established WQOs throughout the region.

In 1990, the Regional Board adopted the Drought Policy, Resolution 90-04. This resolution was intended to provide short-term and temporary relief to dischargers who were unable to comply with limits for chloride due to the effects of drought on chloride levels in supply waters imported to the Region. The Regional Board temporarily reset limits on concentration of chloride at the lesser of: (i) 250 mg/L, or (ii) the chloride concentration of supply water plus 85 mg/L. The Regional Board renewed the Drought Policy in 1993 and again in 1995 because the chloride levels in supply waters remained higher than the chloride levels before the onset of the drought. The Regional Board did not revise the chloride WQO in the Santa Clara River and Calleguas Creek because of the potential to affect present and anticipated AGR.

In 1997, the Regional Board adopted the Chloride Policy, Resolution No. 97-02. The Chloride Policy revised the chloride objective for the Los Angeles River, Rio Hondo, and San Gabriel River. Due to concerns expressed about the potential for future adverse impacts to agricultural resources in Ventura County, WQOs for chloride in the Santa Clara River and Calleguas Creek were not revised. Rather, the chloride policy provided surface water interim limits of 190 mg/L in the Santa Clara River that extended for three years following approval of the amendment. The Regional Board did not revise the chloride WQO in the Santa Clara River and Calleguas Creek because of the potential to affect existing and anticipated AGR. Similarly, the Regional Board did not revise the groundwater objectives for chloride.

The Regional Board first adopted a TMDL for chloride in the USCR (Chloride TMDL) in October 2002 (Resolution No. 2002-018). The TMDL contained an 8-1/2 year implementation plan to attain chloride WQOs. Upon petition by SCVSD, the State Board remanded the Chloride TMDL (State Board Resolution No. 2003-0014) to the Regional Board in February 2003. In response to the remand, the Regional Board revised the TMDL Implementation Plan to extend the interim wasteload allocations and final compliance date to 13 years after the TMDL effective date. It also included two additional special studies and several mandatory reconsiderations of the TMDL by the Regional Board. The Regional Board adopted the revised TMDL in July 2003 (Resolution No. 2003-008).

The TMDL was amended in 2004 (Resolution No. 04-0004) to conform the interim wasteload allocations for the Saugus and Valencia WRPs to the effluent limits in 1994 Time Schedule Orders associated with National Pollutant Discharge Elimination System (NPDES) permits. In May 2004, the Regional Board and SCVSD signed a Settlement Agreement and Stipulation Concerning Chlorides in the UCSR. The Regional Board and SCVSD agreed that, if or when new or revised NPDES permits are subsequently issued to the Saugus or Valencia treatment plants prior to the date that a revised WQO or final wasteload allocations take effect in accordance with the Chloride TMDL Amendments, interim chloride effluent limitations reflecting the interim wasteload allocations in the TMDL, including any revisions thereto, will be included in the revised permits.

3. Technical Advisory Panel (TAP)

3.1 Purpose and Selection Criteria

The purpose of the GSWI Model TAP was to offer recommendations and provide objective review of the technical and scientific adequacy of the GSWI modeling work being. The TAP conducted a final peer review of study plans and recommendations and completed reviews for major documents and reports throughout the course of the study. The TAP served as a neutral panel of technical advisors and followed guidelines set up by the TMDL collaborative process to avoid any potential conflicts of interest.

The following criteria were applied when selecting members for the TAP:

- Panelists should have background and expertise in one or more of the following areas, such that the panel includes expertise in all of these areas: hydrology, hydrogeology, groundwater/surface water modeling and calibration, and statistical methods for hydro-geological applications. Also, it is highly desirable that the candidates have a high degree of proficiency in the development, use and application of numerical methods for the modeling of groundwater and surface water systems, and a proficient background in interpreting/evaluating hydrology, hydrogeology, geologic and groundwater quality data. Individual candidates should have at least 5 years experience in any of the identified areas of expertise. It is very important to select candidates that have technical and peer credibility and to ensure that the make up of the GSWI TAP represents all relevant areas of expertise required to review the scientific and technical information related to the development of a groundwater/surface water interaction model for the Upper Santa Clara River Watershed.

- In assessing an individual's qualifications for participation in the GSWI TAP, all relevant career experience, published papers, experience with implementation of laboratory recommendations in the field, and participation in professional societies shall be considered.

- The selected chair of the GSWI TAP should be experienced in conducting peer review activities and in convening and heading technical discussions and preparing critical review reports.

- Panelists shall have no vested interest in the outcome of the studies. It is important to ensure that the candidates have an absence of real or perceived conflict of interest and bias such that the panel, as a whole, is objective (and is perceived by stakeholders as objective). However, the desire to appear unbiased shall not be used as a reason to exclude local experts in the Santa Clara River Watershed.

- To the extent that different "schools of thought" on some of the technical issues are known to exist within the expert community, the panel should include representatives of different points of view so as to be "balanced."

- Panelists should be available to review, meet, discuss, confer and provide critical review of consultant's technical work products within the timeframe necessary to support the master project schedule.

- Panelists should be prepared to make a commitment to participate on the GSWI TAP for the duration of the project.

- Panelists should be available to meet 3-4 times during the project, and review relevant materials and reports.

3.2 List of TAP Members

The following individuals were members of the TAP:

Drew Ackerman: Scientific Modeler, Southern California Coastal Water Research Project

Arturo Keller: Associate Professor of Biogeochemistry, University of California, Santa Barbara

Mark Wildermuth: Principal, Wildermuth Environmental, Inc.

Dennis Williams: Principal, Geoscience Support Services, Inc.

4. Model Selection and the Model Selected

4.1 Model Selection

The analysis requirements of the groundwater-surface water model were as follows: (1) to determine the interaction between surface water and groundwater and the relationship between surface quality and groundwater quality with respect to chloride and TDS; (2) to determine the groundwater-surface water interactions for Reach 4, 5, and 6 of the USCR and assess the mixing, attenuation, and assimilative capacity of the surface water and groundwater systems in those reaches in relation to Basin Plan water quality objectives; (3) to determine chloride concentration gradients between WRP effluent discharge points and downstream receiving water stations under variable flow and water quality conditions as can occur with climatic/seasonal changes and under variable water quality of imported water supplies. A physically-based, spatially distributed model that can calculated flow and chloride/TDS levels on a discretized representation of the surface and subsurface domains was selected to meet the above analysis requirements.

The TMDL working group considered four different types of water quality models and selected the Modular Hydrogelogical Model System (MODHMS) because it is widely recognized, technically verified, USEPA & United States Army Corps of Engineers (USACE) endorsed, and its public domain/source code meets public access criteria. MODHMS is based on the MODFLOW code developed by the United States Geological Survey (USGS) and by extending HydroGeologic's MODFLOW-SURFACT subsurface modeling code to include overland and channel flow and transport.

Two firms, CH2M Hill and Geomatrix, were selected as consultants because each firm has extensive knowledge of the USCR. Staff notes that the selection of a GSWI consultant through a collaborative process took more time than originally allotted in the TMDL schedule.

4.2 The Model Selected

The MODHMS integrated surface/subsurface flow and transport modeling code was selected for this study. The model can simulate unconfined subsurface flow interacting with river/channel flow domain, with associated transport simulation capabilities within both subsurface and river/channel domains. Further, the model can handle drying, re-wetting of both subsurface and river/channel domains, to correctly evaluate the situation of interest for dry and wet weather conditions or dry and wet portions of the river reaches.

MODHMS is well documented and tested and has been applied for various flow and transport analyses of a similar nature as for the current study. The model has been verified and validated using strict procedures. MODHMS has been found wide acceptance for simulating surface/subsurface flow and transport problems by federal, state and local government agencies and by water resources modeling professionals with the US and worldwide including the USEPA, the Federal Energy Regulatory Commission (FERC), the US Army Corps of Engineers. Peer reviewed articles on the formulation, numerical implementation, verification and validation of MODHMS model have been published in professional journals. These publications demonstrate validation and use of MODHMS model.

5. Data Required and Additional Sampling Data for the Modeling

5.1 Data Required for the Modeling

To satisfy the modeling objectives, key data groups are required for the modeling. The key data group groups include the following:

1. Physical data, such as data relating to well locations and construction, stream gages, rainfall gages, geology and structure, stream channel characteristics, soil and aquifer properties, vegetation and land use, locations of septic

systems, stream diversion locations, locations of reservoirs and other significant surface-water bodies, and treatment plant locations.

2. Historical water quantity data, such as data relating to groundwater levels, streamflow, reservoir release to streams, treatment plant discharges to streams, rainfall, pumping, diversions from streams, and subsurface point discharges to septic systems.

3. Historical water quality data, such as data relating to chloride and TDS concentrations in groundwater, surface-water, and point discharges.

5.2 Additional Sampling Data for the Modeling

However, data were not sufficient for the modeling and data gaps were identified during the development of the model, which fall into the following three categories:

1. Data gaps associated with surface and subsurface characterization (e.g., aquifer properties and alluvial geometry at subbasin boundaries) within the GSWI study domain

2. Data gaps associated with water quantity (e.g., stream flow, diversions, groundwater levels, stage of surface water bodies, and groundwater use)

3. Data gaps associated with quality (e.g., chloride and TDS concentrations in surface-water, groundwater, and point source discharges, and the associated mass loading of chloride and TDS)

To fill data gaps, additional sampling was conducted to better understand and quantify actual conditions in this area such as alluvium geometry, groundwater levels, groundwater quality (specifically chloride and TDS), and aquifer properties.

Additional sampling data for the modeling included the following:

- Surface water quality sampling and flow measurement at six existing and two new locations along the USCR, including monthly sampling at the LACSD receiving water stations (RA, RB, RC, RD, RE, and RF) and the two new stations. The two new surface water stations were located in the East Piru area (near Camulos Ranch and Piru Creek) and near the Fillmore Fish Hatchery near the boundary of Reach 4 of the USCR.

- Groundwater quality and water level monitoring at eight existing and five new wells, with three new wells for the alluvium in Los Angeles County and two new wells were installed in the Piru Basin.

6. Model Setup and Model Calibration

6.1 Model Setup

6.1.1 Model Domain and Boundary

The GWSI model must use discretized grid-blocks of variable size to represent the USCR hydrologic system. It uses relatively small grid-blocks in key areas of the modeling domain, where more resolution in the numerical solution is desired, and larger gridblocks in areas of the modeling domain that are located away from the main areas of interest, and that are less critical to the evaluation of the overall field problem. This strategy seeks to maximize the resolution of the numerical solution in areas of interest within the modeling domain while minimizing model run times. The aerial and vertical characteristics of GSWIM's numerical grid are illustrated in Figure 6-1.

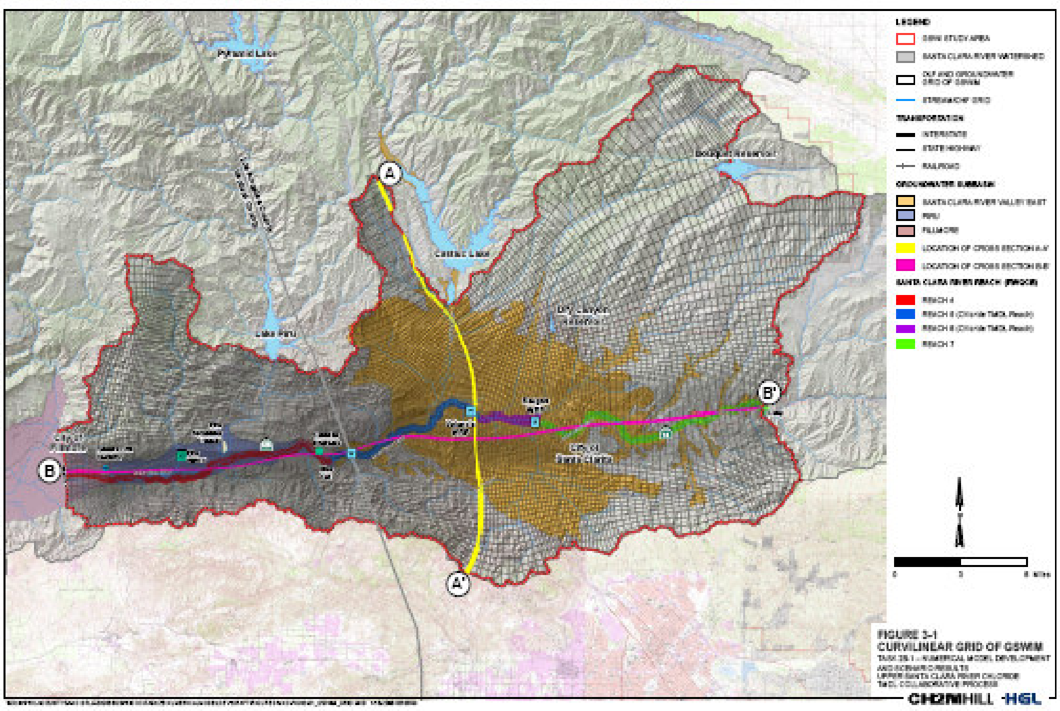


Figure 6-1 Computational Grid System and Model Domain of GSWI Model

The following subsections describe the basis for the locations and geometry of the GSWIM numerical boundary.

6.1.1.1 Western Boundary

At the GSWI TWG and Modeling Subcommittee meetings, it was agreed that the most downstream location at which GSWIM calibration will be focused will coincide with the Piru-Fillmore Subbasin boundary (as designated by USGS) in Reach 4 of the SCR. The Piru-Fillmore Groundwater Subbasin boundary is located in an area of significant groundwater pumping by local irrigators and from Fillmore Fish Hatchery operations. To simulate responses of groundwater levels to this nearby pumping in GSWIM and to minimize numerical model boundary effects at this location, the western numerical boundary of GSWIM was located farther downstream at the A Street bridge, which also marks the end of Reach 4 of the SCR.

6.1.1.2 Northern Boundary

A portion of the SCR watershed located north of Reaches 4, 5, 6, and 7 contains such features as surface-water reservoirs. The larger reservoirs include Bouquet Reservoir, Pyramid Lake, and Castaic Lake and Lagoon in Los Angeles County, and Lake Piru in Ventura County. These surface-water bodies accumulate water that drains from a large portion of the SCR watershed and, in some cases, serve as terminal reservoirs for the State Water Project (SWP). A detailed understanding of the hydrology in areas tributary to these reservoirs is not considered necessary for the GSWI Study because the timing, magnitude, and quality of water downstream of these reservoirs is controlled and measured. Therefore, to further refine the GSWIM domain, the areas upstream of Bouquet Reservoir, Pyramid Lake, Castaic Lake and Lagoon, and Lake Piru were not considered for the GSWI Study area; this is consistent with the approach taken by Systech Engineering (2002a and 2002b) during development of the Watershed Analysis Risk Management Framework (WARMF) model. Release and spill data from these reservoirs were used to account for streamflow and chloride entering the modeling domain at the respective locations.

6.1.1.3 Eastern Boundary

Reach 6 of the Upper SCR begins at the west pier of Bouquet Canyon Road in Los Angeles County, near the Saugus WRP. Selection of an eastern boundary for the GSWI study area considered the upstream distance and extent of the drainage area east of Reach 6, up to the headwaters of the Upper SCR, and the locations of stream gages in the Upper SCR upstream of Reach 6. The portion of the SCR watershed located east of the Lang community in Los Angeles County, where a USGS stream gage exists in the Upper SCR, was not considered for the GSWI study area. An eastern boundary that corresponds to the location of the Lang stream gage and also coincides with the beginning of Reach 7 is consistent with previous modeling of the region conducted by CH2M HILL (2004a, 2004b, and 2005). Streamflow data recorded at the Lang stream gage were used to account for streamflow and chloride entering the modeling domain from the Acton Subbasin of the SCR watershed, which is located east of this stream gage.

6.1.1.4 Southern Boundary

The southern boundary of GSWIM was extended to the southern boundary of the SCR watershed.

6.1.2 Areal Characteristics of Model Grid

A grid that mathematically represents a 418-square-mile area was developed with 271 columns and 111 rows. The grid's areal extent is illustrated on Figure 6-1. The domain boundaries, as shown on Figure 6-1, represent natural hydrologic divides around an area located downstream of three local surface-water reservoirs (Bouquet Reservoir, Castaic Lake and Lagoon, and Lake Piru).

6.1.3 Vertical Characteristics of Model Grid

GSWIM's grid is stacked into multiple layers to provide a three-dimensional representation of the surface and subsurface system. Nine subsurface layers consisting of 59,320 active subsurface nodes were used to discretize the subsurface. The top three layers represent the saturated and unsaturated portions of the Alluvium overlying the East, Piru, and Eastern Fillmore Subbasins. The exception to this is where Alluvium is absent within the East Subbasin; here, Model Layers 1 through 3 represent an upper portion of the Saugus Formation. Model Layers 4 through 9 were used to discretize the Saugus Formation in the East Subbasin, whereas Model Layers 4 and 5 were used to discretize the San Pedro Formation in the Piru and Eastern Fillmore Subbasins. Grid-blocks that generally lie outside the areas representing the groundwater subbasins were made inactive, so that the proper three-dimensional geometry of the groundwater subbasins was delineated with depth by the actively modeled grid system.

6.1.4 Initial Flow Conditions

The establishment of GSWIM as a predictive model necessitates establishment of initial conditions in the hydrologic system from which to simulate hydrologic conditions in a forward-in-time manner. Initial conditions, in this context, refer to the initial distribution of groundwater elevations, streamflow locations, and solute concentrations throughout the modeling domain that are representative of January 1975 (the beginning of the calibration period). Initial flow conditions for the calibration simulations were established in a "charge-up" simulation conducted prior to starting the transient calibration simulation. This involved simulating 1975 surface and subsurface flow conditions in a steady-state manner, and then qualitatively comparing the steady-state solution with conditions observed in the mid-1970s (e.g., groundwater levels and streamflow locations versus Dry Gap locations). Interception storage was disregarded for the steady-state simulation to allow rainfall and evapotranspiration to directly interact with the domain. The transport of chloride was also disregarded for the steady-state flow simulation. Local recharge values were adjusted within zones to give a good initial head match. The steady-state flow condition was then used for simulating transient conditions from calendar years 1975 through 2005.

6.1.5 Initial Chloride Conditions

The curvilinear grid used to simulate surface and subsurface flow was also used to simulate surface and subsurface chloride transport. Chloride transport was simulated under the assumption that chloride in the GSWI Study area is conservative (i.e., there is no sorption or decay of chloride). The initial chloride concentrations were obtained by examining and areally distributing chloride concentration data available from 1970 through 1978 and then modifying the distribution as part of the calibration process to improve the match between simulated and measured chloride concentrations.

6.1.6 Model Time Discretization

Time is continuous in the physical system, but a numerical model must use transient parameter values that describe the field problem at discrete time intervals. The durations of the time intervals were carefully selected for GSWIM in an attempt to input transient parameter values that represent time-continuous hydrologic processes and allow the model solution to be output at a time scale appropriate for the field problem being evaluated. Transient parameter values were discretized using monthly stress periods for the Water Supply System (WSS) variables, including groundwater pumping and imported water. Monthly stress-period durations were selected according to the availability of measured groundwater-level and chloride concentration data, and achieving sufficient resolution in model output. Data for the remaining boundary conditions were input as daily values (e.g., daily precipitation, daily reservoir releases and spills, and daily WRP discharges). Adaptive time stepping was employed when conducting the calibration simulations using both the monthly stress-period data and daily input data.

The GSWIM model was calibrated for low-flow conditions measured on the dates of the first intensive data collection (September 10 and 11, 2000) and then validated to the flow conditions measured during the second monitoring effort (July 29-30, 2001).

6.2 Model Calibration Processes

Calibrating GSWIM was a process of tuning the numerical model to simulate observed surface and subsurface flow conditions and chloride concentrations in the field, to within a reasonable degree of accuracy. This process generally involved adjusting model parameters, flow formulation approaches, and prescribed boundary conditions (i.e., stresses) until the model achieved an acceptable level of accuracy. The model was generally calibrated in accordance with the Standard Guide for Calibrating a Ground-Water Flow Model

Application, published by the American Society for Testing and Materials (1996). Following are discussions of the calibration process, targets, and results.

Because of long model run times and schedule constraints, a formal sensitivity analysis with the final calibrated version of GSWIM was not performed. However, the numerous simulations that were performed as part of the calibration process provided valuable insights to GSWIM's response to input values. Thus, further postcalibration sensitivity analysis is anticipated to provide little additional useful information.

Staff notes that observations and approaches were intended to provide a general understanding of the controlling parameters in GSWIM, in the context of sensitivity. Controlling parameters, in the technical Task 2B-1 report, were defined as the parameters, boundary conditions, and conceptualization details that required the most attention and had the greatest impact on model results during calibration. In this staff report, some typical calibration results for groundwater elevation, streamflow, and chloride concentration are presented for illustrative purpose.

The process of calibrating GSWIM to a 31-year period of daily streamflow data and available groundwater elevation and chloride concentration data has resulted in a model that is suitable for its intended applications. GSWIM was built to quantify potential cause-and-effect relationships between chloride loading from WRP discharges and the resulting responses of the hydrologic system under a variety of future hydrology, land use, and water use assumptions for calendar years 2007 through 2030.

The simulated groundwater elevations versus measured data using all paired measured and simulated groundwater elevation data from all quantitative target locations at all times throughout the calibration period are presented in Figure 6.2. As can be seen from this Figure, the simulated groundwater elevations are considered to well calibrated for the purpose of the GSWI Study. The comparison between simulated and measured daily mean streamflow and daily streamflow exceedances at Old Road Bridge and Blue Cut are shown in Figure 6.3. Simulated streamflows are considered by the GSWI Modeling Team to be well calibrated. Some examples of chloride concentrations in groundwater and surface water are presented in Figure 6.4. Simulated chloride concentrations are considered by the GSWI Modeling Team to be well calibrated for the purpose of the GSWI Study.

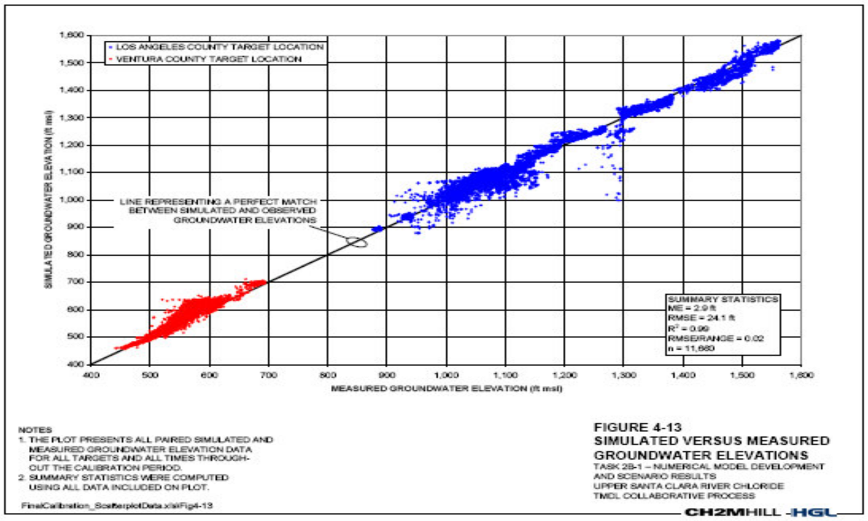


Figure 6.2 Calibration Results of Groundwater Elevations

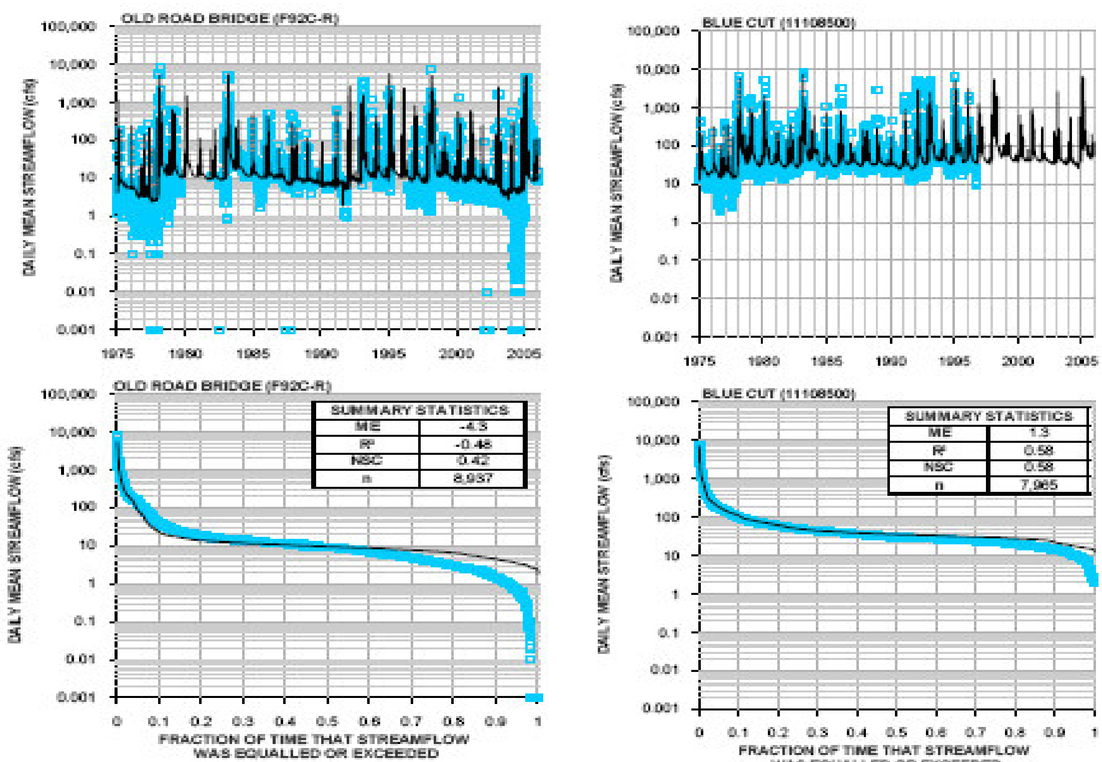


Figure 6.3 Calibration Results of Sreamflow in Upper Santa Clara River
(Black: Simulated Results, Blue: Measured Data)

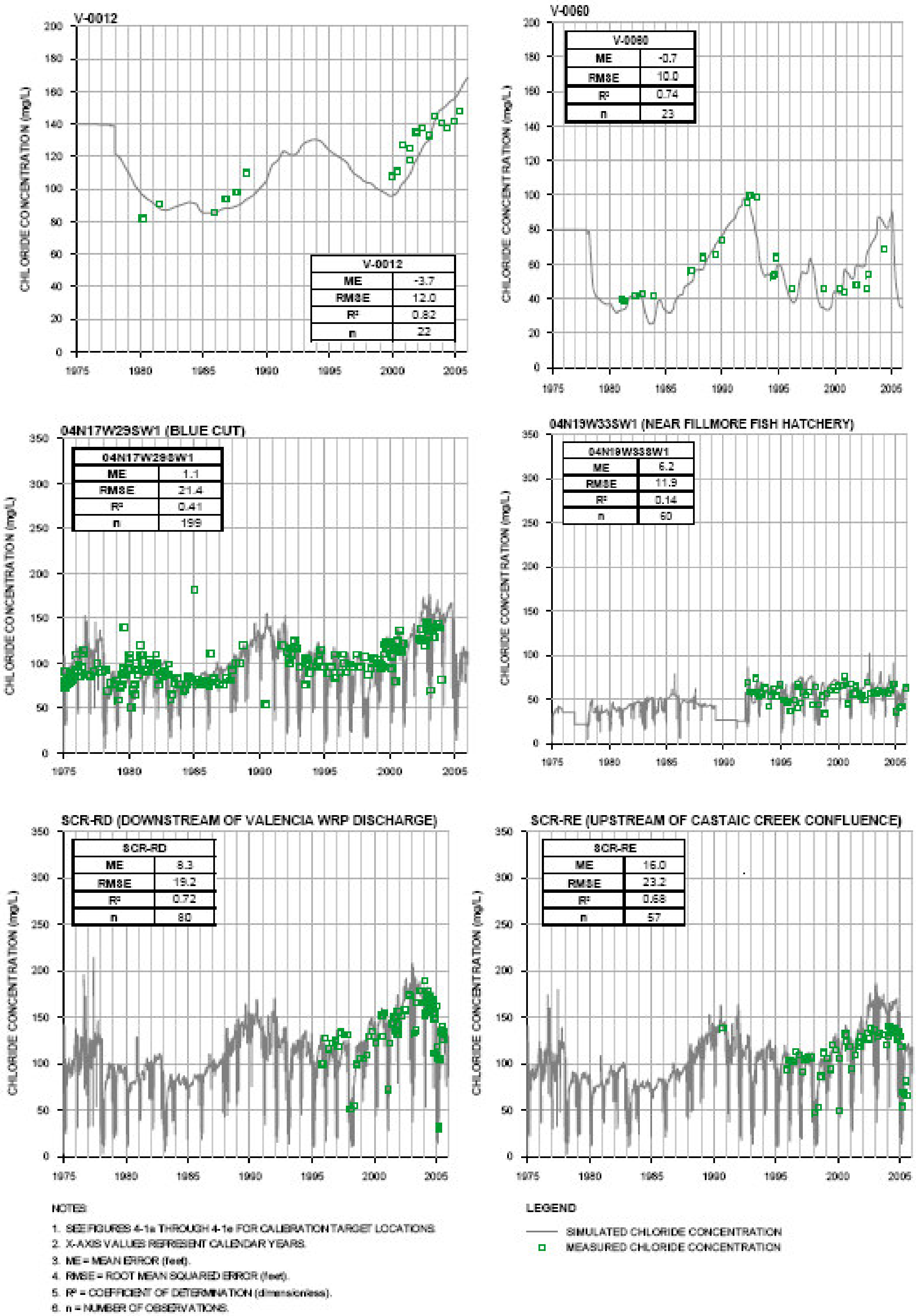


Figure 6.4 Examples of Calibration Results of Chloride Concentrations in Groundwater at V-0012 and V00-60 and in Surface Water at Blue-Cut, Fish Hatchery, SCR-RD and SCR-RE

The processes of calibrating GSWIM to a 31-year period of daily streamflow data and available groundwater elevation and chloride concentration data has resulted in a model that is suitable for its intended application. Staff notes that following are the primary calibration attributes that make GSWIM appropriate for its intended uses:

- GSWIM can simulate historical trends in groundwater elevations and streamflows during a 3-decade period that reflects increased urbanization, increased SWP water imports, and associated changes in land use and water use.

- GSWIM can simulate historical trends in groundwater elevations, streamflows, and dry gaps in the streams during a 3-decade period that reflects wet and dry periods.

- GSWIM can simulate the interacting surface and subsurface flow regimes, the transport of chlorides throughout these regimes, and the complex process of evapotranspiration and evapoconcentration of chlorides.

- GSWIM can simulate, on a daily basis, historical total streamflows in the SCR and groundwater discharge to the SCR.

- GSWIM can simulate short-term and long-term time-varying trends in groundwater elevations, streamflow, and chloride concentrations throughout the domain.

- The numerical solution is adequately constrained by the 88 groundwater level, 50 groundwater chloride, 6 streamflow, and 12 surface-water quality target locations that are spatially distributed throughout the GSWIM domain. Having a variety of calibration targets (e.g., qualitative and quantitative groundwater, surface-water, and water quality data) helps make GSWIM output more reliable.

6.3 GSWI-TAP Review of Model Calibration Process

GSWI-TAP has been involved in the GSWI model calibration processes and reviewed the Draft Task 2B-1 Report. In their professional opinion, the Draft Report of Task 2B-1 meets the standards and criteria generally accepted in the groundwater industry for development and analysis of geohydrological/geochemical problems through use of groundwater modeling. In other words, there are no fatal flaws and the work is consistent with generally accepted principles used in groundwater hydrology.

7. Potential Compliance Options and Modeling Results

7.1 Description of Potential Compliance Options

This section describes the potential compliance options to the chloride TMDL issues in the SCR and the modeling results of assessment of those options utilizing GSWI model. The compliance options include:

(1) Advanced Treatment and Brine Disposal;
(2) Minimal Advanced Treatment / Zero Discharge and Secondary Effluent Pipeline and Outfall;
(3) Alternate Water Reclamation Plant (WRP) Discharge Location; and
(4) Alternative Water Resource Management (AWRM)

7.1.1 Advanced Treatment and Brine Disposal

This compliance option consists of constructing and operating Micro-Filtration (MF) and Reverse Osmosis (RO) treatment facilities to remove chloride from the recycled water produced at the Valencia and Saugus WRPs. Sufficient advanced treatment capacity would be required to reduce all chloride concentrations in WRP recycled water to below the existing WQO of 100 mg/L for SCR downstream of the discharges (Reaches 5 and 6). MF/RO treatment would result in a significant amount of waste brine that would require disposal, most likely through a dedicated 43-mile brine conveyance pipeline from the WRPs to a new Pacific Ocean outfall in Ventura County.

7.1.2 Minimal Advanced Treatment and Secondary Effluent Pipeline and Outfall

This compliance option consists of constructing and operating MF/RO treatment facilities for a limited amount of WRP recycled water. The facilities would be sized to produce sufficient recycled water to meet the existing WQO of 100 mg/L, for discharge to the SCR to maintain river habitat. The balance of the WRP recycled water would be conveyed to the Pacific Ocean in Ventura County via a dedicated pipeline and ocean outfall. The objective of this alternative is to export the chlorides in the WRP recycled water exceeding the existing WQOs directly to the ocean rather than discharging them locally to the SCR.

7.1.3 Alternate WRP Discharge Location

This compliance option consists of relocating the Valencia WRP recycled water discharge location upstream to the upper extent of Reach 7 of the SCR near the United States Geological Survey (USGS) gauging station at Lang (e.g. the Lang Gauge). The objective of this alternative is to move the discharge farther away from downstream salt-sensitive agricultural beneficial uses in Ventura County, and utilize the potential assimilative capacity in upgradient surface water and groundwater, to minimize impacts in Ventura County from the chloride in the WRP recycled water.

7.1.4 Alternative Water Resource Management (AWRM)

This compliance option consists of working with the local water supply, agricultural, and development stakeholders in Los Angeles and Ventura Counties on a regional watershed solution to help achieve compliance with the USCR Chloride TMDL. The objective of this compliance option is to identify the best set of options for compliance that results in the maximum net benefit for all water users along the river, while protecting the salt sensitive agricultural beneficial uses of the SCR in Ventura County. The key elements of the AWRM include:

- implementing measures to reduce chloride in the recycled water from the District's WRPs through removal of SRWS and conversion to UV disinfection technologies;
- constructing advanced treatment for a portion of the recycled water from the District's Valencia WRP through the construction and operation of a 3MGD advanced treatment facility using MF/RO treatment technologies;
- procuring local groundwater or surface water for release to the SCR as supplemental water during drought periods;
- constructing water supply facilities in Ventura County to facilitate export of existing salts in groundwater;
- providing alternative water supply to protect salt-sensitive agricultural beneficial uses of the SCR;
- supporting the expansion of recycled water uses within the Santa Clarita Valley; and
- revising surface water and groundwater WQOs to support all of these elements.

A conceptual schematic of the application of these elements is provided in Figure 7.1.

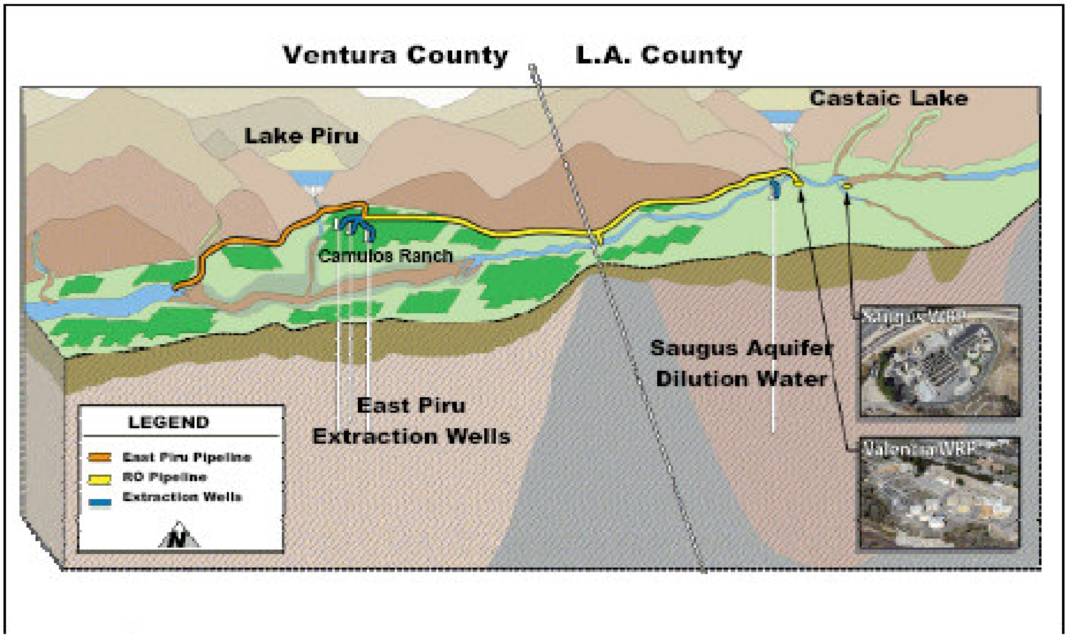


Figure 7.1 Conceptual Schematic Showing AWRM Elements

The summary of these compliance options are presented in the Table 7.1

Table 7.1 Compliance Options for Upper Santa Clara River Chloride TMDL

Compliance Options	Elements	Infrastructure Requirements
Advanced Treatment	Treat all Valencia and Saugus WRP discharges to 100 mg/L	Installation and operation of MF/RO treatment at both WRPs and development of 43 mile brine discharge piping to ocean
Zero Discharge	Divert all Valencia and Saugus WRP discharge to ocean outfall	Development of 43 mile discharge piping to ocean to accommodate all WRP discharge, plus new ocea outfall
Minimal Discharge	Treat 4.6 MGD of Valencia and 5.0 MGD of Saugus discharge using MF/RO, all other discharges to ocean outfall	Installation and operation of MF/RO treatment at both WRPs and development of 43 mile brine waste and WRP discharge piping to ocean, plus new ocean outfall
Alternate WRP Discharge Location	Move Valencia WRP discharge location to top of SCR Reach 7	Development of 16 miles of piping for alternative discharge
Alternative Water Resource Management (AWRM)	Treat 3 MGD of Valencia WRP discharges using MF/RO, develop salt Export pumping in Piru Basin, use dilution flows to moderate chloride concentrations in SCR	Installation and operation of MF/RO treatment at Valencia WRP, 12 mile permeate pipeline for RO flows, outfall to SCR near Blue Cut, brine discharge via deep well injection, installation of 10 well water supply system and piping in Piru Basin, replacement water for dilution flows during drought

7.2 Modeling Results

The Advanced Treatment and Brine Disposal alternative, the Minimal Advanced Treatment / Zero Discharge and Secondary Effluent Pipeline and Outfall alternative, and the Alternate WRP Discharge Location compliance options were evaluated for compliance with the existing WQOs and LRE threshold. The modeling results of this evaluation are summarized in Table 7-2 and Table 7-3. The modeling results of AWRM compliance option for existing WQOs were presented in the tables as well. As shown on the Table 7-2, none of these compliance options were predicted to achieve compliance with the 100 mg/L WQO for chloride at all times and all locations in the SCR receiving waters. As shown on the Table 7-3, the attainment frequencies of the compliance options were increased when WQO is raised up from existing level of 100 mg/L to the LRE threshold level of 120 mg/L. However, most of compliance options were still not predicted to achieve the WQO of 120 mg/L except for Advanced Treatment compliance option. As a result, the revisions to these WQOs were considered that would still be protective of all beneficial uses in Reaches 4B, 5 and 6. Therefore, an AWRM compliance alternative was jointly developed by various TMDL stakeholders, which will achieve compliance with proposed Site-Specific Objectives (SSOs) and provide for a diverse mix of water quality and water supply benefits. The modeling results of the evaluation for the AWRM compliance with proposed SSOs are summarized in Table 7-4.

Table 7.2 Attainment Frequencies of the Compliance Options-Existing Water Quality Objective

Compliance Options	Surface Water at Blue Cut Reach 4B	East Piru Basin Groundwater Reach 4B		West Piru Basin Groundwater Reach 4A	
	Surface Water WQO 100 mg/L	Surface Water WQO 100 mg/L	Ground-water WQO 200 mg/L	Surface Water WQO 100 mg/L	Ground-water WQO 100 mg/L
Advanced Treatment	66.8	55.0	100.0	100.0	100.0
Minimal Discharge	65.5	62.1	100.0	100.0	100.0
Zero Discharge	63.8	68.3	100.0	100.0	100.0
Alternate WRP Discharge Location	48.9	46.1	100.0	100.0	100.0
Alternative Water Resource Management (AWRM)	43.5	56.3	100.0	100.0	100.0

Note: Values represents percentage of days during simulation period that chloride is predicted to be equal to or less than the WQO concentration

Table 7.3 Attainment Frequencies of the Compliance Options-LRE Water Quality Objective

Compliance Options	Surface Water at Blue Cut Reach 4B	East Piru Basin Groundwater Reach 4B		West Piru Basin Groundwater Reach 4A	
	Surface Water WQO 120 mg/L	Surface Water WQO 120 mg/L	Ground-water WQO 200 mg/L	Surface Water WQO 120 mg/L	Ground-water WQO 100 mg/L
Advanced Treatment	99.0	99.6	100.0	100.0	100.0
Minimal Discharge	87.8	98.8	100.0	100.0	100.0
Zero Discharge	80.7	97.5	100.0	100.0	100.0
Alternate WRP Discharge Location	76.0	80.5	100.0	100.0	100.0
Alternative Water Resource Management (AWRM)	88.0	93.0	100.0	100.0	100.0

Note: Values represents percentage of days during simulation period that chloride is predicted to be equal to or less than the WQO concentration

Table 7.4 Attainment Frequencies of the AWRM Compliance Option for Revised WQO

Compliance Option	Reach 4B (at Blue Cut)			Reach 5		Reach 6	
	Surface Water WQO During Non-Drought 117 mg/L	Surface Water WQO During Drought 130 mg/L	Ground-water WQO 150 mg/L	Surface Water WQO 150 mg/L	Ground-water WQO 150 mg/L	Surface Water WQO 150 mg/L	Ground-water WQO 150 mg/L
AWRM Alternative	99.9	99.2	100.0	98.3-99.7	100.0	98.6-99.7	100.0

Note: Values represents percentage of days during simulation period that chloride is predicted to be equal to or less than the WQO concentration

It should be noted that Staff had concerns that the attainment frequencies of all compliance options indicated in the Table 7.1 through Table 7.4 may be affected by the extended simulation periods from 1999 to 2005, which were not included in the model simulation periods for future scenarios, when all historical drought periods are taken into account. To address this concern, a sensitivity study of extended simulation periods was performed by Geomatrix. The modeling results of the sensitivity study have shown that the drought periods of 1999-2005 would not produce higher concentrations in the stream than the revised WQO of 117 mg/L. As such, Staff agrees that the historical drought period of 1999 to 2005 would not affect the attainment frequencies indicated in Tables 7.1 through 7.4.

8. Staff Findings and Recommendation

8.1 Staff Findings

The results of the GSWI study were used to initiate appropriate implementation activities for the TMDL. Based on the modeling results as provided in the reports of Task 2B-1 and Task 2B-2 of the GSWI Study and the Regional Board staff analysis and assessment, staff's findings include:

- Staff finds that none of the simulated chloride concentrations derived from the proposed compliance options result in chloride concentrations less than the existing WQO of 100 mg/L at all times over 24-year simulation periods (2007-2030) and locations in Reaches 4B, 5 and 6. All of the predicted chloride concentrations in groundwater for all compliance options that consistently met the existing WQO of 200 mg/L in groundwater of the Piru Basin except the area between Blue Cut and SCR-RF monitoring locations.

- Staff finds that the predicted high chloride concentrations of 350 mg/L or greater exist in the alluvial groundwater with a thickness of 50-100 ft in the areas between Blue Cut and SCR-RF during drought periods for all proposed compliance options. The high chloride concentration in groundwater near Blue Cut area will migrate downstream through the pumping activity in the proposed extraction well location for AWRM compliance option and will affect the chloride concentration of the mixed water with RO and then will affect the chloride concentration in SCR in Reach 4A.

- Staff finds that the AWRM compliance option can produce better chloride concentration than other proposed compliance options during drought periods and the salt export capability of the AWRM compliance option will help achieve to substantially reduce the amount of chloride loading from salt-water intrusion in the Oxnard Plain.

- Staff finds that the Advanced Treatment and Brine Disposal Compliance Option can not result in full attainment of the 100 mg/L WQO for the USCR at Blue Cut at all times and in all locations of the receiving water. In addition, other compliance options like conveying all recycled water discharges from the Valencia and Saugus WRPs to the ocean outfall (Zero Discharge Compliance Option), limiting discharges from the WRPs and conveying the balance of WRPs recycled water discharges to ocean outfall (Minimal Discharge Compliance Option), and moving the discharge location of WRPs to the beginning of Reach 7 near Lang gauge (Alternative WRP Discharge Location Compliance Option) are also not likely to achieve attainment of the existing 100 mg/L WQO at all times and all locations.

- Staff notes that an alternative compliance option is required to achieve the site specific objective (SSO) when the original proposed compliance options were not able to achieve the existing WQO of 100 mg/L. Staff also notes that the SSOs shall be carefully evaluated based on the GSWI model results of different averaging periods to ensure they are fully protective of the agricultural beneficial uses in the study area.

- Staff finds that the predicted chloride concentrations in both groundwater and surface water at Blue Cut were generally related to concentrations of chloride in the discharges to the SCR from the Saugus and Valencia WRPs.

- Staff find that the GSWI model has been adequately calibrated by 88 groundwater level, 50 groundwater chloride, 6 streamflow, and 12 surface-water quality target locations that are spatially distributed throughout the GSWI domain and it has been considered as an appropriate model for groundwater and surface water interaction modeling purposes.

8.2 Staff Recommendation

According to the modeling results, Staff recommends the AWRM compliance alternative. Staff finds that the remaining compliance options of advanced treatment and brine disposal alternatives will not result in full attainment of the 100 mg/L WQO for the SCR. Staff finds that the AWRM compliance alternative will result in timely attainment of the revised WQOs and reduce the chloride load to the USCR and underlying groundwater basins during the TMDL implementation period. Staff further finds that the AWRM will help provide enough mass loading to protect the SCR downstream from sea water intrusion.

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