GSWI

Final Report

Task 2B-1 – Numerical Model Development and Scenario Results East and Piru Subbasins

Upper Santa Clara River Chloride TMDL Collaborative Process



Prepared for

SANITATION DISTRICTS OF LOS ANGELES COUNTY

Los Angeles Regional Water Quality Control Board

Prepared by

CH2MHILL

in association with

HGL HydroGeoLogic, Inc Exceeding Expectations

March 2008

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Acronyms and Abbreviations

2005 UWMP	*2005 Urban Water Management Plan*
acre-ft/yr	acre-feet per year
ASCII	American Standard Code for Information Interchange
AWRM	Alternative Water Resources Management
Basin Plan	Water Quality Control Plan – Los Angeles Region
C/Co	relative chloride concentration
cfs	cubic feet per second
CH2M HILL-HGL	CH2M HILL, Inc., and HydroGeoLogic, Inc.
CHF	channel flow
Cint	canopy interception storage
CLWA	Castaic Lake Water Agency
cm	centimeter
cm/day	centimeters per day
cm/sec	centimeters per second
CY	calendar year
DEM	Digital Elevation Model
District	Santa Clarita Valley Sanitation District of Los Angeles County
DWR	California Department of Water Resources
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
ETo	reference evapotranspiration
ft bgs	feet below ground surface
ft msl	feet above mean sea level
ft/day	feet per day
ft/mi	feet per mile
ft^2/day	square feet per day
GIS	geographic information system

GSWI	Groundwater/Surface-water Interaction
GSWIM	Groundwater/Surface-water Interaction Model
HGL	HydroGeoLogic, Inc.
HSG	Hydrologic Soil Group
ID	identifier
ITRC	Irrigation Training and Research Center
Kh	horizontal hydraulic conductivity
Kv	vertical hydraulic conductivity
LACFCD	Los Angeles County Flood Control District
LADPW	Los Angeles County Department of Public Works
LAI	Leaf Area Index
LSCE	Luhdorff and Scalmanini Consulting Engineers
LUC	Land Use Code
ME	mean error
mgd	million gallons per day
mg/L	milligrams per liter
M&I	municipal and industrial
NLF	Newhall Land and Farming Company
NSC	Nash-Sutcliffe coefficient
OLF	overland flow
QA	quality assurance
QC	quality control
R^2	coefficient of determination
RCS	Richard C. Slade and Associates, LLC
RDF	root-zone distribution function
RMSE	root mean squared error
RMSE/Range	RMSE divided by the range of observed values
Regional Board	Los Angeles Regional Water Quality Control Board
RO	reverse osmosis
SCR	Santa Clara River

SCVSD	Santa Clarita Valley Sanitation District of Los Angeles County
SCAG	Southern California Association of Governments
SOAR	Save Open-Space & Agricultural Resources
SRWS	self-regenerating water softener
SSO	site-specific objective
SWP	State Water Project
TAP	Technical Advisory Panel
Task 2A Report	*Task 2A – Conceptual Model Development, East and Piru Subbasins. Upper Santa Clara River Chloride TMDL Collaborative Process*
TMDL	total maximum daily load
TWG	Technical Working Group
USGS	U.S. Geological Survey
UV	ultraviolet
UWCD	United Water Conservation District
WARMF	Watershed Analysis Risk Management Framework
WQO	water quality objective
WRP	water reclamation plant
WSS	Water Supply System
WWTP	wastewater treatment plant

SECTION 1.0

Introduction

This report describes the development, calibration, and application of a numerical flow and transport model that was used to aid evaluations related to the Groundwater/Surface-water Interaction (GSWI) Study. Appendix A to this report contains the comments and responses to comments received from the GSWI Technical Advisory Panel (TAP) and Technical Working Group (TWG) on the draft version of this report. The GSWI Study is being jointly conducted by the Santa Clarita Valley Sanitation District of Los Angeles County (SCVSD or District) and the Los Angeles Regional Water Quality Control Board (Regional Board).

1.1 Background

The District and the Regional Board, along with their consultant team, CH2M HILL and HydroGeoLogic, Inc. (HGL) (CH2M HILL-HGL), developed a numerical model for a portion of the Santa Clara River (SCR) watershed. The overall purpose of the GSWI Study is to evaluate fate and transport of chloride in surface water and groundwater basins underlying Reaches 4, 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. The numerical model, known as the Groundwater/Surface-water Interaction Model (GSWIM), is a tool with which 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. The GSWI Study follows an extensive agricultural literature review and evaluation, which was documented in *Literature Review Evaluation. Upper Santa Clara River Chloride TMDL Collaborative Process* (CH2M HILL, 2005a). Figure 1-1 illustrates the GSWI Study area (tables and figures are located at the end of each section).

The GSWI Study includes the following tasks:

- **Task 1A – Evaluate Existing Models, Literature, and Data** – This task included compilation and evaluation of available information from which to develop GSWIM. Results from this task were described in a draft report titled, *Literature Review and Data Acquisition. Task 1A – Evaluate Existing Models, Literature, and Data. Upper Santa Clara River Chloride TMDL Collaborative Process* (CH2M HILL-HGL, 2006a).
- **Task 1B – Conduct Additional Studies/Monitoring and Enhance Monitoring Network, as Necessary** – Geomatrix Consultants was responsible for this task, which included collection of water quality samples from selected monitoring locations, exploratory drilling and surface geophysics in the Blue Cut area, and installation of three monitoring wells in the Blue Cut area. Results from this task have been described in a series of memoranda (Geomatrix Consultants, 2005, 2006a-e, and 2007a-e).
- **Task 2A – Conceptual Model Development** – This task included developing physical descriptions of the study area and processes governing surface and subsurface flow and sources, fate, and transport of chloride using information compiled in Tasks 1A and 1B. Results from this task were described in a final report titled, *Task 2A – Conceptual Model*

Development East and Piru Subbasins. Upper Santa Clara River Chloride TMDL Collaborative Process (Task 2A Report) (CH2M HILL-HGL, 2006b).

- **Task 2B – Numerical Model Development and Calibration** – This task included developing a numerical model, initially based on the conceptual model described in the Task 2A Report, 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. This task also included application of the numerical model to simulate potential chloride impacts from CYs 2007 through 2030 according to 17 future water use and treatment assumptions. Eight of these scenarios were evaluated by CH2M HILL-HGL, and the remaining nine scenarios were evaluated by Geomatrix Consultants. Results from the eight scenarios that were evaluated by CH2M HILL-HGL are described in Section 5.0 of this report. Results from the remaining nine scenarios that were evaluated by Geomatrix Consultants are described in a supplemental Task 2B-1 report (Geomatrix Consultants, 2008). Additionally, Geomatrix Consultants will prepare a Task 2B-2 report that will describe results from simulating various Alternative Water Resources Management (AWRM) alternatives for the future simulation period.
- **Task 3 – Public Review Strategy** – This task included describing the process of making information and analyses available to stakeholders in the SCR watershed. The public review strategy was described in a draft report titled, *Task 3 – Public Review Strategy for the Groundwater/Surface-water Interaction Model. Upper Santa Clara River Chloride TMDL Collaborative Process* (CH2M HILL-HGL, 2007).
- **Task 4 – Reporting, Presentations, and Documentation** – This task included documenting and presenting information, analyses, and results of the GSWI Study, and getting appropriate input from the GSWI TWG, GSWI Modeling Subcommittee, GSWI TAP, and other project stakeholders. Several presentations, meeting summaries, and responses to comments were submitted to the District, Regional Board, and GSWI stakeholder group by CH2M HILL-HGL throughout the Upper SCR Chloride TMDL Collaborative Process.

1.2 Modeling Objectives

The District and Regional Board determined that development of a predictive numerical model was required for the GSWI Study. The predictive numerical model is designed to evaluate future site-specific hydrologic system and chloride transport behavior resulting from implementation of one or more proposed actions. For the GSWI Study, the proposed actions being evaluated by the Regional Board for implementation of the chloride TMDL include the following:

1. Setting chloride waste load allocation limits for discharges from the Saugus and Valencia Water Reclamation Plants (WRP), which are operated by the District in the Santa Clarita Valley
2. Reassessing existing water quality objectives (WQO) or establishing site-specific objectives (SSO) for chloride compliance in local streams and groundwater subbasins underlying portions of Reaches 4, 5, and 6 of the SCR (see Tables 1-1 and 1-2 for surface-water and groundwater WQOs, as provided in the *Water Quality Control Plan – Los Angeles Region* (Basin Plan) [Regional Board, 1994])

As a result of these proposed actions, the modeling objective is 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 CYs 2007 through 2030. Modeling results described in this report will aid the Regional Board by providing a scientific basis from which to make regulatory decisions related to the implementation of the Upper SCR Chloride TMDL.

1.3 Model Function

To fulfill the modeling objectives, GSWIM was developed and calibrated using daily input data over a historical period including CYs 1975 through 2005. This was done to demonstrate the model's ability to replicate hydrologic system behavior over an appropriate historical period using available measured data on climate, land and water use, hydrology, hydrogeology, and chloride conditions over that same period. This historical period and the requirement of model output at a daily frequency were selected collaboratively by the GSWI TWG. The available data and conceptual model that provide the basis for model development were described in *Literature Review and Data Acquisition. Task 1A – Evaluate Existing Models, Literature, and Data. Upper Santa Clara River Chloride TMDL Collaborative Process* and the Task 2A Report (CH2M HILL-HGL, 2006a, 2006b).

Although it is impossible to predict future hydrology, land use, and water use conditions with any certainty, future water use and waste load allocation assumptions for CYs 2007 through 2030 were developed collaboratively by the GSWI TWG for this study. Table 1-3 summarizes the scenarios of future conditions that were developed by SCVSD and the Regional Board and are described in this report. A subsequent Task 2B-2 report will describe results from simulation of the AWRM alternatives over the same future period.

1.4 GSWI Conceptual Model Overview

Prior to developing GSWIM, a theoretical construct representing the field problem was developed and described in the Task 2A Report (CH2M HILL-HGL, 2006b). This theoretical construct, known as the conceptual model, serves as the primary basis for development of GSWIM. Figures 1-2 and 1-3 show schematic representations of the Santa Clarita and Piru Valleys, respectively.

Santa Clarita Valley is located in Los Angeles County along Reaches 5, 6, and 7 of the SCR; the Piru Valley is located in Ventura County along Reach 4 of the SCR. The Santa Clarita Valley, located 35 miles north of downtown Los Angeles off the Golden State Freeway (Interstate 5), serves largely as a bedroom community for the greater Los Angeles area. The Piru Valley, located downstream and west of the Santa Clarita Valley, is predominantly an agricultural area along Reach 4 of the SCR. Significant surface-water reservoirs exist upstream and north of both valleys, including Bouquet Reservoir, Pyramid Lake, and Castaic Lake and Lagoon in Los Angeles County, and Lake Piru in Ventura County.

In both valleys, tributaries located north and south of the SCR contribute intermittent streamflow to SCR during short-term storm runoff or reservoir-release events. Streamflow in Reach 7 of the SCR, located upstream of the Saugus WRP, is also intermittent. Streamflow in most of Reaches 5 and 6, located downstream of the Saugus and Valencia WRPs, is perennial, resulting from groundwater discharge from the underlying alluvial aquifer and discharge of tertiary-treated wastewater from the WRPs (see Figure 1-2). Streamflow remains perennial in the SCR west over the county line, where it begins to infiltrate into the shallow aquifer system underlying the Piru Valley in Ventura County. A short distance downstream of the Las Brisas Bridge, streamflow in Reach 4 of the SCR typically disappears into the streambed, except during short-term storm runoff events. The location at which streamflow disappears marks the beginning of the Dry Gap, in the SCR in the Piru Valley. The Dry Gap typically extends downstream to the Piru Narrows, where groundwater begins to discharge into the SCR streambed near the Fillmore Fish Hatchery (see Figure 1-3). Streamflow is occasionally present in the SCR upstream of the Fillmore Fish Hatchery to the confluence with Piru Creek during short-term storm runoff events and releases or spills from Lake Piru. The Task 2A Report (CH2M HILL-HGL, 2006b) further describes the conceptual model of the GSWI Study area.

TABLE 1-1
Water Quality Objectives for Chloride in Surface Water in the GSWI Study Area
Task 2B-1 – Numerical Model Development and Scenario Results, East and Piru Subbasins

SCR Reach[a]	Chloride (mg/L)[b]
Between Lang Stream Gage and West Pier of Bouquet Canyon Road Bridge (Reach 7)	100
Between West Piers of Bouquet Canyon Road Bridge and Highway 99 Bridge (Reach 6)	100
Between West Pier of Highway 99 Bridge and Blue Cut Stream Gage (Reach 5)	100
Between Blue Cut Stream Gage and A Street Bridge (Highway 23) in Fillmore (Reach 4)	100

[a]As designated by the Regional Board.

[b]According to Table 3-8 in the Basin Plan (Regional Board, 1994).

Note:

mg/L = milligrams per liter

TABLE 1-2
Water Quality Objectives for Chloride in Groundwater in the GSWI Study Area
Task 2B-1 – Numerical Model Development and Scenario Results, East and Piru Subbasins

Groundwater Subbasin	Chloride (mg/L)[a]
East Subbasin	
Santa Clara – Mint Canyon	150
Santa Clara – Bouquet and San Francisquito Canyons	100
Castaic Valley	150
Piru Subbasin	
Santa Clara – Piru Creek Area	
Lower Area East of Piru Creek	200
Lower Area West of Piru Creek	100
Fillmore Area	
Pole Creek Fan Area	100
South Side of SCR	100
Remaining Fillmore Area	50

[a]According to Table 3-10 in the Basin Plan (Regional Board, 1994).

TABLE 1-3
Summary Matrix of Future Scenarios
Task 2B-1 – Numerical Model Development and Scenario Results, East and Piru Subbasins

Assumed Chloride Concentration in SCVSD WRP Effluent (mg/L)[a]	**Scenario 1 Series[b] (High Reuse)**	**Scenario 2 Series[c] (Medium Reuse)**	**Scenario 3 Series[d] (Low Reuse)**
100	1a[f]	2a[g]	3a[f]
120	1b[f]	2b[g]	3b[f]
140[e]	1c[e]	2c[e]	3c[e]
150	1c[g]	2c[g]	3c[g]
160[e]	1d[e]	2d[e]	3d[e]
Chloride Loading above Water Supply with 0 percent SRWS Removal	1e[g]	2e[g]	3e[g]
Chloride Loading above Water Supply with 50 percent SRWS Removal	1f[f]	2f[e]	3f[f]
Chloride Loading above Water Supply with 100 percent SRWS Removal	1g[f]	2g[g]	3g[f]

[a]Chloride concentration assumptions pertain to discharge from the Saugus and Valencia WRPs only. Chloride concentrations in the discharge of the future Newhall Ranch WRP were set at a constant of 100 mg/L.

[b]High water reuse. Assumes that recycled water is applied for outdoor use at selected areas and 100 percent of the total quantities designated in the *Draft Recycled Water Master Plan* (Kennedy/Jenks Consultants, 2002). Also assumes that recycled water is applied for outdoor use within Newhall Ranch at 100 percent of the total quantities described in the *Newhall Ranch Specific Plan* (Forma, 2003).

[c]Medium water reuse. Assumes that recycled water is applied for outdoor use at selected areas and 50 percent of the total quantities designated in the *Draft Recycled Water Master Plan* (Kennedy/Jenks Consultants, 2002). Also assumes that recycled water is applied for outdoor use within Newhall Ranch at 100 percent of the total quantities described in the *Newhall Ranch Specific Plan* (Forma, 2003).

[d]Low water reuse. Assumes that recycled water is applied at quantities actually used in CY 2006 at the Westridge Golf Course and nearby roadway medians. Also assumes that recycled water is applied for outdoor use within Newhall Ranch at 100 percent of the total quantities described in the *Newhall Ranch Specific Plan* (Forma, 2003).

[e]Not evaluated. These scenarios were initially proposed, but the GSWI TWG collaboratively decided that it was not necessary to evaluate them. They are shown here for informational purposes only.

[f]These scenarios were evaluated by CH2M HILL-HGL.

[g]These scenarios were evaluated by Geomatrix Consultants.

Note:

SRWS = self-regenerating water softener

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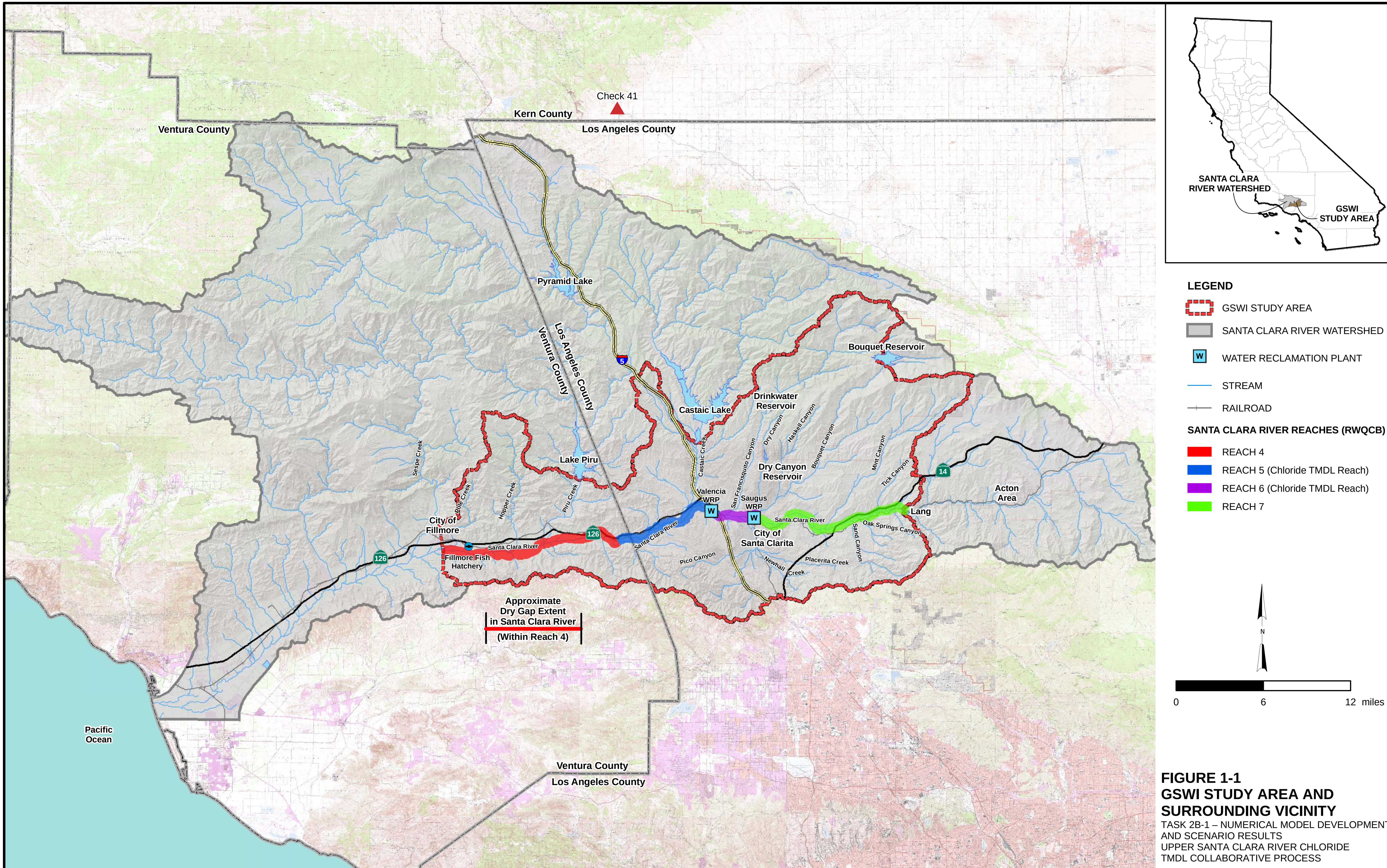

FIGURE 1-1
GSWI STUDY AREA AND SURROUNDING VICINITY
TASK 2B-1 – NUMERICAL MODEL DEVELOPMENT AND SCENARIO RESULTS
UPPER SANTA CLARA RIVER CHLORIDE TMDL COLLABORATIVE PROCESS

CH2MHILL–HGL

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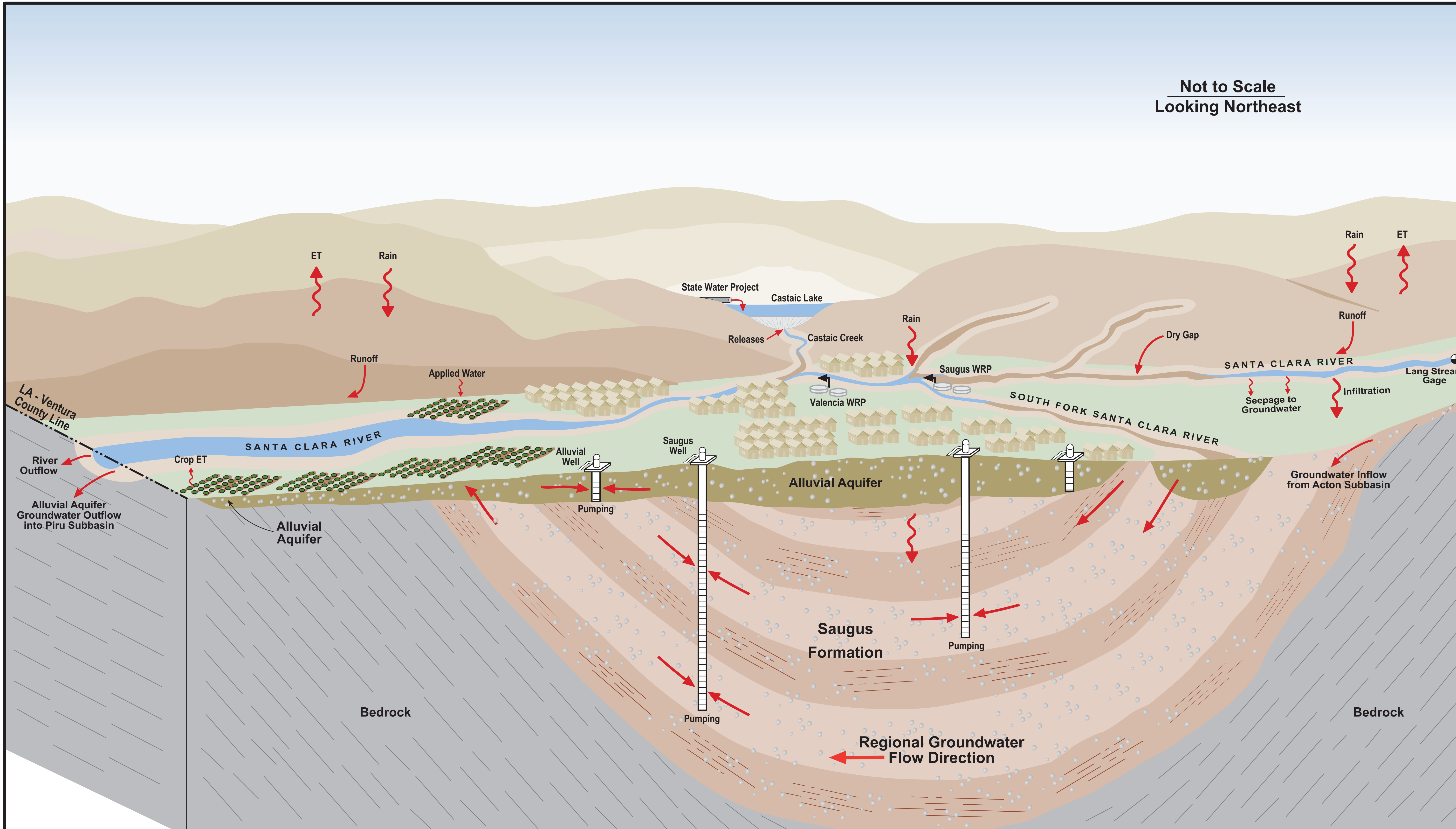

FIGURE 1-2
SANTA CLARITA VALLEY SCHEMATIC
TASK 2B-1 – NUMERICAL MODEL DEVELOPMENT AND SCENARIO RESULTS
UPPER SANTA CLARA RIVER CHLORIDE TMDL COLLABORATIVE PROCESS

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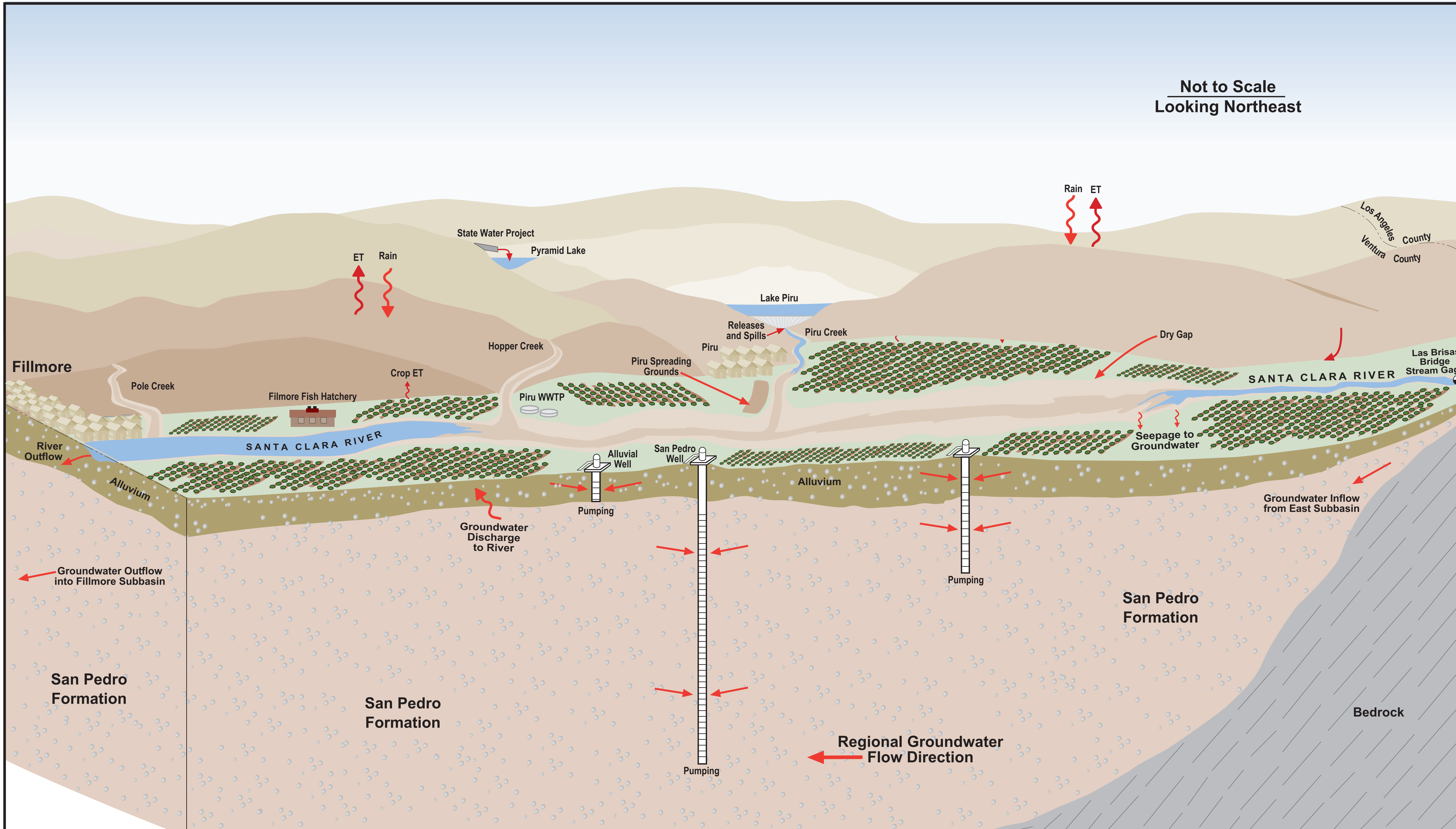

FIGURE 1-3
PIRU VALLEY SCHEMATIC
TASK 2B-1 – NUMERICAL MODEL DEVELOPMENT AND SCENARIO RESULTS
UPPER SANTA CLARA RIVER CHLORIDE TMDL COLLABORATIVE PROCESS

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SECTION 2.0

Computer Code Description

GSWIM was built using a code called MODHMS (HGL, 2006), which has its origins in the popular U.S. Geological Survey (USGS) Modflow model (McDonald and Harbaugh, 1988). MODHMS has been enhanced and further developed by HGL to include numerous features that were not included in the original USGS code. MODHMS is a physically based, spatially distributed numerical model that includes several packages for simulation of fully integrated groundwater and surface-water flow (including saturated and unsaturated flow) and solute transport. This code was selected for the following reasons:

- Project scope requires a computer code that is capable of simulating unconfined subsurface flow interacting with a stream-channel flow domain, and the associated solute transport therein.
- The code needs to be capable of handling drying and re-wetting of both surface and subsurface domains to allow for evaluations of unsteady flow and transport resulting from temporal and spatial wet and dry conditions (e.g., drought or wet periods and the spatial extents of the dry gaps in the SCR and its tributaries).
- MODHMS treats the flow of water and transport of solutes of a hydrologic system in a rigorous and mechanistic manner by mathematically representing surface and subsurface domains as one holistic system whose matrix is solved simultaneously. Therefore, it is not necessary to estimate locations of losing or gaining portions of the SCR outside the model. Furthermore, it is not necessary to manually link approximations of the surface-water and groundwater systems separately. Key processes that control interaction of groundwater and surface water are inherently simulated as part of the numerical solution.
- MODHMS is the product of more than 15 years of development and is built upon the USGS Modflow model. Modflow has been used extensively in groundwater evaluations worldwide for over 20 years.
- MODHMS has been benchmarked and verified, meaning that the numerical solutions generated by the code have been compared with one or more analytical solutions, subject to scientific review, and used on previous modeling projects (e.g., Vrugt et al., 2004; Schoups et al., 2005; Werner et al., 2006). Verification of the code ensures that MODHMS can accurately solve the governing equations that constitute the mathematical model.

The following subsections describe the numerical assumptions, scientific bases, data formats, and limitations inherent in GSWIM (i.e., the customized version of MODHMS, specifically built to aid the GSWI Study). Section 5.0 of *Task 3 – Public Review Strategy for the Groundwater/Surface-water Interaction Model. Upper Santa Clara River Chloride TMDL Collaborative Process* (CH2M HILL-HGL, 2007) and the MODHMS user's manual (HGL, 2006) contain additional information on the MODHMS code.

2.1 Numerical Assumptions

MODHMS is conceptualized mathematically into two hydrologic flow and solute transport regimes: surface flow and subsurface flow. The surface flow regime includes an overland flow (OLF) domain and a channel flow (CHF) domain. The subsurface flow regime includes the unsaturated and saturated zones of the materials underlying the OLF and CHF domains of MODHMS. The following subsections summarize the numerical assumptions associated with the way GSWIM simulates water flow and solute transport throughout the surface and subsurface domains.

2.1.1 Surface Domain

Runoff is simulated on the OLF domain, in an areally two-dimensional manner, and flow in the CHF domain is simulated along a one-dimensional channel network. During high-water periods, when simulated water levels are above the designated CHF domain banks, both OLF and CHF domains can simulate water movement through the stream channel and corridor system. Thus, the CHF domain accounts for scale effects of low-flow channel widths being smaller than the width of an OLF grid-block. The vertical exchange of water between the surface flow domain (including the OLF and CHF domains) and the subsurface domain is governed by a vertical leakance term. The net vertical leakance of the OLF domain is computed as the harmonic mean of the vertical leakance values of the land cover (if present) and topsoils. The basic mass balance for the surface domain can be expressed as precipitation minus canopy storage minus canopy evapotranspiration (ET) minus rill storage minus rill ET minus infiltration equals runoff on the OLF and CHF domains

2.1.2 Subsurface Domain

The flow conditions in the subsurface domain of GSWIM were simulated using both variably saturated flow and saturated flow formulations.

2.1.2.1 Variably Saturated Flow

The variably saturated flow formulation via the Richards Equation is used to simulate flow in Model Layers 1 and 2 (the top subsurface layers). The variably saturated flow formulation was used to facilitate simulation of near-surface processes of moisture retention, unsaturated flow, unsaturated ET, and evapoconcentration of chloride in the vadose zone (i.e., a process of ET that removes water but leaves chloride in the soil column). To maximize robustness of the numerical solution in these two model layers, it was important to have a relatively fine vertical discretization for appropriate parameterization of porosity, moisture retention terms, relative permeability function, and plant- and moisture-related ET terms (e.g., wilting point and field capacity suctions, and root-zone distribution).

2.1.2.2 Saturated Flow

Model Layer 3 is treated as a vertically integrated unconfined layer. Deeper model layers are treated as vertically integrated semi-confined layers to facilitate accurate simulation of fluctuating water-table conditions. Accordingly, Model Layer 3 requires input of specific yield to represent storage in the unconfined groundwater system and does not need the moisture retention or relative permeability parameters required by Model Layers 1 and 2. ET from Model Layers 3 through 9 is simulated as a function of the depth to the water table.

2.2 Scientific Bases

The theory and numerical techniques that are incorporated into MODHMS have been scientifically tested. The governing equations for surface-water flow and transport and for saturated and unsaturated subsurface flow and transport are well established and have been individually solved by several modeling codes over the past few decades on a wide range of field problems. Thus, the scientific bases of the theory and the numerical techniques for solving these equations have been well established. However, historically, these equations have been used to simulate hydrologic processes separately or as partially coupled processes. MODHMS solves the governing flow and transport equations for the surface-water, vadose zone, and groundwater systems simultaneously, to provide a holistic solution of flow and transport in surface and subsurface domains. MODHMS has been developed using strict quality assurance/quality control (QA/QC) guidelines and with various levels of testing, from simple analytical solutions to complex field problems. The MODHMS user's manual (HGL, 2006) details the equations for flow and transport within and between the domains, and the numerical techniques for solving the system of equations.

2.3 Data Formats

Several American Standard Code for Information Interchange (ASCII) USGS Modflow data formats were used to describe and parameterize GSWIM. Table 2-1 shows the grouping of various data items in the GSWIM input data files. Output from GSWIM also follows the USGS Modflow code output file formats, and includes ASCII as well as binary files. Files with the extensions .OUT, .OBW, .OWS, and .OBV are ASCII files that reflect the code run listing. These ASCII files contain observation head, concentration, and flux data. Files with the extensions .HDS, .CBB, .OL1, .CH1, .IS1, and .CON contain binary output of head, cell-by-cell flux, and chloride concentration data at each stress period, as determined by output control data.

2.4 Limitations

GSWIM, and similar mathematical models, can only approximate processes of physical systems. Models are inherently inexact because the mathematical description of the physical system is imperfect and the understanding of interrelated physical processes is incomplete. CH2M HILL-HGL have strived to incorporate as many details of the physical system into GSWIM as possible, within the scope, schedule, and budgetary constraints and collaborative stakeholder input process. GSWIM is a powerful tool that, when used carefully, can provide useful insights into processes of the physical system. Section 4.2.5 of this report details the potential sources of related model input and output error.

TABLE 2-1
Data Grouping of GSWIM Input Files
Task 2B-1 – Numerical Model Development and Scenario Results, East and Piru Subbasins

File Extension	Parameters
BAS	Active domain Initial heads
BCF	Grid spacing – horizontal and vertical Horizontal hydraulic conductivity Subsurface vertical leakance Storage coefficient Porosity Specific yield Unsaturated zone parameters
OLF	Topography Topsoil vertical leakance Rill height
CHF	Reach, junction, and segment connectivity Channel width Channel elevation Streambank elevation Manning's friction coefficient Rill height Obstruction height Segment length Zero-depth gradient at outflow from domain
IPT	Canopy interception Field capacity/wilting point suction Extinction depth Root zone distribution function Evaporation distribution function
ETS	Reference ET time series
RCH	Recharge concentration Recharge zones
RTS	Precipitation time series
WEL	Septic system discharge
FHB	Reservoir releases and spills time series Dam underflow time series Inflow at Lang (surface and subsurface) time series Industrial point-source discharges time series
LUP[a]	Land use fractions Parameter values related to LUC Well associations with each WSS Pumping time series for wells and diversions Imported water time series for each WSS Annual loss fractions for each WSS Monthly duty factors for each land use for each WSS
FWL5	Well location coordinates Well construction Well efficiency
BTN	Transport parameters Initial chloride concentrations
PCG5	Solver iteration and closure parameters Newton-Raphson iteration parameters Backtracking parameters

TABLE 2-1
Data Grouping of GSWIM Input Files
Task 2B-1 – Numerical Model Development and Scenario Results, East and Piru Subbasins

File Extension	Parameters
ATO	Time-step parameters Output control
OBS	Locations for head, flux, and chloride observations
ZNB	Zone numbers for computing subarea water budgets

[a]Includes land use and WSS parameters, such as imported water, water withdrawal and application, diversions, recycled water application, and Piru WWTP discharges.

Notes:

LUC = Land Use Code
WSS = Water Supply System
WWTP = wastewater treatment plant