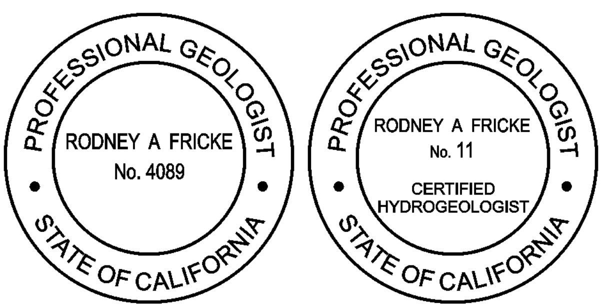
South American Subbasin Alternative Submittal

2014 Sustainable Groundwater Management Act

Final Draft

December 14, 2016



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Notice for Public Comment:

Prior to rendering a decision to submit the Alternative to the State, SCGA complied with the provisions of the California Environmental Quality Act (CEQA) by submitting the draft Alternative to the County of Sacramento Department of Community Development, Planning and Environmental Review Division for preparation of the appropriate CEQA documentation. The draft Alternative qualified for a categorical exemption pursuant to the California Code of Regulations Title 14, Section 15307, Actions by regulatory agencies for protection of natural resources, and Section 15308, Actions by regulatory agencies for the protection of the environment.

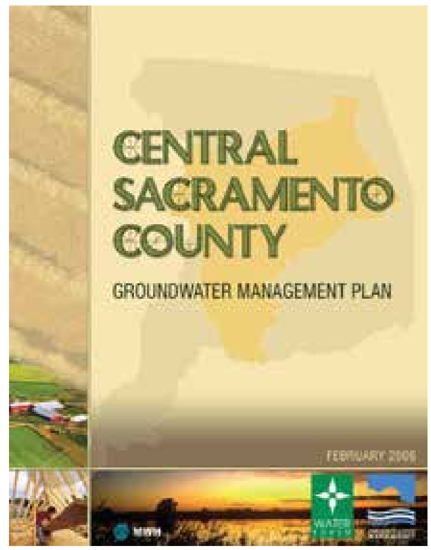
Executive Summary

"10733.6. ALTERNATIVE SUBMITTALS

(a) If a local agency believes that an alternative described in subdivision (b) satisfies the objectives of this part, the local agency may submit the alternative to the department for evaluation and assessment of whether the alternative satisfies the objectives of this part for the basin." – Sustainable Groundwater Management Act

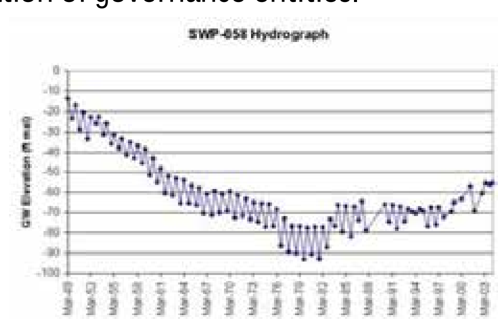
ES1. Introduction

The Sacramento Central Groundwater Authority (SCGA) has been in existence for over 10 years for the purpose of implementing an adopted SB 1938 Groundwater Management Plan which includes:



- Maintaining the regional long-term average groundwater extraction rate at or below the sustainable yield of 273,000 acre-feet annually established by the Water Forum
- Adherence to specific minimum groundwater elevations with a focus on the deepest point of the cone of depression
- Protection against any potential inelastic land surface subsidence
- Protection against any adverse impacts to surface water flows
- Development of specific water quality objectives for several constituents of concern

Formation of SCGA was a product of seven (7) years of negotiation by the Sacramento Area Water Forum, considered by the state to be a milestone in water resources management. Inclusive of all stakeholders, the resulting Water Forum Agreement is a moral commitment amongst those stakeholders to implement a solution containing seven elements, with the sixth element being Groundwater Management and the formation of governance entities.



ES1.Historic Groundwater Elevation Hydrograph

In Central Sacramento County, groundwater has many users and uses. Water users with no access to surface water have relied heavily on groundwater since the 1930's. In the case of agriculture, significant pumping from 1950 to 1970's took place in the region, significantly lowering groundwater elevations (see hydrograph of cone of depression underlying Elk Grove area – Figure ES1), and highlighting the need to protect groundwater resources into the future. In the mid 1980's County policies were being adopted to prevent urban growth from depending solely on the region's groundwater resources, requiring the higher cost of conjunctive use (surface water use in conjunction with groundwater) with application across the entire subbasin. Since the mid 1980's, groundwater levels have recovered by 40 feet and the cone of depression has been removed.

In the 1980's, the Sacramento County Water Agency (SCWA) and City of Sacramento both envisioned the need for consensus-building around water. The City-County Office of Metropolitan Water Planning was formed and directed the Water Forum Process. The Groundwater Management Element of the Water Forum Agreement contains the suite of self-imposed restrictions of groundwater's use and acknowledgment of the importance of groundwater to maintain a reliable and safe water supply for the region's economic health and planned development, and to preserve the fishery, wildlife, recreational, and aesthetic values in the Lower American River (Water Forum's Coequal Objectives).

ES2. Central Sacramento Sustainable Yield

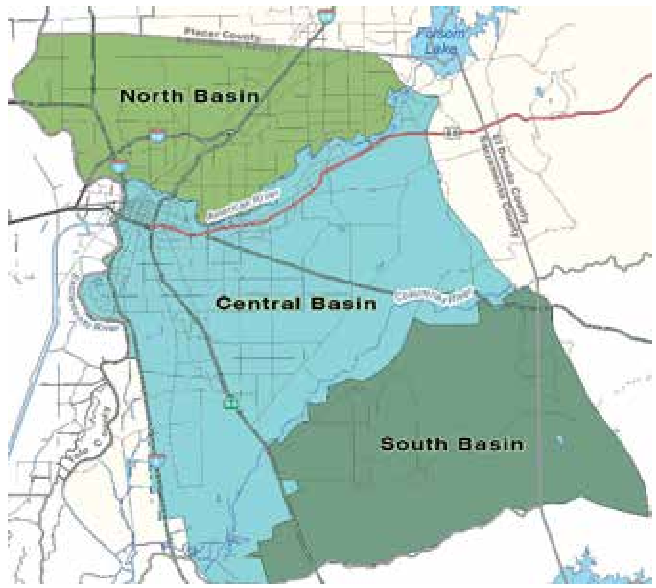
State groundwater models and modeling platforms used in the Water Forum initiated the process of considering "all" impacts resulting from over-pumping and continue to be utilized today with model calibration updates occurring approximately every 5 years. Studied impacts are aligned very closely with SGMA's Undesirable Results, including:

- increased energy usage to pump groundwater from greater depths,
- increased water treatment due to upwelling of saline water from deeper aquifer formations,
- replacement or deepening of wells resulting from lowering of groundwater levels,
- losses of surface water due to steepening of groundwater gradients in the case of hydraulically connected streams and rivers, and
- damage of private and public property due to land surface subsidence caused by dewatering of certain soil types.

Each of these factors was a consideration in the development of the sustainable yield assigned to each of the three Sacramento County subbasins, or portions of subbasins shown in the Figure ES2 below. Boundaries defining the three groundwater areas balanced the following four negotiated criteria: 1) county jurisdictional boundaries, 2) natural hydrogeologic features impeding subsurface flows, 3) persistent recharge areas, and 4) water district/purveyor/agency jurisdictional boundaries.

The long term average annual pumping amounts negotiated for each subbasin (North Basin - 131,000 acre-feet per year (AFA), Central Basin - 273,000 AFA, and South Basin - 115,000 AFA), are integral to the success of other prescribed elements of the Water Forum Agreement. As a result, a high level of local agency and stakeholder commitments have supported projects and actions to maintain rates of pumping at or below the sustainable yield.

More specifically, Central Sacramento's sustainable yield is at the heart of region's water supply planning and land use documents (e.g., Zone 40 Master Plan, City of Sacramento Groundwater Master Plan, and City and County General Plans), and are cited as the source of underlying design and operational criteria justifying hundreds of millions of dollars of water supply conveyance and treatment infrastructure, including, but not limited to, the SCWA/East Bay Municipal Utilities District (EBMUD) Freeport Project, SCWA's Vineyard Surface Water Treatment Plant, and expansions to the City's Sacramento River and American River diversion structures and treatment plants. The sustainable yield values are also used as the cornerstone of the region's determination of sufficiency of conjunctive use water supplies (i.e., SB610 and SB 221) for new development projects since the early 2000's.

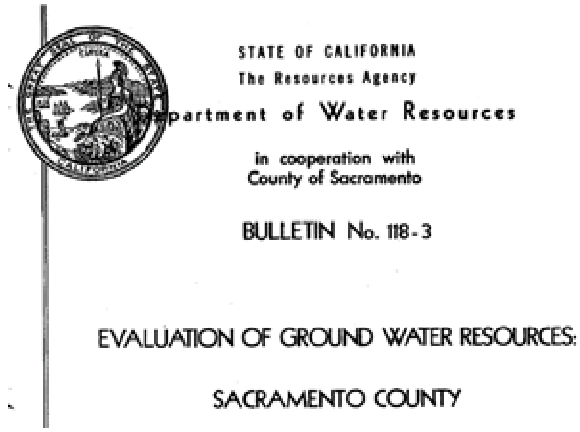


ES2.Water Forum Subbasins

ES3. <u>Formation of Sacramento Central Groundwater Authority (SCGA)</u>

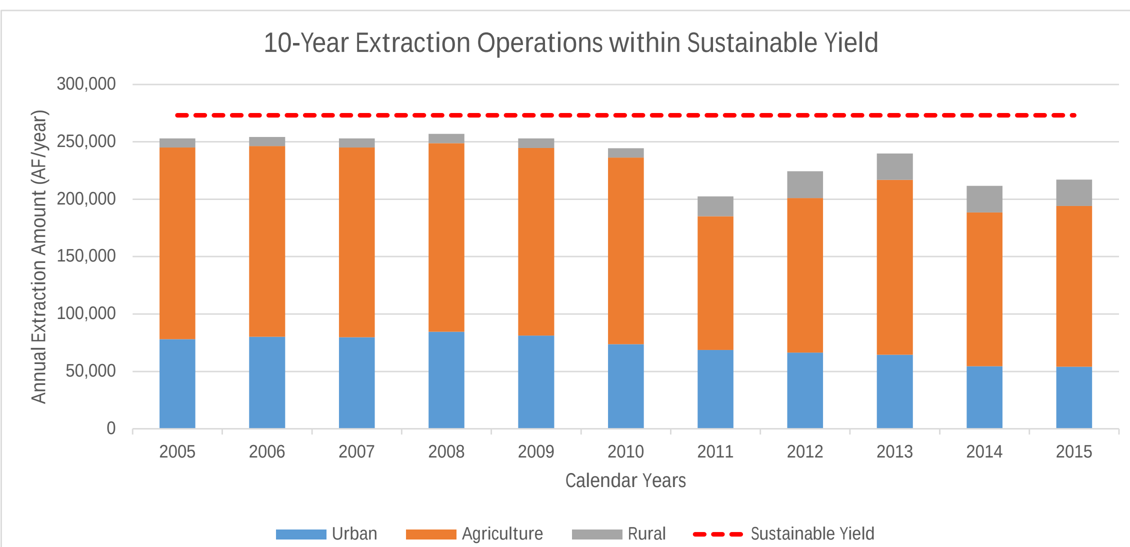
The Groundwater Management Element of the Water Forum Agreement also establishes the need for forming groundwater governance agencies in each subbasin. SCGA was formed to implement the governance policy using a consensus-based setting similar to the Water Forum with a group of 50+ stakeholders. This group met once a month for three (3) years, beginning with fact finding, education, and then negotiation. In the third year, as negotiations were underway, a point was reached where the group decided to not move forward until a draft GMP was completed containing the specific criteria and management actions to agree upon. The initial draft of the 2006 SCGA GMP was developed and contained a progressive threshold-based approach to voluntary groundwater management, and a domestic well protection program providing protection to private domestic well owners if groundwater levels decline and wells become dry as a result of future municipal pumping.

The history and hydrogeology of the Central Sacramento groundwater aquifer system is well-documented by County and State joint efforts in developing Bulletin 118-3 for the Sacramento Region, conducting biannual County-wide well monitoring, publishing biannual groundwater elevation contour maps, and developing calibrated computer groundwater models for use in negotiating federal, state, and local surface water and groundwater policies.



ES4. <u>Why Submit an Alternative to a Groundwater Sustainability Plan</u>

Since 2006, SCGA has had the responsibility of recording monthly and annual municipal pumping data, and, beginning in 2011, estimating agricultural and private domestic pumping using satellite imagery to accurately estimate evapotranspiration for input into State DWR's IWFM Demand Calculator (IDC) to compare total basin pumping with the negotiated long term average sustainable yield of 273,000 AF/year set by the Water Forum. This comparison has resulted in the bar chart below showing that every year of reported pumping is below the negotiated sustainable yield for the Central Basin.



ES4. Annual Comparison of Groundwater Extraction by Water Use Sector

The South American Subbasin Alternative Submittal (Alternative) was developed with the approval of SCGA's 16 governing board members; the Alternative demonstrates subbasin operations from 2005 to 2015 did not exceed the sustainable yield conditions set forth by the Water Forum Agreement.

SCGA's submittal of the Alternative is also seeking to preserve the Groundwater Management Element of the Water Forum Agreement[1] and its 10+ years of interest and investment in using its GMP and management authority for the continued sustainable management of groundwater within the subbasin. If approved, SCGA is committed to continuing its role in sustainable management of the groundwater subbasin and in complying with the California Statewide Groundwater Elevation Monitoring (CASGEM) program. If the Alternative is approved, annual reporting of subbasin conditions is required in April 2018 and five year updates reporting how subbasin operations have stayed below the sustainable yield are due as early as 2022.

ES5. <u>10-Year Analysis of Subbasin Operations within the Sustainable Yield</u>

With this Alternative, SCGA strives to meet both the intent of SGMA legislation and a navigation of the "best" approach to provide the statutorily-required 10-year analysis of sustainable management of the subbasin. The Alternative requires total groundwater extractions based on factual evidence and a demonstration of the subbasin's successful operations within a governance environment where stakeholder concerns regarding groundwater impacts can be heard. The steps used in this process included presentations of the following:

1. **Stakeholder process used in determining sustainable yield** – Brief understanding of open forum consensus and interest-based process to determine the subbasin sustainable yield.
2. **Validity of the SCGA GMP sustainable yield to the South American Subbasin** – Analysis of the groundwater management and sustainable yield differences between the current SCGA Central Basin and the South American Subbasin.
3. **Comparing groundwater extractions with sustainable yield** – Presentation of historic extraction amounts compared to the long-term average sustainable yield.
4. **Remediation and other regulatory programs** – Recognition of the amount of groundwater remediation occurring in the subbasin and the adaptation role of the local groundwater management agency.
5. **South American Subbasin water budgets** – Comparison of water budget data from local and state groundwater surface water models and conclusions.

[1] The redefinition of the Central Basin to align exactly with the South American Subbasin is a changed condition to the Water Forum Agreement's Groundwater Management Element, but does not decrease the amount pumping (or Sustainable Yield) identified to achieve the suite of acceptable groundwater conditions as discussed in Alternative **Section 2.2.2 Aligning SCGA Central Basin with South American Subbasin**.

6. **Water Forum review of undesirable effects** – Outline of the undesirable effects analyzed in the Water Forum process and used by the SCGA GMP to define the long-term average sustainable yield.
7. **Sustainability Indicators** – Presentation of all applicable monitoring data and reports, and findings of sustainability using Sustainability Indicators to show no significant or unreasonable impacts to groundwater.

This report presents the necessary factual data to fully represent and characterize changes taking place as a result of using groundwater for beneficial purposes. In the case of groundwater levels, positive and negative changes are identified as occurring throughout the basin, and will continue to occur, especially as the subbasin's groundwater levels strive to reach new equilibria. Water quality is also shown to be in flux, but at rates expected of an aquifer system with groundwater movement occurring through geologic strata now being exposed to groundwater with natural differences in chemical makeup.

Sustainability Indicators, as defined by SGMA, are also evaluated for the South American Subbasin to show both positive and negative rates of change in the SGMA Undesirable Results (URs), illustrating why none of the negative changes are considered to be URs and why none are directly related to "non-regulatory" groundwater extractions in the South American Subbasin. Additionally, changes occurring as a result of outside influences are being ameliorated by adaptive management actions by its member agencies in cooperation with SCGA. All of the locally-adopted thresholds included in the 2006 GMP evaluated against the Sustainability Indicators indicate that none of the negative changes result in regional or local undesirable results.

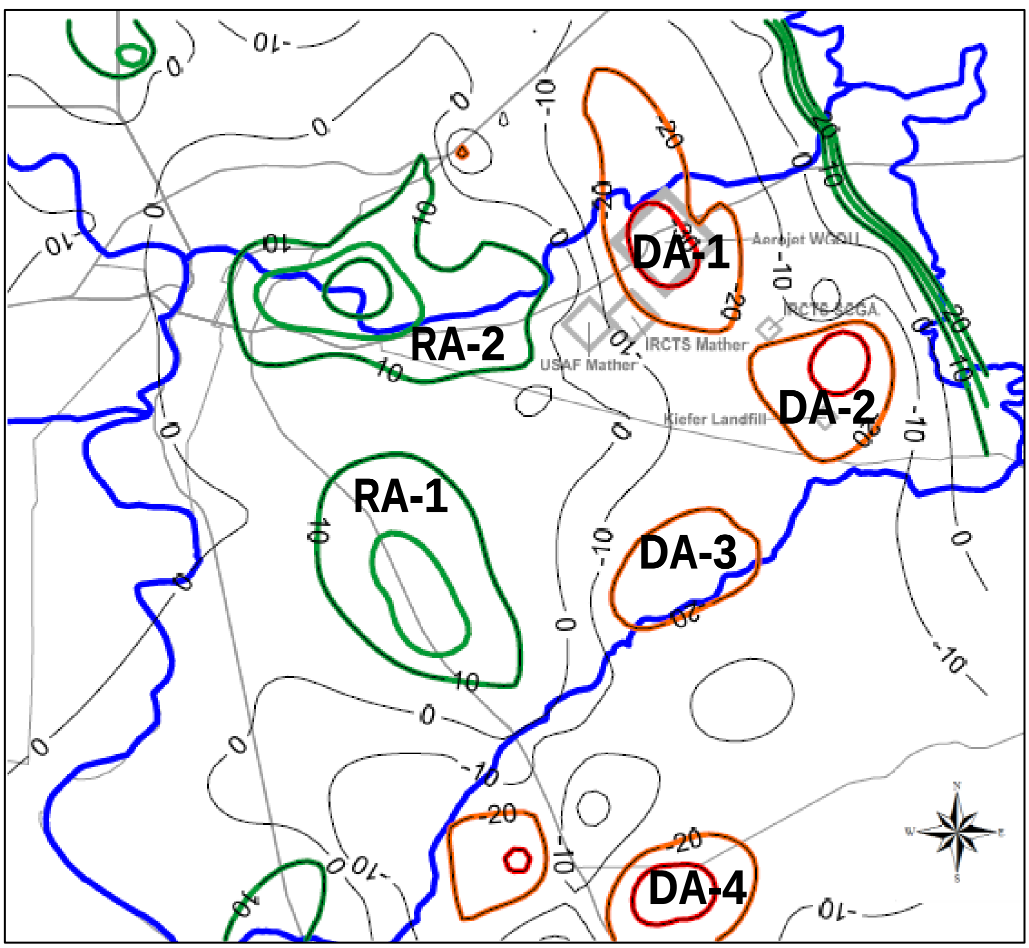
ES6. Public Outreach

Public outreach elements of the Alternative were completed in a compressed timeline due to SGMA's January 1, 2017, compliance deadline. A slightly larger outreach effort was completed by SCGA, through the Water Forum, over the months of October and November 2016 in support of characterizing the thoughts and concerns with the Alternative, and also captures concerns and project ideas being voiced in public meetings. The Water Forum report is included as **Appendix 1B** of the Alternative and provides an excellent summary of Alternative comments and "other" comments identified as being important to stakeholders. In addition, the Alternative includes public comment letters, and responses to the Water Forum and public letter comments, as **Appendix 1C**.

Delta stakeholders were contacted through the efforts of the Local Agencies of the North Delta (LAND). LAND entities through their representative stated support of the Delta Area's inclusion in the Alternative process. Principles of the Delta stakeholder support were articulated in a draft Memorandum of Understanding and Agreement (MOU) that was provided to LAND entities for their Boards' approvals (**Appendix 1D**). While a fully executed copy of this MOU is not available at the time this submittal is due, SCGA and Delta Area interests continue to collaborate.

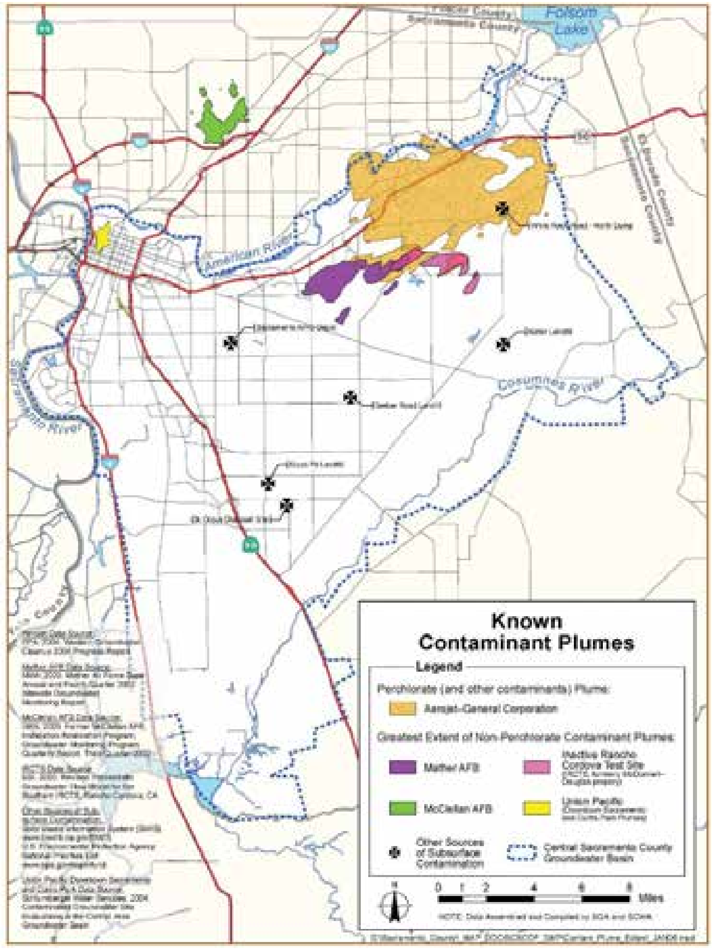
ES7. <u>Summary of Results</u>

The difference contour map below provides the best roadmap to understanding the changes occurring in the groundwater basin and the level of management taking place to increase storage of available drinking water. The contour lines in the figure represent 10 foot (and 5 foot in the extreme points) intervals of elevation change between 2005 and 2015. Red and orange contour lines represent a decrease in groundwater elevations (storage loss), and light green and dark green contours represent an increase in groundwater elevations (storage gain). Each decline area (DA) and 'recharged area' (RA) depicted by one or more colored contour rings can be explained using available hydrologic data, regulatory discharge data, and groundwater hydrograph data found in public on-line databases. Each of the areas is briefly explained below



ES7.Groundwater Elevation Difference (2015 minus 2005)

with additional detail found in Alternative **Section 2.6.2.1 Calculation of Change in Storage**.



Source: SCGA 2006 Groundwater Management Plan

ES6.Central Sacramento Groundwater Contamination Plumes

Most of the water level decline areas shown to have occurred on the eastern side of the subbasin (DA-1), are situated in close proximity to multiple groundwater remediation programs taking place due to groundwater contamination caused by historical disposal practices of multiple chemical constituents harmful to drinking water supplies. Cleanup extractions of contaminated groundwater take place under multiple federal EPA orders for the protection of human health. Pumping activities have been taking place since the 1980's and are forecasted to continue for an undetermined time into the future. SCGA and local land use agencies have a common understanding to adapt to changes in the cleanup program as they occur over time. Local groundwater management agencies have no jurisdiction over cleanup activities, relying on communication and agreements to inform the agencies of proposed changes and remedies to avoid a net loss in groundwater.

The decline area in the southeast portion (DA-2) of the subbasin located near the point where Deer Creek flows out of the foothills into the Central Valley is due to: 1) federal and state remedial activities requiring pump, treat, and discharge to local streams and evaporation ponds, 2) reductions in minimum discharge requirements of El Dorado Irrigation District's wastewater discharge flowing into the Deer Creek watershed, and 3) California's drought conditions reducing the total base flow of Deer Creek in 2015. None of the above are within the management control of SCGA or any SGMA-qualified local agency.

Decline areas along the Cosumnes River (DA-3) are a direct result of drought conditions and less total available water for recharge from flows down the Cosumnes River to the Delta and from water held back for recharge via temporary flash dams. Groundwater in this portion of the basin is reliant on Cosumnes River recharge and local agricultural practices are in place to capture as much water as possible for recharge purposes during late spring of each year. This decline area is expected to recover, and has shown past resilience with the return of wet year conditions.

Decline areas down in the Cosumnes Subbasin to the South (DA-4) are the result of reliance on groundwater by growing water demands in municipal, agriculture, and aquiculture uses, and have been exacerbated by the drought's impact on Cosumnes River flows. The level of groundwater level decline in the Cosumnes Subbasin and impacts to the South American Subbasin have not risen to the level of an undesirable impact, but close coordination is expected with future SGMA activities. Currently SCGA is maintaining storage levels in other areas of the South American Subbasin to offset subsurface losses currently occurring across subbasin boundaries. The overall storage loss, based on the negative difference contours only within the South American Subbasin, is approximated to be 107,000 AF. The annual average storage loss in the decline areas is calculated to be 11,000 AF/year.

A recharged area in the western portion of the subbasin (RA-1) underlying the City of Elk Grove and surrounding areas is the result of in-lieu recharge from the construction of large conjunctive use and surface water infrastructure facilities, fallowing and urban development of historically irrigated agricultural lands, increased use of recycled water, and water conservation. The increase in storage in this portion of the subbasin has filled the long-term cone of depression and has eroded the ridge of higher groundwater separating it from the Cosumnes Subbasin.

Lastly, a recharged area underlying the American River near the City of Sacramento's Fairbairn Water Treatment Plant and Diversion Structure (RA-2) has occurred likely as a result of a long term average increase in flows in the Lower American River, and the flattening of the hydraulic gradient as the cone of depression filled over the ten year period. The overall gain in storage, based on the recharged areas only within the South American Subbasin, is approximately 66,000 AF. The average annual storage increase over these recharged areas totals 7,000 AF/year.

The difference in total annual average change in storage over the 2005 to 2015 timeframe is calculated to be approximately 4,000 AF/year. In terms of order of magnitude, this equates to 4 to 5 large municipal wells in the subbasin, and is representative of a basin in equilibrium where natural recharge from deep percolation, hydraulically connected rivers, and boundary subsurface inflows are keeping up with active pumping and changes in hydrology. Groundwater sustainability has existed since the mid 1980's when recovery of the basin began after a period of overdraft. Over the 10 year period of the Alternative's analysis, the basin continues to recover at its deepest points and management is now focused on working with outside agencies to keep water from leaving the basin, and improving basin conditions where and when possible, in accordance with the SCGA 2006 GMP.

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Tables

Appendices (Included with Electronic Submittal)

List of Acronyms

AFA or AF/Year – Acre-Feet Annually
Alternative – SGMA Alternative Submittal

BMR – Basin Management Report

CASGEM – California Statewide Groundwater Elevation Monitoring
CDPH – California Department of Health
CVGSM – Central Valley Integrated Groundwater Surface Water Model
CWD – Carmichael Water District

DWR or State DWR – California State Department of Water Resources

EID – El Dorado Irrigation District
EIR – Environmental Impact Report

FE – Functional Equivalency
FRCD – Florin Resource Conservation District

GAMA – Ground-Water Ambient Monitoring and Assessment
GMP – SCGA Groundwater Management Plan
GSP – Groundwater Sustainability Plan
GSWC – Golden State Water Company

IRCTS – Inactive Rancho Cordova Test Site

JPA – Joint Powers Agreement/Authority

LAND – Local Agencies of the North Delta

MOU – Memorandum of Understanding

NPDES – Nation Pollutant Discharge Elimination System

OHWD – Omochumne-Hartnell Water District

SacIGSM – Sacramento Integrated Groundwater Surface Water Model
SCGA – Sacramento Central Groundwater Authority
SCWA – Sacramento County Water Agency
SGMA – Sustainable Groundwater Management Act
SWP – State Monitoring Well Program

TDS – Total Dissolved Solids

VOC – Volatile Organic Compound

Chapter 1. Introduction and Purpose

> *"SCGA has significant interest and investment in using its GMP and management authority for the sustainable management of groundwater within the South American Subbasin"* – SCGA Purpose for Alternative Submittal

The Sustainable Groundwater Management Act (SGMA) was adopted in September 2014 with implementation beginning January 1, 2015. Uncodified legislative findings of SGMA state that properly managed groundwater resources help protect communities, farms, and the environment against prolonged dry periods and climate change, thereby preserving water supplies for existing and potential beneficial uses. The same findings declare the legislature's intent to provide local and regional agencies the authority to sustainably manage groundwater. Consistent with this State interest in groundwater sustainability through local management, the California Department of Water Resources (DWR) adopted regulations specifying the components of groundwater sustainability plans, alternatives to such plans, and coordination agreements implementing plans, as well as methods and criteria for DWR to evaluate the plans, alternatives, and agreements.

Primary oversight for implementation of SGMA is through DWR and the State Water Resources Control Board (SWRCB). Under the provisions of SGMA, a Groundwater Sustainability Plan (GSP) is required for all high- and medium-priority groundwater basins. SGMA requires that a GSP be submitted to DWR by January 31, 2020 or January 31, 2022 depending on the priority classification of the basin. SGMA also authorizes a groundwater management agency within a basin compliant with the California Statewide Groundwater Elevation Monitoring (CASGEM) program to prepare an Alternative to a GSP; this Alternative Submittal (Alternative) must be provided to DWR by January 1, 2017. According to the GSP regulations, Alternatives will be evaluated by the same criteria that will be used to assess GSPs.

Requirements for a valid Alternative state that the Alternative must cover the entire Bulletin 118 (2003) groundwater basin/subbasin and to include one of the following: 1) a copy of the GMP, 2) adjudication information, if applicable, or 3) information that demonstrates that the basin has been operated within its sustainable yield for a 10-year period. In addition, the Alternative must explain how its elements are functionally equivalent to Articles 5 and 7 of the adopted GSP Emergency Regulations. These Regulations identify the requirements for content of a GSP (Article 5) and for annual reports and 5-year periodic evaluations (Article 7).

This document is the Sacramento Central Groundwater Authority's (SCGA) Alternative Submittal for the South American Subbasin (5-021.65). This Alternative is comprised of two chapters (or sections) and associated appendices as listed below.

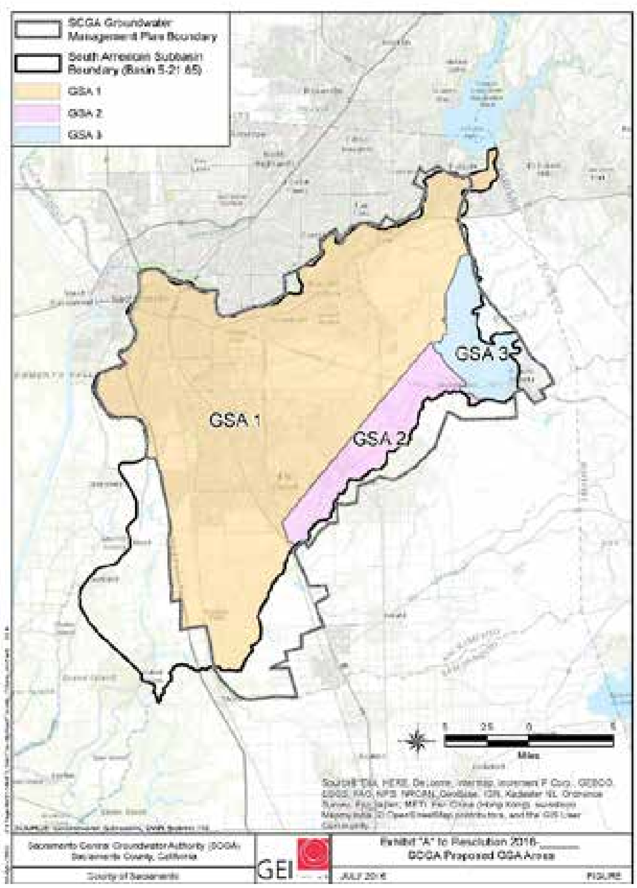
Chapter 1. Introduction

Chapter 2. Introduction

1.1 Background

The Water Forum was established during 1993 and, after many years of negotiations, resulted in the Water Forum Agreement (January 2000), which subsequently led to the formation of SCGA in 2006. SCGA was established as one of the key milestones of the Sacramento Area Water Forum Successor Effort (Water Forum). The Water Forum is a large group of agricultural and business leaders, citizens' and environmental groups, water managers, and local governments who recognized that unless they took action the Sacramento region faced water shortages, environmental degradation, groundwater contamination, threats to groundwater reliability, and limits to economic prosperity.

In addition to the Alternative Submittal, SCGA is moving forward with SGMA compliance and submitted a notice of intent on July 21, 2016, to become a Groundwater Sustainability Agency (GSA) for its area within the South American Subbasin and exclusive status was granted for the majority of that area (see GSA 1 in **Figure 1-1)**. Two overlap areas, submitted as GSA 2 and GSA 3, are present along the southern boundary of the South American Subbasin for the northern portions of the Omochumne-Hartnell Water District (OHWD) and the Sloughhouse Resource Conservation District (SRCD), respectively. Resolution of overlap areas will occur in parallel with the State's review of the Alternative. A GSA notice has not yet been submitted for the Delta Area of the South American Subbasin which lies outside of SCGA's GMP area, but SCGA anticipates that local Reclamation Districts, small communities, and the County will submit their notice prior to the June 30, 2017 deadline.



Source: June 8th SCGA Board Presentation

Figure 1-1. SCGA GSA Notifications

1.1.1 Groundwater Management Plan

The SCGA Groundwater Management Plan (GMP), included as **Appendix 1A**, was intentionally developed prior to the formation and creation of the Joint Powers Agreement (JPA), and was the outcome of three years of education and consensus-based negotiations amongst 50+ stakeholders. The content of the GMP and the quantitative management goals and thresholds were imperative to the ultimate outcome of the JPA governance structure, the adoption of the GMP, and the 10+ years of successful implementation of the GMP in the subbasin.

The SCGA GMP was one of the first GMPs in the state to include numerical thresholds for each of the potentially undesirable effects known to occur from over-pumping of the groundwater basin, including full consideration of a well protection program to mitigate for any quantified, but unavoidable impacts occurring in the basin as a result of increased pumping. Trigger points were established to provide increasing levels of enforcement through the threshold spectrum, or bandwidth, with initial notification that a problem is occurring, then assessing the problem and developing a stakeholder-based solution, and ultimately to perform enforcement actions necessary to solve the problem. Acting as a quantitative goal for groundwater management in the Central Basin, the GMP has served as the basis for the establishment of governance, exercised powers, and financing of SCGA's groundwater management program over the past 10+ years. Governance

SCGA is governed by a JPA between the cities and county – comprising the primary land use agencies and entities with police power authority within the subbasin: the County of Sacramento, and the Cities of Elk Grove, Folsom, Ranch Cordova, and Sacramento. The JPA established a Board of Directors for SCGA which includes representatives from the cities and county as well as each of the groundwater use sectors, including:

- Florin Resource Conservation District/Elk Grove Water Service
- Golden State Water Company
- Californian-American Water Company
- Agricultural interests
- Agricultural-residential groundwater users
- Commercial/industrial self-supplied groundwater users
- Conservation landowners
- OHWD
- Public agencies self-supplied groundwater users
- Rancho Murieta Community Services District
- Sacramento County Regional Sanitation District

1.1.2 Board Member Representation of Stakeholder Groups

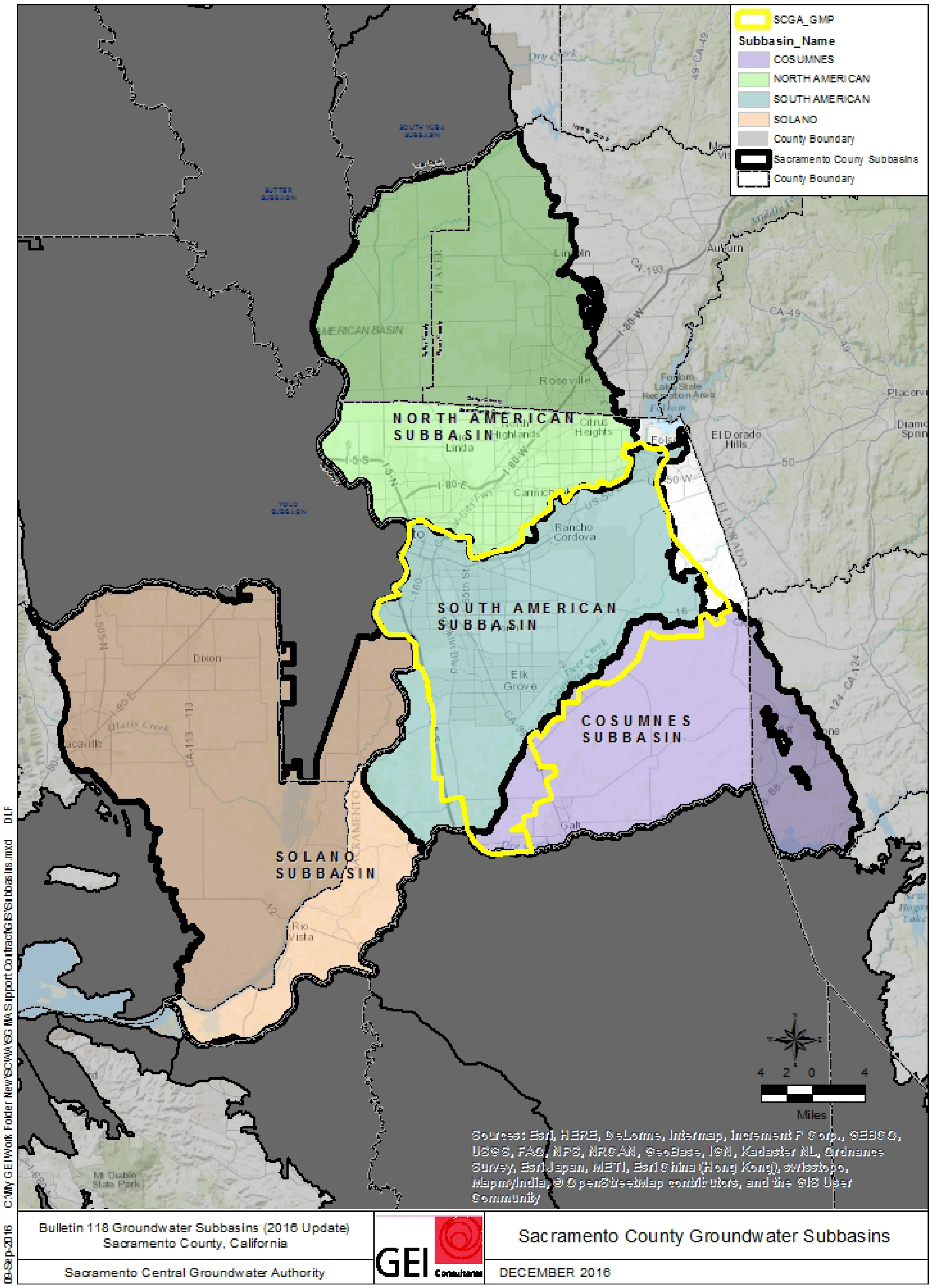
Each of the above representatives agrees to represent the interests of their respective stakeholder groups on the governing board of the SCGA. This responsibility includes, in part, disclosure of all relevant groundwater information and concerns, implementation of applicable groundwater management objectives, and a robust communication process that allows the board members' constituencies to fully participate in groundwater management through their representative.

The importance of the representation process has been critical to reaching out to agricultural and agricultural-residential (rural) groundwater use sectors who are made up of many hundreds of individual land owners. The process is set up to allow an individual well owner to voice concerns through their representative, or at a local district board meeting, and have this concern brought before the SCGA Board by their representative for possible action within the guidelines set forth in the GMP.

1.1.3 South American Subbasin Location

Figure 1-2 shows the location of the South American Subbasin, the existing SCGA GMP area, and portions of the adjacent Bulletin 118 (2003) groundwater subbasins located within Sacramento County. SCGA's GMP area was based on the nodal grid of the Sacramento Integrated Groundwater Surface Water Model (SacIGSM), which was developed initially by the Sacramento County Water Agency (SCWA) and then updated as part of the Water Forum Agreement and includes the South American Subbasin as defined in DWR Bulletin 118.

As shown in **Figure 1-2**, areas of the South American Subbasin which fall outside the SCGA GMP area include three small areas along the eastern boundary of the subbasin due to the early coarseness of the SacIGSM (i.e., placement of 11 nodes along an 8.5-mile length of the boundary) and the best available definition of the eastern alluvial margin relative to the definition in DWR Bulletin 118-3. Today, the model grid extends east to the Sacramento/El Dorado county line and covers these eastern areas. These small areas are included as part of the Alternative.



Note: Includes 2016 groundwater basin boundary modifications

Figure 1-2. South American Subbasin and Sacramento Central Groundwater Authority

The southwestern portion of the South American Subbasin outside of the SCGA GMP area lies within the legal definition of the California Delta (Delta Area). While the Delta Area was not included in SCGA's management area, this area was evaluated in the original modeling grid devised by the Sacramento County Water Agency (SCWA) and Water Forum. The Delta Area was not included as part of SCGA or its GMP because groundwater conditions in the Delta area were recognized to be distinctly different from conditions in the majority of the South American Subbasin. This area is included in the Alternative as described in **Section 1.5.2**.

1.1.4 Origin of SCGA GMP Area Boundaries

In the mid-1990's, the Water Forum, in working with affected agencies, sought to create groundwater focus areas north and south of the American River with the foresight of addressing the linkages between groundwater pumping and surface water flows. At the time, groundwater management at a local level included a different set of technical and socio-political ingredients to achieve success.

The area initially labeled in 1997 by the Water Forum[2] as "South Sacramento Area" was to become the "Central Sacramento County Groundwater Basin" or termed "Central Basin" in 2002 at the start of the Central Sacramento County Groundwater Forum. The Water Forum created three such areas within the county because each area was facing similar groundwater problems and conditions.

Boundaries defining the groundwater areas balanced the following four criteria: 1) county jurisdictional boundaries, 2) natural hydrogeologic features impeding subsurface flows, 3) persistent recharge areas, and 4) water district/purveyor/agency jurisdictional boundaries. Rivers and surface water bodies hydraulically connected with groundwater (i.e., loss rates affected by groundwater levels) were established as hydrogeologic boundaries and includes the American and Sacramento Rivers. The Delta is a persistent recharge boundary on the west, where persistent high groundwater conditions exist. The known extents of saturated regional alluvial material was established as a hydrogeologic boundary along the eastern side of the Sacramento Valley.

The Central Basin's southern boundary delineation considered the Cosumnes River and Deer Creek alignments, both recognized as sources of groundwater recharge but with hydraulic disconnection in the middle reaches, intermittent hydraulic connection for short reaches

[2] See Appendix E of Water Forum Agreement Draft Environmental Impact Report, *Baseline Conditions for Groundwater Yield Analysis*, (Montgomery Watson, 1997)

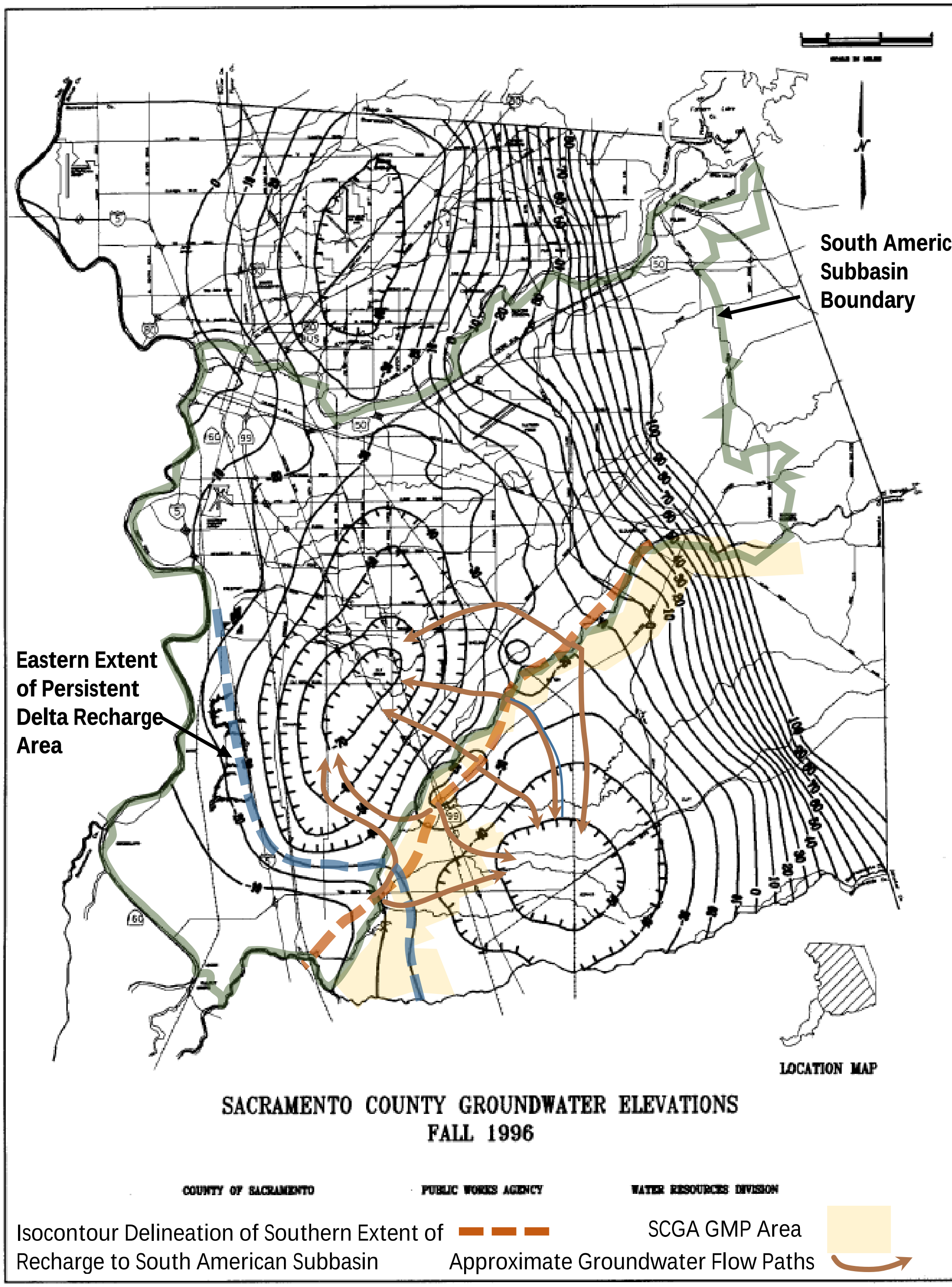
flowing into the Sacramento Valley, and full hydraulic connection as the two surface water sources come together and approach the persistent recharge area of the Delta.

Average fall 1996 groundwater elevation contours shown in **Figure 1-3** confirmed the presence of the persistent recharge influence of the Delta, and a prevalent recharge ridge underlying the floodplain region of the Cosumnes River and Deer Creek water sources. In cooperation with groundwater stakeholders, the Water Forum sought to include the full extent of area affected by the behavior of the Central Basin's cone of depression south of the Cosumnes River. This resulted in an initial boundary delineation aligning slightly south of the Cosumnes River along reaches of the river as shown by the brown dashed line illustrated in **Figure 1-3**. The "potential" flow paths have also been added to approximate the possible recharge pathways.

Basin delineation was further refined by the SacIGSM finite element mesh and model subregions (i.e., logical grouping of model elements based on land use, water district, political, and hydrogeologic boundaries as shown in **Figure 2-2**) which most closely approximated the areas after the initial three criteria were applied. The yellow shaded area in the figure represents the Central Basin boundary delineation and is the current SCGA GMP area.

1.1.5 SCGA GMP Area Not Included in Alternative

The SCGA GMP areas described above as being south of the Cosumnes River include portions of OHWD's service area south of the Cosumnes River and a portion of the area between the Cosumnes River and South Dry Creek (Sacramento County line) west of Highway 99. These areas are situated outside the South American Subbasin, and are not subject to this Alternative. Cosumnes Subbasin GSAs will be asked in the future to coordinate closely with SCGA in these areas because of the continued influence on the recharge and management of the South American Subbasin.



Source: Contour Map published by SCWA
Note: Recharge delineation and flow paths have been added for illustrative purposes only

Figure 1-3. Fall 1996 Groundwater Contours and Central Basin Southern Recharge Boundary

1.2 Timeline of Groundwater Management Affecting South American Subbasin

The 2006 SCGA GMP is a recognized milestone in the Greater Sacramento Region not only because it satisfies requirements set forth in the **Groundwater Element of the Water Forum Agreement**[3] but it is also founded on decades of local agency groundwater management experience:

1. Formation of the Sacramento County Water Agency by a special legislative act and includes countywide groundwater policies – 1952
2. Adoption of policies by the County of Sacramento recognizing that groundwater should be conserved, managed, and protected - 1972
3. Voluntary groundwater elevation (spring and fall) monitoring as part of State Well Monitoring Program and development of groundwater elevation contour maps utilized by the State and local agencies to monitor groundwater use – 1974
4. Partnerships with DWR in Bulletin 118 studies to specifically characterize the region's aquifer and local groundwater conditions – 1975
5. Adoption of a master plan, creation of a benefit zone (i.e., Zone 40 of the Sacramento County Water Agency (SCWA)), and establishing a fee structure to implement conjunctive use programs to support all new growth within groundwater impacted areas – 1986
6. Adoption of county-wide water policies limiting new development's use of groundwater and requiring that alternative supplies be identified to offset increased water demands – 1990
7. Development of a calibrated finite element groundwater-surface water model, and groundwater quality analyses – 1993
8. Development of current and projected water demands for Water Forum planning models (*The Estimate of Annual Water Demand within the Sacramento Metropolitan Area by* Boyle Engineering, 1995)– 1995
9. Delivery of first increment of surface water as part of SCWA's Zone 40's conjunctive use program – 1995
10. Quantitative impacts analysis of undesirable effects and groundwater modeling to support Water Forum negotiations – 1995
11. Establishment of a stakeholder process and significant education to define Sacramento County groundwater management areas and acceptable sustainable yields (Water Forum Process) – 1994-2000
12. Self-imposed and locally financed consensus-based stakeholder process leading to a quantitative threshold-based groundwater management plan and a proposed governance structure – 2000-2006

[3] See Groundwater Element of Water Forum Agreement, or see Section 3(IV) of Water Forum Agreement <http://waterforum.org/wp-content/uploads/2015/09/WF_SEC_3.pdf>

13. Adoption of the SCGA Groundwater Management Plan and Joint Powers Authority Governance Structure – 2006
14. 10+ years of voluntary groundwater management through SCGA and member agencies who represent all subbasin groundwater use sectors – 2006-2016

1.3 Sacramento Water Forum

In 1994, interested stakeholders were brought together through the Sacramento Area Water Forum Process. As part of its charge, the Water Forum determined the role of groundwater in achieving sustainable management of all water resources (i.e., surface water, groundwater, remediated groundwater, and recycled wastewater) in meeting the Water Forum's coequal objectives:

> ***Provide a reliable and safe water supply for the region's economic health and planned development to the year 2030; and Preserve the fishery, wildlife, recreational, and aesthetic values of the Lower American River.***

Much of the success of the 2000 Water Forum Agreement <www.waterforum.org> is based on a continuing partnership between the six interest groups (water suppliers, environmentalists, local governments, business groups, agriculturalists, and citizen groups) formed as part of the original six-year interest-based stakeholder process. The agreement is a living document within the Water Forum Successor Effort which, with affected interest groups, continue to meet and confer as changed conditions warrant. Additions and amendments to the Water Forum Agreement have ensured its on-going relevancy in the present-day regulatory environment and its value in the support and creation of local and regional water policies and practices.

In recognition of the Water Forum's role in the development of SCGA, specific policies and procedures have been included in SCGA's governing documents to provide a role for the Water Forum Successor Effort to assist in resolving conflicts.

1.4 Public Outreach

As public outreach is an important component of SGMA, a notification regarding initiation of this Alternative was included on the agenda of the SCGA Board of Directors meeting on July 13, 2016. This notice[4] included SCGA's intention to prepare this Alternative and provided a website link and contact person for more information about SCGA, its SGMA compliance efforts, and the development of the Alternative. The subject of an Alternative has been regularly included on agendas of SCGA public meetings held throughout 2016 at the Sacramento Regional County Sanitation District (SRCSD) offices, located in Rancho Cordova, as listed below.

- February 10 Board Meeting
- April 7 SGMA Subcommittee
- April 20 Board Meeting
- April 21 SGMA Subcommittee
- May 16 SGMA Subcommittee
- June 8 Board Meeting
- June 22 SGMA Subcommittee
- July 13 Board Meeting
- July 20 SGMA Subcommittee
- August 18 SGMA Subcommittee
- September 14 Board Meeting
- October 5 SGMA Subcommittee
- October 12 Board Meeting
- November 9 Board Meeting
- December 14 Board Meeting

All board and subcommittee meetings are advertised public meetings in compliance with the Brown Act. The SGMA Subcommittee was formed in 2015 and later charged to evaluate the merits, progress, and content of the Alternative as it developed. Feedback from the public and interest groups has been received in both board and subcommittee meetings regarding what an Alternative is, what it achieves with regard to SGMA compliance, and the long-term implications for those reliant upon groundwater as a water supply.

The nature of some concerns indicated that additional outreach was necessary. The Water Forum Successor Effort, being a "neutral space" for the Sacramento Region in resolving water-

[4] See Item 5 on July 13, 2016 Agenda and Board Package
<http://www.scgah2o.org/Documents/2016%2007%2013%20SCGA%20Board%20Meeting%20Agenda%20Package.pdf>

related issues relevant to the Water Forum Agreement, was asked to participate in this effort and secured State funding in order to conduct an intense stakeholder outreach process that ran in parallel with the development of the Alternative, including public review of the draft document. The results of this outreach effort are included as **Appendix 1B – Water Forum Stakeholder Outreach Summary for Public Draft Alternative**. Public comment letters and responses are provided as **Appendix 1C – Public Comment Letters and Responses.**

Focused stakeholder meetings in 2016 included:

- August 10 Delta Reclamation Districts, Local Agencies of North Delta (LAND)
- October 12 Cosumnes Watershed Coalition
- October 13 Florin Resources Conservation District/Elk Grove Water District
- October 18 Sloughhouse Resources Conservation District
- October 18 Omochumne-Hartnell Water District
- October 19 Sheldon residents
- November 2 Sacramento County Farm Bureau
- November 7 Stakeholders Workshop at the SRCSD office

See **Appendix 1B – Water Forum Stakeholder Outreach Summary for Public Draft Alternative** for further discussion of outreach meetings by the Water Forum.

1.5 Eligibility to Submit Alternative

SCGA, in consultation with DWR, has strived to meet both the intent of SGMA legislation and navigate the "best" approach to provide the statutorily-required 10-year history of sustainable management of the subbasin with regulatory-required functional equivalence to the requirements set forth in Articles 5 and 7 of the GSP Regulations. Below are focus areas where direction was sought by SCGA from DWR Staff.

1.5.1 Understanding SGMA's Purpose for Including Alternative Submittals

SCGA has prepared this Alternative to conform with SGMA's promotion and support for local actions to sustainably manage groundwater subbasins, recognizing and preserving the authority of cities and counties to manage groundwater pursuant to their police powers and minimizing state intervention to only when necessary to ensure local agencies manage groundwater in a sustainable manner. To this end, SGMA provides options for local agencies to show they satisfy the objectives of SGMA via a similar level of groundwater management through their existing GMP, and/or by providing sufficient factual evidence demonstrating the subbasin has operated within its locally established sustainable yield for at least 10 years.

SCGA and its GMP were created through consensus-based negotiations; its operational budget continues to be supported through voluntary local funding sources. These local funds have been used to self-govern the subbasin through application of quantitative objectives, thresholds, and triggers that align with each of the applicable Sustainability Indicators described in SGMA statute. SCGA member entities have over 20 years of operating and management experience in the subbasin and make up the 16-member Board of Directors. SCGA is committed to sustainable resource management through avoiding significant or undesirable impacts.

The 2006 SCGA GMP was used as a guide during DWR's development of required GSP content, now established in Article 5 of the 2016 GSP Regulations. While many requirements of the GSP Regulations are met via the SCGA GMP and its voluntary governance and cost structure, the GMP does not cover the entire South American Subbasin. SGMA requires the Alternative to satisfy statutory objectives for the whole subbasin, applying any of three statutory categories[5]. In conformance with statutory and regulatory directives, SCGA provides a technical analysis of 10+ years of subbasin operation within an established sustainable yield that relies, in part, on SCGA's management according to its GMP for the SCGA GMP area of the South American Subbasin. This Alternative includes a companion chapter presenting its functional equivalency

[5] California Water Code Section 10733.6(b)

to elements that will be required for GSPs, as identified in Articles 5 and 7 of the GSP Regulations.

1.5.2 Entire Subbasin Requirement

SGMA requires the Alternative apply to the entire subbasin, with boundaries defined by DWR Bulletin 118-3 (2003). As discussed above and shown in **Figure 1-2** the SCGA GMP management area does not cover the entire South American Subbasin. SCGA's JPA language defines the Authority's eastern boundary to be the El Dorado Countyline, which includes areas to the east of the GMP area boundary. SCGA will conduct management and funding actions consistent with the GMP in these "eastern fringe" areas.

A portion of the South American Subbasin west of Interstate 5 -- entirely within the State-defined 'legal Delta' -- was not included in SCGA's GMP area (Delta Area). Water Forum studies completed in the mid-1990's delineated the Central Basin (i.e., SCGA GMP) boundaries using a set of criteria (see **Section 1.1.4** for full list of criteria) with one being the presence of persistent recharge boundaries contributing to the sustainable yield of the Central Basin, described in detail in **Section 1.1.4** above. The influence of the Delta's abundant surface water and inherent high groundwater conditions creates the Central Basin's western persistent recharge boundary still seen today.

After working with agricultural interests in the Delta through the Local Agencies of the North Delta (LAND), their representative indicated that LAND entities support the Delta Area's inclusion in the Alternative Submittal process, with principles articulated in a draft Memorandum of Understanding and Agreement (MOU) that was provided to LAND entities for their Boards' approvals (see **Appendix 1D – Delta Reclamation District MOU and Alternative Support Letter**). While a fully executed copy of this MOU is not available at the time this submittal is due, SCGA and Delta Area interests will continue to collaborate. SCGA and its member agencies will use existing programs and funding to conduct the required monitoring and annual reporting requirements for this area as part of future SGMA compliance for the Alternative.

1.5.3 Alternative Submittal Content

Over the 4-month period in which the Alternative was developed, a considerable amount of monitoring data and reporting documents were reviewed, evaluated, synthesized, and presented in order to provide DWR with all available monitoring data. Only applicable high quality data were used to demonstrate 10 years of operating within the sustainable yield. In addition, the SCGA GMP and various reference documents were reviewed and scrutinized in order to provide the best and most recent source information for functional equivalence to

Articles 5 and 7, with much of this information being derived from the evidence supporting the analysis demonstrating 10-years of sustainability. However, the Alternative's analysis itself contributes to satisfaction of functional equivalency. Each of the findings is supported with referenced data sources made available through the electronic submittal process. The Alternative is not proposing actions or projects independent of those approved as part of the adopted 2006 SCGA GMP.

1.5.4 Addressing Data Gaps

Data gaps occur where the level of uncertainty creates a need for additional information. Data gaps can be addressed through monitoring and reporting, and through use of other available resources (i.e., DWR provided data, adjacent basin monitoring). Data gaps discussed in the Alternative are mentioned as possible areas for update or enhancement to further refine monitoring and reporting demonstrating continued operation within the sustainable yield of the subbasin. SCGA did not find data gaps, as that term is defined in the GSP regulations, that rise to a lack of information significantly affecting the understanding of the basin setting or evaluation of whether the basin is being managed sustainably.

1.5.5 Water Forum Process Used to Determine Sustainable Yield

The 2000 Water Forum Agreement solidified a long-term average annual sustainable yield for the Central Basin (i.e., SCGA GMP area boundaries) of 273,000 acre-feet (AFA). The basis of this number is documented in Water Forum Agreement and GMP reference documents (included in the electronic submittal of the Alternative). The work completed for the Water Forum Agreement is equivalent to the requirements necessary to fully evaluate each of the Sustainability Indicators identified in SGMA. The results of this work were applied to support the factual findings ultimately used in the negotiation of sustainable yield for each of the three primary Sacramento County groundwater subbasins.

Conjunctive use of groundwater and surface water are a key element of groundwater management in the region. The SCGA sustainable yield was defined by local agencies and other interested parties and is viewed as meeting the competing interests for water without causing significant and unreasonable impacts for SGMA Sustainability Indicators.

1.5.6 Method of Presenting Functional Equivalency

Functional equivalency to Articles 5 and 7 of the GSP Regulations is demonstrated in a separate standalone chapter (Chapter 4) of the Alternative due to its size, structured formatting, and method of uploading documents to State DWR's on-line Alternative Submittal website found at the url <http://wwwdwr.water.ca.gov/groundwater/sgm/alt.cfm>. The Chapter relies on direct reference to **Chapter 2**, the existing GMP, and other reference documents included in the electronic submittal package. Documentation of functional equivalency (FE) includes the following information for each section of Articles 5 and 7:

1. Link(s) to the appropriate section(s) of the GMP (or other reference documents)
2. Brief explanation of how substantial FE is met
3. List of data gaps, if any, for future improvements to the Alternative
4. If FE requirement is not relevant to the Alternative, a brief explanation as to why

All cited documents and figures not in **Chapter 2** or the GMP are included in the electronic Alternative Submittal package as *.pdf files or hyperlinks. The adopted GSP and Alternatives Emergency Regulations published by State DWR[6] is considered a companion document and should be referred to by the reader, as the titling of the functional equivalency chapter follows the same order as the GSP Regulations. State DWR also provides an optional table of the GSP regulations to accomplish what has been done in Chapter 4. Both methods will be considered as the Alternative Submittal is being uploaded.

[6] See url <http://wwwdwr.water.ca.gov/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf>

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Chapter 2. Evaluating 10 Years of Operating within Sustainable Yield

"An Alternative submitted pursuant to Water Code Section 10733.6(b)(3) shall provide information that demonstrates the basin has operated within its sustainable yield over a period of at least 10 years. Data submitted in support of this Alternative shall include continuous data from the end of that 10-year period to current conditions." (**GSP Regulations § 358.2(c)(3))**

2.1 Introduction

The Sustainable Groundwater Management Act of 2014 (SGMA) authorizes local agencies to submit an alternative document to the State Department of Water Resources (DWR) for evaluation and assessment of whether the submitted document satisfies SGMA objectives (Water Code 10733.6(a)). An Alternative Submittal authorizes agencies with 10+ years of proven groundwater management experience, established governance structures, and an effective groundwater management plan the opportunity to comply with SGMA in a manner that is functionally equivalent to the stakeholder-based processes described in Articles 5 (Plan Content) and 7 (Reporting and Evaluation) of the GSP Regulations. SGMA specifically recognizes existing local management agencies where successful stewardship actions have led to 10 years or more of groundwater sustainability without exceeding locally-defined thresholds for any of the six (6) regulatory-identified Sustainability Indicators (SIs) (see GSP Regulations and California Water Code Section 10733.6).

Sustainable yield, as defined under SGMA is "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result."[7] By its definition, the determination of a subbasin's sustainable yield requires the long-term evaluation of SIs and undesirable results over a base period at differing groundwater extractions levels and hydrologic conditions.

The analysis provided in this chapter is based on multiple lines of factual evidence and is used to demonstrate the subbasin's successful operation within a stakeholder-supported quantified sustainable yield. The chapter's organization is structured as follows:

5. **Stakeholder process used in determining sustainable yield** – Brief understanding of open forum consensus and interest-based process to determine the subbasin sustainable yield.

[7] Water Code § 10721(w)

6. **Validity of the SCGA GMP sustainable yield to the South American Subbasin** – Analysis of the groundwater management and sustainable yield differences between the current SCGA Central Basin and the South American Subbasin.
7. **Comparing groundwater extractions with sustainable yield** – Presentation of historic extraction amounts compared to the long-term average sustainable yield.
8. **Remediation and other regulatory programs** – Recognition of the amount of groundwater remediation occurring in the subbasin and the adaptation role of the local groundwater management agency.
9. **South American Subbasin water budgets** – Comparison of water budget data from local and state groundwater surface water models and conclusions.
10. **Water Forum review of undesirable effects** – Outline of the undesirable effects analyzed in the Water Forum process and used by the SCGA GMP to define the long-term average sustainable yield.
11. **Sustainability Indicators** – Presentation of all applicable monitoring data and reports, and findings of sustainability using Sustainability Indicators to show no significant or unreasonable impacts to groundwater.
12. **Conclusion** – Summary of findings and data showing that sustainability can continue going forward.

2.2 Stakeholder Process Used in Determining Sustainable Yield

The long-term average sustainable yield in the Central Basin represents the quantitative description of groundwater management goals as determined by stakeholders in the region. Conjunctive use programs, water policies, and projects within the affected region have, over the past 15 years, resulted in the ability to achieve the sustainable management goals originally set by the interest-based Water Forum Process in 1997 and ultimately included in the 2000 Water Forum Agreement.

The formation of SCGA was a "second stage" process consisting of representatives of the Water Forum and interested parties and stakeholders from within the subbasin to develop a locally-defined voluntary groundwater management program. The program, for the first time, focused on quantitative thresholds, triggers, and reporting actions to alert stakeholders of monitoring data and potential activities threatening the groundwater management goals of the basin. These include, but are not limited to, the comparison of total groundwater extractions to the long-term average sustainable yield.

2.2.1 Water Forum Process and Regional Groundwater Studies

The scientific studies leading to negotiations of sustainable yield for groundwater basins within Sacramento County were developed during the Water Forum process using a numerical finite element groundwater-surface water model, based on the region's state published hydrogeologic conceptual model[8], with an initial node and element mesh as shown in **Figure 2-1**, Education and negotiations amongst representatives of interested parties were completed over a 3-year period, finally achieving consensus on quantified sustainable yields.

The results of the Water Forum process, including sustainable yield determinations, are documented in the January 2000 Water Forum Agreement (**Appendix 1D –Appendix 2A –Water Forum Agreement Groundwater Management Element**). The Water Forum Agreement recommendation for the South Area (also referred to as the Central Basin, see **Section 1.1.4**) is as follows:

> *The recommended estimated average annual sustainable yield is 273,000 acre feet. This represents the year 2005 projected pumping amount and is 23,000 acre feet more than the 1990 pumping amount. The projected 2005 pumping amount for the South Area [Central Basin] took into consideration the cost of delivery of surface water and the impacts which occur due to the lower stabilized groundwater levels. To meet year 2030 demands, a program would be implemented to use the groundwater basin conjunctively with surface water diversions*. (Water Forum Agreement, January 2000)

Central Sacramento's sustainable yield is at the heart of the region's current water supply planning and land use documents (e.g., Zone 40 Master Plan, City of Sacramento Groundwater Master Plan, and City and County General Plans), and are cited as the source of underlying design and operational criteria justifying hundreds of millions of dollars of water supply conveyance and treatment infrastructure, including, but not limited to, the SCWA/East Bay Municipal Utilities District (EBMUD) Freeport Project, SCWA's Vineyard Surface Water Treatment Plant, and expansions to the City's Sacramento River and American River diversion structures and treatment plants. The sustainable yield values are also used as the cornerstone of the region's determination of sufficiency of conjunctive use water supplies (i.e., SB610 and SB 221) for new development projects since the early 2000's.

The Groundwater Management Element of the Water Forum Agreement also establishes the need for forming groundwater governance agencies in each subbasin. SCGA was formed as the governance agency of the Central Basin using a consensus-based setting similar to the Water Forum with a group of 50+ stakeholders. This group met once a month for three (3) years, beginning with fact finding, education, and then negotiation. In the third year, as negotiations were underway, a point was reached where the group decided to not move forward until a draft GMP was completed containing the specific criteria and management actions to agree upon. The initial draft of the 2006 SCGA GMP was developed and contained a progressive

[8] See State DWR Bulletin 118-3 <http://water.ca.gov/groundwater/bulletin118/report2003.cfm>

threshold-based approach to voluntary groundwater management, and a domestic well protection program providing protection to private domestic well owners if groundwater levels decline and wells become dry as a result of future municipal pumping.

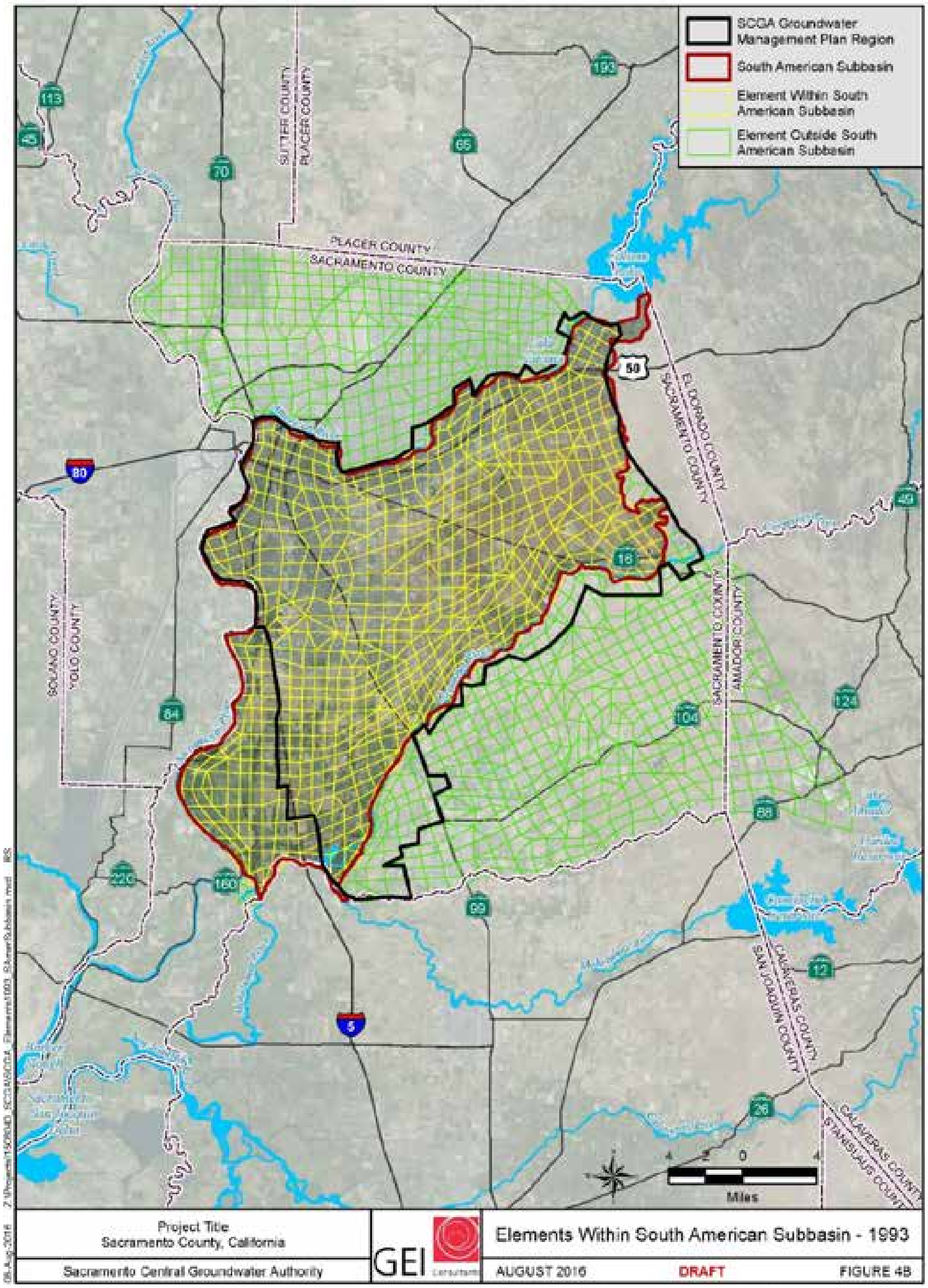


Figure 2-1. 1993 Finite Element Mesh for South American Subbasin and Sacramento County

The sustainable yields of the three subbasins defined by the Water Forum Agreement (see **Figure 2-2** are listed in **Table 2-1** (EDAW and Surface Water Resources, 1999). The 'Courtland Area' (i.e., the Delta Area, shown as dashed line) of the County was included in the modeling studies, but intentionally not included in the Central Basin for reasons explained below.

Table 2-1. Estimates of Annual Sustainable Yield for Sacramento County

Annual Sustainable Yield (acre-feet)	Water Forum Groundwater Basins within Sacramento County
Water Forum Agreement	
131,000	**North Basin** – north of the American River
115,000	**South Basin** – south of the Cosumnes River, south of the Central Basin
273,000	**Central Basin** – south of the American River to the south side of the Cosumnes River to include OHWD and other similar areas, east of Interstate 5; the GMP area of the Sacramento Central Groundwater Authority

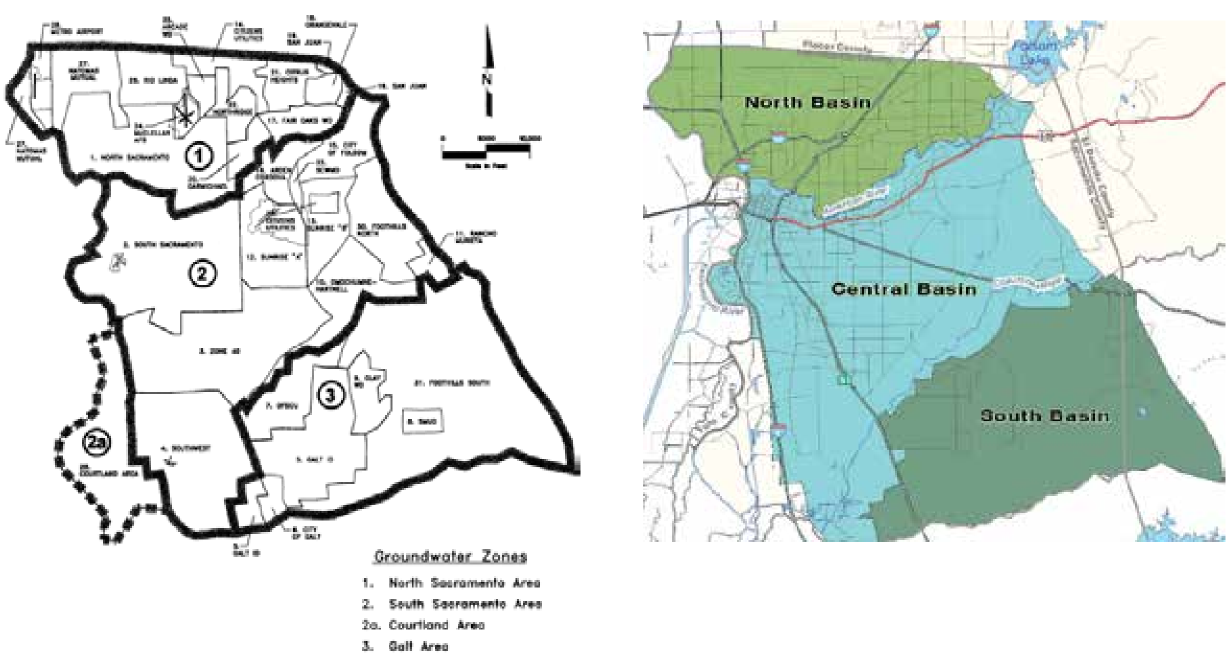


Figure 2-2. Groundwater Model Subregions and Water Forum Subbasins

2.2.2 Aligning SCGA Central Basin with South American Subbasin

Groundwater management in each of the three Water Forum subbasins was focused on developing a set of stakeholder supported activities designed to manage and increase groundwater elevations within the cones of depression shown in **Figure 2-3**. This figure represents average fall 1996 groundwater conditions (across multiple aquifers) showing three distinct subbasins developed from years of agricultural and urban pumping, and from the natural persistent recharge occurring from river flows and the California Delta. To best achieve groundwater management in the Central Basin, the Water Forum delineated the Central Basin's boundaries based on the following general criteria:

- County jurisdictional boundaries
- natural hydrogeologic features impeding subsurface flows such as connections with major rivers
- persistent recharge areas such as the Delta
- water district/purveyor/agency jurisdictional boundaries generally defined by the groundwater model subregion delineations used for model calibration

Based on the above criteria, the boundaries of the Central Basin were delineated as shown in **Figure 2-2**. Areas identified as part of the Delta were not included since the point where regional Central Basin pumping strongly influences recharge and recovery was, and continues to be[9], close to the legal Delta's (and the North Delta Water Agency's) eastern boundary along Interstate 5. Areas south of the Cosumnes River were included in the Central Basin due to the Delta, Mokelumne River, and Cosumnes River confluence recharge source, and to bolster the strength of smaller political agencies and unrepresented lands. Stakeholder representatives were included in the boundary delineation.

This Alternative compares and aligns the Central Basin with the State DWR's Bulletin 118 (2003) South American Subbasin boundaries, and asks the question, "what change, if any, does this realignment have on the Water Forum's quantification of the basin's sustainable yield?"

Figure 2-4 illustrates the latest SacIGSM model subregions and the areas that would be 'removed' from the Central Basin's original calculation, as they are south of the Cosumnes River and within the Cosumnes subbasin (Subtracted Area – portions of subregions 4 and 10), and the

[9] See State Water Data Library Well:
<http://www.water.ca.gov/waterdatalibrary/groundwater/hydrographs/brr_hydro.cfm?CFGRIDKEY=5563>

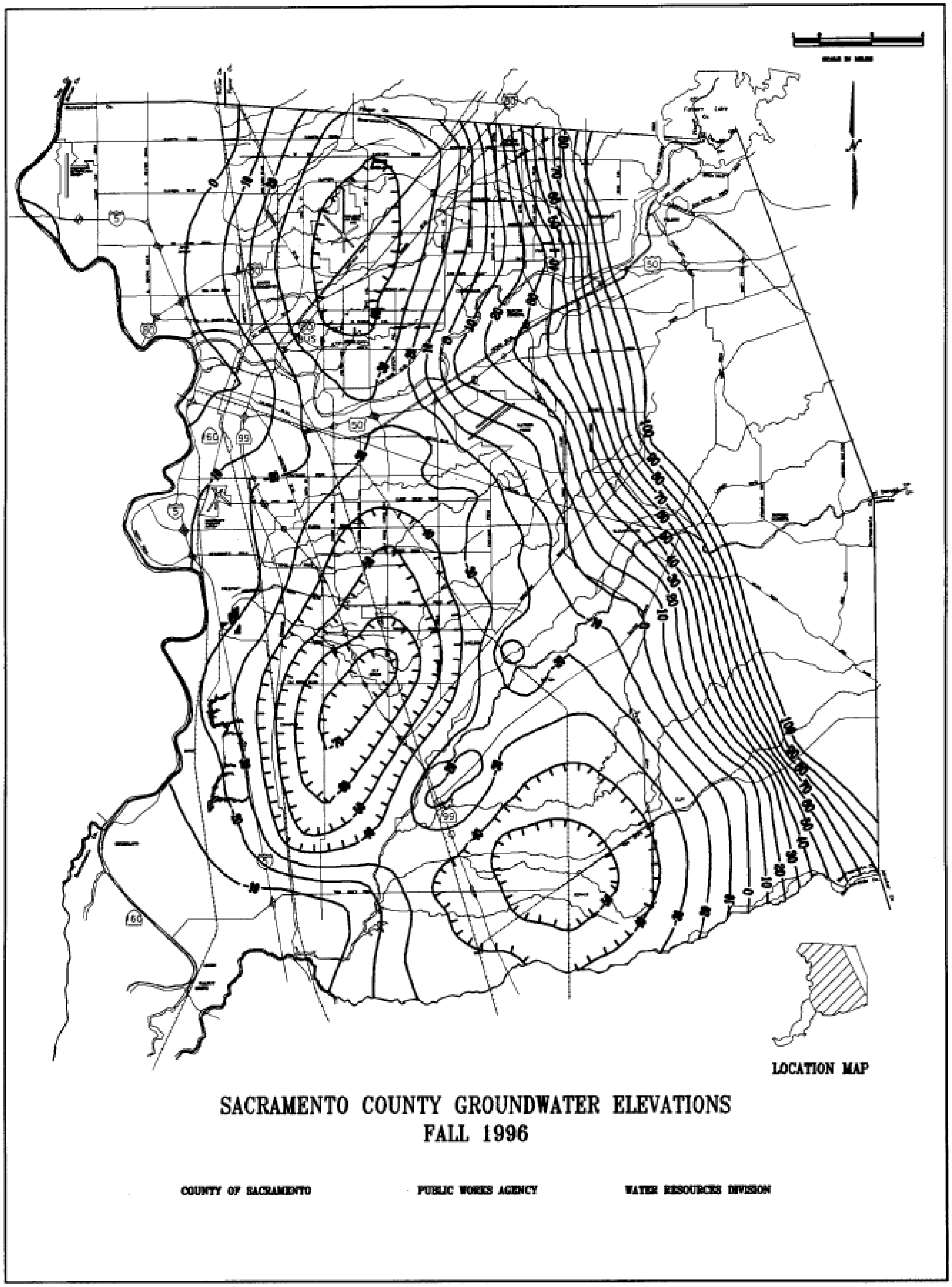


Figure 2-3. Groundwater Elevation Contours for Fall 1996 Used by the Water Forum

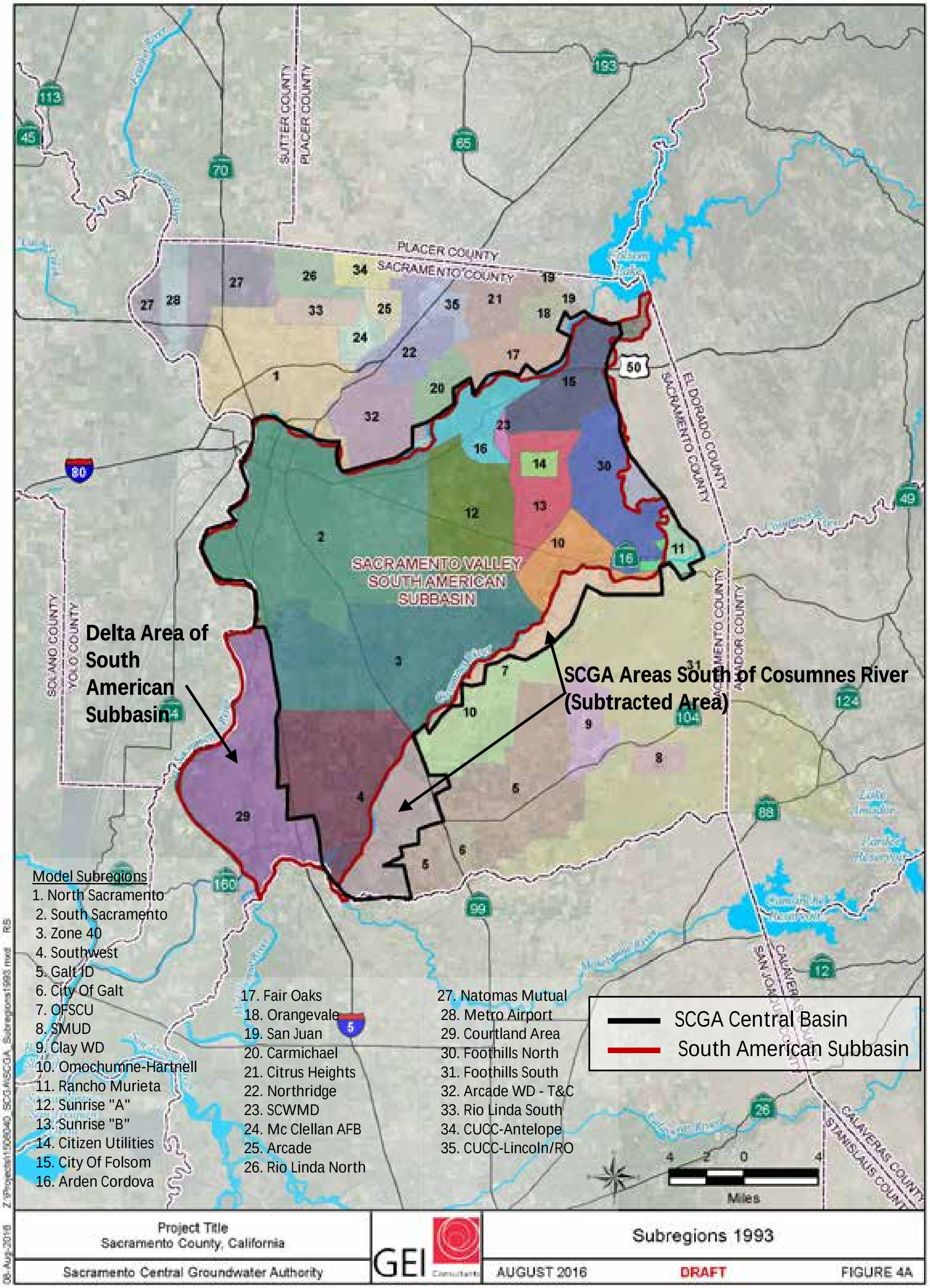


Figure 2-4. Water Forum SacIGSM Model Subregions

areas that would be 'added' to include the Delta Area (subregion 29). The purpose of this analysis is to provide ground-truthing of SCGA's reported management of the Central Basin, as it was defined by the Water Forum, and the ability to continue using the SCGA sustainable yield of 273,000 AFA in this Alternative for the South American Subbasin. The intent is to include the Delta Area and remove the Subtracted Area pumping amounts, and demonstrate basin operations are within the sustainable yield set by Water Forum assuming the Central Basin was defined as the South American Subbasin. This includes use of the original Water Forum water budgets and Original SacIGSM forecast model runs, and the quantification of potential impacts of exceeding the six sustainability indicators.[10]

The hypothesis of this exercise is as follows:

> *If Water Forum studies and models included the Delta Area in the analysis of forecasted changes in groundwater pumping, and the Central Basin sustainability and impacts were based on further deepening of the Elk Grove cone of depression, then the same studies and model runs can be used today to estimate the amount of pumping that was occurring over the South American Subbasin footprint.*

The sustainable yield resulting from the proof of this hypothesis assumes that pumping in areas outside the South American Subbasin, but within the SCGA GMP area, are transferred and evaluated in the context of the appropriate State DWR SGMA subbasin (i.e., Cosumnes Subbasin GSP evaluation of sustainable yield to include these areas).

2.2.3 Assessing Need for Change in Existing Sustainable Yield Due to Realignment

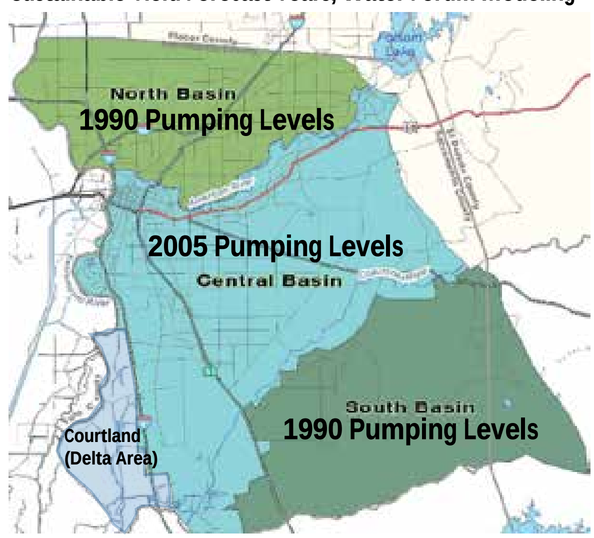
All modeling conducted by the Water Forum for the determination of the sustainable yield included the Delta Area's land use and projected water demands. As stated in the above hypothesis, the Alternative contemplates realigning the Central Basin boundary as defined by the Water Forum to one matching the South American Subbasin footprint, requiring an assessment of the potential change to the basin's sustainable yield. Water Forum studies used increasing levels of regional groundwater pumping, based on growth assumptions in the 1990 Sacramento County General Plan and agricultural growth assumptions from the Farm Bureau. These growth assumptions were in 10-year increments through the year 2030 which represented "build-out conditions." Each 10-year growth scenario was used by local stakeholders as the basis for evaluating and negotiating the threshold for significant or unreasonable impacts. For the Central Basin, the acceptable 273,000 AFA long-term average

[10] See Appendix E of Water Forum Agreement Draft Environmental Impact Report, *Baseline Conditions for Groundwater Yield Analysis*, (Montgomery Watson, 1997) or Alternative Resources: WaterForum_Groundwater Baseline Yield Analysis.pdf

sustainable yield (see Appendix A of the SCGA GMP and Section 2.5 for additional information) was quantified by the Water Forum (1995), based on a forecasted growth scenario assuming future demand relies solely on groundwater, and represents stakeholder negotiation over the long-term average and maximum impacts from forecasted 2005 levels of pumping across the model domain, including the Delta Area as shown below,.

The outcome of the Water Forum modeling approach on the Central Basin also included the following:

Sustainable Yield Forecast Years, Water Forum Modeling



1. Impacts evaluated in Central Basin included unquantified incremental impacts resulting from 2005 forecasted pumping levels across the Original SacIGSM model domain including the Delta Area.
2. The long-term average sustainable yield for adjacent subbasins to the north and south were negotiated to remain at 1990 levels of groundwater pumping.
3. Water Forum Solution Original SacIGSM forecast model included negotiated surface water and groundwater (Water Forum Agreement) policy assumptions assuming 2030 forecasted growth conditions over the model domain (including Delta Area) and resulted in an average long term extraction in the Central Basin of 273,000 AF/year.

2.2.3.1 Change in Central Basin Area to Align with South American Subbasin

The Delta Area is approximately 32,250 acres, and is made up of predominantly agriculture with smaller agriculturally-based communities (i.e., Courtland and Hood) and conservation lands; the approximate area of the SCGA GMP area currently within the Cosumnes Subbasin (Subtracted Area, shown in **Figure 2-4**) is approximately 35,050 acres, an area made up of conservation lands, rural homes, and significantly lower densities of irrigated agricultural lands. The total area of the South American Subbasin (Bulletin 118 (2003)) is 248,000 acres (of which 87% is currently managed by SCGA's GMP). The net difference of total area accounted within the Water Forum-quantified sustainable yield by removing the Subtracted Area and adding the Delta Area is a reduction of 2,800 acres (or 1.1% of the total South American Subbasin area).

2.2.4 Verification of Current and Past Water Demands

Because the sustainable yield management actions of the SCGA GMP are based on the aggregated pumping over the managed area, the 2011 SacIGSM calibration model (most current) is used to present and compare the unit and total demands, and patterns of groundwater pumping, between the Delta Area and the Subtracted Area.

Changes in evapotranspiration and agricultural water supply requirements, both seasonally and hydrologically, between the Subtracted Area and the Delta Area are expected to be closely matched due to their close geographic proximity. Slightly cooler temperatures and less overall evapotranspiration may occur in the Delta Area which could lead to a crop's reduction in overall water supply requirement; however, this natural occurrence is accounted for in the model and will show up in the comparison of pumping for both regions.

Since the Delta Area relies more on surface water for most of its irrigation in dry to wet years, the total <u>unit</u> groundwater pumping per agricultural acre,[11] as represented in the 2011 calibrated SacIGSM, shows the Delta Area groundwater use patterns closely matching those in the Subtracted Area but with approximately half the amount of pumping on a given acre of irrigated land compared to the Subtracted Area, as shown in **Figure 2-5**.

The top (orange) line in this figure represents the average "Subtracted Area" unit pumping amount for each year of the calibration model, or, in other words, the average annual amount of groundwater applied to each acre of irrigated agricultural land, regardless of crop type. The bottom (blue) line is the same for the Delta Area.

[11] Land area-based unit water demands (AF/acre/year) are often used in water demand studies to determine the relative difference in applied groundwater, surface, or total water demand for a region regardless of area.

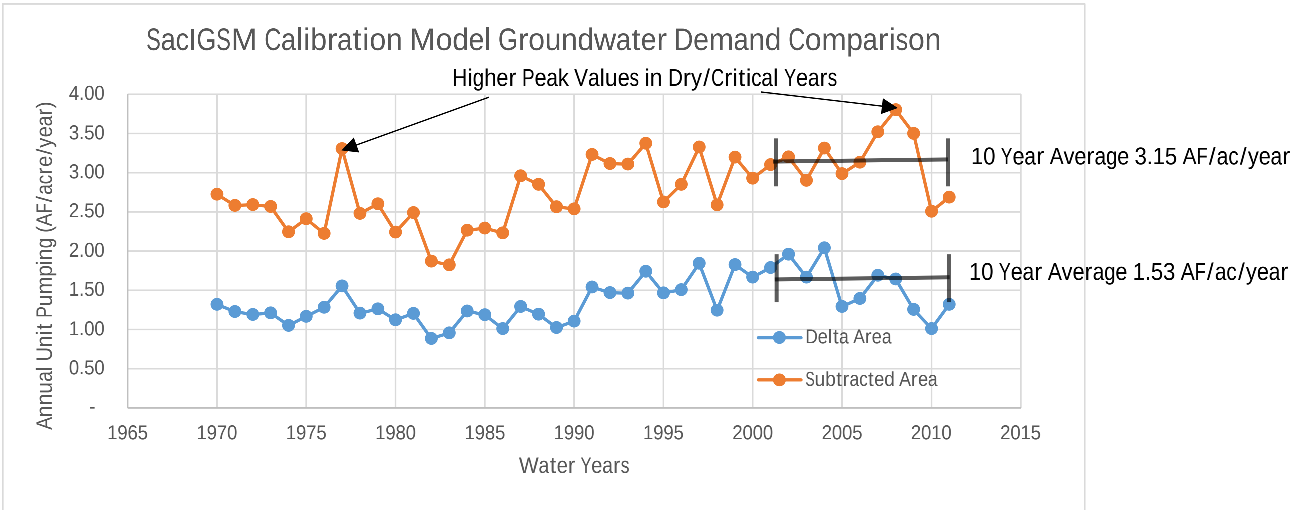


Figure 2-5. Delta and South of Cosumnes Agricultural Unit Groundwater Pumping

Figure 2-5 illustrates the close match in hydrologic variations in groundwater use patterns over a period of 40+ water years with relative dry/critical year peaks in the Subtracted Area being higher than the Delta Area indicating conjunctive use practices taking place as agriculture shifts from surface water to groundwater in dry years. The figure also indicates a similar trend over hydrologic wet and dry periods, with a noticeable decrease in unit pumping in the Subtracted Area over the more recent dry period from 2005 to 2010, likely due to changes in irrigation practices (i.e., flood irrigation to drip irrigation) and land conversion to vineyards with drip irrigation.

Conservatively applying the most recent 10-year model average (2002-2011) of the annual unit pumping values to account for the latest irrigation practices and crops, the Delta Area's average unit pumping factor (1.53 AF/acre/year), as calculated from data in **Figure 2-5**, applied to the average irrigated land area of 26,851 acres (approximately 80% of total Delta Area)[12], results in a total annual average groundwater pumping of approximately 41,000 AF/year. The same calculation for the Subtracted Area results in a 3.15 AF/acre/year average 10-year pumping factor and an estimated 10,176 acres of irrigated agricultural lands[13]. The resulting average annual groundwater use (3.15 AF/acre/year X 10,176 acres) for the Subtracted Area is 32,100 AF/year. Even though the unit demand for agricultural pumping is higher in the Subtracted

[12] Agricultural acreages are based on the Water Forum groundwater model using the 1993 DWR land use survey.
[13] Irrigated area extracted through SacIGSM model land use file for elements south of the Cosumnes River resulting in approximately 30% of the total Subtracted Area (see GIS **Figure 2-7** for visual verification).

Area, the resulting groundwater use for agriculture is lower due to the lesser density of agriculture in the Subtracted Area. The above demands do not include rural water demands associated with the developed areas of large acre lots. This is considerably higher in the Subtracted Area, with a difference of approximately 1,800 AF/year higher in the Subtracted Area taking into account the higher population of rural development south of the Cosumnes River. In sum, the total increase in pumping as result of the realignment of the Central Basin to the South American Subbasin, based on the 2011 SacIGSM, could be as high as 7,100 AF/year.

Given the lower agricultural water supply requirement for groundwater in the Subtracted Area versus the Delta Area, removing the Subtracted Area and adding the Delta Area to the Water Forum sustainable yield calculation shows groundwater pumping for the realigned Central Basin could increase slightly over a normal to dry period (similar to water years 2002 to 2011).

2.2.5 Water Forum's 2005 Forecast Model to Verify Sustainable Yield

This step in the realignment verification recalculates the sustainable yield based on the use of the South American Subbasin as the footprint for the Central Basin. Going back to the Water Forum's 2005 forecast model run (basis for the long-term average sustainable yield), the total (i.e., all land uses) approximated groundwater pumping for all uses within the Delta Area was reported as 31,100 AF/year[14]. For the Subtracted Area, the total groundwater pumping for the OWHD subregion (17,400 AF/year) and the Southwest subregion (94,000 AF/year) were used as the basis for calculating the Subtracted Area pumping using the percentage of agricultural acreage in each subregion relative to the entire subregion (i.e., necessary since Water Forum forecast model subregion data does report or provide for calculating partial demands):

OHWD subregion:

17,400 AF/year total pumping (all uses)[15] * 3,021 agricultural acres (south of the Cosumnes River)/6,272 agricultural acres (in total subregion) = 8,400 AF/year

Southwest subregion:

94,000 AF/year total pumping (all uses) * 7,155 agricultural acres (south of Cosumnes River)/30,000 agricultural acres (in total subregion)) = 22,400 AF/year

Sum of Subtracted Area Water Demand:

[14] See Table 1. Baseline Conditions Summary in *Baseline Conditions for Groundwater Yield Analysis*, (Montgomery Watson, 1997)

[15] See Table 3. Static Baseline Conditions: Groundwater Yield and Water Level Decline in *Baseline Conditions for Groundwater Yield Analysis*, (Montgomery Watson, 1997)

8,400 AF/year + 22,400 AF/year = 30,800 AF/year, which is 300 AF/year less than Delta Area pumping of 31,100 AF/year

The net result of realigning the Central Basin to the South American Subbasin and applying the Water Forum-based sustainable yield conditions is 300 AF/year, a small addition to the sustainable yield quantification. More specifically, if the Central Basin boundary had been drawn co-extensively with the South American Subbasin, the Water Forum-based analysis would have concluded the sustainable yield as being the same or slightly greater than 273,000 AF/year. As a result, SCGA will continue to use the long-term average sustainable yield of 273,000 AF/year for this Alternative Submittal for the South American Subbasin, keeping with the intent of the Water Forum Agreement and principles of the SCGA GMP.

2.3 Comparing Groundwater Extractions with Sustainable Yield

Operating within the long-term average sustainable yield is a comparison of groundwater extractions with the long-term average sustainable yield of the Central Basin. To incorporate the methodology of realigning the Central Basin with the boundaries of the South American Subbasin described in **Section 2.2.2**, SCGA recognizes that reported estimated groundwater pumping in biennial Basin Management Reports (BMRs) provide estimates over a slightly different area. The Alternative's goal of demonstrating that both annual and long-term average South American Subbasin extractions have been below the long-term average sustainable yield includes BMR data and tests whether the possible increase would create an exceedance condition.

Note: reporting of annual pumping consistently below the long-term average sustainable yield evidences highly conservative basin management for basins with active conjunctive use programs.[16]

2.3.1 Annual Groundwater Extraction Comparison with Sustainable Yield

Table 2-2 provides a summary of the BMR groundwater production data beginning in 2005. Since most water purveyors report their usage on a calendar year, the BMRs adopted the calendar year tabulation. In future annual reporting of groundwater usage, pumping amounts will likely be discretized to monthly values and will report both calendar year and water year totals. The comparison of calendar year-based extractions to a water year-based long term average sustainable yield does not appreciably change the comparison being made in this report since estimated values in the highest extraction years (2005-2010) could be reduced for agriculture and rural use sectors by approximately 45,000 AF/year; see **Section 2.3.2** for a detailed description of the change and reporting in methodology for estimating agricultural water supply requirement starting in 2011.

Table 2-2 only includes groundwater use sectors which were originally included for management in the 2006 GMP, and now in SGMA statute. The larger use sector categories include urban, agricultural, and agricultural-residential (rural). Urban uses include large and small water districts, self-supplied pumpers, park districts, and golf courses. Not included are extractions for groundwater remediation, discussed in **Section 2.3.3**.

Figure 2-6 illustrates that groundwater production has been within the sustainable yield on an annual basis during the 11-year reporting period, ending in 2015. Groundwater production over this period is reported to have varied from 202,324 acre-feet in 2011 to 260,200 acre-feet

[16] In future Alternative Updates, a running 10 year pumping average will be used for comparison against the long-term average sustainable yield to account for conjunctive use programs in urban and agricultural areas.

in 2008 (mean over 11 years: 236,800 acre-feet). **Appendix 2B** provides a detailed accounting of groundwater extractions by user including groundwater remediation.

The Central Basin realignment over the South American Subbasin is expected to add a small increment of agricultural extractions and, at the same time, reduce rural extractions with a net increase of no more than 7,100 AF/year on average (see **Section 2.2.2**). The change in methodology for estimating agricultural water supply requirements, discussed in **Section 2.3.2**, will also need to be done for the Delta Area to verify this potential increase.

Table 2-2. Reported Central Basin Groundwater Extractions

Primary Water Use Sectors	Groundwater Production Reported[3] and Estimated (Calendar Years)										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015[2]**
Urban	78,070	80,227	79,780	84,498	81,287	73,680	68,679	66,478	64,547	54,610	54,111
Agriculture[1]	167,062	166,148	165,234	164,320	163,406	162,492	116,500	134,600	152,400	133,900	140,000
Rural	7,852	7,946	8,041	8,136	8,231	8,326	17,200	23,400	22,900	23,100	23,000
Total	**252,984**	**254,321**	**253,055**	**256,954**	**252,924**	**244,498**	**202,379**	**224,478**	**239,847**	**211,610**	**217,111**

Notes:

1. Improved agricultural water supply requirement estimates using State DWR's IDC occurred in 2011.
2. Agriculture and Rural extractions for calendar year 2015 were not available and is based on the nominal average of previous 3 years.
3. Detailed reporting of groundwater extractions are documented in SCGA's BMRs from 2007 to 2014 as published on SCGA's website at <http://www.scgah2o.org/Pages/archive.aspx> and included as **Appendix 2B – Detailed Pumping Data** of the Alternative.

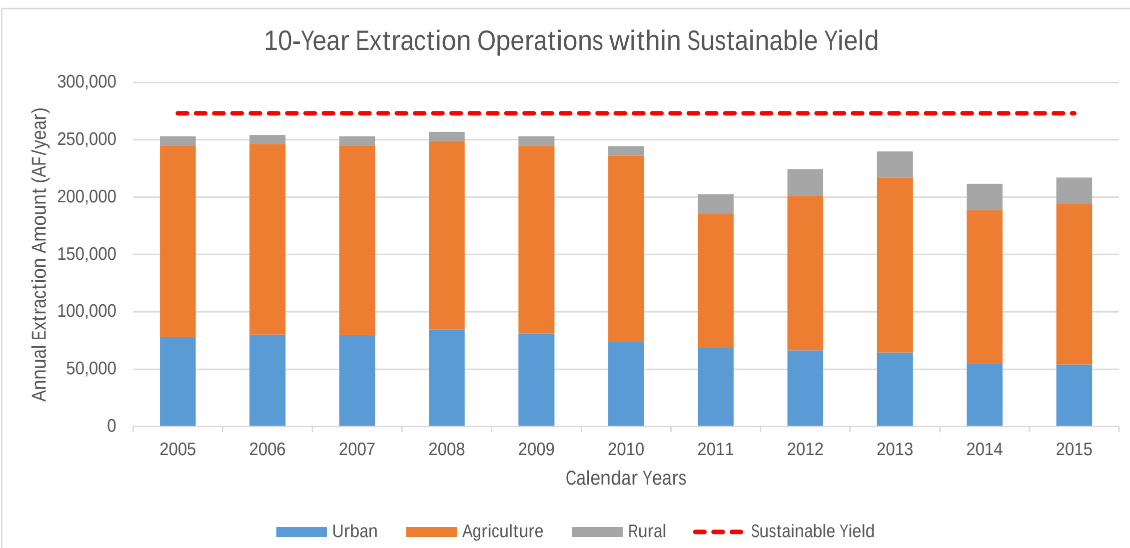


Figure 2-6. Annual Comparison of Groundwater Extractions by Water Use Sector Categories and Sustainable Yield

2.3.2 Change in Estimation Methodology for Agricultural Rural Uses

Figure 2-6 shows a significant change in agricultural and rural demands from 2010 to 2011 and thereafter. Agricultural volumes were originally estimated using assigned crop acreage unit water demand factors according to Water Forum's assumption. The Farm Bureau forecast that agricultural acreage would decrease from the reported 1990 irrigated area (using 1988 and 1993 State DWR land use surveys as source) by approximately 5% each 10-year period to 2020 and then remain constant.

Post-2010 estimates of land use are based on satellite imagery, as shown in **Figure 2-7**, to estimate actual evapotranspiration and then applying State DWR's IDC soil moisture model to estimate the total water supply requirement for agriculture and irrigated rural areas.[17,18]

In addition, the 2015 estimate of agriculture and rural groundwater extractions are repeated from 2014 because the 2015 estimate is not available. Agricultural water supply requirements in 2015 are expected to be higher due to drought conditions and critical water year shortages of surface water (i.e., Delta, Sacramento River, and Cosumnes River) into the South American Subbasin. The possible one year increase in agricultural pumping is not expected to increase the long-term average extraction amounts to above the long-term sustainable yield. The impacts of the drought on 2015 levels of pumping also show up in groundwater level monitoring discussed in **Section 2.6.1**.

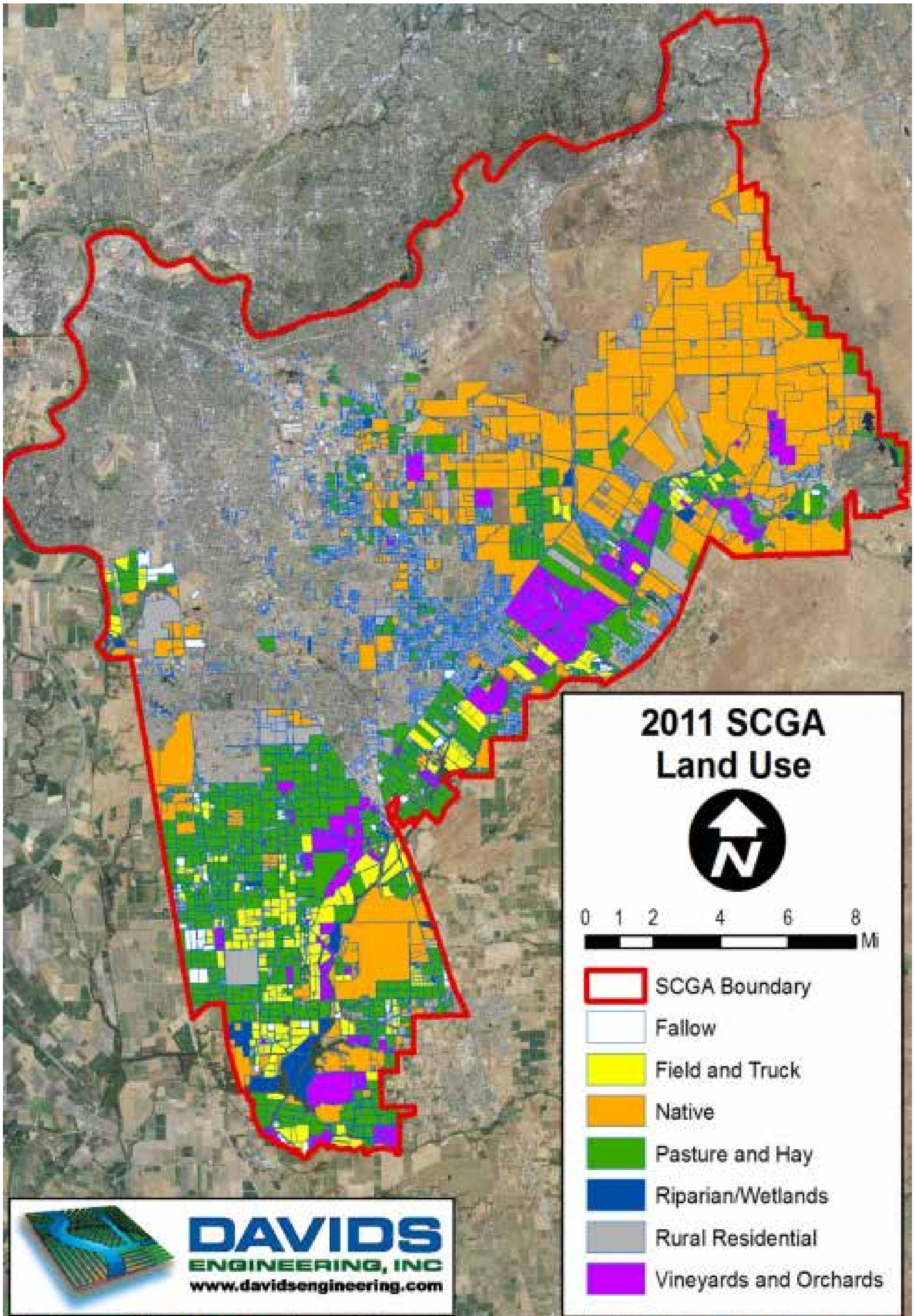
The SacIGSM modeling assumptions used to-date have not included the updated methodology of estimating agricultural water supply requirement. Much like the reporting estimates in **Table 2-2**, where agricultural and rural water supply requirements decreased with the updated methodology, the same will likely hold true for the Delta Area. This will likely result in a similar percentage reduction in agricultural and rural water supply requirements, affecting estimated surface water (riparian diversions) and groundwater use in the Delta Area.

2.3.3 Groundwater Remediation and other Regulatory Programs

Groundwater remediation for the protection of drinking water supplies is a necessary extraction in the South American Subbasin. Remediation is accomplished under various state and federal regulatory programs at several sites within the basin (see **Figure 2-8**). These regulatory remediation activities protect drinking water quality for human use, and take precedence over the potential risk to groundwater reductions and aquifer impacts resulting from these extractions. SCGA has worked with the regulatory community for purposes of education, reporting, and developing strategies and methodologies to keep or return remediated groundwater to the basin. SCGA acknowledges the necessity to adaptively manage to remediation activities outside of SCGA's control until groundwater conditions reach a steady-state condition.

[17] See RMC May 14, 2014 SCGA presentation:
<http://www.scgah2o.org/documents/Ag%20Demand%20and%20BMR%20Board%20Presentation.pdf>

[18] See Davids Engineering, Inc. June 6, 2014. Technical Memorandum, *Instructions for Annual Updates of SCGA ET and Applied Water Estimates Using Integrated Water Flow Model (IWFM) Demand Calculator (IDC) Version 4.0*
<http://www.scgah2o.org/Documents/TM2%20Annual%20Updates.pdf>



Source: RMC May 14, 2014 SCGA presentation

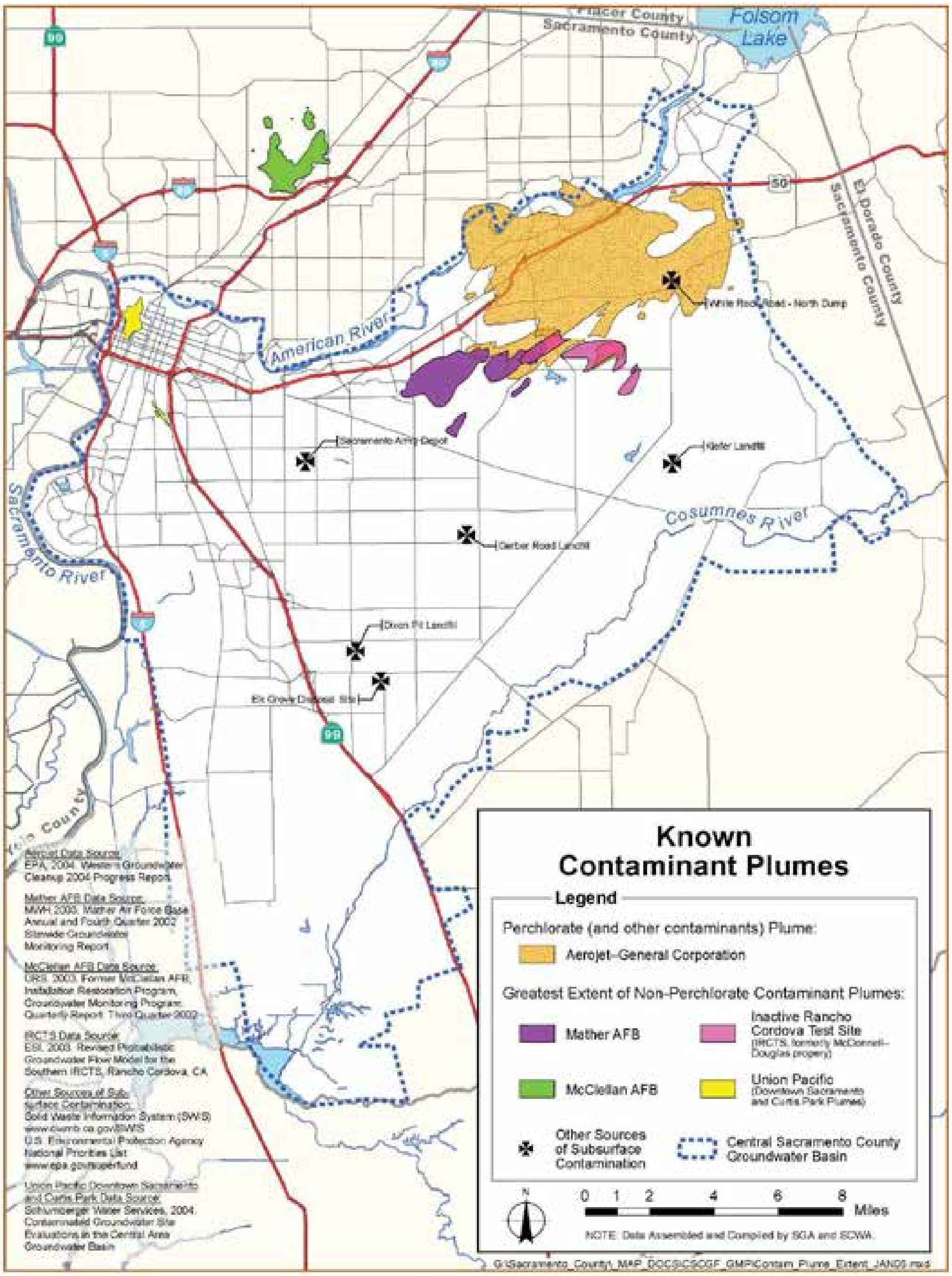
Figure 2-7. Classified 2011 Land Use Based on Satellite Imagery

Awareness of remediation activities has increased gradually over the years as public groundwater supplies have been compromised, and as contaminant plumes continued to migrate downgradient. Groundwater extractions for the purpose of remediation have also increased over the years. During the 11-year reporting period, extraction increased from 23,000 AF/year to 31,400 AF/year (mean: 27,400 AF/year), mostly due to the overall expansion of facilities for the larger Aerojet Superfund Site.

At the time of the initial Water Forum studies, Aerojet was discharging remediated water via injection wells or by discharging the water onto porous dredge tailings; a common practice to maintain a capture zone and reduce further plume migration. Water Forum studies showed that little groundwater was actually lost to the subbasin, so remediation was not included as an element of the 273,000 AF/year long-term average sustainable yield.

Over time, Aerojet has phased out the use of injection wells and dredge tailings and the majority of its remediated discharge is to the American River under a National Pollutant Discharge Elimination System (NPDES) permit. Discharges of Aerojet's treated groundwater also go to Morrison Creek, and are kept onsite for industrial operations. All of the current modes of remediation effluent discharge have the potential for a loss of groundwater to the South American Subbasin.

Aerojet claims ownership of its groundwater discharges to the American River and to Morrison Creek and, during the early 2000s, began seeking partners to perfect these claims. Golden State Water Company (GSWC) is currently authorized to withdraw an annual volume of 5,000 AF/year of Aerojet water from the river. Beginning in 2017, in conjunction with Carmichael Water District (CWD), a new GSWC pipeline running beneath the American River will begin to deliver Aerojet remediation water to GSWC service area in the South American Subbasin. CWD will utilize its existing ranney collector to capture river underflows and treat the water north of the river via a pressurized filtration plant, and then convey the water via the new pipeline to the GSWC service area south of the American River and back into the South American Subbasin. This will allow GSWC to reduce its South American Subbasin groundwater extractions. Similarly, Sacramento County Water Agency (SCWA) is authorized to withdraw an annual volume of 8,900 AF/year of Aerojet water at their Freeport facility along the Sacramento River, less the loss factor (10%) of recharge via the river. This water is then conveyed to the eastern side of the SCWA service area and treated at the Vineyard Surface Water Treatment Plant for application in SCWA's service area in the South American Subbasin. Aerojet has reserved the remainder of its treated groundwater for use as replacement water in Rancho Cordova. In addition, Aerojet has considered various options for changing its discharge from Morrison Creek to the American River.

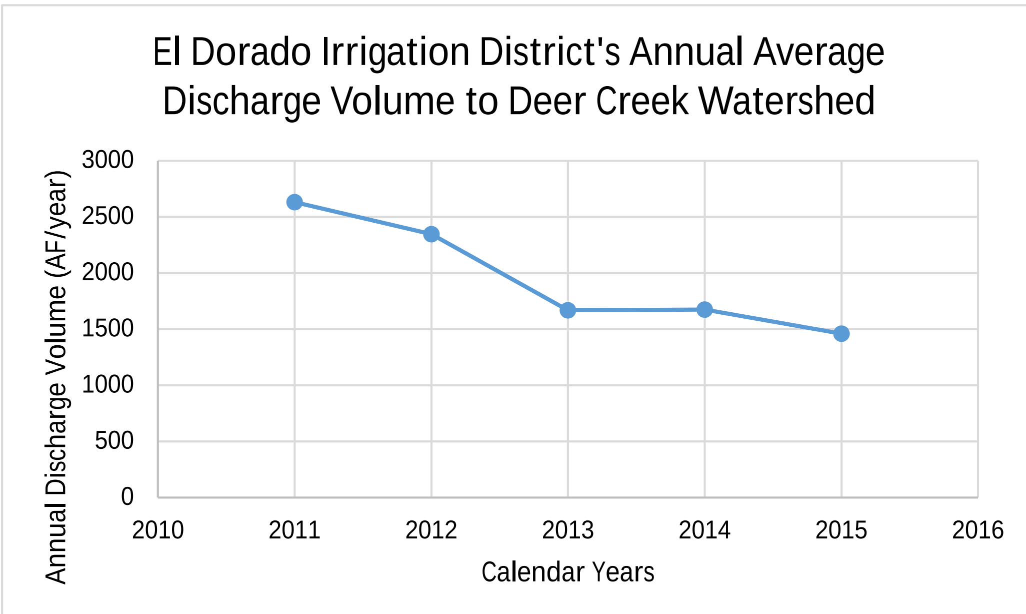


Source: SCGA 2006 Groundwater Management Plan

Figure 2-8. 2006 Known Extent of Groundwater Contamination

2.3.4 Other State and Local Regulatory Programs

In addition to remediation programs, the South American Subbasin is also subject to other regulatory program actions. The State Regional Water Quality Control Board monitors and regulates wastewater flow discharges from El Dorado Irrigation District that ultimately flow into Deer Creek and the Cosumnes River. Over the past 10 years, increased state water quality requirements on discharges for the protection of downstream uses and users has had the effect of reducing discharges to Deer Creek by almost half over the five-year period as shown in **0**. Since the years of higher flow provided significant recharge to the South American Subbasin (i.e., in dry months where 100% of Deer Creek flows go to groundwater recharge), the regulatory-driven reduction of El Dorado Irrigation District's discharge flows unavoidably impacts the subbasin, as discussed in later sections.



Source: EID's Deer Creek Wastewater Treatment Plant Discharge Summary Report (WDID: 5B090102001) <http://ciwqs.waterboards.ca.gov/ciwqs/readOnly/PublicReportEsmrAtGlanceServlet?inCommand=reset>

Figure 2-9. EID's Wastewater Discharge to Deer Creek Watershed

Other County and State cleanup programs are also extracting groundwater for treatment with discharge to sewer systems or evaporation ponds. While most are small in scope compared to larger state and federal programs, the overall result is a loss of water to the basin and lowering of groundwater levels in the South American Subbasin.

The realignment of the Central Basin to the South American Subbasin by adding the Delta Area and removing the Subtracted Area does not change the nature of impacts from reported on-going remediation or reductions in regulatory discharges to eastern tributaries.

2.4 South American Subbasin Conceptual Model

Developing water budgets for the Central Basin has been done historically using reported municipal pumping and estimated agricultural water supply requirements as input into the Original SacIGSM calibration model (see **Figure 2-1** for original finite element mesh of 1,637 elements) to estimate the contribution of subsurface flows both in and out of the Central Basin. Over time, the calibration model input data has essentially become the region's database of pumping, streamflow, and hydrologic data. As technology has improved, modeling resolution and domain has increased to better represent subbasin recharge boundaries. The groundwater model used today (see **Figure 2-10** for 2011 finite element mesh with 5,938 elements) is the evolution of over 25 years of local agency custodianship, improved calibration of the model, and reported effects of changed conditions in all three of the Sacramento region subbasins-- as they were defined by the Water Forum. For purposes of clarity, this report refers to the Original SacIGSM, as the version of the model used in the Water Forum, and simply SacIGSM or Updated SacIGSM for more current versions. The report will distinguish between the "calibration" and "forecast" versions of the Original and Updated SacIGSMs. The forecast SacIGSM is used for purposes of testing water management strategies out over an 85-year historic hydrologic time period.

In addition to SacIGSM, State DWR has developed a second release of the Central Valley Groundwater Surface Water Model titled "C2VSim". This model provides a regional depiction of the entire valley at a coarse level of resolution, and allows for groundwater budget information to be extracted for each Bulletin 118 subbasin. Given the timing of SGMA and the deadline for submittal of the Alternative, both models are in the process of being updated to include 2015 data, but are not currently complete. The purpose of this section is to provide the best available water budget data, understanding that the next 5 year update will include the latest information from both updated models. By using both models in this water budget presentation, this analysis will be compatible with adjacent subbasin GSP analyses and easing the review by State DWR.

2.4.1 Sacramento County Groundwater Model and Description of Basin Setting

SacIGSM utilizes an open-source, public domain, finite element modeling platform, earlier known as the Integrated Groundwater Surface Water Model (IGSM), and was developed during the early 1990s for the Sacramento County Water Agency (Montgomery Watson, 1993). At the beginning of the Water Forum technical studies (circa 1994), IGSM was the preferred water resources management model over other platforms due to its accessibility of both input and output data to a public and stakeholder audience. State DWR was also using the same platform for the Central Valley Groundwater Surface Water Model (CVGSM).

SCWA and the City of Sacramento both funded the development of the Original SacIGSM model due to the heightened interest in a more comprehensive and integrated means of understanding and managing surface water and groundwater resources. In particular, the 1990 General Plan required new growth developments to provide supplemental water supplies and eliminate sole reliance on groundwater.

The Original SacIGSM domain (see **Figure 2-1**) addressed an area of approximately 890 square miles, and was subdivided into 1,637 elements (average element size: 0.5 square miles) via 1,552 nodes. The South American Subbasin was defined by nearly 50 percent of the elements. The North Basin was defined with 22 percent of the elements and the South Basin was defined with 30 percent of the elements, including 5 percent for the SCGA area outside of the South American Subbasin located south of the Cosumnes River (Subtracted Area, as defined in Section 2.2 above). The model area was divided into 35 subregions (see **Figure 2-2**), including 12 subregions within SCGA, which comprised 44 percent of the model area. The South American Subbasin is contained within 13 model subregions, including the Courtland subregion (Delta Area) and portions of three subregions (i.e., Southwest, OHWD, and Rancho Murieta) which also overlie the Cosumnes Subbasin.

The Original SacIGSM utilized two separate DWR land use survey maps, three sets of crop data, four hydrologic soil groups, and USGS topography. Water use was based on historical data for surface water diversions, reported groundwater pumping for municipal and industrial applications, and on crop acreage and crop consumptive use data (i.e., crop type, evapotranspiration, root depth, field capacity, etc.). The model addressed rainfall distribution patterns and evapotranspiration, and surface water in eight creeks, three rivers, and one drain plus streamflow from eight small watersheds to the east of the model domain.

2.4.1.1 Basin Setting

The SacIGSM is a 3-dimensional model comprised of five layers, including an upper aquitard at the surface, two fresh-water aquifers that are separated by a second aquitard, and a non-fresh-water (unusable) zone at the base of the model. Model stratigraphy was based on the 1974 DWR Bulletin 118-3, USGS reports, well logs, and geophysical logs.[19] The upper fresh-water aquifer is wedge-shaped along the eastern side of the basin (dipping and thickening westward) but is relatively flat-lying on the western side (**Figure 2-11**). The thickness can vary up to approximately 300 feet, but is typically 200 feet, and the bottom can extend to an elevation of

[19] See State DWR Bulletin 118-3 <Reference Documents\DWR_b118-3_evalofgwresSacramentoCounty.pdf>

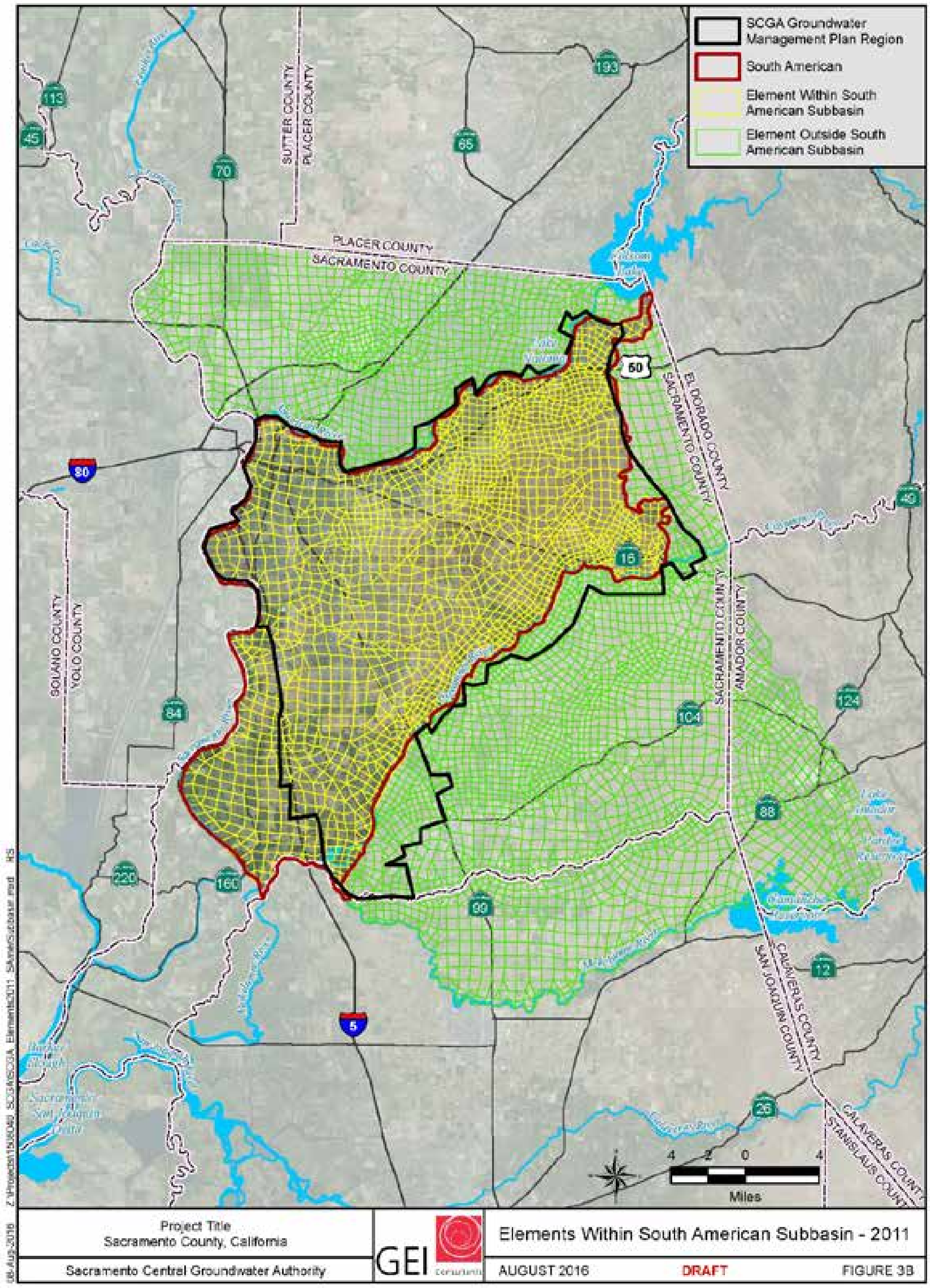


Figure 2-10. 2011 SacIGSM Groundwater Model Finite Element Mesh

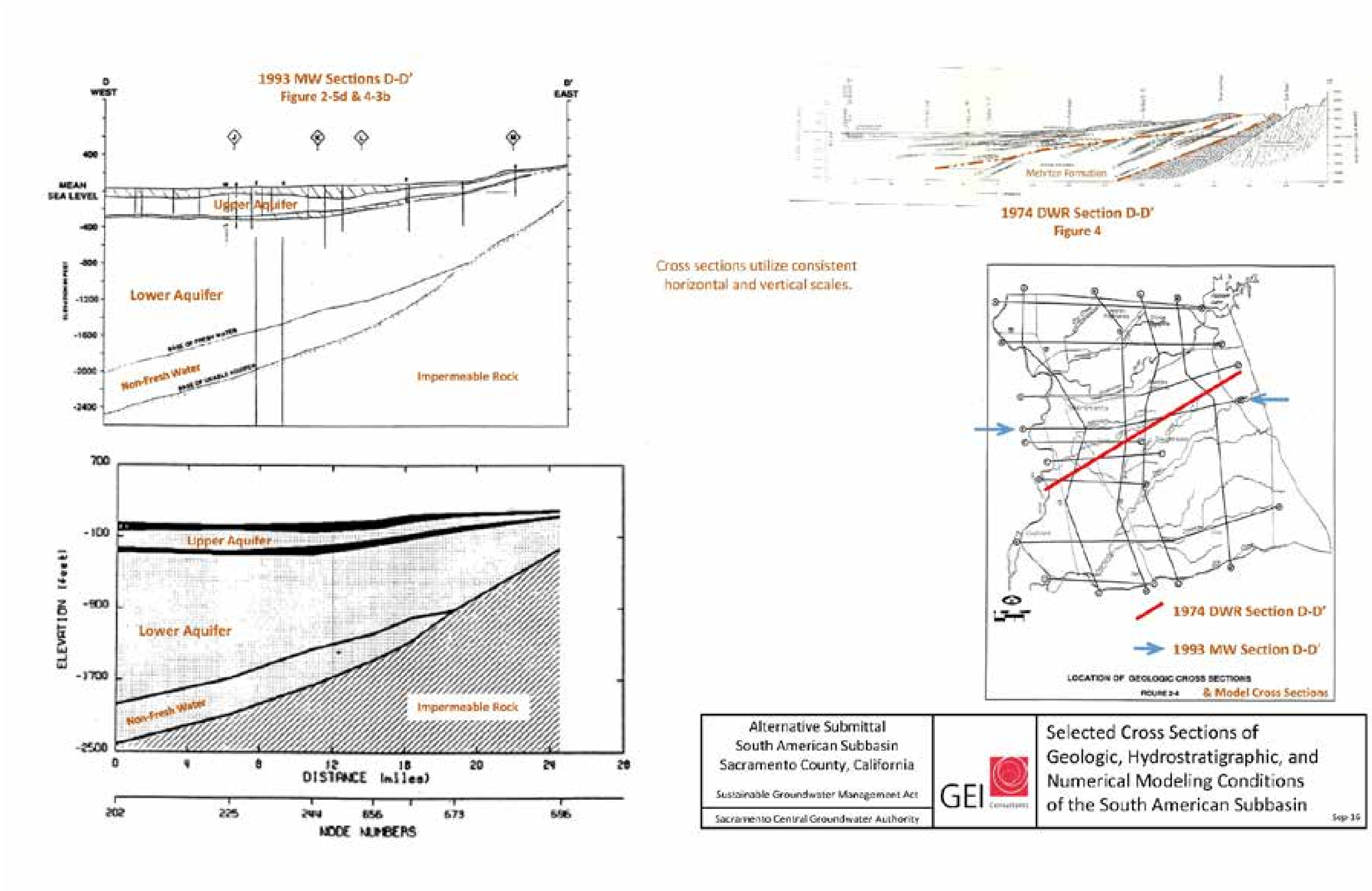


Figure 2-11. Selected Model and Hydrostratigraphic Cross Sections of South American Subbasin

approximately 200 feet below mean sea level. The upper aquifer is generally correlative to the Laguna Formation and other similar/younger sediments.

The lower fresh-water aquifer is similar in shape to the upper aquifer, but considerably larger. The wedge portion of the lower aquifer, on the eastern side of the basin, rests on bedrock (relatively impermeable) and can extend to depths between 800 and 1,200 feet below mean sea level. Within the center and western portions of the basin, the base of the lower aquifer extends to depths between 1,200 and 2,000 feet below mean sea level, to the top of the unusable water. This unusable water may occur at depths of 800 feet below mean sea level beneath the Delta area of the South American Subbasin. The lower aquifer is generally correlative to the Mehrten Formation and pre-Mehrten sediments.

The Laguna and Mehrten Formations were deposited during the Pliocene and Miocene Epochs, respectively, (Gutierrez, 2011) of the Tertiary or Neogene Period (2.6 to 23.0 million years ago) in a fluvial environment (DWR, 1974). These formations are comprised of interbedded layers of gravel, sand, silt, and clay with numerous channel deposits within the South American Subbasin. The deposits are wedge-shaped and dip gently and thicken in a westerly direction. The Laguna Formation is derived from granitic and metamorphic rocks while the Mehrten Formation is derived from andesitic rock. The Mehrten Formation also includes dense, hard layers of tuff-breccia.

At the time of the Water Forum technical studies (circa 1995/96), including improvements to the original SacIGSM, groundwater contours (**Figure 2-3**) indicated flows in a southwesterly direction throughout much of the subbasin towards a cone-of-depression on the western side of the basin underlying what is now the City of Elk Grove. Persistent recharge flows from the Delta flowed easterly and northeasterly toward this depression, and groundwater to the north from the American River, and south from the Deer Creek and Cosumnes River, also flowed toward the depression. Similar conditions existed in the North American and Cosumnes Subbasins. Subsurface groundwater inflows and outflows also occur between the South American Subbasin and adjacent basins beneath the Cosumnes River and the American River, respectively.

The cones-of-depressions of the Water Forum snapshot in 1996 (see **Figure 2-3**) were developed during the middle of the last century as groundwater was pumped extensively for agricultural land uses, and were known to not be in a state of equilibrium (i.e., groundwater levels still falling) in the mid 1980's. The majority of the subbasin's recharge occurs from the percolation of rainfall and irrigation water and from the rivers that bound three sides of the subbasin, including the Delta.

Delta Area groundwater conditions are notably different than groundwater conditions throughout the majority of the South American Subbasin to the east. Groundwater levels are quite shallow in the Delta Area and are intentionally lowered beneath the root zone via ditches and tile drains, while regional groundwater levels were occurring at depths that exceeded 150 feet at the subbasin's cone of depression.

2.4.2 Summary of Original SacIGSM Model Calibration Results

The Original SacIGSM was calibrated for the period October 1969 to September 1990, which included successive dry years (1976-77, 1987-90) and wet years (1982-83). The average difference between simulated and observed water levels over the model domain was less than five feet for the 21-year calibration period.[20] Documented budget information in the very first model was presented for each year of the calibration period for the entire model area, with the average values listed for soil moisture, and for surface water and groundwater, in **Table 2-3** and **Table 2-4**, respectively.

Table 2-3. Original SacIGSM Soil Moisture Budget – 1970 to 1990 Average, inches/year

Components Area:	Agricultural	Municipal	Undeveloped
Rain	18.7	19.3	19.7
Irrigation	35.1	28.3	-
Consumptive Use	24.4	-	-
Evapotranspiration	33.6	17.8	14.9
Direct runoff due to rain	7.1	12.8	4.0
Surface water return flow	4.5	11.7	-
Percolation into unsaturated zone	8.6	5.2	0.8

Table 2-4. Original SacIGSM Surface Water and Groundwater Budgets (1970 to 1990 Average, AF/year)

Surface Water Component	Average Volume
Upstream flow (inflow to model)	17,120,822
Small Watershed/Tributary flow	24,865
Direct runoff due to rain	308,604
Surface water return flow	181,126
Gain (loss) to groundwater	(207,396)
Diversions	(216,278)
Downstream flow (outflow to model)	17,211,744

Groundwater Component	Average Volume
Deep percolation	198,876
Gain from surface water	207,396
Subsurface Boundary inflow	111,846
Pumping	(533,986)
Change in storage	(15,868)
Total model storage in 1990	**48,445,800**

The original model budgets for the entire domain show that over 207,000 AF/year (see Gain from surface water in **Table 2-4)** or 1.2 percent of the surface water passing through the model domain enters the groundwater system of the SacIGSM area. This surface water component is 40 percent of the total groundwater recharge and only slightly higher than recharge from deep

[20] See 1993 Sacramento County Groundwater Model Development Report <Reference Documents\SCWA_Model Development and Basin Groundwater Yield June 1993.pdf>

percolation (199,000 acre-feet or 38 percent) of applied irrigation water plus rain water. Subsurface boundary inflow accounts for the final component of recharge (112,000 acre-feet or 22 percent). The Original SacIGSM model showed an overall loss in groundwater storage for its 21-year calibration period. Nearly all of the subsurface boundary inflow in the model is associated with flows entering or leaving the model domain based on set boundary conditions.

The South American Subbasin accounts for a substantial portion of the Original SacIGSM budgets, ranging between 40 and 55 percent for most components.

2.4.3 South American Subbasin Water Budgets

Using the Updated SacIGSM calibration model with a calibration period from 1969 to 2011, and the most recent version of the State's C2VSim model (Central Valley Integrated Water Flow Model (IWFM)), detailed groundwater budgets have been extracted for the most recent overlapping 10-year time period (water years 2000 to 2009) in both models to provide the best available data and comparison between the two different models. Understanding that each model was developed independently and currently operate on different platforms (i.e., IGSM vs. IWFM), the state model is considered to be the baseline given its regional application by adjacent subbasins and by State DWR staff. The aquifer parameter assumptions remained the same in the Updated SacIGSM, but were not reviewed for the C2VSim, and the evaluation of calibration methodologies of both models is outside the scope of this analysis.

The presentation of water budget information from both models is to provide a sense of the differences in each model with the understanding that each model is currently being updated to reflect the updated groundwater basin delineations and to bring calibration periods to the same SGMA baseline year of 2015. To provide a comparison of the two models, the average water budget for the 10 year time period from water years 2000 to 2009 (October 1999 to September 2009) is used in both models, with C2VSim being the constraining model with the modeling window ending in September 2009.[21]

Spatially, the Updated SacIGSM water budget is based on the current SCGA GMP boundaries plus the Delta Area in order to apply the model's subregion delineations to the best fit of the South American Subbasin. The C2VSim water budget is also based on the closest approximation of the subbasin in the coarse grid model using elements located <u>mostly</u> within the subbasin as shown in **Figure 2-12**.

[21] Note that this comparison is for the purpose of understanding the differences between the two model applications and presenting the possible range in values for complex groundwater flow properties only obtained through computer modeling.

The C2VSim budget is extracted from model output data by applying the ZoneBudget feature of the IWFM platform to provide a detailed groundwater budget; whereas the Updated SacIGSM budget is extracted through the model subregion groundwater budgets files. The aerial extent of the SacIGSM budget is based on the subregion boundaries shown in **Figure 2-10** to closely approximate the South American Subbasin noting that the water budget data will include the full recharge amount from the Cosumnes River and reflect any pumping and surface recharge in the Subtracted Area. The C2VSim output provides the information shown in **Table 2-5** and includes significant detailed information regarding subsurface flows between adjacent groundwater subbasins, as shown by the annual model output data in **Figure 2-13**.

A comparison of the two models is provided in **Table 2-6**.

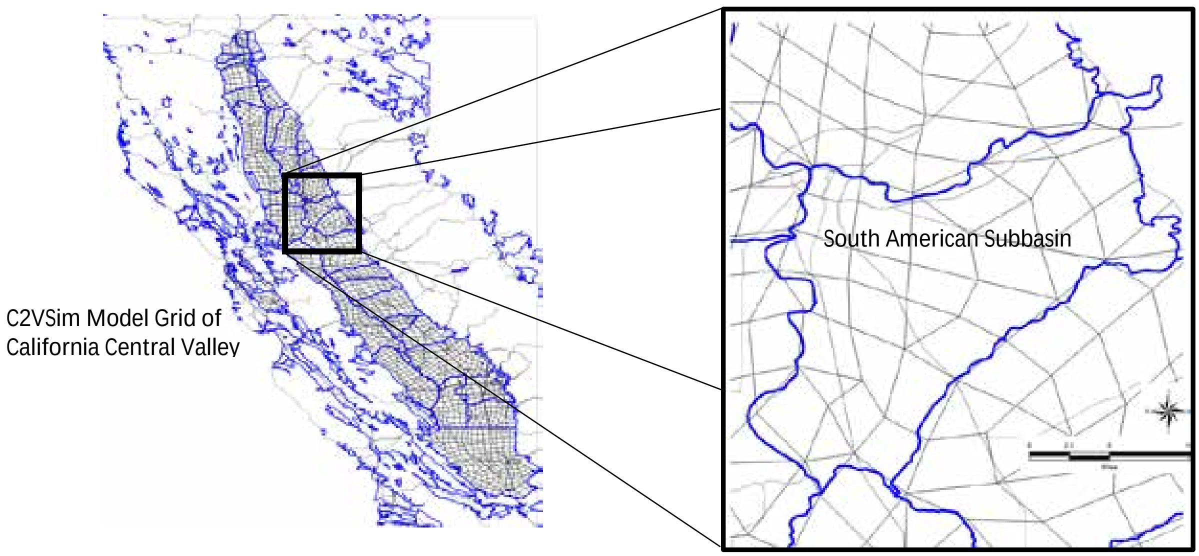


Figure 2-12. C2VSim Model Grid Approximating South American Subbasin

Table 2-5. C2VSim 10-Year Average (2000-2009) Groundwater Budget for South American Subbasin

Inflows	Avg Monthly Volume (AF)	Avg Annual Volume (AF)	Outflows	Avg Monthly Volume (AF)	Avg Annual Volume (AF)
Total Percolation	1,409	16,908	Total Pumping	13,299	159,593
Lakes and Streams Inflow	6,375	76,501	Lakes and Streams	991	11,892
Boundary Recharge Inflow	2,264	27,170	Boundary Recharge Outflow	-	-
SubSurface Inflow	5,127	61,522	SubSurface Outflow	2,758	33,092
Diversion Recoverable Gains	275	3,306	Tile Drain Outflow	-	-
Gain from Subsidence	22	264	Loss from Subsidence	12	142
Total	**15,473**	**185,670**	**Total**	**17,060**	**204,719**
			Difference in Storage	**(1,587)**	**(19,049)**

Table 2-6. Average Annual C2VSim/Updated SacIGSM Groundwater Budget Comparison for South American Subbasin

Inflows	**C2VSim** Avg Annual Volume (AF)	**SACIGSM** Avg Annual Volume (AF)	**Outflows**	**C2VSim** Avg Annual Volume (AF)	**SACIGSM** Avg Annual Volume (AF)
Total Percolation	16,908	111,365	Total Pumping	159,593	212,157
Lakes and Streams Inflow	76,501	69,371	Lakes and Streams	11,892	
Boundary Recharge Inflow	27,170	78,232	Boundary Recharge Outflow	-	
SubSurface Inflow	61,522	(53,024)	SubSurface Outflow	33,092	
Diversion Recoverable Gains	3,306		Tile Drain Outflow	-	
Gain from Subsidence	264		Loss from Subsidence	142	
Total	**185,670**	**205,944**	**Total**	**204,719**	**212,157**
			Difference in Storage	**(19,049)**	**(6,213)**

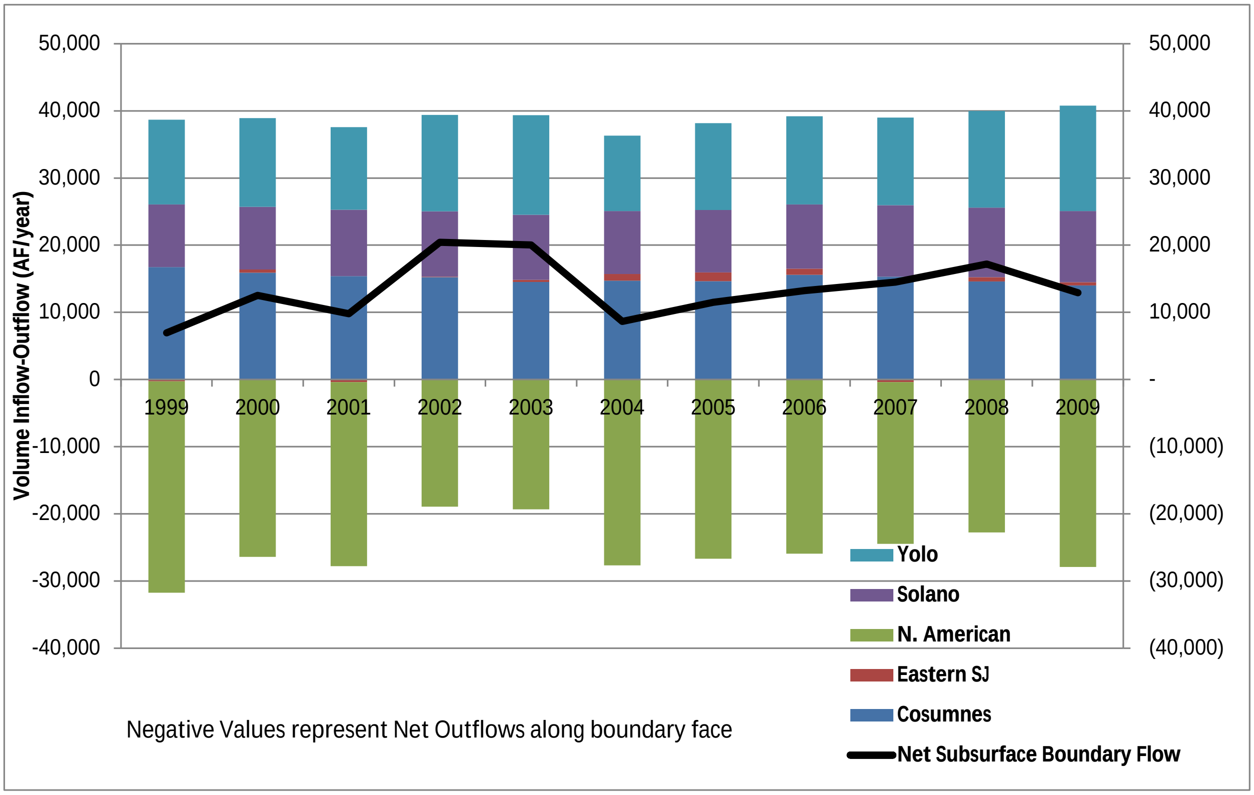


Figure 2-13. Adjacent Subbasin Subsurface Flows (C2VSim Model Results)

Figure 2-13 illustrates the net amount of subsurface flow moving between each of the adjacent groundwater subbasins. Negative flows represent water leaving the subbasin as outflow and positive values represent water entering the basin as net inflows. The line represents the net inflow/outflow occurring over the model time period. In this case, the model consistently indicates a net subsurface inflow ranging between 8,000 AF/year and 20,000 AF/year.

Review of the two models indicate that both are estimating approximately the same slight decrease (<10,000 AF/year) in storage on an annual-basis, but show to be significantly different in terms of the absolute values of inflows and outflows. The significant difference in total percolation, subsurface flows, and pumping for the two models will require investigation as the models are being updated. The SacIGSM likely has more recent pumping and agricultural pumping data (outflows), so the amount of deep percolation from rainfall and irrigation of 4-5 inches per year (vs. 0.6 inches in C2VSim) is more reasonable with a below average rainfall period. A comparative feature in the SacIGSM subregion budget output is not available in the Updated SacIGSM calibration model output file.

C2VSim's low net deep percolation volumes are likely an artifact of its calibration settings to balance the reduced extraction volumes while trying to achieve the groundwater elevations showing up in observation wells. The change in storage (or difference between inflows and outflows) is therefore the better comparison between the two models, as shown in **Figure 2-14**, where change in storage for both models is exaggerated to see the similarities between the two model results, and that these similarities are most relevant to the discussion of model performance and calibration differences.

To place the average negative change in storage (both models) in context with the overall basin budget and the volumes of water moving in and out of the model subbasin, **Figure 2-15** shows the Updated SacIGSM annual inflow and outflow volumes on the left axis represented by the stacked columns either above or below the x-axis. The difference between annual inflows and outflows (i.e., change in storage) is plotted against the right axis as a black line. The fluctuations in change in storage are minimal compared to the total volume of water moving in and out of the basin each year. The changes in storage are expected and not significantly high compared to the total basin volume (i.e., not drying up the basin). Hydrologic wet and dry period stress is a significant driver for these types of year to year changes, with increased pumping contributing to the longer term changes until the basin reaches equilibrium at some point in the future. A regression line (red dotted) to represent the average trend over the designated period and the slight positive change is primarily due to subsurface inflows from adjacent subbasins and effective management of the cone of depression as explained in **Section 2.6.1**.

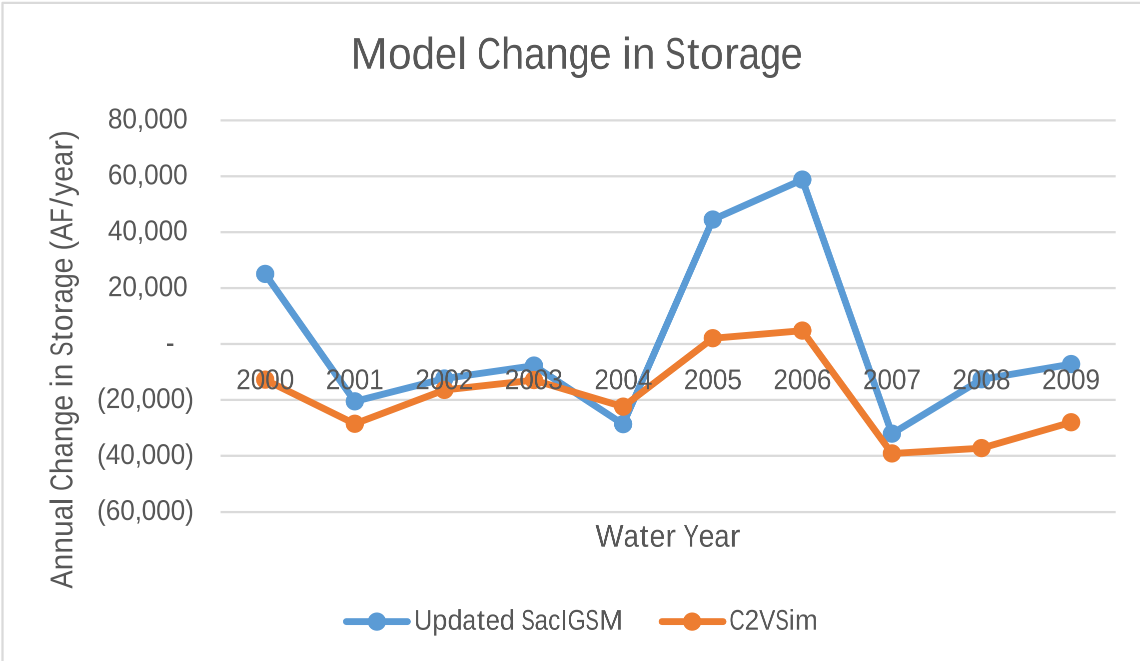


Figure 2-14. Updated SacIGSM vs. C2VSim Calibration Annual Change in Storage

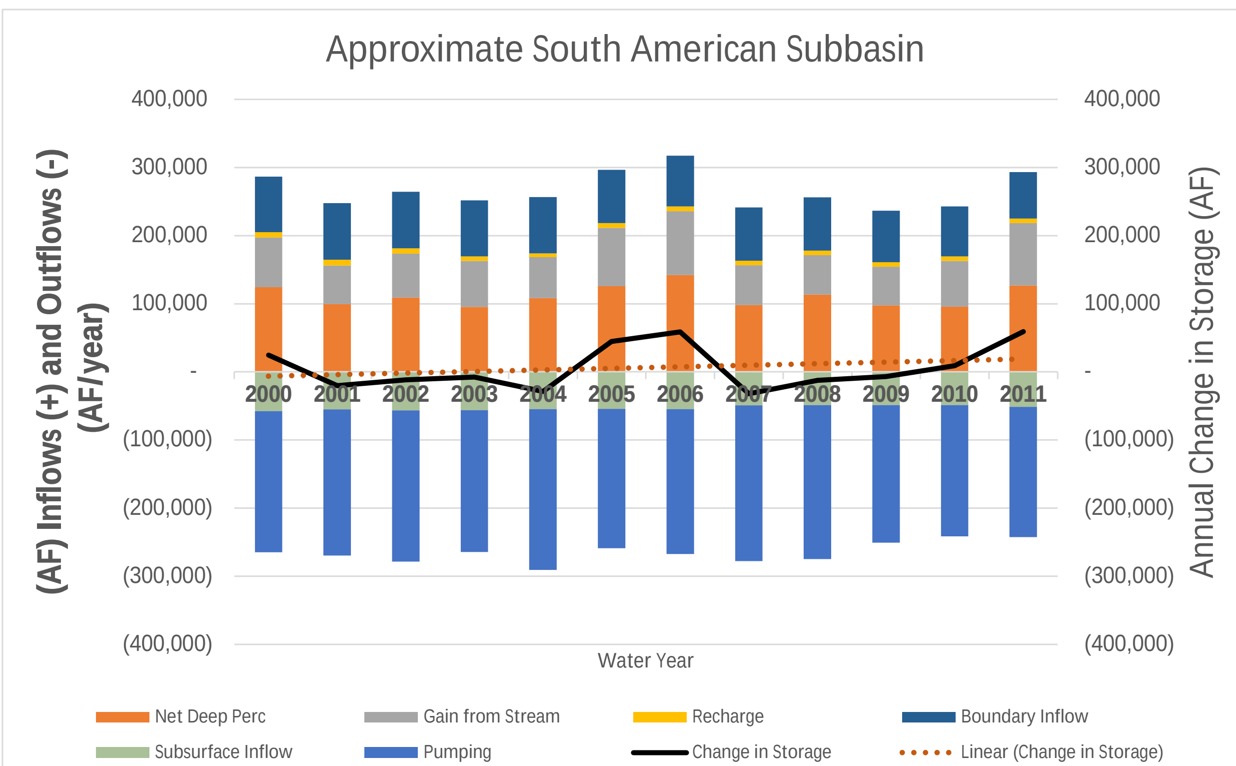


Figure 2-15. Updated SacIGSM Water Budget Summary and Annual Storage Change

2.5 Water Forum Review of Undesirable Effects

The Original SacIGSM model used by the Water Forum in 1995 was converted into a forecast model (Original SacIGSM Forecast) by keeping its calibrated aquifer parameters and geologic framework then adding 69 years of hydrologic data to create a steady-state model where various levels of the 1990 General Plan land uses and water demands at 10-year intervals (between 1990 and 2030) could be evaluated to identify undesirable effects due to increasing extractions in each of the Sacramento County subbasins. In addition, the full historic rainfall and streamflow data between 1922 and 1991 was included in the Original SacIGSM Forecast model to fully consider extreme hydrologic wet and dry periods. Note that the Updated Forecast SacIGSM currently uses 85 years of hydrologic data.

2.5.1 Water Forum Forecast Scenarios

A visual example of the 10-year interval Original SacIGSM Forecast runs are shown in **Figure 2-16** where the lowest groundwater level in the Central Basin is tracked over the model simulation period. This figure illustrates the behavior of the Central Basin with each line representing an increased amount of groundwater extraction for urban development according to the growth projections of the 1990 General Plan. The forecast model holds land use, monthly M&I water demands, and pumping locations static over 69 years of varying hydrologic conditions. Explained and illustrated in Appendix A of the SCGA GMP, is a summary of the original technical report, *Baseline Conditions for Groundwater Yield Analysis*, (Montgomery Watson, 1997), documenting the full range of undesirable effects in the Central Basin associated with each 10-year interval pumping scenario.

2.5.1.1 Physical Effects of Increased Extractions

Each forecast scenario, as represented in **Figure 2-16,** increases pumping above baseline conditions (1990 conditions and 1990 with conservation conditions). The sudden increase in groundwater extractions result in the following physical process: 1) lowering of regional groundwater levels, 2) steepening of gradients with hydraulically connected rivers and the Delta, and 3) natural recharge increasing to ultimately support the higher extractions. The approximate time frame for the Original SacIGSM Forecast model to reach a new stable condition (i.e., inflows approximate outflows) is shown to be approximately 20 years. This initial timeframe becomes important in describing how groundwater level thresholds are determined (Appendix B of the SCGA GMP) through SacIGSM modeling results.

In the case where a hydraulic connection is lost with a recharge source due to over-pumping, stabilization of the basin would not occur, and the basin would be in a constant state of overdraft with continuous reductions in storage and lowering of groundwater levels. In each of the Water Forum forecast scenarios, the physical processes described above take place with hydraulic connections remaining intact with the major recharge sources of the American River, Delta, and Sacramento River. As groundwater extraction increases, the Cosumnes River and Deer Creek floodplain provides increased recharge along hydraulically connected reaches near the confluence of the two surface water sources and the Delta. However, recharge along hydraulically disconnected reaches of Deer Creek and the Cosumnes River shows as remaining close to the same under all scenarios, subject to hydrologic variations. Under a disconnected condition, river recharge is impeded by the river bed and bank seepage properties and not the regional groundwater aquifer, creating a maximum surface water to groundwater recharge condition.

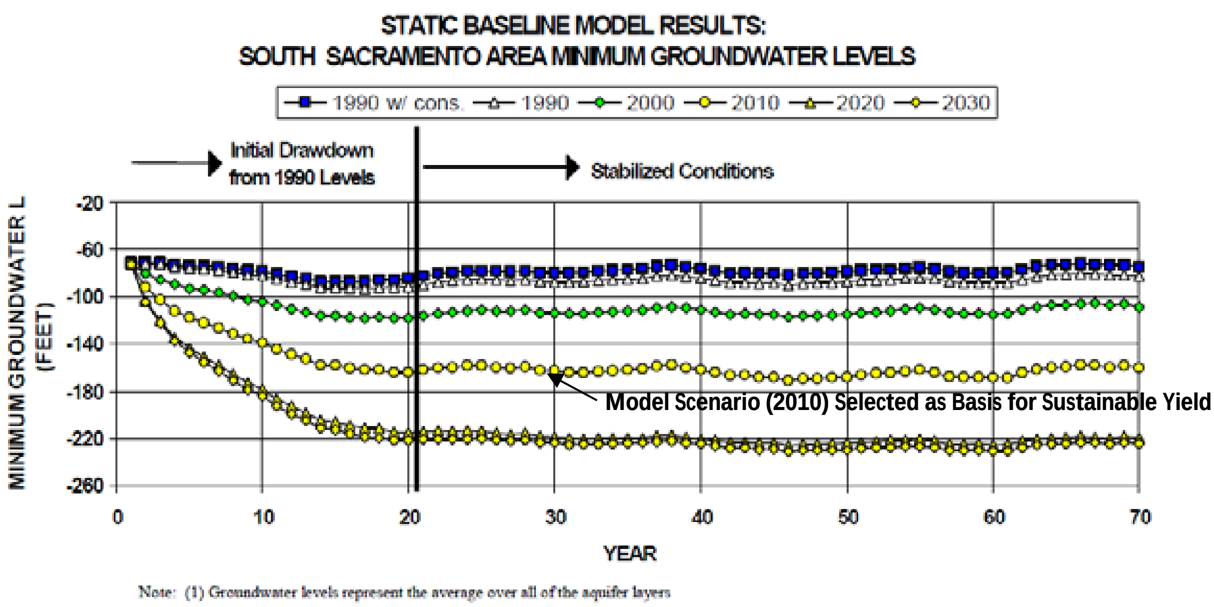


Figure 2-16. Water Forum Static Baseline Model Results for Central Basin

Groundwater levels and all associated impacts were evaluated for each forecast period and the 2005 baseline condition was selected by the Water Forum stakeholders as being the approximate sustainable yield for the Central Basin--quantified as a long-term average of 273,000 AF/year. Note: The long-term average sustainable yield value and associated undesirable effects were interpolated using the 2000 and 2010 Original SacIGSM Forecast scenarios as described in Appendix A of the SCGA GMP.

On average, and using 2010 model results, groundwater levels decreased between 7 and 49 feet (median: 25 feet) within the various subregions of the Central Basin. For the minimum groundwater levels, the decrease varied from 14 to 93 feet (median: 35 feet). For the 2010 model results, the Delta Area identified an average groundwater level decrease of 18 feet along the persistent recharge boundary which is the western boundary of the Central Basin.

2.5.2 Recognition of Reduced Storage in Central Basin

Important to this Alternative's 10-year evaluation of operation within the sustainable yield is that lower groundwater levels from baseline (1990) conditions and reduced storage were recognized by the Water Forum stakeholders as being necessary for balancing regional water resources management. Moreover, the Water Forum based this decision on a detailed evaluation of the undesirable effects of lowering water levels, including: 1) degraded water quality in terms of higher concentrations of iron and manganese, 2) increased migration rates of known contaminant plumes, 3) land subsidence, and 4) reduced efficiency on existing supply wells due to a greater lift of the water or the need to deepen wells.[22]

2.5.3 Water Forum Solution and Water Forum Agreement Draft EIR

The Water Forum's regional goals of potential impact on American River flows was also evaluated by creating a Water Forum Solution version of the 70-year Original SacIGSM Forecast model with 2030 levels of water demand and land use, and surface water allocation rules based on a specialized model to reflect proposed American River flow standards and agreements to cutback or transfer diversions of American River water in drier years. This established both groundwater and surface water thresholds for the region's water policies by concluding the following:[23]

> *Under the Draft [Water Forum] Solution, groundwater levels are generally higher than the long-term groundwater levels previously recommended by the Water Forum groundwater negotiation team. This is due to two factors: (1) the greater level of municipal conservation assumed by the Draft Solution, and (2) the greater volume of surface water supplies assumed by the Draft Solution.* (Water Forum Agreement Draft EIR, Appendix E, January 2000)

2.5.4 Undesirable Effects

The Water Forum Agreement Environmental Impact Report (EIR) characterized the impacts associated with the Water Forum Solution (i.e., 2030 build-out conditions with groundwater and surface water used conjunctively), and the technical findings (included as Appendix E of the Draft EIR) of undesirable effects based on the Original SacIGSM Forecast model results, as less-than-significant (EDAW and SWR, 1999). The Water Forum and its numerous stakeholders

[22] See Appendix E of Water Forum Agreement Draft Environmental Impact Report, *Baseline Conditions for Groundwater Yield Analysis*, (Montgomery Watson, 1997)

[23] See Appendix E of Water Forum Agreement, Page 86. <http://www.waterforum.org/wp-content/uploads/2015/09/WF_DEIR_Appendix_res7.pdf>

concluded the value of the groundwater taken from storage exceeded the costs to install and maintain treatment for iron and manganese and/or to deepen wells or pump groundwater from greater depths.

2.5.4.1 Water Quality

The Water Forum Agreement Draft EIR presented cumulative water quality impacts by showing a 67,700-acre area within the South American Subbasin that could be impacted by groundwater with elevated levels of iron and manganese, and possibly arsenic, due to an 80-foot decline in water levels since pre-development conditions (decades before 1990s). Most of the area was located in the south-central portion of the South American Subbasin but a fraction of the area extended into the Courtland/Delta Area along the eastern boundary.

Contaminant plumes from the sources identified in **Figure 2-8** were evaluated as mitigated (contained) by the remedial actions of the responsible parties. The EIR concluded the increased extraction rates and changes in regional groundwater gradients as a result of the Water Forum Solution would not substantially affect the migration rate of the plumes.

2.5.4.2 Land Subsidence

Land subsidence has been recorded in the South American Subbasin, up to 0.4 feet in the vicinity of Elk Grove, according to three leveling profiles between 1947 and 1966. Subsidence was not identified on the eastern side of the basin, which was considered to be less susceptible due to the older age of the sediments. Additionally, these east-side sediments are likely to be more coarse-grained and less likely to contain significant compressible material than sediments further west. Land subsidence has been shown to be directly proportional to the decline in groundwater levels and was calculated to be 0.007 feet per foot of groundwater decline (see **Section 2.6.4.1)** in the South American Subbasin, based on an Elk Grove well located in the cone of depression near the intersection of Poppy Ridge and Bruceville Roads. This value was consistent with wells in the North and Galt Basins. For the expected water level declines of 49 feet (highest average) to 93 feet (lowest minimum), the calculated potential subsidence might vary between 0.34 and 0.65 feet over a period of several decades at a gradual rate of 0.020 feet per year. The EIR concluded that this potential subsidence was minor and would not likely damage infrastructure.

2.5.4.3 Pumping Efficiencies and Well Deepening or Replacement

The EIR recognized that well efficiency would be lower at some supply wells because lower water levels would require a deeper pump setting and additional power, which would result in higher costs to lift the water from greater depths. Moreover, some wells might need to be drilled deeper. The EIR estimated that 14 municipal wells (9 percent) would require deepening along with 19 agricultural wells (5 percent) and 350 rural domestic wells (6 percent), based on the Original SacIGSM Forecast baseline simulation technical findings. The EIR concluded that this condition was a less-than-significant impact. Nevertheless, the SCGA 2006 GMP included a Well Protection Program to cover the cost of deepening or replacing an existing agricultural or domestic well. This program was developed but has not been funded due to the economic recession of the late 2000s. SCGA has not received any claims of well loss.

2.5.5 Protecting Private Domestic Wells and Water Quality

Protection of private domestic wells is considered to be a top priority in the SCGA GMP. The SCGA member agencies have municipal well construction policies minimizing the impact of increased municipal pumping on rural domestic well owners who depend on untreated shallow aquifer groundwater for drinking water. Municipal well proximity impacts to private wells, like drawdown of groundwater levels, and the potential for vertical upwelling of poor quality water from deep aquifer units, are mitigated by identifying wells in the region and calculating the screen depth and minimum distance at which the new well drawdown effects will be less than one foot with no upward vertical migration from deeper aquifer units.

2.5.6 Vertical Movement of Groundwater

The potential for vertical movement of groundwater is known to occur in the South American Subbasin whenever a difference exists in the potentiometric surface (i.e., standing water head in feet) between the shallow unconfined aquifer and the deeper semi-confined aquifer. A higher head value (shallow>deep) in the shallow aquifer creates a downward vertical gradient; whereas, a lower head value (shallow<deep) in the shallow aquifer creates an upward vertical gradient possibly moving deeper water with higher TDS, manganese, and iron concentrations to the shallow aquifer. For this reason, all new municipal wells are required to screen in the deep aquifer units to maintain a lower head value in the deep aquifer and then expect to treat for iron and manganese to meet secondary drinking water quality standards. SacIGSM is used to model new well pumping impacts and differentiates between natural and anthropogenic reasons for vertical groundwater movement.

2.6 Applying Sustainability Indicators

The validity of the sustainable yield applied to the South American Subbasin can be evaluated by assessing the condition of several sustainability indicators:

1. chronic lowering of groundwater levels,
2. reduction in groundwater storage,
3. seawater intrusion,
4. degraded water quality,
5. land subsidence, and
6. depletions of interconnected surface water.

Unmanaged utilization of groundwater resources can produce undesirable results that necessitate corrective management action(s) when these results are determined to be significant and unreasonable and occur throughout the subbasin. The following text describes the Alternative's use of available scientific data for each of the monitored sustainability indicators (i.e., monitoring data and published reports) for the South American Subbasin. This section supports the preceding sections by using these data to confirm there are no Undesirable Results occurring as a result of the South American Subbasin's operation within the sustainable yield over the past 10 years.

2.6.1 No Chronic Lowering of Groundwater Levels

Numerous wells are identified in the DWR databases for the South American Subbasin, including 30 wells in the California Statewide Groundwater Elevation Monitoring (CASGEM) program and more than 100 "voluntary" wells. Most of the CASGEM wells (27) are located within the SCGA management area and are listed in the SCGA (2012) CASGEM monitoring plan. Three CASGEM wells are located within the Courtland/Delta Area of the South American Subbasin, although water level data are not available for one well. SCGA has published four biennial Basin Management Reports (BMRs)[24] and presented hydrographs for 18 to 21 wells, including 11 CASGEM wells. One of the CASGEM wells (385541N1211812W001) was reported as destroyed during the spring to fall reporting period in 2012.

Figure 2-17 and **Figure 2-18** are groundwater elevation contour maps for Fall 2005 and Fall 2015, respectively, for the South American Subbasin and portions of the adjoining basins to the north and south. These maps were produced by the Surfer computer program using default Kriging to distribute the irregularly spaced well data across a uniform grid of the area. This default grid included 100 nodes in the east-west direction and 91 nodes in the north-

[24] SCGA's BMRs from 2007 to 2014 as published on SCGA's website at <http://www.scgah2o.org/Pages/archive.aspx>

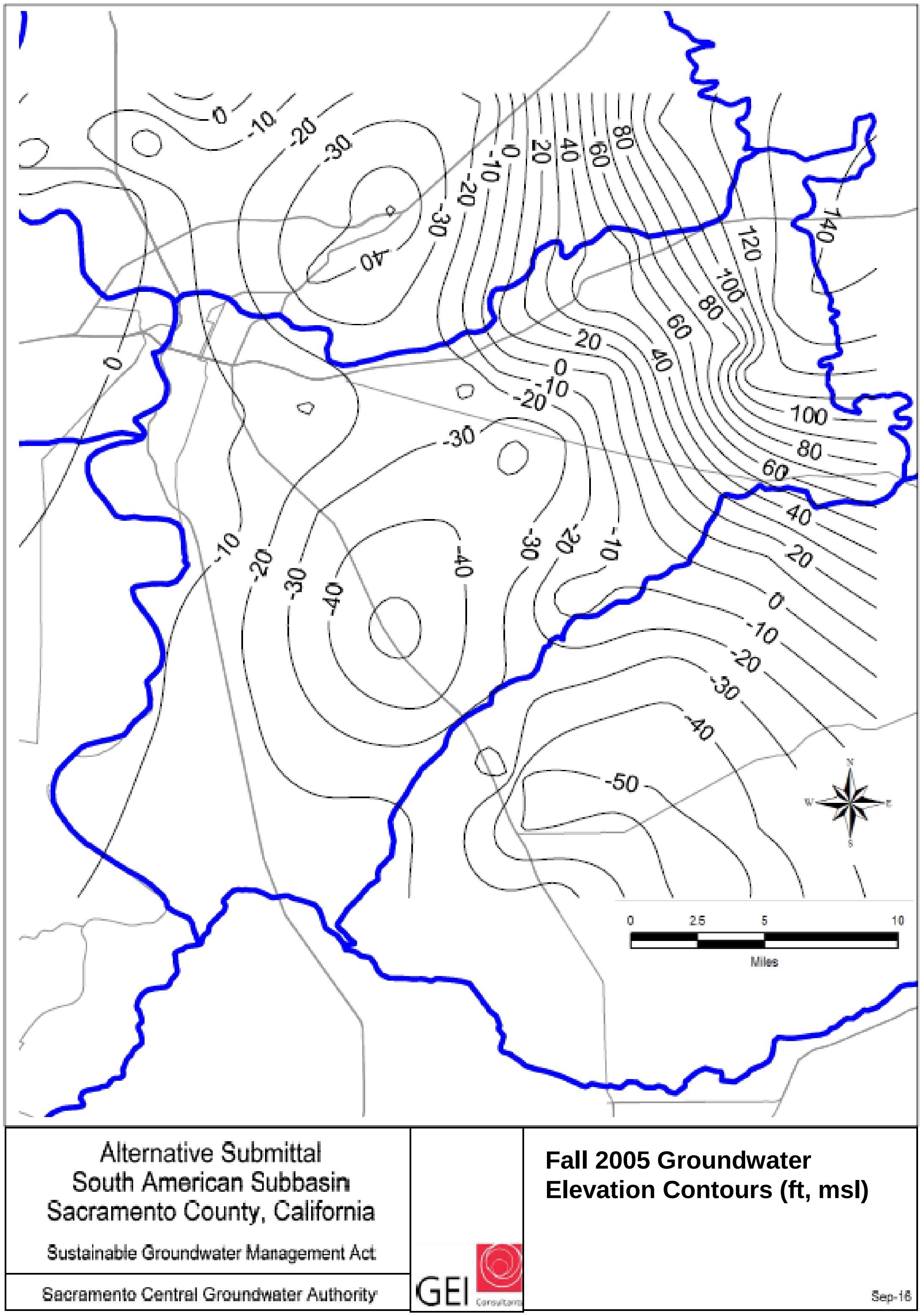


Figure 2-17. Fall 2005 Groundwater Elevations Contours (ft, msl)

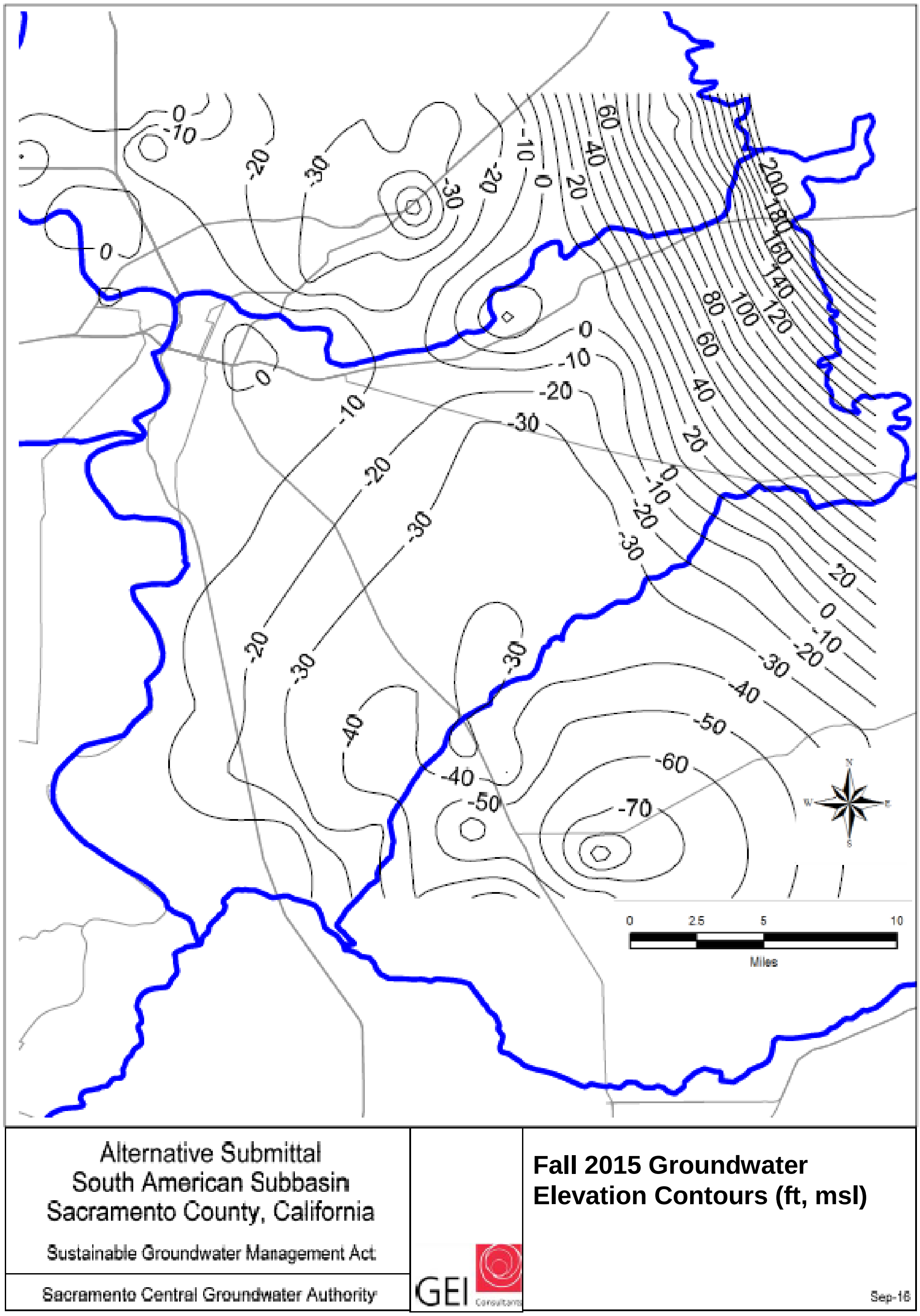


Figure 2-18. Fall 2015 Groundwater Elevation Contours (ft, msl)

south direction. Elevation data were obtained from the CASGEM website for October of each year or for November if a well was not measured during October.

In comparing the Fall 2005 monitoring data to the Fall 1996 monitoring data (**Figure 2-3**), elevation contours show water levels increasing (+20 feet) in the South American Subbasin cone of depression and the North American Subbasin cone decreasing in size. Conversely, the Cosumnes Subbasin cone of depression increased in size and the 50-foot elevation contour has changed shape from circular to an elongated arch. Groundwater stakeholders in the regional Cosumnes Subbasin have been aware of these groundwater levels, but have been unsuccessful in establishing a governance and management plan to address agricultural or urban pumping activities in any portion of the Cosumnes Subbasin, as evidenced by the failed implementations of three groundwater management plans. This lack of management will likely harm adjacent subbasins.

2.6.1.2 Increase in Fall 2005 and 2015 Groundwater Levels

Fall 2005 data indicates that highland recharge into the South American Subbasin flowed in a southwesterly direction under a relatively steep gradient toward the central area of the subbasin where lower water level elevations were shown to exist. Groundwater along the Sacramento River flowed in an east/southeasterly direction under a lesser gradient toward this central area. The westward flow gradient was three to four times greater than the eastward gradient. The contours also show groundwater flowing from the South American Subbasin into the adjacent subbasins, particularly the Cosumnes Subbasin to the south, as the Cosumnes Subbasin cone expanded in size.

Fall 2015 contours show the continuing rise in contours in the central portion, and the deepening and expansion of the cone of depression to the south of the Cosumnes River. Contouring of monitoring data is now placing the South American Subbasin cone-of-depression under the direct influence of pumping in the Cosumnes Subbasin, as defined by the -40-foot contour.

In the last three years, the two subbasins appear to have merged with a single Cosumnes Subbasin cone-of-depression. In the Fall 2015 contours, the Cosumnes Subbasin cone-of-depression has increased in size and depth, extending to -80 feet MSL. The South American cone-of-depression has risen and filled in the extreme low point, making it broader in the Fall 2015 contours as compared to Fall 2005 insofar as the -30-foot contour encompasses a larger area within the center of the South American Subbasin. However, this areal increase is related to and influenced by the Cosumnes Subbasin cone of depression, as the contours show the -30-foot contour extends from the Cosumnes Subbasin into the South American Subbasin and defines the outer limits of the Cosumnes Subbasin cone. The 2015 contours clearly suggest that the Cosumnes Subbasin cone receives groundwater from the South American Subbasin.

2.6.1.3 Verification of Groundwater Level Behavior Using Groundwater Hydrographs

Groundwater conditions were further assessed through a review of hydrographs (**Appendix 2B – Detailed Pumping Data**) for 153 wells in the CASGEM / Water Data Library database system for the South American Subbasin, with the data coming from 47 primary wells, including 21 wells in the 2012 CASGEM monitoring plan and one CASGEM well in the Delta area, 13 DWR Well Monitoring Program (SWP) wells that have been utilized by the BMRs, and 21 other wells (voluntary) with recent and historic data. Note that nine of the SWP wells were selected to be CASGEM wells.

The reported depths of 39 primary wells varied from 72 to 600 feet, with an average of 233 feet and a median depth of 200 feet. Total depth was not reported for eight primary wells.

Forty-four (44) of the 153 wells were classified into four secondary groups because the water level data did not span the 11-year period of 2005 to 2015. These wells provided more qualitative insight into the groundwater conditions of the South American Subbasin. The partial-data groupings included:

- 8 wells with data before SCGA was created and recent data
- 13 wells with data up to 2013
- 7 wells with data only after 2010
- 16 wells with data before SCGA, before 2006

The reported depths of 36 primary wells varied from 20 to 780 feet, with an average of 275 feet and a median depth of 234 feet. Total depth was not reported for eight secondary wells. Fifty-five (55) of the 153 wells only had data prior to 2000 and could not be used for this evaluation. Water level data were not available for seven (7) wells. **Table 2-7** provides a summary of characteristics for the hydrographs.

2.6.1.3.1 Hydrographs

All available data (**Appendix 2C – Groundwater Hydrographs**) were plotted as hydrographs with uniform scales so water level depths and variations can be compared easily. **Figure 2-19** shows the location of three selected hydrographs from **Appendix 2C – Groundwater Hydrographs**, as shown in **Figure 2-20**, **Figure 2-21**, and **Figure 2-22**. These hydrographs span the three types of groundwater behavior showing up in the larger set of hydrographs. For each hydrograph, the elevation scale is constant and ranges from 400 to -150 feet MSL to accommodate the highest ground surface elevation in Folsom to the lowest historic water level

Table 2-7. Summary of Water Level Trends – South American Subbasin

Well Type	Total # of Wells	Water Level Trend (Linear Regression) 2005 - 20015/16			Water Levels versus 2006 Threshold Bandwidth 2010 - 2015/16			Water Levels versus 2006 Threshold Bandwidth 2000 - 2005								
		Rising	Flat	Falling	Above	Within	Below	Above	Within	Below	Total	No Data	CASGEM SCGA-	BMR SWP-	Both BMR & CASGEM	Comments
Primary Wells - 2005 to 2015	47 100%	13 28%	6 13%	28 60%	14 30%	16 34%	17 36%	13 29%	19 42%	13 29%	45 100%	2	22 73%	13 65%	9	
Secondary Wells - Before SCGA & Recent	8 100%	2 25%	0 0%	6 75%	2 25%	2 25%	4 50%	1 13%	5 63%	2 25%	8 100%	0	1 3%	1 5%	0	Visual trends
Secondary Wells - Partial SCGA (up to 2013)	13 100%	3 23%	1 8%	9 69%	4 31%	3 23%	6 46%	2 15%	6 46%	5 39%	13 100%	0	3 10%	4 20%	2	Visual trends
Secondary Wells - Recent (after 2010)	7 100%	0 0%	4 57%	3 43%	1 14%	0 0%	5 71%	0	0	0	0	7	2 7%	0 0%	0	Visual trends, Invalid threshold for 1 well
Secondary Wells - Just before SCGA (up to 2005)	16 100%	7 44%	3 19%	6 38%	11 69%	3 19%	2 13%	8 50%	6 38%	2 13%	16 100%	0	1 3%	2 10%	0	Visual trends
Older Data Wells - Before 2000	55												0	0	0	
No Data Wells	7												1	0	0	
Total	153												30 100%	20 100%	11	
	Total	25 28%	14 15% 100%	52 57%	32 36%	24 27% 100%	34 38%	24 29%	36 44%	22 27%	82 100%	9				

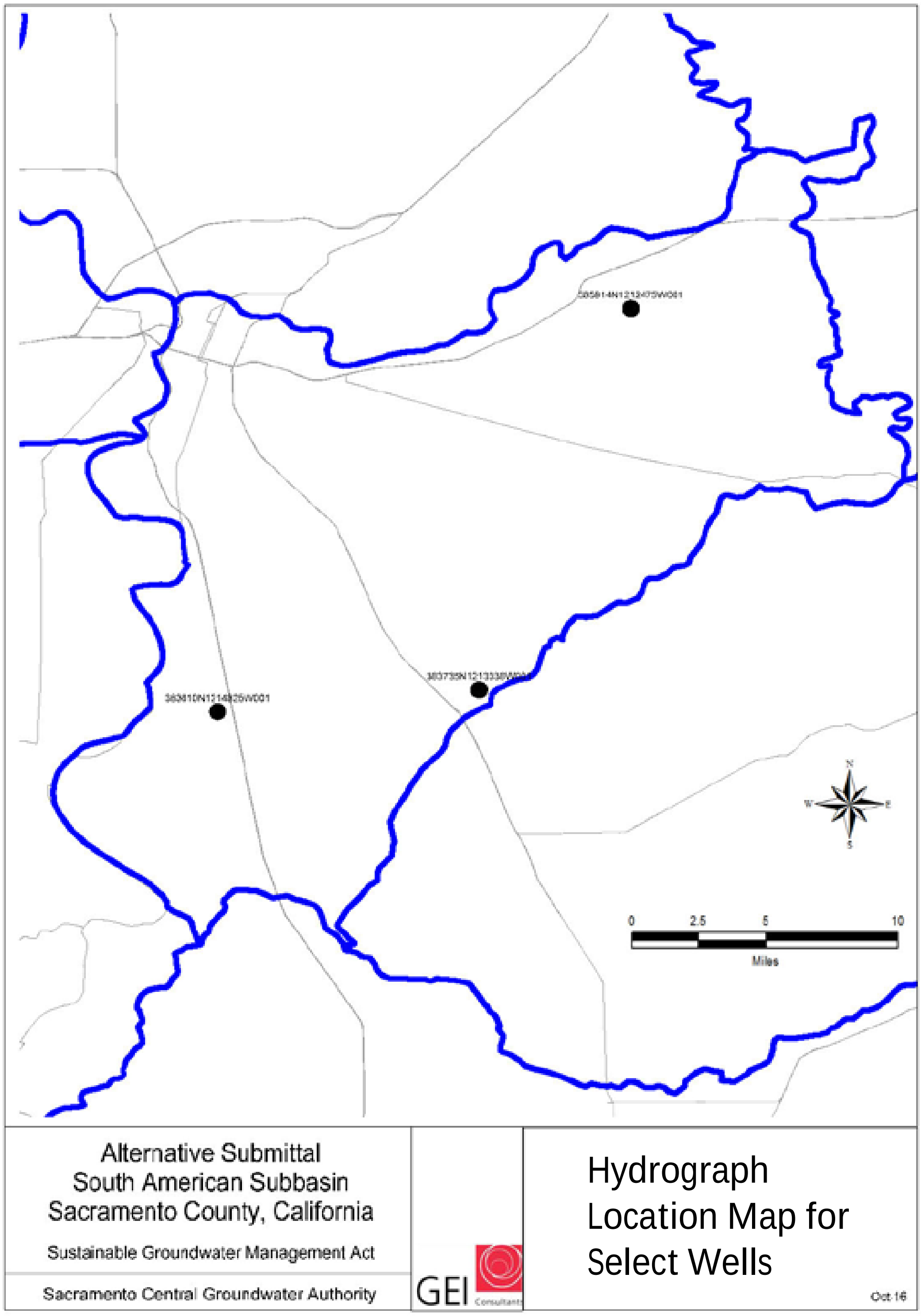


Figure 2-19. Hydrograph Location Map for Select Monitoring Wells

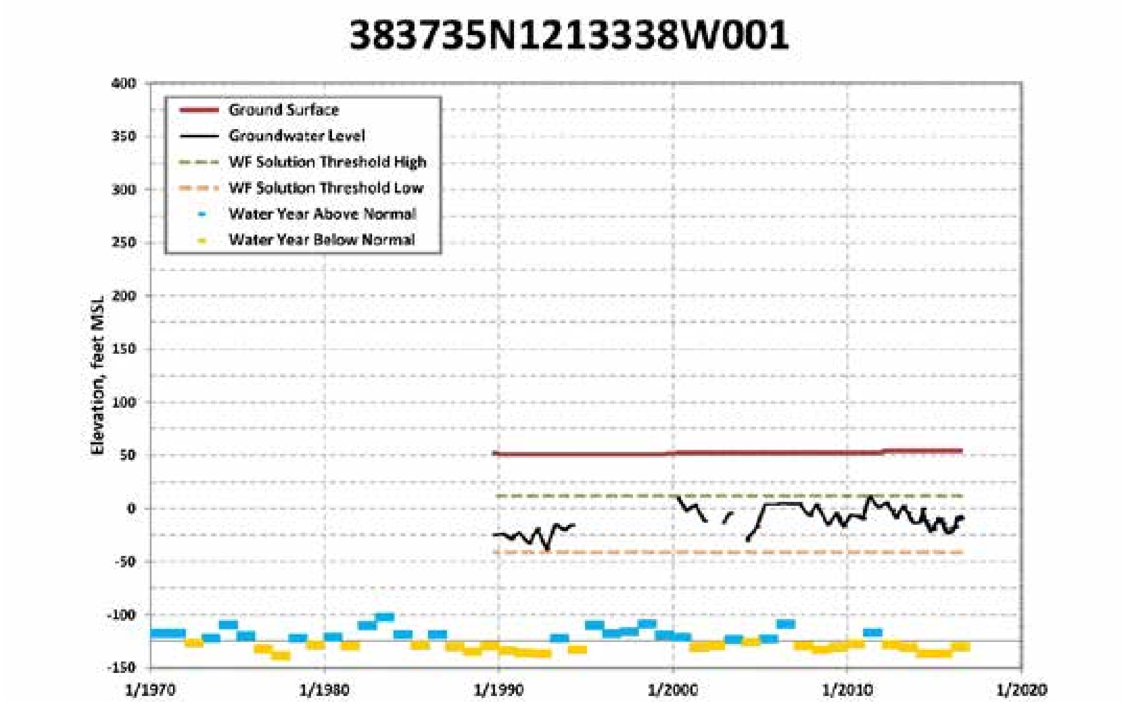


Figure 2-20. Groundwater Hydrograph Operating Above Minimum Thresholds with Flat Trend

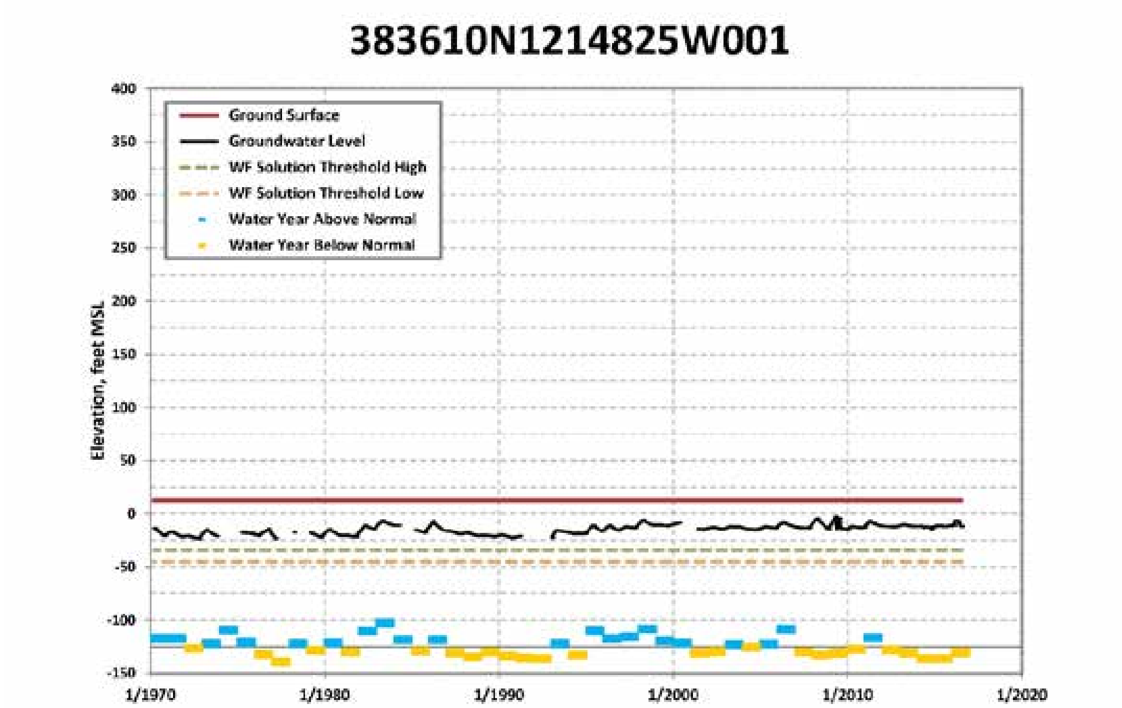


Figure 2-21. Groundwater Hydrograph Operating Above Maximum Threshold

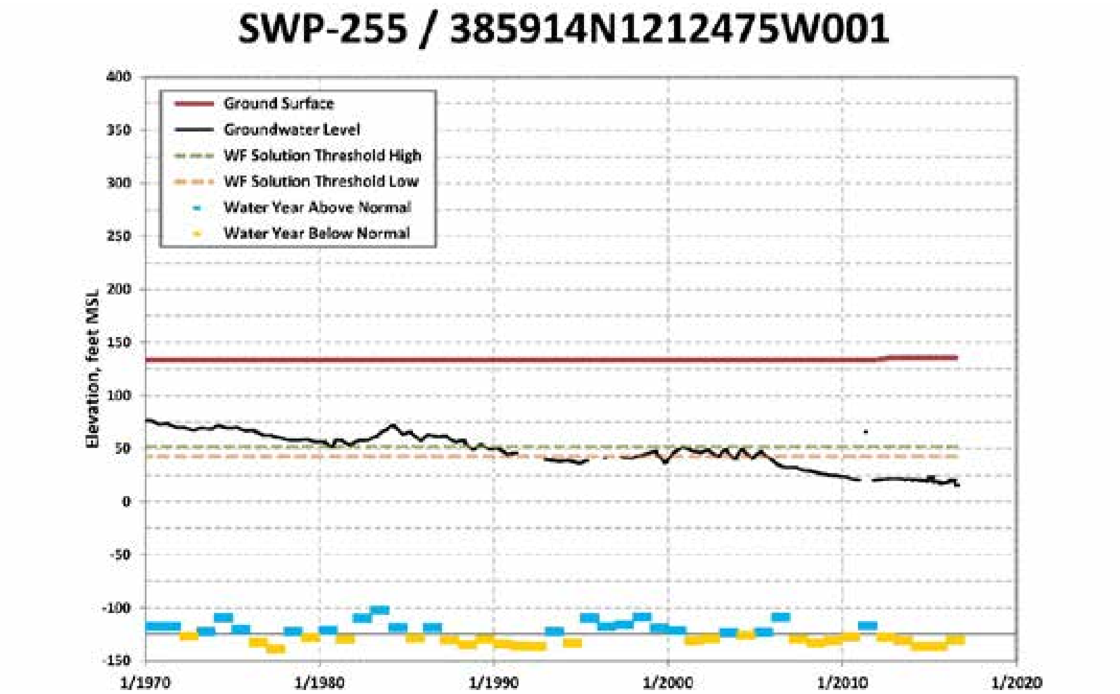


Figure 2-22. Groundwater Hydrographs Operating Through Thresholds

elevation in the Elk Grove area. The time scale starts with January 1970. The hydrographs show the maximum and minimum thresholds defined by Appendix B of the SCGA GMP that were established via the Water Forum Solution Original SacIGSM Forecast groundwater modeling, included by reference in the 2006 SCGA GMP. These thresholds are shown in **Figure 2-23** and **Figure 2-24**, and are considered representative of hydrologic years 1986 and 1977 for the maximum (high) and minimum (low) thresholds, respectively.

In addition, the hydrographs illustrate along the bottom the hydrologic classification of each water year, based on the Sacramento Valley Water Year Index (DWR, 2016). During the 10+ year period for this Alternative's sustainability evaluation, the index shows three years above normal and eight years below normal, including critical conditions during 2014 and 2015. Above normal or wet conditions occurred during 2005, 2006, and 2011.

Water level trends were assessed via linear regression of spring data beginning in 2005, and the slope of the regression line was divided into three primary groups: rising and falling trends (0.001 or greater and -0.001 or lower) and flat (0.000). **Figure 2-25** shows the locations for these water level trends according to various colors and solid symbols. In addition, open symbols show the recent water level data (since 2010) relative to the local range of Water Forum-set threshold values. **Appendix 2C – Groundwater Hydrographs** includes specific information on each well and hydrograph and a rating of performance as to the causes for upward or downward water level trends.

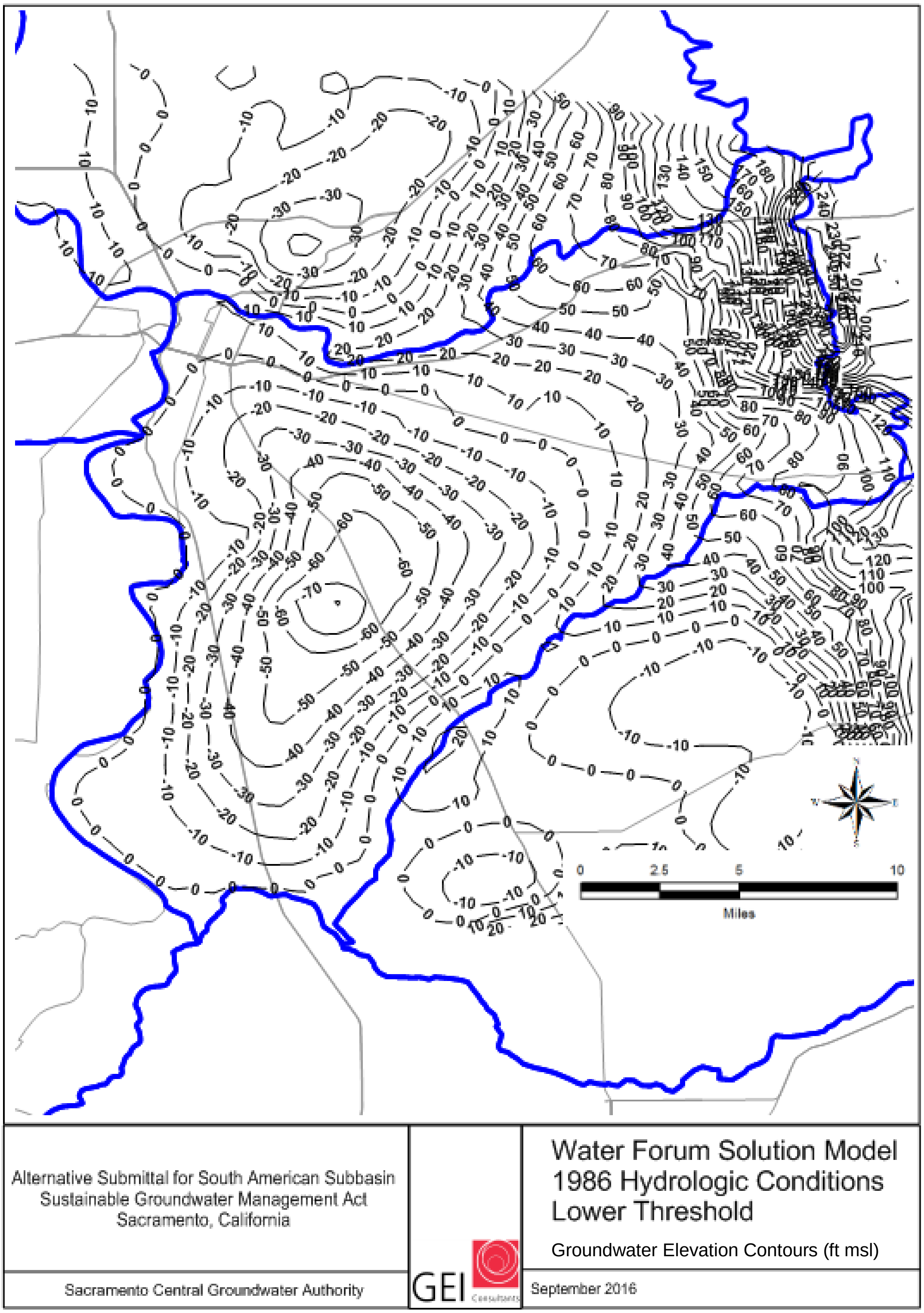


Figure 2-23. Upper Threshold Contours from Water Forum Solution Model

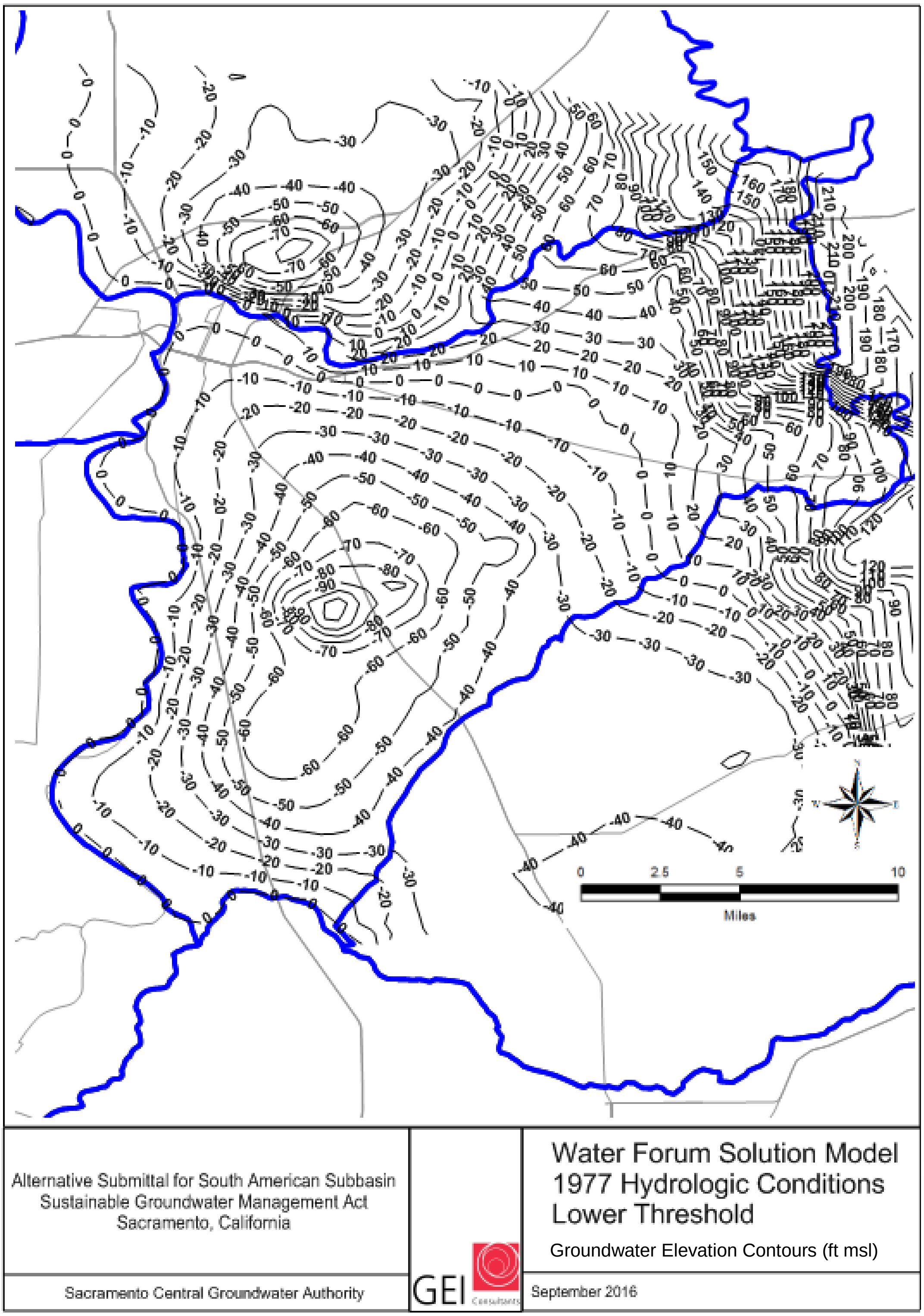


Figure 2-24. Lower Threshold from Water Forum Solution Model

2.6.1.4 Use of Minimum and Maximum Thresholds

The two threshold figures represent the modeled groundwater table (upper unconfined layer) topography under the Water Forum Solution conditions using 2030 water demand and land use conditions and implementation of conjunctive use programs. Knowing that groundwater storage losses and groundwater level declines were planned to occur, the Original SacIGSM Water Forum Solution Forecast models were the best source for defining potential long term groundwater level management thresholds in the future. The SCGA intended to update its GMP in 2014/15 (i.e., delayed due to SGMA), including an update to the Water Forum Solution model using the most recent calibration model year for initial conditions and the latest Water Forum changed conditions. This update process would eventually result in real world thresholds that groundwater elevations would fluctuate within or above over time due to hydrologic differences and, as a goal and over a long term average period, maintain an elevation at or above the maximum threshold.

2.6.1.5 Available Trigger Points

The SCGA GMP included specific trigger points (see SCGA GMP Table 4-1. Monitoring Actions and Trigger Points for each Basin Management Objective) and corrective actions if groundwater levels declined to unacceptable levels (defined by local stakeholders). If stakeholders become concerned or wells are impacted by lowering groundwater levels, the bandwidths would become the baseline for effective enforcement for the specific area of concern. To date, these triggers have not been exercised by the SCGA Board because no undesirable results have been reported by local stakeholders that are the direct result of non-regulatory pumping practices of SCGA member agencies, or their stakeholders.

2.6.1.6 Summary of Hydrograph Trends

The evaluation of separate hydrographs provides a unique story to each location and is sensitive to the uncertainties of groundwater level measurements, well construction data, groundwater layer(s) being measured, and interference with pumping wells located nearby. Below is a summary of the types of hydrograph trends taking place in the South American Subbasin assuming the monitoring data provided is an average measurement of the regional aquifer's behavior. The secondary groupings of wells were not plotted but show similar characteristics, as presented in **Table 2-7**. For example, the proportions of water level trends for the primary wells are similar to the proportions for the primary plus secondary wells.

2.6.1.6.1 Flat to Rising Water Levels

In general, flat to rising water levels[25] above or within the threshold range[26] mostly occur within the west-central area of the South American Subbasin in the vicinity of the cone-of-depression that has been present for many decades, and along the American River. The Elk Grove cone has been the focus of groundwater management starting with SCWA Zone 40's creation during the 1980s, the Water Forum during the 1990s, and then Sacramento Central Groundwater Authority since 2006. The attenuation of this cone-of-depression is evidence of beneficial management practices and outcomes by SCGA and its member agencies.

Falling Water Levels

Falling water levels[27] below the thresholds[28] occur in the northeastern portion of the subbasin in the vicinity of three groundwater remediation projects, including the Aerojet Superfund Site, the US Air Force Mather Field Superfund Site, and the McDonnell Douglas[29] Inactive Rancho Cordova Test Site (IRCTS) at Mather Field and south of Security Park. Note that the Aerojet remediation extends eastward nearly to the boundary of the South American Subbasin and has extracted 5 to 8 times more groundwater than the IRCTS and Mather Site, as shown **Figure 2-25**. In addition, California American Water Company and GSWC produce groundwater from numerous wells that are located to the west of these remediation projects.

These remediation projects are intended to contain the migration of contaminated groundwater by drawing groundwater levels down and reducing flow gradients. The expectation is that other projects have been or will be installed to address the currently untreated source areas within the center of the Aerojet Site. Thus, the mission of these regulatory projects intentionally causes falling water levels (below basin-wide thresholds) and steeper gradients in these discrete areas of the South American Subbasin.

Falling water levels below threshold also occur further south on the eastern side of the subbasin to the Cosumnes River. These wells are located downgradient of the remediation projects, including Sacramento County's Kiefer Landfill. This area is also affected by lower surface water discharges to Deer Creek from the El Dorado Irrigation District's (EID) wastewater

[25] Green diamond or blue up triangle

[26] Open black circle or square

[27] Orange down triangle

[28] Black X

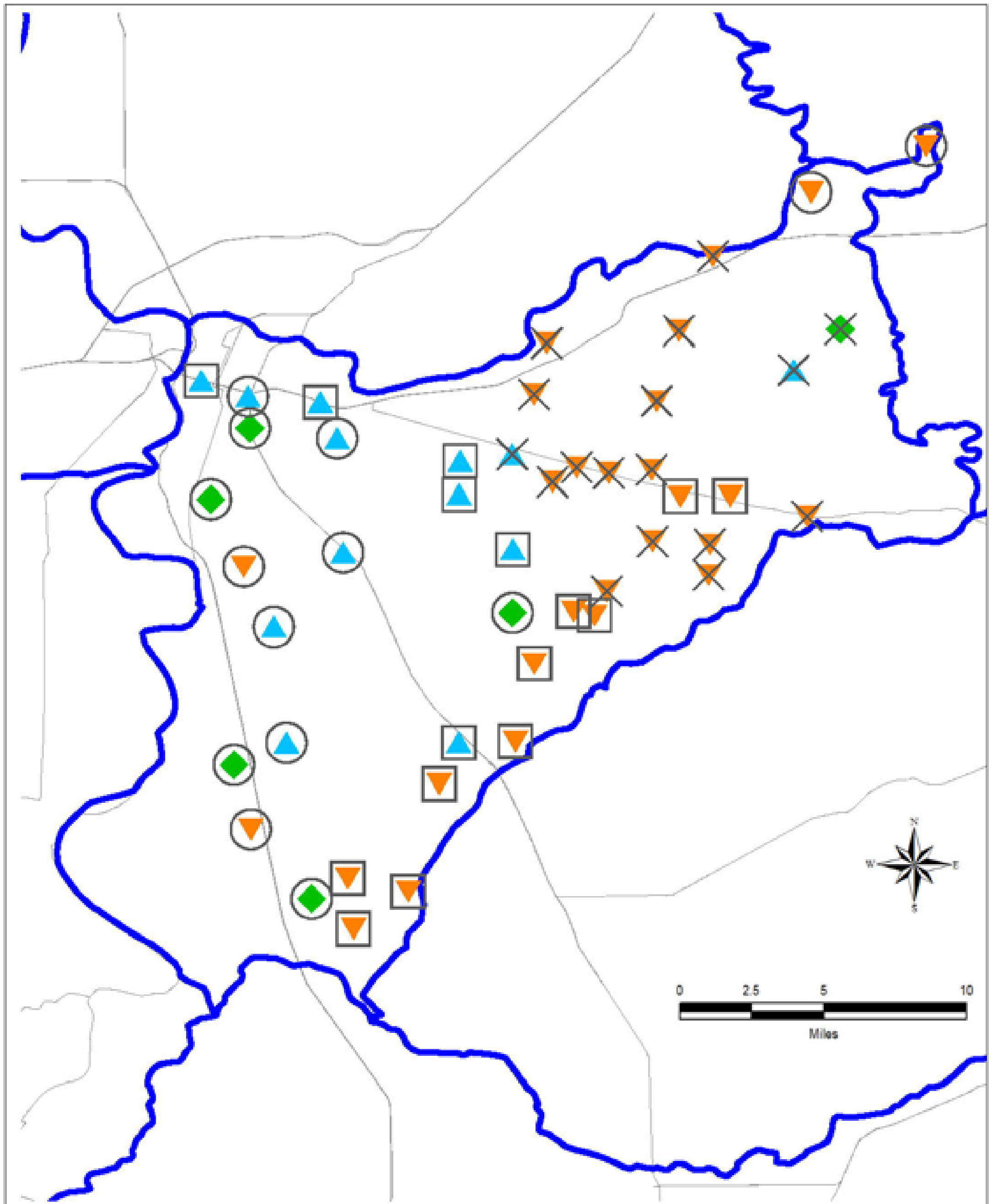
[29] Subsidiary of The Boeing Company

treatment plant (see **Figure 2-9**). Since 2011, the EID discharge has been reduced by 40 percent. Recent drought conditions and agricultural pumping in the Cosumnes Subbasin (i.e., fall 2015 represents the highest stress year in the 10+ years of data analysis) have also likely affected this area by less recharge to the Cosumnes River and Deer Creek.

Falling water levels below the thresholds also occur along the Cosumnes River on the southeastern side of the South American Subbasin. These wells are located along the subbasin boundary and heavily influenced by the large cone of depression in the Cosumnes Subbasin, as discussed above.

While discrete areas of the subbasin show falling water levels below Water Forum thresholds, one area can be attributed to the required regulatory projects that intentionally lower water levels for plume containment, and these actions are outside of SCGA's control. The southern boundary area of the South American Subbasin is influenced by reduced flows in Deer Creek by EID and by activities in the adjacent Cosumnes Subbasin and also outside of SCGA's control. SCGA will continue to track the extraction volumes of remediation projects and work with the remediation entities to maximize the beneficial use of the treated groundwater. SCGA will work with the Cosumnes subbasin as they develop their GSP to collaborate on solutions for the Cosumnes subbasin cone of depression.

Note that water levels in 13 of the 47 primary wells were below the thresholds during 2000 through 2005, prior the start of SCGA. Water levels in 19 wells were within the bandwidth and were above the thresholds at 13 wells. (Water levels were not measured in two primary wells prior to the start of SCGA.)



Alternative Submittal
South American Subbasin
Sacramento County, California

Sustainable Groundwater Management Act

Sacramento Central Groundwater Authority

GEI Consultants

Water Level Trends in 47 Primary Wells

6

Figure 2-25. Water Level Trends

2.6.2 Groundwater Storage

The threshold to prevent the South American Subbasin's loss of storage due to over-pumping by its non-regulatory water use sectors (i.e., urban, agricultural, and rural use categories) is the long-term average sustainable yield of 273,000 AF/year. As shown in **Table 2-2**, basin-wide non-regulatory groundwater extractions have not exceeded this sustainable yield over the last 10+ year period. A detailed look at actual storage change, based on measured groundwater levels, provides a general understanding of where groundwater storage is changing in the basin. Regulatory and non-regulatory pumping, wastewater discharge to surface water, irrigation practices, and hydrologic changes (i.e., stream and river flows, rainfall, and evapotranspiration) are all captured in this evaluation. A brief explanation of the contributing factors to storage changes in different parts of the South American Subbasin is provided below.

2.6.2.1 Calculation of Change in Storage

Figure 2-26 is a contour map of the differences between the water level contours for Fall 2015 and Fall 2005. This difference map was created by subtracting the grid values (water level elevations) for Fall 2005 from the grid values for Fall 2015. The map excludes the contours from the Folsom area, north of Highway 50 because water level was not measured in this area during Fall 2005.

Figure 2-26 shows similar groundwater behavior information as **Figure 2-25.** However, **Figure 2-26** shows average increases and decreases of aquifer storage: an area of higher positive difference, as much as 15 feet (green contours), is located in the west-central portion of the South American Subbasin in the vicinity of the historic, relatively deep cone of depression.

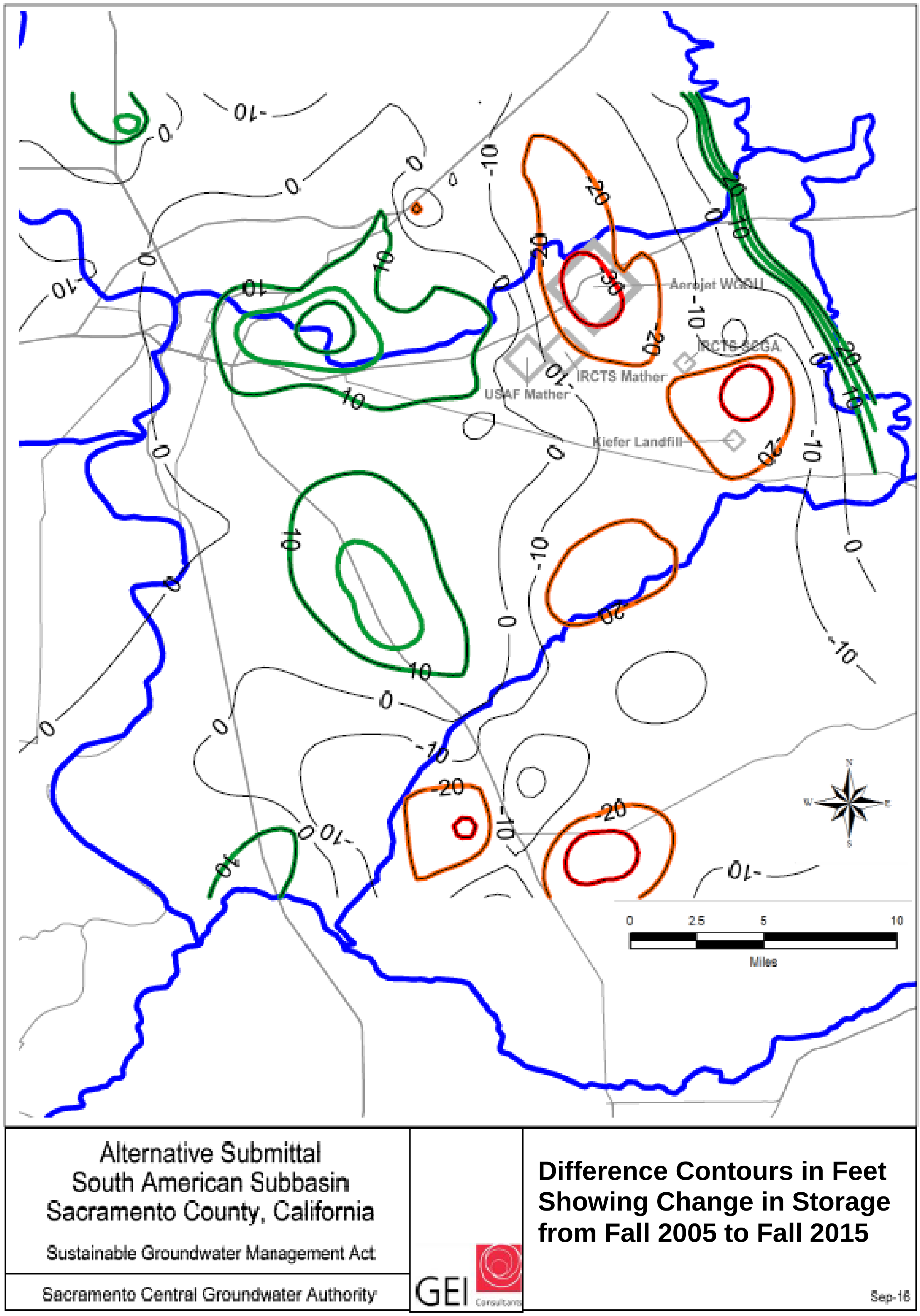


Figure 2-26. Groundwater Difference Contours Showing Changes in Storage

Notably higher increases are also present along the American River, as much as 20 feet, likely due to increased flow periods over the last 10+ year period.

Declining water level areas (orange and red contours) in **Figure 2-26** occur on the eastern side of the subbasin. The larger area of decline, as much as 30 feet, is centered near the intersection of Highway 50 and Sunrise Boulevard, and is within the overall area of the Aerojet Superfund Site, the US Air Force Superfund project at Mather Field to the southwest, and the IRCTS project at Mather Field and along Douglas Road to the southeast. A second area of 30-foot decline is located on the north side of the Jackson Highway with its center between remediation projects at Kiefer Landfill and along Douglas Road on the south side of the IRCTS. The size of the gray diamond indicates the relative amounts of groundwater remediation occurring within this area of the subbasin.

Reduced areas of storage are also located along the Cosumnes River within the South American Subbasin and further south within the Cosumnes Subbasin. These areas of decrease are likely related to agricultural production of groundwater, while municipal (Galt & Herald) production likely contributes to the area along Highway 104. The reasons for areas of significant storage losses attributed to the Cosumnes Subbasin appear complex, and may be due to fewer measurements in the subbasin. Nevertheless, this low level area extends northwestward into the South American Subbasin.

The areas of higher and lower water levels show a relatively small change in storage in comparison to the thick aquifer system (>1000 feet) beneath the South American Subbasin. For the 70-foot interval between the vertical limits (-45 to 25 feet msl) of the volume calculation, the higher water level (cut) area and volume were smaller than the lower water level (fill) area. The change in storage is estimated to be approximately 40,000 acre feet for the period between 2005 and 2015 or an average loss of 4,000 acre feet per year. This estimate is based on a 7.5 percent specific yield (DWR, 1974), which is consistent with other values of 7.0 and 7.6 percent (USGS, 1991, 1989). The volume estimate excluded the band of higher water level on the east side of the subbasin (Figure 2-26) because this higher-level area arises from a well in Folsom that was measured in 2015 but not in 2005. This average change in storage is comparable to the SacIGSM value of 6,200 acre-feet per year in Table 2-6 but smaller than the C2VSim value of 19,000 acre-feet per year, notwithstanding the differences in time periods. DWR (1974) estimated changes in storage for Sacramento County for a 7-year period, 1962 through 1698. Extracting the South American Subbasin portion (248,000 acres) from the total area of valley and hill lands (628,000 acres) produced an average loss of -9,000 acre feet per year (39 percent of the total). The DWR changes in storage were quite variable and ranged from a loss of 196,200 acre-feet per year in 1966 to a gain of 303,400 acre-feet per year in 1967. The average Water Year Index (WYI) for this 7-year period equated to above normal while the average WYI for the recent 11-year period is below normal.

Factoring this change in storage over the entire aquifer storage would likely result in less than one percentage decrease in storage for the South American Subbasin. Moreover, much of this small decrease can be attributed to groundwater remediation in the northeast and to the Cosumnes Subbasin in the southwest. This finding is consistent with the SacIGSM water budget provided in **Table 2-6**. (Note: Over 100,000 acre-feet of storage has been lost from the portion of the Cosumnes Subbasin shown on Figure 2-26, based on the above method.)

2.6.3 Degraded Water Quality

Quantitative water quality degradation thresholds that could affect pumping activities in the basin include:

- TDS not exceeding 1000 mg/L
- VOCs exceed established maximum contaminant levels
- Nitrates exceed primary drinking water standard (40 mg/l)

These constituents are sustainability indicators to conduct management actions in the subbasin. Below is an independent evaluation of available water quality data and studies representing the subbasin, to establish the current state of the subbasin and trends over the past 10+ years.

2.6.3.1 Current State of Water Quality

The overall quality of groundwater is adequate for most purposes within the South American Subbasin, notwithstanding the areas of known contamination and ongoing remediation activities in the northeastern portion of the subbasin. Groundwater quality assessments have been conducted within the subbasin, starting with the investigation of the Folsom-East Sacramento area (DWR, 1964), the investigation of the southern Sacramento Valley (USGS, 2008), and the assessment of the Sacramento-Amador Subwatershed (CH2M, 2016). Three basin management reports (BMRs) have been produced for SCGA and have included illustrations for the geographic occurrence of various water quality constituents, including total dissolved solids (TDS), iron, manganese, nitrate, and arsenic (RMC, 2014; SCGA).

In general, dilute and aggressive recharge water enters the groundwater system on the east side of the South American Subbasin. This water develops a mixed cation-bicarbonate composition (DWR, 1964, 1974; RMC 2015) as the carbon dioxide-rich water dissolves the calcium, magnesium, and sodium from the sediments. Carbon dioxide is derived from the atmosphere and from the root zone to produce acidic conditions. The concentrations of these constituents increase as the groundwater migrates down-gradient and deeper into the aquifer system. The flow paths and residence times are not long enough for the groundwater to evolve to a sulfate- or chloride-rich composition, although the very deep unusable groundwater will be dominated by a sodium-chloride composition from the original marine deposition.

Figure 2-27A through **Figure 2-27F** illustrate variations in concentrations with time for the above constituents, plus chloride. The water quality data were obtained from the Geotracker GAMA website via a California Department of Health (CDPH) link for the South American Subbasin. These data were subdivided by sampling date into six 3-year intervals, beginning with 1998, and these six time intervals were plotted as "box and whisker" where the box represents the concentration range for the middle 50 percent of the data and the two whiskers each represent either the upper or lower 25% of the data. The concentration scale is on the right side of each illustration. The blue columns show the number of samples for each 3-year periods, with the scale on the left side. The database included numerous non-detects (ND) for nitrate, iron, manganese, and arsenic and the ND values were quite variable. As such, ND values were not included in these box and whisker plots.

The following table provides some general characteristics of these water quality constituents.

Table 2-8. General Groundwater Quality Characteristics

	TDS*	Chloride*	Nitrate*	Iron‡	Manganese‡	Arsenic‡
1998-2000 Median	170	8	11	170	11	6.8
2013-2015 Median	210	12	14	270	14	9.8
Non-Detects			18 – 25%	41 – 79%	20 – 57%	10 – 36%

* Concentrations units in milligrams per liter or parts per million (ppm)
‡ Concentration units in micrograms per liter or parts per billion (ppb)

The concentration of these constituents show variable to slight increasing trends that are likely not related to the overproduction of groundwater. Rather, these naturally-occurring constituents, except for nitrate, could be expected to increase as the groundwater flow system became more dynamic during the last century of production, and due to wells that are drilled deeper to increase production capacity. Iron and manganese are known to be present in the deeper groundwater and development of this groundwater resource must include plans for treatment.

Arsenic is a constituent known to occur naturally in the aquifer sediments and some trace of arsenic would be expected to occur in shallow groundwater wells. This occurrence was not a

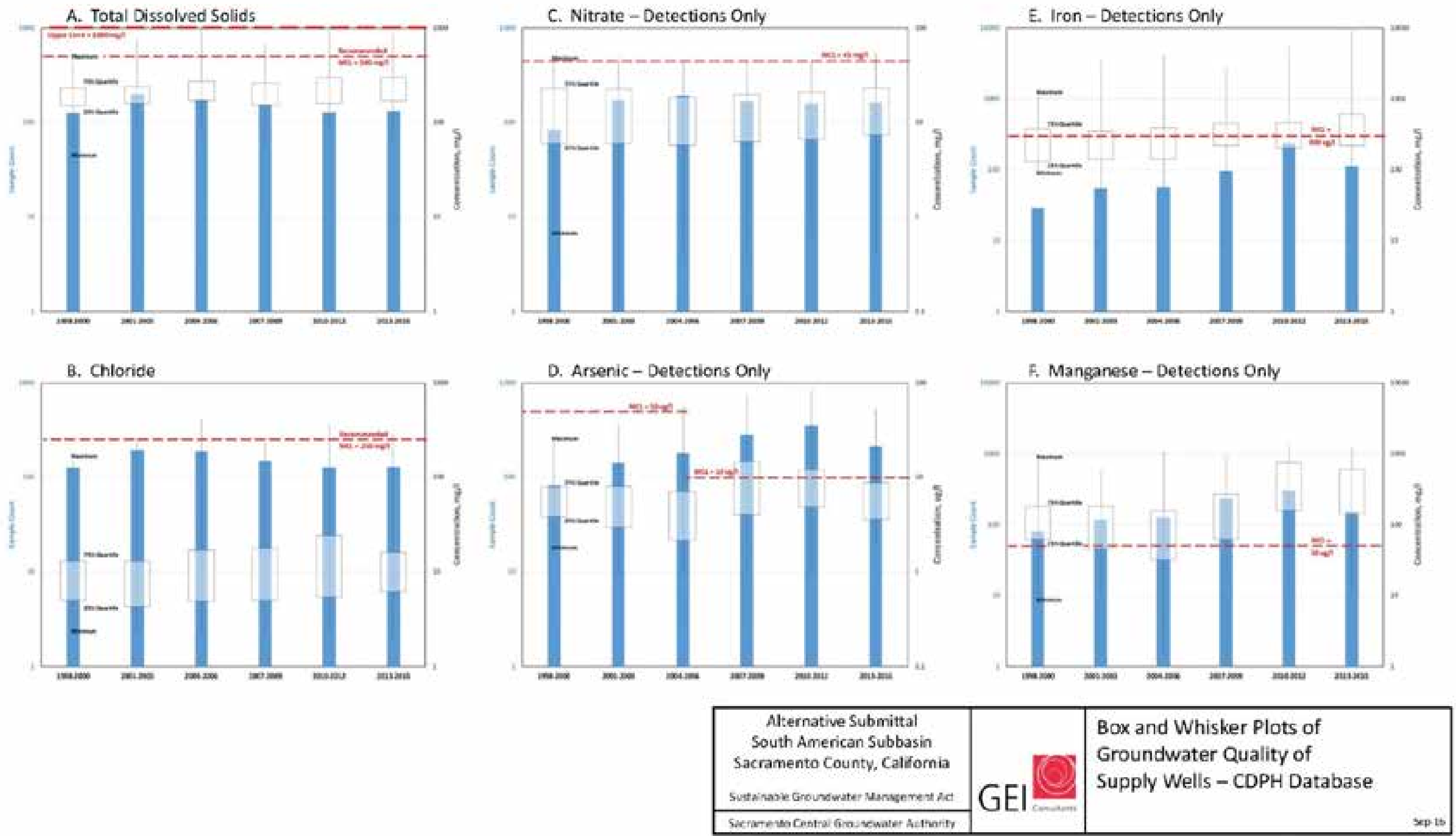


Figure 2-27. Groundwater Quality Box and Whisker Plots

significant issue until the public drinking water standard was lowered from 50 ppb to 10 ppb. The SCWA abandoned many of their older public supply wells in their Laguna service area by replacing with deeper wells designed for centralized treatment of iron and manganese. Private domestic well owners are notified and encouraged through outreach to have their water tested once a year for nitrates and arsenic. The BMRs provide an illustration on the geographic occurrence of arsenic as well as the other constituents.

2.6.3.2 Assessment Developed by GAMA Program

The Ground-Water Ambient Monitoring and Assessment program (GAMA) has addressed conditions throughout much of California via a spatially-unbiased selection protocol for wells and a comprehensive suite of laboratory analyses. A total of 83 wells were sampled from five regions in the Southern Sacramento Valley during 2005, including 16 wells within the South American Subbasin (USGS, 2008). All of these wells were measured in the field for specific conductance, an indirect measurement of TDS, and analyzed for isotopes (deuterium, oxygen-18, and tritium). Selected wells were analyzed for volatile organics (13), pesticides (6), and inorganic compounds and noble gases (5).

The GAMA assessment did not identify any eminent issues with the groundwater quality of the South American Subbasin, and recognizes the groundwater contaminant clean-up efforts taking place. The assessment reported that one of the five wells exceeded the secondary drinking water standard for manganese (230 ppb versus 50 ppb) and this well is located along the Sacramento River. Another of these wells exceeded the standard for 1,2,3-trichloropropane (0.006 ppb versus 0.005 ppb) and this well is located along the American River on the west side of Rancho Cordova, in the vicinity of former orchards and other agricultural lands as wells as downgradient of the Aerojet and Mather Field plumes. This volatile organic compound (VOC) is a cleaning solvent and is associated with pesticides. While the report indicated that the South American Subbasin had the highest frequency of VOC and pesticide detections compared to the other four subbasins, the source of contamination is influenced by past application and disposal practices and not associated with groundwater use or its management. The three most frequent VOCs included trichloromethane (chloroform), trichloroethylene (TCE), and tetrachloroethylene (PCE). The highest frequency pesticide included 2-chloro-4-isopropylamino-6-amino-s-triazine and atrazine.

2.6.3.3 Assessment Developed for Sacramento-Amador Subwatershed

The 2016 CH2M Hill assessment of the Sacramento-Amador Subwatershed relied on the 2006 GMP for its overall description of groundwater quality of the South American Subbasin and focused on the most recent sampling data for nitrate (317 wells) and salinity (TDS values for

447 wells). Some of these data were several decades old. They restated what is in the GMP as follows:

- Better quality groundwater is present in the upper aquifer system although arsenic can exceed its drinking water standard at some locations
- Higher TDS is present in the lower aquifer system
- Treatment may be required for iron and manganese
- Contaminant plumes emanate from several sources, including the Aerojet Superfund Site, the Mather Field Superfund Site, the Inactive Rancho Cordova Test Site (IRCTS), the former Army Depot, the former Southern / Union Pacific railyards, and Kiefer Landfill.

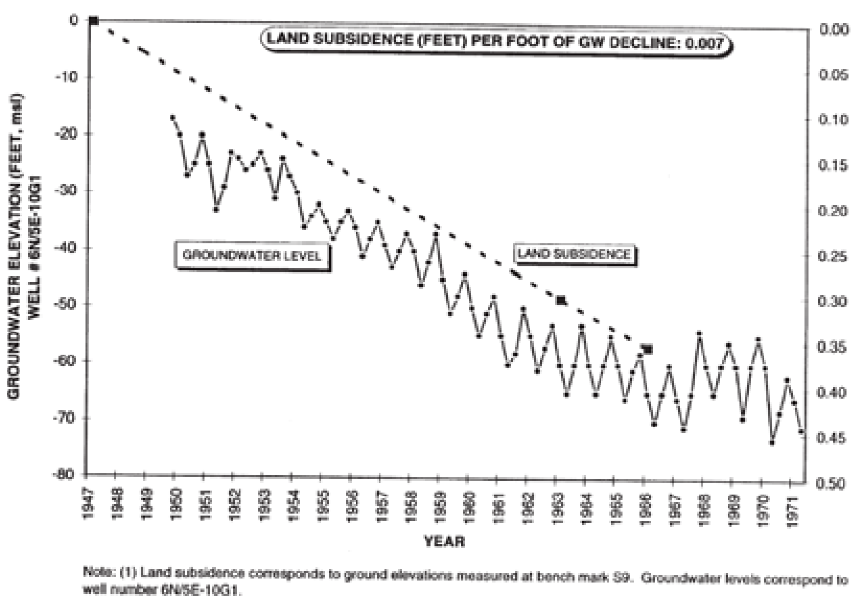
The Assessment text did not differentiate between the South American and Cosumnes Subbasins or the Amador County watershed to the Cosumnes Subbasin but the figures provide details for the South American Subbasin. Nitrate was found to exceed the drinking water standard during the 1980s in a group of wells along Snodgrass Slough on the east side of the Courtland / Delta Area. Nitrate concentrations are lower for other wells with more recent samples and this decrease is attributed to changes in agricultural land use. TDS was found to exceed the drinking water standards at several locations along Snodgrass Slough and within the Pocket area of Sacramento. An increasing TDS trend was shown for two locations between Elk Grove and the Pocket. The Assessment designated the Courtland / Delta Area as an area of high vulnerability to groundwater contamination by nitrate. The Assessment was completed to satisfy the regulatory requirements of the Irrigated Lands Program, with oversight from the State Regional Water Quality Control Board. All agricultural lands not under an existing point source discharge program, are subject to this program, and will require monitoring activities for the protection of drinking water supplies. Water quality degradation due to groundwater pumping, as defined and regulated through SGMA, is not occurring in the subbasin.

2.6.4 Land Subsidence

The current threshold for ground subsidence is 0.007 feet per foot of groundwater “drawdown” in the subbasin, as described in the 2006 GMP. Instead of “drawdown”, the threshold should have referred to an overall ‘water level decline’ in the basin, as shown in Figure 2-28, since drawdown is present around any pumping well in operation. Similar to groundwater levels, the focus of land subsidence was on the cone-of-depression near Elk Grove. The correlation described below to arrive at the acceptable level of subsidence was performed on a well within the cone. The first trigger of subsidence is the measurement of subsidence in either the North American Subbasin or South American Subbasin. Below is the latest quantitative and descriptive understanding of ground subsidence in the South American Subbasin, and a reporting of information based on monitoring currently taking place in the southwest portion of the subbasin near the Delta.

2.6.4.1 Land Subsidence Monitoring and Subbasin Designation

The South American Subbasin has been designated as an area with a medium to high potential for subsidence, based on a ranking process (DWR, 2014) that included groundwater conditions and the presence of historic and/or recent subsidence with some consideration of the CASGEM Overall Basin Priority. Groundwater conditions are ranked medium-high because water levels in 13 of 35 long-term monitoring wells (greater than 10 years) had water levels at or below historic lows. (One of these wells appears to be located within the Eastern San Joaquin Subbasin along the boundary with the South American Subbasin.) This ranking compared a well's historic spring low through 1998 to the recent spring low between 2008 and 2014. Actual subsidence was listed as historic – unknown period or amount, and a current subsiding trend at a continuous GPS station (P274) on the west side of the intersection of Interstate 5 and Twin Cities Road – 0.11 feet of subsidence versus a DWR threshold value of 0.1 foot. Moreover, the DWR Interactive Map provides a link to the GPS data which shows a trend between 5 and 10 inches but does not provide a time frame for this range. This trend designation may not be valid, based on a review of the daily GPS data (see **Appendix 2D – Location and Data of Measured Subsidence Data** for locations and data). Overall, positive trends were found for the daily values of 2006 and 2007, although the 2007 coefficient was less than half of 2006. Negative trends were found for 2008 through 2012, followed by positive trends during 2013 through 2015, although the 2014 coefficient is quite low due to highly variable daily readings for five or six months. (Note: The northern component of the GPS data shows a distinct positive trend while the eastern component of the data shows a more variable, but distinct negative trend.)



Source: Appendix E of Water Forum Agreement, 1997 Baseline Conditions for Groundwater Yield Analysis

Figure 2-28. Ground Subsidence Correlation with Groundwater near Elk Grove

Subsidence at the GPS station was determined to be attributed to "oxidation of organic deposits", which is common in the Delta. According to the Delta Atlas (DWR, 1995), agricultural activities promote this oxidation which leads to subsidence, and the Atlas (and topographic maps) shows that land surface elevations are as much as 10 feet below sea level throughout most of the Courtland / Delta Area. The GPS station is located east of this sub-sea level area, within 3 miles.

As discussed above, the GMP identified a subsidence threshold of 0.007 feet of subsidence per foot of groundwater decline, based on a well (SWP-58 / 383884N1214167W001) in Elk Grove with falling water levels (~50 feet) and a bench mark (S9) with 0.35 feet of subsidence between 1947 and 1966. This well is located 7.6 miles north-northeast of the GPS station. Water levels at the well continued to decline (~20 feet) through 1983 and then increased (~30 feet) by 2004 – the last year of record. Subsidence typically includes a significant elastic component so this 10-foot net rise in water levels could have reduced the subsidence by 0.07 feet (0.84 inches) to 0.28 feet.

Based on current management and pumping practices, subsidence due to groundwater production in the South American Subbasin is likely minimal. Most of the wells with low water levels (11 of 13) are located in the eastern half of the subbasin where aquifers are likely to be coarser grained than the western half of the subbasin. Thick accumulations of interbedded aquitard and aquifer layers are not as prevalent as other locations within the Central Valley. As such, the production of groundwater will not likely induce a dewatering of aquitard layers or the collapse of these layers to produce significant subsidence.

During 2008, DWR and the US Bureau of Reclamation authorized a subsidence project throughout the Sacramento Valley using GPS technology (Frame Surveying & Mapping, 2008). Eight stations were located within the northeastern portion in the South American Subbasin in the vicinity of the declining water levels. These stations can be surveyed periodically to evaluate the potential for subsidence.

2.6.5 Depletions of Interconnected Surface Water

The Original SacIGSM has been used to assess impacts occurring to the subbasin's rivers and streams. The two trigger points for management actions have been a 5% and 25% increase over the Original SacIGSM Water Forum Solution Model loss rate based on total flow in the river.

The positive changes in groundwater elevations in the Elk Grove cone-of-depression have served to benefit rivers and persistent recharge sources hydraulically connected with the South

American Subbasin by reducing the gradient (or slope) of the hydraulic barrier from that included in the Original SacIGSM Water Forum Solution Model.

Below is the current understanding of potential areas where changes in river loss rates (positive and negative) from rivers and streams to groundwater in the subbasin could occur.

2.6.5.1 Potential Changes in River Losses Due to Groundwater Pumping

Surface water provides substantial recharge to the groundwater resources of the South American Subbasin, as described above in the section on groundwater modelling. The most direct connections would occur with the uppermost groundwater at the same or somewhat deeper horizons as the rivers. The connection would become less direct with increasing depths to water, depending on aquifer material and the presence and continuity of aquitard material. Levees along the American and Sacramento Rivers would limit the interconnection to the groundwater by reducing the floodplain. Levee cut-off walls would further restrict interconnections to the uppermost groundwater. Deeper groundwater is not readily connected to surface water, as evidenced by the two Aerojet plumes that have flowed under the American River and are being contained by extraction wells within the North American Subbasin.

The Cosumnes River is the last unregulated river in California, and its headwaters are relatively small and low in elevation compared to other rivers in California. These conditions do not allow a significant amount of runoff to flow into the valley and this flow has historically not lasted throughout the summer. Moreover, groundwater production on both sides of the river lowered the water table many decades ago and the middle reaches of the river have become disconnected from the groundwater system – long before the creation of the Water Forum or the Sacramento Central Groundwater Authority. Nevertheless, the Cosumnes River floodplain is a significant recharge area for the South American and Cosumnes Subbasins. This recharge is derived from flow down Deer Creek and the Cosumnes River and from irrigation waters that are applied to fields throughout the floodplain. The amount of recharge per subbasin is dependent on the directions and gradients of groundwater flow and on aquifer characteristics.

Restoration of flows in the Cosumnes River was not a specific goal of the 2006 SCGA GMP, although the SCGA GMP identifies an interest in this topic along with conjunctive use management and enhanced recharge in a reference to a Memorandum of Agreement between the Sacramento County Water Agency, The Nature Conservancy, and the Southeast Sacramento County Agricultural Water Authority. In addition, the Sacramento Regional County Sanitation District (SRCSD) has promoted the use of recycled water in the Elk Grove area for many years. The SRCSD released a draft Environmental Impact Report (RMC, 2016) in July 2016 for the use of 50,000 acre-feet per year of recycled water from its wastewater treatment plant. This project will contribute to groundwater storage and flows in the downstream portions of the

Cosumnes River, as well as the nearby Sacramento River, via in-lieu recharge by not pumping irrigation wells, recharge via deep percolation of the recycled water, and return flows to the Cosumnes River. Hydraulically connected recharge sources affected by the deepening of the Cosumnes Subbasin cone-of-depression, including upper and lower reaches of the Cosumnes River, are being impacted and require evaluation and updated modeling studies through a joint study effort between both subbasins as the Cosumnes GSP development takes place.

2.6.6 Seawater Intrusion

The South American Subbasin is not likely to experience seawater intrusion due to extractions of groundwater or groundwater management actions.

The Sacramento River does experience tidal fluctuations, approximately 3 feet per day, but does not contain seawater in the vicinity of the South American Subbasin. According to the Sacramento-San Joaquin Delta Atlas (DWR, 1995), salinity intrusions have not advanced beyond Brannan Island, 14 miles downstream of the Delta Cross Channel (southwestern limit of the South American Subbasin), during the period of 1944 through 1990, based on a chloride concentration of 1000 mg/l. During an earlier period (1921 to 1943), prior to the operation of the Shasta Dam, salinity intrusions occurred throughout the Delta and, in 1931, salinity intrusion extended 9 miles up the Sacramento River along the western boundary of the South American Subbasin (2 miles upstream of Courtland). More recent work indicates that salinity intrusions are unlikely to reach the western limit of the South American Subbasin, based on low electrical conductivity values (less than 200 micromhos per centimeter or 140 mg/l TDS) during August 1992, December 1999, July 2004, and June 2005.

2.7 Summary of Findings

This report has shown through multiple lines of evidence that the South American Subbasin, as a whole, has been operating within a locally-defined, long-term average sustainable yield for the past 10+ years as a result of stewardship practices of SCGA, its member agencies, and local agencies in the Delta Area.

Groundwater development began during the early 1900s with the installation of wells, and became an important resource for for urban and agricultural water supply. This nominal 100-year time period is very short relative to the flow of groundwater and relative to geologic time. Prior to groundwater development, the aquifer's deeper stored groundwater remained volumetrically and chemically static for millennia. Recent groundwater extractions and changes in surface water flow patterns have created a highly dynamic environment where both volumetric and chemical stabilities are constantly changing to reach new equilibria. The presented data in this report reflects these changes in a manner that is consistent with locally-defined groundwater management thresholds.

This report has also presented the necessary factual data to represent changes taking place as a result of using groundwater for beneficial purposes. In the case of groundwater levels, positive and negative changes are occurring throughout the basin, and will continue to occur, especially as the subbasin's groundwater levels strive to reach new equilibria. Water quality is also in flux, but at rates expected of an aquifer system with groundwater movement occurring through geologic strata now being exposed to groundwater with natural differences in chemical makeup.

Sustainability Indicators for the South American Subbasin show both positive and negative rates of change in the SGMA URs, with none of the negative URs considered to be directly related to non-regulatory groundwater extractions in the South American Subbasin. Additionally, changes occurring from outside influences are being ameliorated by adaptive management actions by its member agencies in cooperation with SCGA. All locally-adopted thresholds evaluated against the Sustainability Indicators indicate that none of the negative changes result in basin-wide undesirable results.

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