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Basin 8-1 Alternative 2022 Update

Submitted by: Orange County Water District
City of La Habra
Irvine Ranch Water District

Submitted to: California Department of Water Resources

January 1, 2022

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BASIN 8-1 ALTERNATIVE OVERVIEW

The Sustainable Groundwater Management Act (SGMA) requires all high- and medium-priority basins, as designated by the California Department of Water Resources (DWR), be sustainably managed. DWR designated the Coastal Plain of Orange County Groundwater Basin ("Basin 8-1" or "Basin") as a medium-priority basin, primarily due to heavy reliance on the Basin's groundwater as a source of water supply.

The agencies within Basin 8-1 collaborated to prepare and submit an Alternative to a Groundwater Sustainability Plan (GSP) on December 22, 2016. Within this document, this Alternative to a GSP will be referred to herein as the "Basin 8-1 Alternative" or "Alternative". In accordance with Water Code §10733.6(b)(3), the Alternative presented an analysis of basin conditions that demonstrated that Basin8-1 had operated within its sustainable yield over a period of at least 10 years. On July 17, 2019, DWR determined that the Alternative satisfied SGMA objectives and was therefore approved.

Approved alternatives are required to submit annual reports to DWR on April 1 of each year, and to resubmit the alternative by January 1 every five years. Annual reports were submitted to DWR as follows:

- Water Year 2016-17 – March 29, 2018
- Water Year 2017-18 – March 29, 2019
- Water Year 2018-19 – March 30, 2020
- Water Year 2019-20 – March 30, 2021

This document represents the first five-year update, which is due January 1, 2022.

This update has been jointly prepared by the Orange County Water District (OCWD), Irvine Ranch Water District (IRWD); and the City of La Habra Groundwater Sustainability Agency (collectively the "Submitting Agencies"); pursuant to this Alternative, the Submitting Agencies will ensure the entire Basin 8-1 continues to be sustainably managed and data reported as required by SGMA. Pursuant to Water Code §10733.6(b)(3), the Basin 8-1 Alternative has been prepared by or under the direction of a professional geologist or professional engineer.

For purposes of this report, the Basin 8-1 Alternative approved by DWR on July 17, 2019 is referred to as the 2017 Alternative. The first five-year update will be referred to as the 2022 Update. The 2017 Alternative was a comprehensive document showing that Basin 8-1 had been managed sustainably for more than 10 years. For the 2022 Update, the focus is on documenting that the basin has continued to be operated sustainably during the five years since the 2017 Alternative was submitted and to present any new information. As such, background information, such as Basin Hydrogeology, and other sections with no new information is not repeated in the 2022 Update.

As described in the 2017 Alternative, Basin 8-1 was sub-divided into four management areas: La Habra-Brea, OCWD, South East, and Santa Ana Canyon Management Areas (Figure 1-1). The 2022 Update contains four chapters, one for each management area.

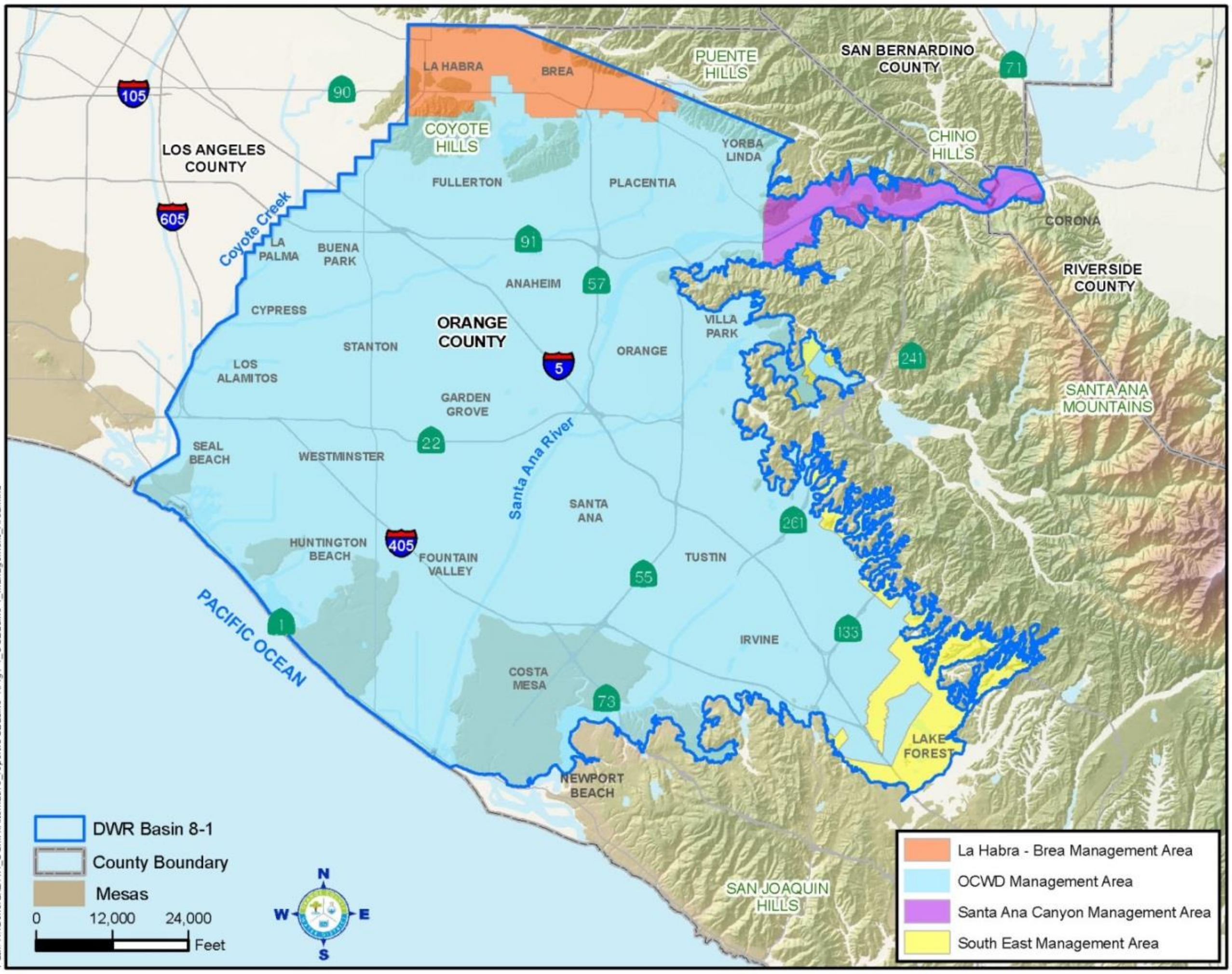

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Figure 1-1: Basin 8-1 Management Area Boundaries

In its evaluation of the Basin 8-1 Alternative, DWR provided four recommendations that they encouraged “be given due consideration and suggest incorporating any resulting changes to the Alternative in future updates.” The recommendations and responses to these recommendations are in Attachment 1 and incorporated into the 2022 Update where appropriate.

ABBREVIATIONS AND ACRONYMS

afy	acre-feet per year
AWPF	Advanced Water Purification Facility
basin	Orange County groundwater basin
Basin Model	OCWD groundwater model
BEA	Basin Equity Assessment
BPP	Basin Production Percentage
CDPH	California Department of Public Health
cfs	cubic feet per second
DATS	Deep Aquifer Treatment System
DOC	dissolved organic compound
DWR	Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection
EDCs	Endocrine Disrupting Compounds
EIR	Environmental Impact Report
EPA	U.S. Environmental Protection Agency
FY	fiscal year
GAC	granular activated carbon
GIS	geographic information system
GWRS	Groundwater Replenishment System
IAP	Independent Advisory Panel
IRWD	Irvine Ranch Water District
LACPW	Los Angeles County Public Works
maf	million acre feet
MCAS	Marine Corps Air Station
MCL	maximum contaminant level
MF	microfiltration
MODFLOW	Computer modeling program developed by USGS
mgd	million gallons per day
mg/L	milligrams per liter
MTBE	methyl tertiary-butyl ether
MWD	Metropolitan Water District of Southern California
MWDOC	Municipal Water District of Orange County
NDMA	n-Nitrosodimethylamine
NF	nanofiltration
ng/L	nanograms per liter
NBGPP	North Basin Groundwater Protection Program
NO_2	nitrite
NO_3^-	nitrate
NPDES	National Pollution Discharge Elimination System
NWRI	National Water Research Institute

ABBREVIATIONS AND ACRONYMS

O&M	operations and maintenance
OCHCA	Orange County Health Care Agency
OCSD	Orange County Sanitation District
OC Survey	Orange County Survey
OCWD	Orange County Water District
PCE	perchloroethylene
PFAS	Per- and polyfluoroalkyl substances
PPCPs	pharmaceuticals and personal care products
Producers	Orange County groundwater producers
RA	replenishment assessment
RO	reverse osmosis
Regional Water Board	Regional Water Quality Control Board
SARI	Santa Ana River Interceptor
SARMON	Santa Ana River Monitoring Program
SARWQH	Santa Ana River Water Quality and Health
SAWPA	Santa Ana Watershed Project Authority
SBGPP	South Basin Groundwater Protection Program
SDWA	Safe Drinking Water Act
SOCs	synthetic organic chemicals
SWP	State Water Project
SWRCB	State Water Resources Control Board
TCE	trichloroethylene
TDS	total dissolved solids
TIN	total inorganic nitrogen
µg/L	micrograms per liter
USFWS	U.S. Fish & Wildlife Service
USGS	U.S. Geological Survey
UV	ultraviolet light
VOCs	volatile organic compounds
WACO	Water Advisory Committee of Orange County
WEI	Wildermuth Environmental Inc.
WF-21	Water Factory 21
WLAM	Waste Load Allocation Model
WRD	Water Replenishment District of Southern California
WRMS	Water Resources Management System

La Habra Management Area

This section is under construction and will be added as soon as it is ready.

DRAFT

Basin 8-1 Alternative

OCWD Management Area

2022 UPDATE

Prepared by: Orange County Water District

January 1, 2022

Basin 8-1 Alternative

OCWD Management Area

2022 UPDATE

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Prepared for the Department of Water Resources, pursuant to Water Code §10733.6(b)(3), (c) and §10733.6

January 1, 2022

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SECTION 1 EXECUTIVE SUMMARY

The Orange County Water District (OCWD) is a special district formed in 1933 by an act of the California Legislature, the “OCWD Act”. OCWD manages the groundwater basin that underlies north and central Orange County pursuant to the OCWD Act. Water produced from the basin is the primary water supply for approximately 2.5 million residents living within the service area boundaries. The mission of OCWD includes sustainably managing the Orange County Groundwater Basin, Basin 8-1, over the long-term. Additionally, as a special act district listed in Water Code § 10723 (c)(1), OCWD is the exclusive local agency within its jurisdictional boundaries with powers to comply with the Sustainable Groundwater management Act (SGMA) via a groundwater sustainability plan (“GSP”) or via an Alternative prepared in accordance with Water Code § 10733.6.

The OCWD Management Area includes 89 percent of the area designated by the Department of Water Resources (DWR) as Basin 8-1, the “Coastal Plain of Orange County Groundwater Basin” in Bulletin 118 (DWR, 2003). The OCWD Management Area includes the same land area as the OCWD service area within Basin 8-1 except for a small 6.7-square mile area in the northeast corner of the basin that is part of the Santa Ana Canyon Management Area. The boundaries of Basin 8-1, the OCWD service area and the OCWD Management Area are shown in Figure 1-1.

The agencies within Basin 8-1 collaborated to prepare and submit an Alternative to a Groundwater Sustainability Plan (GSP). In accordance with Water Code §10733.6(b)(3)(c), the Basin 8-1 Alternative presented an analysis of basin conditions that demonstrated that Basin 8-1 had operated within its sustainable yield over a period of at least 10 years. The Alternative was submitted to DWR on December 22, 2016. On July 17, 2019, DWR determined that the Alternative satisfied SGMA objectives and was therefore approved.

Approved alternatives are required to submit annual reports to DWR on April 1 of each year. Annual reports for Basin 8-1 were submitted to DWR as follows:

- Water Year 2016-17, submitted on March 29, 2018
- Water Year 2017-18, submitted on March 29, 2019
- Water Year 2018-19, submitted on March 30, 2020
- Water Year 2019-20, submitted on March 30, 2021

*Note, the DWR Water Year extends from Oct. 1 to Sept. 30.

According to Water Code §10733.8, “At least every five years after initial submission of a plan pursuant to Section 10733.4, the department shall review any available groundwater sustainability plan or alternative submitted in accordance with Section 10733.6, and the implementation of the corresponding groundwater sustainability program for consistency with this part, including achieving the sustainability goal. The department shall issue an assessment for each basin for which a plan or alternative has been submitted in accordance with this chapter, with an emphasis on assessing progress in achieving the sustainability goal within the basin. The assessment may include recommended corrective actions to address any deficiencies identified by the department."

This document, called the 2022 Update, represents the first five-year update, which is due January 1, 2022.

For purposes of this report, the Basin 8-1 Alternative submitted on December 22, 2016, will be referred to as the 2017 Alternative. The first five-year update will be referred to as the 2022 Update for ease of reference. The 2017 Alternative was a comprehensive document showing that Basin 8-1 had been managed sustainably for more than 10 years. For the 2022 Update, the focus is on documenting that the basin has been sustainably managed during the five years since the 2017 Alternative was submitted and to present relevant new information from the last five years. As such, the 2017 Alternative is considered a key reference document with background information that is not duplicated in the 2022 Update.

1.1 GROUNDWATER BASIN CONDITIONS

GROUNDWATER ELEVATIONS

OCWD prepares groundwater elevation contour maps for each of the three major aquifer systems (Shallow, Principal, and Deep) annually. In addition to illustrating regional groundwater gradients, the maps are used to prepare water level change maps and to calculate the amount of groundwater in storage and the annual storage change. OCWD's basin-wide network of monitoring wells is used to monitor groundwater levels and quality, assess effects of pumping and recharge, estimate groundwater storage, characterize basin hydrogeology, and develop and calibrate a numerical flow model of the basin. Groundwater elevation contours for the Principal Aquifer as of June 2021 are shown in Figure 1-2.

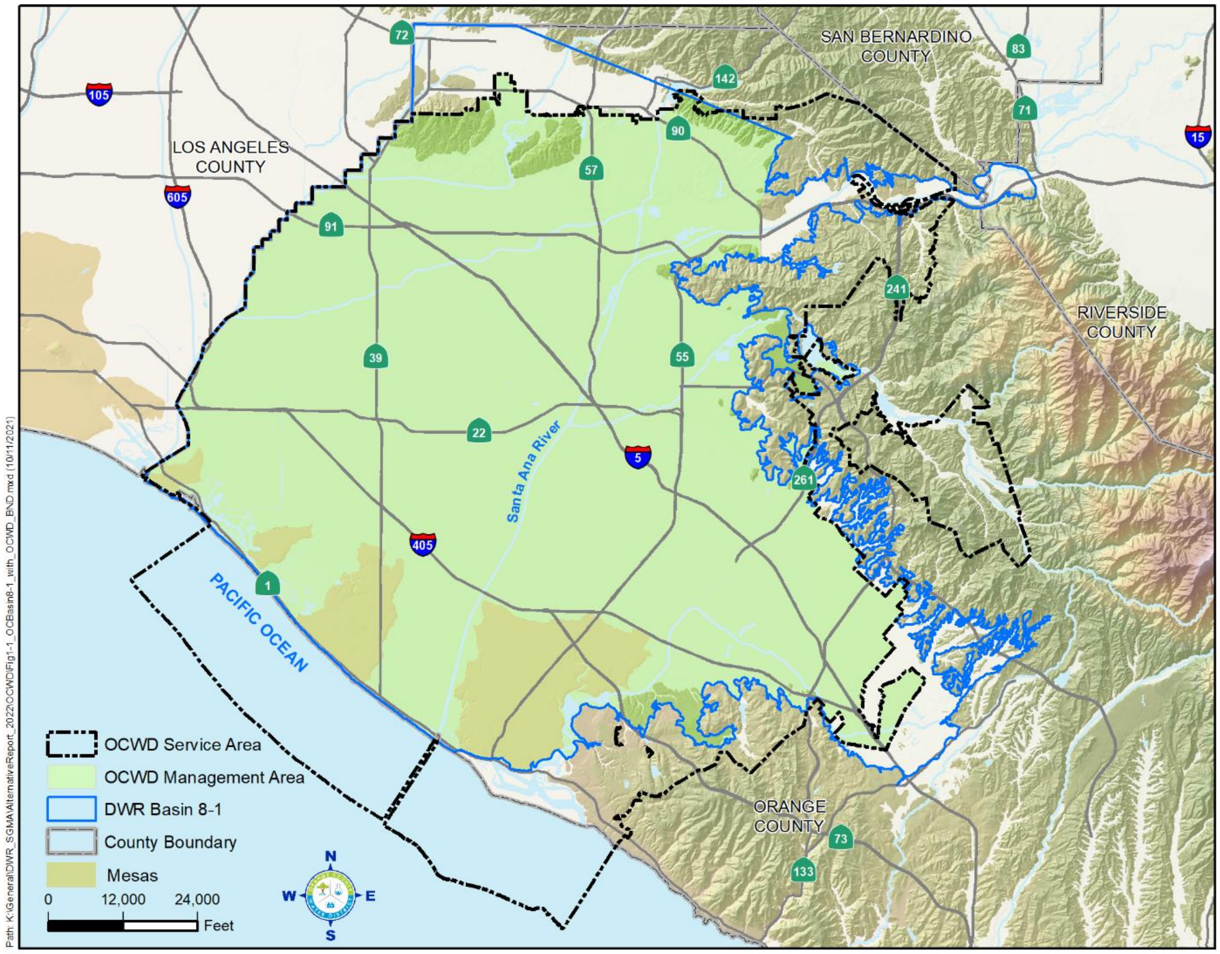


Figure 1-1: Basin 8-1, OCWD Service Area and OCWD Management Area

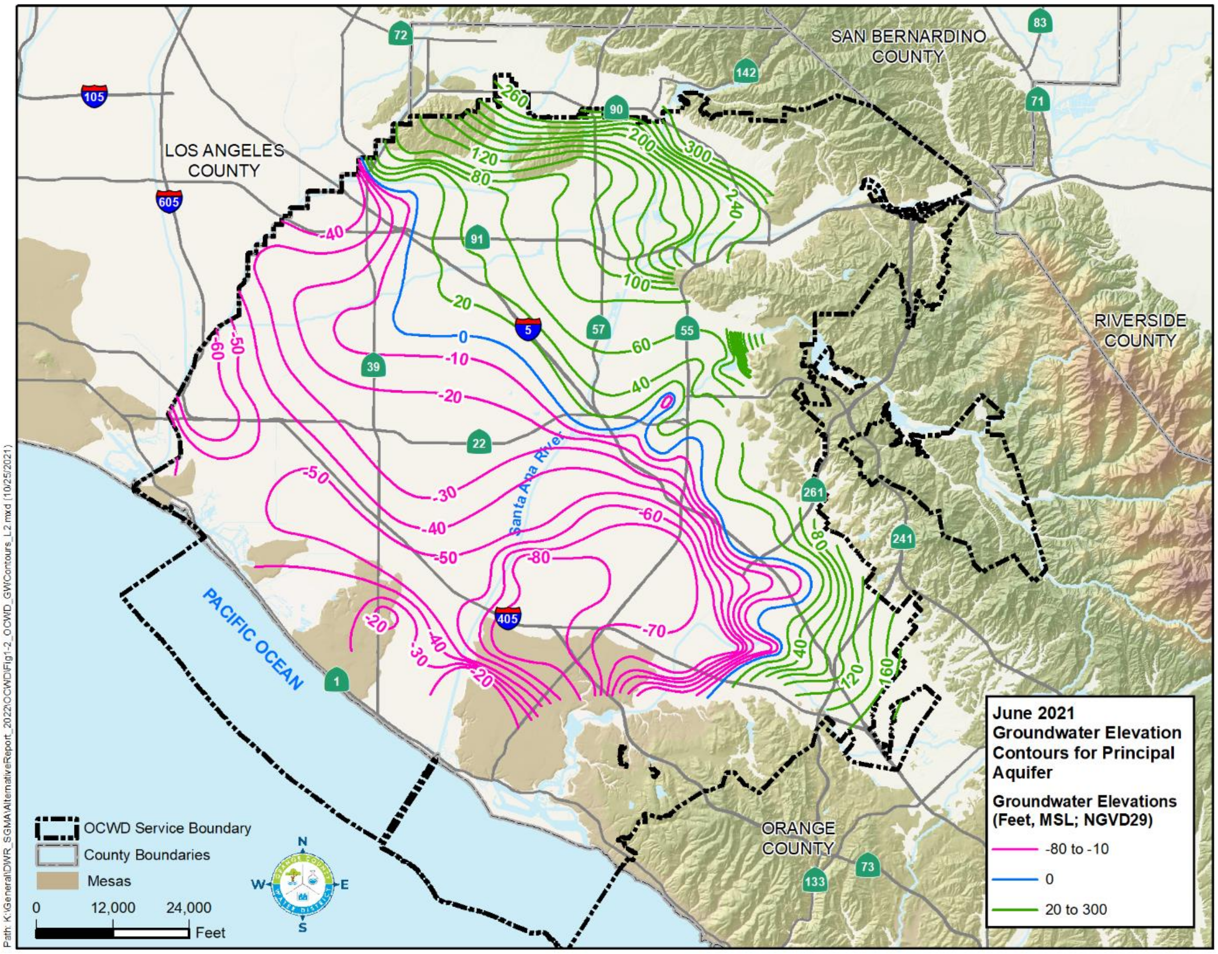


Figure 1-2: Groundwater Elevation Contours for the Principal Aquifer, June 2021

GROUNDWATER STORAGE

The groundwater basin contains an estimated 66 million acre-feet when full. However, OCWD manages the basin within an established operating range of up to 500,000 acre-feet below full condition. This operating range was established to designate the levels of groundwater storage within which the basin that can be maintained without causing adverse impacts. In order to manage the basin within this operating range, OCWD calculates the amount of groundwater in storage on an annual basis. Long-term groundwater storage levels based on OCWD's water year (July 1 to June 30) are shown in Figure 1-3.

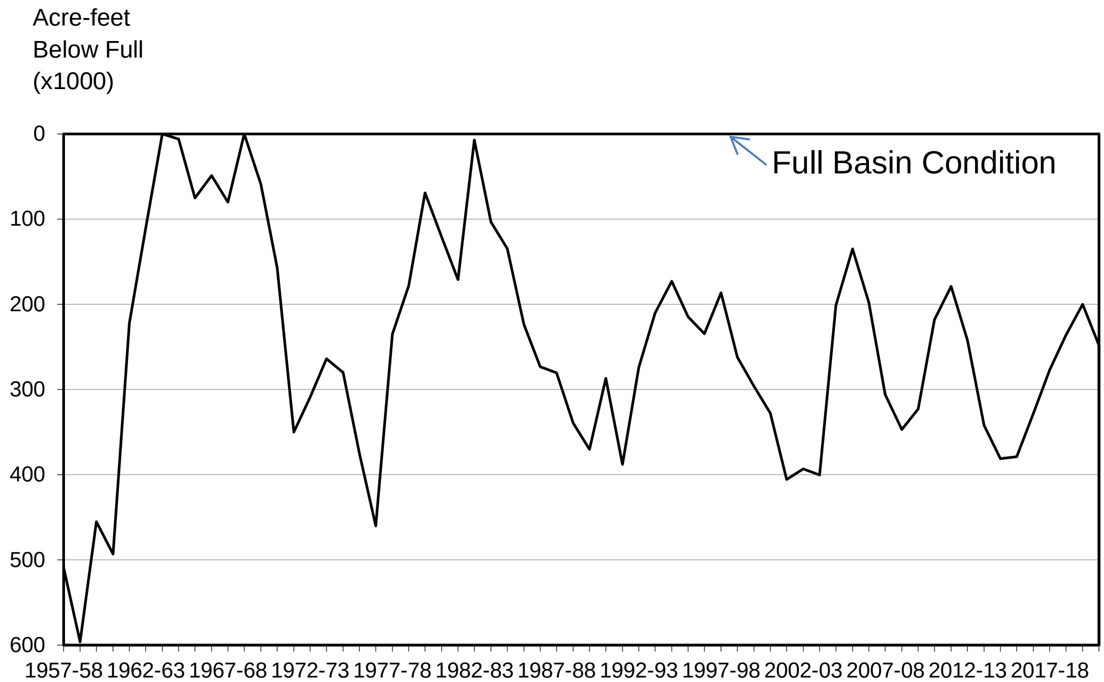


Figure 1-3: Available Basin Storage WY1957-58 to 2020-21

WATER QUALITY

The California Regional Water Quality Control Board, Santa Ana Region (Regional Water Board) is responsible for protection and enhancement of the quality of waters in the watershed, which includes surface water and groundwater in the OCWD Management Area. The watershed's salinity management program, overseen by the Regional Water Board, is managed by the Basin Monitoring Program Task Force. Water quality objectives for total dissolved solids (TDS) and nitrate-nitrogen in groundwater management zones were adopted by the Regional Water Board based on historical water quality data. Every three years the Task Force calculates the current ambient water quality for each groundwater management zone. The most recent recalculation for the groundwater basin was completed in 2020 (OCWD, 2020).

There are several regional groundwater contamination plumes within the OCWD Management Area, all of which are under active remediation, and some are being evaluated for additional remediation. The U.S. Environmental Protection Agency (EPA) is the lead agency in overseeing a remedial investigation/feasibility study (RI/FS) to develop an interim remedy for the VOC plume in the North Basin area. OCWD is conducting an RI/FS to develop an interim remedy for the plume in the South Basin area. Investigations and remediation for individual contaminant source sites within the North Basin and South Basin areas are within the jurisdiction of either the California Department of Toxic Substances Control or the Regional Water Board. The U.S. Navy is taking the lead in remediation of plumes from the former El Toro and Tustin Marine Corps Air Stations and the Naval Weapons Station Seal Beach.

Per- and Polyfluoroalkyl Substances (PFAS)

Per- and polyfluoroalkyl substances (PFAS) are a group of thousands of manmade chemicals that includes perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). PFAS compounds have been commonly used in many products including, among many others, stain- and water-repellent fabrics, nonstick products (e.g., Teflon), polishes, waxes, paints, cleaning products, and fire-fighting foams. Beginning in the summer of 2019, the California Division of Drinking Water (DDW) began requiring testing for PFAS compounds in some groundwater production wells in the OCWD area.

As a result of required testing, as of September 2021, approximately 60 wells in the OCWD service area have been temporarily turned off until treatment systems can be constructed. As additional wells are tested, this figure may increase.

In April 2020, OCWD as the groundwater basin manager, executed a multi-party agreement with the impacted groundwater producers to fund and construct the necessary treatment systems for production wells impacted by PFAS compounds. OCWD expects the treatment systems to be constructed for the approximately 60 impacted wells within the next 2 to 3 years.

LAND SUBSIDENCE

Ground surface elevations rise and fall due to groundwater conditions in the OCWD Management Area and do not show a pattern of widespread, permanent lowering of the ground surface. There is no evidence of permanent, inelastic land subsidence within the OCWD Management Area.

1.2 WATER BUDGET

OCWD developed a hydrologic budget for the purpose of constructing a basin-wide numerical groundwater flow model and for evaluating basin production capacity and recharge requirements. The key components of the budget include measured and unmeasured (estimated) recharge, groundwater production and subsurface outflows.

The groundwater basin is not operated on an annual safe-yield basis. The net change in storage in any given year may be positive or negative; however, over a period of several years, the basin is maintained in an approximate balance. Amounts of total basin production and total water recharged from OCWD water years (WY)1999-2000 to 2020-21 are shown in Figure 1-4. The OCWD water year extends from July 1 to June 30.

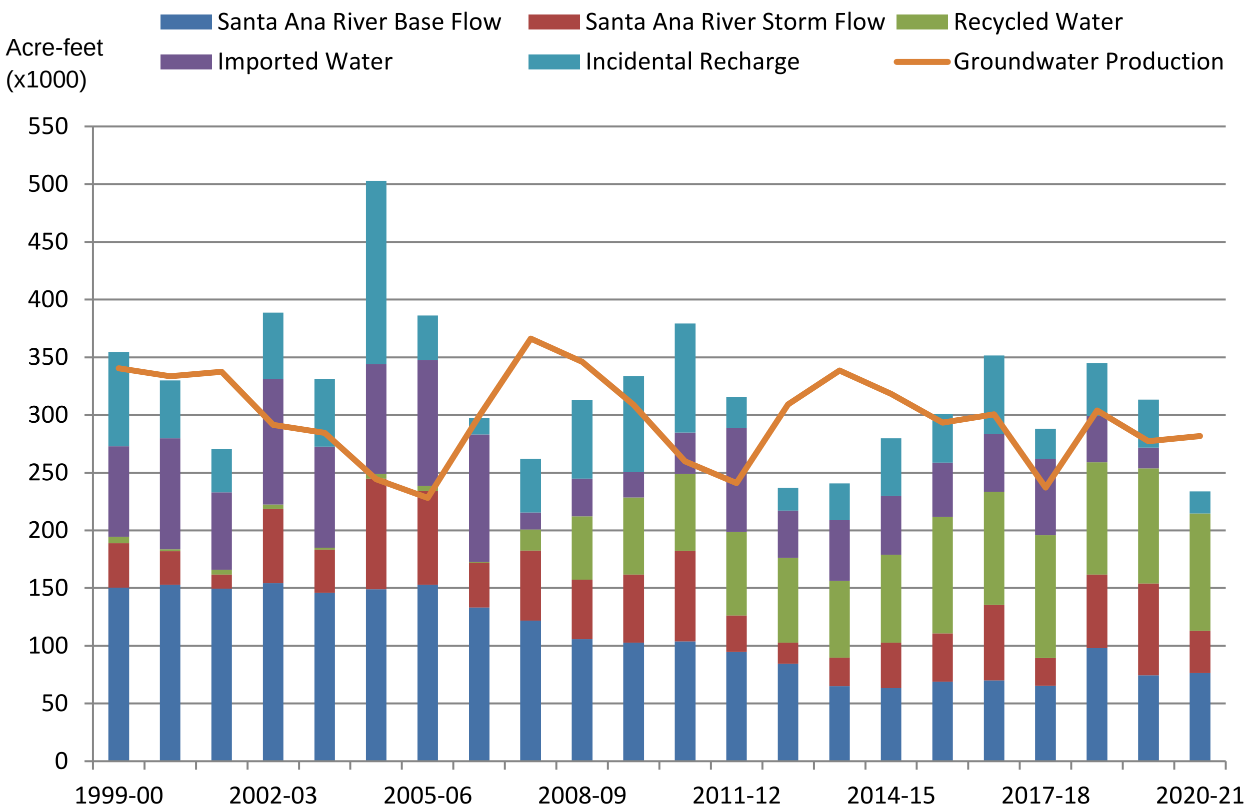


Figure 1-4: Basin Production and Recharge Sources, WY1999-20 to 2020-21

1.3 WATER RESOURCE MONITORING PROGRAMS

Water resource monitoring programs for groundwater, surface water, recycled water, and imported water remain unchanged (see 2017 Alternative for list). The only slight modification is the replacement of the CA Statewide Groundwater Elevation Monitoring (CASGEM) Program with annual data reports required for SGMA compliance.

1.4 GROUNDWATER MANAGEMENT PROGRAMS

LAND USE

The OCWD Management Area is highly urbanized. As such, OCWD monitors, reviews and comments on local land use plans, environmental documents, and proposed regulatory agency permits to provide input to land use planning agencies regarding proposed projects and programs that could cause short- or long-term water quality impacts to the groundwater basin.

DEMAND MANAGEMENT

The average annual water demand within the OCWD Management Area for the most recent five water years, WY2016-17 to 2020-21 is approximately 400,000 acre-feet. Total water demands in the management area are met by a combination of groundwater, imported water, and recycled water. From WY1996-97 to present, water demands have ranged between 367,000 and 526,000 acre-feet per year but have generally decreased, as shown in Figure 1-5. It is noted that water demands in WY2015-16 reflect mandatory demand reductions imposed by the State Water Board in response to an extended drought. OCWD strives to sustainably maximize both production from the basin and recharge of the groundwater basin.

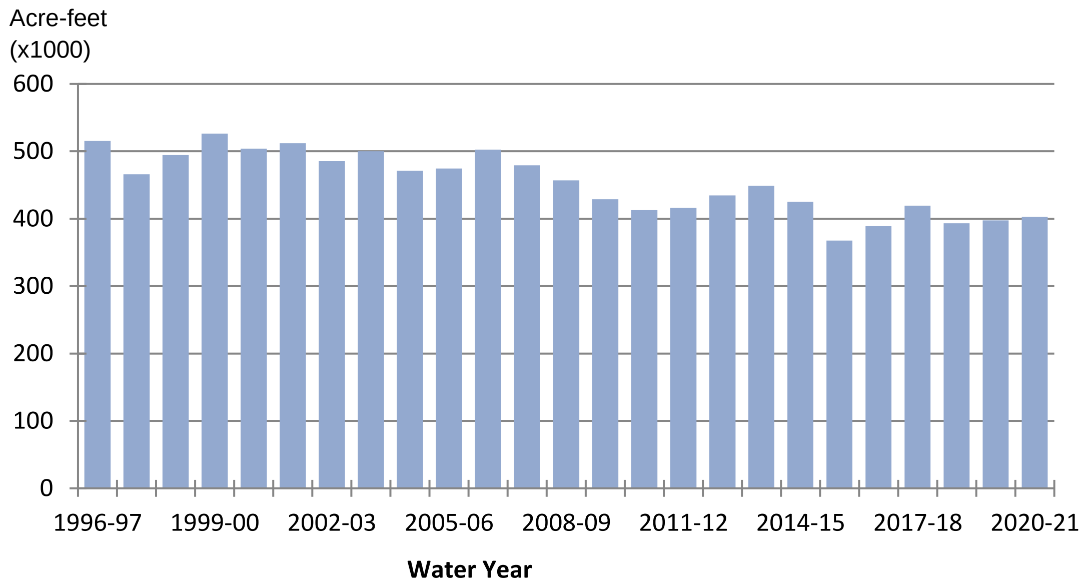


Figure 1-5: Total Water Demands within OCWD, WY1997-98 to 2020-21

GROUNDWATER QUALITY PROTECTION AND MANAGEMENT

OCWD adopted a Groundwater Quality Protection Policy in 1987 and updated it in 2014. This policy guides the actions of OCWD to maintain groundwater quality suitable for all existing and potential beneficial uses; prevent degradation of groundwater quality and protect groundwater from contamination; maintain surface water and groundwater quality monitoring programs, a monitoring well network and data management system; and assist regulatory agencies in remediating contaminated sites.

In January 2020, in preparation for the impacts of PFAS to groundwater supply, OCWD adopted a Per- and Polyfluoroalkyl Substances (PFAS) Policy. Central to this policy is OCWD's desire to maintain a groundwater supply of suitable quality for all existing and potential beneficial uses. Among other items, the policy states that OCWD will fund the lowest reasonable and efficient treatment system design and construction costs to remove PFAS compounds for groundwater producers. Additionally, the policy states that OCWD will fund 50 percent of operation and maintenance expenses up to $75 per acre-foot plus potential adjustments.

As of September 2021, approximately 60 production wells operated by 11 groundwater producers have been temporary shut down until treatment systems can be constructed. OCWD expects these treatment systems to be constructed within the next 2 to 3 years.

RECYCLED WATER PRODUCTION

OCWD's Groundwater Replenishment System (GWRS) produces up to 100 million gallons per day (mgd) of highly treated recycled water. The GWRS Final Expansion is under construction and will be on-line in early 2023. The final expansion will increase plant capacity to 130 mgd. GWRS water is recharged into the groundwater basin and is the primary source of water for the Talbert Seawater Barrier. OCWD also operates the Green Acres Project, a non-potable recycled water supply for irrigation and industrial water users.

CONJUNCTIVE USE PROGRAMS

Recharge water sources include the Santa Ana River and tributaries, imported water, and recycled water supplied by the GWRS as well as incidental recharge from precipitation and subsurface inflow. OCWD's conjunctive use program includes over 1,500 acres of land on which there are 1,067 wetted acres of recharge facilities.

MANAGEMENT OF SEAWATER INTRUSION

The Alamitos and Talbert Seawater Intrusion Barriers control seawater intrusion through the Alamitos and Talbert Gaps by injecting fresh water into susceptible aquifers through a series of injection wells to create a hydraulic barrier.

Work is underway to characterize intrusion in the Sunset Gap, including installation of monitoring wells, development of a groundwater flow model, and feasibility studies. This information is needed to guide design of a potential new seawater barrier in the Sunset Gap.

1.5 NOTICE AND COMMUNICATION

The local agencies that produce the majority of the groundwater from the basin include 19 cities, water districts, and a private water company. OCWD staff holds monthly meetings with this group to provide information and seek input on issues related to groundwater management. OCWD has a proactive community outreach program that includes conducting an annual Children's Water Education Festival attended by over 7,000 elementary school students and a monthly electronic newsletter with approximately 5,700 subscribers.

1.6 SUSTAINABLE BASIN MANAGEMENT

The sustainability goal for the OCWD Management Area is to:

> Continue to manage the groundwater basin to prevent basin conditions that would lead to significant and unreasonable (1) lowering of groundwater levels, (2) reduction in storage, (3) water quality degradation, (4) seawater intrusion, (5) land subsidence and (6) depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Existing monitoring and management programs in place today enable OCWD to sustainably manage the groundwater basin. Since its founding in 1933, OCWD has developed a managed aquifer recharge program, constructed hundreds of monitoring wells, developed an extensive water quality monitoring program, installed seawater intrusion barriers, and doubled the volume of groundwater production while protecting the long-term sustainability of the groundwater resource. OCWD's management of the OCWD Management Area will continue to provide long-term sustainable basin management that is able to adapt to changing conditions affecting the groundwater basin.

1.6.1 Sustainable Management: Water Levels

OCWD manages the basin for long-term sustainability by maximizing groundwater recharge and managing basin production within sustainable levels. Long-term groundwater level trends demonstrate the undesirable result of "chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply" is not present. Hydrographs representative of long-term water levels in the basin are shown in Figure 1-6. These hydrographs demonstrate that groundwater levels in the OCWD Management Area are being managed at long-term sustainable levels. Chronic lowering of groundwater levels is not anticipated to occur in the future in the OCWD Management Area due to OCWD's management programs.

1.6.2 Sustainable Management: Basin Storage

OCWD manages basin storage within an established operating range of up to 500,000 acre-feet below full condition. Maintaining basin storage within this range protects the basin from detrimental impacts such as land subsidence, chronic lowering of groundwater levels and chronic reduction in storage. OCWD manages groundwater pumping such that it is sustainable over the long-term; however, in any given year pumping may exceed recharge or vice versa. Thus, the amount of groundwater stored in or withdrawn from the basin varies from year to year and often goes through multi-year cycles of emptying and filling, which typically correlates with state-wide and/or local precipitation patterns and other factors.

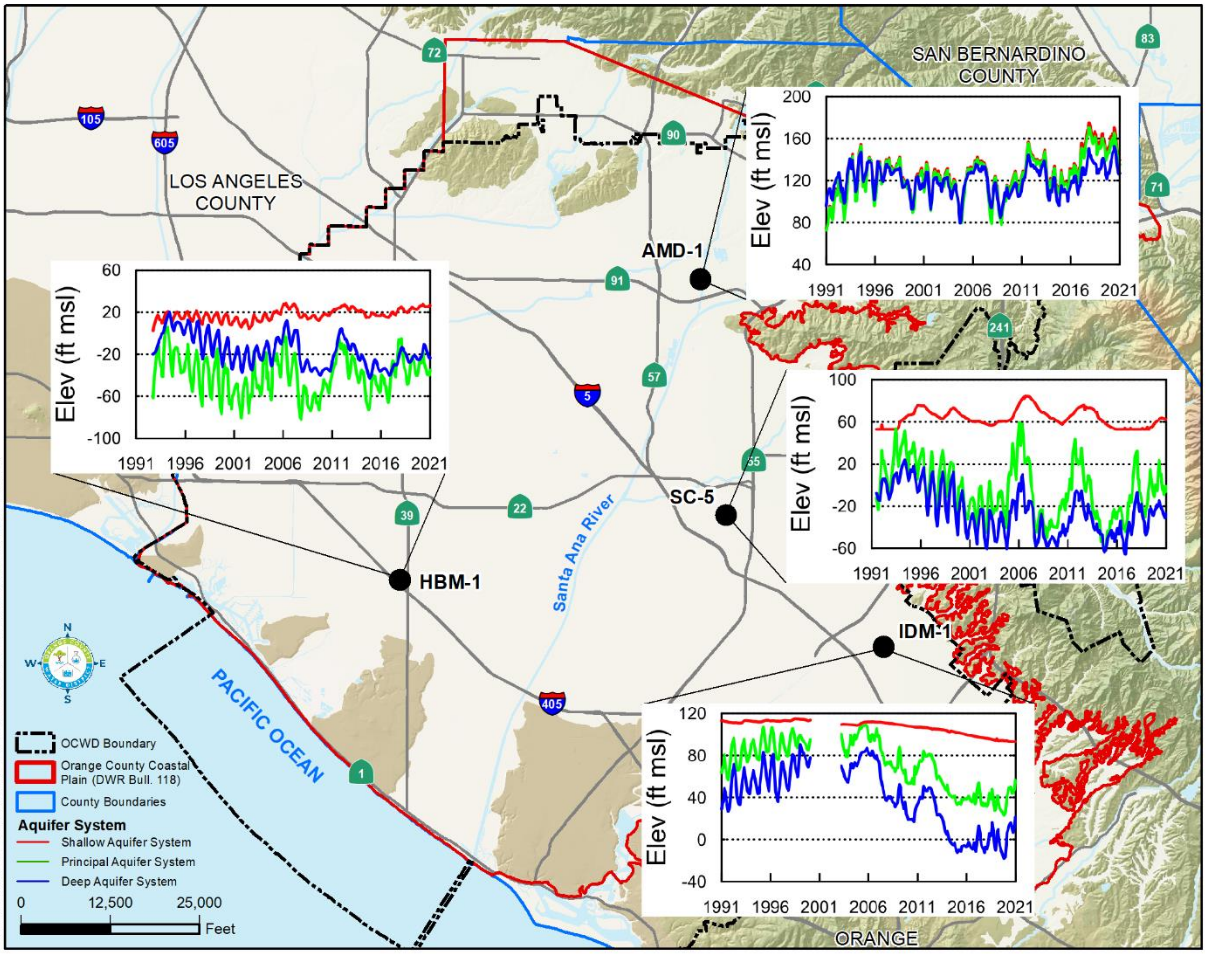


Figure 1-6: Example Hydrographs

Each year OCWD calculates the volume of groundwater storage change from a theoretical "full" benchmark condition based on a calculation using changes in groundwater elevations in each of the three major aquifer systems and aquifer storage properties. This calculation is checked against an annual water budget that accounts for all production, measured recharge and estimated unmeasured recharge (also referred to as "incidental recharge"). The amount of available or unfilled storage from the theoretical full condition is shown on Figure 1-3. Maintaining the basin storage condition on a long-term basis within the established operating range allows for long-term sustainable management of the basin without experiencing undesirable effects. Therefore, the undesirable result of "significant and unreasonable reduction of groundwater storage" is not present and is not anticipated to occur in the OCWD Management Area in the future due to OCWD's management programs.

1.6.3 Sustainable Management: Water Quality

OCWD has extensive monitoring and management programs in place to monitor and protect groundwater quality. OCWD's network of approximately 400 monitoring wells is distributed throughout the basin. Water quality in these wells is tested on a regular basis for a large number of parameters. OCWD also conducts groundwater quality sampling of approximately 200 production wells on behalf of the groundwater producers to comply with Title 22 requirements. An additional approximately 120 private, domestic, and irrigation production wells area also sampled periodically.

OCWD has a sampling protocol in place that includes standards for increased monitoring of individual wells. In cases where there is a detection of an organic compound for the first time, for example, OCWD will resample that well and if the detection is confirmed will increase the sampling frequency of that well. Another example is an increased frequency for monitoring when there is a detection of nitrate at 50% of the Maximum Contaminant Level (MCL). These sampling protocols are designed to detect water quality problems at the earliest possible stage.

The recent detections of per- and polyfluoroalkyl substances (PFAS) in groundwater have affected the use of groundwater by 11 groundwater producers. As described in detail later in this report, OCWD is taking steps to restore the beneficial uses of impacted groundwater by installing treatment systems to remove PFAS.

The undesirable result of "significant and unreasonable degradation of water quality that impair water supplies" is not present and is not anticipated to occur in the future in the OCWD Management Area due to OCWD's management programs.

1.6.4 Sustainable Management: Seawater Intrusion

OCWD's management of seawater intrusion is implemented through a comprehensive program that includes operating two seawater intrusion barriers, monitoring and evaluating barrier performance, monitoring and evaluating susceptible coastal areas, and coastal groundwater management.

The Alamitos Seawater Intrusion Barrier manages seawater intrusion in the Alamitos Gap. The Talbert Seawater Intrusion Barrier manages seawater intrusion in the Talbert Gap. Work is underway to further characterize intrusion in the Sunset Gap, including construction of additional monitoring wells, further development of the Alamitos Barrier groundwater model to evaluate seawater intrusion in the area of the Sunset Gap, and feasibility studies to evaluate potential future barrier design.

Monitoring and evaluating barrier performance and potential seawater intrusion consists of sampling monitoring wells semi-annually, measuring water levels at least quarterly, installing monitoring wells when needed to fill data gaps, and conducting other management activities to reduce potential for seawater intrusion, such as construction of additional injection wells and the Coastal Pumping Transfer Program.

The undesirable result of "significant and unreasonable seawater intrusion" is not present and is not anticipated to occur in the future in the OCWD Management Area due to OCWD's management programs.

1.6.5 Sustainable Management: Land Subsidence

Management of the groundwater basin by maintaining storage levels within the established operating range has prevented the undesirable result of significant and unreasonable land subsidence that substantially interferes with surface uses. Within the OCWD Management Area ground surface movements rise and fall as basin storage levels rise and fall. There is no evidence of long-term inelastic land subsidence, nor any land subsidence that has interfered with surface uses. Therefore, the undesirable result of "significant and unreasonable land subsidence that substantially interferes with surface uses" is not present and is not anticipated to occur in the OCWD Management Area in the future due to OCWD's management programs.

1.6.6 Sustainable Management: Depletion of Interconnected Surface Waters

There are no surface water bodies within the OCWD Management Area that are interconnected with groundwater in which the groundwater connection to the surface water provides surface water flow to sustain beneficial uses in a surface water body. Therefore, the undesirable result of "depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water due to groundwater conditions occurring throughout the basin" is not present and is not anticipated to occur in the OCWD Management Area due to OCWD's management programs.

1.7 PROTOCOLS FOR MODIFYING MONITORING PROGRAMS

Protocols that trigger a change in a monitoring program include a change in regulations, a first-time detection of a constituent in a water sample, an increase in a constituent in a water sample that approaches or exceeds a regulatory limit or MCL, an indication of an adverse water quality trend or water level, a special study, or a recommendation from OCWD's Independent Expert Panel.

1.8 EVALUATION OF POTENTIAL PROJECTS

OCWD regularly evaluates potential projects and conducts studies to improve existing operations. This may include:

- Increasing the capacity of existing recharge basins
- Constructing new recharge facilities
- Constructing new production wells
- Improving seawater intrusion barriers

- Constructing a new seawater barrier in the Sunset Gap
- Constructing water quality improvement projects

1.9 CONCLUSION

OCWD has been managing the OCWD Management Area since its formation by the State Legislature in 1933. Monitoring and management programs described in the 2017 Alternative, submitted in compliance with CA Code of Regulations (Title 23, Division 2, Chapter 1.5, Subchapter 2) demonstrated that the groundwater basin has been and will continue to be sustainably managed. The Alternative submitted in 2017 and approved by DWR in 2019 demonstrated that the OCWD Management Area operated within its sustainable yield over a period of at least 10 years, as required by CCR Title 23, Division 2, Chapter 1.5, Subchapter 2, Article 9, Section 358.2 (c)(3). The 2022 Update, prepared to satisfy Water Code §10733.8, shows that the OCWD Management area continues to be managed sustainably.

Please note that for consistency, the same chapter headings used in the 2017 Alternative are used in the 2022 Update. The goal of the update is to present new relevant information that has become available over the last five years. Where there is no new relevant information, the reader is directed to the 2017 Alternative by reference.

SECTION 2 AGENCY INFORMATION

2.1 HISTORY OF OCWD

The Orange County Water District (OCWD) is a special district formed in 1933 by an act of the California Legislature, the OCWD Act. Additionally, as a special act district listed in Water Code § 10723 (c)(1), OCWD is the exclusive local agency within its jurisdictional boundaries with powers to comply with the Sustainable Groundwater Management Act (SGMA) via a groundwater sustainability plan ("GSP") or via an Alternative prepared in accordance with Water Code § 10733.6.

OCWD manages the groundwater basin that underlies north and central Orange County. Water produced from the basin is the primary water supply for approximately 2.5 million residents living within OCWD's boundaries. With passage of SGMA (Water Code §10723(c)) in 2014, OCWD was designated the exclusive local agency within its jurisdictional boundaries with powers to comply with SGMA.

Nineteen major groundwater producers, including cities, water districts, and a private water company, pump groundwater from approximately 200 large-capacity wells for retail water use. There are also approximately 120 small-capacity wells that pump water from the basin. OCWD protects and manages the groundwater resource for long-term sustainability, while meeting approximately 75 percent of the water demand within its service area.

Since its founding, OCWD has grown in area from 162,676 to 243,968 acres and has experienced an increase in population from approximately 120,000 to 2.5 million people. OCWD has employed groundwater management techniques to increase the annual yield from the basin including operating over 1,500 acres of recharge basins in the cities of Anaheim, Orange, and unincorporated areas of Orange County. Annual groundwater production increased from approximately 150,000 acre-feet per year in the mid-1950s to a high of over 366,000 acre-feet per year in WY2007-08.

OCWD has managed the basin to provide a reliable supply of relatively low-cost water, accommodating rapid population growth while at the same time avoiding the costly and time-consuming adjudication of water rights experienced in many other major groundwater basins in Southern California. Facing the challenge of increasing demand for water has fostered a history of innovation and creativity that has enabled OCWD to increase available groundwater supply while ensuring the long-term sustainability of the groundwater basin.

A brief history of OCWD from 1933 to 2015 is provided in the 2017 Alternative. Significant events that have occurred during the last five years are as follows:

2018: GWRS sets the Guinness World Record for most wastewater recycled in 24 hours. The official amount was 100,008,000 gallons.

2019: OCWD's Philip L. Anthony Water Quality Laboratory was the first public agency laboratory in California to achieve state certification to analyze for PFAS in drinking water. OCWD launched the nation's largest pilot program to test various treatment options for PFAS.

2019: Construction of the GWRS Final Expansion began. Construction is anticipated to be completed in early 2023. Once complete the plant will produce up to 130 mgd and recycle 100 percent of reclaimable sources from the Orange County Sanitation District.

2021: U.S. Army Corps of Engineers approves Prado Conservation Pool increase up to elevation 505 feet mean sea level (approx. 20,000 acre-feet of storage) based on the Prado Basin Ecosystem Restoration and Water Conservation Feasibility Study.

2021: The first PFAS treatment system, at Fullerton's KIM-1A production well, is completed and the well returned to service.

2.2 GOVERNANCE AND MANAGEMENT STRUCTURE

The Orange County Water District was created by the OCWD Act for the purpose of:

> "providing for the importation of water into said district and preventing waste of water in or exportation of water from said district and providing for reclamation of drainage, storm, flood and other water for beneficial use in said district and for the conservation and control of storm and flood water flowing into said district; providing for the organization and management of said district and establishing the boundaries and divisions thereof and defining the powers of the district, including the right of the district to sue and be sued, and the powers and duties of the officers thereof; providing for the construction of works and acquisition of property by the district to carry out the purposes of this act; authorizing the incurring of indebtedness and the voting, issuing and selling of bonds and the levying and collecting of assessments by said district; and providing for the inclusion of additional lands therein and exclusion of lands therefrom."
> (Stats.1933, c. 924, p. 2400)

Further details on OCWD governance and management are described in the 2017 Alternative. The nineteen major groundwater producers meet on a monthly basis with OCWD staff to consult with and provide advice on basin management issues. This group is described in more detail in Section 7.1.

2.3 LEGAL AUTHORITY

A description of OCWD's legal authority is described in the 2017 Alternative.

A copy of the OCWD Act, which has been the basis for OCWD's sustainable management of its portion of Basin 8-1 over many years, can be found at:
http://www.ocwd.com/media/2681/ocwddistrictact_201501.pdf

2.4 BUDGET

The mission of OCWD is to provide a reliable, high quality water supply in a cost-effective and environmentally responsible manner and to manage the Orange County groundwater basin in a sustainable manner over the long-term.

For a summary description of OCWD's budget structure, see the 2017 Alternative. For more recent information, see OCWD's website at www.ocwd.com where detailed budget reports are published annually.

SECTION 3 MANAGEMENT AREA DESCRIPTION

3.1 OCWD MANAGEMENT AREA

OCWD's service area covers approximately 430 square miles and is co-extensive with the OCWD Management Area for purposes of the Alternative, except as identified below. The OCWD service area includes 90 percent of the area designated by the Department of Water Resources (DWR) as Basin 8-1, the "Coastal Plain of Orange County Groundwater Basin" in Bulletin 118 (DWR, 2003). For the purposes of this Alternative, the OCWD Management Area contains the same geographical area as the portion of the OCWD service area within Basin 8-1 except for a small 6.7-square mile area in the northeast corner of the basin that is part of the Santa Ana Canyon Management Area. The boundaries of Basin 8-1, the OCWD service area and the OCWD Management Area are shown in Figure 3-1.

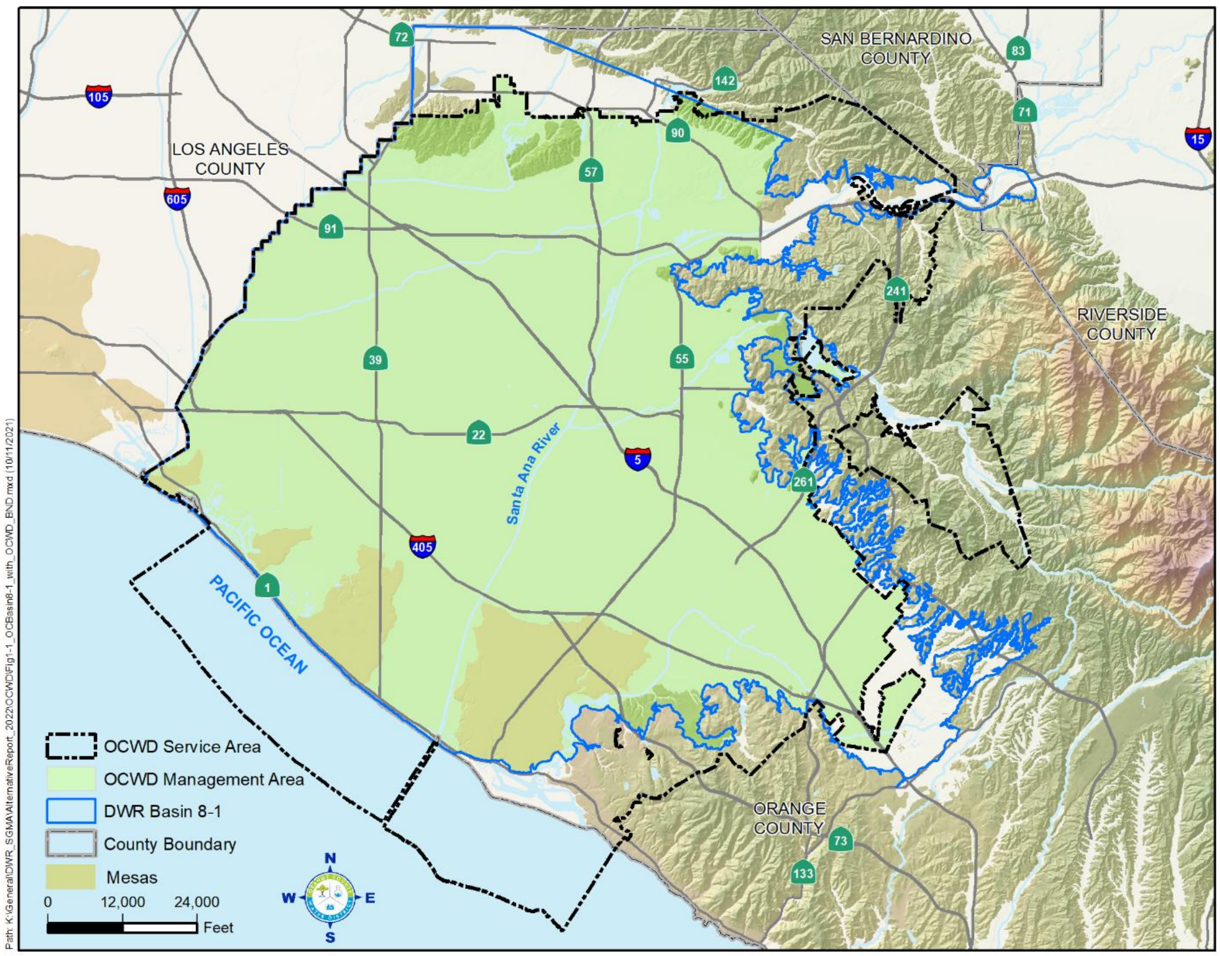


Figure 3-1: Basin 8-1, OCWD Service Area and OCWD Management Area

Jurisdictional Areas within OCWD Management Area

Federal and state lands within the OCWD Management Area as well as city boundaries are shown in Figure 3-2 and have not changed since the 2017 Alternative. Retail water providers within OCWD's service area are shown in Figure 3-3. The OCWD Management Area with a population of approximately 2.5 million is highly urbanized, as shown in Figure 3-4. Each of the 22 cities within OCWD's jurisdiction has an adopted general plan. There are no federally recognized tribes with land and there are no adjudicated groundwater areas within the OCWD Management Area. The unincorporated areas are managed by the County of Orange. Groundwater supplies are managed as a single, shared resource with no separate water use sectors.

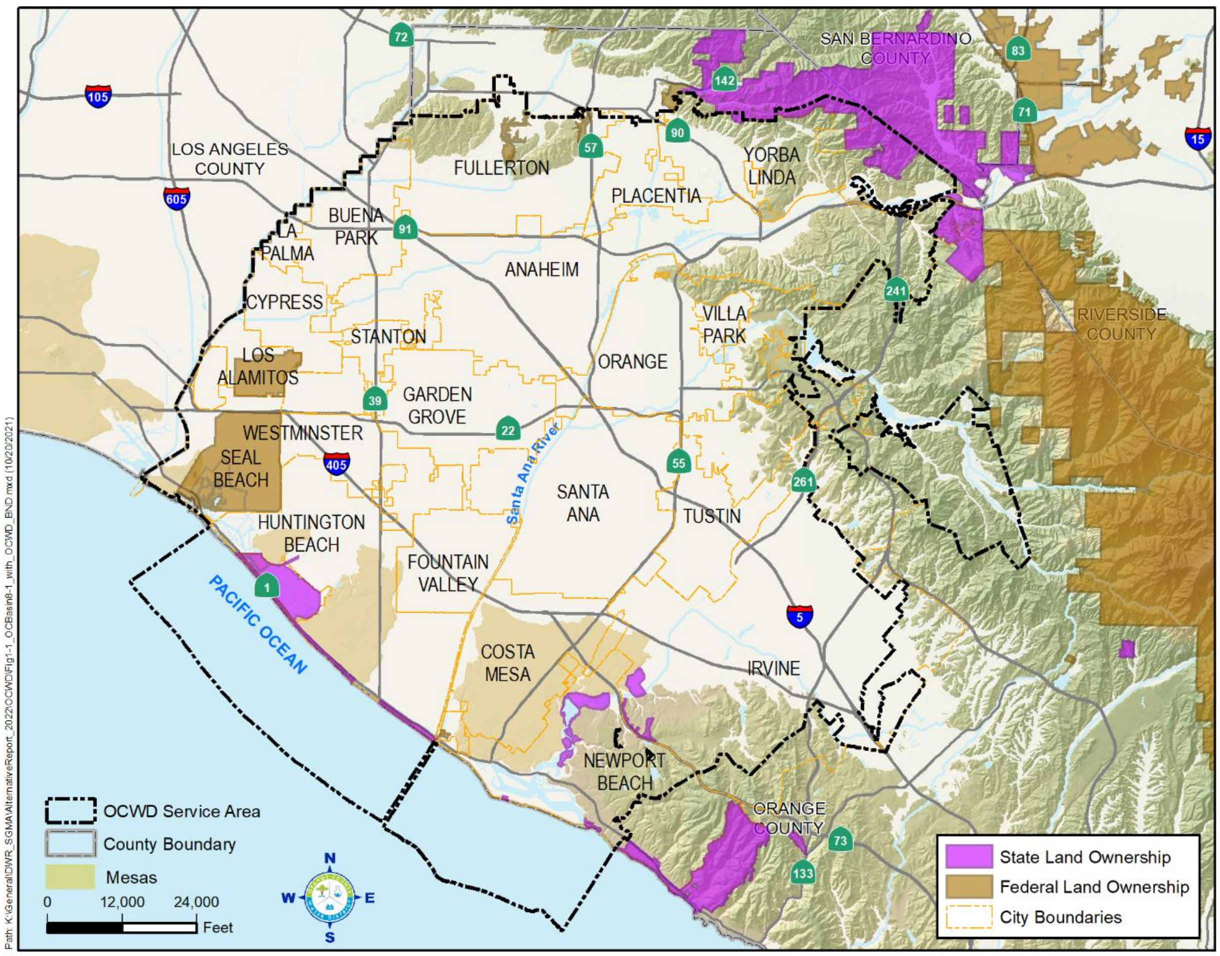


Figure 3-2: Federal and State Lands

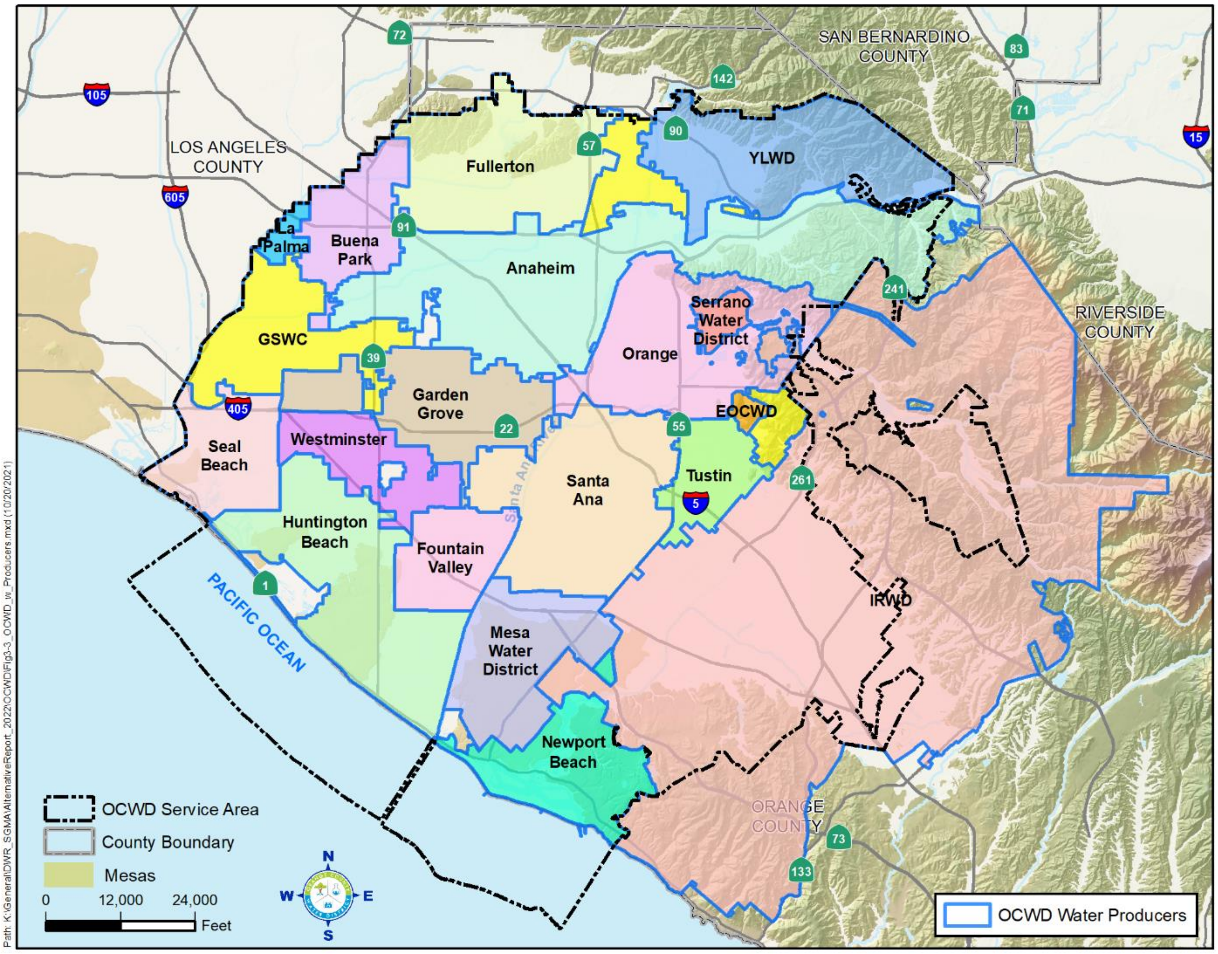


Figure 3-3: Retail Water Supply Agencies

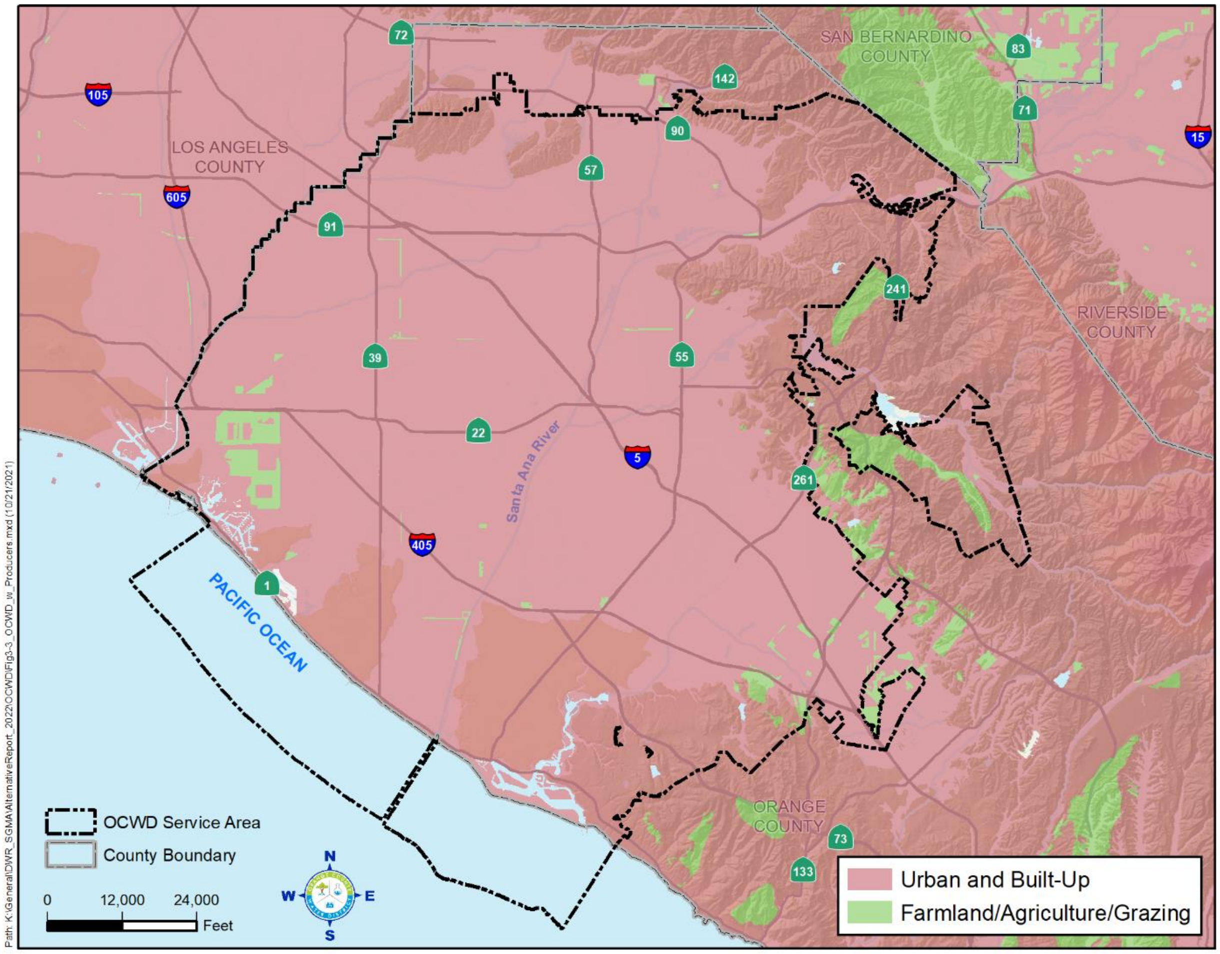


Figure 3-4: Land Uses

3.2 GROUNDWATER CONDITIONS

This section describes the groundwater conditions within the OCWD Management Area. The focus is on data from the last five years. For some historical data, please see the 2017 Alternative. The description includes groundwater elevation, pumping patterns, storage levels, groundwater quality, information concerning land subsidence, seawater intrusion, and interactions between surface water and groundwater. All elevations in this report are in units of feet above mean sea level referenced to vertical datum NGVD29, which can be converted to NAVD88. Geographic locations are reported in GPS State Plane coordinates referenced to NAD83.

Groundwater Elevation Contours

Figures 3-5, 3-6 and 3-7 show the contoured water levels for the Shallow, Principal and Deep Aquifers in June 2021. The contour maps for each of the three aquifer systems are prepared annually. The contour maps are used to prepare water level change maps for the three major aquifer systems and to calculate the amount of groundwater in storage and the annual storage change.

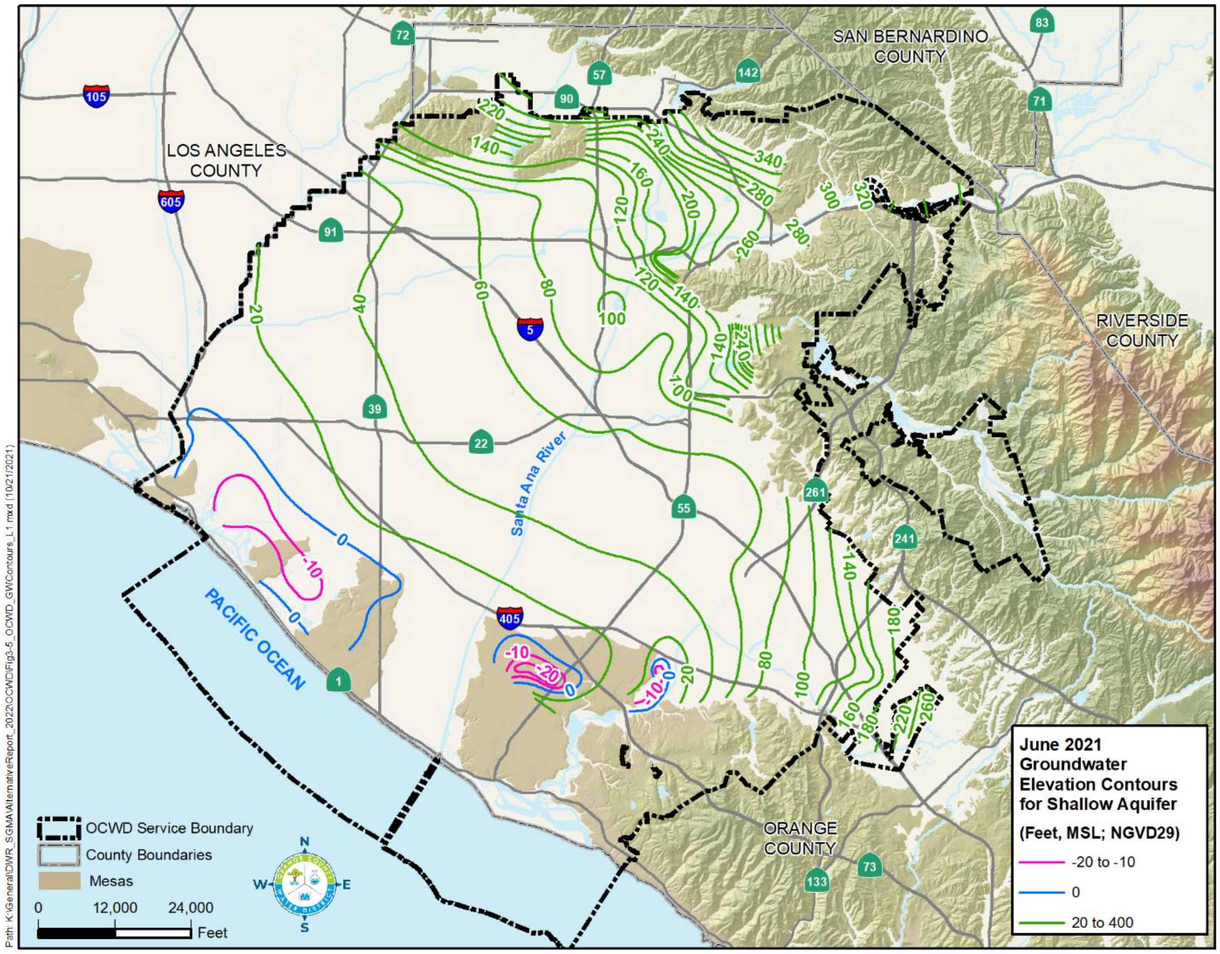


Figure 3-5: Groundwater Elevation Contours for the Shallow Aquifer, June 2021

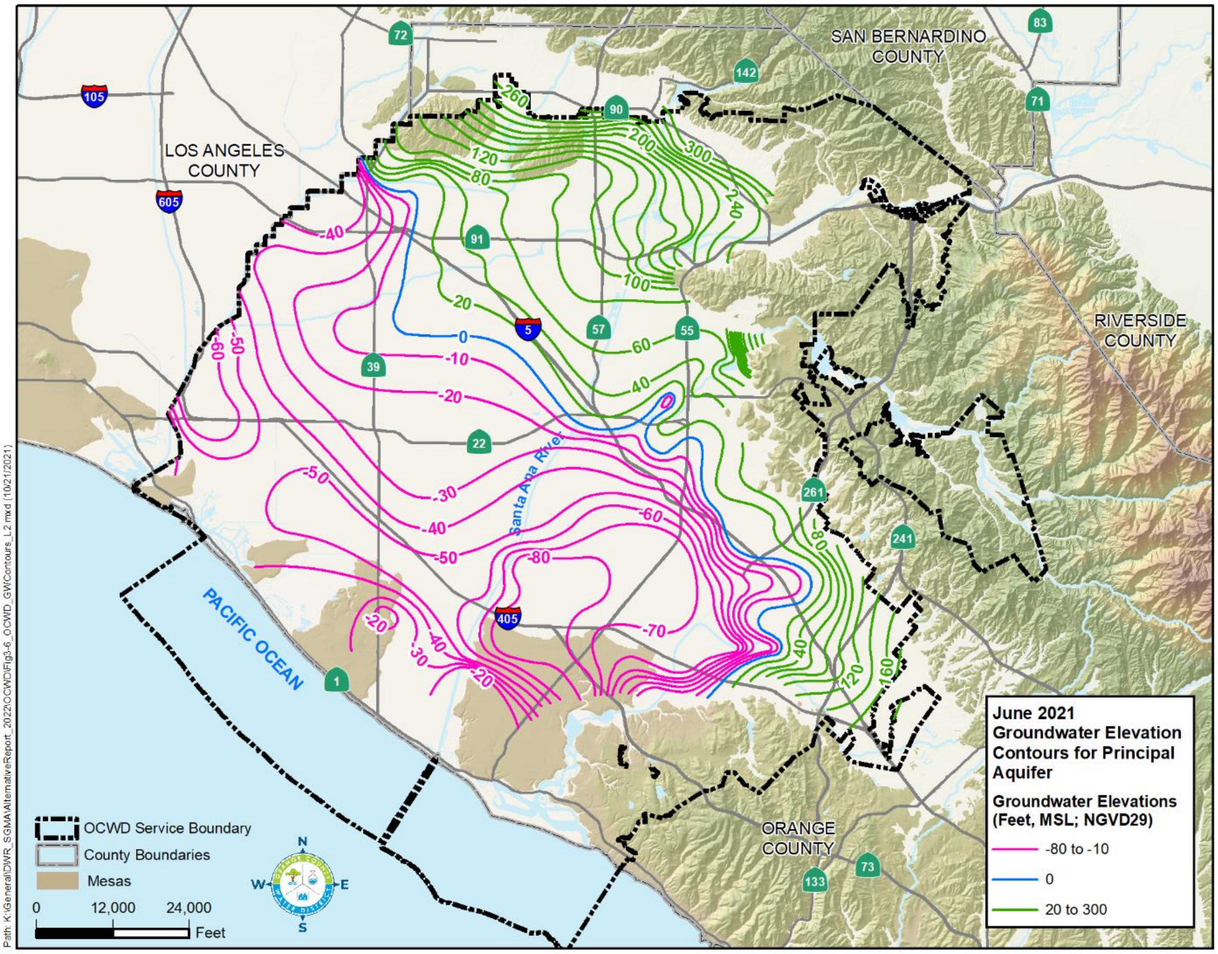


Figure 3-6: Groundwater Elevation Contours for the Principal Aquifer, June 2021

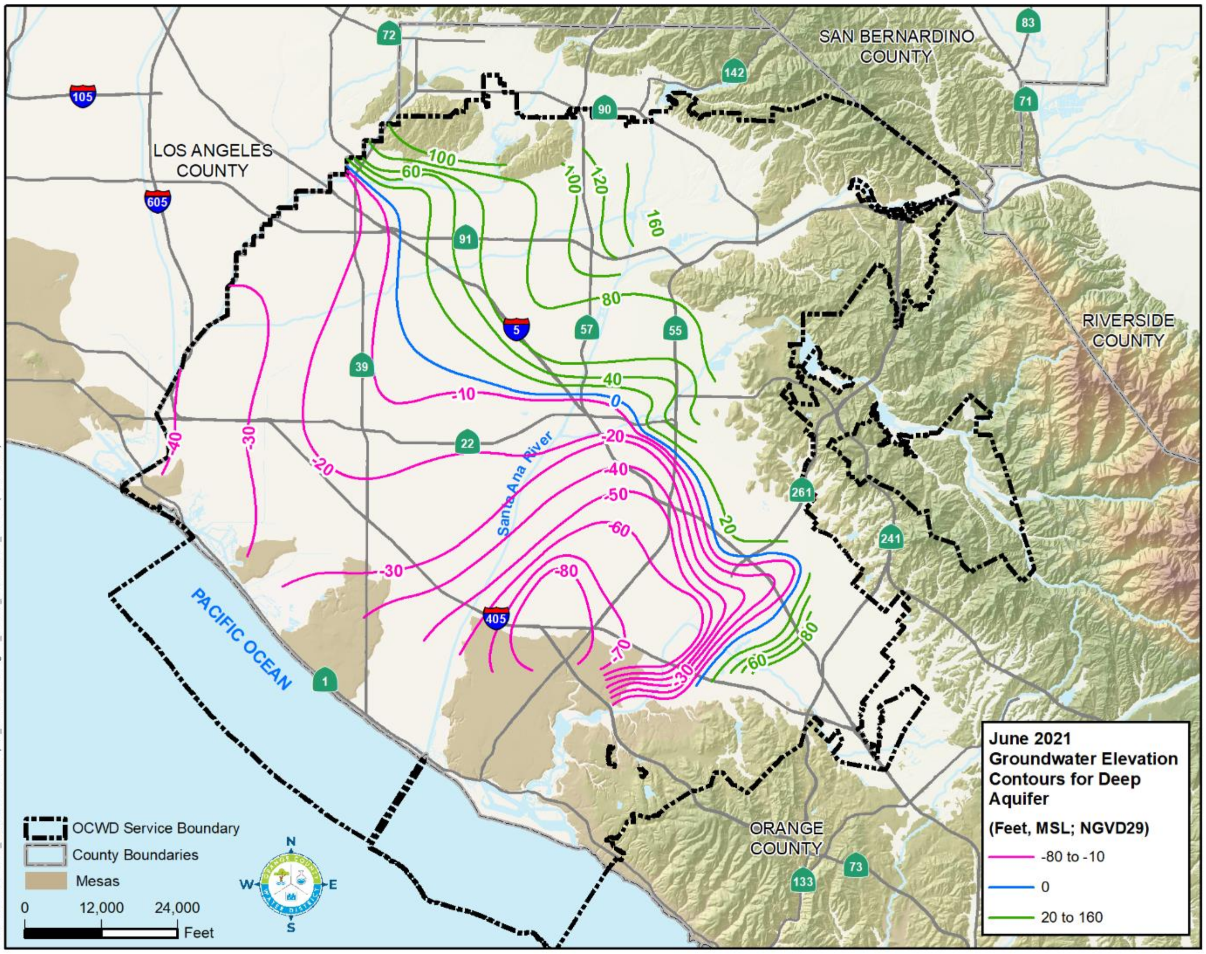
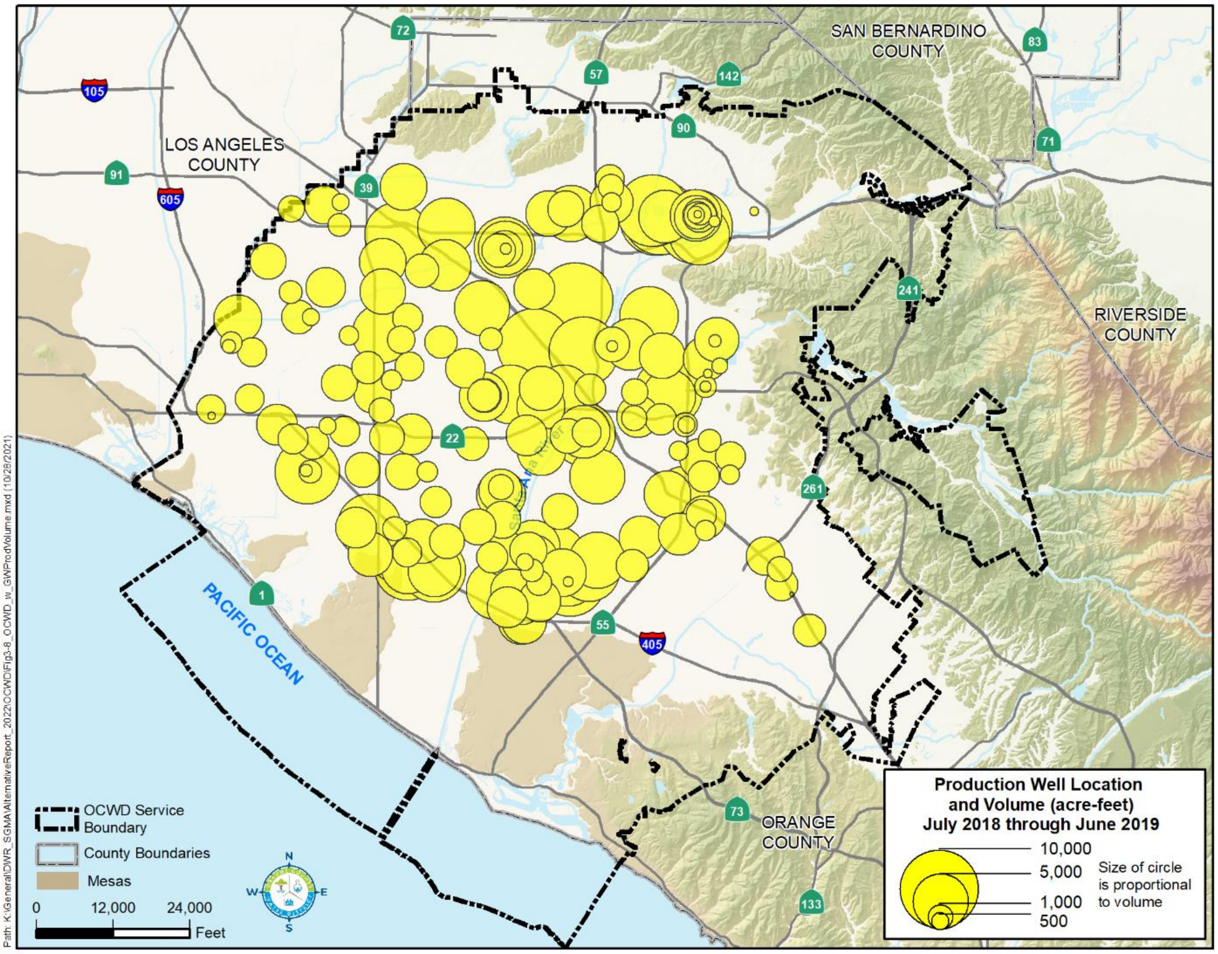


Figure 3-7: Groundwater Elevation Contours for the Deep Aquifer, June 2021

Regional Pumping Patterns

Active wells pumping water from the basin are shown in Figure 3-8. The approximately 200large-system wells account for an estimated 97 percent of the total basin production. The remaining three percent of total basin production includes agricultural and industrial producers, small mutual water companies, domestic well producers, and production from privately-owned wells. As can be seen in Figure 3-8, groundwater production is distributed throughout the basin. Please note that due to the recent impacts of COVID and PFAS, data from WY2018-19 is presented to show the typical average distribution of pumping in the basin.



* Due to impacts from COVID-19 FY 2018-19 groundwater production was chosen to be representative of typical pumping patterns.

Figure 3-8: Groundwater Production, WY2018-19

Long-Term Groundwater Elevation Hydrographs

Groundwater elevation trends exhibit both short-term (seasonal) and long-term fluctuations. Seasonal elevation changes reflect short-term variations in pumping and recharge, while multi-year trends reflect the effects of extended periods of above- or below-average precipitation and/or availability of imported water.

OCWD measures elevations in three principal aquifer systems. In general, groundwater elevations in the Shallow Aquifer system show less amplitude than those in the underlying Principal and Deep Aquifer systems due to the higher degree of pumping and confinement of the Principal and Deep Aquifer systems. Because approximately 95 percent of all production occurs from wells screened within the Principal Aquifer system, groundwater elevations within this system are typically lower than those in the overlying Shallow Aquifer system and, in some areas, the underlying Deep Aquifer system. As a result, vertical gradients created by pumping and recharge drive groundwater into the Principal Aquifer system from the overlying Shallow Aquifer system and, to a lesser extent, from the Deep Aquifer system.

Groundwater elevation trends can be examined using seven wells with long-term groundwater level data, the locations of which are shown in Figure 3-9. Figures 3-10 and 3-11 show water level hydrographs for wells SA-21 and GG-16 representing historical conditions in the Pressure Area and well A-27 representing historical conditions in the Forebay. Water level data for well A-27 near Anaheim Lake dates back to 1932 and indicate that the historic low water level in this area occurred in 1951-52. The subsequent replenishment of Colorado River water essentially refilled the basin by 1965. Water levels in this well reached a historic high in 1994 and have generally remained high as recharge has been nearly continuous at Anaheim Lake since the late 1950s. Well A-27 was destroyed in May 2012. To continue this hydrograph, water levels from nearby OCWD monitoring well, AMD-9/1 is used. A comparison of water levels when the two wells were in operation show they are nearly identical.

The hydrograph for well SA-21 indicates that water levels in this area have decreased since 1970. Also noteworthy is the large range of water level fluctuations from the early 1990s to early 2000s. The increased water level fluctuations during this period were due to a combination seasonal water demand-driven pumping and participation in the Metropolitan Water District of Southern California's (MWD) Short-Term Seasonal Storage Program by local groundwater producers (Boyle Engineering and OCWD, 1997), which encouraged increased pumping from the groundwater basin during summer months when MWD was experiencing high demand for imported water. Although this program did not increase the amount of pumping from the basin on an annual basis, it did result in greater water level declines during the summer during the period of 1989 to 2002 when the program was active.

Figure 3-12 presents water level hydrographs of two OCWD multi-depth monitoring wells, SAR-1 and OCWD-CTG1, showing the relationship between water level elevations in aquifer zones at different depths. The hydrograph of well SAR-1 in the Forebay exhibits a similarity in water levels between shallow and deep aquifers, which indicates the high degree of hydraulic interconnection between aquifers characteristic of much of the Forebay.

The hydrograph of well OCWD-CTG1 is typical of the Pressure Area in that there are large differences in water levels in different aquifers, indicating a reduced level of hydraulic interconnectivity between shallow and deep aquifers caused by fine-grained layers that restrict vertical groundwater flow. Water levels in the deepest aquifer zone at well OCWD-CTG1 are higher than overlying aquifers, in part, because few wells directly produce water from these zones. The lack of production from the deepest aquifers is due to the presences of amber-colored water, the cost to construct very deep wells, and the fact that sufficient high-quality groundwater is readily available within the overlying Principal aquifer.

Two additional hydrographs for wells HBM-1 and IDM-1 show multi-depth water levels representative of the coastal area and the southwestern portion of the management area. The downward trend in water levels at well IDM-1 shows the effects of a water quality improvement project known as the Irvine Desalter Project. This joint project between OCWD and IRWD, in collaboration with the U.S. Department of Navy, went on line in 2006 and consists of production wells, pipelines, and treatment facilities to remove, treat, and put to beneficial use groundwater that contains elevated TDS, nitrate, and/or trichloroethylene. To provide the intended hydraulic containment of this impacted groundwater, lowered groundwater levels in the Irvine area were necessary and expected based on model projections.

For additional information and background information on groundwater level measurements, see the 2017 Alternative.

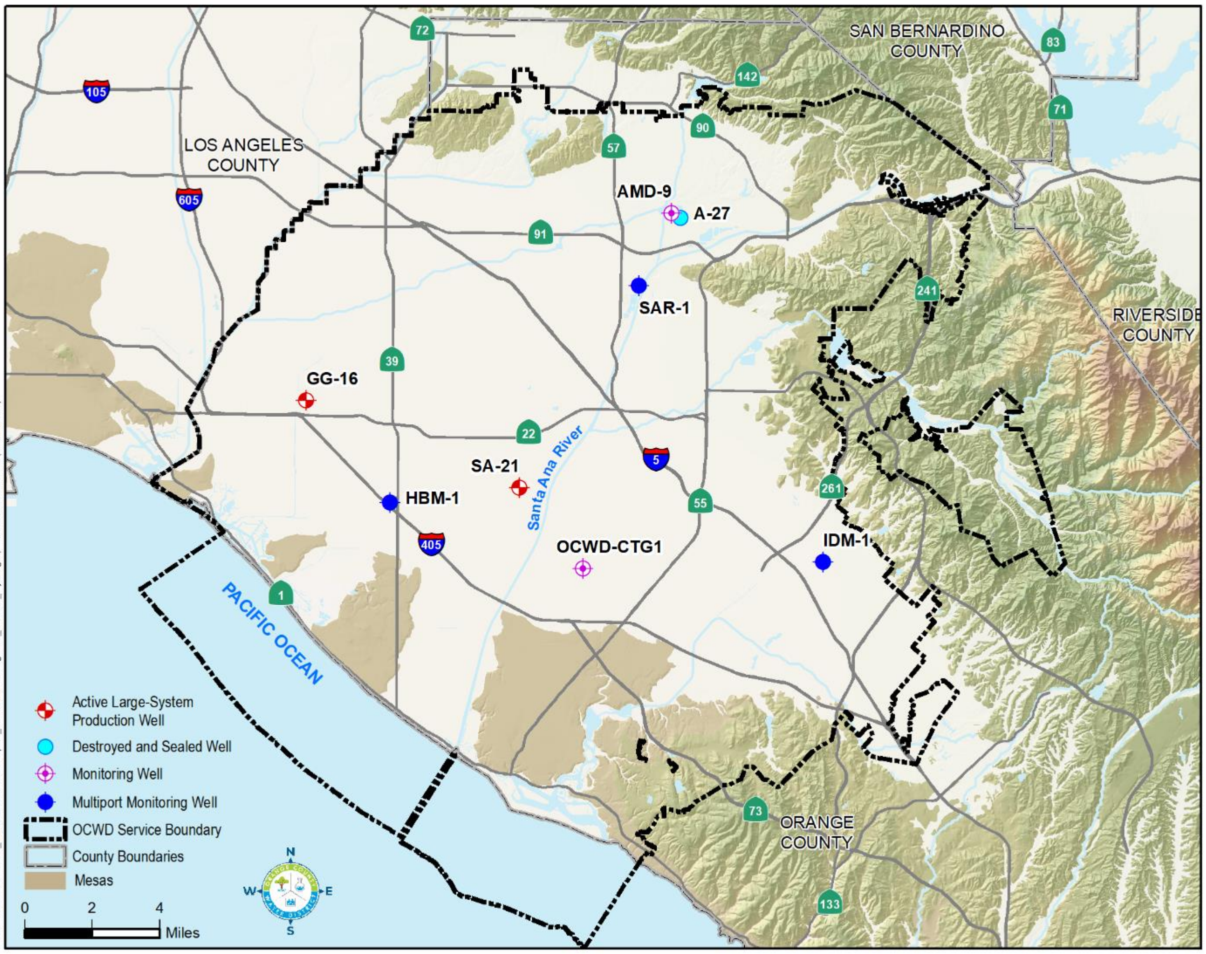


Figure 3-9: Location of Long-Term Groundwater Elevation Hydrographs

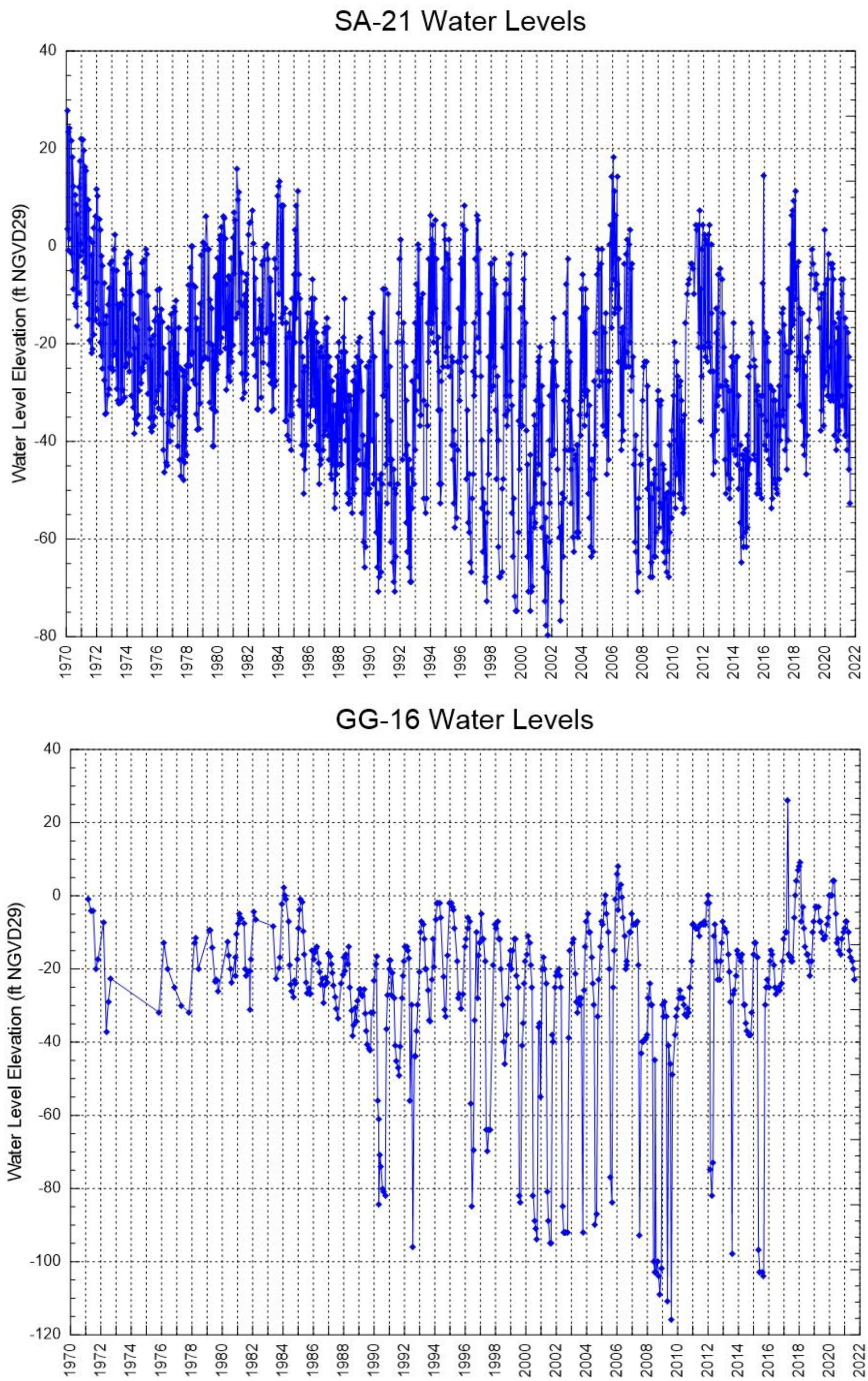


Figure 3-10: Water Level Hydrographs of Wells SA-21 and GG-16 in Pressure Area

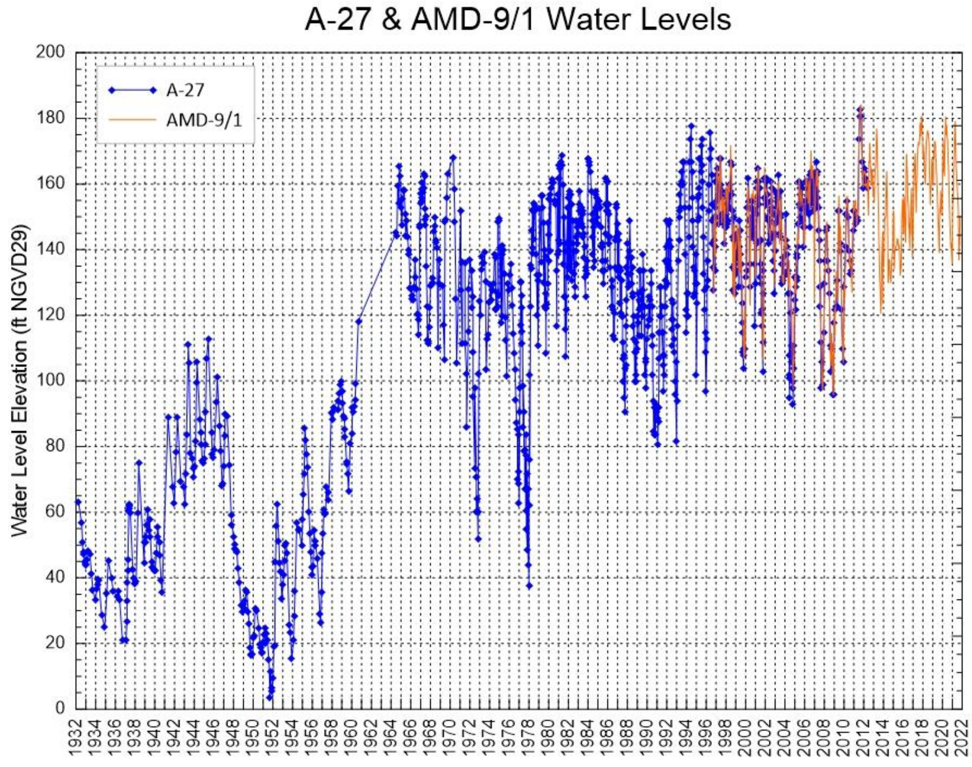


Figure 3-11: Water Level Hydrograph of Well A-27/AMD-9 in Forebay Area

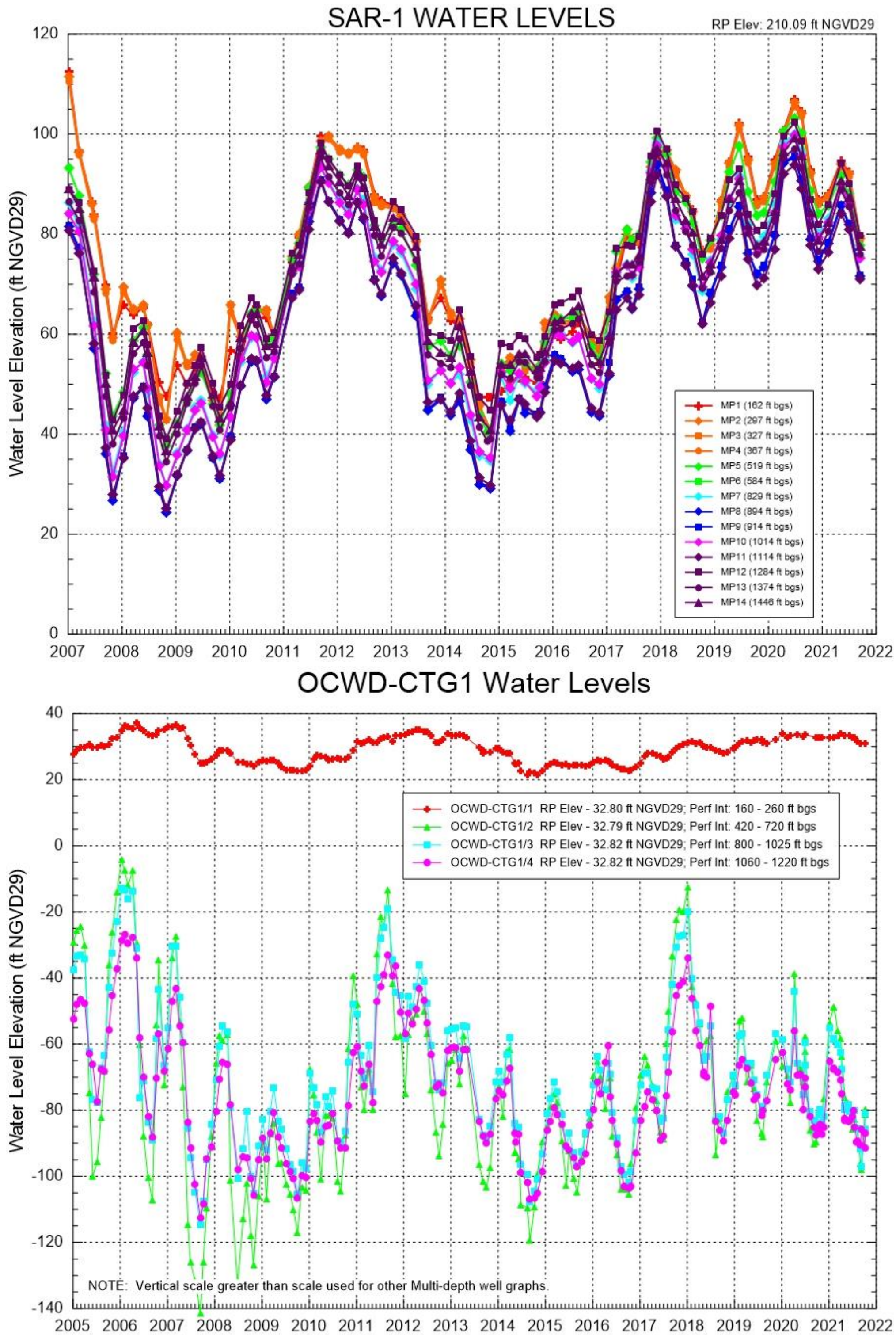


Figure 3-12: Water Level Hydrographs of Wells SAR-1 and OCWD-CTG1

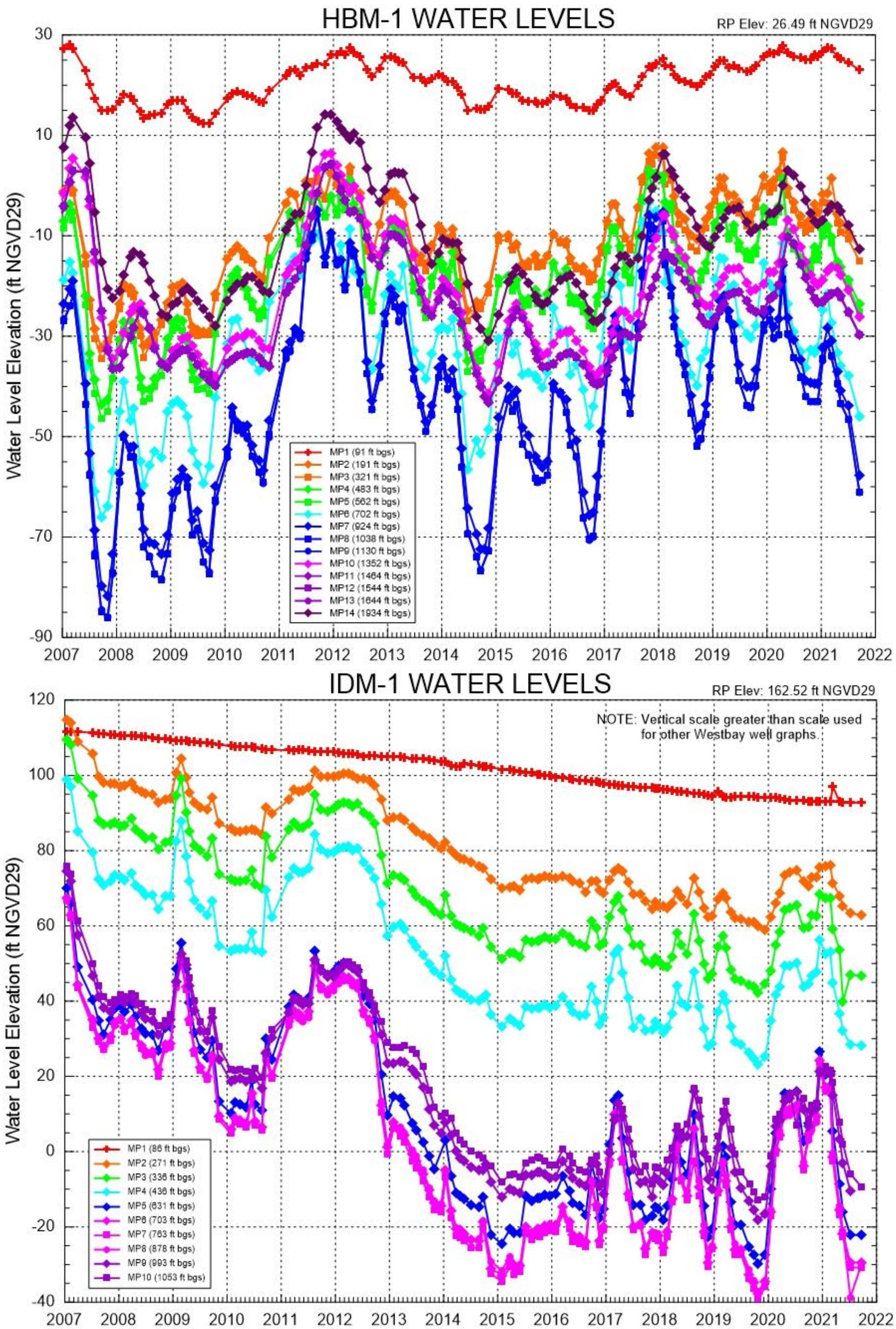


Figure 3-13: Water Level Hydrographs of Wells HBM-1 and IDM-1

Groundwater Storage Data

OCWD operates the basin within an operating range from a full condition to approximately 500,000 acre-feet below full to protect against seawater intrusion, inelastic land subsidence, and other potential undesirable results. Figure 1-3 shows how storage has fluctuated from 1958 to 2021. On a short-term basis, the basin can be operated at an even lower storage level in an emergency.

In order to manage the basin within this operating range, OCWD calculates the change in storage relative to a full basin condition on an annual basis for the three aquifer layers, an example of which is shown in Figure 3-14.

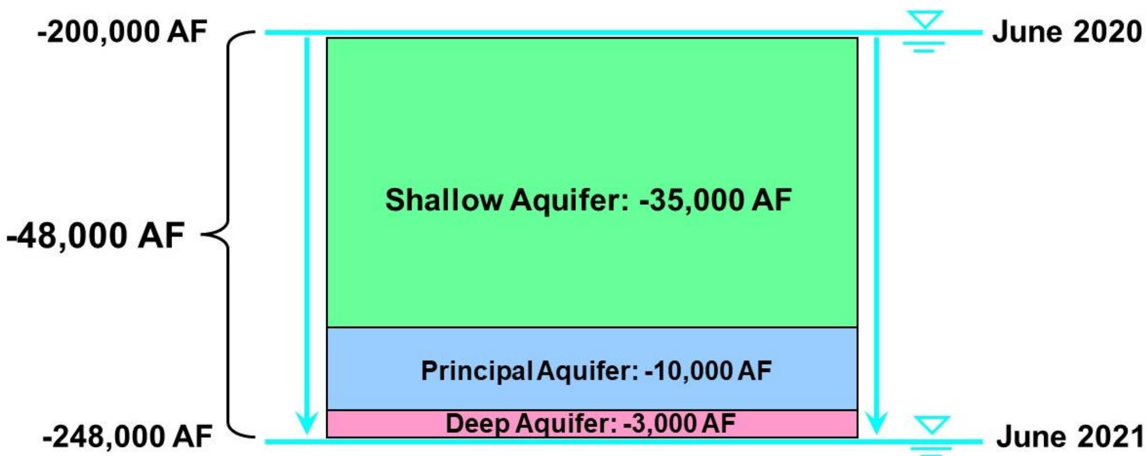


Figure 3-14: Groundwater Storage Change, June 2020 to June 2021

3.3 BASIN MODEL

OCWD's basin model encompasses most of Basin 8-1 and extends approximately three miles into the Central Basin in Los Angeles County to provide for more accurate model results than if the model boundary stopped at the county line (see Figure 3-15). The county line is not a hydrogeologic boundary, and groundwater freely flows through aquifers that have been correlated across the county line. The model provides a tool to supplement the storage change calculations that are done each year with actual groundwater elevation data. The model also provides a tool to conduct evaluations of proposed projects and operating scenarios.

For more detailed information about the model, please refer to the 2017 Alternative.

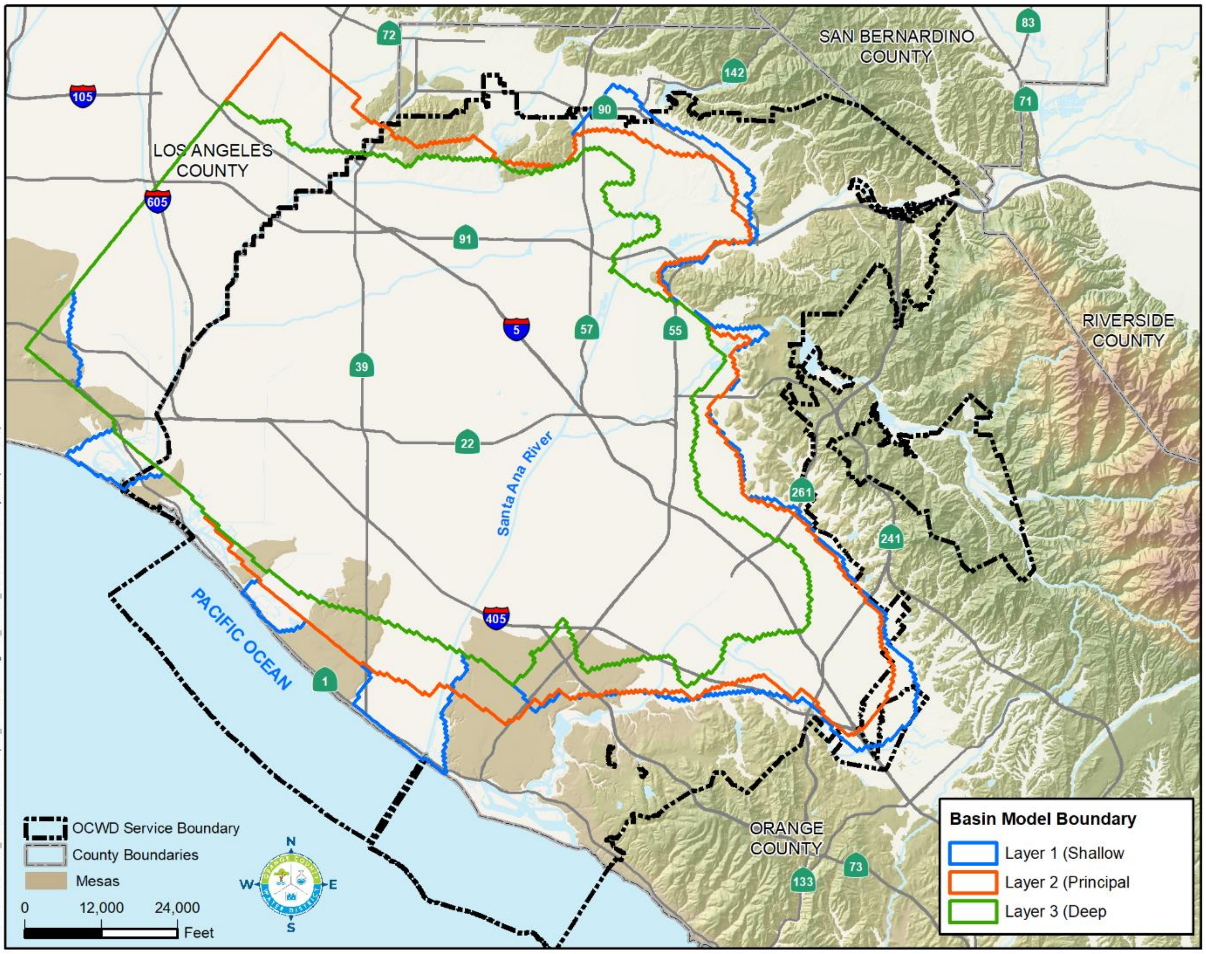


Figure 3-15: OCWD Groundwater Basin Model Boundaries

OCWD staff update the basin groundwater model approximately every three to five years. Major changes and improvements since the 2017 Alternative was submitted include:

1. Extension of the model transient calibration through WY2016-17. The new calibration period is November 1990 to June 2017 which includes a wide range of basin storage conditions as well as a wide range of hydrologic conditions.
2. Addition of new recharge basin, La Palma Basin.
3. Updating aquifer parameters, i.e., hydraulic conductivity and storage parameters, changes during calibration (still in progress).
4. Model layer revision in Irvine Sub Basin area.

1.1.1 Groundwater Quality Conditions

Salinity

At the state level, the State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards have authority to manage TDS concentrations in water supplies. The salinity management program for the Santa Ana River Watershed is implemented by the Basin Monitoring Program Task Force (Task Force), a group comprised of water districts, wastewater treatment agencies and the Regional Water Board. OCWD is a member of the Task Force.

Historical ambient or baseline conditions were calculated for levels of TDS and nitrate (as N) in each of the 39 groundwater management zones in the watershed. Management Zones established by the Regional Water Board within the OCWD Management Area are shown in Figure 3-16. The TDS water quality objectives and ambient water quality levels for the two zones within the OCWD Management Area are shown in Table 3-1.

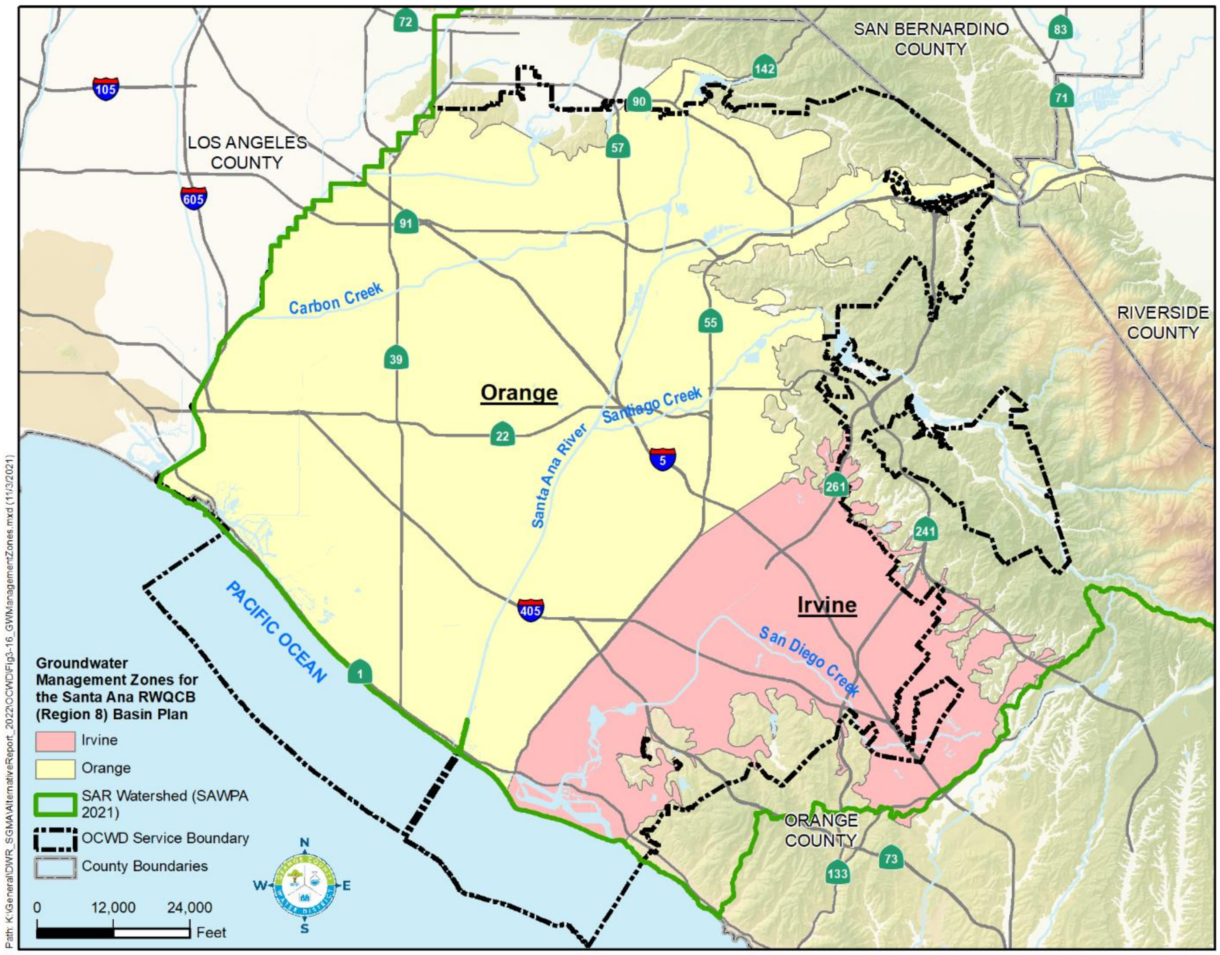


Figure 3-16: Regional Water Board Groundwater Management Zones

Table 3-1: TDS Water Quality Objectives for Lower Santa Ana River Basin Management Zones

Groundwater Management Zone	Water Quality Objective	2018 Ambient Quality*
Orange	580 mg/L	603 mg/L
Irvine	910 mg/L	877 mg/L

*Water Systems Consulting, 2020.

Figure 3-17 shows the average TDS at production wells in the basin for WY2016-17 to 2020-21. In general, the TDS concentrations in the Principal Aquifer in the Orange Groundwater Management Zone generally range from 300 to 400 mg/L in the Pressure Area and from 500 to 700 mg/L in the Forebay Area. In the Irvine Groundwater Management Zone, TDS concentrations range from approximately 400 mg/L west of Culver Drive to 1,000 mg/L in the area northeast of Interstate 5.

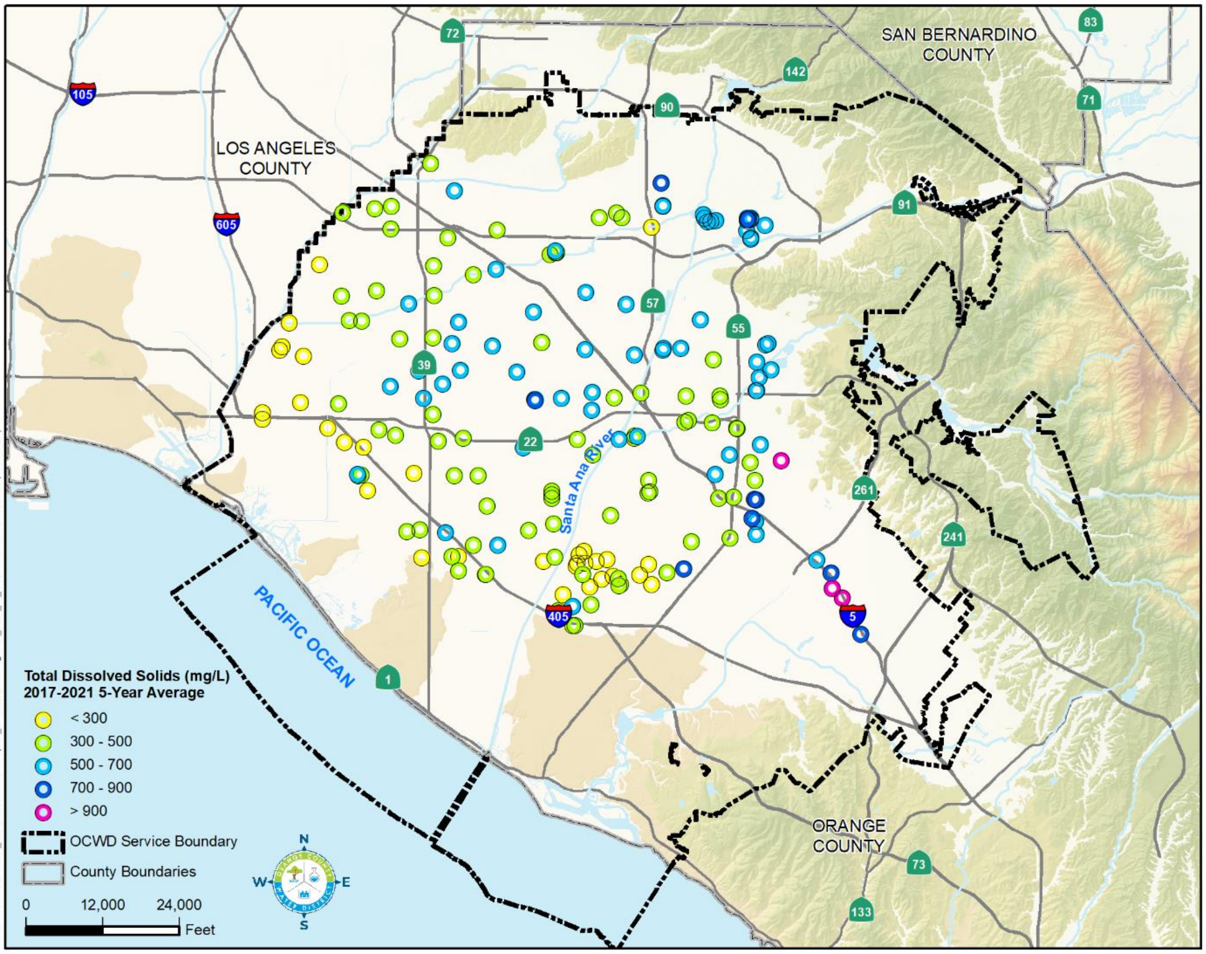


Figure 3-17: TDS in Groundwater Production Wells,
5-year average, WY2016-17 to 2020-21

Nitrate

Management of nitrate is a component of the salinity management program in the Santa Ana River Watershed. Along with TDS objectives, water quality objectives for nitrate (as N) are established for each of the 39 groundwater management zones in the watershed. Water quality objectives and ambient quality levels for the zones within the OCWD Management Area are shown in Table 3-2.

Figure 3-18 shows the 5-year average nitrate (as N) levels in production wells for WY2016-17 to 2020-21. In general, nitrate (as N) concentrations in the Orange Groundwater Management Zone are generally less than 5 mg/L. There are some localized areas with concentrations greater than 10 mg/L. In cases where pumped groundwater exceeds the MCL, the groundwater producer treats the water to reduce nitrate (as N) levels prior to being served to customers.

Table 3-2: Nitrate (as N) Water Quality Objective for Lower Santa Ana River Basin Management Zones

Groundwater Management Zone	Water Quality Objective	2018 Ambient Quality*
Orange	3.4 mg/L	3.0 mg/L
Irvine	5.9 mg/L	6.37 mg/L

*Water Systems Consulting, 2020.

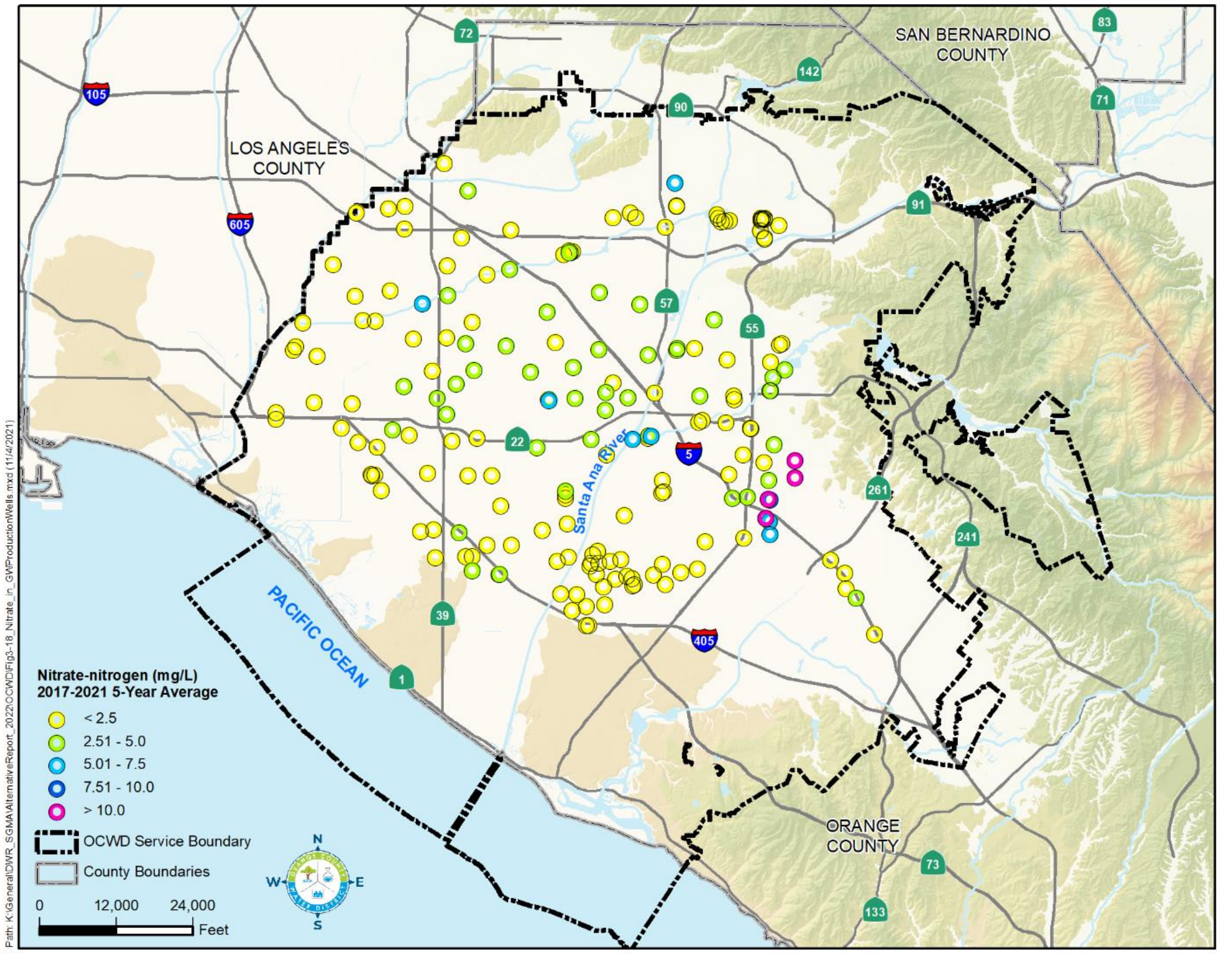


Figure 3-18: Nitrate (as N) Levels in Groundwater Production Wells, 5-year average, WY2016-17 to 2020-21

Per- and polyfluoroalkyl substances (PFAS)

Per- and polyfluoroalkyl substances (PFAS) are a group of thousands of manmade chemicals that includes perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). PFAS compounds have been commonly used in many products including, among many others, stain- and water-repellent fabrics, nonstick products (e.g., Teflon), polishes, waxes, paints, cleaning products, and fire-fighting foams. Beginning in the summer of 2019, the California Division of Drinking Water (DDW) began requiring testing for PFAS compounds in some groundwater production wells in the OCWD area.

In February 2020, the DDW lowered its Response Levels (RL) for PFOA and PFOS to 10 and 40 parts per trillion (ppt or nanogram/L, ng/L), respectively. In March 2021, DDW established a third PFAS RL for perfluorobutane sulfonate (PFBS) at 5,000 ppt. The DDW recommends the public water systems not serve any water exceeding the RL – effectively making the RL a *de facto* interim MCL while the state undertakes the formal process to set an enforceable MCL. In response to DDW's issuance of the revised RL, as of September 2021, approximately 60 wells in the OCWD service area have been temporarily turned off until treatment systems can be constructed. As additional wells are tested, this figure may increase. The state has begun the process of establishing MCLs for PFOA and PFOS; in July 2021, the state Office of Environmental Health Hazard Assessment (OEHHA) released draft Public Health Goals (PHGs) for PFOA and PFOS or 0.007 ng/L and 1 ng/L, respectively, for public comment. After the PHGs are finalized, DDW will formally begin developing corresponding MCLs and currently anticipates issuing a final MCL by 2023 or 2024. OCWD anticipates the MCLs will be set at or below the RLs.

In April 2020, OCWD as the groundwater basin manager, executed a multi-party agreement with the impacted groundwater producers to fund and construct the necessary treatment systems for production wells impacted by PFAS compounds. The PFAS treatment projects include the design, permitting, construction, and operation of PFAS treatment systems for impacted production wells. Each well treatment system will be evaluated for use with either granular activated carbon (GAC), ion exchange (IX), or an alternative novel sorbent for the removal of PFAS compounds. These treatment systems utilize vessels in a lead-lag configuration to remove PFOA and PFOS to less than 2 ppt, the current laboratory detection limit. These PFAS treatment systems are designed to ensure the groundwater supplied by producer wells can be served in compliance with current and future PFAS regulations. The groundwater producers will own the treatment systems once they are completed. With financial assistance from OCWD, the groundwater producers will operate and maintain the new treatment systems once they are constructed.

To minimize alternative water supply expenses and provide maximum protection to the public water supply, OCWD initiated design, permitting, and construction of the PFAS treatment projects on a schedule that allows rapid deployment of treatment systems. As of September 2021, construction contracts have been awarded for treatment systems for production wells owned by the cities of Orange (Phase 1), and Garden Grove, Serrano Water District, and Yorba Linda Water District. The City of Anaheim has also awarded a design-build contact (phase A) for 8 impacted wells, that will be reimbursed by OCWD. The City of Fullerton's well KIM-1A treatment system has been completed and is in operation. Additional construction contracts are anticipated to be awarded for impacted wells operated by the cities of Fullerton (Main Plant), Orange (Phase 2), Santa Ana, Tustin, Irvine Ranch Water District and East Orange County Water District by early 2022. OCWD expects the treatment systems to be constructed for the approximately 60 impacted wells within the next 2 to 3 years.

As monitoring continues and additional wells are taken off-line due to PFAS detections reported at or near the current RL (or future MCL), OCWD will continue to partner with the affected groundwater producers and take action to design and construct necessary treatment systems to bring the impacted wells back online as quickly as possible.

Groundwater production in WY2020-21 was expected to be approximately 325,000 acre-feet but declined to 282,000 acre-feet primarily due to PFAS impacted wells being turned off around February 2020. OCWD expects groundwater production to be in the area of 250,000 acre-feet in WY2021-22 due to the currently idled wells and additional wells being impacted by PFAS and turned off. As PFAS treatment systems are constructed, OCWD expects total annual groundwater production to slowly increase back to levels similar to years prior to PFAS impacts.

Contamination Plumes

Major groundwater contamination sites within the OCWD Management Area include areas where contamination has migrated significantly beyond the contamination sources and threaten to further impact the groundwater quality. These plumes, shown in Figure 3-19, are in the process of being remediated, and some are being evaluated for additional remediation.

The North Basin Volatile Organic Compound (VOC) plume area contains contaminated groundwater primarily in the Shallow Aquifer, which is generally less than 200 feet deep with migration downward into the Principal Aquifer. OCWD is performing a remedial investigation/feasibility study (RI/FS) under the oversight of the U.S. EPA and working with state regulatory agencies and stakeholders to evaluate and develop effective remedies to address the contamination under the National Contingency Plan process. The U.S. EPA is the lead agency for this North Basin RI/FS.

The South Basin plume area contains VOCs and perchlorate. OCWD has collected extensive data to delineate the comingled plumes. OCWD is performing an RI/FS in consultation with the Regional Water Board, Department of Toxic Substances Control, and stakeholders to evaluate and develop effective remedies to address the contamination under the National Contingency Plan process, designated as the South Basin Groundwater Protection Project (SBGPP).

The U.S. Navy is taking the lead in remediation of three groundwater contamination plumes of VOCs in the vicinity of the former El Toro Marine Corps Air Station (MCAS), former Tustin MCAS, and the Naval Weapons Station Seal Beach.

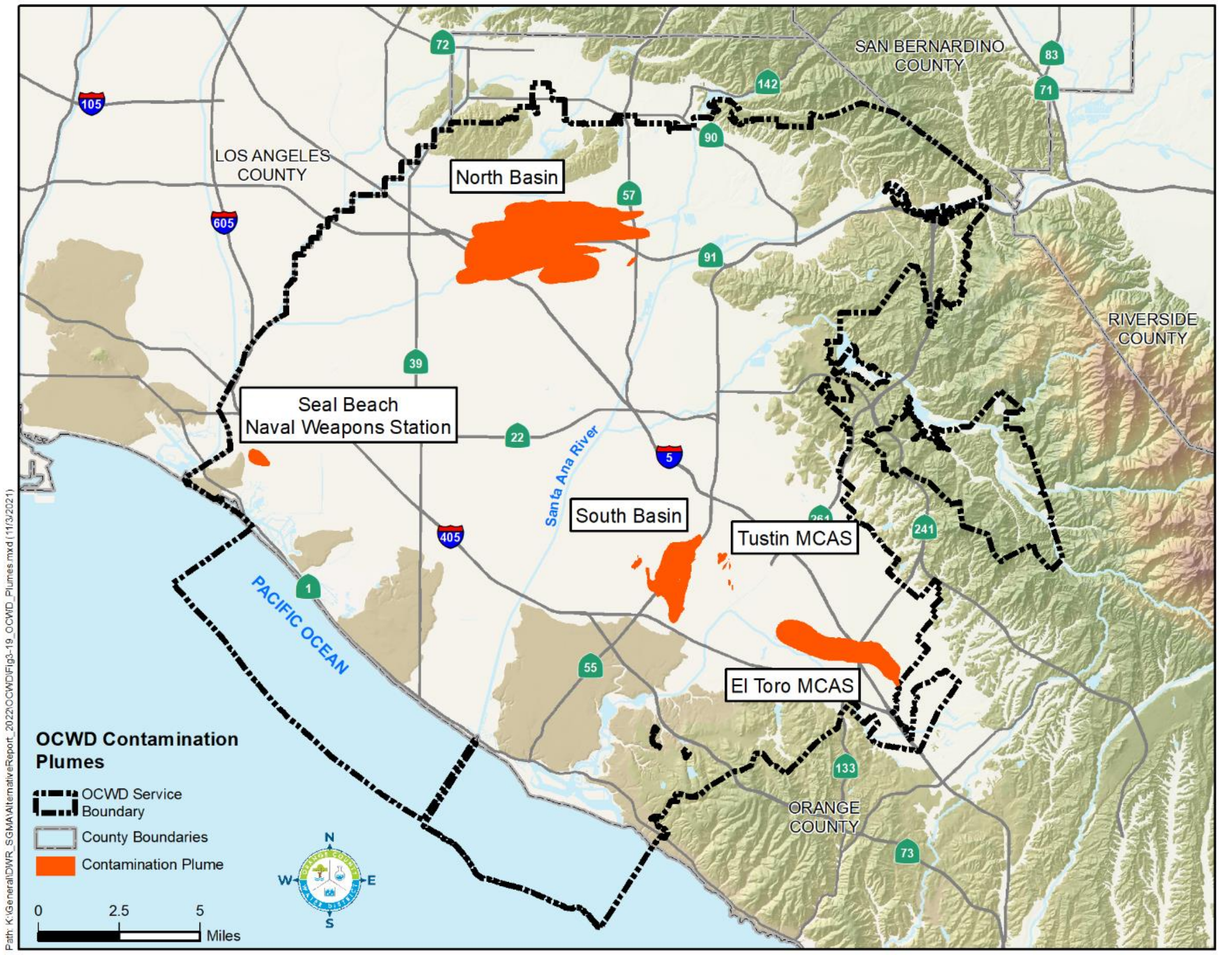


Figure 3-19: Groundwater Contamination Plume Locations

Coastal Gaps

In the coastal area of Orange County, the primary source of saline groundwater is seawater intrusion into the basin through permeable aquifer sediments underlying topographic lowlands or gaps between the erosional remnants or mesas of the Newport-Inglewood Uplift. The susceptible locations from north to south are the Alamitos, Sunset, Bolsa, and Talbert gaps as shown in Figure 3-20. Note that new wells added within the last five years are shown in Figure 3-20.

Background information on these gaps is contained in the 2017 Alternative. Ongoing activities related to seawater intrusion protection is described in subsequent sections of this report.

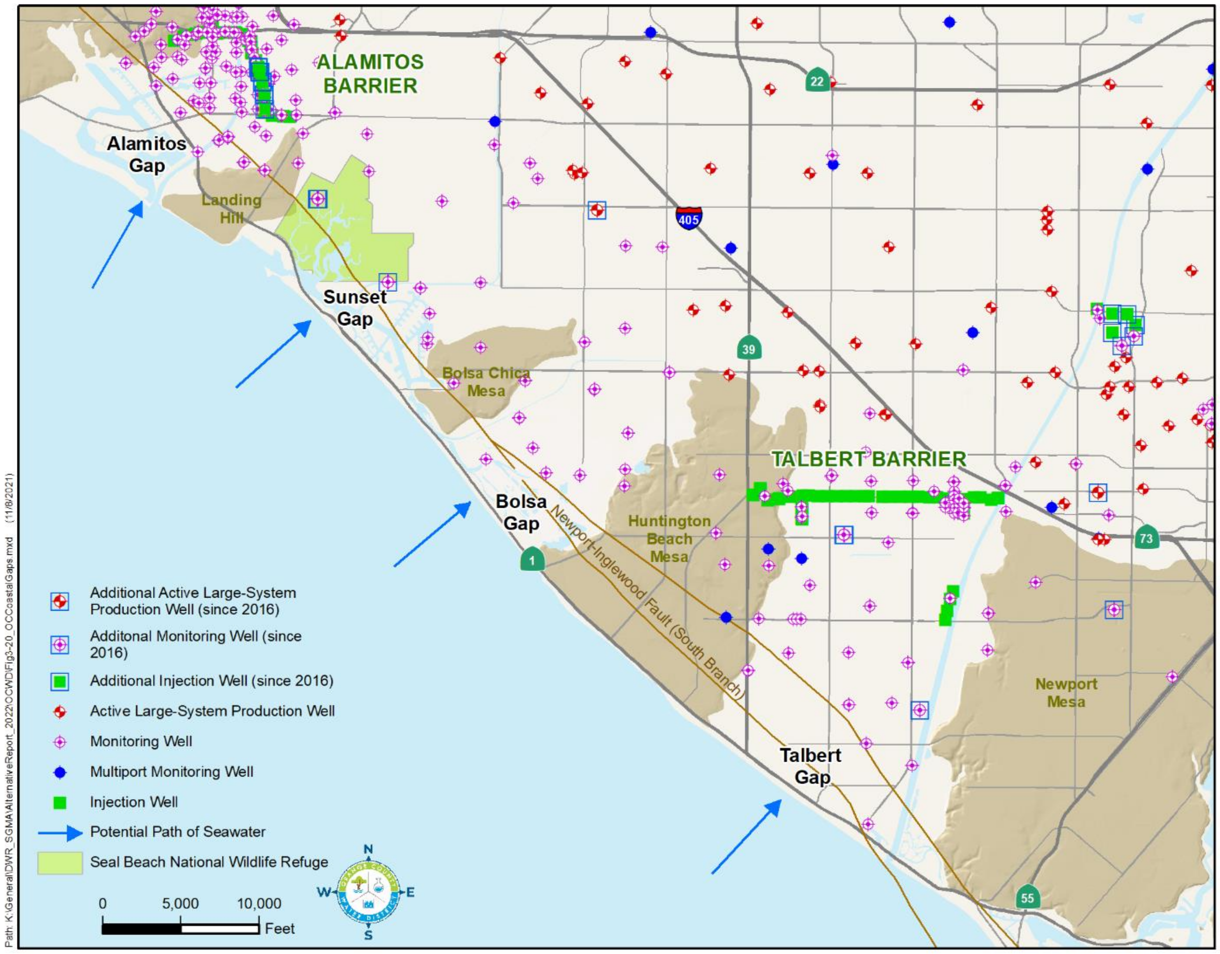


Figure 3-20: Orange County Coastal Gaps

Land Subsidence

In Orange County, subsidence in swampy low-lying coastal areas underlain by shallow organic peat deposits started as early as 1898 when development of these areas for agriculture resulted in excavation of unlined drainage ditches. The ditches drained the swamps and intercepted the shallow water table which was lowered to allow the land to drain adequately for irrigated agriculture. When the shallow water table was lowered, it exposed the formerly saturated peat deposits to oxygen that caused depletion and shrinkage of the peat due to oxidation (Fairchild and Wiebe, 1976).

Subsidence related to shallow peat deposits was associated with land development practices that occurred in Orange County in the late 1800s and early 1900s and, as such, is not something associated with or controlled by groundwater withdrawals in the basin. Another documented cause of subsidence in Orange County unrelated to groundwater basin utilization is oil extraction along the coast, particularly in Huntington Beach (Morton et al., 1976).

Ground surface elevations rise and fall due to groundwater conditions in the OCWD Management Area, and there is no indication of widespread irreversible lowering of the ground surface. Storage conditions in the groundwater basin were at historical lows in the mid-1950s, but since this time OCWD has operated the groundwater basin within a storage range above this historical low. There are reports that some subsidence may have occurred before OCWD began refilling the groundwater basin in the late 1950s (Morton, et al., 1976); however, the magnitude and scope of this subsidence is uncertain, and it is not clear if this subsidence was permanent. As such, there is no evidence of permanent, inelastic land subsidence in the OCWD Management Area (see Section 13), and future subsidence is not expected as long as OCWD continues to manage basin storage above the historic low observed in the late 1950s.

Groundwater/Surface Water Interactions and Groundwater Dependent Ecosystems

Frequent and destructive flooding of the Santa Ana River in Orange County was the impetus for construction of Prado Dam in 1941. Prior to the construction of flood control facilities, the banks of the Santa Ana River naturally overflowed periodically and flooded broad areas of Orange County. Coastal marshes were inundated during winter storms, and the mouth of the river moved both northward and southward of its present location. In the days before flood control, surface water naturally percolated into the groundwater basin, replenishing groundwater supplies.

Subsequent flood protection efforts included construction of levees along the river and concrete-lined bottoms along portions of the river. Flood risk was reduced, increased pumping of groundwater lowered water levels, and low-lying areas were filled in and/or equipped with drains, pumps and other flood control measures to allow for urban development. Since at least the 1950s, groundwater levels throughout the OCWD Management Area have been low enough that the rising and lowering of groundwater levels do not impact surface water flows or ecosystems.

Although it is outside the OCWD Management Area (within the Santa Ana Canyon Management Area described later), it is noted that from Prado Dam to Imperial Highway, the wide soft-bottomed Santa Ana River channel supports riparian habitat. Riparian habitat is dependent on river water released through Prado Dam, which is predominantly treated wastewater discharged in the upper watershed when storm flow is not present. In aggregate, this stretch is generally considered to be in equilibrium between surface water and groundwater based on available stream gage and groundwater level data, although some infiltration may occur due to minor groundwater pumping in the Santa Ana Canyon Management Area.

As the Santa Ana River enters the OCWD Management Area, from Imperial Highway to 17th Street in Santa Ana, there is minimal riparian habitat, and the river is a losing reach with engineered facilities to infiltrate surface water into the groundwater basin. OCWD conducts recharge operations within the soft-bottomed river channel except for a portion of the river where the Riverview Golf Course occupies the river channel. The river levees are constructed of either rip-rap or concrete.

From 17th Street to near Adams Avenue in Costa Mesa, the river channel is concrete-lined for flood control with vertical to sloping concrete side walls and a concrete bottom. From Adams Avenue to the coast, the channel has vertical concrete side walls or rip-rap for flood control and a soft bottom. Estuary conditions within the concrete channel exist at the mouth of the river where the ocean encroaches at high tide. The tidal prism extends from the ocean approximately three miles inland to the Adams Avenue Bridge.

There are no surface water bodies within the boundaries of the OCWD Management Area that are dependent on groundwater. Therefore, there are no groundwater-dependent ecosystems in the OCWD Management Area.

Some areas in the basin experience relatively high groundwater levels due to perched groundwater where shallow groundwater is impeded from flowing into deeper groundwater by a layer of low-permeable clay or silt, known as an aquitard. Except in very low-lying areas near sea level, the high groundwater is not close enough to the surface to support hydrophilic vegetation. OCWD carefully monitors water levels in the vicinity of the Talbert Seawater Barrier in order to maintain injection well rates to assure that groundwater levels do not rise to levels that could threaten urban infrastructure.

SECTION 4 WATER BUDGET

OCWD developed a hydrologic budget (inflows and outflows) for the purpose of constructing a basin-wide groundwater flow model, (Basin Model) and for evaluating basin production capacity and recharge requirements. The key components of the budget include measured and unmeasured (estimated) recharge, groundwater production, and subsurface flows along the coast and across the Orange County/Los Angeles County line. Because the basin is not operated on an annual safe-yield basis, the net change in storage in any given year may be positive or negative; however, over the long-term, the basin is operated within the established operating range. The components of the water budget are described below. OCWD's water year (WY) begins on July 1 and ends on June 30.

WATER BUDGET COMPONENTS

Measured Recharge

Measured recharge consists of all water artificially recharged at OCWD's surface water recharge facilities, water injected in the Talbert and Alamitos Barriers, and water injected in the Mid-Basin Injection wells. The majority of measured recharge occurs in the District's surface water system, which receives Santa Ana River baseflow and storm flow, GWRS water, and imported water.

Unmeasured Recharge

Unmeasured recharge also referred to as "incidental recharge" accounts for a significant amount of the basin's recharge, particularly in wet periods. This includes recharge from precipitation, irrigation return flows, urban runoff, seawater inflow through the gaps as well as subsurface inflow at the basin margins along the Chino, Coyote, and San Joaquin hills and the Santa Ana Mountains, and beneath the Santa Ana River and Santiago Creek. Subsurface inflow beneath the Santa Ana River and Santiago Creek refers to groundwater that enters the basin at the mouth of Santa Ana Canyon and in the Santiago Creek drainage below Villa Park Dam. Estimated average subsurface inflow to the basin is shown in Figure 4-1.

OCWD has estimated total unmeasured recharge, sometimes referred to as "incidental recharge," between 20,000 and 160,000 acre-feet per year. Net unmeasured recharge is the amount of unmeasured recharge remaining in the basin after accounting for underflow losses to Los Angeles County and relatively minor groundwater inflows/outflows at the coastal gaps. Under average hydrologic conditions, net incidental recharge averages 66,000 acre-feet per year. This average was substantiated during calibration of the Basin Model and is also consistent with the estimate of 58,000 acre-feet per year reported by Hardt and Cordes (1971) as part of a USGS modeling study of the basin. Because unmeasured recharge is one of the least understood components of the basin's water budget, the error margin for any given year is likely in the range of 10,000 to 20,000 acre-feet. Since unmeasured recharge is well distributed throughout the basin, the physical significance (e.g., water level drawdown or mounding in any given area) of overestimating or underestimating the total recharge volume within this error margin is considered to be minor.

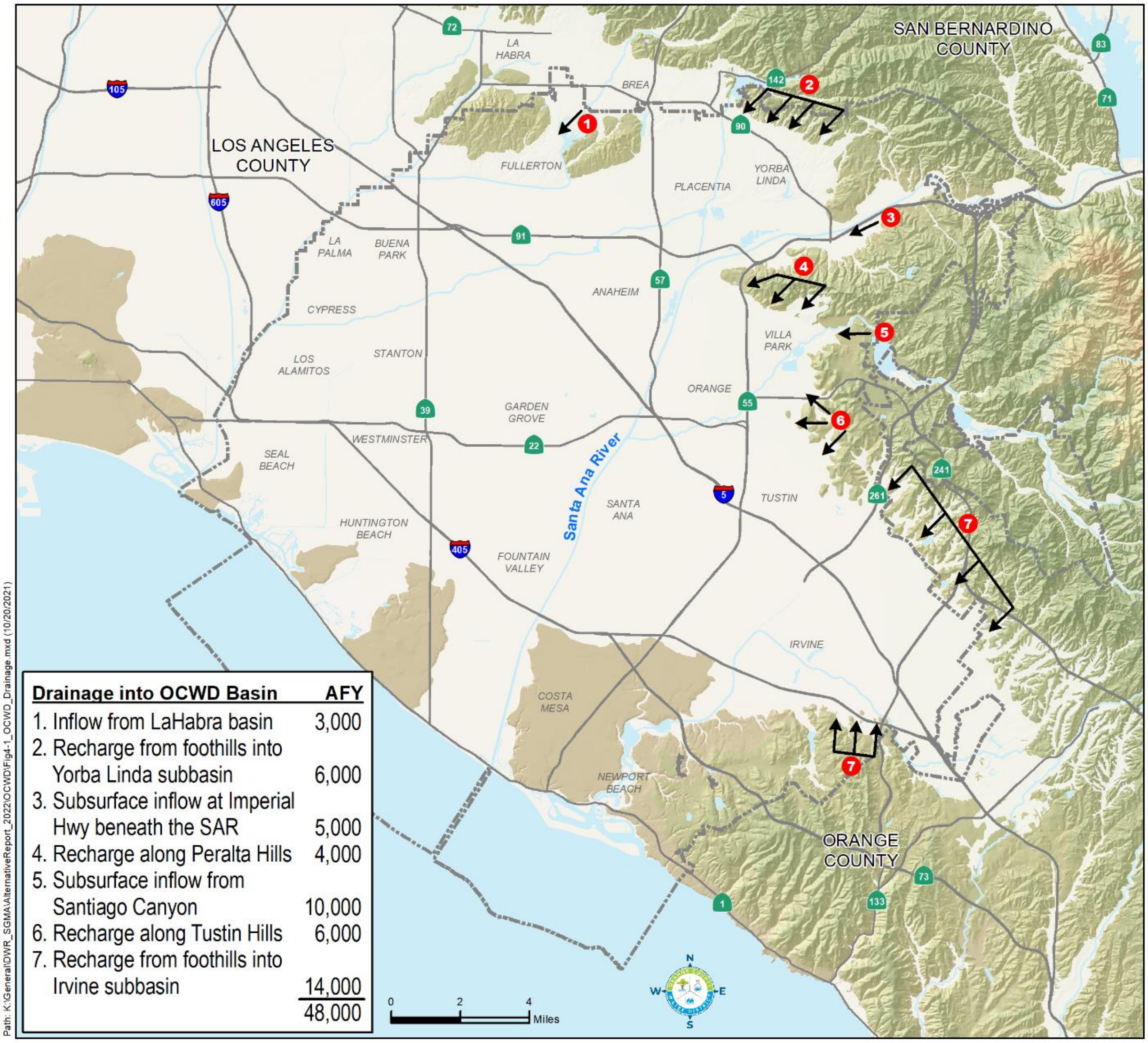


Figure 4-1: Estimated Subsurface Inflow

Groundwater Production

Entities that produce groundwater within the OCWD Management Area include major groundwater producers and small groundwater producers. Ninety-eight percent of groundwater production within Basin 8-1 occurs within the OCWD Management Area. The major groundwater producers include cities, water districts and a private water company that account for approximately 97 percent of the total basin production. These 19 major producers operate approximately 200 large-system wells. Small groundwater producers include entities that typically produce less than 500 acre-feet per year. These include small mutual water companies, agricultural companies, golf courses, cemeteries (irrigation wells), and private-well owners. Groundwater pumping for agricultural irrigation use accounts for less than one percent of total basin production.

Subsurface Outflow

Groundwater outflow from the basin across the Los Angeles County/Orange County line has been estimated to range from approximately 1,000 to 14,000 acre-feet per year based on groundwater elevation gradients and aquifer transmissivity (DWR, 1967; McGillicuddy, 1989). The Water Replenishment District of Southern California (WRD) also has estimated underflow from Orange County to Los Angeles County within the aforementioned range. Groundwater outflow cannot be directly measured and is accounted for in the basin water budget within the net unmeasured recharge described above. Modeling by OCWD indicates that underflow to Los Angeles County increases by approximately 7,500 acre-feet per year for every 100,000 acre-feet of increased groundwater in storage in Orange County, given the assumption that groundwater elevations in Los Angeles County remain constant.

Recent updates to the OCWD groundwater model show that subsurface outflow averaged approximately 13,000 acre-feet per year during the period 1991 to 2017 with a range of 5,000 to 25,000 acre-feet per year. Due to differences in model-estimated inter-basin groundwater flows, OCWD and WRD are jointly conducting a study to evaluate OCWD's Basin Model and WRD's groundwater model of Central Basin in Los Angeles County constructed by the USGS. The goal is to improve each model's ability to more closely represent local groundwater conditions and thereby more accurately estimate inter-basin groundwater flows.

With the exception of unknown amounts of semi-perched (near-surface) groundwater being intercepted and drained by submerged sewer trunk lines and unlined flood control channels along coastal portions of the basin, no other significant basin outflows are known to occur.

Evaporation

The total wetted area of the District's recharge system is over 1,000 acres. OCWD estimates the evaporation from this system on a monthly basis. Generally, total evaporation is on the order of 2,000 acre-feet per year which is approximately one percent of the total volume recharged annually. The relatively minor impact of evaporation reflects moderate temperatures in the region and high percolation rates (1 to 10 feet per day).

WATER YEAR TYPE

As explained previously, OCWD manages groundwater pumping and basin storage over the long-term, which includes wet and dry years. Basin storage levels from WY1957-58 to 2020-21 are shown in Figure 1-3. Typically, basin storage levels increase during wet periods and decrease during dry periods. Operating the basin within the operating range provides for maximum basin production while preventing significant and unreasonable undesirable results.

ESTIMATE OF SUSTAINABLE YIELD

Even though the groundwater basin contains an estimated 66 million acre-feet when full, OCWD operates the basin within an operating range of up to 500,000 acre-feet below full condition to protect against seawater intrusion, inelastic land subsidence, and other potential undesirable results. On a short-term basis, the basin can be operated at an even lower storage level in an emergency.

OCWD manages groundwater production and recharge to maintain groundwater storage levels within the established operating range. In this sense, the basin's sustainable yield can be defined as the volume of groundwater production that can be sustained while maintaining groundwater in storage within the operating range. Basin storage is determined on an annual basis by calculating the difference between groundwater production and recharge based on OCWD's July 1 to June 30 water year.

The sustainable yield of the basin is a function of the amount of groundwater recharge from OCWD's managed aquifer recharge program and natural recharge as a result of precipitation and percolation of irrigation flows. The process that determines a sustainable level of pumping on an annual basis considers the basin's operating range, basin storage conditions and the amount of available recharge water supplies.

As mentioned in Section 1.2, the groundwater basin is not operated on an annual safe-yield basis. The net change in storage in any given year may be positive or negative; however, over a period of several years, the basin is maintained in an approximate balance. Amounts of total basin production and total water recharged from WY1999-2000 to 2020-21 are shown in Figure 1-4.

WATER BUDGETS

The OCWD Management Area water budget for WY2016-17 to 2020-21 is presented in Table 4-1. Estimated water budgets for dry years, average years and wet years as well as a future projected budget are presented in the 2017 Alternative.

Table 4-1 Water Budget, WY2016-17 to 2020-21

FLOW COMPONENT	2016-17	2017-18	2018-19	2019-20	2020-21
INFLOW					
Santa Ana River baseflow	70,000	65,400	98,000	74,500	76,400
Santa Ana River stormflow	65,400	24,100	63,700	79,500	36,600
Recycled Water (GWRS/Alamitos Barrier)	98,000	106,400	97,200	99,700	101,700
Imported Water	50,400	66,100	40,300	18,100	0
Net Estimated Unmeasured or Incidental Recharge*	67,900	26,200	45,600	41,400	19,100
TOTAL INFLOW:	351,700	288,200	344,800	313,200	233,800
OUTFLOW					
Groundwater Production	300,700	237,200	303,800	277,200	281,800
TOTAL OUTFLOW:	300,700	237,200	303,800	277,200	281,800
CHANGE IN STORAGE:	51,000	51,000	41,000	36,000	(48,000)

SECTION 5 WATER RESOURCE MONITORING PROGRAMS

OVERVIEW

Water resource monitoring programs can be categorized into groundwater, surface water, and recycled and imported water programs. These programs are summarized in Table 5-1 in the 2017 Alternative. The only change is related to the termination of CASGEM, which is being replaced by annual reporting required by SGMA.

GROUNDWATER MONITORING PROGRAMS

OCWD collects samples and analyzes water elevation and water quality data from approximately 400 District-owned monitoring wells (shown in Figure 5-1) and at over 250 privately-owned and publicly-owned large and small system drinking water wells that are part of OCWD's Title 22 program, shown in Figure 5-2. OCWD also has access agreements to sample a number of non-District-owned monitoring wells and privately-owned irrigation, domestic and industrial wells, shown in Figure 5-3. New wells constructed in the last five years are highlighted in these figures. Inactive wells are included in District monitoring programs when feasible. An inactive well is defined as a well that is not currently being routinely operated. The number and location of wells that are sampled change regularly as new wells come online and old ones are abandoned and destroyed.

The District collects, stores, and uses data from wells owned and sampled by other agencies. For example, data collected by the WRD from wells in Los Angeles County along the Orange County boundary are part of the network of wells evaluated to determine annual groundwater elevations and are used for basin modeling. Also included in OCWD's monitoring network are wells that are owned and operated by the U.S. Navy for remediation of contamination plumes in the cities of Irvine, Seal Beach and Tustin, and wells that are related to operation of the Alamitos Barrier that are located in Los Angeles County. Los Angeles County wells are also used to model the Orange County groundwater basin as groundwater flow is unrestricted across the county line.

Wells sampled under various monitoring programs change in response to fluctuations in the number of available wells, basin conditions, observed water quality, and regulatory and non-regulatory requirements. Appendix A of the 2017 Alternative presented a comprehensive list of all wells in OCWD's database. This list included well name, owner, type of well, casing sequence number, depth, screened interval, and aquifer zone monitored, when known.

In some cases, well depth and screened intervals are listed in the database as unknown. OCWD maintains data on these wells when water quality or elevation data continues to be collected by the owner or operator. OCWD uses data from these wells in monitoring programs, for groundwater modeling, or for other basin programs. Wells on the list also include inactive wells when water quality or water elevation data continues to be collected or the data is utilized in one or more current basin programs. Groundwater elevation and monthly production data are used to quantify total basin pumping, evaluate seasonal groundwater level fluctuations and assess basin storage conditions.

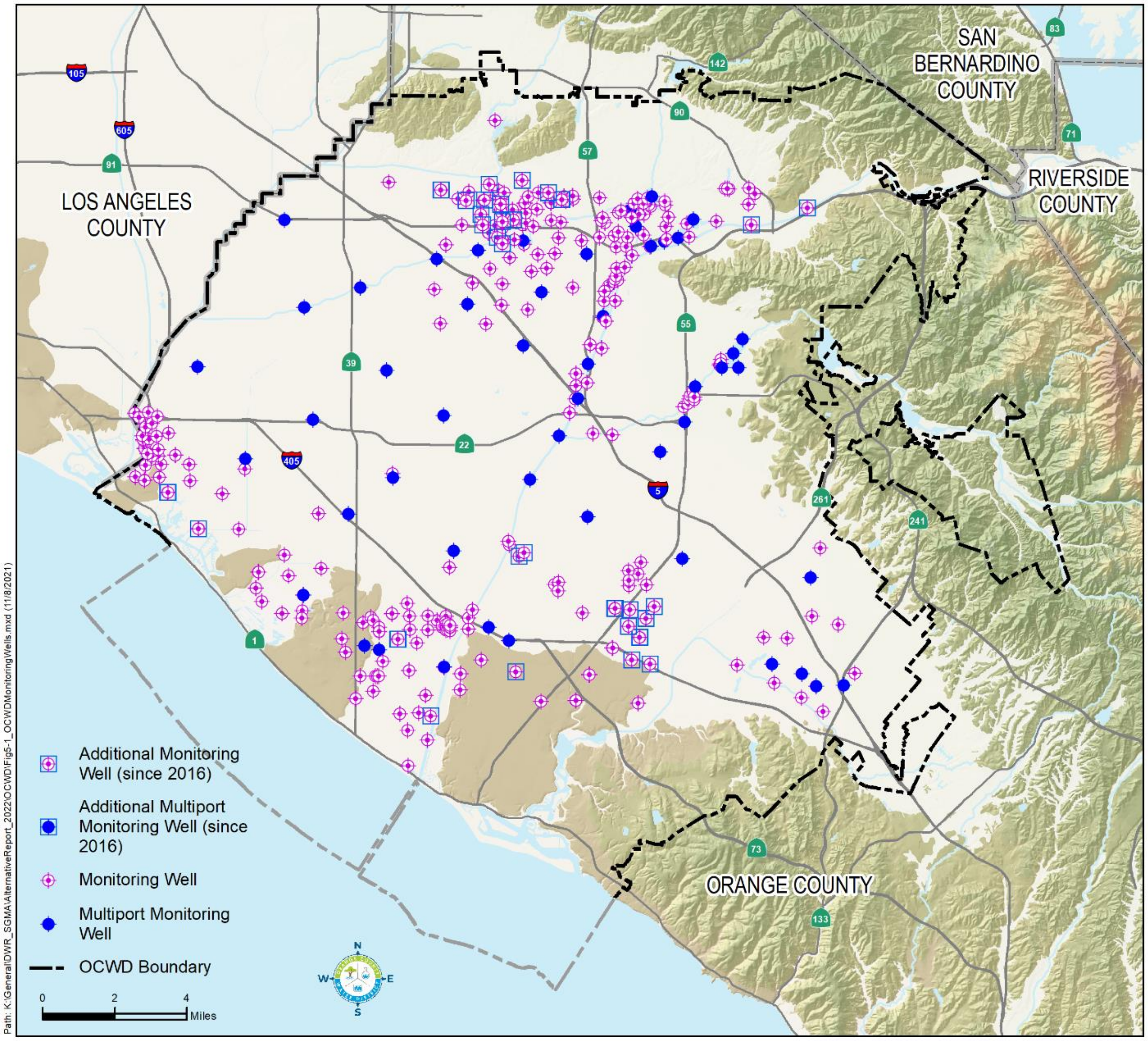


Figure 5-1: OCWD Monitoring Wells

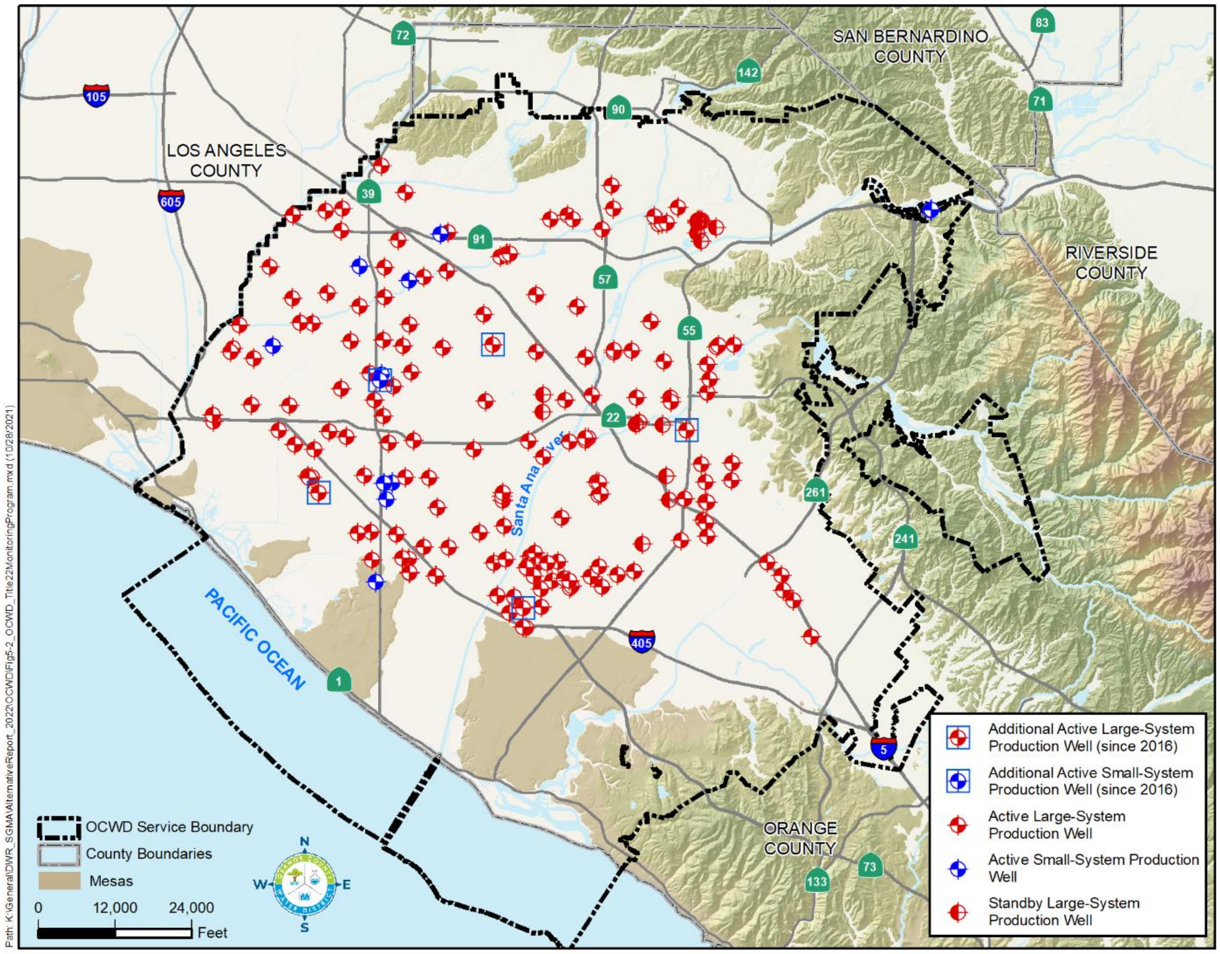


Figure 5-2: Large and Small System Drinking Water Wells in Title 22 Monitoring Program

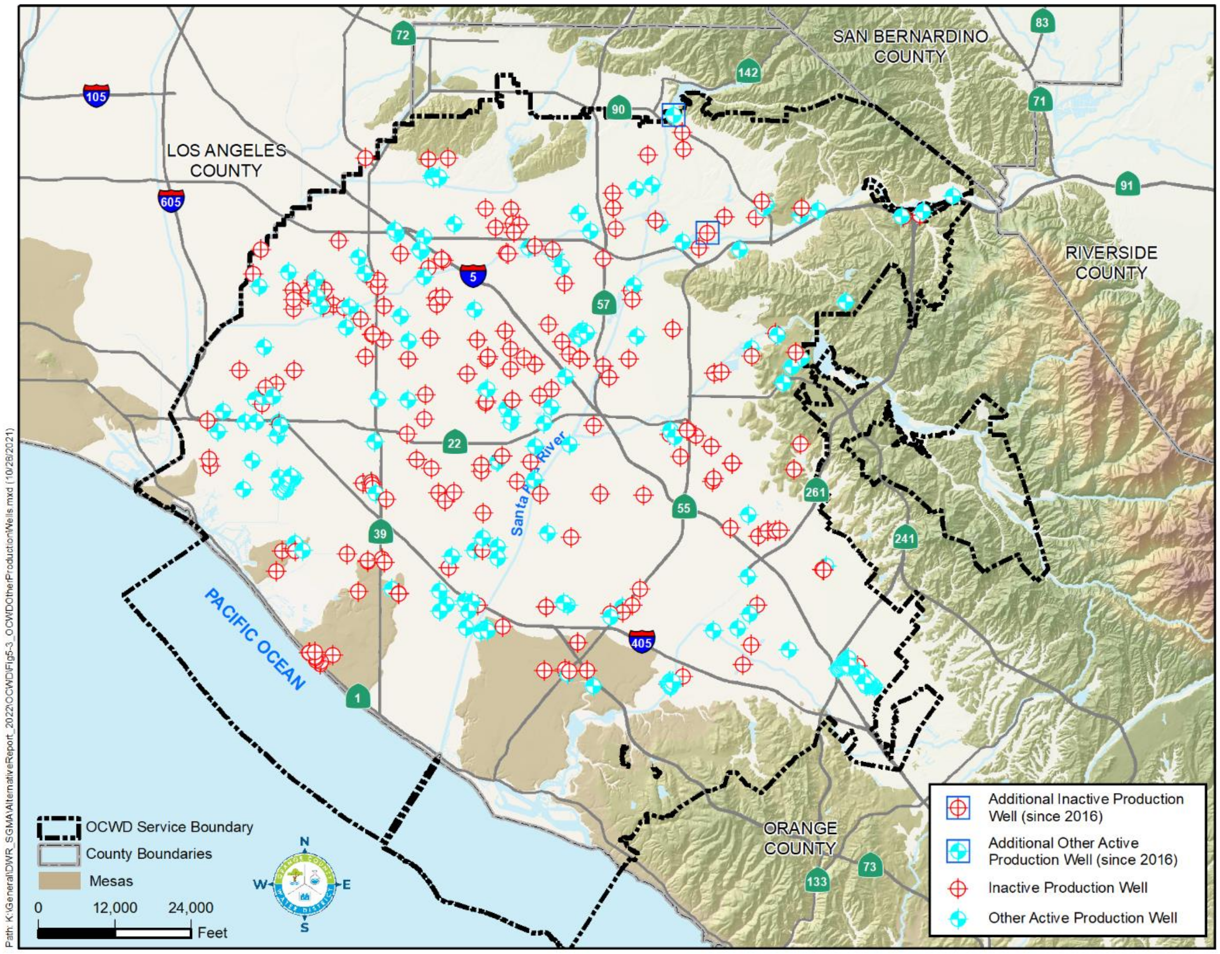


Figure 5-3: Private Domestic, Irrigation and Industrial Wells
in OCWD Monitoring Program

Groundwater Production Monitoring

All entities that pump groundwater from the basin are required by the OCWD District Act to report production every six months and pay a Replenishment Assessment. Owners or operators of wells with discharge outlets of two inches in diameter or less and supply an area of no more than one acre pay an annual flat fee as the Replenishment Assessment and do not have to report their production.

Approximately 200 large-capacity production wells owned by 19 major water retail agencies account for ninety-seven percent of production. Large-capacity well owners voluntarily report monthly groundwater production for each of their wells. The production volumes are verified by OCWD field staff. Production data are used to evaluate basin conditions, calculate and manage basin storage, run groundwater model scenarios, and collect revenues.

5.2.2 Groundwater Elevation Monitoring

Production and monitoring wells in the basin are measured for groundwater elevation at varying intervals, as explained below:

- Water elevation measurements are collected for every OCWD monitoring well at least once a year with most wells measured at least monthly;
- Monitoring of production wells is typically monthly but may vary depending on operational status, well maintenance, abandonment, new well construction, and related factors;
- Over 1,000 individual measuring points are monitored for water levels on a monthly or bi-monthly basis to evaluate short-term effects of pumping, recharge or injection operations; and
- Additional monitoring is done as needed in the vicinity of OCWD's recharge facilities, seawater barriers, and areas of special investigation where drawdown, water quality impacts or contamination are of concern.

Beginning in 2011, OCWD began reporting seasonal groundwater elevation measurements to DWR as part of the CASGEM program. The monitoring well network developed for the CASGEM program provide a detailed and representative data set, both spatially and temporally. The initial network established in 2011 consisted of a total of 77 monitoring stations distributed laterally and vertically throughout the groundwater basin. Most of the wells are owned by OCWD and have detailed borehole geologic logs and downhole geophysical logs.

In 2021, DWR instructed agencies that submitted an Alternative to begin submitting data to the SGMA portal. As a result, CASGEM data was incorporated into annual data submittals required for SGMA compliance. For the 2022 Update, OCWD reviewed the CASGEM network and updated it, primarily in removing wells that were no longer accessible, and changed the name to the SGMA Monitoring Well Network.

Figures 5-4 to 5-6 present the monitoring well locations for each of the three aquifer systems. The SGMA network includes wells within the OCWD, La Habra-Brea, Santa Ana Canyon, and Southeast Management Areas. The City of La Habra Groundwater Sustainability Agency will be reporting water levels from the La Habra Management Area separately. Two wells monitored by the Irvine Ranch Water District (IRWD) that are located in the Southeast Management area, IRWD-LA1 and IRWD-LA4 (Figure 5-5) are included in the SGMA reports that OCWD will submit to DWR.

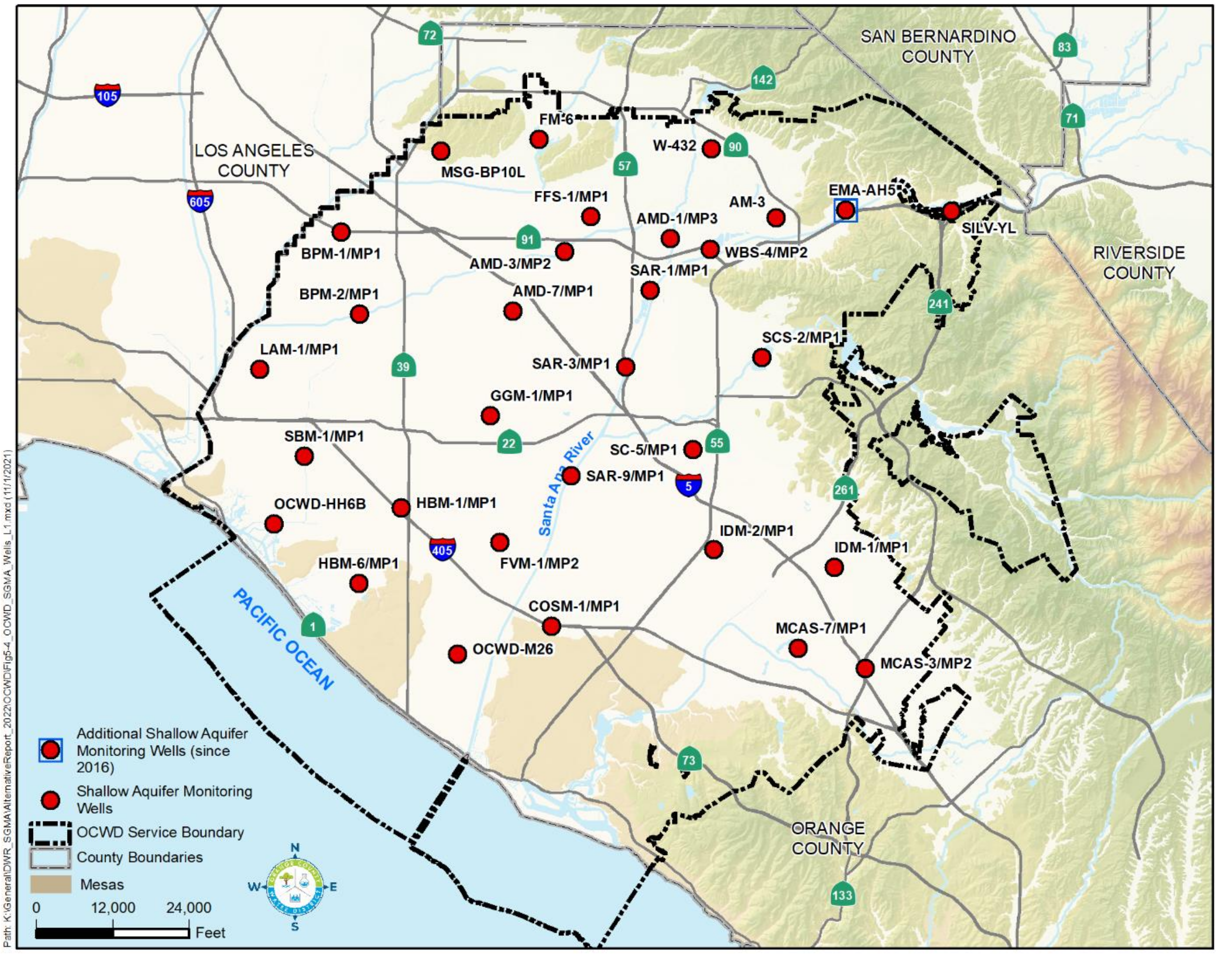


Figure 5-4: SGMA Shallow Aquifer System Monitoring Well Network

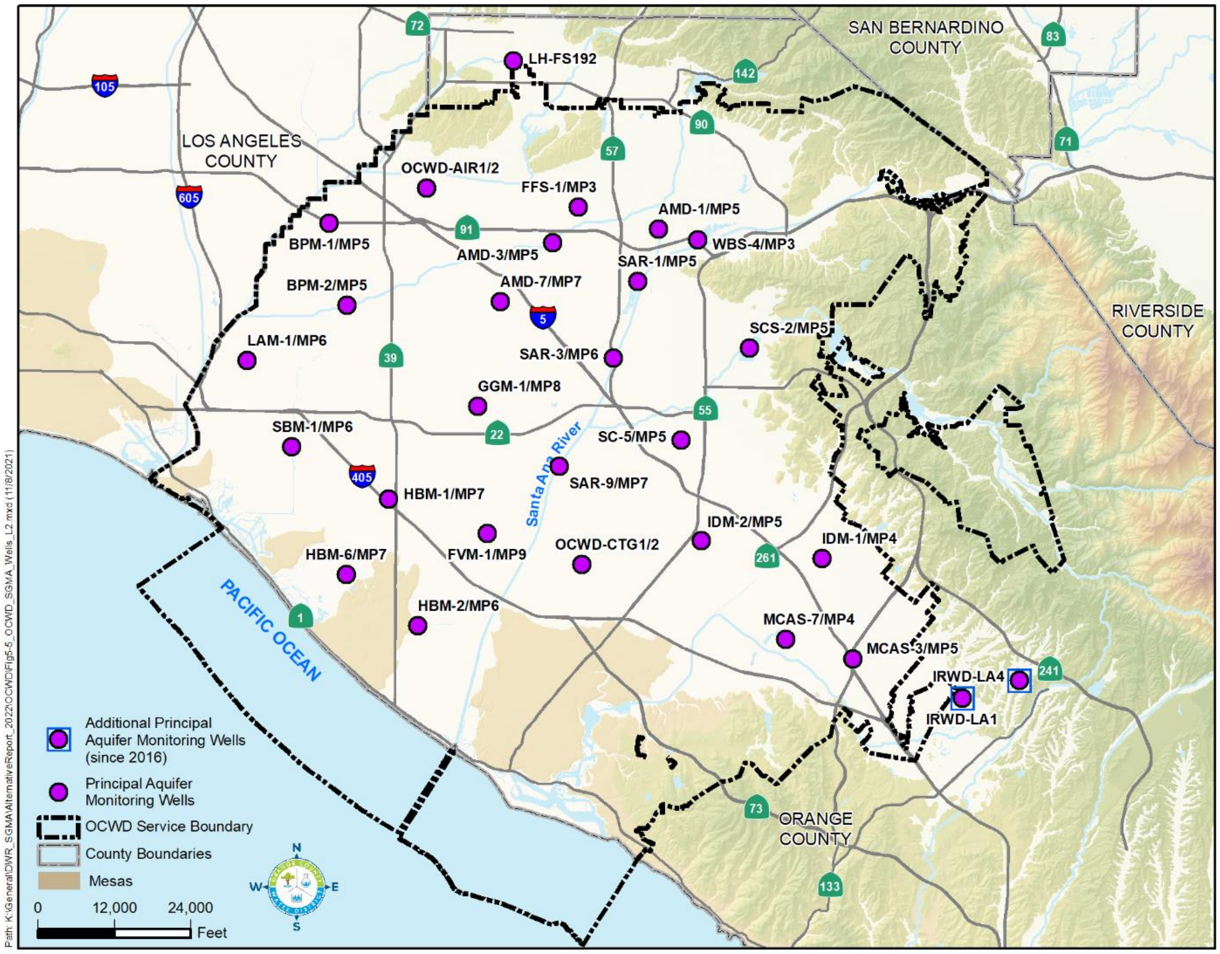


Figure 5-5: SGMA Principal Aquifer System Monitoring Well Network

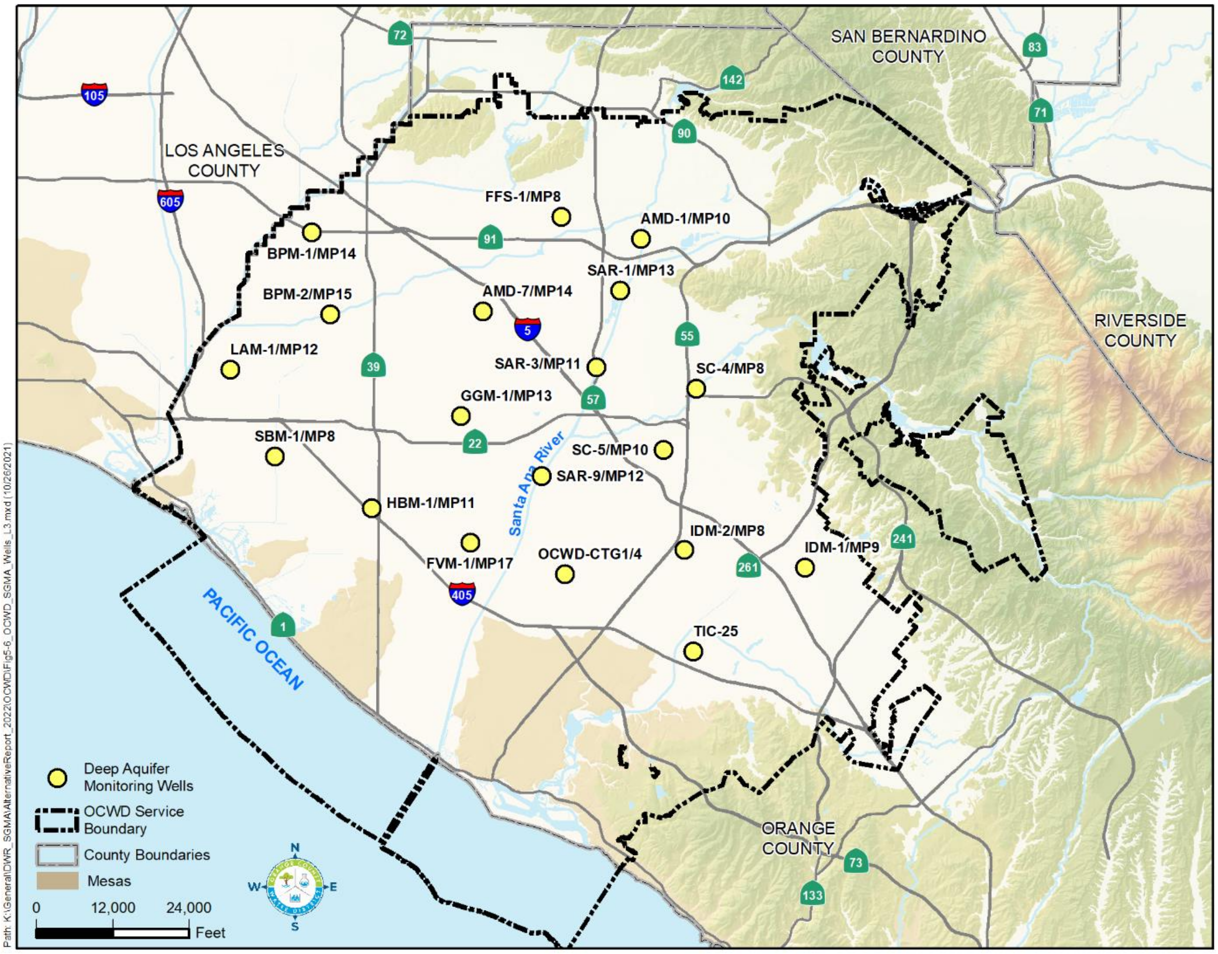


Figure 5-6: SGMA Deep Aquifer System Monitoring Well Network

Groundwater Quality Monitoring

OCWD monitors water quality in production wells on behalf of the groundwater producers for compliance with state and federal drinking water regulations. Samples are analyzed for more than 100 regulated and unregulated chemicals at frequencies established by regulations from the DDW and EPA. Over 425 monitoring and production wells are sampled semi-annually to assess water quality conditions during periods of lowest (winter) and peak production (summer).

The total number of water samples analyzed varies year-to-year due to regulatory requirements, conditions in the basin and applied research and/or special study demands. In 2020, OCWD water quality staff collected 15,496 samples, 4,139 of which were collected from drinking water wells.

OCWD developed specific programs to monitor the North Basin and South Basin plumes \\as described in the 2017 Alternative. Several new monitoring wells were constructed within the last five years for the North Basin and South Basin plume areas as shown on Figures 5-7 and 5-8.

Continual monitoring of groundwater near the coast is done to assess the effectiveness of the Alamitos and Talbert Barriers and track salinity levels in the Bolsa and Sunset Gaps. Key groundwater monitoring parameters used to determine the effectiveness of the barriers include water level elevations, chloride, TDS, electrical conductivity, and bromide. Groundwater elevation contour maps for the aquifers most susceptible to seawater intrusion are prepared to evaluate whether the freshwater mound developed by the barrier injection wells is sufficient to prevent the inland movement of saline water.

OCWD's extensive network of monitoring wells within the groundwater basin includes concentrated monitoring along the seawater barrier and near the recharge basins. GWRS-related monitoring wells in the vicinity of Kraemer, Miller, La Palma and Miraloma basins are used to measure water levels and to collect water quality samples. In addition to ensuring the protection of water quality, these wells have been used to determine travel times from recharge basins to production wells.

Permits regulating operation of GWRS require adherence to rigorous product water quality specifications, extensive groundwater monitoring, buffer zones near recharge operations, reporting requirements, and a detailed treatment plant operation, maintenance and monitoring program. GWRS product water is monitored daily, weekly, and quarterly for general minerals, metals, organics, and microbiological constituents. Focused research-type testing has been conducted on organic contaminants and selected microbial species.

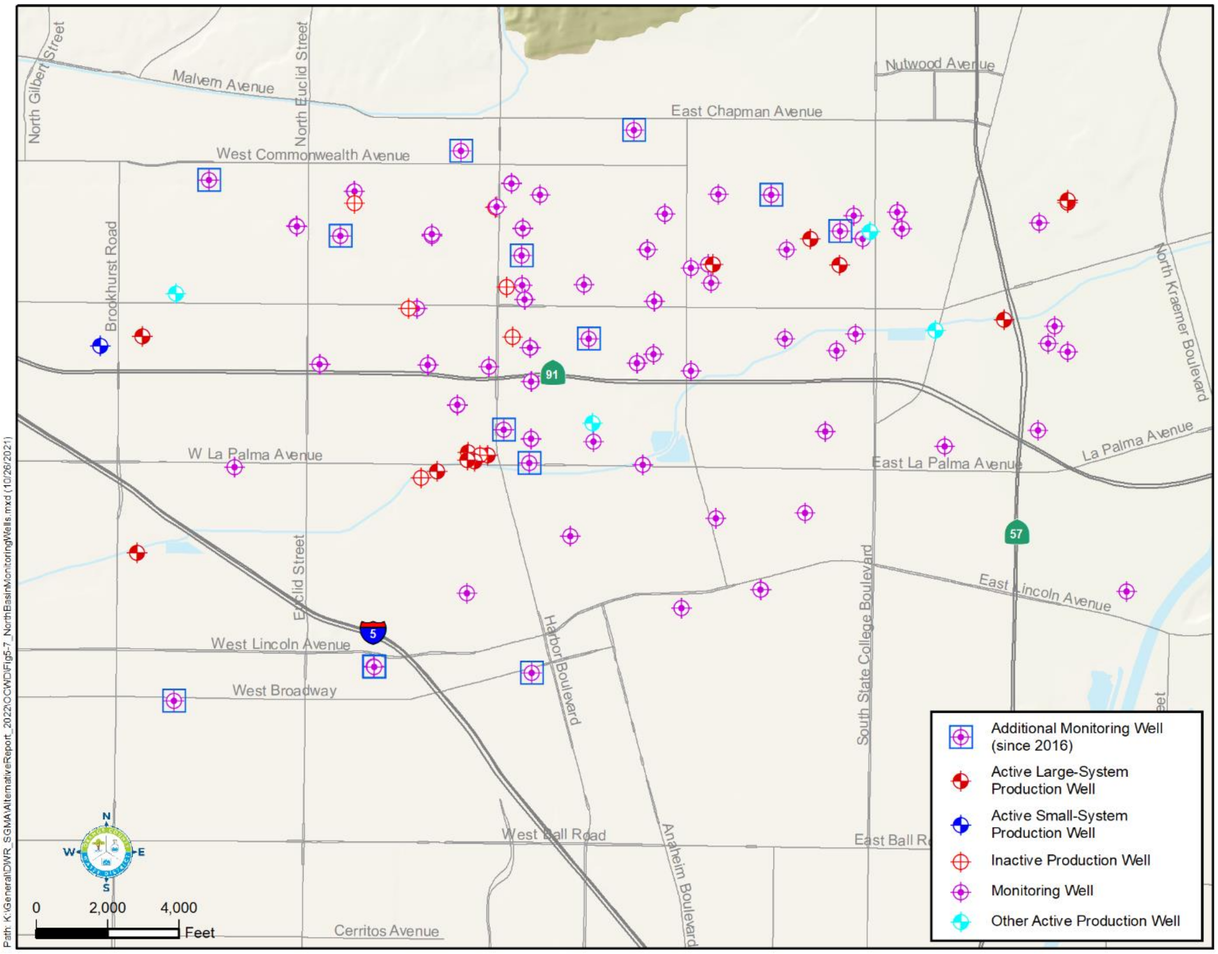


Figure 5-7: North Basin Groundwater Protection Program Monitoring Wells

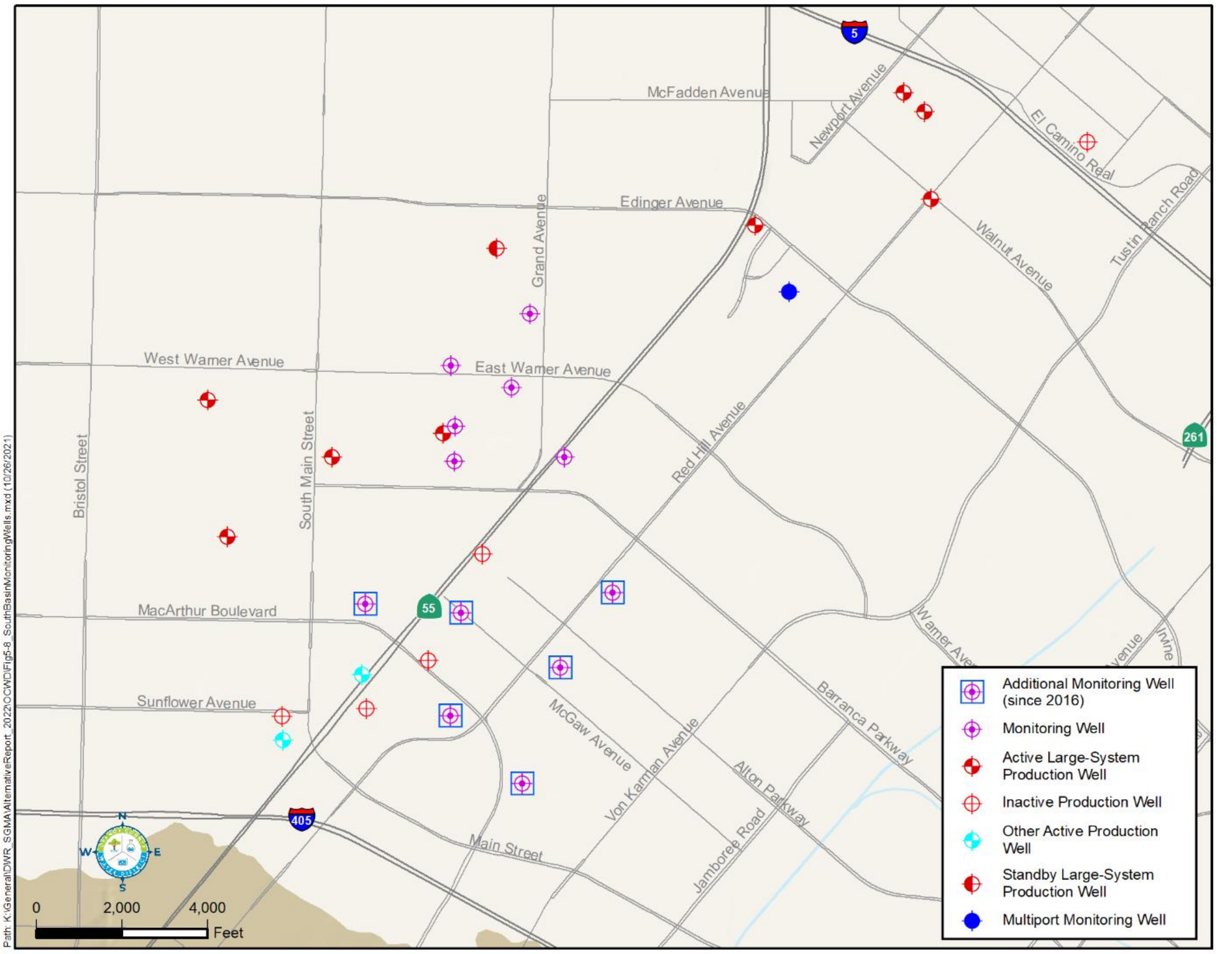


Figure 5-8: South Basin Groundwater Protection Program Monitoring Wells

Coastal Area Monitoring

OCWD operates and maintains a network of coastal area monitoring wells that provide water level and water quality data that allow staff to evaluate the performance of seawater intrusion barriers and to identify potential intrusion in coastal areas. The monitoring well network has been expanded and improved over time based on new information and a greater understanding of the basin hydrogeology.

Approximately 200 monitoring and production well sites are monitored for groundwater levels and quality within a 4- to 5- mile area from the coast, generally seaward or south of the 405 freeway, as shown in Figure 5-9. The monitoring wells are largely located in the coastal gaps as well as on the coastal mesas. The mesas are not impermeable features; rather, the marine deposition Pleistocene aquifers extend beneath the mesas to the basin production wells and provide potential avenues for seawater intrusion.

OCWD conducts the groundwater monitoring for the majority of the monitoring wells with the exception of the Alamitos Barrier monitoring wells. The Alamitos Seawater Intrusion Barrier is located along the border of Los Angeles and Orange counties and is jointly owned by OCWD and Los Angeles County Public Works (LACPW). LACPW operates, maintains, and samples Alamitos Barrier monitoring and injection wells, including those owned by OCWD located within Orange County. Through an interagency cooperative agreement dating to 1964, operational costs and data are shared between the two agencies with a joint report on the status of the barrier prepared on an annual basis.

Most of the monitoring wells shown in Figure 5-9 are owned by OCWD and are either single-point or nested. Single-point monitoring wells have one screened interval in one targeted aquifer zone, while nested wells have multiple (2 to 6) casings within the same borehole, with each casing screened in a separate aquifer zone at a discrete depth. A handful of OCWD monitoring wells in the coastal area are Westbay multi-port type, having only one well casing but with multiple monitoring ports each separated by inflatable packers. Therefore, although there are approximately 200 monitoring and production well sites in the coastal groundwater monitoring program, there are over 430 individual sampling points.

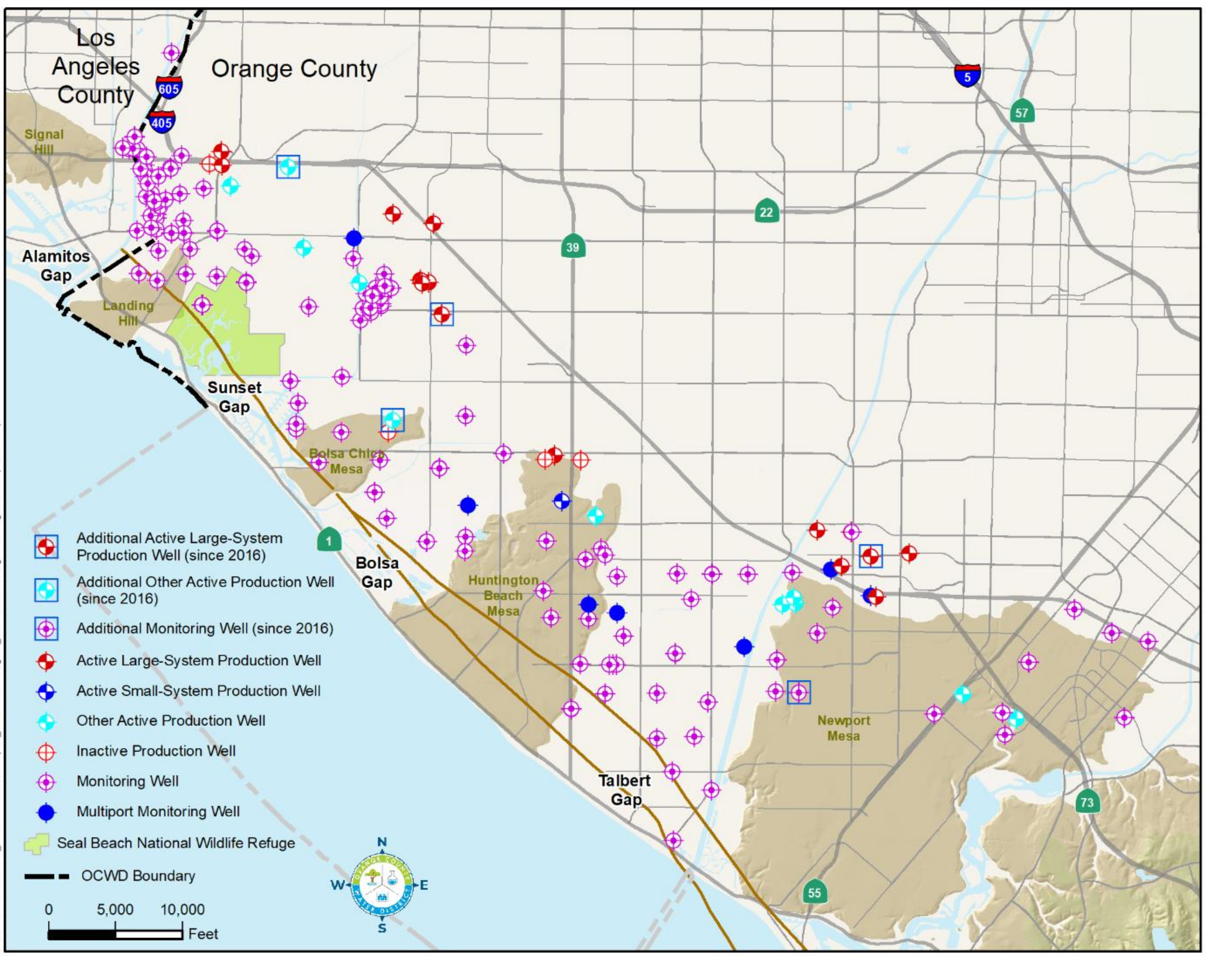


Figure 5-9: Seawater Intrusion Monitoring Wells

In addition to OCWD monitoring wells, there are a few privately owned monitoring wells and active municipal production wells included in OCWD's coastal monitoring program. For example, in Sunset Gap there are a few monitoring wells owned by The Boeing Company (Boeing) related to a shallow VOC plume in the area; Boeing monitors these wells twice a year (groundwater levels and VOCs), and OCWD obtains split samples with Boeing for seawater intrusion monitoring. The retail water agency production wells in the coastal monitoring program include three wells inland of the Alamitos Barrier (City of Seal Beach and Golden State Water Company) and three wells just inland of Sunset Gap (City of Huntington Beach). A complete list of all wells in the coastal groundwater monitoring program, along with their screened interval depths, was presented in Appendix A of the 2017 Alternative.

Groundwater levels are measured bi-monthly (every 2 months) at the majority of coastal monitoring wells and nearly all of the coastal monitoring wells are sampled semi-annually (March and September) for key groundwater quality parameters to assess seawater intrusion and barrier operations. Key groundwater quality parameters analyzed for the coastal monitoring program include chloride, bromide, and electrical conductivity (EC), which is a surrogate for TDS. The EC is typically measured both in the field at the time of sampling and in the laboratory.

Dissolved chloride concentrations and EC are used both to track seawater intrusion and to trace the injection of purified recycled water at the barriers, especially the Talbert Barrier in which the injection supply consists of 100 percent recycled water having a much lower salinity signal than native fresh groundwater. Chloride is considered to be a good conservative intrinsic tracer since it is relatively unaffected by sorption- and chemical-, or biological reactions in the subsurface. Bromide concentrations in brackish groundwater samples are valuable to help determine the origin or source of intrusion by evaluating the chloride to bromide ratio. Chloride to bromide ratios in the range of 280-300 in brackish coastal samples suggest relatively young active intrusion from the ocean or water body connected to the ocean, whereas lower ratios may indicate intrusion from past oil brine disposal or an influence of very old connate water from the original marine depositional process when these coastal aquifers were first formed.

SURFACE WATER AND RECYCLED WATER MONITORING

Surface water from the Santa Ana River is a major source of recharge supply for the groundwater basin. As a result, the quality of the surface water has a significant influence on groundwater quality. Therefore, characterizing the quality of the river and its effect on the basin is necessary to verify the sustainability of continued use of river water for recharge and to safeguard a high-quality drinking water supply for Orange County. Several on-going programs monitor the condition of Santa Ana River water. OCWD monitoring sites along the river and its tributaries are shown in Figure 5-10.

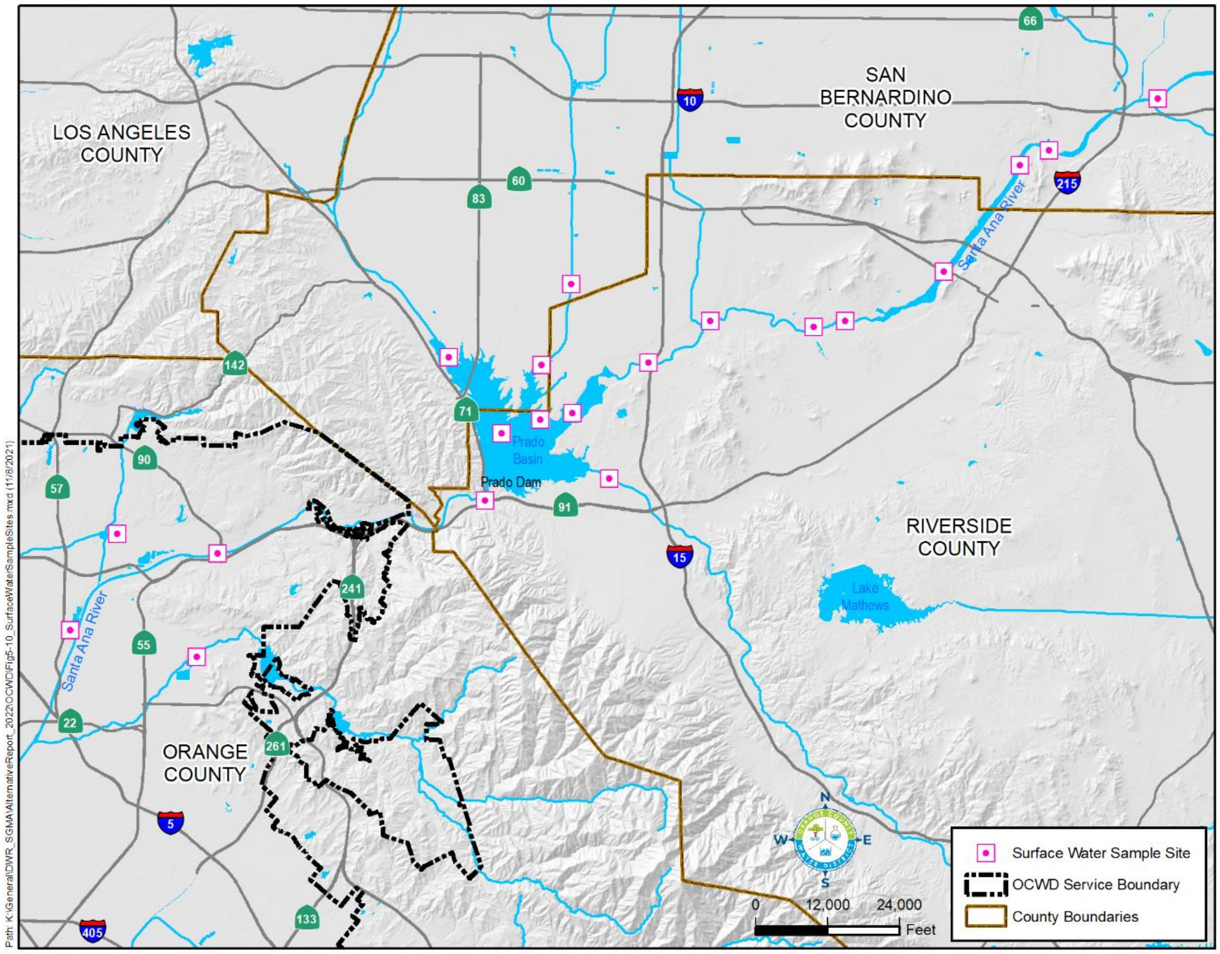


Figure 5-10**:** Surface Water Monitoring Locations

Surface Water Monitoring Programs

The surface water monitoring programs include:

- Santa Ana River Monitoring (SARMON) Program
- The Basin Monitoring Program Task Force (Task Force)
- Santa Ana River Watermaster
- Emerging constituents
- Imported water from MWD

Detailed descriptions of each program are contained in the 2017 Alternative.

Within the last five years, additional work has been done by the watershed-wide Emerging Constituents Monitoring Task Force administered by the Santa Ana Watershed Project Authority (SAWPA). This group was formed in 2010 to characterize emerging constituents in 1) municipal wastewater effluents, 2) the Santa Ana River at various locations, and 3) imported water. Three years of testing (2011-2013) were completed as directed by the Regional Water Board (R8-

2009-0071). OCWD monitored two sites twice a year on the Santa Ana River for this program. The SAWPA testing program was resumed voluntarily 2019, with the addition of PFAS monitoring; the program was not continued in 2020 and has been functionally replaced by the statewide PFAS Investigation Orders issued to upper watershed wastewater dischargers.

OCWD monitors for Constituents of Emerging Concern (CECs), including PFAS, at two surface water sites quarterly on the Santa Ana River and at various locations within District recharge facilities below Prado Dam. Samples are analyzed for pharmaceuticals, endocrine disruptors and other emerging constituents such as personal care products, food additives, and pesticides.

Recycled Water Monitoring

Use and monitoring of GWRS water is regulated by the Regional Water Board and DDW. Performance of the GWRS is monitored on a routine basis. Monitoring wells to monitor and track GWRS water are located adjacent to surface recharge basins located in Anaheim, downgradient of Mid-Basin Injection wells, and near the injection wells of the Talbert Seawater Barrier as shown on Figure 5-11. Additional details on recycled water monitoring and reporting are presented in the 2017 Alternative. Similar monitoring is performed at the WRD-owned Leo J. Vander Lans Advanced Water Treatment Facility that supplies recycled water to the Alamitos Seawater Barrier for injection.

In March 2020, OCWD’s Mid-Basin Injection (MBI) Project went on-line. This project started in April 2015 with the operation of a demonstration well (MBI-1). The MBI Project is located in the city of Santa Ana, primarily at Centennial Park and injects up to 10 million gallons of GWRS water a day into the Principal Aquifer and includes four new injection wells, MBI-2, 3, 4, and 5. Additionally, a total of four nested monitoring wells were installed as part of the MBI Project to track the quality and movement of injection water prior to reaching down gradient production wells. Nested wells SAR-10 and -11 were installed downgradient of MBI-1. To track the movement of GWRS water from the four new injection wells, SAR -12 and -13 were constructed (see Figure 5-11).

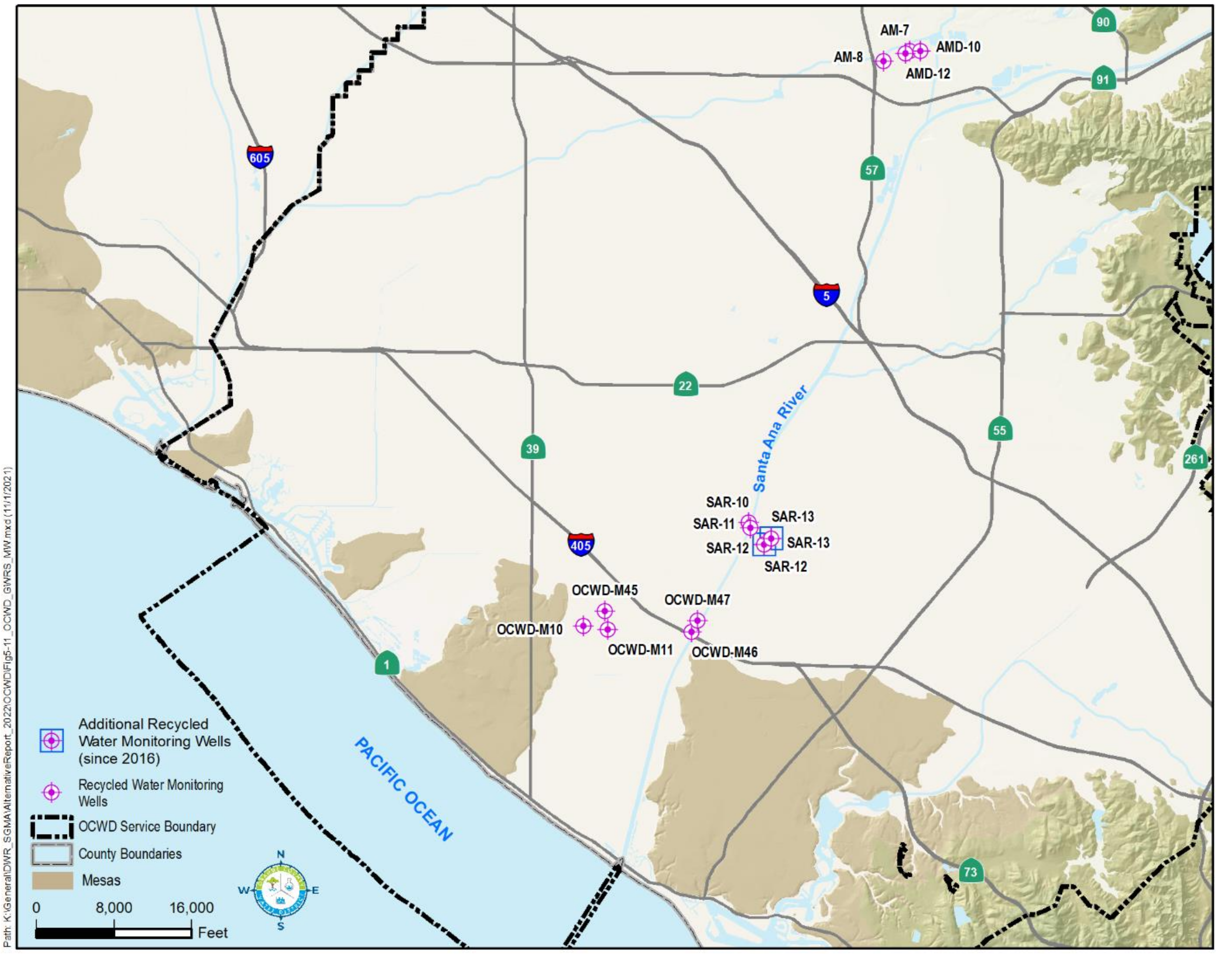


Figure 5-11: Recycled Water Monitoring Wells

SECTION 6 WATER RESOURCE MANAGEMENT PROGRAMS

LAND USE ELEMENTS RELATED TO BASIN MANAGEMENT

The OCWD Management Area is highly urbanized as shown on Figure 3-4. Monitoring potential impacts from proposed new land uses and planning for future development are key management activities essential for sustainable management of the groundwater basin.

OCWD monitors, reviews and comments on local land use plans and environmental documents such as environmental impact reports, notices of preparation, amendments to local general plans and specific plans, proposed zoning changes, draft water quality management plans, and other land development plans. District staff also review draft National Pollution Discharge Elimination System and waste discharge permits issued by the Regional Water Board. The proposed projects and programs may have elements that could cause short- or long-term water quality impacts to source water used for groundwater replenishment or have the potential to degrade groundwater resources. Monitoring and reviewing waste discharge permits provides OCWD with insight on activities in the watershed that could affect water quality.

The majority of the basin's land area is located in a highly urbanized setting and requires tailored water supply protection strategies. Reviewing and commenting on stormwater permits and waste discharge permits adopted by the Regional Water Board for the portions of Orange, Riverside and San Bernardino counties that are within the Santa Ana River watershed are conducted by OCWD on a routine basis. These permits can affect the quality of water in the Santa Ana River and other water bodies, thereby impacting groundwater quality in the basin.

OCWD works with local agencies having oversight responsibilities on the handling, use and storage of hazardous materials; underground tank permitting; well abandonment programs; septic tank upgrades; and drainage issues. Participating in basin planning activities of the Regional Water Board and serving on technical advisory committees and task forces related to water quality are also valuable activities to protect water quality.

Summary of Plans Related to Basin Management

The 2017 Alternative presented a comprehensive list of plans related to basin management, including:

- Municipal Stormwater Permit
- The OC Plan which is the combined North Orange County Integrated Regional Water Management Plan (IRWM), Central Orange County IRWM, and Coastal Watershed Management Plan
- OWOW 2.0 Plan which is the IRWM Plan for the Santa Ana Watershed
- Municipal Water District of Orange County (MWDOC) 2020 Regional Urban Water Management Plan

- Municipal Water District of Orange County (MWDOC) 2016 Orange County Reliability Study

Land Use Development and Water Demands and Supply

Water demands within the OCWD Management Area between WY1989-90 and 2020-21 have fluctuated between approximately 367,000 and 526,000 acre-feet per year but have leveled off in the past few years to approximately 400,000 acre-feet per year as shown in Figure 1-5.

Since its founding, OCWD has grown in area from 162,676 to 243,968 acres and has experienced an increase in population from approximately 120,000 to 2.5 million people. OCWD has employed groundwater management techniques to increase the annual yield from the basin including operating over 1,000 wetted acres of infiltration basins. Annual groundwater production increased from approximately 150,000 acre-feet in the mid-1950s to a high of over 366,000 acre-feet in WY2007-08. OCWD strives to maximize production from the basin through maximizing recharge of the groundwater basin. The basin is managed within the established groundwater storage operating range independently of total regional water demands as total water demands are met by a combination of groundwater and imported water.

Well Construction, Management, and Closure

Well construction, management and closure are regulated by various state agencies. To comply with federal Safe Drinking Water Act requirements regarding the protection of drinking water sources, the DDW created the Drinking Water Source Assessment and Protection (DWSAP) program. Water suppliers must submit a DWSAP report as part of the drinking water well permitting process and have it approved before providing a new source of water from a new well. OCWD provides technical support to groundwater producers in the preparation of these reports.

Well construction ordinances adopted and implemented by the Orange County Health Care Agency (OCHCA) and certain municipalities follow state well construction standards established to protect water quality under California Water Code Section 231. Cities within OCWD boundaries that have local well construction ordinances and manage well construction within their local jurisdictions include the cities of Anaheim, Fountain Valley, Buena Park, and Orange. To provide guidance and policy recommendations on these ordinances, the County of Orange established the Well Standards Advisory Board in the early 1970s. The five-member appointed Board includes OCWD’s Chief Hydrogeologist. Recommendations of the Board are used by the OCHCA and municipalities to enforce well construction ordinances within their jurisdictions.

A well is considered abandoned when the owner has permanently discontinued its use, or it is in such a condition that it can no longer be used for its intended purpose. This often occurs when wells have been forgotten by the owner, were not disclosed to a new property owner, or when the owner is unknown.

A properly destroyed and sealed well has been filled so that it cannot produce water or act as a vertical conduit for the movement of groundwater. In cases where a well is paved over or under a structure and can no longer be accessed it is considered destroyed but not properly sealed. Many of these wells may not be able to be properly closed due to overlying structures, landscaping or pavement. Some of them may pose a threat to water quality because they can be conduits for contaminant movement as well as physical hazards to humans and/or animals.

OCWD supports and encourages efforts to properly destroy abandoned wells. As part of routine monitoring of the groundwater basin, OCWD will investigate on a case-by-case basis any location where data suggests that an abandoned well may be present and may be threatening water quality. When an abandoned well is found to be a significant threat to the quality of groundwater, OCWD will work with OCHCA and the well owner, when appropriate, to properly destroy the well.

The City of Anaheim has a well destruction policy and has an annual budget to destroy one or two wells per year. The funds are used when an abandoned well is determined to be a public nuisance or needs to be destroyed to allow development of the site. The city's well permit program requires all well owners to destroy their wells when they are no longer needed. When grant funding becomes available, the city uses the funds to destroy wells where a responsible party has not been determined and where the well was previously owned by a defunct water consortium.

Information on the status of wells is kept within OCWD's Water Resource Management System data base. Since the 2017 Alternative was submitted, a total of 15 production wells were properly destroyed and sealed. During this same period, a total of 9 new production wells were constructed.

GROUNDWATER QUALITY PROTECTION AND MANAGEMENT

OCWD has a number of policies and programs to project groundwater quality. The list of programs below is described in detail in the 2017 Alternative.

- OCWD Groundwater Protection Policy (2014)
- Various Salinity Management Programs
  - Seawater Intrusion Barriers
  - Coastal Pumping Transfer Program
  - Groundwater Replenishment System
  - Septic Systems
  - Nitrogen and Selenium Management Program
  - Groundwater Desalters and Inland Empire Brine Line and Non-Reclaimable Waste Line
  - Basin Monitoring Program Task Force
  - Salinity Management and imported Water Workgroup
  - Nitrate Management Program

Regulation and Management of Contaminants

A variety of federal, state, county and local agencies have jurisdiction over the regulation and management of hazardous substances and the remediation of contaminated groundwater supplies. OCWD does not have regulatory authority to require responsible parties to clean up pollutants that have contaminated groundwater. In some cases, OCWD has pursued legal action against entities that are responsible for contaminating the groundwater basin to recover OCWD's remediation costs or to compel those entities to implement remedies. OCWD also coordinates and cooperates with regulatory oversight agencies that investigate sources of contamination. OCWD efforts to assess the potential threat to public health and the environment from contamination in the Santa Ana River Watershed and within the County of Orange include:

- Reviewing ongoing groundwater cleanup site investigations and commenting on the findings, conclusions, and technical merits of progress reports
- Providing knowledge and expertise to assess contaminated sites and evaluating the merits of proposed remedial activities
- Conducting third-party groundwater split samples at contaminated sites to assist regulatory agencies in evaluating progress of groundwater cleanup and/or providing confirmation data of the areal extent of contamination

The following is a list of potential contaminants of greatest concern for basin water quality management. More details on these are presented in the 2017 Alternative.

- Per- and polyfluorinated Alkyl Substances (PFAS)
- Methyl Tertiary Butyl Ether (MTBE)
- Volatile Organic Compounds (VOCs)
- N-Nitrosodimethylamine (NDMA)
- 1,4-Dioxane
- Constituents of Emerging Concern (CECs)

As new chemicals become of scientific interest or are regulated, the OCWD laboratory develops the analytical capability and becomes certified in the approved method to process compliance samples. In 2019, the District's lab became the first public agency laboratory in the state of California to achieve state certification to analyze PFAS in drinking water. The District has invested over $1 million in monitoring equipment to test for PFAS and other CECs.

OCWD is committed to (1) track new compounds of concern; (2) research chemical occurrence and treatment; (3) communicate closely with the DDW on prioritizing investigation and guidance; (4) coordinate with OC San, upper watershed wastewater dischargers and regulatory agencies to identify sources and reduce contaminant releases; and (5) inform the groundwater producers on emerging issues.

RECYCLED WATER PRODUCTION

Overview

The Groundwater Replenishment System (GWRS) is a joint project built by OCWD and OC San that began operating in 2008. Secondary treated wastewater that otherwise would be discharged to the Pacific Ocean is purified using a three-step process to produce high-quality water used to control seawater intrusion and recharge the basin. As shown on Figure 6-1, the system includes four major components (1) the Advanced Water Purification Facility (AWPF), (2) the Talbert Seawater Intrusion Barrier, (3) Mid-Basin Injection wells, and (4) four dedicated recharge basins.

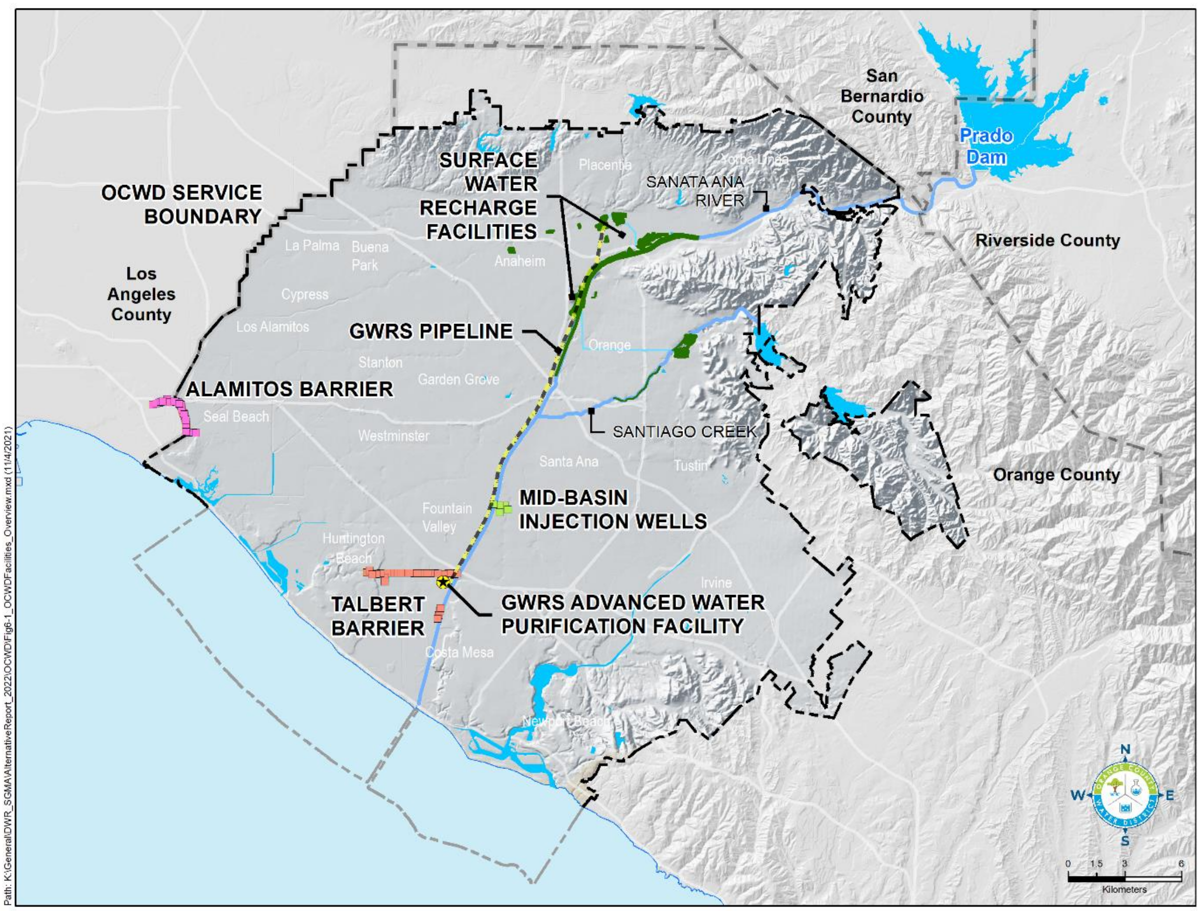


Figure 6-1: Groundwater Replenishment System

FINAL EXPANSION

The GWRS Final Expansion (GWRSFE) Project began in 2019 with a budget of $310 million. It is the third and final phase of the project to build-out capacity of the GWRS facility that treats secondary effluent from OC San to drinking water standards for groundwater replenishment. As discussed above, the GWRS first began operating in 2008 producing 70 mgd and in 2015, it underwent a 30 mgd expansion. When the Final Expansion is completed in 2023, the plant will have the capacity to produce 130 mgd.

In order to produce 130 mgd, additional treated wastewater from the OC San is required. This additional water will come from OC San's Treatment Plant 2, which is located in the city of Huntington Beach approximately 3.5 miles south of the GWRS. Since the current GWRS facility only receives influent from OC San's Plant No. 1, new secondary effluent conveyance facilities are required at OC San' Plant No. 2 to convey the secondary effluent to GWRS. These conveyance facilities include an effluent pump station, two flow equalization tanks and rehabilitation of an existing pipeline.

In order for secondary effluent from OC San's Plant No. 2 to be recycled by GWRS, Santa Ana Regional Interceptor (SARI) flows must be segregated. Currently, SARI flows are not permitted to be recycled through GWRS due to the industrial and treatment facility discharges that currently flow in the SARI pipeline. Therefore, in addition to the conveyance facilities, modifications will be made to OC San Plant No. 2 headworks facilities to segregate the SARI flows and treat these flows separately for discharge to the ocean outfall. This project is referred to as the Plant No. 2 Headworks Modification Project. In addition to the Plant No. 2 Headworks Modification Project, an upgrade to OC San's Plant No. 2 water pump station is required to feed the headworks with reclaimable water. This Plant Water Pump Station Project is also considered part of the complete GWRSFE Project. An overview of the sites and the project locations of the GWRSFE are shown in Figure 6-2.

Figure 6-2: GWRS Final Expansion Overview

The GWRSFE is anticipated to be completed and operational in 2023. Once completed, the GWRS will recycle 100 percent of OC San's reclaimable sources and produce enough water to meet the needs of over one million people.

CONJUNCTIVE USE PROGRAMS

The conjunctive use of surface and groundwater has been the foundation of OCWD's basin management strategy since it was formed in 1933. OCWD Managed Aquifer Recharge (MAR) program began in 1936 when it began purchasing portions of the Santa Ana River channel, eventually acquiring six miles of the channel in Orange County, in order to maximize the recharge of river water to the basin.

Recharge of imported water began in 1949 when OCWD began purchasing Colorado River water from MWD. In 1958, OCWD purchased and excavated a 64-acre site one mile north of the Santa Ana River to create Anaheim Lake, OCWD's first recharge basin. Today OCWD operates a network of 25 facilities that recharge an average of over 230,000 acre-feet per year.

OCWD has developed a diverse recharge portfolio including water from the Santa Ana River and tributaries, imported water, and recycled water supplied by the GWRS. The basin also receives natural recharge (also called incidental recharge) from precipitation and subsurface inflow.

Sources of Recharge Water Supplies

Water supplies used to recharge the groundwater basin are listed in Table 6-1. Figure 6-3 shows the historical recharge by source from 1936 to 2021. Table 4-1 presents the annual recharge by source for WY2016-17 to 2020-21.

Santa Ana River

Water from the Santa Ana River is a primary source of water used to recharge the groundwater basin. OCWD diverts river water into recharge facilities where the water percolates into the groundwater basin. Recharge facilities are capable of recharging all of the base flow. Both the Santa Ana River base flow and storm flow vary from year to year. The volume of storm water that can be recharged into the basin is highlight dependent on the amount and timing of precipitation in the upper watershed, which is highly variable. OCWD has water rights to all storm flows and base flows that reach Prado Dam. When storm flows exceed the capacity of the diversion facilities, river water reaches the ocean, and this portion is lost as a water supply.

Santiago Creek

Santiago Creek is the primary drainage for the northwest portion of the Santa Ana Mountains and ultimately drains into the Santa Ana River. OCWD captures and recharges water in Santiago Creek that flows into the Santiago Recharge Basins. During dry periods, the Santiago basins are used to recharge Santa Ana River flows which are pumped to the basins.

Table 6-1: Sources of Recharge Water Supplies

SUPPLY SOURCES AND DESCRIPTION			RECHARGE LOCATION
Santa Ana River	Base Flow	Perennial flows from the upper watershed in Santa Ana River; predominately treated wastewater discharges	Santa Ana River, recharge basins, and Santiago Creek
	Storm Flow	Precipitation from upper watershed flowing in Santa Ana River through Prado Dam	Santa Ana River, recharge basins, and Santiago Creek
Santiago Creek	Storm Flow / Santa Ana River	Storm flows in Santiago Creek and Santa Ana River water pumped from Burris Basin via Santiago Pipeline	Santiago Creek, Santa Ana River, recharge basins
Incidental Recharge	Precipitation and subsurface inflow	Precipitation and runoff from Orange County foothills, subsurface inflow from basin boundaries	Basin-wide
Recycled Water	Groundwater Replenishment System	Advanced treated wastewater produced at GWRS plant in Fountain Valley	Injected into Talbert Barrier and Mid-Basin Injection Wells, recharged in Kraemer, Miller, La Palma and Miraloma basins
	Water Replenishment District of Southern CA	Water purified at the Leo J. Vander Lans Treatment Facility in Long Beach	Injected into Alamitos Barrier
Imported Water	Untreated	State Water Project and Colorado River Aqueduct	Various recharge basins
	Treated	State Water Project and Colorado River Aqueduct treated at MWD Diemer Water Treatment Plant	Injected into Alamitos Barrier

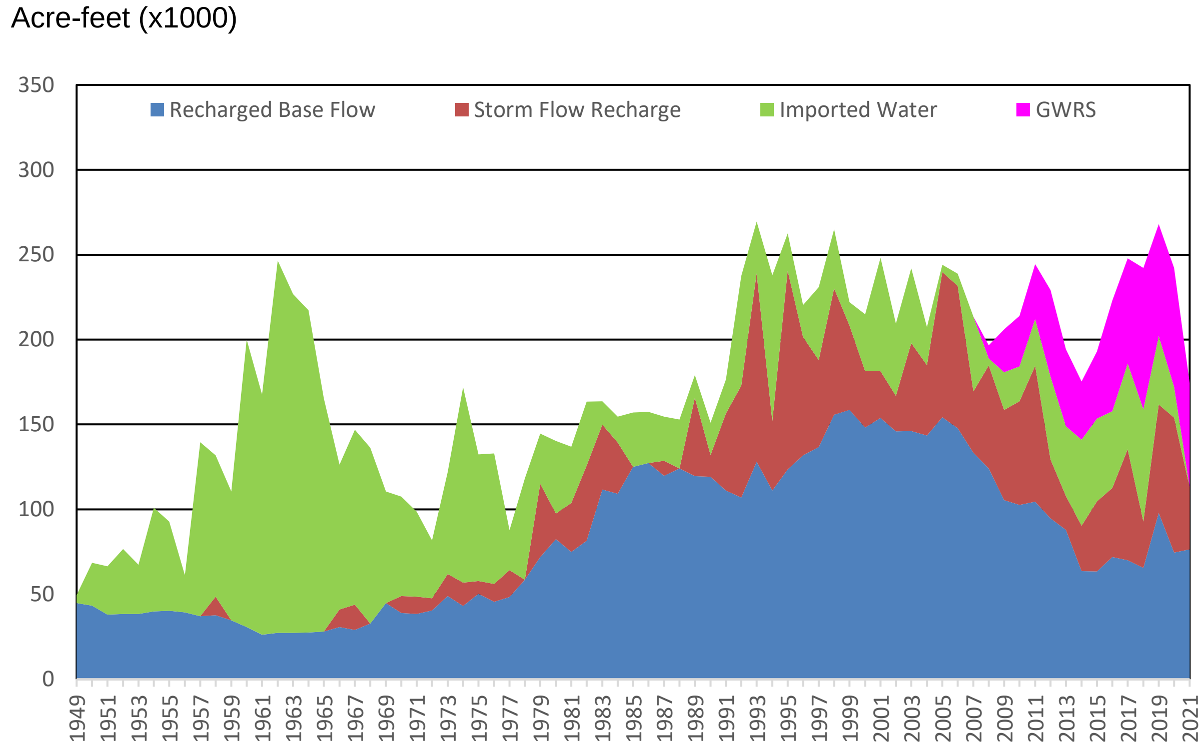


Figure 6-3: Historical Recharge in Surface Water Recharge System

Incidental Recharge

Incidental recharge is comprised of subsurface inflow from the local hills and mountains, infiltration of precipitation and irrigation water, recharge in small flood control channels, and groundwater underflow to and from Los Angeles County and the ocean. Since the amount of incidental recharge cannot be directly measured, it is also referred to as unmeasured recharge. Each year, an estimate is made of the amount of net incidental recharge based on OCWD's annual groundwater storage calculation. In general, since the Central Basin in Los Angeles County is usually operated at a lower level than the Orange County basin, there is usually a net flow of water out of the Orange County basin to the Central Basin. This outflow is subtracted from the total incidental recharge to get the net incidental recharge to the basin, which is the value reported in this document.

Recycled Water

The basin receives two sources of recycled water for recharge. The primary source is the GWRS, which currently has the capacity to produce 103,000 acre-feet per year of recycled water. This will be increasing to 134,000 acre-feet per year, when the GWRS Final Expansion is complete in 2023. Recycled water from the GWRS is percolated in the surface water system and injected into the Talbert Seawater Barrier, and the Mid-Basin Injection wells. Operation of GWRS is explained in detail in Section 5.

The second source of recycled water is the Leo J. Vander Lans Treatment Facility which supplies water to the Alamitos Seawater Barrier. The capacity of the Vander Lans Treatment

Facility was expanded from 3 mgd to 8 mgd but has generally not operated above 4 mgd for extended periods of time for various reasons. WRD is working on increasing this facility's online performance. A portion of the water recharged in the Alamitos Barrier recharges the Orange County Groundwater Basin with the remainder recharging the Central Basin in Los Angeles County.

Imported Water

OCWD purchases imported water for recharge from the Municipal Water District of Orange County (MWDOC), which is a member agency of MWD. Untreated imported water can be delivered to the surface water recharge system in multiple locations, including Anaheim Lake (OC-28/28A), Santa Ana River (OC-11), Irvine Lake (OC-13A), and San Antonio Creek near the City of Upland (OC-59). These locations are shown in Figure 6-4. Connections OC-28, OC-11 and OC-13A supply OCWD with Colorado River Aqueduct water. Connection OC-59 supplies OCWD with State Water Project water, and OC-28A (co-located with OC-28) supplies OCWD with a variable blend of water from these two sources.

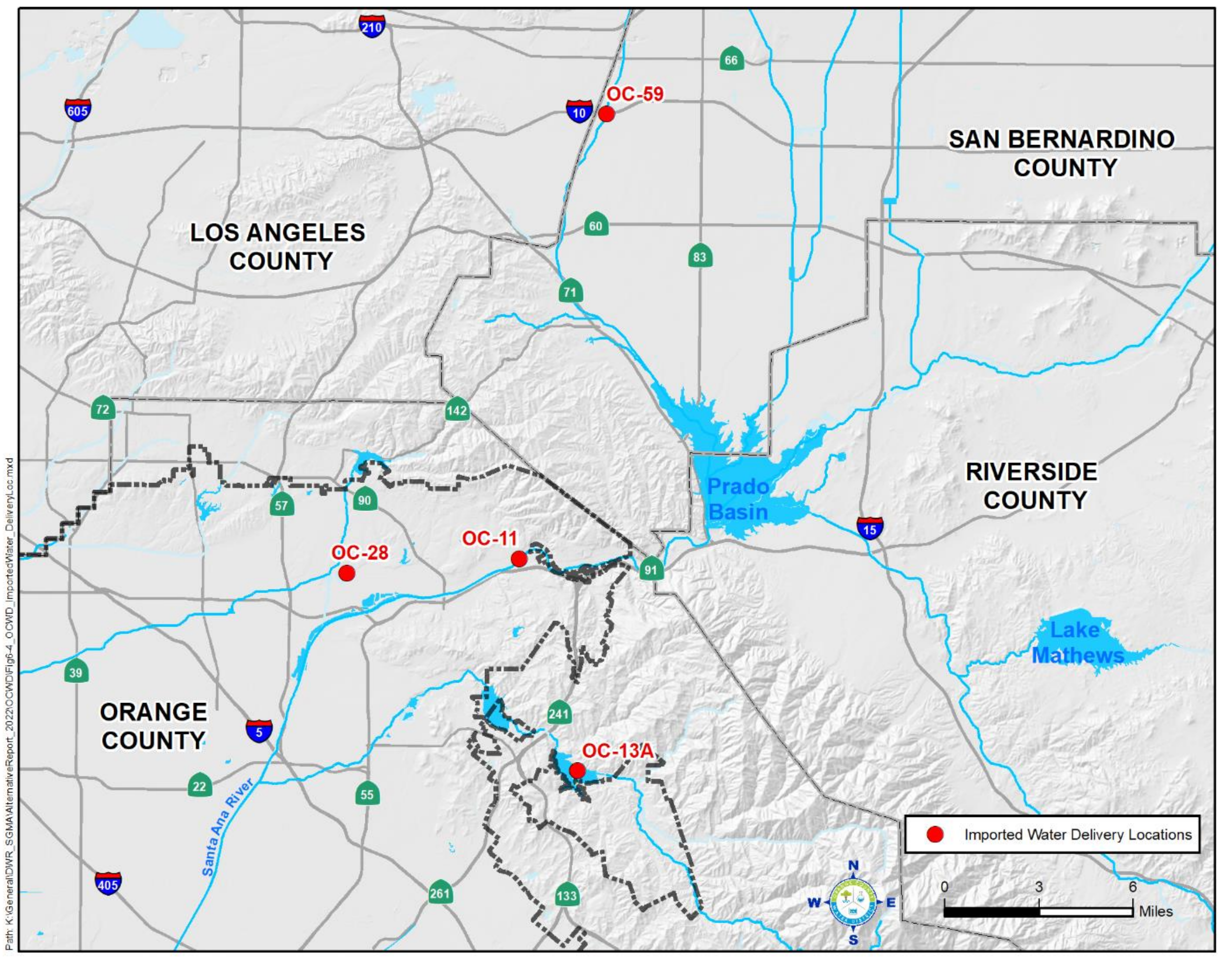


Figure 6-4: Locations of Imported Water Deliveries

Surface Water Recharge Facilities

OCWD operates a network of 25 surface water facilities located adjacent to the Santa Ana River in the City of Anaheim and Santiago Creek in the City of Orange as shown in Figure 6-5. The system has a total storage capacity of over 25,000 acre-feet. OCWD carefully tracks the amount of water being recharged in each facility on a daily basis.

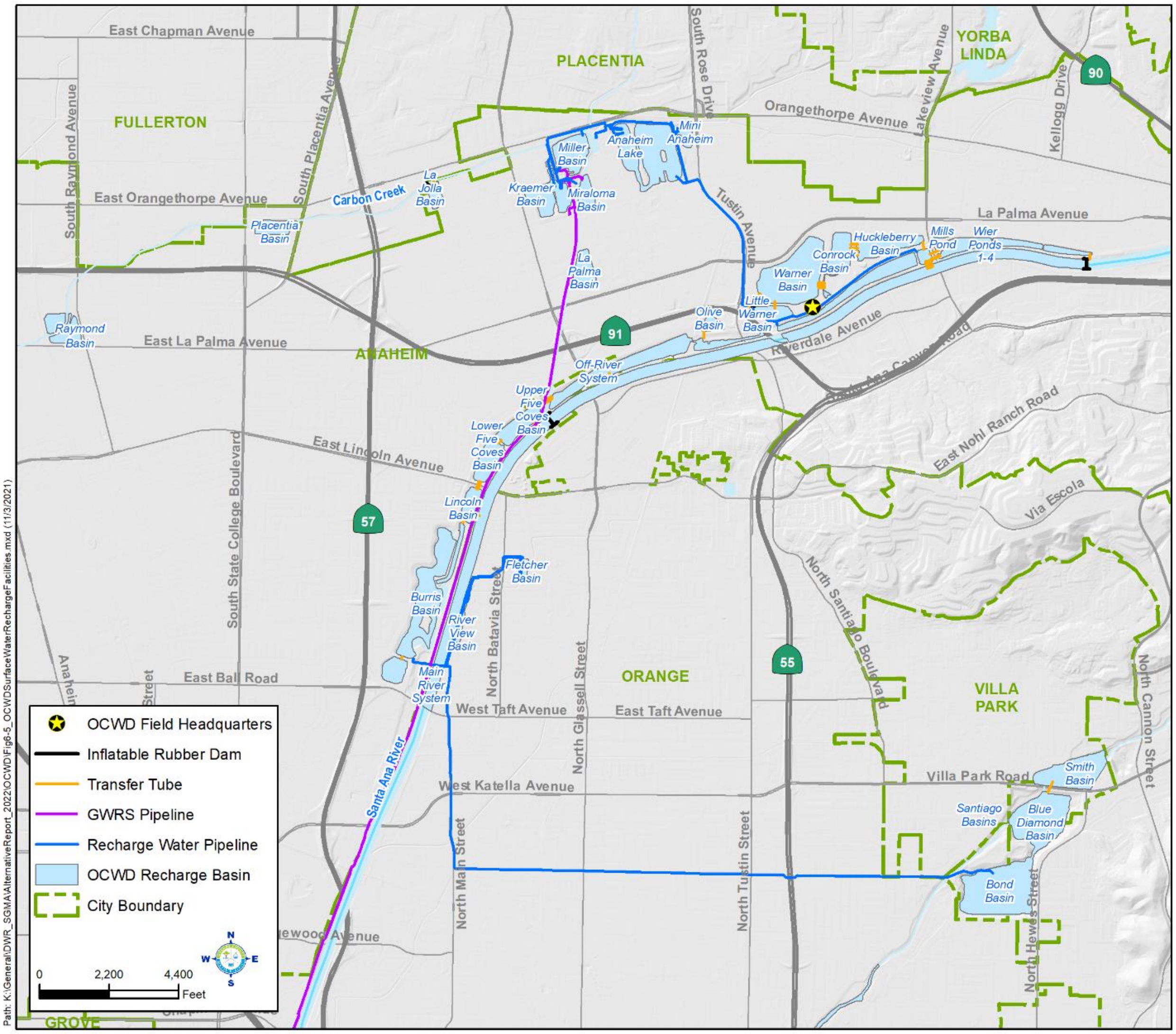


Figure 6-5: OCWD Surface Water Recharge Facilities

Three full-time hydrographers control and monitor the recharge system. These hydrographers and other OCWD staff prepare a monthly *Water Resources Summary Report*, which lists the source and volume for each recharge water supply, provides an estimate of the amount of water percolated in each recharge basin, documents total groundwater production from the basin, and estimates the change in groundwater storage. The report also estimates the amount of incidental recharge, evaporation and losses to the ocean – essentially a monthly water budget accounting. The monthly figures are compiled to determine yearly recharge and production totals and used in the year-end determination of groundwater storage change.

MANAGEMENT OF SEAWATER INTRUSION

In the coastal area of Orange County, the primary source of saline groundwater is seawater intrusion into the groundwater basin through permeable sediments underlying topographic lowlands or gaps between the erosional remnants or mesas of the Newport-Inglewood Uplift. Areas susceptible to intrusion are the Talbert, Bolsa, Sunset, and Alamitos gaps as shown in Figure 3-26.

Seawater intrusion in the Talbert Gap area began as early as the 1920s as the previously flowing artesian conditions within the shallow Talbert aquifer were gradually lowered until groundwater levels declined below sea level due to unrestricted agricultural pumping. By the 1930s and 1940s, seawater had advanced more than one mile inland within the Talbert Gap, forcing the closure of municipal supply wells owned and operated by the cities of Newport Beach and Laguna Beach due to elevated salinity.

Seawater intrusion became a critical problem in the 1950s. Overdraft of the basin caused water levels to drop as much as 40 feet below sea level. By the mid-1960s seawater had intruded nearly four miles inland within the Talbert Gap. Intrusion was also observed in the Alamitos Gap area along the Orange County/Los Angeles County border. During the 1950s and 1960s seawater intrusion investigations in coastal Orange County were conducted by the USGS, DWR and OCWD to define the nature and extent of the problem. During this time, OCWD slowed seawater intrusion by filling the basin with imported Colorado River water in the Anaheim Forebay area, thus reducing the overdraft throughout the basin and raising coastal groundwater levels (DWR, 1966).

Largely based on the 1966 DWR study, OCWD constructed the initial Talbert Seawater Intrusion Barrier in 1975 with 23 injection well sites. In 1965, a line of injection wells was constructed across the Alamitos Gap to form a subsurface freshwater hydraulic barrier. The Alamitos and Talbert barriers control seawater intrusion in their respective gaps by injecting fresh water into a series of multi-depth wells targeting each individual aquifer zone that is susceptible to seawater intrusion. The pressure mound resulting from this injection minimizes seawater intrusion through these gaps into the basin.

Both the Alamitos and Talbert barriers have been expanded and improved periodically and have allowed the basin to be operated more flexibly as a storage reservoir with an operating range of 500,000 acre-feet below full condition.

In July 2014, the OCWD Board of Directors adopted a Seawater Intrusion Prevention Policy that contained the following tenets:

- Prevent degradation of the quality of the groundwater basin from seawater intrusion
- Effectively operate and evaluate the performance of the seawater barrier facilities

- Adequately identify and track trends in seawater intrusion in susceptible coastal areas and evaluate and act upon this information, as needed, to protect the groundwater basin

Talbert Seawater Intrusion Barrier

The Talbert Barrier consists of 36 injection well sites, shown in Figure 3-26, with the primary alignment along Ellis Avenue approximately four miles inland from the ocean. Barrier injection raises groundwater levels in the immediate vicinity and thus creates a groundwater mound that acts as a hydraulic barrier to seawater that would otherwise migrate inland toward areas of groundwater production.

From 1975 until 2008, a blend of deep well water, imported water and recycled water from the former Water Factory 21 was injected into the barrier. In 2008, GWRS recycled water became the primary supply used for the injection wells, with a small and intermittent portion of the supply from potable imported water delivered via the City of Huntington Beach at the OC-44 turnout and potable water delivered by the City of Fountain Valley (a blend of groundwater and imported water). Since approval by the Regional Water Board in 2009, OCWD uses recycled water for all of the injection well supply at the Talbert Barrier.

Prior to GWRS, barrier capacity averaged approximately 15 mgd but now averages approximately 30 mgd with a typical seasonal range of 20 to nearly 40 mgd. Doubling the injection capacity was necessary to prevent seawater intrusion as groundwater production increased and was made possible by construction of additional injection wells and pipelines, superior water quality (GWRS water), and improved barrier operations, such as more frequent backwashing and rehabilitation. Barrier injection rates are adjusted based on overall basin storage conditions and seasonally varying coastal water levels. Therefore, injection is typically lower in the winter months and higher in the summer when increased coastal production causes lower coastal groundwater levels. Approximately 85 to 90 percent of barrier injection is typically targeted into the shallow and intermediate aquifer zones for seawater intrusion control on an annual basis, while the other 10 to 15 percent goes into the deeper Main aquifer zone primarily for basin replenishment. Based on the much steeper hydraulic gradient inland toward pumping depressions (relative to that toward the coast), OCWD estimates that approximately 95 percent of the water injected at the Talbert Barrier flows inland to replenish the basin, with the remainder ultimately flowing to the ocean as subsurface outflow.

Alamitos Seawater Intrusion Barrier

The Alamitos Barrier Project was initially constructed in 1964 and went into operation in 1965 to create a freshwater pressure ridge to prevent seawater intrusion from migrating through the Alamitos Gap into the Central Basin of Los Angeles County and the Orange County groundwater basin. The barrier alignment straddles the Los Angeles-Orange County line and spans approximately 1.8 miles across the Alamitos Gap from Bixby Ranch Hill in the City of Long Beach to the vicinity of Landing Hill in the City of Seal Beach.

Under the terms of the 1964 Agreement for Cooperative Implementation of the Alamitos Barrier Project (1964 Agreement), the barrier facilities are co-owned by OCWD and the Los Angeles County Flood Control District (LACFCD, a division of LACPW) and currently include 58 injection wells and 238 active monitoring wells as shown in Figure 3-26. The barrier is operated and maintained by LACPW under the direction of the Alamitos Barrier Joint Management Committee (JMC), whose membership includes OCWD, LACPW, WRD, City of Long Beach, and Golden State Water Company.

The barrier has been incrementally expanded over time to include the construction of additional injection and monitoring wells. Since the initial 14 injection wells were constructed in 1964, an additional 44 injection wells have been installed over eight phases of well construction. Most recently in 2018, with the addition of 17 new injection wells at 8 locations to control breaches through the barrier where well spacing was too large and injection capacity too small.

Similar to the Talbert Barrier, the Alamitos Barrier consists of both nested and cluster-type injection wells screened discretely in each aquifer zone in order to control the injection rate and injection pressure into each targeted aquifer zone independently since each aquifer zone has different physical characteristics and groundwater levels. In addition, there are a couple “dual-point” injection wells that consist of only one well casing, but two different screened interval depths separated inside the well by an inflatable packer and two separate injection drop pipes.

SECTION 7 NOTICE AND COMMUNICATION

DESCRIPTION OF GROUNDWATER USERS

The local agencies that produce the majority of the groundwater from the basin are listed in Table 7-1 with geographic boundaries shown in Figure 3-3. OCWD meets monthly with 19 major water retail agencies, referred to as the groundwater producers, to discuss and evaluate basin management issues and proposed projects and work cooperatively among the agencies in the OCWD Management Area.

Table 7-1: Major Groundwater Producers

CITIES		
Anaheim	Huntington Beach	Santa Ana
Buena Park	La Palma	Seal Beach
Fountain Valley	Newport Beach	Tustin
Fullerton	Orange	Westminster
Garden Grove		

WATER DISTRICTS AND WATER COMPANIES	
East Orange County Water District	Mesa Water District
Golden State Water Company	Serrano Water District
Irvine Ranch Water District	Yorba Linda Water District

The monthly meeting with OCWD staff and the groundwater producers provides a forum for the groundwater producers to provide their input to OCWD on important issues such as:

- Setting the Basin Production Percentage (BPP) each year
- Reviewing the merits of proposed capital improvement projects
- Purchasing imported water to recharge the groundwater basin
- Reviewing water quality data and regulations
- Maintaining and monitoring basin water quality
- Budgeting, replenishment assessment and considering other important policy decisions

PUBLIC PARTICIPATION

On September 30, 2021, OCWD sent a letter via email to all of the Basin 8-1 agencies to inform them that the 2017 Alternative was being updated and would be available for review and comment. No comments were received by any of the agencies contacted.

A draft of the 2022 Update was presented to the OCWD Board and posted on the OCWD website on November 18, 2021, to allow for public review and comment. The final 2022 Update was presented to the OCWD Board on December 15, 2021. At this board meeting, a resolution was adopted to support the submission of the 2022 Update to DWR.

COMMUNICATION PLAN

Proactive community outreach and public education are central to OCWD. The 2017 Alternative provides detailed information on OCWD's communication plan.

SECTION 8 SUSTAINABLE BASIN MANAGEMENT

SUSTAINABILITY GOAL

The sustainability goal for the OCWD Management Area is as follows:

> Continue to manage the groundwater basin to prevent basin conditions that would lead to significant and unreasonable undesirable results as defined by California Water Code Section 10721(x).

Existing monitoring and management programs in place today enable OCWD to sustainably manage the groundwater basin. Since its formation in 1933, OCWD has developed a managed aquifer recharge program, constructed hundreds of monitoring wells, developed water quality monitoring programs, constructed a large surface water recharge system, installed seawater intrusion barriers, and managed the volume of groundwater production through a scientifically based understanding of the basin's sustainable yield and the use of financial incentives. Continued successful protection of the groundwater basin requires that OCWD's management of the basin be able to adapt to changing conditions affecting the groundwater basin. The following sections describe the sustainable basin management for each of the undesirable results as defined in the California Water Code, Section 10721(x).

SECTION 9 SUSTAINABLE MANAGEMENT RELATED TO GROUNDWATER LEVELS

HISTORY/SUMMARY

OCWD manages the basin for long-term sustainability by maximizing recharge of the basin and managing basin production within sustainable levels. This section will discuss the relationship between groundwater elevations and sustainable groundwater management.

Groundwater elevations over the last twenty years exhibit short-term changes and long-term (multi-year) trends see Figures 3-10 through 3-13). Short-term elevation changes typically reflect seasonal variations in pumping and recharge, while multi-year trends reflect the effects of extended periods of above- or below-average precipitation and/or availability of imported water.

Groundwater elevation is monitored at over 1,000 individual measuring points, including key wells formerly designated under the CASGEM program which has been superseded by annual reporting required under SGMA. OCWD will be reporting water level data for the basin except for the La Habra-Brea Management Area.

In general, groundwater elevations in the Shallow Aquifer system show less amplitude than those in the underlying Principal and Deep Aquifer systems due to the higher degree of pumping and confinement of the Principal and Deep Aquifer systems. Because approximately 95 percent of all production occurs from wells screened within the Principal Aquifer system, groundwater elevations within this system are typically lower than those in the overlying Shallow Aquifer system and, in some areas, the underlying Deep Aquifer system. Vertical hydraulic gradients created by pumping and recharge drive groundwater into the Principal Aquifer system from the overlying Shallow Aquifer system and, to a lesser extent, from the Deep Aquifer system.

Long-term data demonstrates that groundwater elevations in the basin have exhibited multi-year cyclical patterns and have not experienced chronic lowering due to OCWD's management approach of maintaining basin storage within the established operating range. As a result, the undesirable effect of "chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply" is not occurring in the OCWD Management Area and is not expected to occur in the future as OCWD continues to manage the basin as described in this report.

MONITORING OF GROUNDWATER LEVELS FOR SUSTAINABILITY

As explained in Section 3.2, OCWD monitors water levels at over 1,000 individual measuring points on a monthly or bi-monthly basis to evaluate the effects of pumping, recharge or injection operations. Additional monitoring is conducted as needed in the vicinity of OCWD's recharge facilities, seawater barriers and areas of special investigation where drawdown, water quality impacts or contaminants are of concern.

Groundwater elevation contour maps for the Shallow, Principal and Deep Aquifers are prepared annually and are scanned and digitized into OCWD's GIS database. Figures 3-5, 3-6, and 3-7 show the groundwater elevation contours for June 2021 for all three basin aquifers. The changes in groundwater elevations for the three aquifers are also calculated on an annual basis. The water level changes for each of the three aquifers for June 2020 to June 2021 are shown in Figures 9-1, 9-2 and 9-3.

MANAGEMENT OF GROUNDWATER LEVELS FOR SUSTAINABILITY

For each of the three major aquifer systems, GIS mapping is used to multiply the water level changes by a grid of aquifer storage properties from OCWD's calibrated groundwater flow model. This results in a storage change volume for each of the three aquifer layers which are totaled to provide a net annual storage change for the basin. Thus, measurements of groundwater elevations are ultimately used to calculate total basin storage levels each year.

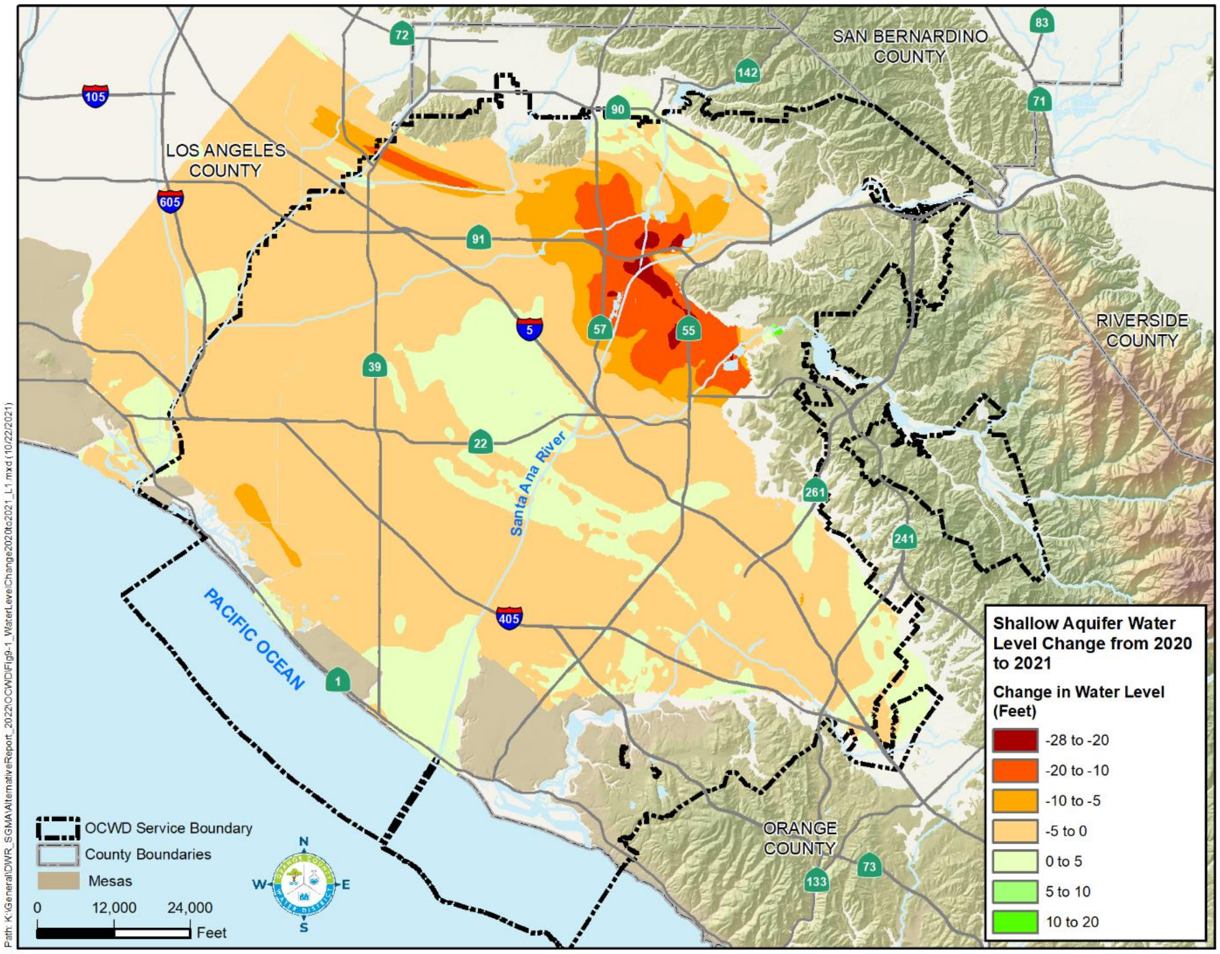


Figure 9-1: Shallow Aquifer Water Level Change, June 2020 to June 2021

In determining the operating range for groundwater storage levels, OCWD considered the potential negative impacts that could occur due to unreasonable and chronic lowering of groundwater elevations. These potential negative impacts include increased costs for groundwater producers to pump groundwater, decreased yield in production wells, increased risk of land subsidence, and increased risk of seawater intrusion.

Monitoring and management of groundwater elevations in the OCWD Management Area is most important in the coastal areas in order to protect groundwater basin water quality from seawater intrusion. Management programs that enable long-term sustainable basin management related to groundwater elevations in the coastal areas include the operation of the Alamitos and Talbert Seawater Intrusion Barriers and the Coastal Pumping Transfer Program.

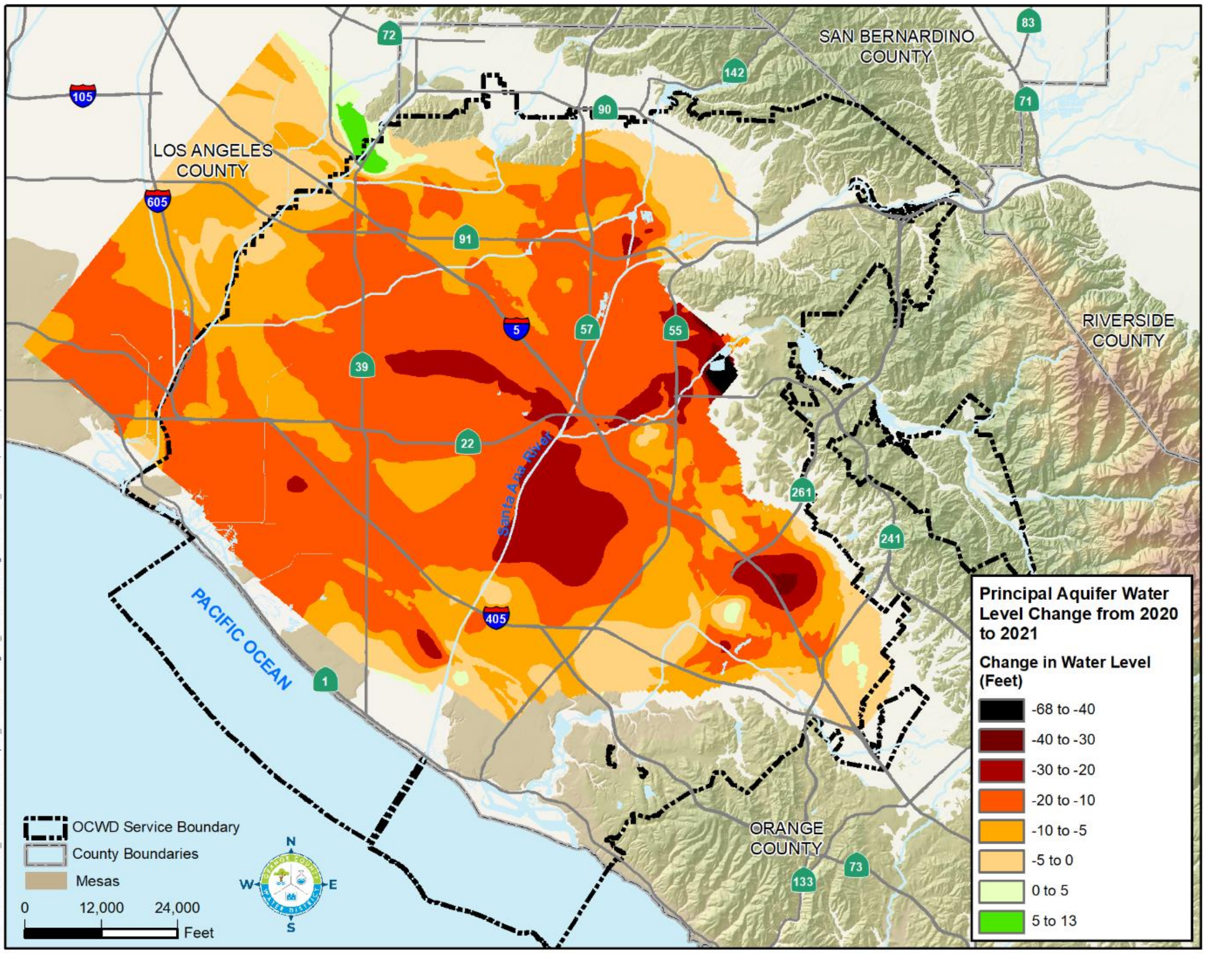


Figure 9-2: Principal Aquifer Water Level Change, June 2020 to June 2021

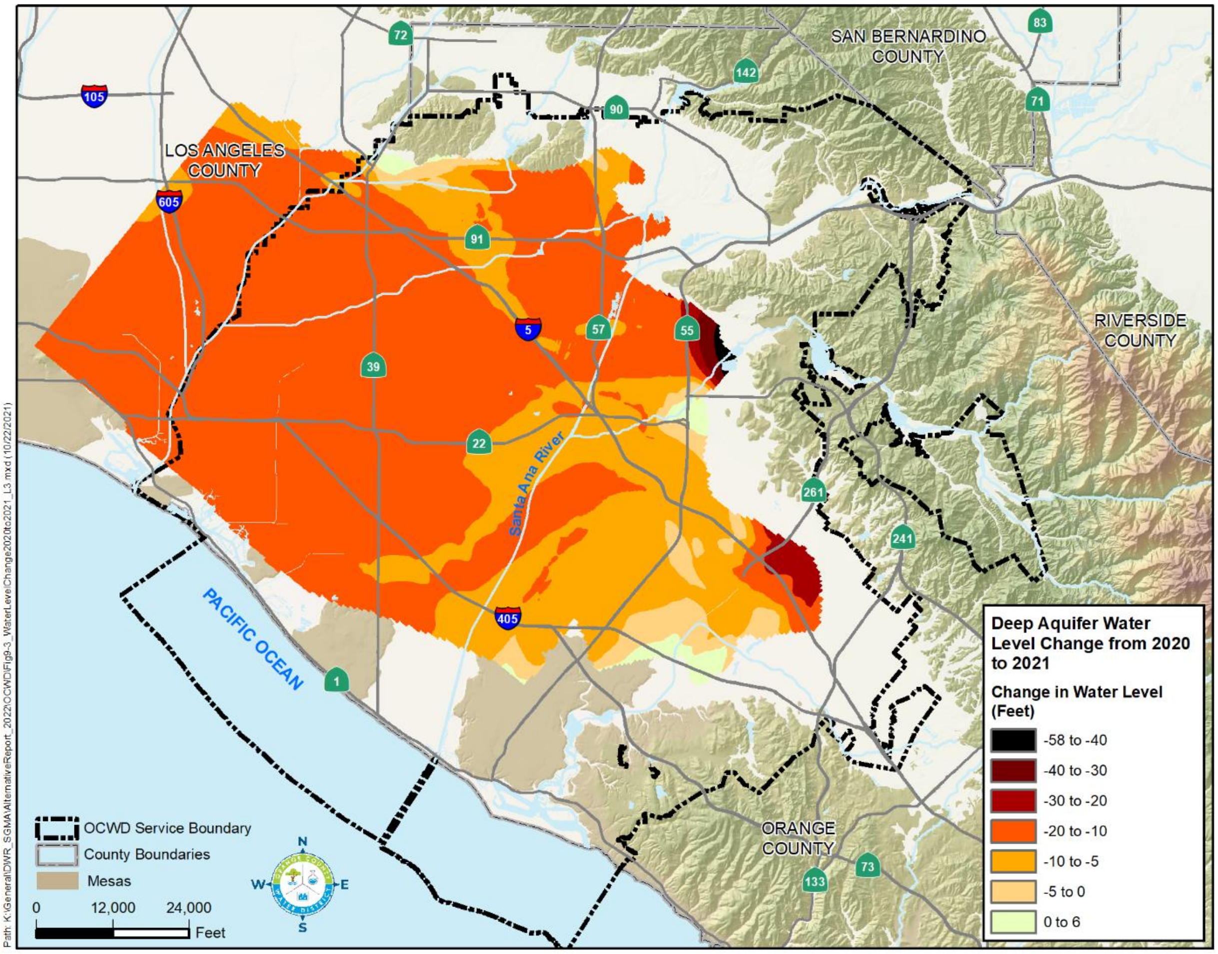


Figure 9-3: Deep Aquifer Water Level Change, June 2020 to June 2021

DEFINITION OF SIGNIFICANT AND UNREASONABLE LOWERING OF GROUNDWATER LEVELS

OCWD closely monitors groundwater levels in the three major aquifer systems (Shallow, Principal and Deep) for a number of purposes including determination of groundwater storage within the basin. OCWD uses groundwater storage conditions to manage the basin sustainably by keeping storage levels within an operating range up to 500,000 acre-feet below full condition. Significant and unreasonable reduction of groundwater in storage could occur in the event that the volume of groundwater in storage fell below the 500,000 acre-feet below full condition for an extended period of time. If OCWD were to consider an operating range below 500,000 acre-feet from full condition, additional analysis and monitoring would be needed.

DETERMINATION OF MINIMUM THRESHOLD

The minimum threshold for significant and unreasonable reduction in groundwater levels is reached when the storage volume of the groundwater basin falls below the operating range of up to 500,000 acre-feet below full condition for an extended period of time.

SECTION 10 SUSTAINABLE MANAGEMENT RELATED TO BASIN STORAGE

HISTORY

Within the Orange County Groundwater Basin, there is an estimated 66 million acre-feet of water in storage (OCWD, 2007). In spite of the large amount of stored water, there is a comparatively narrow operating range within which the basin can be safely operated.

The operating range of the basin is considered to be the maximum allowable storage range over the long-term without incurring detrimental impacts. The upper limit of the operating range is defined by the full basin condition. Although it may be physically possible to fill the basin higher than this full condition, it could lead to detrimental impacts such as percolation reductions in recharge facilities and increased risk of shallow groundwater seepage in low-lying coastal areas.

The lower limit of the operating range is considered to be 500,000 acre-feet below full condition. Although it may be considered to be acceptable to allow the basin to decline below 500,000 acre-feet below full condition for brief periods due to severe drought conditions and lack of imported water for basin recharge, it is not considered to be an acceptable management practice to intentionally manage the basin for sustained periods at this lower limit for the following reasons:

- Increased risk of seawater intrusion
- Increased risk of land subsidence
- Depletion of water in storage available for future drought conditions
- Some wells potentially becoming inoperable due to lower groundwater levels
- Increased costs to pump groundwater for groundwater users
- Increased potential for upwelling of amber-colored groundwater from the Deep Aquifer

It is important to note that detrimental impacts do not suddenly happen when storage levels fall to 500,000 or more acre-feet below full condition; rather, they occur incrementally, or the potential for their occurrence grows as the basin declines to lower levels. OCWD has used the basin model computer simulations to evaluate the potential for detrimental impacts if storage were to fall to 700,000 acre-feet from full. Basin model runs at 700,000 acre-feet below full condition indicates the potential for increased seawater intrusion and considerably more production wells being impacted by low pumping levels. Thus, a reduction of up to 700,000 acre-feet of groundwater in storage is only considered acceptable during an extreme emergency, such as a disruption in imported water supplies due to an earthquake. Negative or adverse impacts that are considered when establishing the operating range include chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the long-term, increased seawater intrusion, significant and unreasonable land subsidence that substantially interferes with surface land uses, and increased pumping costs.

The current policy of maintaining a groundwater storage level of up to 500,000 acre-feet below full was established based on completion of a comprehensive hydrogeological study of the basin in 2007 (OCWD, 2007).

The basin's storage level is quantified based on a benchmark defined as the full basin condition. Although the groundwater basin rarely reaches the full basin condition, basin storage has fluctuated within the operating range for many decades. OCWD manages groundwater pumping such that it is sustainable over the long term; however, in any given year pumping may exceed recharge or vice versa. Thus, the amount of groundwater stored in or withdrawn from the basin varies from year to year and often goes through multi-year cycles of emptying and filling, which generally correlates with state-wide and/or local precipitation patterns.

Each year OCWD calculates the volume of groundwater storage change from a theoretical "full" benchmark condition based on a calculation using changes in groundwater elevations in each of the three major aquifer systems and aquifer storage coefficients. This calculation is checked against an annual water budget that accounts for all production, measured recharge, and estimated unmeasured recharge. The amount of available or unfilled storage from the theoretical full condition from WY1958-59 to 2020-21 is shown in Figure 1-3.

Maintaining the basin storage condition on a long-term basis within this operating range allows for long-term sustainable management of the basin without experiencing undesirable effects. Short-term excursions from the operating range due to extreme drought or other factors are not expected to cause adverse impacts but would need to be monitored closely and be of limited duration. In the California Water Plan Update 2013 (DWR, 2014) this manner of groundwater basin management is described as follows:

> "Change in groundwater storage is the difference in stored groundwater volume between two time periods…However, declining storage over a period characterized by average hydrologic conditions does not necessarily mean that the basin is being managed unsustainably or is subject to conditions of overdraft. Utilization of groundwater in storage during years of diminishing surface water supply, followed by active recharge of the aquifer when surface water or other alternative supplies become available, is a recognized and acceptable approach to conjunctive water management." (p. SC-77)

CALCULATION OF GROUNDWATER STORAGE LEVELS

The estimated historical minimum storage level of 500,000 to 700,000 acre-feet below full condition occurred in 1956-57 (DWR, 1967; OCWD, 2003). Since this time, the basin storage fluctuated within the operating range reaching a full condition in 1969 and 1983.

OCWD uses two methods to calculate the storage condition of the basin: (1) water budget method and (2) three-layer storage change method. The water budget method is simply an accounting of the inflows to the basin and outflows. This data is collected and compiled on a monthly basis. Estimates of unmeasured or incidental recharge are used based on a statistical relationship between historical local precipitation and calculated unmeasured recharge. Unmeasured recharge is trued up at the end of the year with the final reports of inflows and outflows and basin storage change (based on groundwater level changes). This method produces a monthly estimate of the change in groundwater storage and allows for real-time decision making with respect to managing the basin.

In 2007, OCWD instituted a new three-layer change in storage method for calculating the amount of groundwater in storage (OCWD, 2007). The three-layer method involves creating groundwater elevation contour maps for each of the three aquifer layers (Shallow, Principal and Deep aquifers) for conditions at the end of June of each year. Prior to this time, groundwater storage was determined based on a single groundwater elevation map that was essentially a composite of the Shallow and Principal aquifers.

SUSTAINABLE MANAGEMENT PROGRAMS

Basin Operating Range

Each year OCWD assesses current basin storage and projected water supply availability as factors in establishing how much groundwater can be pumped from the basin for the following year. If basin storage approaches or falls within the lower end of the established operating range, issues that are evaluated when considering the management of the basin include the current status of seawater intrusion protective measures, monitoring of ground surface elevations to assess the risk of land subsidence, inflow of amber-colored water or poor quality groundwater into the Principal Aquifer from underlying or overlying aquifers, and the number of shallow production wells that would become affected by lower groundwater levels. On the other hand, when operating the basin near the higher end of the storage range, considerations include the potential to increase groundwater pumping, purchase less imported replenishment water, and the potential for more groundwater outflow to Los Angeles County.

Balancing Production and Recharge

Over the long-term, the basin must be maintained in an approximate balance to ensure the long-term viability of basin water supplies. In a given year, water withdrawals may exceed water recharged as long as over the course of a number of years this is balanced by years where water recharged exceeds withdrawals. Levels of total basin production and total water recharged since WY1999-00 are shown in Figure 1-4.

Managing Basin Pumping

The primary mechanisms used by OCWD to manage pumping are the Basin Production Percentage (BPP) and the Basin Equity Assessment (BEA). The ability to assess the BPP and the BEA were provided to OCWD through an amendment to the OCWD Act in 1969. Section 31.5 of the OCWD Act empowers the Board to annually establish the BPP, defined as:

> "…the ratio that all water to be produced from groundwater supplies with the district bears to all water to be produced by persons and operators within the District from supplemental sources and from groundwater within the District during the ensuing water year."

In other words, the BPP is a percentage of each Producer's water supply (supplemental and groundwater sources) that comes from groundwater pumped from the basin. The BPP is set uniformly for all groundwater producers. Groundwater production at or below the BPP is assessed the Replenishment Assessment (RA). Production above the BPP is charged the RA plus the Basin Equity Assessment (BEA). The BEA is set by the Board and is presently calculated so that the cost of groundwater production above the BPP is equivalent to the cost of purchasing imported potable supplies. This approach serves to discourage, but not eliminate, production above the BPP. In practice, groundwater producers rarely pump in excess of the BPP as doing so triggers a requirement to pay the BEA, thereby eliminating any cost savings that a pumper might obtain by pumping an amount in excess of the BPP. Collection of the BEA provides funds for OCWD to purchase additional replenishment water (where determined appropriate by OCWD). If necessary, the BEA can be increased to further discourage production above the BPP.

The BPP is set after evaluating groundwater storage conditions, availability of recharge water supplies and basin management objectives. OCWD's goal is to set the BPP as high as possible to allow groundwater producers to sustainably maximize pumping and reduce their overall water supply cost.

To change the BPP, the Board of Directors must hold a public hearing. Raising or lowering the BPP allows OCWD to manage the amount of pumping from the basin. The BPP is lowered when basin conditions necessitate a decrease in pumping. A lower BPP results in the need for groundwater producers to purchase additional, more expensive imported water.

The methodology for setting the BPP and OCWD polices related to the BPP are described further in the 2017 Alternative.

Table 10-1 shows the management actions to be used to guide OCWD in setting the BPP. As the BPP is annually set in April for the following fiscal year (but may be changed throughout the year), the projected change in basin storage would be estimated for the end of that fiscal year (as of June 30), given various assumptions of basin pumping, inflows and outflows. Maintaining some available storage space in the basin allows for maximizing surface water recharge when such supplies are available, especially in relatively wet years. By keeping the basin relatively full during wet years and for as long as possible in years with near-normal recharge, the maximum amount of groundwater could be maintained in storage for future drought conditions. During dry hydrologic years when less water would be available for recharge, the BPP could be lowered to maintain groundwater storage levels.

At the beginning of 2015, OCWD committed to purchase 650,000 acre-feet of imported water to recharge the basin over a ten-year time period. This amount of imported water for recharge into the basin will help maintain the BPP and assist in managing the basin storage level within the operating range. OCWD works to maintain a Water Reserve Fund to purchase imported water from MWD. Each year, a specific amount of money is budgeted to purchase imported water and, if water is not available from MWD, the funds are carried over to the next year in the Water Reserve Fund.

Table 10-1: Management Actions based on Change in Groundwater Storage

Available Storage Space (amount below full basin condition)	Basin Management Actions to Consider
Less than 100,000 acre-feet	Raise BPP
100,000 to 300,000 acre-feet	Maintain and/or raise BPP towards 75% goal
300,000 to 350,000 acre-feet	Seek additional supplies to refill basin and/or lower the BPP
Greater than 350,000 acre-feet	Seek additional supplies to refill basin & lower the BPP

Basin Production Limitation

Another management tool that enables OCWD to sustainably manage the basin is the Basin Production Limitation. Section 31.5(g)(7) of the OCWD Act authorizes limitations on production and the setting of surcharges when those limits are exceeded. This provision can be used when it is necessary to shift pumping from one area of the basin to another. An example of this is the Coastal Pumping Transfer Program, which shifts pumping from the coastal area to inland to minimize seawater intrusion, when necessary.

Supply Management Strategies

One of OCWD's basin management objectives is to maximize groundwater recharge. This is achieved through increasing the efficiency of and expanding OCWD's recharge facilities and the supply of recharge water. Construction and operation of the GWRS has provided a substantial increase in supply of water available to recharge the basin. Additional OCWD supply management programs include developing increased stormwater capture programs behind Prado Dam in cooperation with the U.S. Army Corps of Engineers, encouraging and participating in water conservation efforts, and working with MWD and the Municipal Water District of Orange County in developing and conducting other supply augmentation projects and strategies.

DEVELOPING NEW LOCAL WATER RESOURCES POLICY

In July 2020, the District adopted a policy called the Developing New Local Water Resources Policy to acknowledge that the local multi-billion-dollar economy and 2.5 million citizens that rely on groundwater as their primary water supply require a reliable, sustainable and economical water source to remain healthy and strong. It further acknowledges that the imported water that is purchased annually to meet the needs of the groundwater producers is becoming uncertain as environmental, agricultural, and urban interests maneuver to obtain a greater share and is susceptible to impacts from climate change. The Policy contains the following tenets:

- The District recognizes the impacts of climate change and their ability to disrupt predictions of future local water supplies for the District's service territory
- The District will evaluate and undertake economical and environmentally sensitive projects and programs to work towards the goal of ensuring adequate water supplies are always available to its service territory
- The types of projects that will be evaluated include: (1) Maximizing Santa Ana River base and storm flow capture, (2) Increasing water conservation, (3) Increasing water recycling, (4) Improving the reliability of imported water supplies, (5) Brackish water desalination, (6) weather modification/cloud seeding; and (7) Seawater desalination

Conjunctive Use and Water Transfers

By agreement with OCWD, MWD established a Conjunctive Use Project (CUP) in the OCWD Management Area by purchasing the right to store up to 66,000 acre-feet of water in the groundwater basin until 2028. OCWD used the funds provided by MWD to improve basin management facilities including the construction of eight new production wells for water retail agencies and new injection wells for the Talbert Barrier. Under the agreement, MWD may request that stored water be extracted up to a maximum of 22,000 acre-feet each year.

OCWD reviews opportunities for additional conjunctive use projects that would store water in the basin and potentially in other groundwater basins. Additionally, OCWD reviews opportunities for water transfers that could provide additional sources of recharge water. Such projects are evaluated carefully with respect to their impact on available storage, reliability and cost effectiveness.

Water Demands

Water demands within the OCWD Management Area for WY2016-17 to 2020-21 averaged 400,000 acre-feet per year (Figure 6-1). Total demand includes the use of groundwater, surface water from Santiago Creek and Irvine Lake, recycled water, and imported water.

Projected Water Demands

OCWD estimated future total water demands (including recycled water) within the OCWD Management Area to be approximately 431,000 acre-feet per year in 2050. This is based on a water demand study jointly funded by OCWD and MWDOC. This study was undertaken to assist the 19 major groundwater producers in the development of their 2020 Urban Water Management Plans. Water Demands within the OCWD Management Area was determined by summing the 19 producer future estimates and water produced by private, mutual water company, and irrigation wells.

Drought Management

During a drought, flexibility to manage pumping from the basin becomes increasingly important. The OCWD Management Area may experience a decline in the supply of recharge water (local supply of Santa Ana River water and net incidental recharge) of 55,000 acre-feet per year or more during drought.

Provided that the basin has available water in storage within the established operating range, this stored water provides a valuable water supply asset during drought conditions. Ensuring that the basin can provide a buffer against drought conditions requires:

- Maintaining sufficient water in storage that can be pumped out in time of need; and
- Possessing a plan to recover basin storage following the drought, including having a reserve account with sufficient funds to purchase replenishment water.

A sufficient supply of stored groundwater provides a safe and reliable buffer to manage for drought periods. If the basin, for example, has an available storage level of 150,000 acre-feet and can be drawn down to 500,000 acre-feet without irreparable seawater intrusion, a supply of 350,000 acre-feet is available for increased production. In a hypothetical five-year drought, an additional 70,000 acre-feet per year may be produced from the basin for five years without jeopardizing the long-term health of the basin. In addition to reducing pumping when the basin is at lower storage levels, planning for refilling the basin is important. Approaches for refilling the basin are described in Table 10-2.

DEFINITION OF SIGNIFICANT AND UNREASONABLE REDUCTION OF GROUNDWATER STORAGE

OCWD manages the groundwater basin to maintain groundwater storage levels within an operating range of up to 500,000 acre-feet below the full condition. Significant and unreasonable reduction of groundwater in storage would occur when the volume of groundwater in storage fell below the 500,000 acre-feet below full condition for an extended period of time. If OCWD were to consider an operating range below 500,000 acre-feet additional analysis and monitoring would be needed.

Table 10-2: Approaches to Refilling the Basin

APPROACH	DISCUSSION
Decrease Total Water Demands	• Increase water conservation and water-use efficiency measures
Decrease BPP	• Allows groundwater levels to recover rapidly • Decreases revenue to the OCWD • Increases water cost for groundwater producers • Does not require additional recharge facilities • Dependent upon other sources of water (e.g., imported water) being available to substitute for reduced groundwater pumping
Increase Recharge	• Dependent on increased supply of recharge water • Replenishment could be in the form of in-lieu water (additional imported water delivered to groundwater producers instead of groundwater pumping) • Water transfers and exchanges could be utilized to provide the increased supply of recharge water • May be dependent on building and maintaining excess recharge capacity (which may be underutilized in non-drought years)
Combination of the Above	• A combination of the approaches provides flexibility and a range of options for refilling the basin

DETERMINATION OF MINIMUM THRESHOLDS

The minimum threshold for significant and unreasonable reduction in groundwater in storage is reached when the storage volume of the groundwater basin falls below the operating range of up to 500,000 acre-feet below full condition for an extended period of time.

SECTION 11 SUSTAINABLE MANAGEMENT RELATED TO WATER QUALITY

OCWD has extensive monitoring and management programs in place to protect the groundwater basin from significant and unreasonable degradation of water quality including migration of contaminant plumes that impair water supplies. These programs include monitoring, remediation of contaminated groundwater, and recharging high-quality recycled water. This section describes sustainable basin management related to the water quality programs and projects instituted to prevent degradation of water quality and to remediate water quality problems in the OCWD Management Area.

SALINITY MANAGEMENT

Management of salt and nitrate concentrations in groundwater is important to maintaining the long-term sustainable use of groundwater supplies. OCWD also operates the Prado Wetlands to remove nitrate from Santa Ana River (SAR) water that is recharged into the groundwater basin. These efforts help provide high-quality groundwater to water users in Orange County.

In 2020, OCWD completed an evaluation of future TDS and nitrate concentrations in the Orange and Irvine Management Zones (OCWD, 2020). Figure 3-16 shows the areal extent of these zones, which are not to be confused with the OCWD Management Area that is the subject of this report. The 2020 update is similar to an analysis conducted in 2016 (OCWD, 2016) and involved using a model to evaluate the effects of different basin management scenarios on TDS and nitrate concentrations over the next 30 years. One of the key outputs of the model is the calculated ambient TDS and nitrate concentrations for groundwater in the Orange and Irvine Management Zones. The model-calculated ambient concentration represents a volume-weighted average value for the Shallow and Principal Aquifers. The report was prepared to meet regulatory requirements of the Regional Water Board as part of the watershed-wide salt and nutrient management plan.

Data and information used for this analysis included:

- Quantity and quality of water recharged through surface recharge facilities and injection wells
- Quantity and quality of unmeasured recharge, such as percolation of irrigation water into the groundwater basin
- Measurements of groundwater pumping
- Estimates of groundwater outflow from the Orange Management Zone

The most significant change from the prior analysis is the impact of the GWRS Final Expansion, which increases the volume of low-TDS recycled water recharged by 30,000 acre-feet per year. Because OCWD is obtaining the additional water from OC San Plant No. 2, the overall TDS of the recycled water generated increases slightly from 60 mg/L to 86 mg/L.

The quantity and quality of water recharged in the model for the Baseline Scenario are shown in Table 11-1.

Table 11-1: Baseline Projected Future Salt Inflows

Source of Water Recharge	Volume (acre-feet/yr)	TDS Conc. (mg/L)	Mass (tons/yr)
Deep percolation of precipitation*	6,500	100	900
Percolation of applied water*	9,000	1,900	23,200
Subsurface inflow*	44,500	1,290	78,200
SAR base flow	52,000	700	49,500
SAR storm flow	50,000	200	13,600
Recycled water (GWRS)	133,000	86	15,600
Alamitos Barrier	2,500	350	950
MWD imported water	0	0	0
Total	297,000	449	181,200

*Component of unmeasured recharge

The Baseline Scenario assumes that no imported water is used for recharge for the 30-year period and is utilized to compare with other model runs and determine how changing model inputs affect the predicted concentration. The projected trend for TDS for the Baseline declines from the current ambient groundwater concentration of 603 mg/L to 569 mg/L in 30 years as shown in Figure 11-1. Seven additional scenarios were run to model different quantities of recharge source water. The projected 30-year TDS for these scenarios range from 559 mg/L to 580 mg/L. This shows the tremendous impact of low-TDS GWRS water in lowering the overall salinity in the basin over time regardless of how much water is obtained from other recharge sources, such as higher TDS imported water.

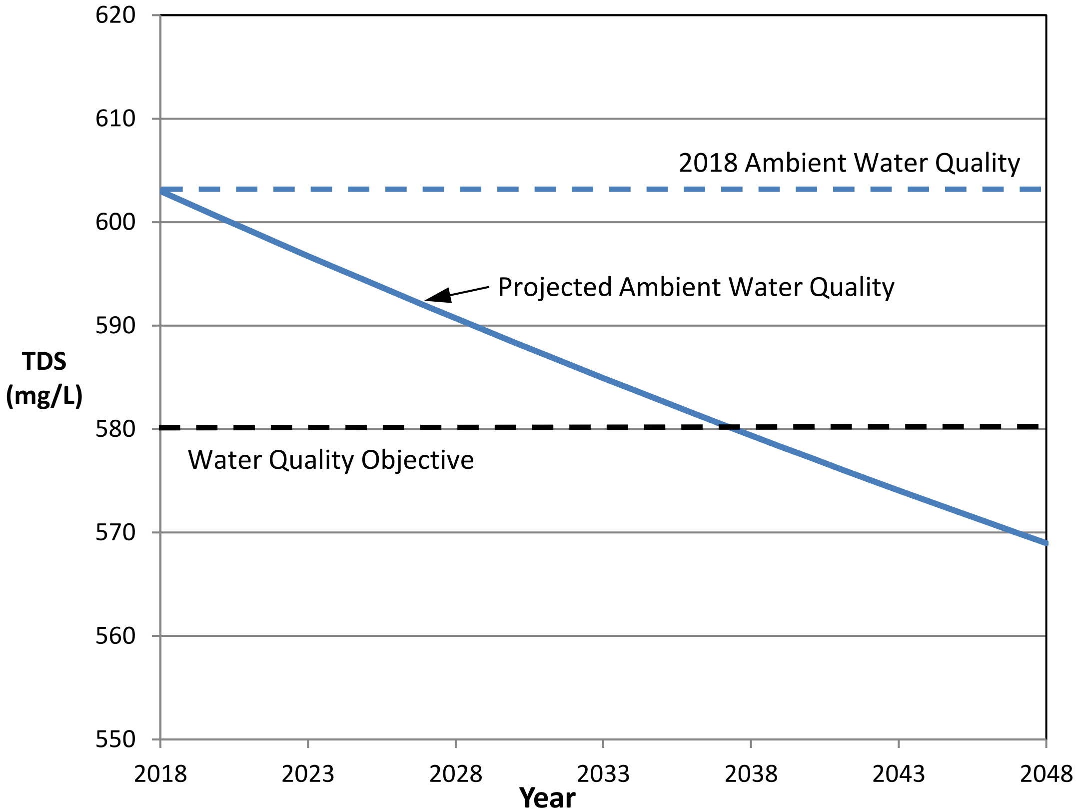


Figure 11-1: Estimated TDS Concentration in Base Case for 30-year Period

With regards to nitrate, the approach used to estimate future nitrate concentrations was similar to the approached used for TDS projections. The nitrate (as nitrogen, N) concentration for each inflow component was estimated using available data. Table 11-2 summarizes the inflow terms and their nitrate-N concentrations for the Baseline Scenario.

The flow-weighted average nitrate (as N) concentration for all inflows to the management zone is 2.3 mg/L. The initial concentration was set at 2.95 mg/L (based on the current ambient concentration for the most recent 20-year period).

Since the inflow concentration is less than the initial concentration, the estimated future nitrate (as N) concentration gradually decreases. For the Baseline Scenario, the ambient nitrate (as N) concentration is projected to decrease from 2.95 mg/L to 2.8 mg/L over the course of 30 years. Again, as with TDS, the impact of recharging large volumes of high quality GWRS water lowers nitrate concentrations in basin groundwater over time.

Table 11-2: Baseline Future Nitrate (as N) Inflows

Inflow	Volume (Acre-Feet/yr)	Nitrate-N Conc.(mg/L)	Mass (tons/yr)
Deep percolation of precipitation*	6,500	1	9
Percolation of applied water*	9,000	10	122
SAR base flow	52,000	3.6	255
SAR storm flow	50,000	1.3	88
Imported water recharge	0	0	0
Recycled water recharge (GWRS)	133,000	1.0	181
Subsurface inflow*	44,500	4.2	253
Alamitos Barrier	2,000	1.4	4
Total	297,000	2.3	657

*component of unmeasured recharge

GROUNDWATER QUALITY IMPROVEMENT PROJECTS

This section describes specific projects that improve groundwater quality by removing TDS, nitrate, VOCs and other constituents, including PFAS. The locations of these projects, except for PFAS, are shown in Figure 11-2. PFAS projects are located at specific groundwater producer wells.

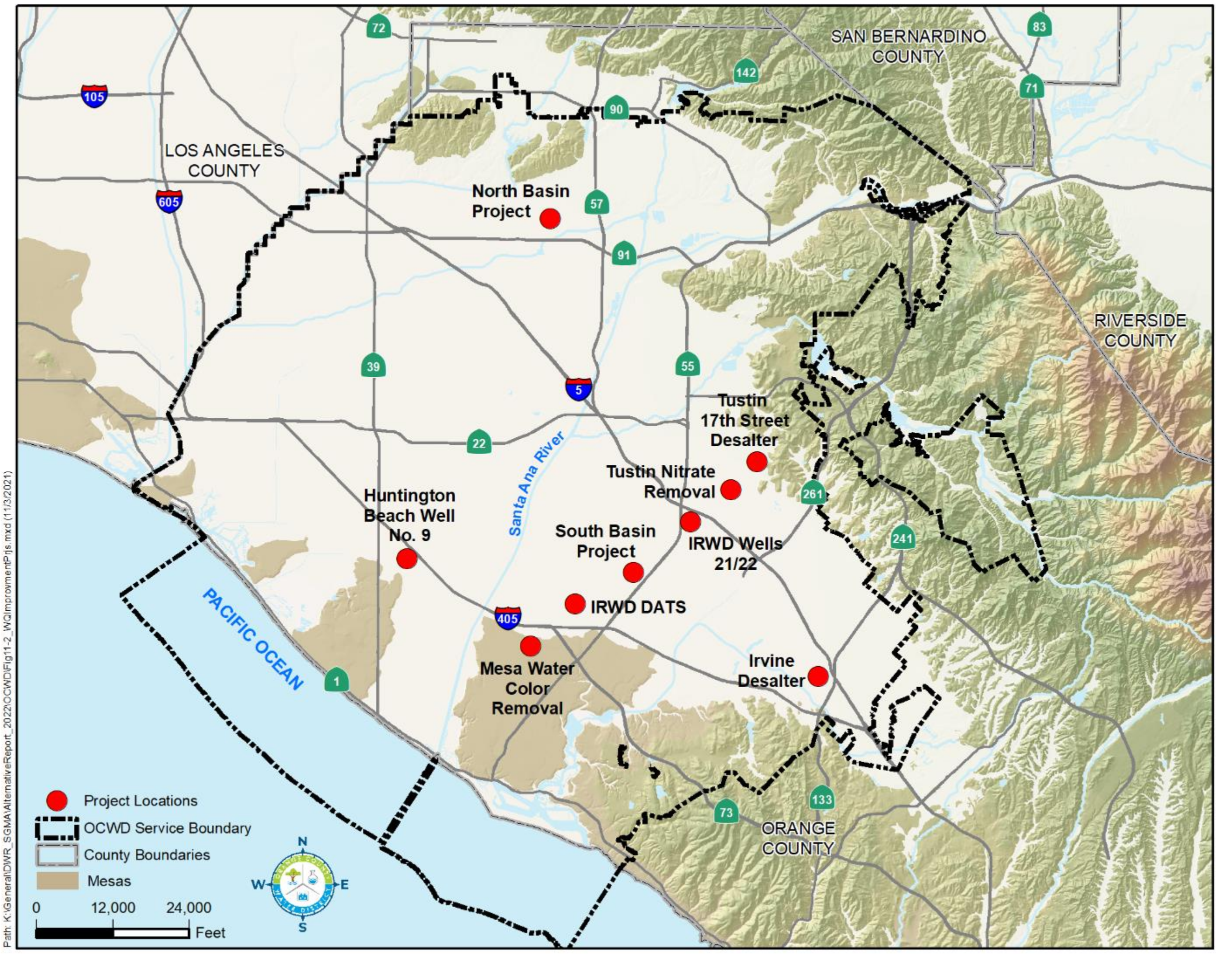


Figure 11-2: Water Quality Improvement Projects and Programs

North Basin Groundwater Protection Program

The U.S. Environmental Protection Agency (USEPA) is taking the lead to remediate a VOC plume in the North Basin area of the groundwater basin as shown in Figure 11-3. Groundwater contamination is primarily found in the Shallow Aquifer, which is generally less than 200 feet deep; however, VOC-impacted groundwater has migrated downward into the Principal Aquifer tapped by production wells. The contamination continues to migrate both laterally and vertically threatening downgradient production wells operated by the cities of Fullerton and Anaheim and other agencies. OCWD is conducting a remedial investigation/feasibility study under USEPA oversight to evaluate and develop effective remedies to address the contamination under the National Contingency Plan (NCP) process. In September 2020 the USEPA included the North Basin site on the National Priorities (Superfund) List.

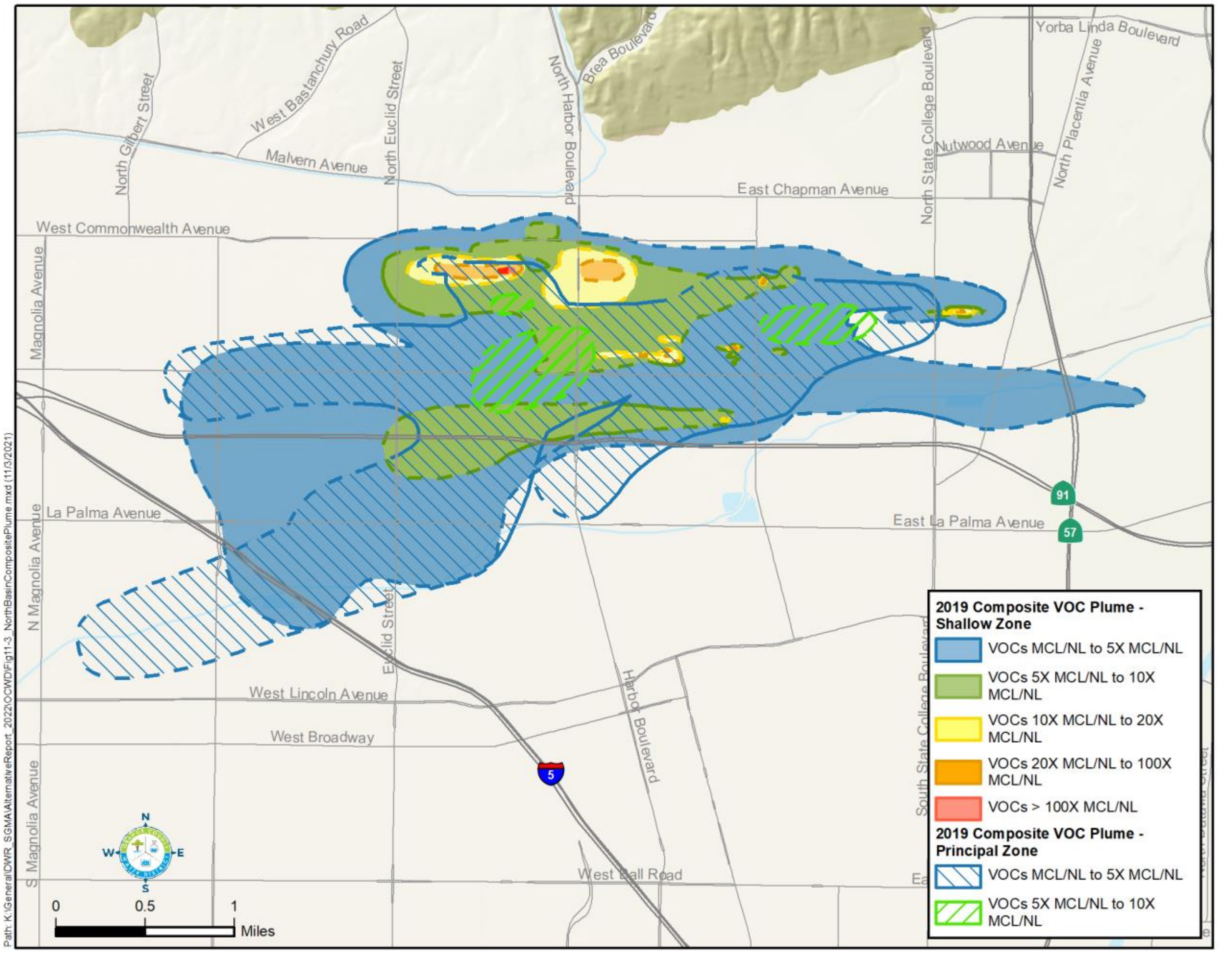


Figure 11-3: North Basin Groundwater VOC Plume

South Basin Groundwater Protection Program

Groundwater contaminated with VOCs and perchlorate in the South Basin area of the groundwater basin is shown in Figure 11-4. Elevated concentrations of perchloroethylene (PCE), trichloroethylene (TCE), and perchlorate were detected in Irvine Ranch Water District's Well No. 3, located in Santa Ana. OCWD's remedial investigation has resulted in the delineation of an approximately 2-mile long comingled contaminant plume. With the remedial investigation complete, OCWD is proceeding with a feasibility study to evaluate and develop remedial measures in cooperation with regulatory agencies and stakeholders following the NCP process. In tandem with OCWD's remediation program to address off-site contamination, the Regional Water Board and DTSC are overseeing investigation and remediation activities at the contaminant source sites.

MTBE Remediation

In 2003, OCWD filed suit against numerous oil and petroleum-related companies that produce, refine, distribute, market, and sell MTBE and other oxygenates. The suit seeks funding from these responsible parties to pay for the investigation, monitoring and removal of oxygenates from the basin. Most of the major defendants have settled the litigation with OCWD, and funds from these settlements have been set aside for use at such time as treatment is required at drinking water wells.

Treatment technologies used to remove MTBE from groundwater include granular activated carbon or advanced oxidation. Depending upon site-specific requirements, a treatment train of two or more technologies in series may be appropriate (i.e., use one technology to remove the bulk of MTBE and a follow-up technology to polish the effluent water stream).

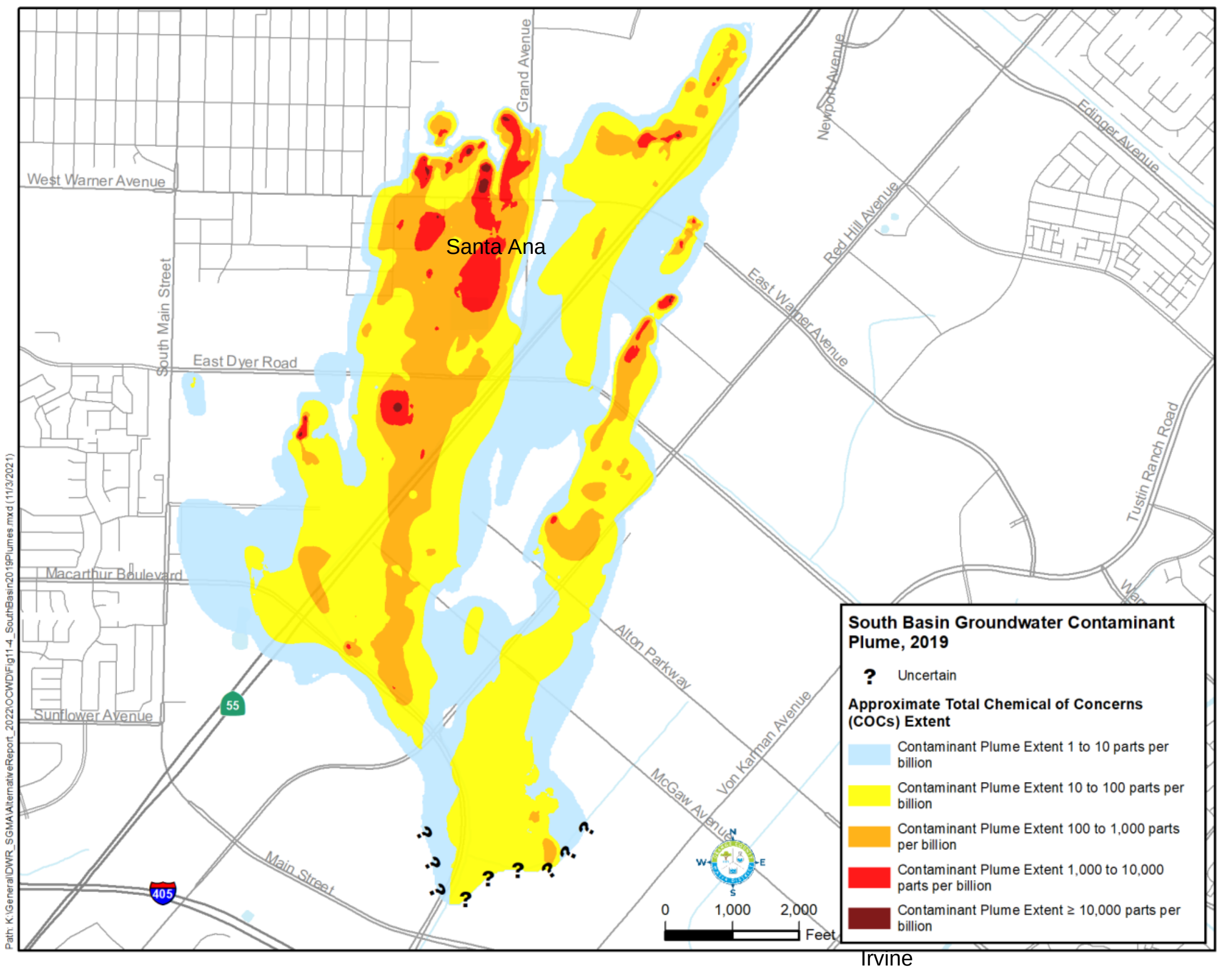


Figure 11-4: South Basin Groundwater Contaminant Plume

Irvine Desalter

The Irvine Desalter was built in response to elevated TDS and nitrate and the discovery in 1985 of VOCs beneath the former El Toro Marine Air Corps Station and the central area of Irvine. A plume of TCE migrated off base and impacted the groundwater basin. In 1990 the USEPA placed the site on the National Priorities List. Irvine Ranch Water District and OCWD cooperated with the U.S. Department of Navy in building production wells, pipelines and two treatment plants, both of which are now owned and managed by IRWD. Operating since 2007, the two plants remove VOCs by air-stripping and vapor-phase carbon adsorption with the treated water used for irrigation and recycled water purposes. A third plant treats groundwater outside the plume to remove excess nitrate and TDS concentrations using reverse osmosis (RO) membranes for drinking water purposes. Combined production of the Irvine Desalter wells is approximately 8,000 acre-feet per year. OCWD provides a financial subsidy to IRWD in the form of a BEA exemption to help offset the treatment costs.

Tustin Desalters

Tustin's Main Street Treatment Plant has operated since 1989 to reduce nitrate levels from the groundwater produced by Tustin's Main Street Wells Nos. 3 and 4. The groundwater undergoes either RO or ion exchange treatment. The RO membranes and ion exchange units operate in a parallel treatment train. Approximately 1 mgd is bypassed and blended with the treatment plant product water to produce up to 2 mgd or 2,000 acre-feet per year.

The Tustin Seventeenth Street Desalter began operation in 1996 to reduce high nitrate and TDS concentrations from the groundwater pumped by Tustin's Seventeenth Street Wells Nos. 2 and 4 and Tustin's Newport Well. The desalter utilizes two RO membrane trains to treat the groundwater. The treatment capacity of each RO train is 1 mgd. Approximately 1 mgd is bypassed and blended with the RO product water to produce up to 3 mgd or 3,000 acre-feet per year. OCWD provides a financial subsidy to the City of Tustin in the form of a BEA exemption to help offset the treatment costs.

Irvine Ranch Water District Wells 21 and 22

Water produced by IRWD Wells 21 and 22 contain nitrate (as N) at levels exceeding the primary MCL of 10 mg/L. TDS concentrations range from 650-740 mg/L, which is above the secondary MCL of 500 mg/L. Because of the elevated nitrate, TDS, and hardness concentrations, IRWD constructed a RO treatment facility to reduce concentrations in the water before conveying to the potable supply distribution system. Operation of the treatment facility provides 6,300 acre-feet per year of drinking water and benefits the groundwater basin by reducing the spread of impaired groundwater to other portions of the basin. OCWD provides a financial subsidy to IRWD in the form of a BEA exemption to help offset the treatment costs.

Amber-Colored Groundwater

Amber-colored water is found in the Deep Aquifer (600 to 2,000 feet below ground surface). Natural organic material from ancient, buried plant and wood material gives the water an amber tint and a sulfur odor. Although this water is of high quality, its color and odor produce negative aesthetic qualities that require treatment before use as drinking water.

Two facilities currently treat colored groundwater in Orange County for potable supply. In 2001, Mesa Water District opened its Colored Water Treatment Facility capable of treating 5.8 mgd. This facility was replaced in 2012 by the 8.6-mgd Mesa Water Reliability Facility that uses nano-filtration membranes to remove color. OCWD provides a financial subsidy to Mesa Water District in the form of a BEA exemption to help offset the treatment costs. The second facility is the Deep Aquifer Treatment System (DATS), a treatment facility owned and operated by the IRWD since 2002 that uses nano-filtration membranes. This facility purifies 7.4 mgd of amber-colored water.

PFAS Treatment Systems

In 2020 OCWD as the groundwater basin manager, executed a multi-party agreement with the impacted groundwater producers to fund and construct the necessary treatment systems for production wells impacted by PFAS compounds. The PFAS treatment projects include the design, permitting, construction, and operation of PFAS treatment systems for impacted production wells. Each well treatment system will be evaluated for use with granular activated carbon (GAC), ion exchange (IX), or an alternative novel sorbent for the removal of PFAS compounds. These treatment systems utilize vessels in a lead-lag configuration to remove PFOA and PFOS to less than 2 ppt, the current laboratory detection limit. These PFAS treatment systems are designed to ensure the groundwater supplied by producer wells can be served in compliance with current and future PFAS regulations. The groundwater producers will own the treatment systems once they are completed; with financial assistance from OCWD, the groundwater producers will operate and maintain the new treatment systems once they are constructed.

To minimize alternative water supply expenses and provide maximum protection to the public water supply, OCWD initiated design, permitting, and construction of the PFAS treatment projects on a schedule that allows rapid deployment of treatment systems. As of September 2021, construction contracts have been awarded for treatment systems for production wells owned by the cities of Orange (Phase 1) and Garden Grove, Serrano Water District, and Yorba Linda Water District. The City of Anaheim has also awarded a design-build contact (Phase A) for 8 impacted wells, that will be reimbursed by OCWD. The City of Fullerton's well KIM-1A treatment system has been completed and is in operation. Additional construction contracts are anticipated to be awarded for impacted wells operated by the cities of Fullerton (Main Plant), Orange (Phase 2), Santa Ana, and Tustin; Irvine Ranch Water District; and East Orange County Water District by early 2022. OCWD expects the treatment systems to be constructed for the approximately 60 impacted wells within the next 2 to 3 years. Figure 11-5 shows locations of wells affected by and to be treated for PFAS.

As monitoring continues and additional wells are anticipated to be taken off-line due to PFAS detections reported at or near the current RL (or future MCL), OCWD will continue to partner with the affected groundwater producers and take action to design and construct necessary treatment systems to bring the impacted wells back online as quickly as possible.

Groundwater production in WY2020-21 was expected to be approximately 325,000 acre-feet but declined to 282,000 acre-feet primarily due to PFAS-impacted wells being turned off around February 2020. OCWD projects groundwater production to be approximately 250,000 acre-feet in WY2021-22 due to the currently idled wells and additional wells being impacted by PFAS and turned off. As PFAS treatment systems are constructed, OCWD expects total annual groundwater production to increase back to levels similar to years prior to PFAS impacts.

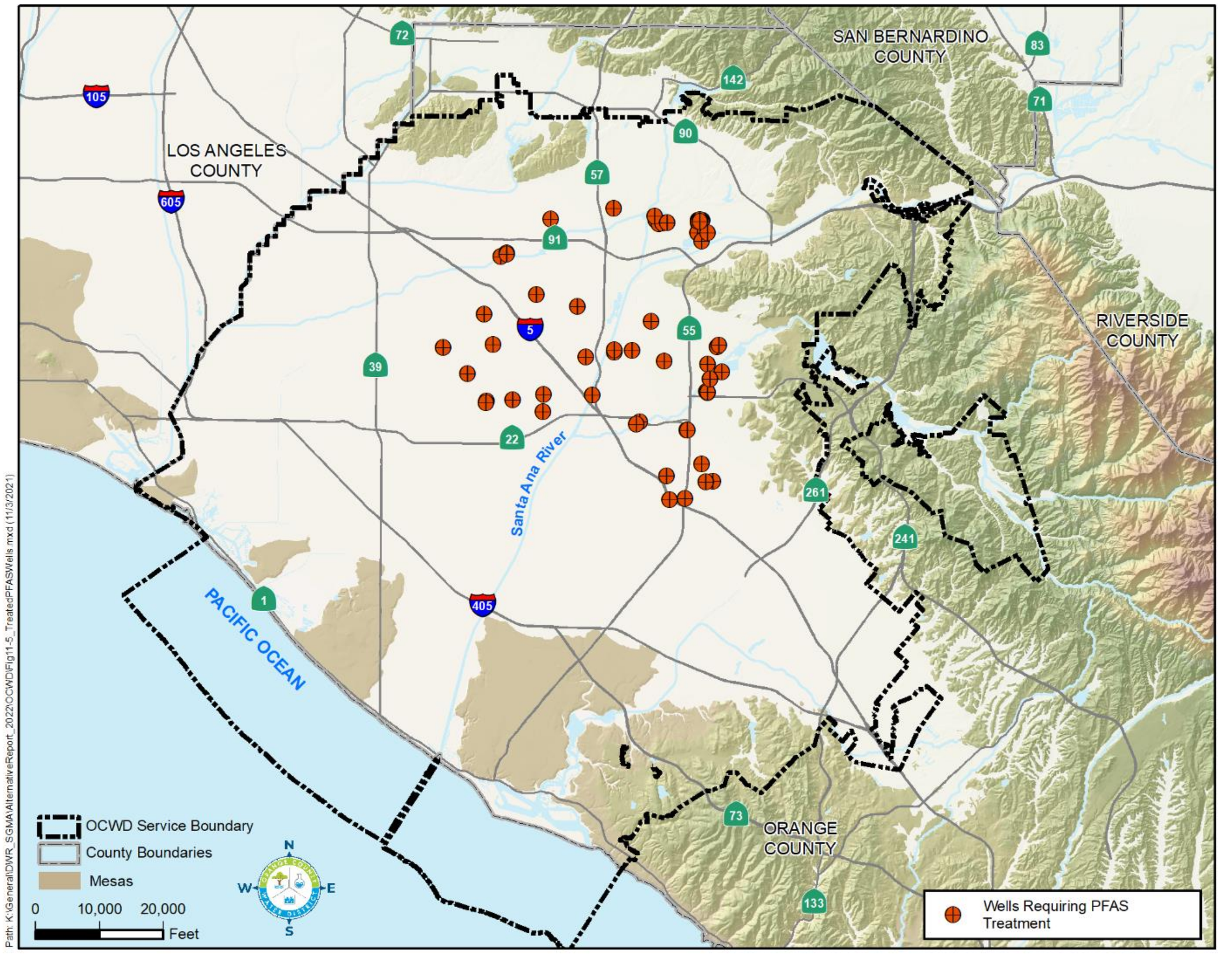


Figure 11-5: Production Wells to be Treated to Remove PFAS

BEA Exemption for Water Quality Improvement Projects

In some cases, OCWD encourages the pumping of groundwater that does not meet drinking water standards in order to protect water quality. This is achieved by using a financial incentive called the Basin Equity Assessment (BEA) Exemption. The benefits to the basin include promoting beneficial uses of poor-quality groundwater and reducing or preventing the spread of poor-quality groundwater into non-degraded aquifer zones.

OCWD uses a partial or total exemption of the BEA to compensate a qualified participating groundwater producer for the costs of treating poor-quality groundwater. These costs typically include capital, interest and operations and maintenance (O&M) costs for the treatment facilities.

Using this approach, OCWD has exempted all or a portion of the BEA for pumping and treating groundwater for removal of nitrates, TDS, VOCs, and other contaminants. Water quality improvement projects that currently are receiving BEA exemptions are listed in Table 11-3.

Table 11-3: Summary of BEA Exemption Projects

Project Name	Project Description	BEA Exemption Approved	Max Production Above BPP (afy)	OCWD BEA Subsidy
Irvine Desalter	Remove nitrates, TDS, and VOCs	2001	10,000	Exemption
Tustin Desalter	Remove nitrates and TDS	1998	3,500	Exemption
Tustin Nitrate Removal	Remove nitrates	1998	1,000	Exemption
Mesa Water Colored Water Removal	Remove color	2011	8,700	Exemption
IRWD Wells No. 21 and 22	Remove nitrates	2012	7,000	Exemption
Huntington Beach Well No. 9	Remove odor	2018	3,000	Partial exemption

DEFINITION OF SIGNIFICANT AND UNREASONABLE DEGRADATION OF WATER QUALITY

Three elements must be considered when evaluating the impact of groundwater quality degradation with regard to SGMA undesirable results.

The first element is considering the causal nexus between groundwater management activities and groundwater quality. For example, groundwater contamination due to improper handling of toxic materials impacts groundwater quality; however, this water quality degradation is not caused by groundwater management activities.

The second element is the beneficial uses of the groundwater and water quality regulations, such as MCLs and other potable water quality requirements.

The third element that must be considered is the volume of groundwater impacted by quality degradation. If small volumes are negatively affected that do not materially affect the overall use of the aquifer or basin for its existing beneficial uses, then this would not represent a significant and unreasonable degradation of water quality. However, if the impacted volume grows, then it could reach a level that it becomes significant and unreasonable.

When considering all three elements, “significant and unreasonable degradation of water quality” is defined as degradation of groundwater quality attributable to groundwater production or recharge practices in the OCWD Management Area and to the extent that a significant volume of groundwater becomes unusable for its designated beneficial uses.

DETERMINATION OF MINIMUM THRESHOLDS

The minimum thresholds for groundwater quality are exceedances of MCLs or other applicable regulatory limits that are directly attributable to groundwater management actions in the OCWD Management Area that prevent the use of groundwater for its designated beneficial uses.

SECTION 12 SUSTAINABLE MANAGEMENT RELATED TO SEAWATER INTRUSION

In the coastal area of the Orange County groundwater basin, the primary source of saline groundwater is seawater intrusion through permeable aquifer sediments underlying topographic lowlands or gaps between the erosional remnants or mesas of the Newport-Inglewood Uplift. The susceptible locations from north to south are the Alamitos, Sunset, Bolsa, and Talbert gaps as shown in Figure 3-20.

OCWD's policy regarding control of seawater intrusion is implemented through a comprehensive program that includes operating seawater intrusion barriers, monitoring and evaluating barrier performance, monitoring and evaluating susceptible coastal areas, and coastal groundwater management. These programs enable OCWD to sustainably manage groundwater conditions in the basin in order to prevent significant and unreasonable seawater intrusion.

TALBERT GAP

The Talbert Gap, also referred to as the Santa Ana Gap, is shown in Figure 12-1. The furthest seaward mergence zone between the Talbert and Lambda aquifers in the vicinity of Adams Avenue is a primary pathway by which seawater can potentially migrate inland and downward within the Talbert Gap.

OCWD monitoring well M26 is a key monitoring well for evaluating barrier injection requirements versus seawater intrusion potential and is used to assess whether protective groundwater elevations are being achieved in the Talbert Gap. The well is strategically located seaward of the barrier in the middle of the Talbert Gap and is screened within the merged Talbert and Lambda aquifers (see Figure 12-2). At the location of well M26, the protective groundwater elevation is approximately 3.5 feet above mean sea level (msl), as explained below.

The protective groundwater elevation is based on the Ghyben-Herzberg relation (Ghyben, 1888; Herzberg, 1901; Freeze and Cherry, 1979, pp. 375-376), which takes into account the depth of the Talbert aquifer at a given location along with the density difference between saline and fresh groundwater. Using this relation, for every 40 feet that the bottom of the aquifer is below sea level, there should be about one foot of head of fresh water above sea level to overcome the density effect of seawater. In the case of well M26, the bottom of the merged Talbert-Lambda aquifer is approximately 140 feet below sea level. Therefore, the freshwater head (protective elevation) should be approximately 140 feet divided by 40 which equals 3.5 feet above sea level. Achieving this protective elevation at well M26 is OCWD's goal to prevent brackish water in the Talbert aquifer from migrating down into the Lambda aquifer that is tapped by inland production wells.

Figure 12-2 shows the historical interrelationship between coastal groundwater production, Talbert Barrier injection, and groundwater elevations at well M26 from 2008 to 2021. This figure shows that groundwater elevations at well M26 have consistently been maintained at or above protective elevations since 2010 with the exception of brief periods related to GWRS shutdowns.

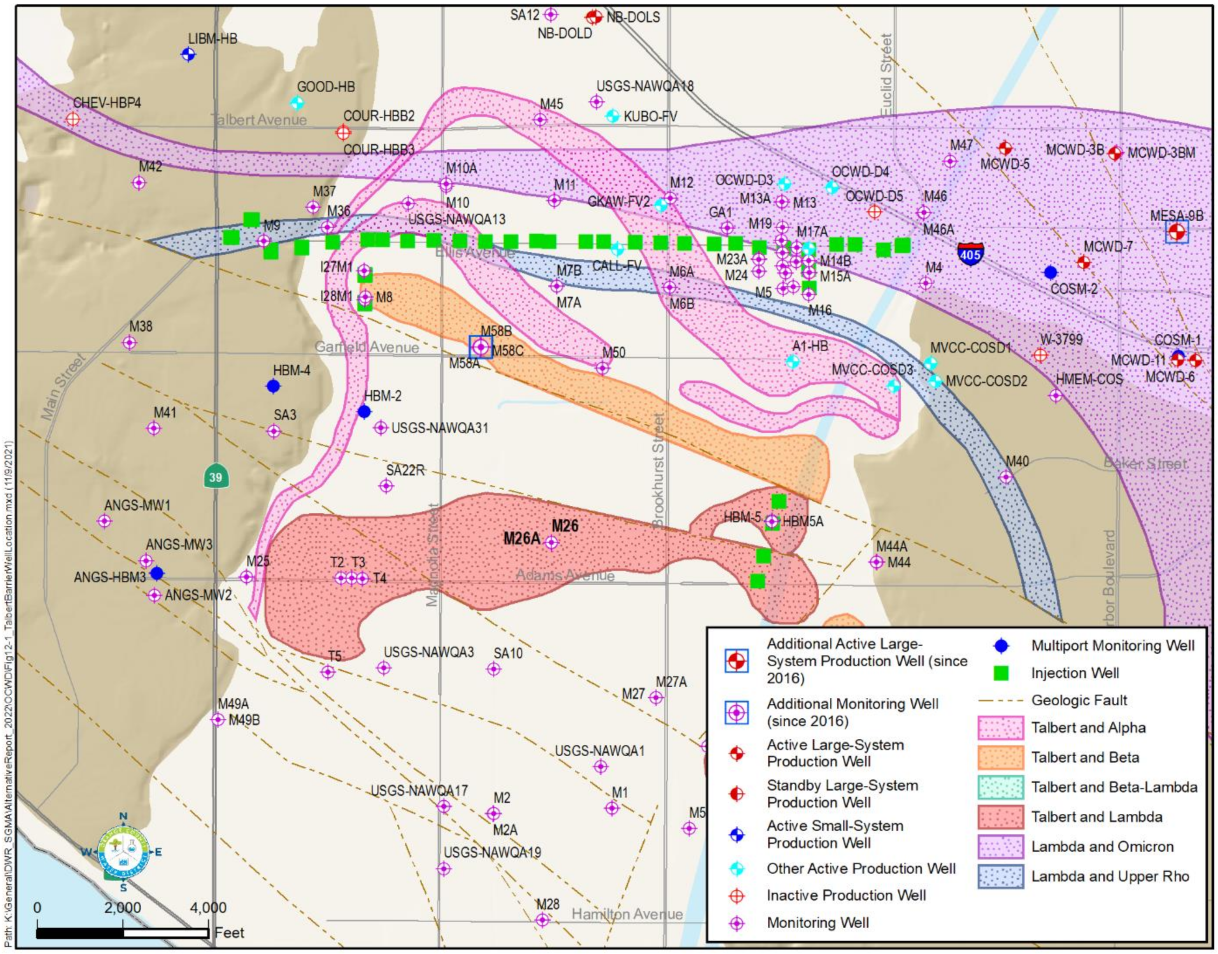


Figure 12-1: Talbert Gap – Seawater Intrusion Barrier

Figure 12-3 shows the 250 mg/L chloride concentration contour in the Talbert and Bolsa gaps and adjacent mesas for 1993, 1998, 2008, and 2020. The 250 mg/L chloride contour is used to delineate the inland extent of intrusion because this is above ambient (non-intruded) groundwater quality and is equal to the secondary drinking water standard. Native fresh groundwater in this area typically has a chloride concentration well below 100 mg/L, while the GWRS injection supply has a chloride concentration of approximately 10 mg/L. This figure shows that the 250 mg/L chloride contour has remained relatively unchanged from 2008 to 2020, indicating that the barrier and other basin management programs are keeping seawater intrusion from taking place.

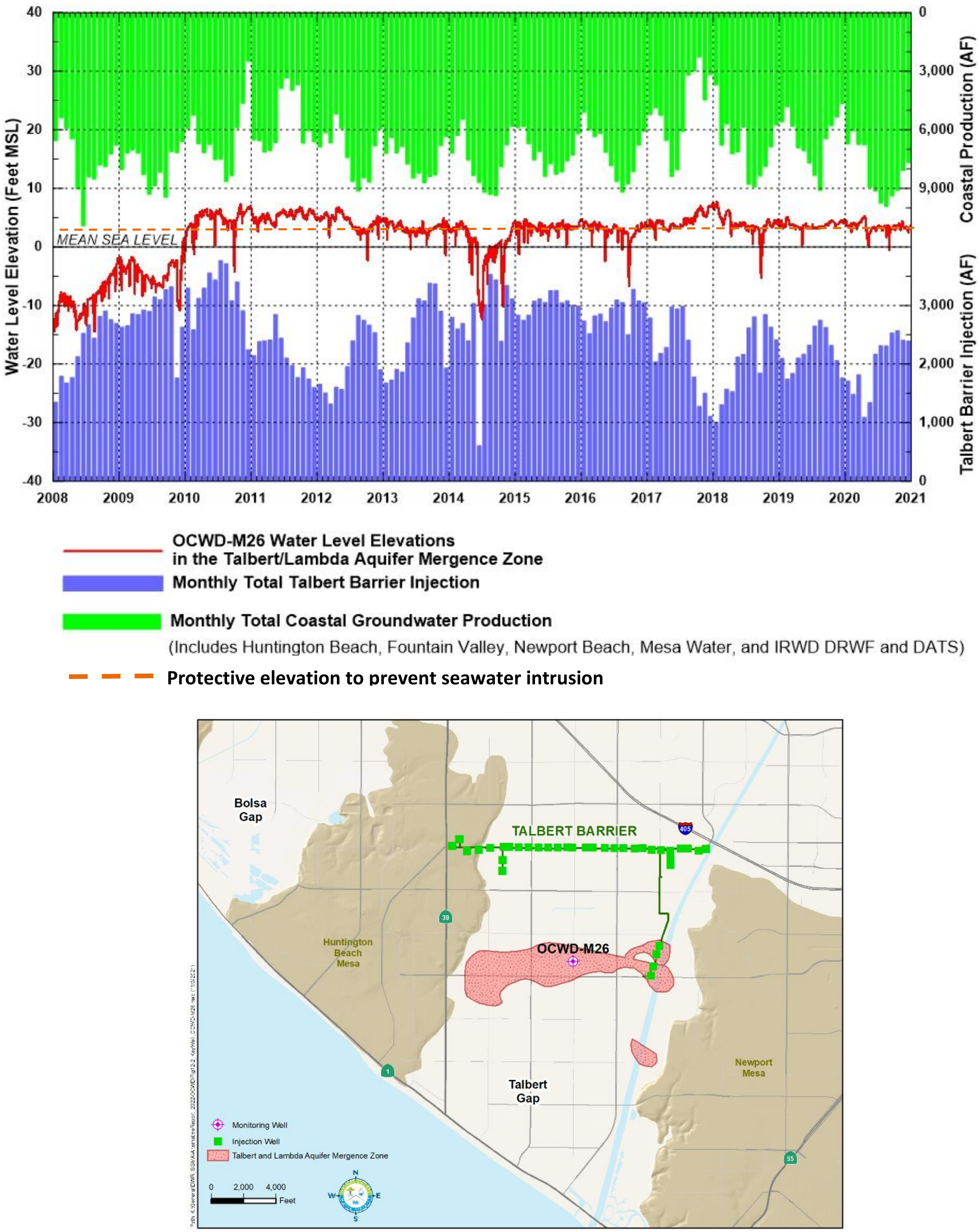


Figure 12-2: Key Well OCWD-M26 Groundwater Levels,
Talbert Barrier Injection, and Coastal Pumping

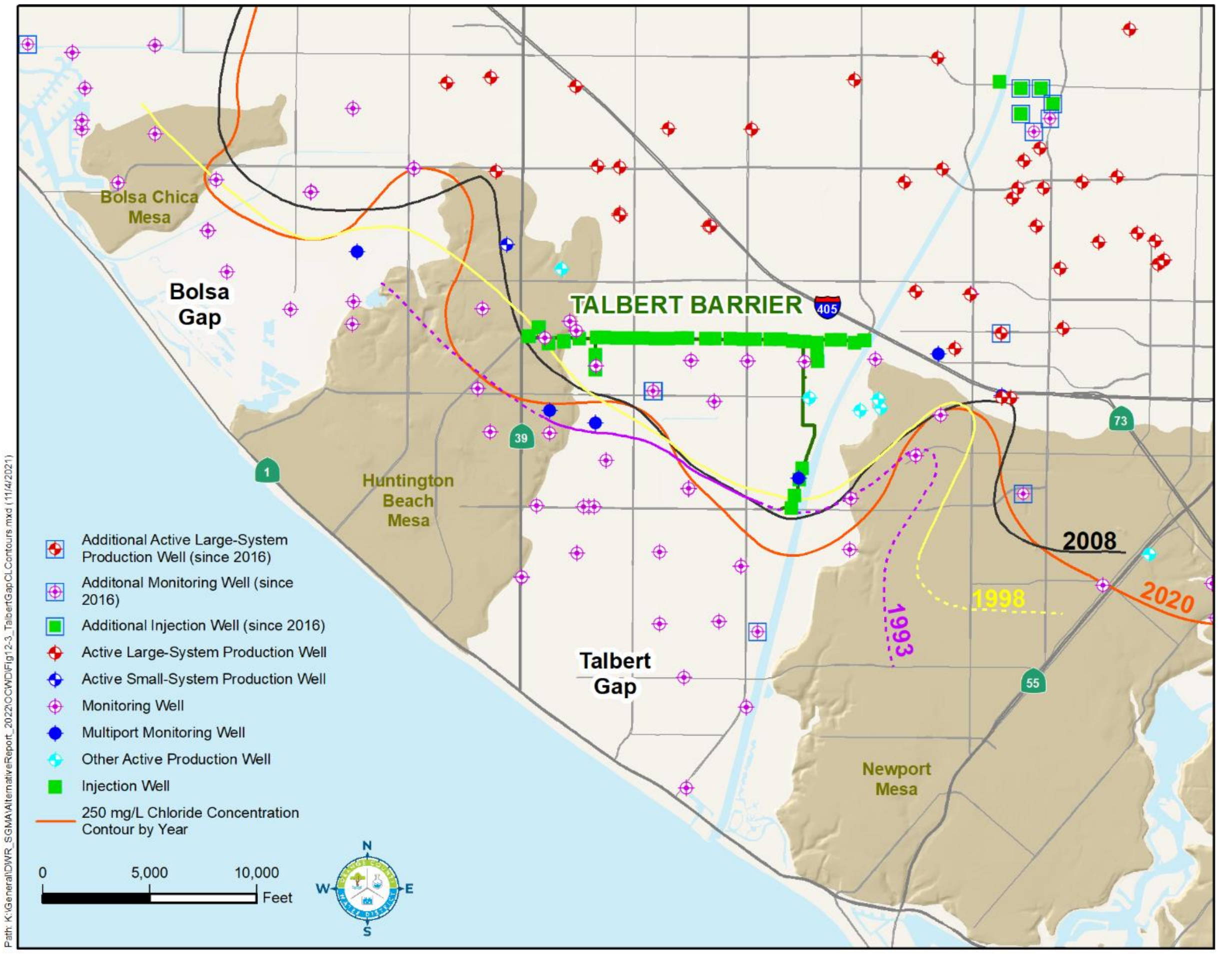


Figure 12-3: Talbert Gap 250 mg/L Chloride Concentration Contours for Selected Years

Talbert Barrier Groundwater Model

OCWD has developed a calibrated MODFLOW groundwater model of the Talbert Barrier and surrounding area (Talbert Model). In addition to helping to guide the planning, location, and hydraulic effectiveness of the supplemental injection wells for the Talbert Barrier during pre-GWRS planning activities, the Talbert Model was also used to estimate the general groundwater flow paths and subsurface residence time of barrier injection water by using the USGS particle tracking code MODPATH (Pollack, 1994). This modeling work provided the basis for delineating a recycled water retention buffer area surrounding the Talbert Barrier at a distance of 2,000 feet and one-year travel distance. No new drinking water production wells are allowed within this buffer area, as required by the California Department of Public Health requirements contained within the original permit to operate GWRS (RWQCB, 2004; OCWD, 2005). For more information on the Talbert Model, see the 2017 Alternative.

ALAMITOS GAP

The Alamitos Barrier Project was initially constructed in 1964 and became operational in 1965 to manage seawater intrusion in the Alamitos Gap. The barrier has been expanded over time to include the construction of additional injection and monitoring wells (Figure 12-4).

Similar to the Talbert Barrier, the Alamitos Barrier consists of both nested and cluster-type injection wells screened discretely in each aquifer in order to control the injection rate and injection pressure into each targeted aquifer independently since each aquifer has different physical characteristics and groundwater levels.

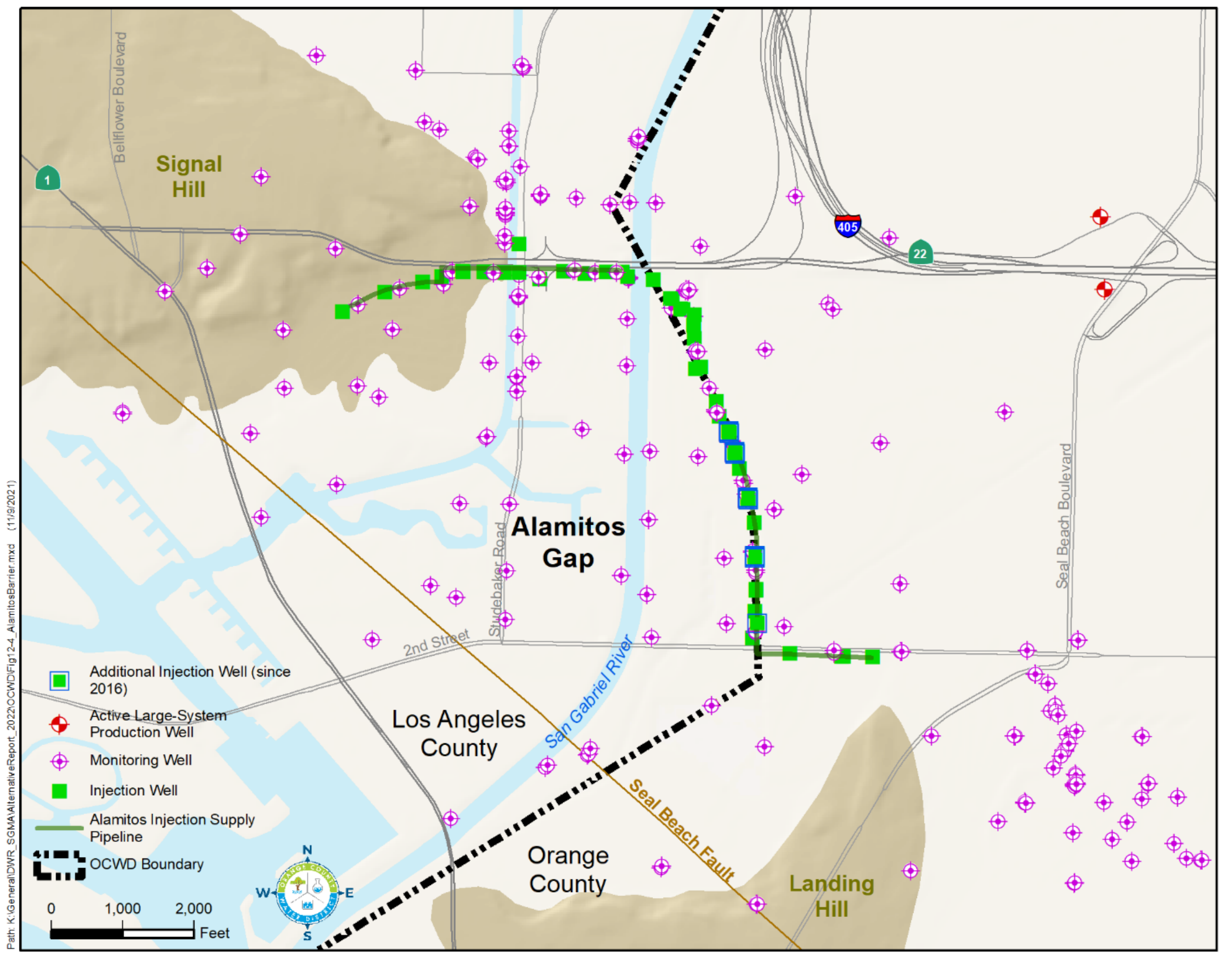


Figure 12-4: Alamitos Gap – Seawater Intrusion Barrier

The pathways for intrusion in Alamitos Gap are similar to the Talbert Gap with the uppermost Recent aquifer connected to the Pacific Ocean. Once seawater migrates inland within the Recent aquifer past the Seal Beach Fault, the brackish water can then migrate downward into the C, B, A, and I aquifers via areas of hydraulic mergence with the Recent aquifer where the intervening low-permeability aquitards are absent. These susceptible Pleistocene aquifers were warped upward by the Newport-Inglewood Fault Zone and then during Recent geologic time were eroded away and subsequently overlain by the Recent aquifer river deposits. The aquifers susceptible to intrusion are generally thinner and finer-grained than their counterparts in Talbert Gap. Therefore, per-well injection capacity in the Alamitos Barrier is about half that of the Talbert Barrier and thus requires more injection wells and denser spacing to achieve sufficient injection for creating a continuous pressure ridge that achieves protective elevations.

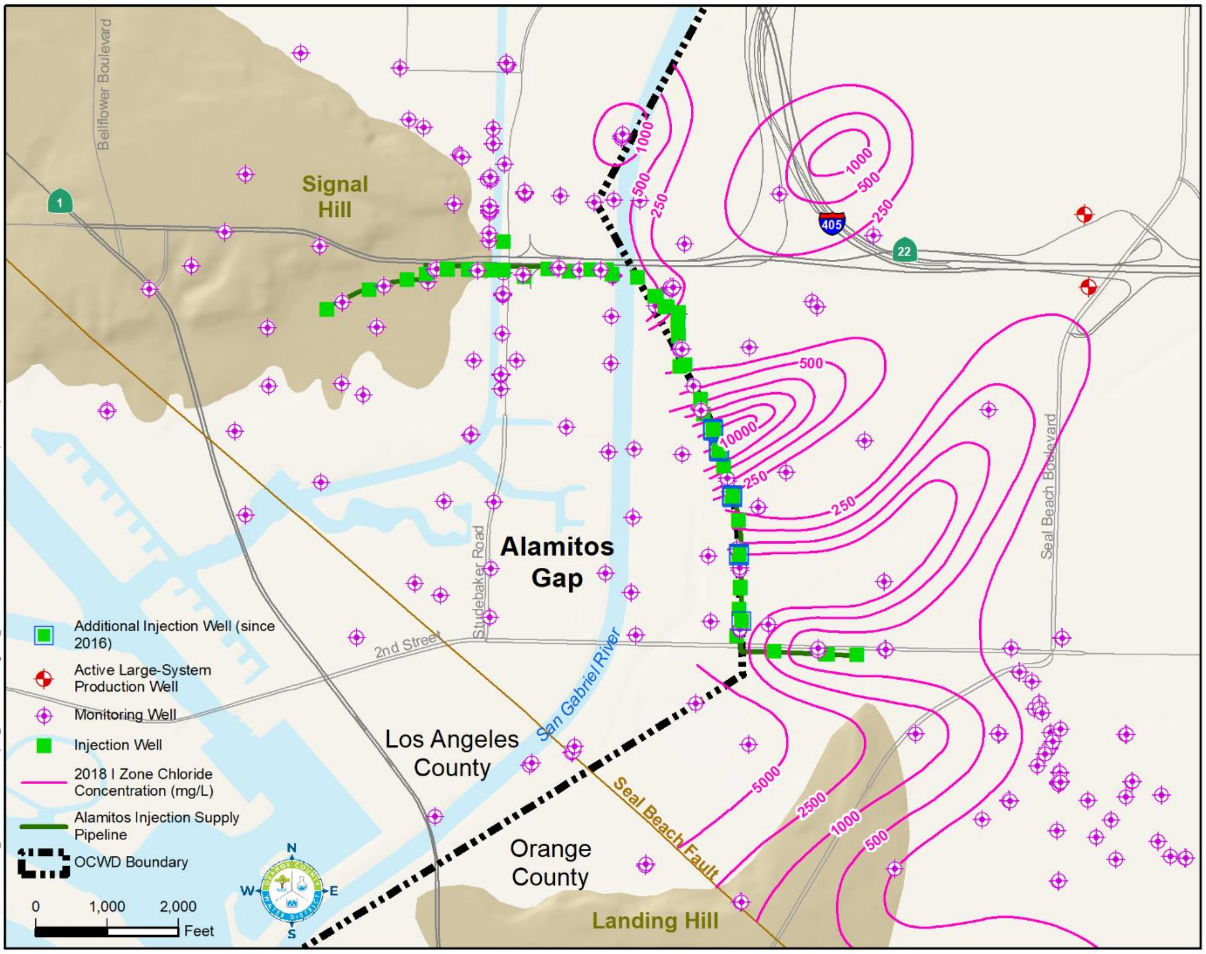


Figure 12-5: Alamitos Gap I Zone Chloride Concentration Contours, 2018

Additional injection wells were constructed as part of the Alamitos Barrier Improvement Project to control the identified breaches through the barrier and to address barrier deficiencies along the north-south reach where injection well spacing was too large and injection well capacity too small. In addition, four monitoring wells and two piezometer were installed to improve monitoring near the barrier.

Since the completion of the Alamitos Barrier Improvement Project in 2018, freshwater injection capacity along the north-south barrier alignment has improved with the even distribution of injection flow through the added new wells and water levels along this barrier reach have achieved and maintained protective elevations, a first since the barrier was constructed over 50 years ago.

LACPW continues to operate and maintain the existing and new barrier facilities as OCWD will continue to work alongside LACPW to monitor the water levels and the barrier performance along the stretch affecting Orange County.

Alamitos Barrier Groundwater Model

A transient groundwater flow and solute transport model of the Alamitos Barrier area was developed and calibrated in 2010 by Intera, Inc. with oversight and cost sharing from OCWD, LACPW, and WRD. The model was developed to provide a useful tool to evaluate the existing barrier's effectiveness, determine barrier expansion requirements, evaluate migration of saline intrusion as well as migration of recycled injection water towards production wells for regulatory purposes, and optimize existing barrier operations. For more information on this model, see the 2017 Alternative.

SUNSET GAP

Sunset Gap was historically considered to be a much lesser seawater intrusion threat compared to the Talbert and Alamitos Gaps. Recent monitoring data, however, indicate that seawater intrusion is occurring in Sunset Gap, as shown schematically in a cross-section in Figure 12-6. Figure 12-7 shows the location of this cross-section.

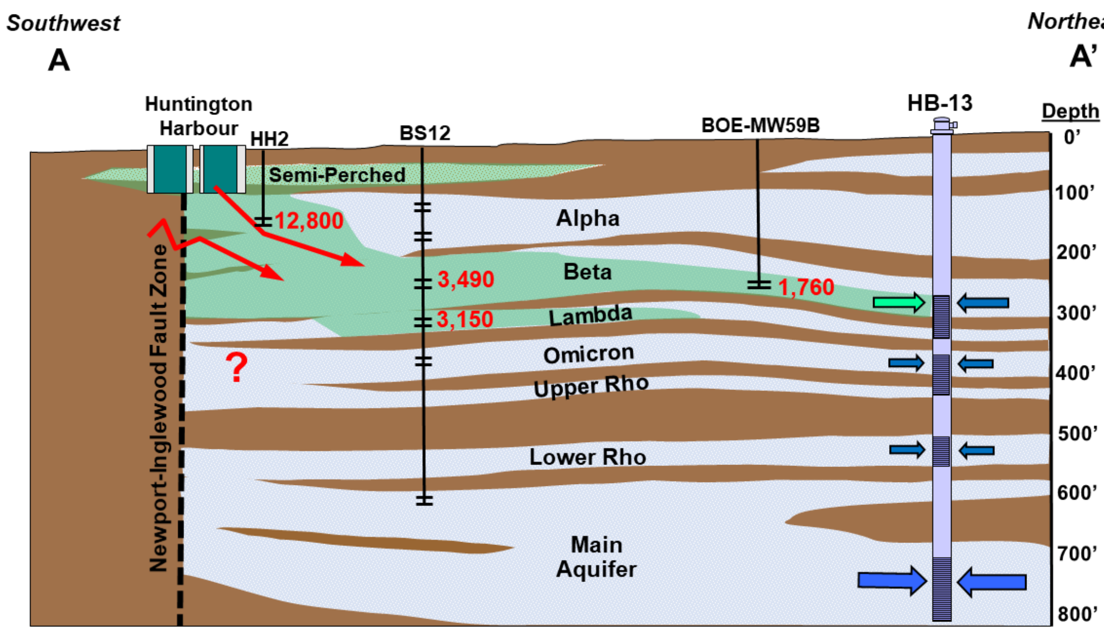


Figure 12-6: Schematic Geologic Cross-Section from Huntington Harbor through Sunset Gap (Fall 2020 Chloride Concentrations, mg/L)

Three potential seawater intrusion source areas appear likely:

- Intrusion from Alamitos Gap south of Alamitos Barrier moving in an easterly direction
- Intrusion moving north-northeasterly from the Huntington Harbor Marina where dredged canals may have breached through the shallow aquitard overlying the shallow-most potable aquifer
- Lateral leakage across the Newport/Inglewood Fault Zone (Seal Beach Fault) in the Landing Hill area in one or more of the Upper Pleistocene aquifers

In the southeast portion of Sunset Gap, dredging associated with construction of the boat canals in Huntington Harbor during the 1960s was the subject of several studies at that time regarding the potential for causing saline intrusion. Conclusions of these studies were inconsistent and inconclusive. Studies done by the USGS (1967) and DWR (1968) found that seawater intrusion into the semi-perched aquifer (generally the uppermost 50 feet) associated with the harbor development was occurring, but this was considered to be of little to no significance due to the lack of beneficial use of this near-surface water-bearing zone.

Approximately 10 years after construction of Huntington Harbor, chloride concentrations began to rise during the mid-1970s at OCWD monitoring well HH2 screened in the shallow-most Pleistocene Alpha aquifer at a depth of 85-95 ft bgs and located just inland of the Bolsa-Fairview Fault in the Huntington Harbor area. The Bolsa-Fairview Fault is the farthest inland branch of the Newport-Inglewood Fault Zone in the area. Chloride concentrations at this well rose steadily over time to very brackish levels today, suggesting an inland gradient and active pathway for inland intrusion.

In 2004, elevated chloride concentrations ranging from 300 to 800 mg/L were discovered at two monitoring wells owned by the Boeing Company (BOE-MW16 and BOE-MW17) screened in the Beta aquifer. OCWD commissioned a geophysical survey in 2010 at the Seal Beach Naval Weapons Station to investigate the extent and depth of intrusion and to help guide the number and location of proposed monitoring wells necessary to sufficiently define the extent of intrusion.

One large system production well (HB-12) was shut down and destroyed due to impacts from advancing intrusion in Sunset Gap. From 2012 to 2016, OCWD constructed seven multi-depth monitoring wells to depths up to 1,000 feet in Sunset Gap to better define the source areas, pathways, and overall inland extent of seawater intrusion as the first step towards identifying feasible remedies.

In 2021, OCWD began a project to install 11 monitoring wells clustered at five locations: one site in Seal Beach (BS25) and four in Huntington Beach (BS23, BS26, BS27 and BS28). Figure 12-7 shows the location of new wells installed in the last five years and the wells being installed in 2021. The multiple wells at each site will allow for the measurement of groundwater levels and collection of groundwater samples for water quality analyses in specific aquifers at different depths. The information from these monitoring wells may be used to determine if the groundwater flow model needs refinement before finalizing recommendations regarding a potential new seawater barrier in Sunset Gap (e.g., locations and number of injection wells and their injection rates).

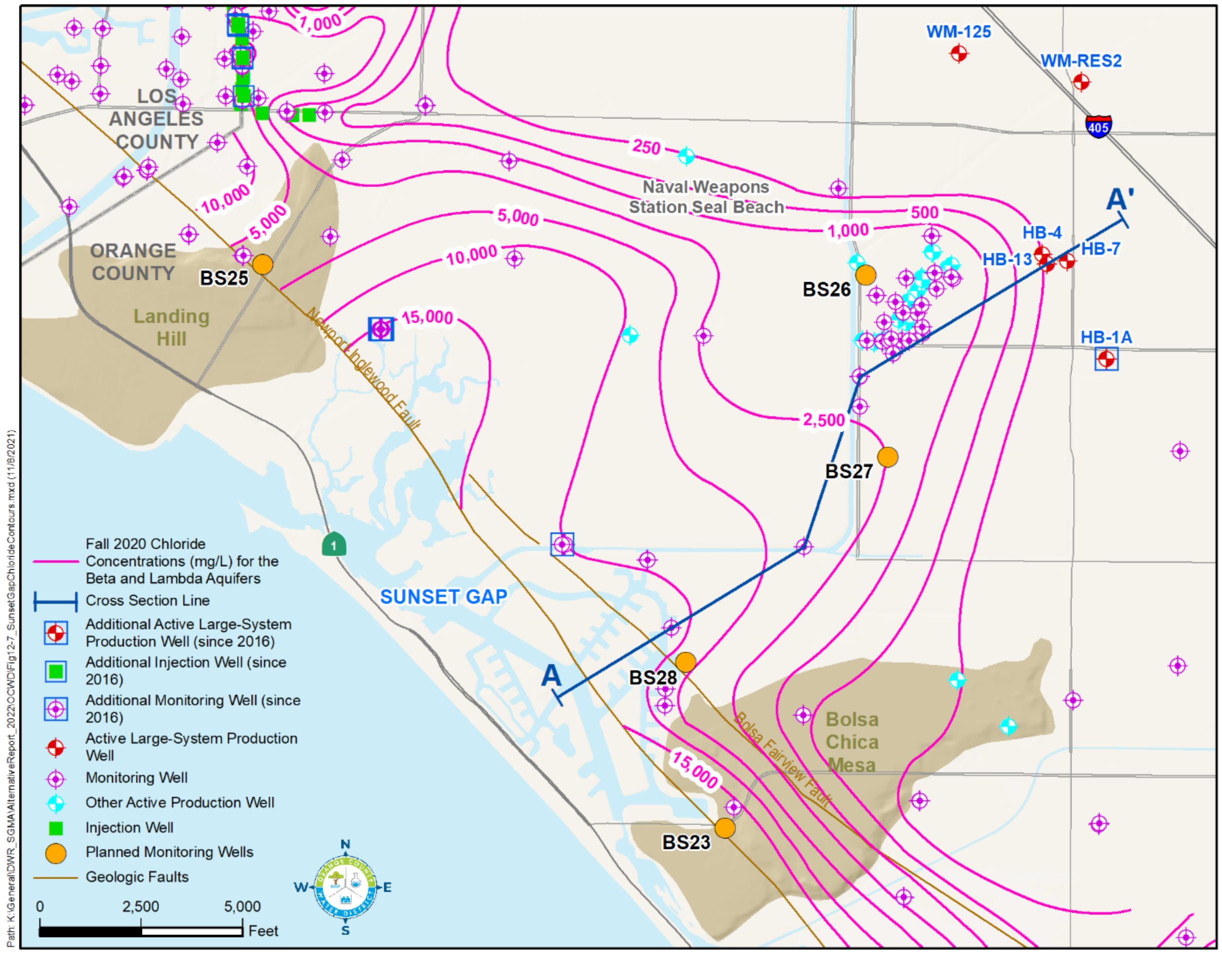


Figure 12-7: Sunset Gap Chloride Concentrations, 2020

Evaluation of Sunset Gap Alternatives

The Alamitos Barrier groundwater flow and transport model was recently updated and expanded to include the Sunset Gap area and thereby utilize data from newer OCWD monitoring wells on the Naval Weapons Station Seal Beach (NWSSB). The Alamitos-Sunset Gap model boundaries are shown in Figure 12-8.

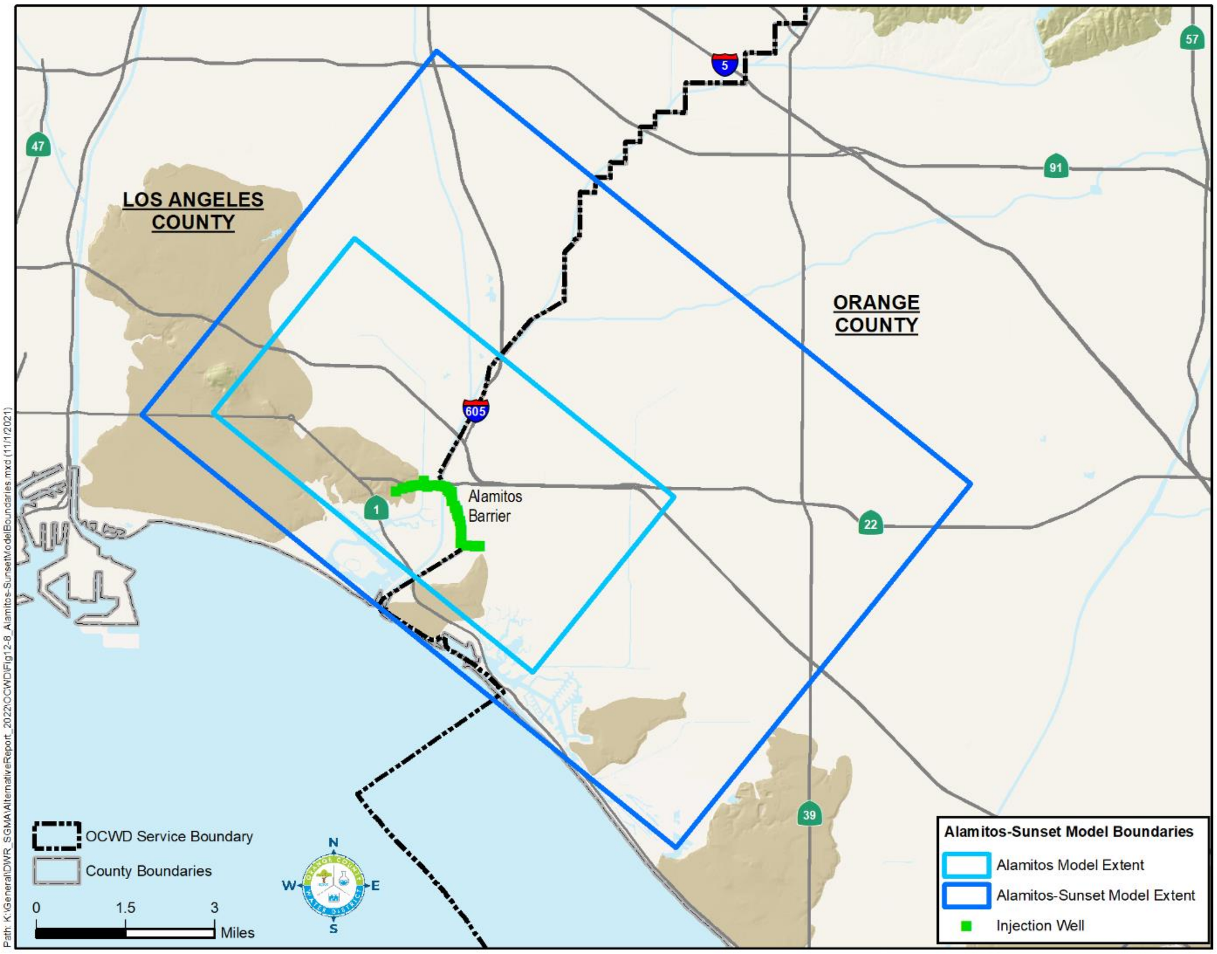


Figure 12-8: Alamitos-Sunset Gap Groundwater Model Boundaries

To date, the calibrated Alamitos-Sunset Gap model has been used to evaluate the effectiveness of five alternatives for a potential seawater intrusion barrier. These and other alternatives will be evaluated with the goal of halting the inland movement of seawater intrusion without significantly raising or lowering groundwater levels in the environmentally sensitive tidal marsh on the NWSSB. The effects, if any, of the simulated alternatives on nearby contaminant plumes will also be evaluated. Other factors to evaluate once the additional predictive scenarios are modeled will include feasibility, constructability, injection water supply, brackish extraction disposal/reuse, and cost.

The number of injection and extraction wells, well spacing, and injection volumes were varied from scenario to scenario to determine the preferred barrier scenario that prevents seawater intrusion by maintaining a seaward gradient without significantly raising or lowering groundwater levels in the environmentally sensitive tidal marsh on the NWSSB. Additionally, the model will run a series of no-barrier predictive scenarios to evaluate the potential maximum future inland extent of seawater intrusion and associated impacts and measures that would likely occur as a result, e.g., groundwater production well loss and/or inland groundwater desalters.

Preliminarily and subject to further analysis, the most favorable approach based on the five predictive scenarios completed so far includes a dual injection/extraction barrier, with an L-shaped injection well alignment around the perimeter of the NWSSB (Figure 12-9). A potential Sunset Gap Barrier Project (SGBP) would be designed to prevent the inland advancement of seawater intrusion near the NWSSB and the Huntington Harbor areas, thus protecting production wells in the cities of Huntington Beach, Seal Beach, and Westminster.

The preliminary favorable injection alignment would include approximately 20 injection well sites spaced approximately 1,500 to 2,000 feet apart (subject to further analysis). Total modeled injection was 13 mgd, with the majority being injected into the Beta and Lambda aquifers.

The preliminary favorable extraction alignment would include three single-point extraction wells screened across the Beta and Lambda aquifers. Total modeled extraction was 3 mgd, or 1 mgd per well. The three potential extraction wells were strategically located just outside (inland) of the Seal Beach National Wildlife Refuge perimeter to provide ample distance from the injection wells while also remaining outside of the NWSSB ordnance areas. Initially, the extracted brackish groundwater would be expected to have a chloride concentration ranging from 5,000 to 15,000 mg/L.

Depending on extracted water disposal/use feasibility and cost, a groundwater treatment plant may be appropriate to remove the high salinity from the groundwater produced by the barrier extraction wells. Reverse osmosis would be the likely treatment process. The technical and economic viability of this supply option would need to be evaluated as part of the future technical work described below.

To provide the injection wells with high-quality fresh water, the several water supply alternatives will be considered, including: (1) Groundwater treatment plant (brackish extraction wells and/or Deep aquifer amber-colored water wells); (2) Satellite wastewater treatment plant; (3) GWRS water via new pipeline; and (4) Imported water.

Future technical analysis that would need to be conducted as part of the feasibility study includes the following:

- Evaluate injection water supply alternatives
- Perform siting study for pipelines and wells
- Evaluate extraction well discharge alternatives
- Identify hydrogeologic data necessary to design, construct, and monitor the performance of barrier facilities
- Develop preliminary project design to support CEQA evaluation
- Estimate staffing needs for barrier operation and maintenance (O&M)
- Provide capital and O&M cost estimate

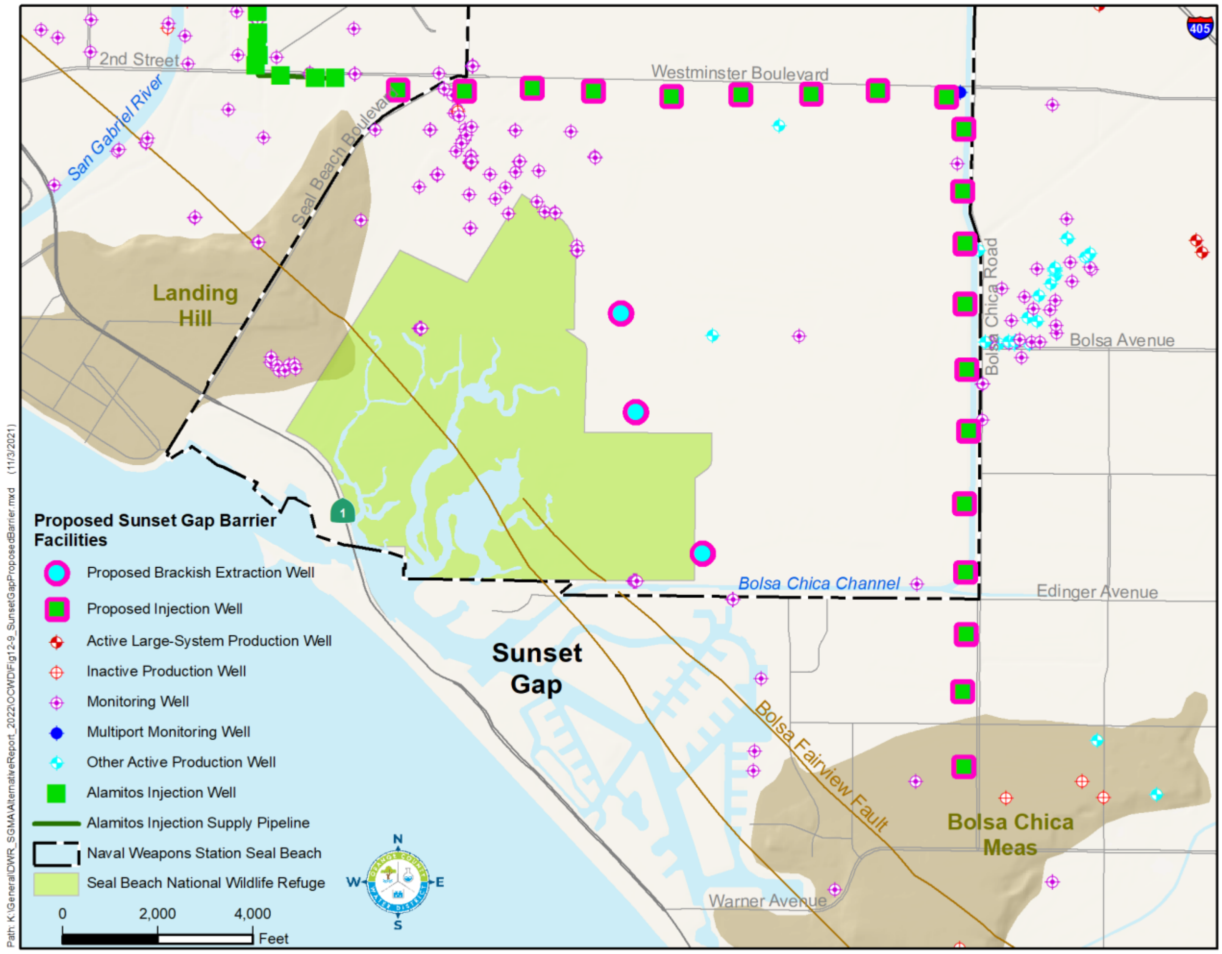


Figure 12-9: Potential Sunset Gap Barrier Project Facilities

BOLSA GAP

In the Bolsa Gap, seawater intrusion extends approximately 1.3 miles inland from the Pacific Ocean. Groundwater monitoring data show that the highest chloride concentrations in Bolsa Gap have remained seaward of the Bolsa-Fairview Fault, which is the farthest inland branch of the Newport-Inglewood Fault Zone in that area. Therefore, the saline groundwater appears to be largely restricted from migrating inland across the Bolsa-Fairview Fault within the Bolsa aquifer under normal basin conditions, as the Bolsa aquifer zones of mergence with the underlying Pleistocene aquifers are all inland of the Bolsa-Fairview Fault. An area of slightly elevated salinity has existed beneath the Huntington Beach Mesa for many years and is thought to be due to past disposal practices of oil field brines in the early 1900s rather than active seawater intrusion from the ocean. This area of saline groundwater is being pushed westerly into Bolsa Gap due to increased injection at the west end of the Talbert Barrier but is not expected to be a threat to active production wells or groundwater resources.

NEWPORT MESA

Chloride concentrations in the Beta/Lambda aquifers beneath the Newport Mesa east of the Talbert Gap have either remained stable or decreased over the last 10 years even though groundwater elevations have typically been below sea level in these aquifers in this area. Chloride concentrations in the underlying Main aquifer in this area have either decreased or have remained relatively stable for the last 10 years. A proposed extension of the Talbert Barrier eastward along Adams Avenue onto the Newport Mesa has been preliminarily evaluated and modeled by OCWD staff using the Talbert Model. Such a project would serve to provide insurance against future intrusion in the Beta/Lambda and Main aquifers under lower basin conditions and would thus protect production wells owned by Mesa Water District in addition to replenishing the basin. Based on the stability of chloride concentrations in the Newport Mesa, there is no need to advance this project at this time.

In 2014, OCWD constructed four new multi-depth monitoring wells (M51, M52, M53, MRSH) farther east on the Newport Mesa, as shown on Figure 12-10. These four well sites are now a part of OCWD's coastal monitoring program for both groundwater levels and seawater intrusion sampling. The East Newport Mesa area is at the southern margin of the groundwater basin, which geologic formations (including the aquifers with them) have been faulted, uplifted, and eroded. It has been a data gap in which the aquifer stratigraphy and groundwater flow patterns were not well understood. To further characterize this complex portion of the basin, OCWD plans to install a multi-depth cluster of monitoring wells east of John Wayne Airport in early 2022.

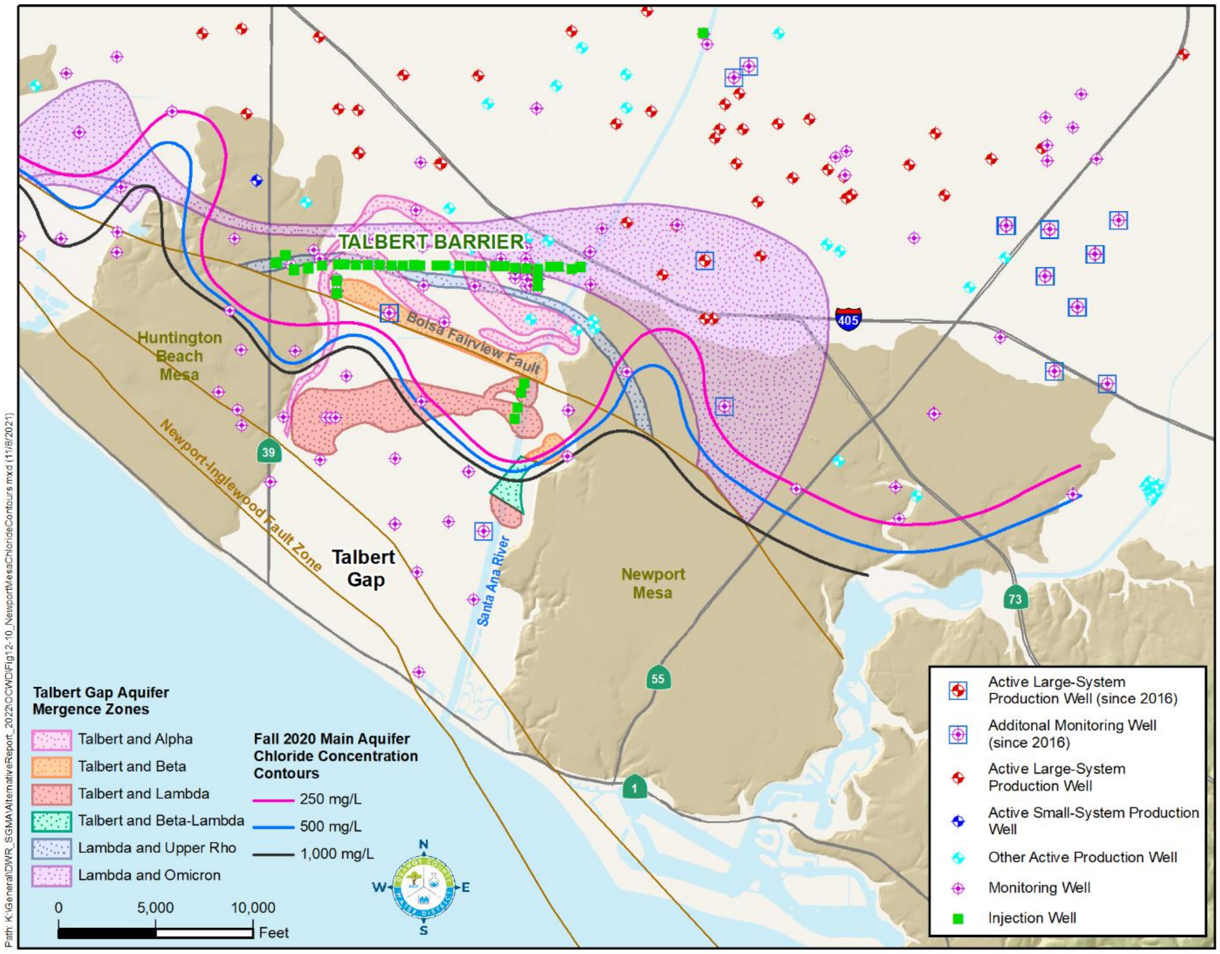


Figure 12-10: Newport Mesa Chloride Contours, 2020

IMPLEMENTATION OF SEAWATER INTRUSION PREVENTION POLICY

Implementation of OCWD's seawater intrusion prevention policy is summarized below. These programs enable OCWD to continue sustainably managing the groundwater basin to prevent significant and unreasonable seawater intrusion.

Effective Barrier Operations

The effective operation of the Talbert and Alamitos barriers is critical to the protection of the basin aquifers from seawater intrusion. This program includes, but is not limited to, the following activities:

1. Injection of sufficient water quantities combined with other basin management programs, such that protective groundwater elevations are established and maintained, where applicable, based on local hydrogeologic characteristics.
2. Regular maintenance of injection facilities to provide sufficient injection quantities. Such maintenance includes backwashing, redevelopment, and replacement (if necessary) of injection wells and operational fitness checks/repairs of flow meters, pressure reducing valves, and telemetry equipment.
3. Regular communications and coordination between operations, hydrogeology, and engineering staff on barrier operations and activities.
4. Annual reporting on barrier facilities status and operations. The reports include recommendations, as necessary, for barrier improvements to achieve policy objectives.

Barrier Performance Monitoring and Evaluation

Monitoring and evaluating barrier performance provides the basis on which to determine if the barriers are preventing seawater intrusion from occurring. This program consists of the following activities:

1. Semi-annual sampling and testing of designated monitoring wells in the vicinity of the seawater barriers. Testing includes parameters such as TDS, chloride, and electrical conductivity as indicators of seawater intrusion. Wells have been designated to provide adequate spatial coverage, particularly near likely seawater pathways and near the interface between seawater and freshwater.
2. Quarterly water level measurements at designated monitoring wells in the vicinity of the seawater barriers. More frequent measurements will be collected as needed at key locations.
3. Installation of monitoring wells in areas where it is determined that data gaps exist near the seawater barriers that may allow seawater intrusion to go undetected or would otherwise significantly impede the ability to assess barrier performance.
4. Annual evaluation and reporting of barrier performance based on surrounding groundwater level and quality data.

Susceptible Coastal Area Monitoring and Evaluation

This program addresses the assessment and ongoing monitoring of the coastal gaps and other areas that are not currently protected from seawater intrusion by the Talbert and Alamitos barriers. These areas include the Bolsa and Sunset gaps and adjacent mesas. This program includes the following activities:

1. Semi-annual sampling and testing of designated monitoring wells. Testing includes parameters such as TDS, chloride, and electrical conductivity as indicators of seawater

intrusion. Wells have been designated to provide adequate spatial coverage, particularly near likely seawater pathways.

2. Quarterly water level measurements at designated monitoring wells. More frequent measurements will be collected as needed at key locations.
3. Installation of monitoring wells in areas where it is determined that data gaps exist that may allow seawater intrusion to go undetected or would significantly impede the ability to understand the location of and trends in seawater intrusion.
4. Annual evaluation and reporting of the coastal area monitoring program, including recommendations, as needed, for further investigation or other potential actions to address seawater intrusion.

Coastal Groundwater Management

In addition to operating the seawater barriers, OCWD has implemented other basin management activities to lessen the potential for seawater intrusion. These activities have included the Coastal Pumping Transfer Program, Coastal In-Lieu Program, and maintaining basin storage levels within the operating range. Each of these activities shall continue to be considered and implemented as deemed necessary along with other potential actions to complement and enhance the OCWD seawater prevention program.

DEFINITION OF SIGNIFICANT AND UNREASONABLE SEAWATER INTRUSION

As explained above, OCWD conducts comprehensive programs to protect the groundwater basin from the undesirable effect of significant and unreasonable seawater intrusion. Seawater intrusion in the OCWD Management Area would be considered significant and unreasonable if a significant and continuing reduction in usable storage volume in the groundwater basin occurs as a result of increased salinity due to seawater intrusion.

DETERMINATION OF MINIMUM THRESHOLDS

The minimum threshold for seawater intrusion that defines an undesirable result is (1) the shutdown of active large system production wells due to seawater-derived salinity, and (2) continuing loss of a significant amount of basin storage due to seawater-derived salinity.

SECTION 13 SUSTAINABLE MANAGEMENT RELATED TO LAND SUBSIDENCE

Management of the groundwater basin by maintaining storage levels within OCWD's established operating range has prevented significant and unreasonable land subsidence that substantially interferes with surface uses. Within the OCWD Management Area there is no evidence of continuing irreversible land subsidence, nor is there evidence that land subsidence has interfered with surface uses. Therefore, the undesirable result of "significant and unreasonable land subsidence that substantially interferes with surface uses" is not present and is not anticipated to occur in the OCWD Management Area in the future.

Subsidence due to changes in groundwater conditions in the Orange County groundwater basin is variable and does not show a pattern of irreversible permanent lowering of the ground surface. Some subsidence may have occurred before OCWD began refilling the groundwater basin in the late 1950s after storage conditions reached a historic low (Morton, et al., 1976); however, the magnitude and scope of this subsidence is uncertain, and it is not clear if this subsidence was permanent. Since this time OCWD has operated the groundwater basin within the established operating range.

More recent data show a consistent pattern of the ground surface rising and falling in tandem with groundwater levels and overall changes in basin groundwater storage. This is referred to as elastic subsidence. Interferometric Synthetic Aperture Radar (InSAR) data collected from satellites and data collected by the Orange County Surveyor (Surveyor) show that ground surface elevations in Orange County both rise and fall in response to groundwater recharge and withdrawals. InSAR data during the period 1993-1999 shows temporary seasonal land surface changes of up to 4.3 inches (total seasonal amplitude from high to low) in the Los Angeles-Orange County area and a net decline of approximately 0.5 inch/year near Santa Ana over the period 1993 to 1999, which happened to coincide with a period of a net decrease in groundwater storage in the basin (Bawden, 2001; 2003).

The 2017 Alternative presented GPS data collected by the Orange County Surveyor's office. These data showed that ground surface elevation changes at selected sites from 2002 to 2014 correlate well with changes in groundwater storage.

Recently, as part of DWR's SGMA technical assistance to provide important SGMA-relevant data to Groundwater Sustainability Agency's (GSAs) for Groundwater Sustainability Plan (GSP) development and implementation, DWR contracted with TRE ALTAMIRA, Inc. to provide vertical displacement estimates derived from InSAR data that are collected by the European Space Agency (ESA) Sentinel-1A satellite.

The DWR-commissioned dataset represents measurements of vertical ground surface displacement in more than 200 of the high-use and populated groundwater basins across the California between January 2015 and October 2020. InSAR data coverage began in late 2014 for parts of California, and coverage for the entire study area began on June 13, 2015. Included in this dataset are point data that represent average vertical displacement values for 100 square meter areas, as well as GIS rasters that were interpolated from the point data; rasters for total vertical displacement relative to June 13, 2015, and rasters for annual vertical displacement rates with earlier coverage for some areas, both in monthly time steps. The level of accuracy is approximately 0.05 feet.

To show subsidence in Basin 8-1, OCWD used the used a layer showing the total land subsidence since the start of the InSAR data on 6/13/2015 and ending on 7/1/2020, which corresponds to the end of the OCWD water year. The GIS layer used was: https://gis.water.ca.gov/arcgisimg/rest/services/SAR/Vertical_Displacement_TRE_ALTAMIRA_v2020_Total_Since_20150613_20200701/ImageServer

Figure 13-1 shows the total land displacement in Basin 8-1 from June 2015 to July 2020. During this time period as shown on Figure 1-3, basin storage increased from 381,000 acre-feet below full conditions to 200,000 acre-feet below full conditions; that is, basin storage increased by 181,000 acre-feet. In addition to increasing groundwater levels, this rise in groundwater storage manifests itself as a rise in ground surface elevation over much of the basin, particularly in the center of the basin where there was as much as 0.15 feet of rise.

A localized area of downward (negative) displacement was observed in Tustin centered around production well T-ED. This is a relatively new well that came on-line in October 2016. Due to pumping of this well, water levels in the Principal Aquifer in the vicinity of the well declined by approximately 60 feet from June 2015 to July 2020. The small decline in ground surface in the vicinity of this well is not surprising given that it is a new well and the relatively fine-grained nature of the aquifer sediments in the area. As with other locations in the basin, we expect the impact of this well to stabilize with future displacements expected to be small.

Finally, there is little potential for future widespread permanent, irreversible subsidence given OCWD's commitment to sustainable groundwater management and policy of maintaining groundwater storage levels within a specified operating range. Nevertheless, OCWD will continue to review InSAR data and other data sources to evaluate ground surface fluctuations within OCWD's service area. If irreversible subsidence was found to occur in a localized area in relation to groundwater pumping patterns or groundwater storage conditions, OCWD would coordinate with local officials to investigate and develop an approach to address the subsidence. This could include OCWD managing the basin at higher groundwater storage levels.

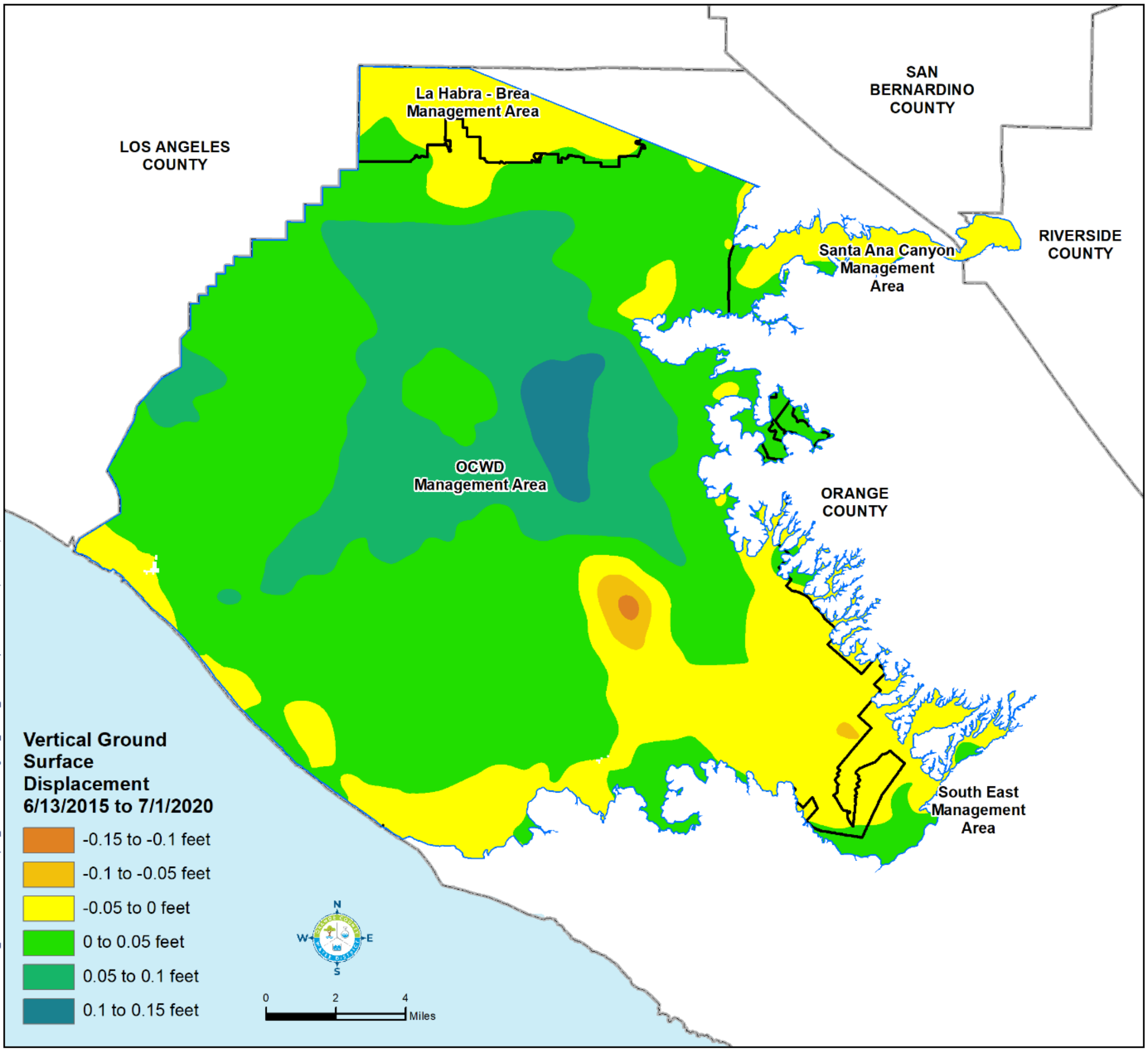


Figure 13-1: Total Vertical Ground Surface Displacement from June 2015 to July 2020

DEFINITION OF SIGNIFICANT AND UNREASONABLE LAND SUBSIDENCE THAT SUBSTANTIALLY INTERFERES WITH SURFACE USES

As stated above, data indicates that there is no inelastic land subsidence within the OCWD Management Area due to changes in groundwater elevation or groundwater storage levels. Land subsidence would be considered to be significant and unreasonable if ground surface elevation changes are determined to be inelastic over a significant period of time, these elevation changes are attributed to declines in groundwater storage, and these changes are likely to significantly interfere with surface uses.

DETERMINATION OF MINIMUM THRESHOLDS

The minimum threshold for land subsidence that defines an undesirable result is a sustained lowering of ground surface elevation that is attributable to lowering of groundwater storage in the basin and is likely to significantly interfere with surface uses.

SECTION 14 SUSTAINABLE MANAGEMENT RELATED TO GROUNDWATER DEPLETIONS IMPACTING SURFACE WATER

There are no surface water bodies within the OCWD Management Area that are interconnected and dependent on groundwater basin conditions. Therefore, the undesirable result of “depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water due to groundwater conditions occurring throughout the basin” is not present and in the future is not anticipated to occur in the OCWD Management Area due to OCWD’s management programs.

The two main surface water sources in Orange County are the Santa Ana River and Santiago Creek. The Santa Ana River in Orange County flows through a highly urbanized environment. Flood protection infrastructure has constrained the flow of the river with engineered levees along most of its course. Santiago Creek, a major tributary of the Santa Ana River, is the primary drainage for the northwest portion of the Santa Ana Mountains. Under natural conditions, the creek is ephemeral, with dry conditions predominant during most of the year. Additional information on these sources can be found in the 2017 Alternative.

SECTION 15 PROTOCOLS FOR MODIFYING MONITORING PROGRAMS

Protocols that trigger a change in a monitoring program include:

- a recommendation by the GWRS Independent Advisory Panel for resampling or increased monitoring of a particular constituent of concern;
- a recommendation by the Independent Advisory Panel that reviews OCWD use of Santa Ana River water for groundwater recharge and related water quality;
- a change in regulation or anticipation of a change in regulation;
- a constituent in a sample approaches or exceeds a regulatory water quality limit or Maximum Contaminant Level, notification level, or first-time detection of a constituent;
- the computer program built by OCWD to validate water quality data prior to transfer to the WRMS data base flags a variation in historical data that may indicate a statistically significant change in water quality;
- analysis of water quality trends conducted by water quality, hydrogeology, or recycled water production staff indicate a need to change monitoring; or
- OCWD initiates a special study, such as quantifying the removal of contaminants using treatment wetlands or testing the infiltration rate of a proposed new recharge basins.

SECTION 16 EVALUATION OF POTENTIAL PROJECTS

As described in the 2017 Alternative, OCWD regularly evaluates potential projects, conducts studies and prepares reports and plans (e.g., Long Term Facilities Plan) to continue to sustainably manage the groundwater basin and advance the mission of OCWD. Described below are a few of the key projects and activities OCWD has undertaken over the last five years.

Key activities/projects that were completed in the last five years include:

- Four deep mid-basin injection wells were constructed in Santa Ana (MBI wells). The wells are injecting approximately 8-10 mgd of GWRS water into the center of the basin where groundwater levels tend to be the lowest.
- Alamitos Barrier Improvement Project. (Additional description to be added in final draft).
- Shallow geophysical exploration of the Lower Off-River Channel to characterize the shallow subsurface sediments. This data will be useful in assessing whether or not it is feasible to remove areas of fine-grained sediments to increase facility recharge rates.
- Continued testing of the Riverbed Filtration System (RFS), which is a shallow underdrain system designed to filter SAR water prior to delivery to a recharge basin. Testing conducted thus far shows it has the potential to double the capacity of a receiving basin. Work is also ongoing on how to potentially expand the RFS to the main SAR channel.
- Geophysical evaluation of deeper sediments in the lower SAR to assess the potential of installing a horizonal collector well (e.g., Ranney well) that would be used for recharge of GWRS water. Modeling was also conducted to assess the potential recharge capacity of a “Ranney” type well.

Key activities/projects that are underway include:

- Final expansion of the GWRS to 130 mgd capacity. This is scheduled to be complete in 2023. This project will provide OCWD 30 mgd of new water supply.
- Construction of water treatment facilities at production wells currently impacted by PFAS is ongoing. This is scheduled to be complete by 2024.
- Continued assessment of potential seawater intrusion in the Sunset Gap, including installation of additional monitoring wells, modeling, and feasibility studies.
- Completion of the Integrated Santa Ana River Watershed Model (ISARM), which is the integration of several surface and groundwater models in the upper SAR watershed above Prado Dam. This model will assist OCWD and other upper SAR

watershed stakeholders in determining potential future SAR flows arriving at Prado Dam and the potential impact of future projects on these flows.

- A study to examine the use of Forecast Informed Reservoir Operations (FIRO) at Prado Dam. A Preliminary Viability Assessment (PVA) was completed in July 2021, which showed that FIRO is viable at Prado Dam and able to provide an average of up to 7,000 acre-feet of water depending on how much water can be temporarily impounded (Ralph et al., 2021). Work on the Final Viability Assessment (FVA) is underway and scheduled for completion in mid-2023. In parallel to the FVA is work with the US Army Corps of Engineers to test FIRO at Prado Dam (through a minor deviation from the approved Water Control Plan) for a five-year period, starting in fall 2023.

Future anticipated activities and projects:

- Additional treatment systems may need to be constructed on production wells based on water quality results or changes in regulations.
- Additional groundwater monitoring wells may need to be constructed to fill data gaps, including the Sunset Gap, and other areas in the basin.
- Design and construction of a potential seawater barrier at the Sunset Gap.
- Implementation of a groundwater contamination remedy in the South Basin area.

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Five Year Update to:

Basin 8-1 Alternative

South East Management Area

Prepared for the Department of Water Resources, pursuant to Water Code §10733.6(b)(3)

January 1, 2022

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Figures

Tables

SECTION 1. EXECUTIVE SUMMARY

The South East Management Area is located in the south east portion of the Coastal Plain of Orange County Groundwater Basin (Basin 8-1). The South East Management Area consists of several small, fringe areas south east of the Orange County Water District (OCWD) Management Area. These areas fall within the boundaries of the Irvine Ranch Water District (IRWD), El Toro Water District (ETWD) and the City of Orange service areas. Figure 1-1 shows the IRWD, ETWD and City of Orange areas within the boundaries of the South East Management Area along with the OCWD Management Area.

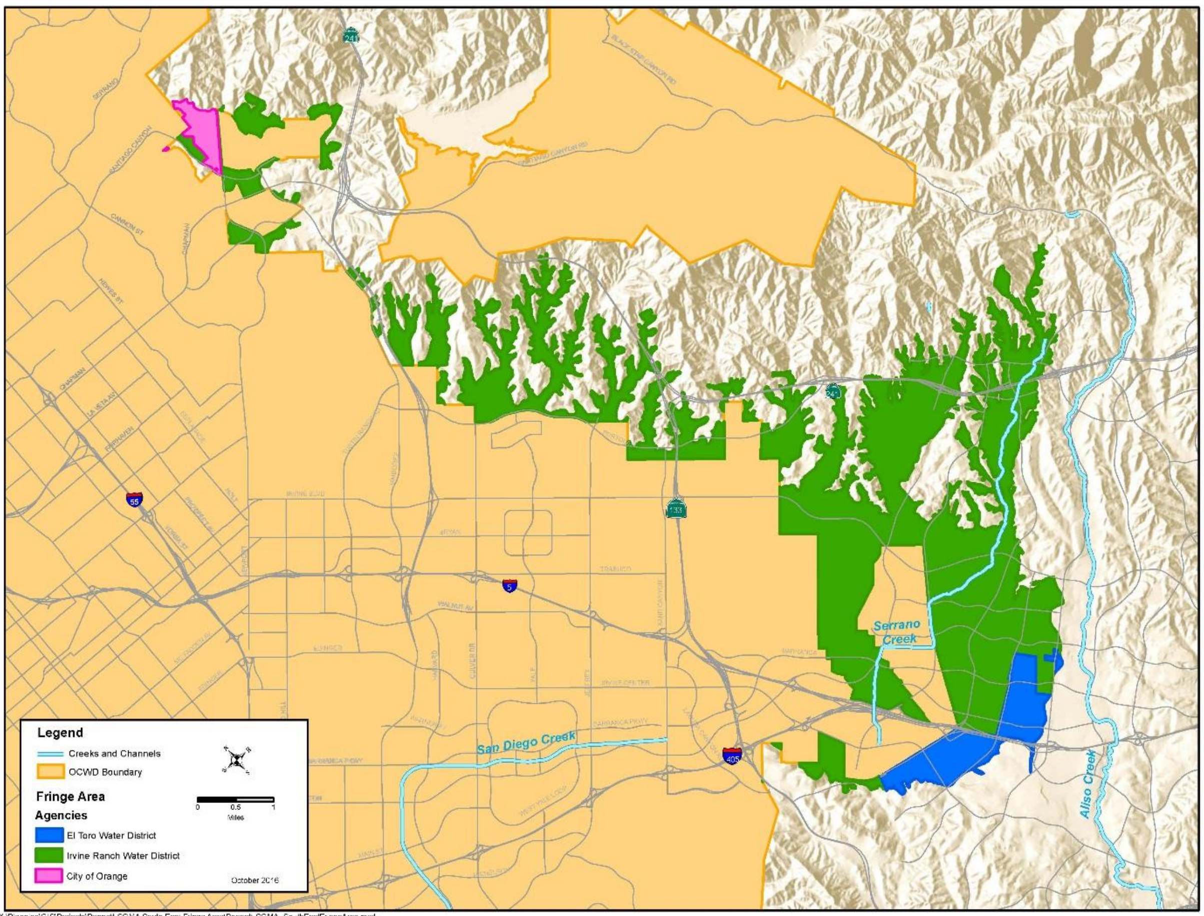

Figure 1-1: Agencies in the South East Management Area

Table 1-1 shows the area (in acres) associated with each agency within the South East Management Area. The South East Management Area covers approximately 4.4 percent of Basin 8-1, which has a total area of 223,600 acres.

Table 1-1: Agencies in South East Management Area and Area Covered

Agency	Area (acres)
Irvine Ranch Water District	8,870
El Toro Water District	762
City of Orange	134
Total Area	9,766

Update to 2017 Alternative

This document provides any updates to the 2017 Alternative for the South East Management Area plan, submitted by OCWD on December 2, 2016. The 2017 Alternative, including the South East Management Area was reviewed by the State of California Department of Water Resources (DWR) in July 2019. Based on DWR's assessment, the 2017 Alternative was found to meet the requirements under SGMA and was approved.

Approved alternatives are required to submit annual reports to DWR on April 1 of each year. Annual reports for Basin 8-1 were submitted to DWR as follows:

- Water Year 2016-17, Submitted on March 29, 2018
- Water Year 2017-18, Submitted on March 29, 2019
- Water Year 2018-19, Submitted on March 30, 2020
- Water Year 2019-20, Submitted on March 30, 2021

According to Water Code §10733.8, "At least every five years after initial submission of a plan pursuant to Section 10733.4, the department shall review any available groundwater sustainability plan or alternative submitted in accordance with Section 10733.6, and the implementation of the corresponding groundwater sustainability program for consistency with this part, including achieving the sustainability goal. The department shall issue an assessment for each basin for which a plan or alternative has been submitted in accordance with this chapter, with an emphasis on assessing progress in achieving the sustainability goal within the basin. The assessment may include recommended corrective actions to address any deficiencies identified by the department."

This document represents the first five-year update, which is due January 1, 2022.

Important Note:

For purposes of this report, the Basin 8-1 Alternative submitted on December 22, 2016, will be referred to as the 2017 Alternative. The first five-year update will be referred to as the 2022 Update for ease of reference. The 2017 Alternative was a comprehensive document showing that Basin 8-1 had been managed sustainably for more than 10 years. For the 2022 Update, the focus is on documenting that the basin has been continued to be sustainably managed during the five years since the 2017 Alternative was submitted and to present any new information from the last five years. As such, the 2017 Alternative is considered a key reference document with background information that is not duplicated in the 2022 Update.

The water resources in the South East Management Area include Serrano Creek, numerous smaller tributaries and groundwater. Serrano Creek provides surface waters that flow into and/or out of the IRWD's Lake Forest portion of the South East Management Area (Boyle, 2002). Imported water received through the Metropolitan Water District of Southern California is the primary water supply source to meet the water demands within the South East Management Area.

Historically, the only groundwater production in the South East Management Area has been from six wells located in the city of Lake Forest, within IRWD's service area. Currently, there is no groundwater production within the South East Management Area, however, in the past the production has represented less than 2 percent of the potable water supply for IRWD's Lake Forest area and historically less than 0.2 percent of IRWD's overall potable water supply. Due to the relatively low yield of the Aquifer in the South East Management Area, groundwater production is expected to remain a relatively insignificant water supply source for the area.

None of IRWD's six wells have been active since February 2018. At the time of the preparation of the Basin-8 Alternative, IRWD had one active well in the South East Management Area. In early 2018, due to poor water quality of the well water, IRWD ceased well pumping and the well has been inactive since. IRWD has plans to rehabilitate this well, well LF-2. In addition, in February 2020, one of the wells (LF-5) was decommissioned to make way for a new pump station on the site where the well was located. The well LF-5 was decommissioned due to poor water production and high salinity. While no plans are currently in place, placement for a potential new well was included with the pump station siting.

The five remaining wells within IRWD's Lake Forest portion of the Management Area are currently monitored for groundwater levels on a monthly basis. There are no other programs in the South East Management Area responsible for managing or monitoring groundwater resources at this time. As of the beginning of 2018, the monthly water quality monitoring of the operational well was halted temporarily due to lack of production. Sampling and water quality monitoring will resume at this well when the planned well rehabilitation project is completed. In addition, two wells are to be designated as groundwater level monitoring wells (LF-1 and LF-4) and added to the Basin 8-1 SGMA monitoring program. The groundwater levels at these wells will be monitored on a monthly basis with the results transmitted to DWR as part of the Basin 8-1 monitoring program.

The approach to sustainably managing the South East Management Area is to continue to monitor to ensure that conditions do not lead to significant and unreasonable and undesirable conditions such as (1) lowering of groundwater levels, (2) reduction in storage, (3) water quality degradation, (4) inelastic land subsidence or (5) unreasonable adverse effect on surface water resources. Description of these can be found in Sections 8 through 14.

SECTION 2. AGENCY INFORMATION

2.1 HISTORY OF AGENCIES IN SOUTH EAST BASIN MANAGEMENT AREA

No update since the 2017 Alternative – See 2017 Alternative.

2.2 GOVERNANCE AND MANAGEMENT STRUCTURE

No update since the 2017 Alternative – See 2017 Alternative.

2.3 LEGAL AUTHORITY

No update since the 2017 Alternative – See 2017 Alternative.

2.4 BUDGET

The budget required to monitor and report groundwater information for the South East Management Area has not been defined. As part of its standard operations, IRWD regularly collects and maintains information on its groundwater production, groundwater levels and water quality testing. Funding for well monitoring, operation, and rehabilitation where applicable is defined in the IRWD's operating or capital budgets. Since the preparation of the 2017 Alternative, there continues to be no groundwater production within ETWD or City of Orange areas of the South East Management Area, therefore these agencies are not be responsible for monitoring and reporting groundwater information.

For this 2022 update, it should be noted that two monitoring wells (LF-1 and LF-4) will be designated to report on monthly water levels which will be transmitted to DWR as part of the Basin 8-1 SGMA monitoring program.

SECTION 3. MANAGEMENT AREA DESCRIPTION

3.1 SOUTH EAST SERVICE AREA

No update since the 2017 Alternative – See 2017 Alternative.

3.1.1 Jurisdictional Boundaries

No update since the 2017 Alternative – See 2017 Alternative.

3.1.2 Land Use Designations

No update since the 2017 Alternative – See 2017 Alternative.

3.2 GROUNDWATER CONDITIONS

There continues to be relatively little existing, or potential, groundwater development within the South East Management Area. Historically, IRWD's Lake Forest portion of the South East Management Area has had limited, inconsistent groundwater production from IRWD's six existing wells. Figure 3-3 shows the locations of the constructed wells within the South East Management Area.

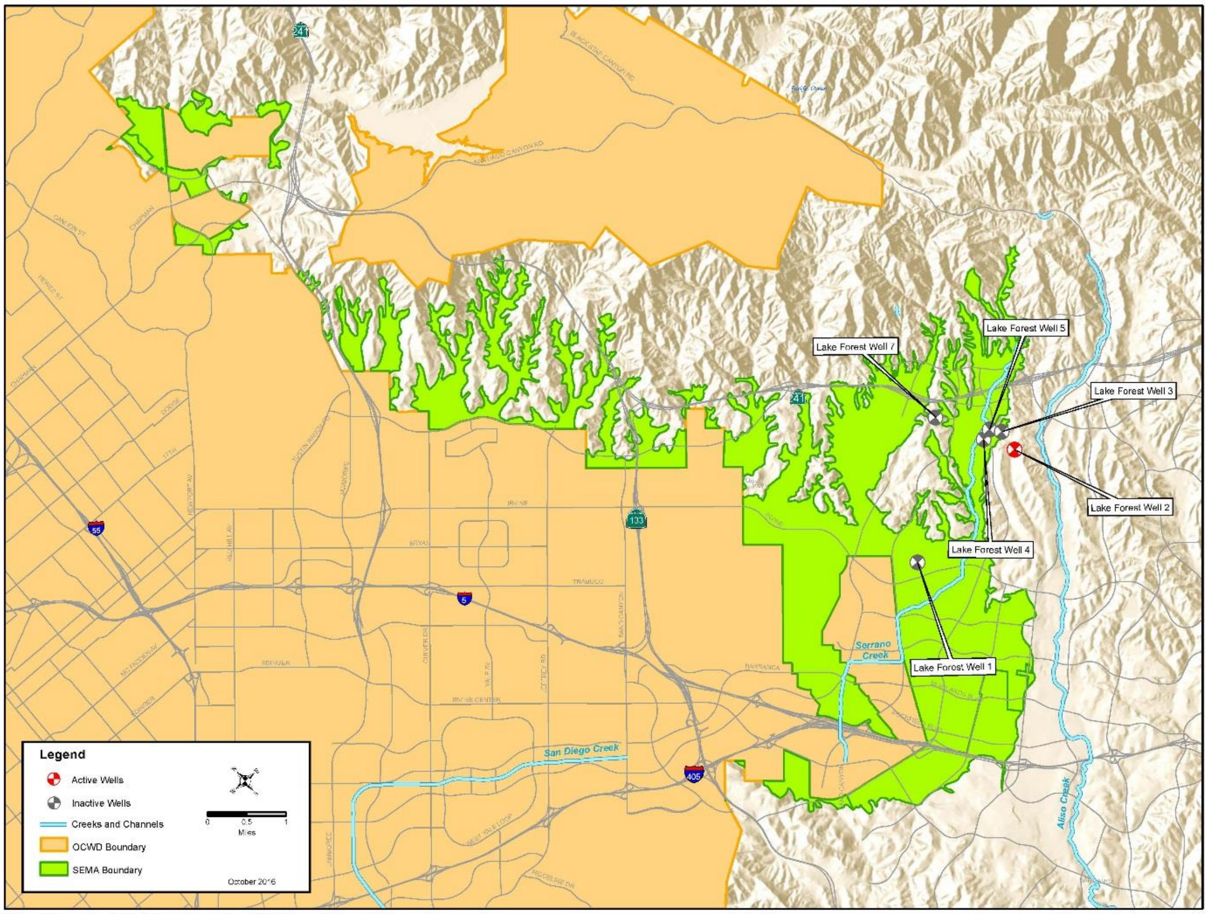

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Figure 3-3: Groundwater Production Wells (Active and Inactive)

A study completed in 2002 assessed the potential of the development of future wells in the IRWD Lake Forest area. It was noted that based on available well driller's logs there was considerable clay in the alluvium and that the specific capacity of these wells is very low. Based on the very low specific capacity results, it appears that the alluvium is characterized by low permeability This seems to be reflected in the low production capacity of the wells (Boyle 2002).

Since the preparation of the 2017 Alternative, only well LF-2 was operational up through January 2018. Due to water quality issues related to iron and manganese, well LF-2 was taken offline in early 2018 and IRWD plans to rehabilitate the well and construct treatment for the removal of iron and manganese. The rehabilitation project is planned to be performed in late 2022 and depending on the performance and water quality testing results from the well, IRWD may construct a treatment facility to remove iron and manganese. While well LF-2 has not been active in last few years, it is shown as "active" on Figure 3-3 because IRWD plans to put well LF-2 back into production once it is rehabilitated and treatment facilities are constructed.

In 2020, well LF-5 was decommissioned to make way for a new planned pump station on the site. Well LF-5 was previously used to supplement water in IRWD's recycled water system. However, due to continual poor water production and high salinity, IRWD ceased the operation of well LF-5 and planned to decommission the well. At the site of the decommission well LF-5, IRWD plans to construct a new recycled water pump station. Although construction and operation of a new well is not a currently planned project, space is being allocated on the existing site adjacent to the pump station to accommodate a potential new well in the future.

3.2.1 Groundwater Levels

The range of observed groundwater levels in the South East Management Area from 2016 to 2021 are summarized in Table 3-1 by agency. As shown, no groundwater level data exists in the ETWD and City of Orange portions of the South East Management Area. Historic and estimated groundwater levels from 1991 to 2021 for IRWD's Lake Forest wells are shown in Figure 3-4. Historic groundwater level data is available from 1991 through 2001, after which there is no consistent data available until 2015. More recent groundwater level data is available from 2015 to present. Current monthly groundwater levels from IRWD's Lake Forest wells for 2020 to 2021 are shown in Figure 3-5.

Table 3-1: South East Management Area Groundwater Levels 2016-2021

Agency	From (ft-bgs)	To (ft-bgs)
IRWD	11.4	168.3
ETWD	N/A	N/A
City of Orange	N/A	N/A

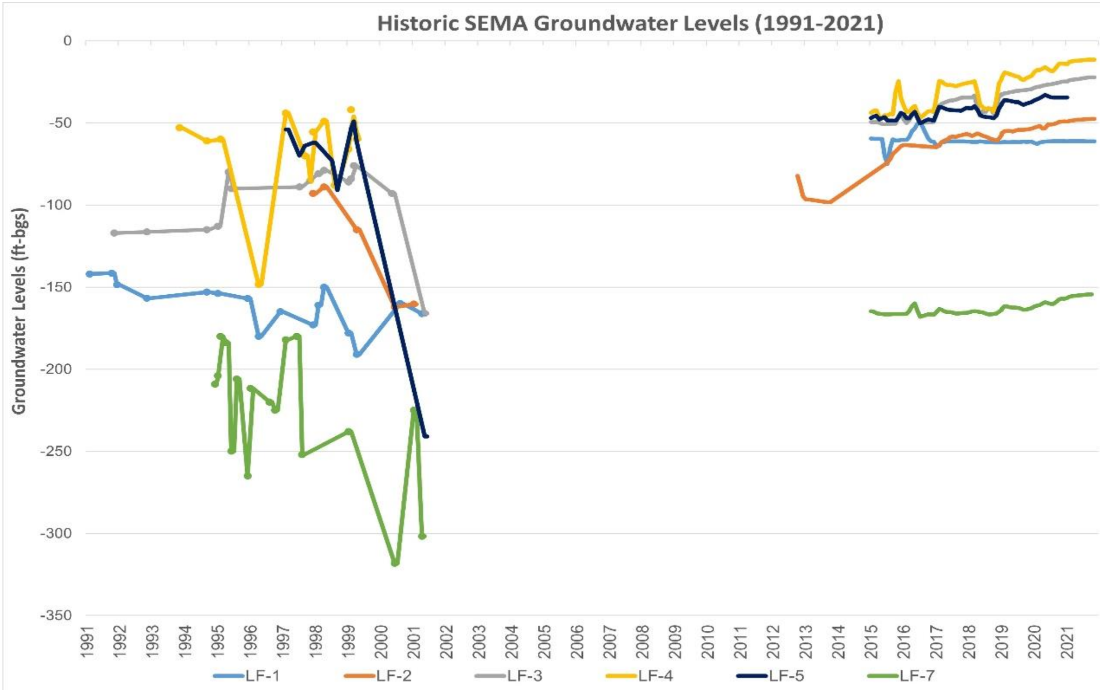

Figure 3-4:Historic Groundwater Levels in South East Management Area, 1991-2021

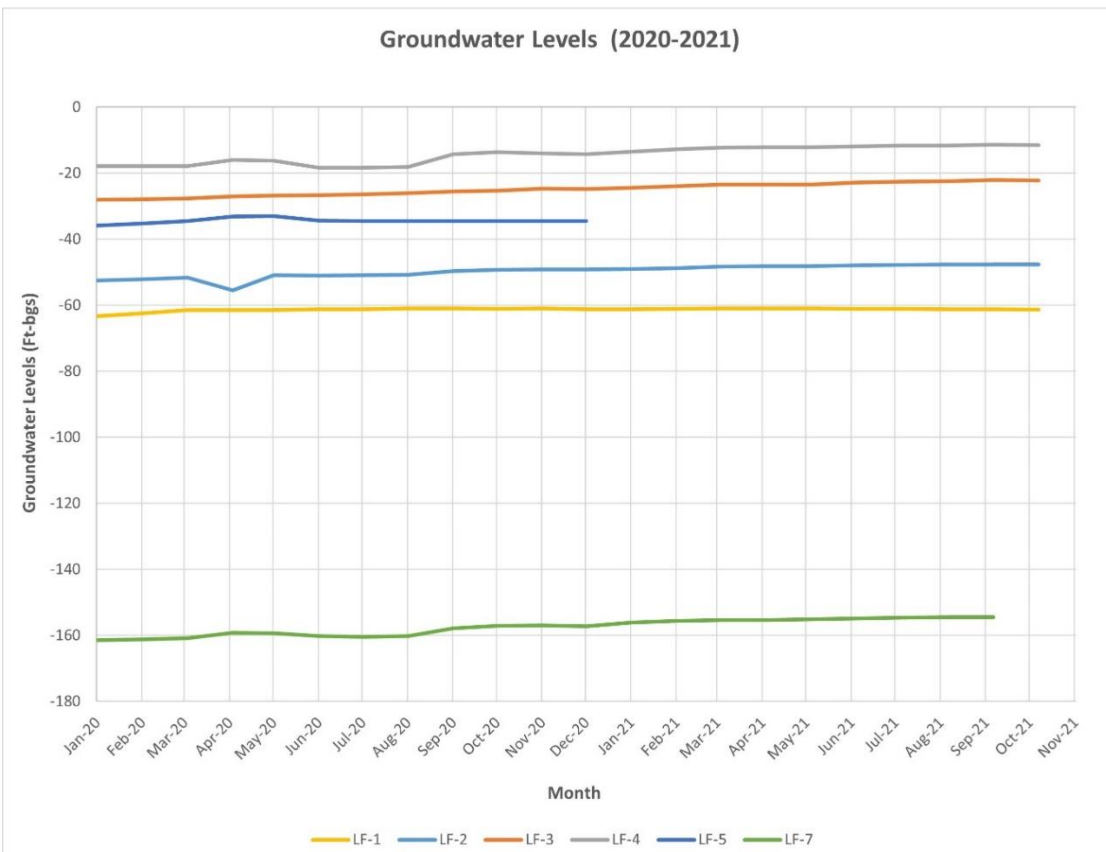

Figure 3-5: Current Groundwater Levels in South East Management Area, 2020-21

3.2.2 Regional Pumping Patterns

Table 3-2 summarizes information on all of the wells that are known to exist within the South East Management Area by agency. As presented, well design flows range from 125 to 350 gallons per minute (gpm) and well depths range from 675 to 1,000 feet below ground surface (ft-bgs).

Table 3-2: Wells and Flow Data

Agency	Well	State Well No.	System	Status	Design Flow (gpm)	Drilled	Depth (ft-bgs)	Perforated Intervals (ft)
IRWD	LF-1	06S/08W-15A00	Nonpotable	Inactive	300	1989	800	200-790
IRWD	LF-2	06S/08W-12Q02	Potable	Inactive	300	1957, redrilled 2010	675	200-675
IRWD	LF-3	06S/08W-12J01	Potable	Inactive	350	1950	800	270-395; 400-785
IRWD	LF-4	06S/08W-12L02	Nonpotable	Inactive	200	1993	810	350-470 510-790
IRWD	LF-5	06S/08W-12A01	Nonpotable	N/A	140	1997	800	350-780
IRWD	LF-7	06S/08W-12E00	Potable	Inactive	125	1994	1000	430-980
ETWD	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
City of Orange	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

For the 2022 Update, Table 3-3 summarizes average annual pumping from 2016-2021 within the South East Management Area by agency. As shown, no groundwater development exists in the ETWD and City of Orange portions of the South East Management Area. In IRWD's portion of the South East Management Area none of the existing wells are currently active. Over the last 5 years, well LF-2 annual pumping ranged from 0 acre-feet to 389 acre-feet and averaged approximately 87 acre-feet.

Table 3-3: Annual Pumping Average 2016-2021

Agency	Average Annual Production (acre-feet/yr)
IRWD	87
ETWD	0
City of Orange	0
Total	87

Historical groundwater development within IRWD's portion of the South East Management Area has been limited to six wells in the Lake Forest region. However, as of February 2018 none of these wells are currently operating. Due to the relatively low yield of these wells, IRWD considers production from these wells as a supplemental supply and does not rely on these wells to meet its firm water demands.

In the last five years, pumping from LF-2 occurred in 2016 and 2018, after which LF-2 was taken offline. Figure 3-6 shows monthly pumping patterns for LF-2 from 2016 to 2021. Figure 3-7 shows annual pumping by water year (October-September) for 2017 through 2021.

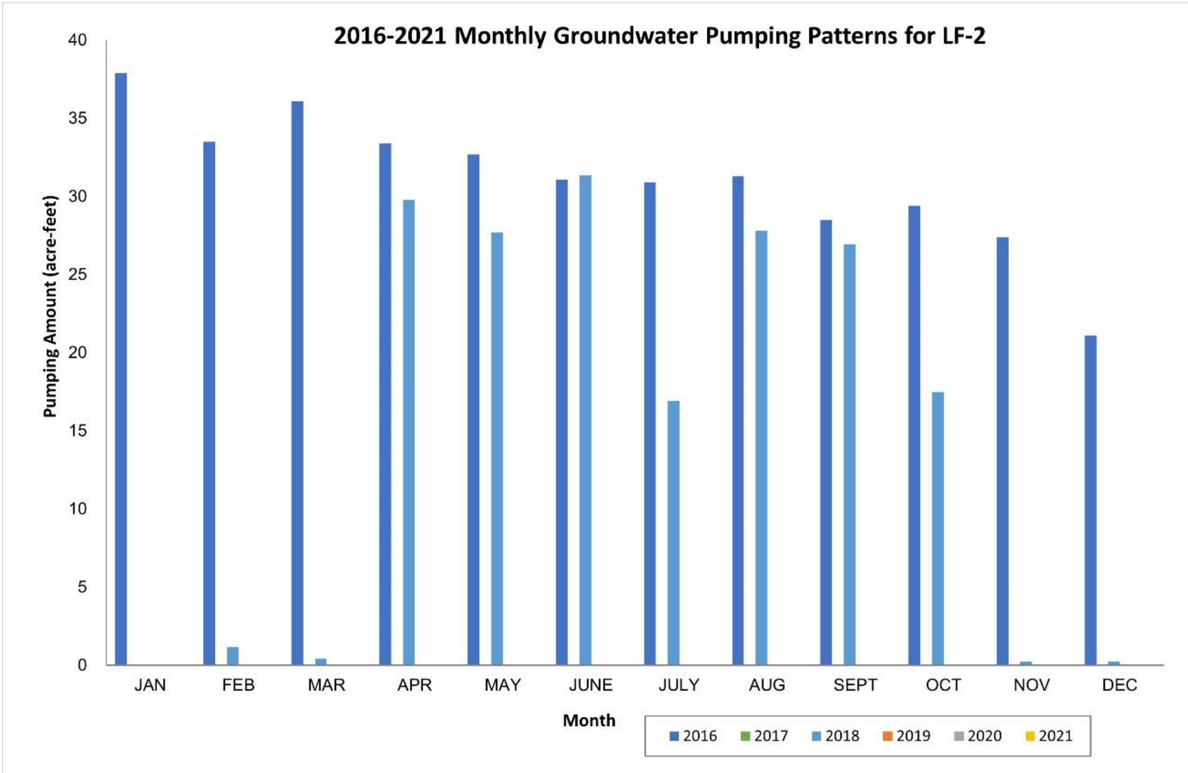

Figure 3-6: Monthly Groundwater Pumping Pattern in Well LF-2, 2016-2021

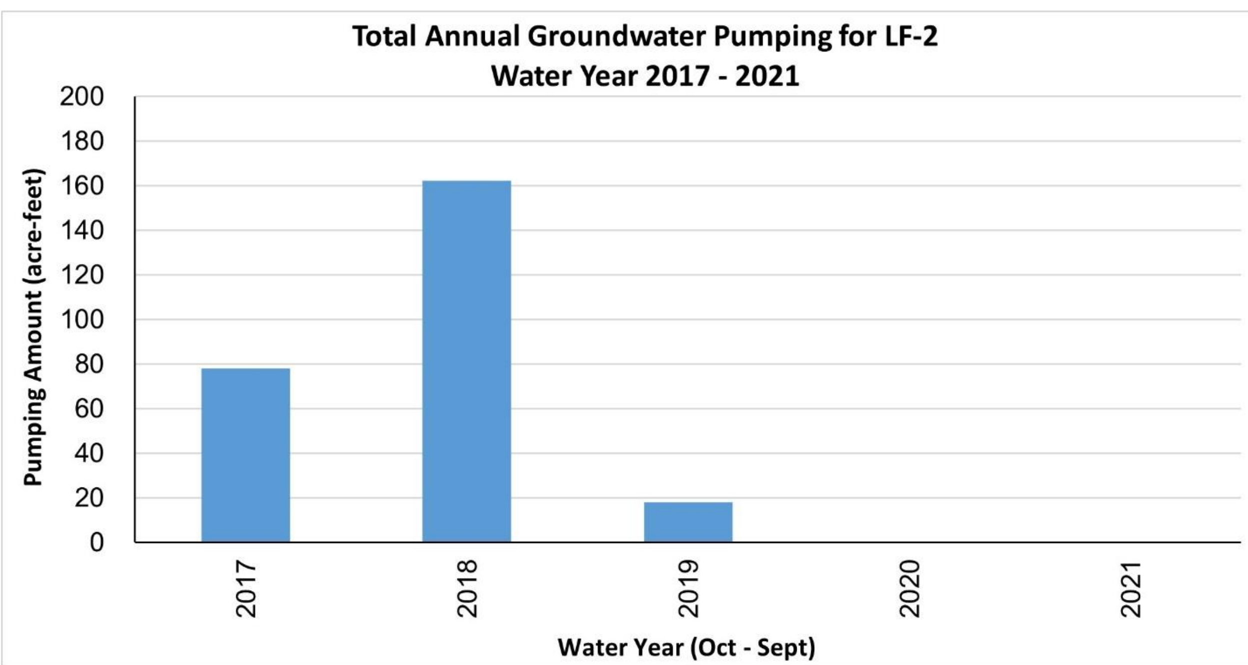

Figure 3-7: Total Annual Pumping for Well LF-2, Water Year 2017-2021

3.2.3 Groundwater Storage Data

No update since the 2017 Alternative – See 2017 Alternative.

3.2.4 Groundwater Quality Conditions

Historically, only three of the six IRWD Lake Forest wells were permitted for potable use as the other three Lake Forest wells have had elevated levels of iron, manganese (Mn), electrical conductivity (EC) and total dissolved solids (TDS). Recent groundwater quality data for the South East Management Area which includes arsenic (As) is presented in Table 3-4. As presented, no other water quality data exists for the ETWD and City of Orange areas within the South East Management Area.

Table 3-4: Ground Water Quality in Selected Wells

Agency	Well Name	Well Use	Date Range	Avg TDS (#)[1] (mg/L)	Avg As (ug/L)	Avg Mn (mg/L)
IRWD	LF-2	Production	2016-2018*	602	0.51	22.3
IRWD	LF-1	Production	1961-2000	>500 (21)		
IRWD	LF-4	Production	1993-2000	>500 (12)		
IRWD	LF-5	Production	1997-2001	>500 (5)		
IRWD	LF-3	Production	1991-1998	>500 (12)		
IRWD	LF-7	Production	1994-2001	<500 (12)		
City of Orange	N/A	N/A	N/A	N/A	N/A	N/A
ETWD	N/A	N/A	N/A	N/A	N/A	N/A

1 # = Number of Samples
* LF-2 Turned Offline in February 2018

3.2.5 Land Subsidence

No known land subsidence issues are known to exist in the South East Management Area. Subsidence is not believed to be an issue for the South East Management Area given the following:

1. Minimal groundwater development exists in the South East Management Area.
2. The presence of shale and sandstone bedrock underlying the alluvial aquifer.

3. The alluvial aquifer is relatively thin and comprised mainly of sand and gravel with little clay.
4. Steady groundwater and storage levels.
5. Low risk of substantial groundwater level declines due to de minimis amount of groundwater production.

For additional information, see Section 13.

3.2.6 Groundwater and Surface Water Interactions and Groundwater Dependent Ecosystems

IRWD's Lake Forest portion of the South East Management Area contains quaternary alluvium and terrace deposits that interact with and are drained by Serrano Creek. Serrano Creek is an intermittent stream that only flows during the rainy season following storm events. As stated in the Boyle 2002 Groundwater Supply Evaluation study, there is limited information available for local surface and subsurface inflow to the area. It states as surface water flows within the Serrano Creek drainage, a portion of that flow percolates into the sediments that line the drainage courses and provides recharge to the groundwater resources. With regards to subsurface inflow, the Boyle study does state that groundwater inflow to the area is assumed to occur within the alluvium and Capistrano Formation. A value for the transmissivity of the alluvium and bedrock materials was estimated from the specific capacity values of the six Lake Forest wells. Based on the production capacity of IRWD's Lake Forest wells, the specific capacity is very low and the well driller's logs noted considerable clay in the alluvium and it appears that the alluvium is characterized by low permeability. Furthermore, based on the available information, it is expected that there are no groundwater dependent ecosystems present in the South East Management Area.

SECTION 4. WATER BUDGET

No groundwater production exists within the ETWD and City of Orange portions of the South East Management Area. In IRWD's Lake Forest portion of the South East Management Area none of the existing wells are currently operational. IRWD's LF-2 groundwater production is dependent upon infiltration from ephemeral creeks, precipitation and incidental recharge from irrigation. Well LF-2 was turned offline in 2016 for potable production and 2018 for non-potable production due to concerns of elevated levels of iron and manganese and reduced well performance. From 2016-2021, LF-2's annual pumping ranged from 0 acre-feet to 389 acre-feet and averaged 87 acre-feet. With this current well shut down, groundwater production is now at zero acre-feet per year in the South East Management Area. An average annual groundwater budget for the South East Management Area for the last 5 years is presented in Table 4-1. The simple water budget for the South East Management Area is based on measured groundwater production and the subsurface flow calculated by the numerical model for the OCWD Management Area. The development of individual components in the average annual groundwater budget are described in the following subsections.

4.1 BUDGET COMPONENTS

Currently, no groundwater development exists in the ETWD and City of Orange portions of the South East Management Area. For IRWD's Lake Forest portion of the South East Management Area, the components of the groundwater budget are presented in Table 4-1 and described below. Groundwater Production includes an average from 2016-2021 As of 2018, the groundwater production is considered to be zero until the LF-2 well can be rehabilitated and placed back in service.

Table 4-1: Average Annual Groundwater Budget

South East Management Area Groundwater Budget 2016-2021 (acre-feet)	
Item	**Total (acre-feet)**
Recharge	2,897
Total Inflow	2,897
Groundwater Production	87
Subsurface Outflow	2,810
Total Outflow	2,897
Change in Storage	0

4.1.1 Recharge

Recharge includes infiltration from ephemeral creeks, precipitation and incidental recharge from irrigation. It was estimated to equal the total outflow as summarized in Table 4-1.

4.1.2 Groundwater Production

Groundwater production was taken from measured records by IRWD as summarized in Table 4-1. The remaining operating Lake Forest well (LF-2) went offline officially (for potable and non-potable supplies) in 2018 with no additional production values recorded past that year. Average well LF-2 groundwater production from 2016-2021 was used in the annual water budget presented, including the years of non-production.

4.1.3 Subsurface Outflow

Subsurface outflow was estimated to equal the subsurface inflow to the OCWD Management Area from foothills into the Irvine subbasin prorated by the fraction of that area located in the South East Management Area as summarized in Table 4-1.

4.2 CHANGES IN GROUNDWATER STORAGE

As presented in Section 4.1, groundwater pumping in the South East Management Area is relatively minor and averages only 125 acre-feet per year over the previous 10 years (2006-2015), and 87 acre-feet in the last six years (2016-2021). In addition, Section 3.2 indicates historic groundwater levels from 1991 to 2021 have been variable without any undesirable results. In the past, groundwater levels in this basin are consistently at or above historical high levels despite increased groundwater production over some years and multiple years of below normal precipitation. Based on the historic groundwater level conditions , any changes in groundwater storage within the South East Management Area are small and insignificant and are within an acceptable range.

4.3 WATER YEAR TYPE

No update since the 2017 Alternative – See 2017 Alternative.

4.4 ESTIMATE OF SUSTAINABLE YIELD

As shown in Table 4-1 and described in Section 3.2, the annual groundwater production over the last 5 years has ranged from 0 acre-feet to 389 acre-feet and has averaged approximately 87 acre-feet without significant reductions in groundwater elevations, including years of non-operation. However, the due to the non-operation of certain wells, the sustainable yield of the South East Management Area may be significantly greater than the 5-year average under normal and wet hydrologic cycles. Based upon the limited groundwater resources in the area it is unlikely demands would ever rise to the level of straining the water budget of the area. In terms of sustainable yield, it is more appropriate to look at the South East Management Area as part of the larger OCWD Management Area.

4.5 CURRENT, HISTORICAL, AND PROJECTED WATER BUDGET

In IRWD's Lake Forest portion of the South East Management Area, a 2002 study by Boyle Engineering Corporation and a 2015 study by Dudek were performed in order to assess the potential for development of two future wells, LF-6 and LF-8, as well as the re-drilling of existing inactive wells.

A capital project for the design, construction and equipping of LF-1 has been included in IRWD's capital budget, however, there are no plans to begin this project. IRWD also has no near-term plans to drill wells LF-6 and LF-8. In 2000, its last active year, LF-1 pumped approximately 230 acre-feet. Over the last 5 years well LF-2 annual pumping has ranged from 0 acre-feet to 389 acre-feet and averaged approximately 93 acre-feet including years of non-operation. It is expected that when LF-1 is redrilled, groundwater production from IRWD's southern portion of the South East Management Area could increase.

Water produced from LF-1 could be used to provide supply to the nearby lake which currently is supplied by untreated imported water. Water produced could also potentially be pumped and conveyed to the Baker Water Treatment Plant for treatment if needed (Dudek, 2015). Due to the consistently lower yields from the aquifer in this area, it is expected that additional production from LF-1 will continue to be considered supplemental, and therefore insignificant in terms of IRWD's overall water supply for its Lake Forest area. As of 2021, LF-1 is still currently off line although there are future plans to potentially re-drill and rehabilitate the well in the future.

More recently, the IRWD capital budget for fiscal years (FY) 2021-2022 and 2022-2023 includes project funds for a LF-2 treatment and bypass to rehabilitate the existing well. Projected expenditures for well rehabilitation (across all IRWD projects) includes approximately $1.4 million for FY2021-2022 and $2.2 million for FY2022-2023.

No projected water production is currently anticipated within the ETWD and city of Orange portions of the South East Management Area.

SECTION 5. WATER RESOURCE MONITORING PROGRAMS

5.1 OVERVIEW

This section describes surface and groundwater monitoring programs in the South East Management Area

5.2 GROUNDWATER MONITORING PROGRAMS

No groundwater development exists in the ETWD and City of Orange portions of the South East Management Area. In IRWD's Lake Forest portion of the South East Management Area the now five wells (whether active or inactive) have been, and will continue to be, used to monitor the groundwater levels on a monthly basis. Section 3.2.1 provides information on the South East Management Area groundwater levels, and Figure 3-3 shows the locations of the Lake Forest wells within the South East Management Area.

5.3 OTHER MONITORING PROGRAMS

IRWD monitors groundwater quality in LF-2, when operating, as required by the California Code of Regulation (Title 22) and California Division of Drinking Water, Santa Ana District. In addition, as of 2021 two monitoring wells will be designated (LF-1 and LF-4) for the monitoring and reporting groundwater elevations in the South East Management Area which will be transmitted to the DWR under the SGMA monitoring program for Basin 8-1. DWR currently requires bi-annual reporting for well monitoring data.

SECTION 6. WATER RESOURCE MANAGEMENT PROGRAMS

IRWD works with ETWD and City of Orange on plans for groundwater development within the South East Management Area and updates demand projections and the water budget accordingly.

IRWD: The compilation of land use data is the basis for IRWD's water resource planning including its portion of the South East Management Area. Per IRWD's 2020 Urban Water Management Plan (UWMP), the land use data obtained from multiple jurisdictions in IRWD's service area is used in conjunction with IRWD's applied water use factors in order to estimate water requirements.

ETWD: ETWD's water resource planning is based on the 2020 UWMP demand projections. Regional demands are forecasted by the Municipal Water District of Orange County and are then tailored to ETWD's service area using available data for land use, population, and economic growth, intermixed with a trajectory of conservation, which includes both additional future passive measures and active measures.

City of Orange: The City of Orange's current UWMP (2020) provides the basis for water resource planning in Orange's water service area. The UWMP, in conjunction with applicable water use factors, form the basis for any potential water use estimates required for potential planning use in the service area.

SECTION 7. NOTICE AND COMMUNICATION

There are three agencies within the South East Management Area, as follows:

- IRWD
- ETWD
- City of Orange

On September 30, 2021, OCWD sent a letter via email to all of the Basin 8-1 agencies, including each of the agencies listed above to let them know that the 2017 Alternative was being updated and would be available for review and comment. No comments were received by any of the agencies contacted. The three South East Management Area agencies coordinated with OCWD and the other management areas to prepare the 2022 Update, in accordance with SGMA requirements.

A draft 2022 Update was presented to the OCWD Board and posted on the OCWD website on November XX to allow for public review and comment. The final 2022 Update was received and filed by the OCWD board in December XX, 2021.

SECTION 8. SUSTAINABLE MANAGEMENT APPROACH

The Sustainable Management Approach for the South East Management Area is to continue monitoring sustainable conditions and monitor to ensure that conditions do not lead to significant and unreasonable (1) lowering of groundwater levels, (2) reduction in storage, (3) water quality degradation, or (4) inelastic land subsidence or (5) unreasonable adverse effect on surface water resources.

SECTION 9. SUSTAINABLE MANAGEMENT RELATED TO GROUNDWATER LEVELS

9.1 HISTORY

As shown on Figure 3-4 historic groundwater levels in the IRWD's Lake Forest portion of the South East Management Area have been variable but have recovered to historical highs. Because existing groundwater pumping in the South East Management Area is expected to be relatively minor groundwater levels are expected to remain relatively steady in the future.

9.2 MONITORING OF GROUNDWATER LEVELS

Groundwater levels are currently monitored in multiple wells located in IRWD's Lake Forest portion of the South East Management Area and will continue to do so.

9.3 DEFINITION OF SIGNIFICANT AND UNREASONABLE LOWERING OF GROUNDWATER LEVELS

No long-term reduction in groundwater levels in the South East Management Area is expected to occur.

9.4 DETERMINATION OF MINIMUM THRESHOLDS

It is not possible to determine a minimum threshold at this time since no undesirable effects due to water levels have occurred in the past and are not foreseen in the future. Nevertheless, the South East Management Area well monitoring program is expected to continue to monitor water levels and groundwater quality in the future. If water levels start to show a consistent, long-term decline and undesirable results are observed, action would be taken and minimum thresholds would be evaluated and established as appropriate.

SECTION 10. SUSTAINABLE MANAGEMENT RELATED TO BASIN STORAGE

No groundwater development exists in the ETWD and City of Orange portions of the South East Management Area. The total volume of groundwater storage in IRWD's portion of the South East Management Area has been estimated to be approximately 360,000 acre-feet (see Section 3.2.3).

10.1 DEFINITION OF SIGNIFICANT AND UNREASONABLE REDUCTION IN STORAGE

No significant long-term reduction in groundwater storage is expected to occur in the South East Management Area because of the limited groundwater use. However, a decline in groundwater storage may be determined unreasonable if one more of the following occurred:

1. Significant loss of well production capacity.
2. Degradation of water quality that significantly impacts the use of groundwater.

10.2 DETERMINATION OF MINIMUM THRESHOLDS

A minimum threshold for the reduction of groundwater storage in the South East Management Area is not anticipated since no undesirable effects have occurred in the past and are not foreseen in the future. Nevertheless, IRWD's Lake Forest monitoring program continuously tracks water levels and groundwater quality. If water levels show a consistent decline, IRWD's Lake Forest monitoring program would be expanded to examine any potential impacts and action would be taken to identify minimum thresholds as appropriate.

SECTION 11. SUSTAINABLE MANAGEMENT RELATED TO WATER QUALITY

No groundwater development exists in the ETWD and City of Orange portions of the South East Management Area. Groundwater quality in IRWD's portion of the South East Management Area is affected by the quality of recharge from Serrano Creek and precipitation and incidental recharge from irrigation. Groundwater from subsurface inflow could contain naturally elevated concentrations of TDS and manganese. Additionally, IRWD has the ability to utilize water produced from non-potable wells to supplement its extensive recycled water system which serves irrigation demands.

11.1 DEFINITION OF SIGNIFICANT AND UNREASONABLE DEGRADATION OF WATER QUALITY

There are three elements that must be considered when evaluating the impact of groundwater quality degradation.

The first element is considering the causal nexus between groundwater management activities and groundwater quality. For example, groundwater contamination due to improper handling of toxic materials impacts groundwater quality; however, this water quality degradation is not caused by groundwater management activities.

The second element is the beneficial uses of the groundwater and water quality regulations, such as Maximum Contaminant Levels (MCLs) and other potable water quality requirements.

The third element that must be considered is the volume of groundwater impacted by groundwater quality degradation. If small volumes are negatively affected that don't materially affect the use of the aquifer or basin for its existing beneficial uses, then this would not represent a significant and unreasonable degradation of water quality. However, if the impacted volume grows, then it could reach a level that it becomes significant and unreasonable.

When considering all three elements, the definition of significant and unreasonable degradation of water quality is defined as degradation of groundwater quality in the South East Management Area to the extent that a significant volume of groundwater becomes unusable for its designated beneficial uses.

11.2 DETERMINATION OF MINIMUM THRESHOLDS

The minimum thresholds for groundwater quality are exceedances of Maximum Contaminant Levels (MCLs) or other applicable regulatory limits that are directly attributable to groundwater management actions in the South East Management Area that prevents the use of groundwater for its designated beneficial uses

SECTION 12. SUSTAINABLE MANAGEMENT RELATED TO SEAWATER INTRUSION

The South East Management Area is located far from the ocean and thus there is no reason to consider the potential impact of seawater intrusion in this management area.

SECTION 13. SUSTAINABLE MANAGEMENT RELATED TO LAND SUBSIDENCE

Subsidence is not an issue for the South East Management Area given the following:

- Minimal groundwater development exists in the South East Management Area.
- The presence of shale and sandstone bedrock underlying the alluvial aquifer.
- The alluvial aquifer is relatively thin and comprised mainly of sand and gravel with little clay.
- Steady groundwater and storage levels.
- Low risk of substantial groundwater level declines due to de minimis amount of groundwater production.

As shown in Figure 3-8, the South East Management Area experienced between -0.05 and 0.05 feet of vertical displacement across years 2015 to 2020 with an accuracy of approximately 0.05 feet in data readings.

Recently, as part of DWR's SGMA technical assistance to provide important SGMA-relevant data to Groundwater Sustainability Agency's (GSAs) for Groundwater Sustainability Plan (GSP) development and implementation, DWR contracted with TRE ALTAMIRA, Inc. to provide vertical displacement estimates are derived from InSAR data that are collected by the European Space Agency (ESA) Sentinel-1A satellite.

This dataset represents measurements of vertical ground surface displacement in more than 200 of the high-use and populated groundwater basins across the State of California between January of 2015 and October of 2020. InSAR data coverage began in late 2014 for parts of California, and coverage for the entire study area began in June 13, 2015. Included in this dataset are point data that represent average vertical displacement values for 100 meter by 100 meter areas, as well as GIS rasters that were interpolated from the point data; rasters for total vertical displacement relative to June 13, 2015, and rasters for annual vertical displacement rates with earlier coverage for some areas, both in monthly time steps. The level of accuracy is approximately 0.05 feet.

To show subsidence in Basin 8-, the layer showing total land subsidence since the start of the InSAR data on 6/13/2015 and ending on 7/1/2020, which corresponds to the end of the water year was used. (GIS layer used: https://gis.water.ca.gov/arcgisimg/rest/services/SAR/Vertical_Displacement_TRE_ALTAMIRA_v2020_Total_Since_20150613_20200701/ImageServer.)

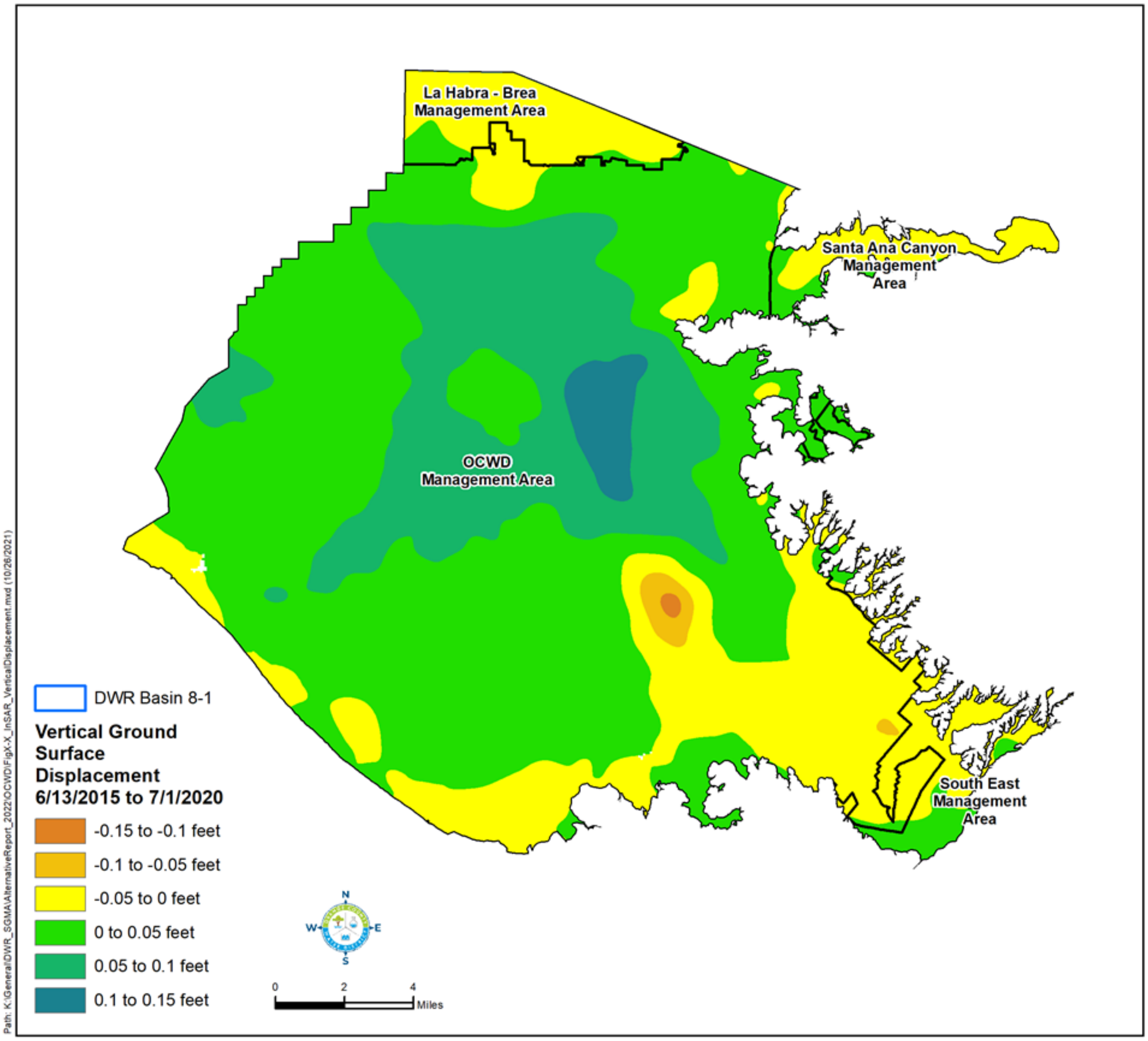

Figure 13-1: Total Vertial Ground Surface Displacement from June 2015 to July 2020

Regardless, the Basin 8-1 area will continue to be monitored for changes in InSAR data (via OCWD and consultants) to evaluate ground surface fluctuations within the service area. If irreversible subsidence was found to occur in a localized area in relation to groundwater pumping patterns or groundwater storage conditions, the South East Management Area managers would coordinate with local officials to investigate and develop an approach to address the subsidence.

SECTION 14. MANAGING GROUNDWATER DEPLETIONS IMPACTING SURFACE WATER

Existing groundwater use in the South East Management Area is relatively minor and insignificant (see section 4.1.1). Therefore, groundwater production in the South East Management Area has a de minimis impact on any groundwater dependent systems in the Management Area. Therefore, the undesirable result of “depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water due to groundwater conditions occurring throughout the basin” does not apply.

SECTION 15. PROTOCOLS FOR MODIFYING MONITORING PROGRAMS

Protocols for modifying monitoring programs are based on changes from historical conditions or changes in water quality that begin to approach or exceed regulatory limits.

15.1 ESTABLISHMENT OF PROTOCOLS FOR WATER QUALITY

Protocols for modifying monitoring programs are described in the 2017 Alternative.

SECTION 16. PROCESS TO EVALUATE NEW PROJECTS

When new projects are proposed within the South East Management Area, the agency proposing the project will be responsible for preparing a CEQA document to ensure alternatives have been evaluated and any significant and unreasonable results are mitigated. Plans to rehabilitate the well are currently going out for construction bid and construction is expected to potentially start in fall of 2022. The project may include facilities to remove high levels of iron and manganese as needed to meet potable water quality requirements.

There are a number of potential projects currently in development in the South East Management Area. These include:

- LF-1 and LF-4 designated monitoring well operations.
- LF-2 rehabilitation and water quality treatment planned construction in 2022.
- LF-5 decommission including the removal and transfer of existing equipment.
- LF-5 (replacement) future projects may include the possible development of a new production well on or near the existing decommissioned site.
- General well rehabilitation and monitoring projects across the South East Management Area, with approved funding allocated in the capital budgets approved for 2021-2023.

Based on past studies of the area (2002 study by Boyle Engineering Corporation and 2015 study by Dudek) considered the potential for development of two future wells, LF-6 and LF-8, as well as the re-drilling of existing inactive wells.

Although IRWD has no near-term plans to drill wells LF-6 and LF-8, it has included a capital project for the design, construction and equipping of LF-1. There is not a time frame established for this LF-1 work, however it was determined that water produced from LF-1 could be used to provide supply to the nearby lake which currently is supplied by untreated imported water. Water produced could also potentially be pumped and conveyed to the Baker Water Treatment Plant for treatment if needed (Dudek, 2015). Due to the consistently lower yields from the aquifer in this area, it is expected that additional production from LF-1 will continue to be considered supplemental, and therefore insignificant in terms of IRWD's overall water supply for its Lake Forest area. As of 2021, LF-1 remains off line although there are future plans to potentially re-drill and rehabilitate the well in the future.

SECTION 17. REFERENCES

Following are references and technical studies for the South East Management Area.

- Communication with OCWD. Email dated November 28, 2016.
- Communication with OCWD. Email dated October 21, 2021.
- Geohydrology and Acritical-Recharge Potential of the Irvine Area Orange County, California. J. A. Singer, January 8,1973.
- Groundwater Supply Evaluation for the Los Alisos System Phase 1. Boyle Engineering Corporation, July 2002.
- Ground Water Management, Irvine Area, Orange County, California. Harvey O. Banks, Consulting Engineer, Inc.
- Lake Forest Groundwater Conveyance Analysis Results. Dudek, November 5, 2015.
- 2015 Urban Water Management Plan, Irvine Ranch Water District, 2016
- 2020 Urban Water Management Plan, Irvine Ranch Water District, 2021

DRAFT

Basin 8-1 Alternative

Santa Ana Canyon Management Area

2022 Update

Prepared by: Orange County Water District

January 1, 2021

Basin 8-1 Alternative

2022 Update

Santa Ana Canyon Management Area

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Prepared for the Department of Water Resources, pursuant to Water Code §10733.6(b)(3),(c) and §10733.8

January 1, 2022

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SECTION 1. EXECUTIVE SUMMARY

The Santa Ana Canyon Management Area covers the easternmost extent of the Department of Water Resources (DWR) Basin 8-1, Coastal Plain of Orange County Groundwater Basin (Basin). This Management Area was created for this Alternative (under 23 CCR 354.20) because of the unique characteristics of the Santa Ana Canyon and the appropriateness of developing different management objectives and strategies for this portion of the Basin. These different objectives and management approaches, as described in this Section, account for the significant differences in groundwater use, geology, aquifer characteristics, and other factors which distinguish Santa Ana Canyon from other portions of the Basin. Figure 1-1 shows the extent of the Santa Ana Canyon Management Area and the agencies with jurisdiction in the Santa Ana Canyon Management Area. Table 1-1 lists the agencies shown on Figure 1-1.

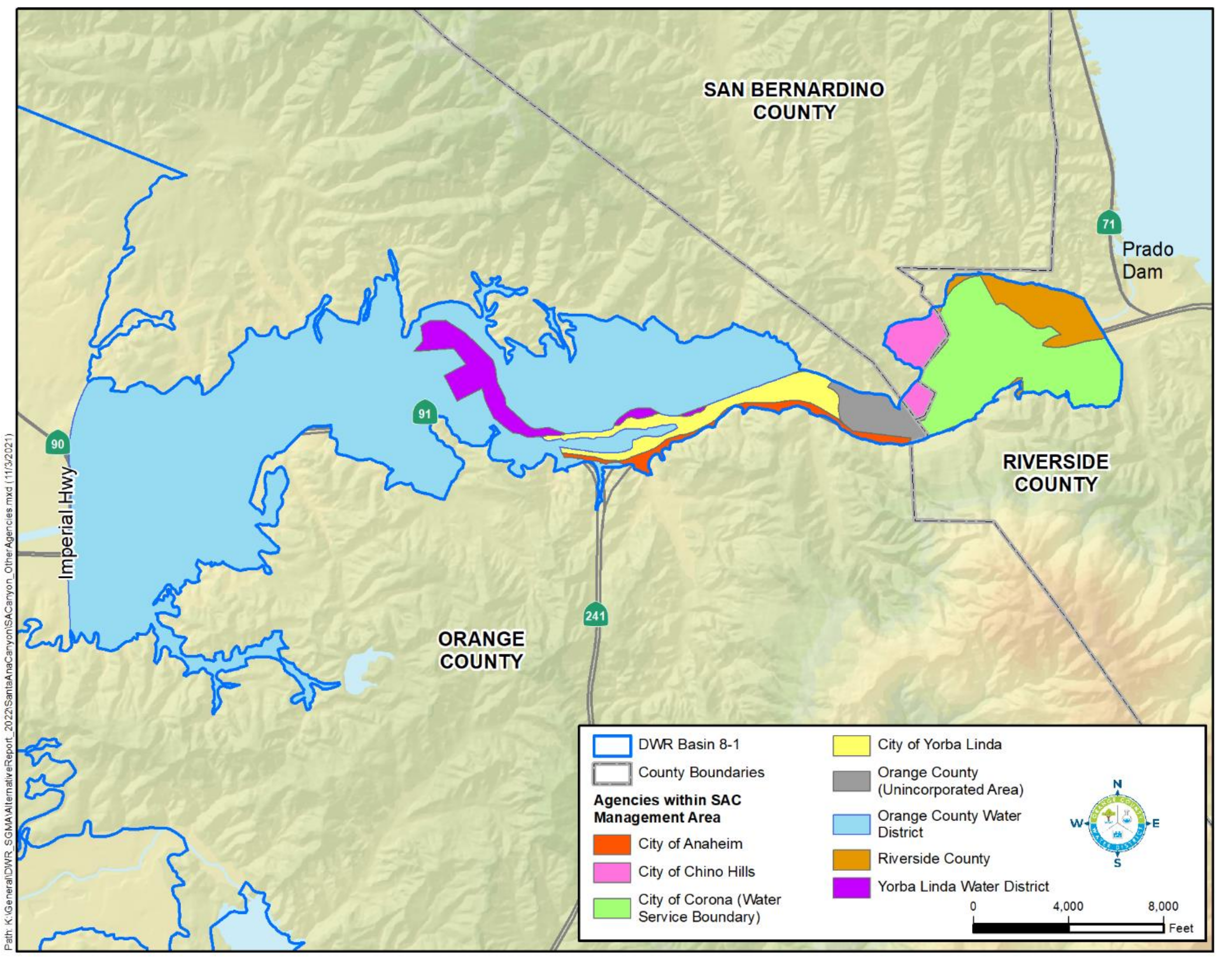

Figure 1-1: Agencies in the Santa Ana Canyon Management Area

The agencies within Basin 8-1 collaborated to prepare and submit an Alternative to a Groundwater Sustainability Plan (GSP). In accordance with Water Code §10733.6(b)(3), the Alternative presented an analysis of basin conditions that demonstrated that the Basin had operated within its sustainable yield over a period of at least 10 years. The Alternative was submitted to DWR on December 22, 2016. On July 17, 2019, DWR determined that the Alternative satisfied SGMA objectives and was therefore approved.

Agencies with approved alternatives are required to submit annual reports to DWR by April 1 of each year. Annual reports for Basin 8-1 were submitted to DWR as follows:

- Water Year 2016-17, submitted on March 29, 2018
- Water Year 2017-18, submitted on March 29, 2019
- Water Year 2018-19, submitted on March 30, 2020
- Water Year 2019-20, submitted on March 30, 2021

According to Water Code §10733.8, "At least every five years after initial submission of a plan pursuant to Section 10733.4, the department shall review any available groundwater sustainability plan or alternative submitted in accordance with Section 10733.6, and the implementation of the corresponding groundwater sustainability program for consistency with this part, including achieving the sustainability goal. The department shall issue an assessment for each basin for which a plan or alternative has been submitted in accordance with this chapter, with an emphasis on assessing progress in achieving the sustainability goal within the basin. The assessment may include recommended corrective actions to address any deficiencies identified by the department."

This document, called the 2022 Update, represents the first five-year update, which is due January 1, 2022.

For purposes of this report, the Basin 8-1 Alternative submitted on December 22, 2016, will be referred to as the 2017 Alternative. The first five-year update will be referred to as the 2022 Update for ease of reference. The 2017 Alternative was a comprehensive document showing that Basin 8-1 had been managed sustainably for more than 10 years. For the 2022 Update, the focus is on documenting that the basin has been sustainably managed during the five years since the 2017 Alternative was submitted and to present relevant new information from the last five years. As such, the 2017 Alternative is considered a key reference document with background information that is not duplicated in the 2022 Update.

The water resources in the Santa Ana Canyon Management Area include the Santa Ana River and limited groundwater. Groundwater is primarily located in a thin alluvial aquifer that is 90 to 100 feet thick and is a combination of infiltrated Santa Ana River water and subsurface inflow from the adjacent foothills. Groundwater produced from the alluvial aquifer is primarily used for irrigation, but some is also used for potable purposes. The volume of produced groundwater represents less than one percent of the total available water supply to the Santa Ana Canyon Management Area due to the significantly larger flow of the Santa Ana River as shown on Table 1-2. Even under projected dry conditions, groundwater production is expected to be less than four percent of the total available water supply (see 2017 Alternative, Santa Ana Canyon Management Area).

Table 1-1: Agencies in Santa Ana Canyon Management Area

Agency
City of Anaheim
City of Chino Hills
City of Yorba Linda
City of Corona
Orange County Water District
County of Orange
Riverside County
Yorba Linda Water District

Table 1-2: Water Budget, 5-Year Average (2016-21)

Flow Component	5-Yr Avg: 2016-21 (afy)
INFLOW	
Santa Ana River Base Flow	76,860
Santa Ana River Storm Flow	78,750
Subsurface Inflow	6,000
TOTAL INFLOW	**161,610**
OUTFLOW	
Santa Ana River Base Flow	76,120
Santa Ana River Storm Flow	78,750
Evapotranspiration	740
Groundwater Production	1,000
Subsurface Outflow	5,000
TOTAL OUTFLOW	**161,610**

Per the monitoring discussed in Section 5, groundwater levels in the Santa Ana Canyon Management Area are relatively stable, having been consistently 20 to 30 feet below ground surface since 1991, indicating that the supply of subsurface inflow and surface water from the Santa Ana River is more than sufficient to sustain local groundwater production. Groundwater quality is suitable for irrigation and potable uses. Native groundwater from the surrounding foothills tends to have naturally elevated total dissolved solids (TDS) and manganese concentrations. Most wells in the canyon appear to produce a blend of infiltrated Santa Ana River water and native groundwater, with some wells producing more infiltrated Santa Ana River water than others.

The Orange County Water District (OCWD) monitors Santa Ana River flow and quality as well as groundwater levels, quality, and production in the Santa Ana Canyon Management Area (see Section 5). Moreover, OCWD has a wide variety of water resource management programs that cover the OCWD Management Area as well as programs in the upper Santa Ana River watershed to address Santa Ana River flow and quality (see Section 6). These programs are important in protecting the quality of the Santa Ana River, which has a significant influence on the groundwater quality in the Santa Ana Canyon Management Area.

The approach to managing the Santa Ana Canyon Management Area is for OCWD, in cooperation with the County of Orange, to continue monitoring groundwater levels and quality to ensure that no significant and unreasonable undesirable results occur in the future, both in the Santa Ana Canyon portion of the Basin and in the other hydrologically connected portions of the Basin.

Due to the conditions documented within the Santa Ana Canyon Management Area, it will <u>not</u> be difficult to prevent conditions that could lead to significant and unreasonable undesirable results due to the low risk of increased groundwater production, little available developable land, and continued high flows of the Santa Ana River relative to the amount of groundwater production. A summary of the applicable undesirable results that must be prevented under SGMA is presented below. A more detailed description of these can be found in Sections 8 to 13.

1. **Water Levels:** Long-term reduction in groundwater levels in the Santa Ana Canyon Management Area are not expected given the high volume of Santa Ana River flow relative to the amount of groundwater production and the ability of the shallow alluvial aquifer to be recharged as a result of continuous and abundant surface flow in the Santa Ana Canyon; however, if an unforeseen long-term reduction in groundwater levels were to occur, water levels could reach a significant and unreasonable level if one or more of the following occurred as a result of reduced groundwater levels:
    a. Significant loss of riparian habitat along the Santa Ana River.
    b. Significant loss of well production capacity (in the Santa Ana Canyon Management Area).
    c. Degradation of water quality that significantly impacts the beneficial uses of groundwater.
2. **Storage:** As with groundwater levels, long-term reduction in groundwater storage in the Santa Ana Canyon Management Area is not projected to occur; however, an unforeseen decline in groundwater storage could reach a significant and unreasonable level if such a decline caused one or more of the following:
    a. Loss of significant riparian habitat along the Santa Ana River.
    b. Significant loss of well production capacity.
    c. Degradation of water quality that significantly impacts the beneficial uses of groundwater.
3. **Water Quality:** The significant and unreasonable degradation of water quality is defined as the degradation of groundwater quality in the Santa Ana Canyon Management Area that is attributable to groundwater production or recharge practices within the Santa Ana

Canyon Management Area that cause a significant volume of groundwater to become unusable for its designated beneficial uses.

4. **Seawater Intrusion:** This does not apply to the Santa Ana Canyon Management Area because this area if far removed from the coastline.
5. **Subsidence:** No vertical changes have been noted using DWR-supplied InSAR data. It is unlikely that this will occur in the Santa Ana Canyon Management Area due to:
   a. The presence of shale and sandstone bedrock underlying the alluvial aquifer.
   b. The alluvial aquifer is thin, generally less than 100 feet, and comprised mainly of sand and gravel with little clay.
   c. Groundwater levels and groundwater storage are stable.
   d. Very low risk of substantial groundwater level declines due to a de minimis amount of groundwater production relative to the overall inflow of water to the Santa Ana Canyon Management Area.
6. **Groundwater Depletions Impacting Surface Water:** Due to hydrogeologic conditions and land use limitations, groundwater production in the Santa Ana Canyon Management area has had and is projected to have a de minimis effect on groundwater conditions and flows of surface water through the canyon. Therefore, this factor does not apply to the Santa Ana Canyon Management Area.

SECTION 2. AGENCY INFORMATION

2.1 HISTORY OF AGENCIES IN SANTA ANA CANYON MANAGEMENT AREA

As shown on Figure 1-1, eight agencies have jurisdiction within the Santa Ana Canyon Management Area. The footprint of the various agencies within the Santa Ana Canyon Management Area has not changed since the 2017 Alternative. Table 1-1 lists the agencies and the approximate area covered by each.

The Santa Ana Canyon Management Area covers 2.6 percent of Basin 8-1, which has a total area of 223,600 acres or 350 mi^2.

2.2 GOVERNANCE AND MANAGEMENT STRUCTURE

There are currently no groundwater withdrawals or plans for withdrawals within the portions of the Santa Ana Canyon Management Area that are within the City of Anaheim, City of Chino Hills, City of Yorba Linda, Riverside County, and the Yorba Linda Water District. Key reasons for the lack of significant groundwater production are the lack of demands in these areas, the relatively high mineral content of groundwater in the Santa Ana Canyon Management Area, and lack of developable land due to land use limitations. In addition, there are no groundwater withdrawals or plans for withdrawals by the City of Corona. Although there are existing groundwater withdrawals within the Corona service area, the wells are owned and operated by the County of Orange for golf course irrigation. As mentioned above, Corona delivers water from sources outside of the Santa Ana Canyon Management Area.

Accordingly, no additional groundwater governance and management structure is needed for the areas in the Santa Ana Canyon Management Area beyond the existing monitoring program that OCWD already carries out in accordance with its authorities under the OCWD Act, in cooperation with the other jurisdictional agencies. The governance and management structure of OCWD is described in the OCWD Management Area part of this report. As will be shown later in this section, groundwater withdrawals by the County of Orange and private well owner within the Santa Ana Canyon Management Area are de minimis compared to the overall flow of water through the Santa Ana Canyon Management Area, and they are expected to remain at current sustainable levels. As a result, there is no need for other agencies to establish groundwater governance or management in the Santa Ana Canyon Management Area beyond the existing groundwater production, level and quality data collection and reporting to DWR by OCWD per SGMA requirements.

2.3 LEGAL AUTHORITY

The legal authority of OCWD is described in the OCWD Management Area part of this report. As described in the OCWD Management Area part of the report, OCWD has obtained water rights from the State Water Resources Control Board (SWRCB) to all of the flows in the Santa Ana River arriving at Prado Dam. As a result, any future groundwater production within the

Santa Ana Canyon Management Area would be reviewed by OCWD and the SWRCB to ensure it does not interfere with OCWD's existing water rights. Moreover, though outside of OCWD's boundaries, OCWD currently monitors portions of Santa Ana Canyon pursuant to its authority under Section 2, subparagraphs 5, 6, 7 and 14, of the OCWD Act.

The Orange County Well Ordinance (County Ordinance No. 2607) requires that a permit be obtained from Orange County prior to the construction or destruction of any well. In unincorporated areas and in 29 of 34 Orange County cities, the Orange County Health Officer is responsible for enforcement of the well ordinance. In the remaining five cities (Anaheim, Buena Park, Fountain Valley, Orange and San Clemente), well ordinances are enforced by city personnel. Any plans for wells in areas covered by Riverside and San Bernardino Counties would be reviewed by OCWD to ensure they did not interfere with OCWD's rights to Santa Ana River flows.

2.4 BUDGET

OCWD's costs for data collection within the Santa Ana Canyon Management Area are contained within OCWD's budget for data collection in the OCWD Management Area, which is presented in the OCWD Management Area portion of this report. The County of Orange is responsible for costs associated with collecting production data from wells used to irrigate the County-owned Green River Golf Course. The other agencies within the Santa Ana Canyon Management Area do not incur any additional data collection costs since no further monitoring other that already undertaken by OCWD, and Orange County is believed needed in order to prevent undesirable results from occurring. As a result, an estimated budget for other agencies has not been prepared for the Santa Ana Canyon Management Area due to the minimal nature of the effort to collect and report groundwater production, level and water quality data.

SECTION 3. MANAGEMENT AREA DESCRIPTION

3.1 SANTA ANA CANYON MANAGEMENT AREA

The Santa Ana Canyon is a narrow east-west trending canyon between the Santa Ana Mountains to the south and the Chino Hills to the north near the intersection of Orange, San Bernardino and Riverside Counties. As shown on Figure 3-1, a key feature is the Santa Ana River. Just upstream of the Santa Ana Canyon is Prado Dam, which was constructed by the US Army Corps of Engineers in 1941 to reduce flood risks to Orange County.

Detailed geologic information, including cross sections, is presented in the 2017 Alternative.

The Santa Ana Canyon Management Area covers the area of alluvial deposits in the Santa Ana Canyon east of Imperial Highway (Hwy 90), as shown on Figure 3-1. Imperial Highway was selected as the western boundary of the Santa Ana Canyon Management Area because this is where the groundwater basin transitions from a relatively thin alluvial aquifer to a deep multi-layered alluvial basin. Moreover, Imperial Highway is the approximate boundary of OCWD's groundwater flow model, allowing subsurface outflows from the entire Santa Ana Canyon Management Area to be readily quantified for purposes of the water budget and monitoring groundwater in storage.

Previously published reports indicated that the alluvial deposits in Santa Ana Canyon ranged from 90 to 100 feet thick (USGS, 1964). Cross-sections presented in the 2017 Alternative using more recent data showed that the thickness of the alluvial deposits in the Santa Ana Canyon are consistent with those reported by the USGS (1964).

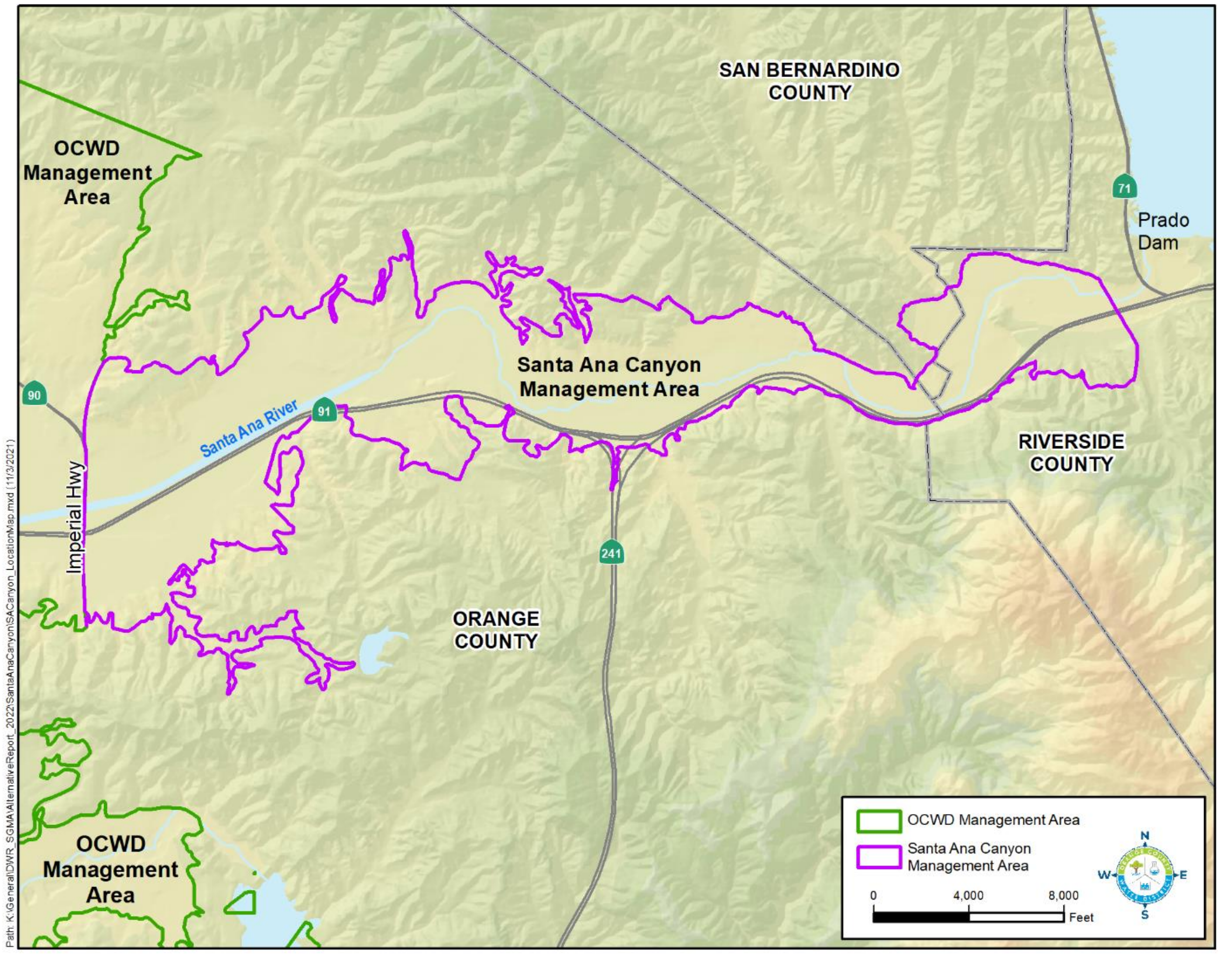

Figure 3-1: Boundary of Santa Ana Canyon Management Area

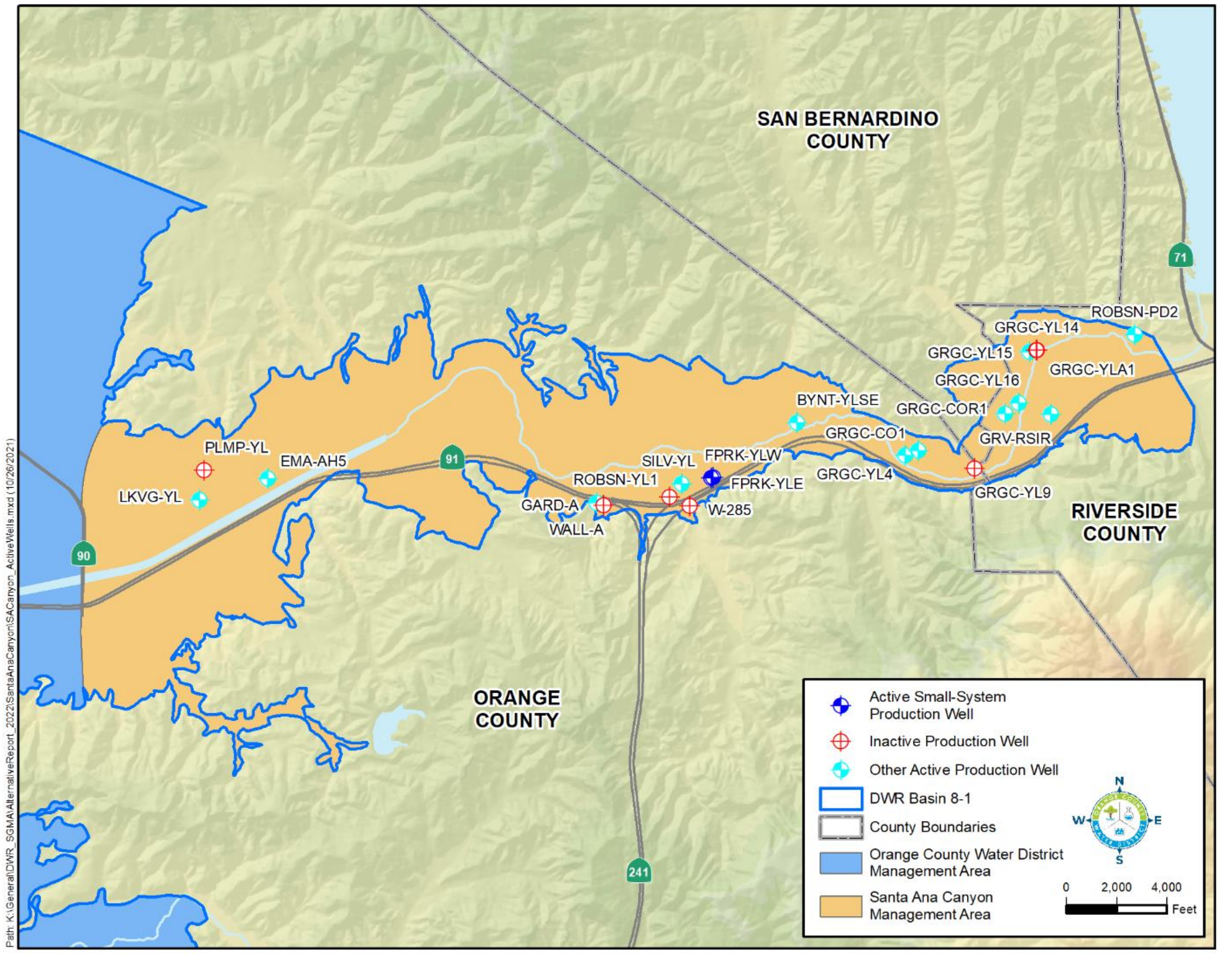

Figure 3-2: Groundwater Production Wells (Active and Inactive)

3.1.1 Jurisdictional Boundaries

As described in Section 2, there are eight agencies with jurisdiction in the Santa Ana Canyon Management Area as shown on Figure 2-1. The western boundary of the Santa Ana Canyon Management Area coincides with Imperial Highway and is within OCWD's jurisdiction.

3.1.2 Existing Land Use Designations

As described in the OCWD Management Area part of this report, much of the land use in Orange County is urban. The Santa Ana Canyon Management Area has some dedicated open-space due to the presence of the Santa Ana River and adjacent floodplain and the Chino Hills State Park, located in the far northeastern portion of the Santa Ana Canyon Management Area. The Green River Golf Club owned by the County of Orange covers approximately 220 acres along the river near the intersections of Orange, Riverside, and San Bernardino counties. Land use has remained essentially unchanged in the last five years.

3.2 GROUNDWATER CONDITIONS

Groundwater within the Santa Ana Canyon Management Area occurs in a narrow canyon within a relatively thin alluvial aquifer that is less than 100 feet thick in most places.

3.2.1 Groundwater Elevation

Groundwater elevations in the Santa Ana Canyon Management Area tend to be stable. Hydrographs from four wells show that water levels vary over a narrow range as shown on Figure 3-3. Well locations are shown on Figure 3-2 and cover the eastern (GRV-RSIR), south-central (FPRK-YLE/SILV-YL), and western (SCE-YLCS, EMA-AH5) areas of the Santa Ana Canyon Management Area.

Maximum water level elevations in many wells were recorded in 2004, which was a record-breaking wet year with very high sustained flows in the Santa Ana River. Low water levels appear to be primarily related to short-term local pumping. In the vicinity of all the wells, groundwater is approximately 20 to 30 feet below ground surface. Since the Santa Ana River channel is incised in some areas by 10 to 15 feet below the surrounding area, the depth to groundwater is even shallower directly beneath the river channel where it is not covered by the river itself.

The consistent, stable nature of groundwater elevations in the Santa Ana Canyon Management Area shows that the aquifer is generally full and at equilibrium, which is consistent with the finding that here are no measurable losses of flows between Prado Dam upstream and OCWD's diversion to its recharge system just below Imperial Highway.

Within the last five years, OCWD, in cooperation with the County of Orange, began collecting groundwater elevation data at selected wells at the Green River Golf Course to complement existing groundwater elevation monitoring data. Note that wells SILV-YL and SCE-YLCS were formerly monitored for the CASGEM program. Well SCE-YLCS was destroyed and replaced by well EMA-AH5. As a result, water level data from SILV-YL and EMA-AH5 will be included in annual reports required to comply with SGMA.

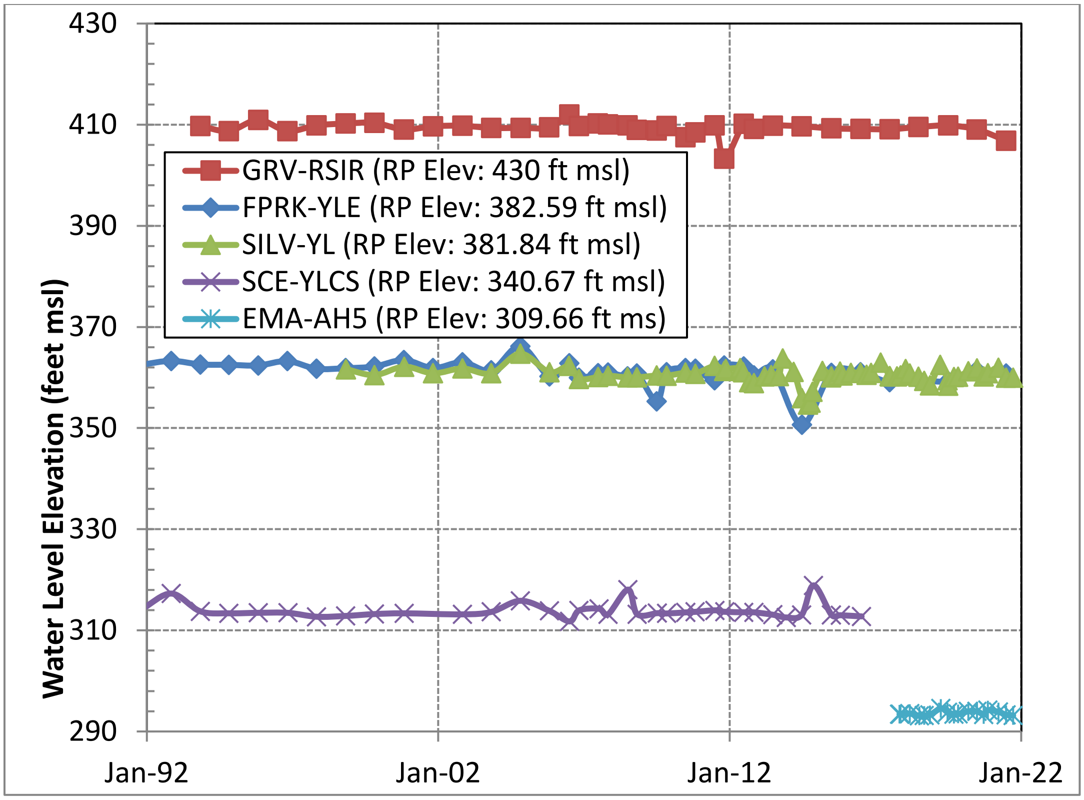

Figure 3-3: Water Level Hydrographs of Selected Wells

3.2.2 Groundwater Beneficial Uses and Regional Pumping Patterns

The Santa Ana Canyon Management Area is within the Santa Ana Region of the California Water Boards and is subject to the Santa Ana Region Basin Plan (January 24, 2014; updated July 2014). The Basin Plan designates zones related to groundwater management. The Santa Ana Canyon Management Area is included in the Orange County Management Zone. Within this Zone, groundwater has been designated for municipal, agricultural, and industrial (service supply and process) beneficial uses. Currently, local groundwater provides primarily irrigation supply with some residential drinking water (RV Park) and domestic uses.

There are 18 wells that can withdraw groundwater within the Santa Ana Canyon Management Area as shown on Figure 3-2; however, some of the wells shown are not currently being used (e.g., inactive). At the time the 2017 Alternative was prepared, some wells, namely those owned by the County of Orange to supply irrigation water to the Green River Golf Course, were not metered. OCWD worked with the County of Orange to have all their wells metered and production reported to OCWD. Prior estimates of pumping before meters were installed was on the order of 1,000 acre-feet per year (Personal Communication, Merrie Weinstock, County of Orange). Data collected in recent years shows that total production is less, averaging just over 600 acre-feet per year.

As shown on Table 3-1, total groundwater production within the Santa Ana Canyon Management Area over the last 5 years has averaged just over 1,000 acre-feet per year. Table

3-1 lists the production wells, meter status, and 5-year average production for wells located within the Santa Ana Canyon Management Area.

Table 3-1: Production Wells, Flow-Meter Status, and 5-Year Average Production

Well Name	Well Use	Owner	Metered	Production 5-Yr Avg 2016-21 (afy)*	Notes
BYNT-YLSE	IR	Neff Ranch, Ltd	Yes	69.8	
EMA-AH5	IR	County Of Orange	Yes	118.2	SGMA monitoring well.
FPRK-YLE	DW/IR	Canyon RV Park	Yes	79.5	
FPRK-YLW	DW/IR	Canyon RV Park	Yes	36.9	
GARD-A	IR	Kindred Outreach Ministries	Yes	1	
GRGC-CO1	IR	OCFCD	Yes	82.2	Monthly metering started Jan. 2019. Avg based on Jan. 2019-June 2021.
GRGC-COR1	IR	OCFCD	Yes	295.0	Monthly metering started Jan. 2019. Avg based on Jan. 2019-June 2021
GRGC-YL14	IR	OCFCD	Yes		Inactive
GRGC-YL15	IR	OCFCD	No		Inactive, only used for emergencies.
GRGC-YL16	IR	OCFCD	Yes	161.0	Monthly metering started Jan. 2019. Avg based on Jan. 2019-June 2021
GRGC-YL4	IR	OCFCD	Yes	75.5	Monthly metering started Jan. 2019. Avg based on Jan. 2019-June 2021
GRGC-YL9	IR	OCFCD	Yes		Inactive
GRGC-YLA1	IR	OCFCD	Yes		Inactive
GRV-RSIR	IR	Green River Village	Yes	6.2	
LKVG-YL	IR	Eastlake Village HOA	Yes	70.8	
ROBSN-PD2	IR	Robertson Ready Mix	Yes	5.4	Monthly metering started Jan. 2018. Avg based on Jan. 2018-June 2021
ROBSN-YL1	IR	Robertson Ready Mix	Yes		Inactive
WALL-A	DOM	Kindred Outreach Ministries	No		Inactive
			Total	**1,007**	

*Five-year average except where noted.
IR= Irrigation; DW=Drinking Water; DOM=Domestic
OCFCD = Orange County Flood Control District

3.2.3 Groundwater Storage Data

Groundwater storage in Basin 8-1 is estimated at 66 million acre-feet (OCWD, 2007), which does not include the Santa Ana Canyon Management Area. To estimate the amount of storage in the alluvial aquifer within Santa Ana Canyon Management Area, all well data were used and depths to bedrock estimated. The thickness of the alluvial deposits is assumed to be zero at the basin margin. Using a Topo to Raster Interpolation function in ArcGIS, the total volume of alluvial deposits was estimated at 174,000 acre-feet. Assuming a porosity of 25 percent gives a total potential groundwater storage volume of 43,500 acre-feet. The actual volume of groundwater in storage is smaller given that this estimate does not take into account that the depth to groundwater is typically 20 to 30 feet below ground surface.

3.2.4 Groundwater Quality Conditions

Groundwater quality in the Santa Ana Canyon Management Area is generally good and suitable to meet beneficial uses. Groundwater in the Santa Ana Canyon Management Area is a mixture of infiltrated Santa Ana River water and subsurface inflow. Detailed water quality information is presented in the 2017 Alternative. No substantive changes in groundwater quality have occurred within the last five years.

3.2.5 Land Subsidence

Land subsidence measurements derived from InSAR data provided by DWR show that land displacement in the Santa Ana Canyon Management Area from June 2015 to July 2020 is within the accuracy of the method (0 to 0.05 ft). This is not surprising given the following:

1. The presence of shale and sandstone bedrock underlying the alluvial aquifer is not thought to be sufficiently compressible to cause inelastic subsidence.
2. The alluvial aquifer is thin, generally less than 100 feet, and composed mainly of sand and gravel with only minor amounts of clay.
3. Groundwater levels and storage volumes have not changed significantly over the last five years.

3.2.6 Groundwater and Surface Water Interactions and Groundwater Dependent Ecosystems

Groundwater within the Santa Ana Canyon alluvial aquifer is consistently 20 to 30 feet below ground surface and even shallower in the incised portions of the Santa Ana River channel. As described in Section 4, Water Budget, the flow of surface water through the canyon dwarfs the documented groundwater production. As a result, groundwater production has a de minimis impact on groundwater conditions and flows of surface water through the canyon. This in turn demonstrates that groundwater production in the Santa Ana Canyon has little to no impact on local groundwater dependent ecosystems in the Santa Ana Canyon Management Area.

SECTION 4. WATER BUDGET

The water budget of the Santa Ana Canyon Management Area is dominated by surface flows of the Santa Ana River with a minor contribution of subsurface inflow, return flows from irrigation, and a small amount of groundwater production. Table 1-2 presents the water budget for the Santa Ana Canyon Management Area for the last five years. Additional water budget information was presented in the 2017 Alternative. The water budget contains both surface water and groundwater components and is not used to analyze change in groundwater storage. The purpose of presenting this water budget is to show the relative contributions of different sources in the Santa Ana Canyon Management Area.

Groundwater level data suggest that groundwater conditions in the Santa Ana Canyon Management Area are essentially at steady state conditions with inflow equaling outflow and no change in groundwater storage. Inflow to the shallow alluvial aquifer includes subsurface inflow and infiltrated Santa Ana River water. Outflow includes evapotranspiration, groundwater production and subsurface outflow. Table 4-1 presents the groundwater budget for the Santa Ana Canyon Management Area.

Table 4-1: Groundwater Budget, 5-Year Average (2016-21)

Flow Component	5-Yr Avg: 2016-21 (afy)
INFLOW	
Subsurface Inflow (1)	6,000
Infiltrated Santa Ana River Flow (2)	740
TOTAL INFLOW	**6,740**
OUTFLOW	
Evapotranspiration (3)	740
Groundwater Production	1,000
Subsurface Outflow to OCWD Management Area (4)	5,000
TOTAL OUTFLOW	**6,740**
NET CHANGE	0

(1) Subsurface inflow is estimated and includes irrigation return flow and areal recharge from precipitation.
(2) Estimated infiltration of Santa Ana River flow to balance outflow.
(3) Evapotranspiration is based on 370 acres of riparian habitat and a usage rate of 2 afy/acre of habitat per Santa Ana River Watermaster Reports.
(4) Subsurface outflow is based on OCWD's calibrated groundwater flow model.

4.1 BUDGET COMPONENTS

The components of the groundwater budget are described below.

4.1.1 Subsurface Inflow/Outflow

In the 2017 Alternative, the estimated subsurface outflow was 4,000 acre-feet per year based on the steady state groundwater flow model. More recent transient groundwater flow modeling using the period 1999 to 2017, showed that average outflow from the Santa Ana Canyon to the main basin to be approximately 5,000 acre-feet per year. As a result, the water budget tables have been updated accordingly.

Subsurface inflow is a combination of subsurface mountain front recharge, areal recharge from precipitation, and irrigation return flow. It is estimated to be approximately 6,000 acre-feet per year.

4.1.2 Infiltrated Santa Ana River Flow

Water quality data suggests that some of the groundwater produced from wells in the Santa Ana Canyon Management Area is a blend of subsurface inflow and infiltrated Santa Ana River water; however, there is not enough data to determine the relative contribution of each source. For purposes of the groundwater budget, the amount of infiltrated Santa Ana River flow is the amount necessary to balance the water budget assuming subsurface inflow is 6,000 acre-feet per year. If the assumed amount of subsurface inflow were to change, the amount of infiltrated Santa Ana River water needed to balance the water budget would change accordingly.

Evapotranspiration

Evapotranspiration is assumed to be due to riparian vegetation adjacent to the Santa Ana River. The County of Orange, as part of developing a Habitat Management Plan (HMP), established a baseline of 370 acres of riparian vegetation within the Santa Ana Canyon Management Area (County of Orange, 2016).

The Santa Ana River Watermaster reports that riparian vegetation consumes approximately 2 acre-feet per year per acre of vegetated area. Using this approach, the estimated evapotranspiration within the Santa Ana Canyon Management area is estimated to be 740 acre-feet per year.

4.1.3 Groundwater Production

As described in Section 3.2.2, there are 18 wells that can withdraw groundwater within the Santa Ana Canyon Management Area (Figure 3-2); however, some of the wells shown are not currently being used (e.g., inactive). Groundwater production from these wells is summarized in Table 3-1.

4.2 CHANGES IN GROUNDWATER STORAGE

As shown in Figure 3-3, groundwater levels in the Santa Ana Canyon Management Area are stable, indicating that the thin, alluvial aquifer is generally always in a near-full equilibrium condition. Therefore, any changes in groundwater storage are small and insignificant.

4.3 WATER YEAR TYPE

The water year type has little impact on the water budget in the Santa Ana Canyon Management Area given the minimal changes in groundwater level observed through time due to the ever-present Santa Ana River flow and subsurface inflow. Water budgets for wet and dry year water types are presented in the 2017 Alternative.

4.4 ESTIMATE OF SUSTAINABLE YIELD

As described in Table 4-1, average groundwater production over the last five years is less than one percent of the total inflow to the Santa Ana Canyon Management Area. This condition is the same as what was presented in the 2017 Alternative. It is clear the sustainable yield of the Santa Ana Canyon Management Area is much greater than current production levels. Nevertheless, there are no plans for additional wells or groundwater production in the Santa Ana Canyon Management Area, and it is highly unlikely that groundwater demands would rise to the level of changing the water budget of this area significantly. In terms of sustainable yield, it is more appropriate to look at Basin 8-1 as a whole.

4.5 CURRENT, HISTORICAL, AND PROJECTED WATER BUDGET

Current water budgets are presented in presented in Tables 4-1 and 4-2. Historical and projected water budgets, including Dry and Wet Year Water Budgets, are presented in the 2017 Alternative.

SECTION 5. WATER RESOURCE MONITORING PROGRAMS

5.1 OVERVIEW

This section describes OCWD's surface water and groundwater monitoring programs in the Santa Ana Canyon Management Area.

5.2 GROUNDWATER MONITORING PROGRAMS

OCWD monitors groundwater levels, quality and production in the Santa Ana Canyon Management Area. As shown on Figure 5-1, groundwater levels are monitored at six wells. Within the last five years, well SCE-YLCS was destroyed and replaced in the monitoring network by well EMA-AH5. Water level data from wells SILV-YL and EMA-AH5 will be reported annually to DWR in compliance with SGMA. In addition, OCWD worked with the County of Orange to install meters on wells used to supply Green River Golf Course and to begin collecting and reporting production data. Data provided in this report utilizes metered data for all wells that pump groundwater in the Santa Ana Canyon Management area.

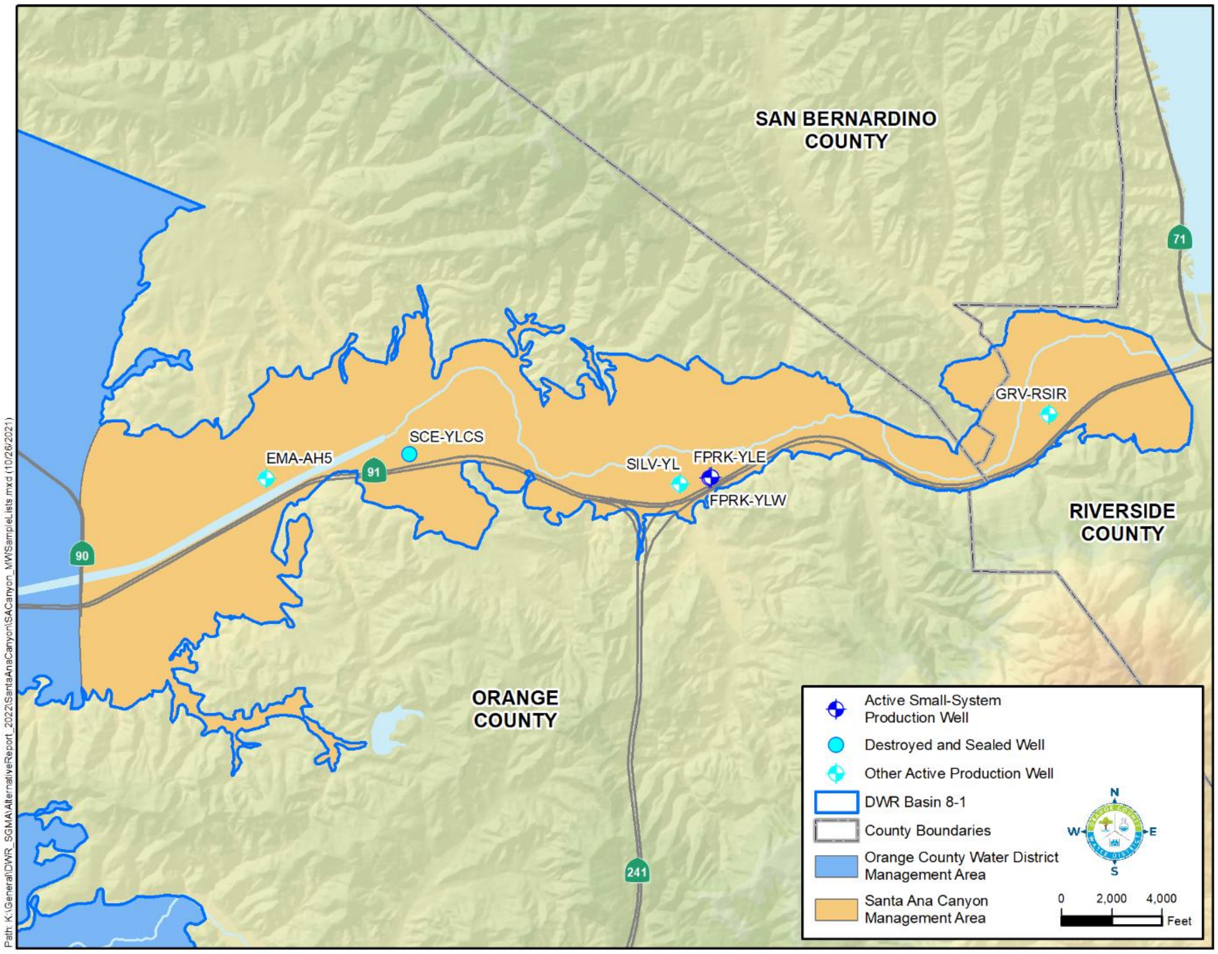

Figure 5-1: Wells Used to Monitor Groundwater Levels

For wells within OCWD's boundaries, groundwater production must be reported at a minimum frequency of every 6 months. Groundwater production volumes from the County of Orange's wells that supply the Green River Golf Course are now being collected monthly.

OCWD also monitors groundwater quality in selected wells in the Santa Ana Canyon Management Area. Table 5-1 lists the wells monitored and the groundwater quality monitoring program each well is part of, which is based on its use (e.g., irrigation, potable). Wells used for irrigation are sampled every year for volatile organic compounds (VOCs) and every three years for general minerals (major cations and anions), 1,4-dioxane, and perchlorate (ClO_4). The two wells in Featherly Park used for potable supplies are monitored in accordance with drinking water regulations.

Table 5-1: Wells Monitored for Water Quality

Well Name	Water Quality Monitoring Program
IRRIGATION WELLS BYNT-YLSE EMA-AH5 GARD-A GRGC-CO1 GRGC-COR1 GRGC-YL15 GRGC-YL16 GRGC-YL4 GRV-RSIR LKVG-YL ROBSN-PD2	Annual: Volatile Organic Compounds (VOCs) Every 3 yrs: General Minerals, 1,4-Dioxane, and ClO_4
POTABLE USE WELLS FPRK-YLE FPRK-YLW	Annual: NO_3, ClO_4, 1,4-Dioxane, Mn, TDS, EC Atrazine/Simazine: every 3 yrs Title 22 Inorganics: every 3 yrs CN: every 9 yrs CrIV: every 3 yrs Radioactivity: every 6 yrs (Gross Alpha, Uranium) Radioactivity: every 9 yrs (Radium 226 & Radium 228)

5.3 OTHER MONITORING PROGRAMS

OCWD monitors the quantity and quality of water in the Santa Ana River just below Prado Dam. The flow of the Santa Ana River below Prado Dam is measured by the United States Geological Survey (USGS) at station No. 11074000 (http://waterdata.usgs.gov/ca/nwis/dv/?site_no=11074000). In addition to flow, the USGS measures the electrical conductivity (EC) of the water as well as sampling the water two times per month for TDS. One use of these data is to calculate the flow-weighted average TDS of base and storm flow discharged from Prado Dam. The flow and quality data are collected for the Santa Ana River Watermaster, which was formed to implement the Stipulated Judgement in the case of Orange County Water District v. City of Chino, et al., Case No. 1172628-County of Orange, entered by the court on April 17, 1969. Copies of the watermaster reports can be found on OCWD's website at http://www.ocwd.com. In addition to OCWD, the Santa Ana River Watermaster is comprised of representatives from the Inland Empire Utilities Agency, San Bernardino Valley Municipal Water District, and Western Municipal Water District.

The significance of the 1969 Judgment is that it guarantees a minimum base flow at Prado Dam of 42,000 acre-feet per year; however, per the terms of the Judgment, the upstream agencies have received (and will continue to receive) credits when base flows exceed of 42,000 acre-feet at Prado. With these cumulative credits, the required minimum base flow is 34,000 acre-feet. As a point of reference, the base flow in Water Year 2020-21 was estimated to be 76,000 acre-feet (Note that this is an OCWD estimate to be finalized in a future SAR Watermaster Report).

OCWD also closely monitors the quality of water in the Santa Ana River before it is diverted into OCWD's recharge system below Imperial Highway. More information about this program can be found in Section 5 of the OCWD Management Area section of this report.

SECTION 6. WATER RESOURCE MANAGEMENT PROGRAMS

OCWD has a wide variety of water resource management programs that cover the main groundwater basin as well as the upper Santa Ana River watershed to address Santa Ana River flow and quality. These programs are important in protecting the quality of the Santa Ana River, which affects groundwater quality in the Santa Ana Canyon Management Area. These programs are described in detail in Section 6 of the OCWD Management Area part of the 2017 Alternative.

SECTION 7. NOTICE AND COMMUNICATION

There are eight stakeholder agencies within the Santa Ana Canyon Management Area, including the following:

- City of Anaheim
- City of Chino Hills
- City of Yorba Linda
- City of Corona
- Orange County Water District
- County of Orange
- Riverside County
- Yorba Linda Water District

On September 30, 2021, OCWD sent a letter via email to all of the Basin 8-1 agencies, including each of the agencies listed above to let them know that the 2017 Alternative was being updated and would be available for review and comment. No comments were received by any of the agencies contacted.

A draft of the 2022 Update was presented to the OCWD Board and posted on the OCWD website on November 18, 2021, to allow for public review and comment. The final 2022 Update was presented to the OCWD Board on December 15, 2021. At this board meeting, a resolution was adopted to support the submission of the 2022 Update to DWR.

SECTION 8. SUSTAINABLE MANAGEMENT APPROACH

The approach to sustainably managing the Santa Ana Canyon Management Area is to continue monitoring conditions to ensure that no significant and unreasonable results occur in the future.

SECTION 9. SUSTAINABLE MANAGEMENT RELATED TO GROUNDWATER LEVELS

9.1 HISTORY

As shown on Figure 3-3, groundwater levels in the Santa Ana Canyon Management Area have been steady over the last 20 years. Given the large amount of surface inflow to the Santa Ana Canyon Management Area relative to the amount of groundwater production, groundwater levels are expected to remain steady in the future.

9.2 MONITORING OF GROUNDWATER LEVELS

OCWD monitors groundwater levels at multiple wells in the Santa Ana Canyon Management Area and will continue to do so in the future.

Within the last five years, several wells at the Green River Golf Course were added to the OCWD monitoring network and destroyed well SCE-YLCS was replaced in the network by well EMA-AH5.

9.3 DEFINITION OF SIGNIFICANT AND UNREASONABLE LOWERING OF GROUNDWATER LEVELS

No long-term reduction in groundwater levels is foreseen in the Santa Ana Canyon Management Area; however, if that were to occur, a decline in groundwater levels could reach a significant and unreasonable level if one more of the following occurred as a result of reduced groundwater levels:

1. Significant and unreasonable loss of riparian habitat along the Santa Ana River.
2. Significant and unreasonable loss of well production capacity.
3. Degradation of water quality that significantly impacts the beneficial uses of groundwater.

9.4 DETERMINATION OF MINIMUM THRESHOLDS

It is not possible to determine a minimum threshold at this time since no undesirable effects due to water levels have occurred in the past and are not foreseen. Nevertheless, OCWD's monitoring program continuously tracks water levels and groundwater quality in the Management Area. If water levels started to show a consistent long-term decline, OCWD's monitoring program would be expanded to examine potential impacts to riparian habitat, well yields, and groundwater quality. If impacts were observed, action would be taken, and minimum thresholds would be evaluated and established as appropriate.

SECTION 10. SUSTAINABLE MANAGEMENT RELATED TO BASIN STORAGE

The total volume of groundwater storage in the OCWD Basin is estimated to be 66 million acre-feet (OCWD, 2007). The total potential storage volume in the Santa Ana Canyon Management Area is estimated to be 43,500 acre-feet, as described in Section 3.2.3.

10.1 DEFINITION OF SIGNIFICANT AND UNREASONABLE REDUCTION IN STORAGE

As with groundwater levels, no long-term reduction in groundwater storage is foreseen in the Santa Ana Canyon Management Area; however, if that were to occur, a decline in groundwater storage could reach a significant and unreasonable level if one more of the following occurred due to a reduction in storage:

1. Significant and unreasonable loss of riparian habitat along the Santa Ana River.
2. Significant and unreasonable loss of well production capacity.
3. Degradation of water quality that significantly impacts the beneficial uses of groundwater.

10.2 DETERMINATION OF MINIMUM THRESHOLDS

It is not possible to determine a minimum threshold at this time since no undesirable effects due to a change in groundwater storage levels have occurred in the past and are not foreseen in the future. Nevertheless, OCWD's monitoring program continuously tracks water levels, which is a proxy for groundwater storage, and groundwater quality in the Management Area. If water levels showed a consistent long-term decline, OCWD's monitoring program would be expanded to examine potential impacts to riparian habitat, well yields and groundwater quality. If impacts were observed, action would be taken, and minimum thresholds would be evaluated and established as appropriate.

SECTION 11. SUSTAINABLE MANAGEMENT RELATED TO BASIN WATER QUALITY

Groundwater quality in the Santa Ana Canyon Management Area is affected by the quality of Santa Ana River water and subsurface inflow from the surrounding foothills. As mentioned in Section 6, Water Resource Programs, OCWD is involved in multiple programs to protect and improve the quality of water in the Santa Ana River. Groundwater from subsurface inflow contains naturally elevated concentrations of TDS and manganese.

OCWD has an extensive groundwater monitoring program in the Santa Ana Canyon Management Area as described in Section 5, Water Resource Monitoring Programs.

11.1 DEFINITION OF SIGNIFICANT AND UNREASONABLE DEGRADATION OF WATER QUALITY

There are three elements that must be considered when evaluating the impact of groundwater quality degradation.

The first element is considering the causal nexus between local groundwater management activities and groundwater quality. For example, if subsurface inflow from the surrounding foothills increases during a wet period, TDS and manganese levels could increase; however, this increase is not caused by groundwater management activities, but by natural events. A similar situation applies to the quality of Santa Ana River water. Although OCWD is involved in many programs to protect and improve the quality of Santa Ana River water, there could be changes in water quality that are outside of the control of Santa Ana Canyon Management Area stakeholders.

The second element to consider is if the beneficial uses of the groundwater have been negatively affected and/or if water quality regulations, such as Maximum Contaminant Levels (MCLs) and other potable water quality requirements have been exceeded.

The third element that must be considered is the volume of groundwater impacted by groundwater quality degradation. If small volumes are negatively affected yet do not materially affect the use of the aquifer for its existing beneficial uses, then this would not represent a significant and unreasonable degradation of water quality. However, if the impacted volume grows, then it could reach a level that it becomes significant and unreasonable.

When considering all three elements, “significant and unreasonable degradation of water quality” is defined as degradation of groundwater quality in the Santa Ana Canyon Management Area that is attributable to groundwater production or recharge practices within the Santa Ana Canyon Management Area and to the extent that a significant volume of groundwater becomes unusable for its designated beneficial uses.

11.2 DETERMINATION OF MINIMUM THRESHOLDS

The minimum thresholds for groundwater quality are exceedances of Maximum Contaminant Levels (MCLs) or other applicable regulatory limits that are directly attributable to groundwater production and recharge practices in the Santa Ana Canyon Management Area that prevents the use of groundwater for its designated beneficial uses.

SECTION 12. SUSTAINABLE MANAGEMENT RELATED TO SEAWATER INTRUSION

The Santa Ana Canyon Management Area is located far from the ocean and thus there is no reason to consider the potential impact of seawater intrusion in this management area.

SECTION 13. SUSTAINABLE MANAGEMENT RELATED TO LAND SUBSIDENCE

Recently, as part of DWR's SGMA technical assistance to provide important SGMA-relevant data to Groundwater Sustainability Agency's (GSAs) for Groundwater Sustainability Plan (GSP) development and implementation, DWR contracted with TRE ALTAMIRA, Inc. to provide vertical displacement estimates are derived from InSAR data that are collected by the European Space Agency (ESA) Sentinel-1A satellite.

This dataset represents measurements of vertical ground surface displacement in more than 200 of the high-use and populated groundwater basins across the State of California between January of 2015 and October of 2020. InSAR data coverage began in late 2014 for parts of California, and coverage for the entire study area began on June 13, 2015. Included in this dataset are point data that represent average vertical displacement values for 100 square meter areas, as well as GIS rasters that were interpolated from the point data; rasters for total vertical displacement relative to June 13, 2015, and rasters for annual vertical displacement rates with earlier coverage for some areas, both in monthly time steps. The level of accuracy is approximately 0.05 feet.

To show subsidence in Basin 8-1, OCWD used the used a layer showing the total land subsidence since the start of the InSAR data on 6/13/2015 and ending on 7/1/2020, which corresponds to the end of the OCWD water year. The GIS layer used was: https://gis.water.ca.gov/arcgisimg/rest/services/SAR/Vertical_Displacement_TRE_ALTAMIRA_v2020_Total_Since_20150613_20200701/ImageServer

Figure 13-1 shows the total land displacement in Basin 8-1 from June 2015 to July 2020. In the Santa Ana Canyon Management Area, vertical displacement is essentially unchanged and within the accuracy of the method (0 to 0.05 ft). This is not surprising given the following:

- The presence of shale and sandstone bedrock underlying the alluvial aquifer is not thought to be sufficiently compressible to cause inelastic subsidence.
- The alluvial aquifer is thin, generally less than 100 feet, and composed mainly of sand and gravel with only minor amounts of clay.
- Groundwater levels and storage volumes are stable.
- Substantial groundwater level declines are highly unlikely due to the de minimis amount of groundwater production relative to the overall inflow of water to the Santa Ana Canyon Management Area.

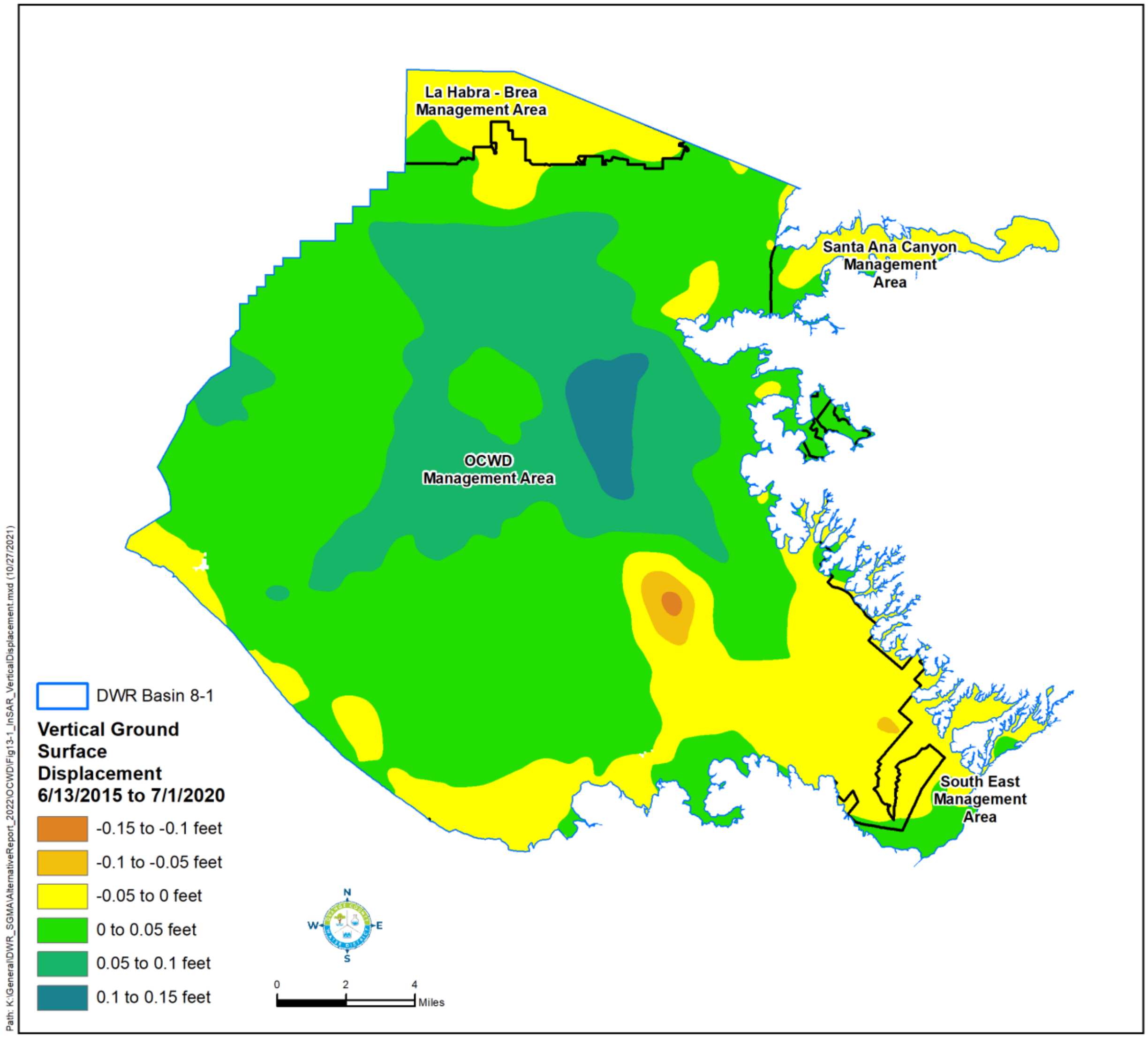

Figure 13-1: Total Vertical Ground Surface Displacement from June 2015 to July 2020

SECTION 14. MANAGING GROUNDWATER DEPLETIONS IMPACTING SURFACE WATER

The primary surface water feature in the Santa Ana Canyon Management Area is the Santa Ana River. In the Santa Ana Canyon Management Area, the Santa Ana River is a soft-bottomed channel that supports riparian habitat. Riparian habitat is dependent on river water released through Prado Dam, which is predominantly treated wastewater discharged in the upper watershed when storm flow is not present.

Groundwater within the Santa Ana Canyon alluvial aquifer is consistently 20 to 30 feet below ground surface and even shallower in the incised portions of the Santa Ana River channel. As described in Section 4, Water Budget, the flow of surface water through the canyon is two orders of magnitude larger than groundwater production. As a result, groundwater production has a de minimis impact on groundwater conditions and the flows of surface water through the canyon. This, in turn, means that groundwater production in the Santa Ana Canyon has a de minimis impact on the groundwater dependent ecosystems in the Santa Ana Canyon Management Area. Therefore, the undesirable result of “depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water due to groundwater conditions occurring throughout the basin” does not apply.

SECTION 15. PROTOCOLS FOR MODIFYING MONITORING PROGRAMS

Protocols for modifying monitoring programs are described in the 2017 Alternative.

SECTION 16. PROCESS TO EVALUATE NEW PROJECTS

For projects within OCWD, the process described in the OCWD Management Area part of this report applies. If new projects are proposed by others outside of OCWD's boundaries, OCWD would collaborate with the agency proposing the project to ensure that any proposed project would not cause significant and unreasonable results. Moreover, OCWD would review proposed projects through the CEQA process (i.e., reviewing and commenting on draft CEQA documents).

SECTION 17. REFERENCES

County of Orange, 2016. County of Orange, Santa Ana River Canyon and Brush Canyon Habitat Management Areas, 2016 Annual Monitoring Report, June 2016.

OCWD, 2007. Report on Evaluation of Orange County Groundwater Basin Storage and Operational Strategy, February 2007.

USGS, 1964. Geology and Oil Resources of the Eastern Puente Hills Area, Southern California. By D.L. Durham and R.F. Yerkes. USGS Professional Paper 420-B.