ORANGE COUNTY WATER DISTRICT

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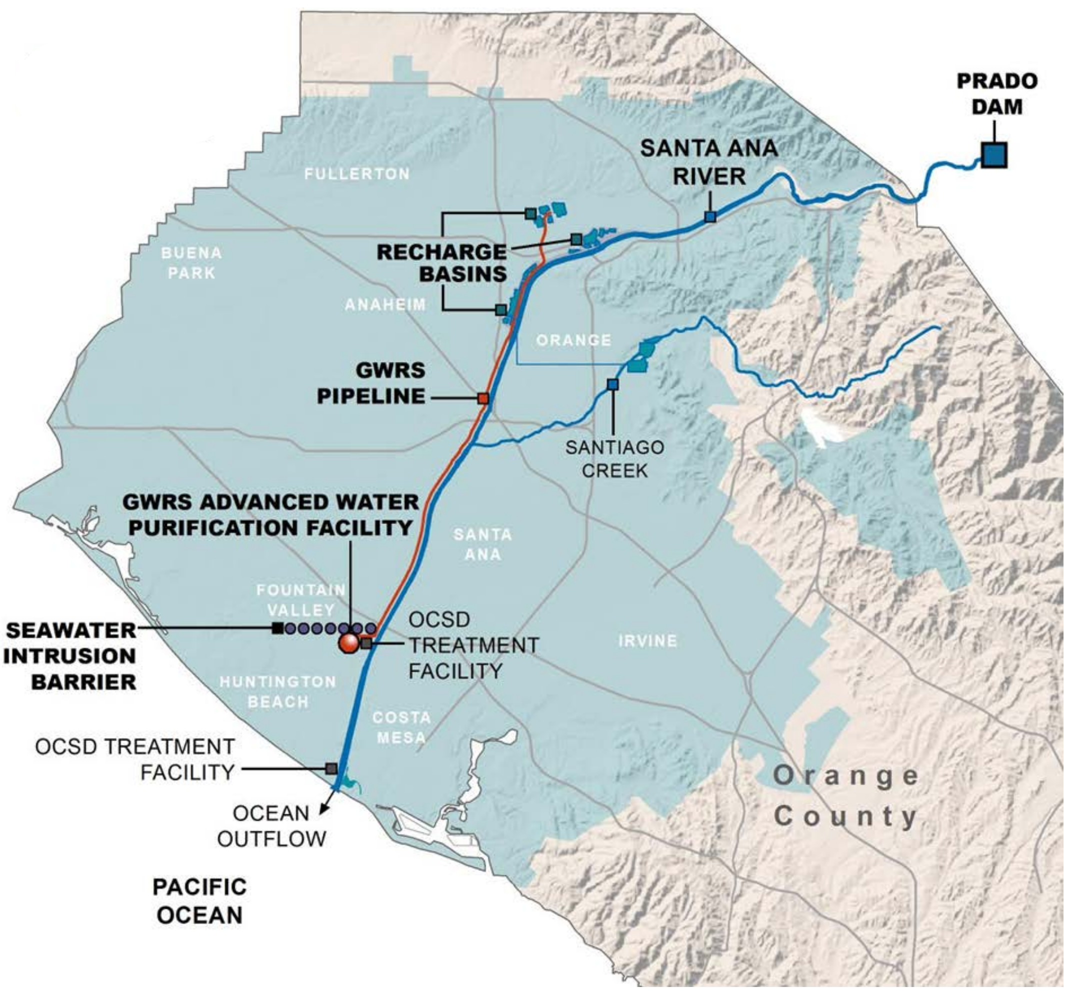
Orange County Water District Groundwater Management Plan 2015 Update



Orange County Water District Groundwater Management Plan 2015 Update

June 17, 2015

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The primary authors of the Groundwater Management Plan wish to acknowledge Steve Strand who prepared the majority of maps and assisted with data management.

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APPENDICES

EXECUTIVE SUMMARY

The Orange County Water District (OCWD; the District) is a special district formed to manage the Orange County Groundwater Basin. Water from the basin provides approximately 70 percent of the water supply for residents in north and central Orange County.

INTRODUCTION

OCWD was created in 1933 by the California legislature to manage the Orange County Groundwater Basin. The District operates the basin in order to protect and increase the basin's sustainable yield in a cost-effective manner. Water produced from the basin is the primary water supply for approximately 2.4 million residents living within the District boundaries.

OCWD manages the groundwater basin and seeks to expand the basin's annual yield by maximizing the amount of water recharged into the basin, developing new sources of water to recharge the basin, and increasing the effectiveness of the District's facilities. OCWD is governed by a 10-member Board of Directors. Cities, water agencies and other groundwater producers meet on a monthly basis with District staff to provide input and advice on basin management issues.

Water demands have grown substantially since the District's founding. This has challenged OCWD to increase groundwater recharge, establish methods to effectively manage demands on the basin, and balance the amount of total recharge and total pumping to maintain water levels and storage within the established safe operating range.

Figure ES-1: Burris Basin - OCWD Recharge Facility in Anaheim

The District's first Groundwater Management Plan was published in 1989; the *Groundwater Management Plan 2015 Update* is the fifth update. In 2014, the California Sustainable Groundwater Management Act was passed. The new law provides authority for agencies to develop and implement Groundwater Sustainability Plans or alternative plans that demonstrate the basin has operated within its sustainable yield over a period of at least 10 years. Elements to be included in sustainability plans as described in the California Water Code (§10727.2, 10727.4, and 10727.6) have been incorporated into this plan.

Groundwater basin management goals are (1) to protect and enhance groundwater quality, (2) to protect and increase the sustainable yield of the basin in a cost-effective manner, and (3) to increase the efficiency of District operations.

BASIN HYDROGEOLOGY

The Orange County Groundwater Basin is located within an area designated by the California Department of Water Resources as Basin 8-1. The boundaries of the "Coastal Plain of Orange County Groundwater Basin" and OCWD boundaries are shown in Figure ES-2. The basin stores an estimated 66 million acre-feet of water, although only a fraction of this can be sustainably pumped without causing physical damage such as seawater intrusion or potential land subsidence. Annual changes in the amount of groundwater stored in the basin are estimated using groundwater elevation measurements and aquifer storage coefficients for the three primary aquifer systems in the basin. These estimated storage changes are backed up with comprehensive measurements of groundwater production and managed recharge so that a fairly precise estimate of groundwater storage is known on a monthly basis.

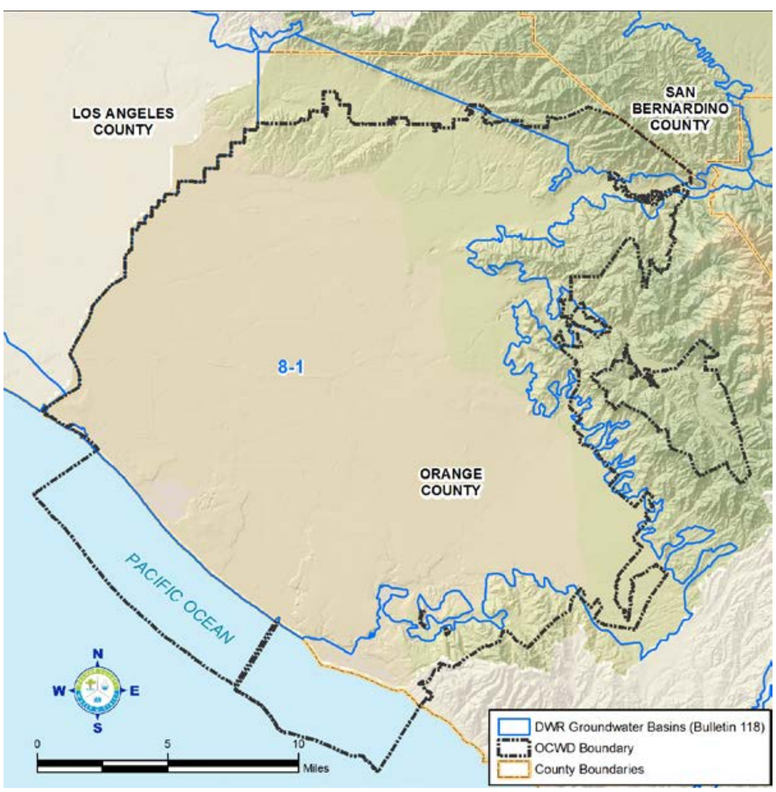


Figure ES-2: DWR Basin 8-1 and OCWD Boundary

OCWD's groundwater basin model was developed to evaluate basin production capacity and recharge requirements and has improved the district's overall understanding of groundwater flow dynamics. Typical applications of the basin model include estimating annual change in groundwater storage and the effects of potential future pumping and recharge projects on groundwater levels, storage, and the water budget.

WATER SUPPLY MONITORING

OCWD collects water elevation and water quality data from nearly 700 wells, including over 400 District-owned monitoring wells, shown in Figure ES-3. Comprehensive water quality monitoring programs are conducted to comply with permits and drinking water regulations, to conduct research programs, and to manage the groundwater basin. The District operates its own laboratory that is state-certified to perform bacteriological, inorganic, and organic analyses.

All entities that operate large-capacity wells must equip their wells with meters and report their production totals every six months. Approximately 200 large-capacity municipal and privately-owned supply wells account for 97 percent of production. At the District's request, for the purposes of more precise and current knowledge of basin conditions and model calibration, owners of large-capacity wells have reported monthly production for each of their wells since 1988. All production and monitoring wells are measured for groundwater elevation at least every six months.

Water quality sampling programs vary year-to-year based on regulatory requirements and basin conditions. In 2014, OCWD water quality staff collected 17,046 samples, 4,142 of which were collected from drinking water wells. OCWD conducts Title 22 drinking water quality monitoring on behalf of the Groundwater Producers. Additional groundwater programs include monitoring of groundwater contamination plumes, recycled recharge water quality and extent of seawater intrusion.

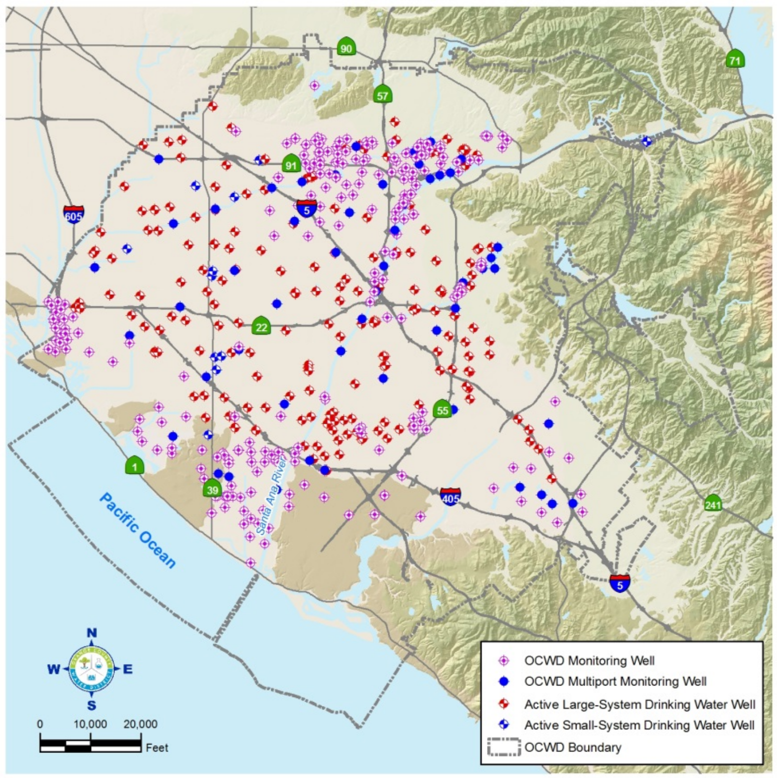


Figure ES-3: OCWD-Owned Wells and Wells in Title 22 Drinking Water Monitoring Program

OCWD monitors surface water used for groundwater recharge including Santa Ana River water and imported water as well as recycled water produced by the District's Groundwater Replenishment System. Flows in and out of the District's Prado Wetlands are monitored to evaluate changes in water quality and to evaluate the effectiveness of the treatment wetlands.

Data collected by OCWD are stored in the District's electronic database and geographic information system, known as the Water Resources Management System. The database contains comprehensive well information, current and historical data, and information on sub-surface geology and groundwater modeling.

MANAGEMENT AND OPERATION OF RECHARGE FACILITIES

Replenishing the groundwater basin is essential to support pumping from the basin. Although the amount of recharge and basin pumping may not be the same each year, over the long-term recharge needs to approximately equal total pumping, as it has for decades. Recharge water supplies and their respective proportion of total recharge supplies are shown in Figure ES-4.

The District's surface water recharge system is comprised of 23 recharge facilities with a combined maximum storage capacity of approximately 26,000 acre-feet. Recharge basins are located adjacent to the Santa Ana River in the City of Anaheim and Santiago Creek in the City of Orange.

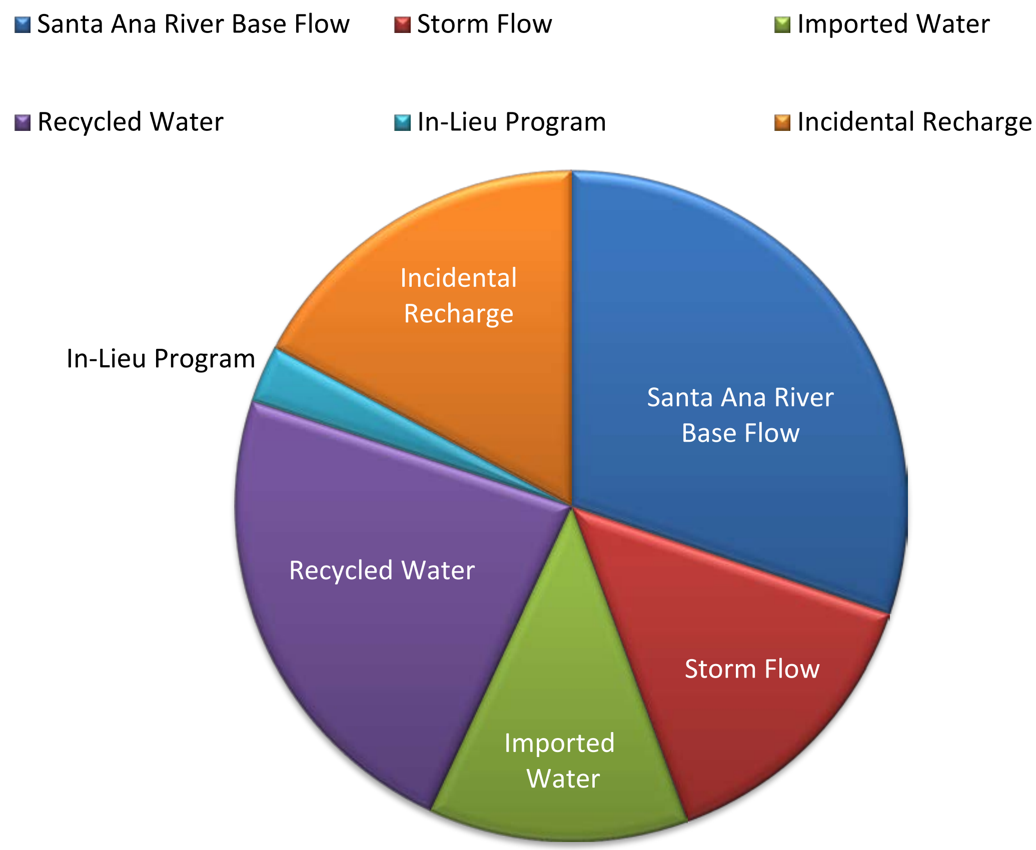


Figure ES-4 Sources of Groundwater Recharge
Average for Water Years 2009-10 to 2013-14

GROUNDWATER REPLENISHMENT SYSTEM

The Groundwater Replenishment System (GWRS) is OCWD's recycled water purification system in operation since 2008 (Figure ES-5). The plant was jointly constructed by OCWD and the Orange County Sanitation District. Wastewater that would otherwise be discharged to the Pacific Ocean is purified using a three-step process (microfiltration, reverse osmosis, and advanced oxidation/disinfection) to produce high-quality water used to recharge the groundwater basin and for injection into the Talbert Seawater Intrusion Barrier. When first completed, the plant produced up to 70 million gallons per day or approximately 72,000 acre-feet per year (afy) of product water. Initial expansion of the plant was completed in 2015 increasing production up to 100,000 afy of recycled water.

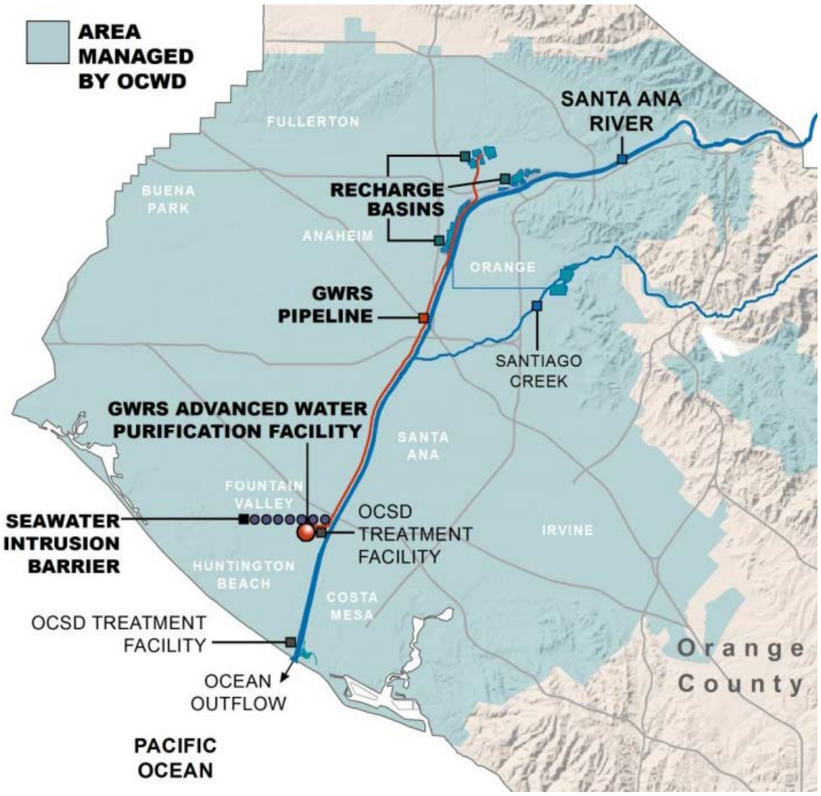


Figure ES-5: GWRS Facilities

SEAWATER INTRUSION MONITORING AND BARRIER MANAGEMENT

Monitoring and preventing the encroachment of seawater into fresh groundwater zones along the coast is a major component of OCWD's sustainable basin management. 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; seawater intruded three miles inland. Risk of seawater intrusion is greatest in coastal lowland areas, or gaps, between relatively flat elevated areas referred to as mesas as shown in Figure ES-6.

The Alamitos Seawater Intrusion Barrier was constructed in 1965 to protect the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion through the Alamitos Gap. The barrier facilities are jointly owned by the Los Angeles County Flood Control District and OCWD and include 43 injection wells and 177 active monitoring well sites.

OCWD constructed the Talbert Seawater Barrier in 1975 with 23 injection well sites to halt seawater intrusion through the Talbert Gap, a 2.5 mile geological feature between the

Newport and Huntington Mesas. Today, the Talbert Barrier is composed of a series of 36 well sites that are used to inject an average of 36,000 afy of water into four aquifer zones. This forms a hydraulic barrier to seawater that would otherwise migrate inland toward areas of groundwater production.

ES-6: Mesas and Gaps Along the Orange County Coast

Basin monitoring for potential seawater intrusion in the vicinity of the Sunset Gap began in the 1950s. In 2007, a well in the City of Huntington Beach was permanently removed from service due to high salinity levels. Studies commenced and monitoring wells were constructed. Strategies to control intrusion being considered include design of a potential future southerly extension of the Alamitos Barrier. Additional remedial measures beyond source control may be considered, such as brackish groundwater extraction and desalination.

WATER QUALITY PROTECTION

OCWD adopted the first Groundwater Quality Protection Policy in 1987; the latest revision was adopted by the Board of Directors in 2014. The policy guides the actions of OCWD to prevent groundwater quality degradation, undertake investigation and clean up as necessary to protect the basin from contamination, and encourage appropriate treatment of poor-quality groundwater.

Salinity Management

Since Santa Ana River water is a major source of recharge for the basin, salt management programs in the upper watershed are vital to protect the water quality in Orange County. A watershed-wide salinity management program is implemented by watershed stakeholders under the direction of the Santa Ana Regional Water Quality Control Board.

In addition, recharging the Orange County Groundwater Basin with recycled water produced by the GWRS is expected to reduce salinity levels over the long-term.

To reduce the level of nitrate in Santa Ana River water, OCWD operates an extensive system of wetlands in the Prado Basin, shown in Figure ES-7. OCWD diverts approximately half of the non-storm flows of the Santa Ana River through the wetland ponds that remove approximately 15 to 40 tons of nitrates a month, depending on the season.

Figure ES-7: OCWD Prado Wetlands

Groundwater Contamination

OCWD efforts to protect the groundwater basin and to assess the potential threat to public health and the environment from contamination in the Santa Ana River watershed and within Orange County include:

- Reviewing on-going 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; and
- Conducting third-party groundwater split samples at contaminated sites to assist regulatory agencies in evaluating progress of groundwater cleanup.

OCWD lacks the regulatory authority to require responsible parties or potentially responsible parties to clean up pollutants that have contaminated groundwater. In some cases, the District has pursued legal action against entities that have contaminated the groundwater basin to recover the District's remediation costs. In other cases, the District coordinates and cooperates with regulatory oversight agencies that investigate sources of contamination.

The District also uses financial incentives to encourage pumping and treatment of groundwater that does not meet drinking water standards in order to protect water quality by reducing the spread of poor-quality groundwater.

NATURAL RESOURCES AND COLLABORATIVE PROGRAMS

OCWD's collaborative efforts in the Santa Ana River Watershed include natural resource programs to replace invasive plants with native plants and manage habitat for endangered and threatened species. These programs protect the water quality in the Santa Ana River and fulfill mitigation requirements for impacts to natural resources from District operations in the Prado Basin.


ES-8 Least Bell's Vireo

During the 1960s, the U.S. Army Corps of Engineers began working with OCWD to conserve water behind Prado Dam in order to support OCWD's groundwater recharge operations. OCWD's natural resource programs began in response to concerns that increased water storage behind the dam could negatively impact the Prado Basin ecosystem.

The Prado Basin contains the single largest stand of forested riparian habitat remaining in coastal southern California, which supports an abundance and diversity of wildlife including many listed and sensitive species. Habitat management programs in the Prado Basin are responsible for the recovery of a federally endangered species, the least Bell's vireo, shown in Figure ES-8.

In addition to programs in the Prado Basin, the District is a partner in watershed-wide efforts to eradicate the invasive plant *Arundo donax*, to manage habitat for rare and endangered birds, and to protect the Santa Ana Sucker, an endangered fish. Wildlife protection programs within Orange County include the construction of a bird island on Burris Basin and on-going participation in programs to manage water resources in the watershed.

SUSTAINABLE BASIN MANAGEMENT

In the early 1950s, increased pumping from the basin outpaced the rate of recharge. Water levels dropped and seawater intruded into coastal areas threatening the basin's water quality. The District began purchasing imported water to recharge the basin.

Groundwater producers supported legislative changes to the OCWD Act that provided for management of the basin as a common pool of water rather than allocating individual basin water rights. The adopted legislation allowed all producers to pump as much as they wanted provided that they pay for the costs of replenishing the basin. Sustainable management has allowed for basin production to grow from less than 200,000 afy in the mid-1960s to over 300,000 acre-feet in the 2000s as shown in Figure ES-9.

The basin must be maintained in an approximate balance to ensure the long-term viability of basin water supplies. In any given year, groundwater withdrawals may exceed water recharged as long as over the course of a number of years this is balanced by years when water recharged exceeds withdrawals. OCWD calculates the basin storage level annually and sets the target amount of production to manage pumping to either increase or decrease groundwater storage levels in response to hydrological conditions.

The primary mechanism used by OCWD to manage pumping is the Basin Production Percentage (BPP). The BPP is a percentage of each Producer's water supply that comes from groundwater pumped from the basin. The BPP is set on an annual basis and is uniform for all Producers. Groundwater pumping above the BPP is assessed an additional charge that creates a disincentive for over-producing.

The basin is managed to maintain water storage levels of not more than 500,000 acre-feet below full condition to avoid permanent and significant negative or adverse impacts. The basin is operated within a safe operating range as shown in Figure ES-10. Operating the basin in this manner enables the District to encourage reduced pumping during wet years when surface water supplies are plentiful and increased pumping during dry years to provide additional local water supplies during droughts.

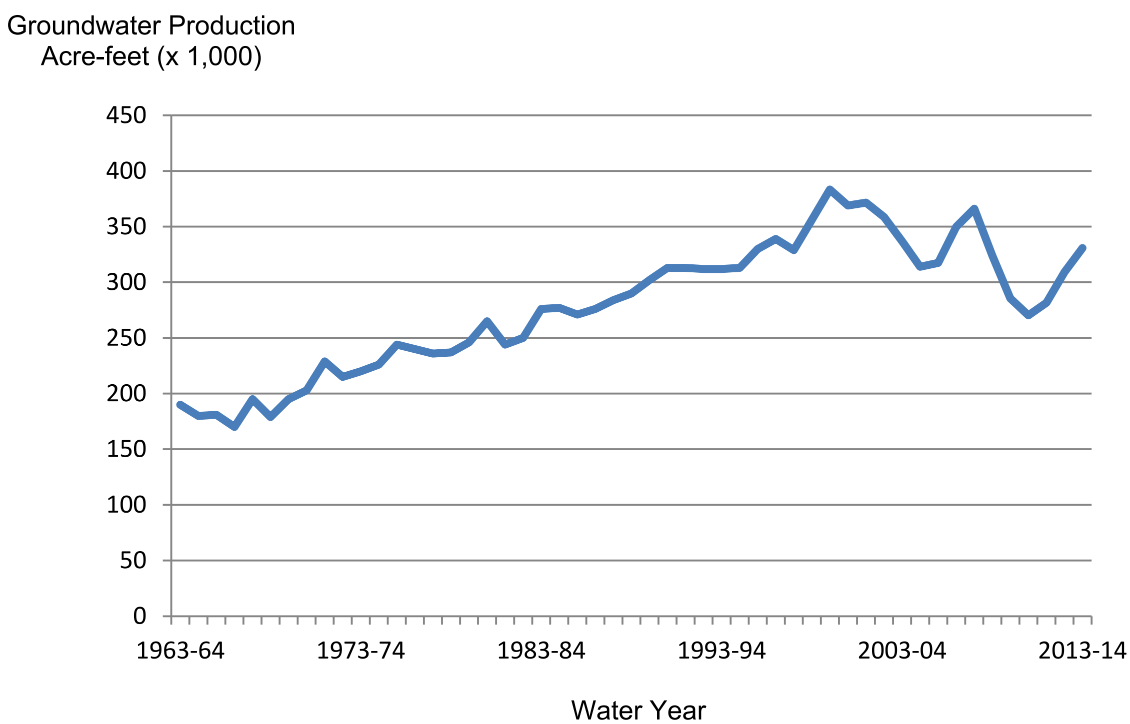


Figure ES-9: Groundwater Production, Water Year 1963-64 to 2013-14

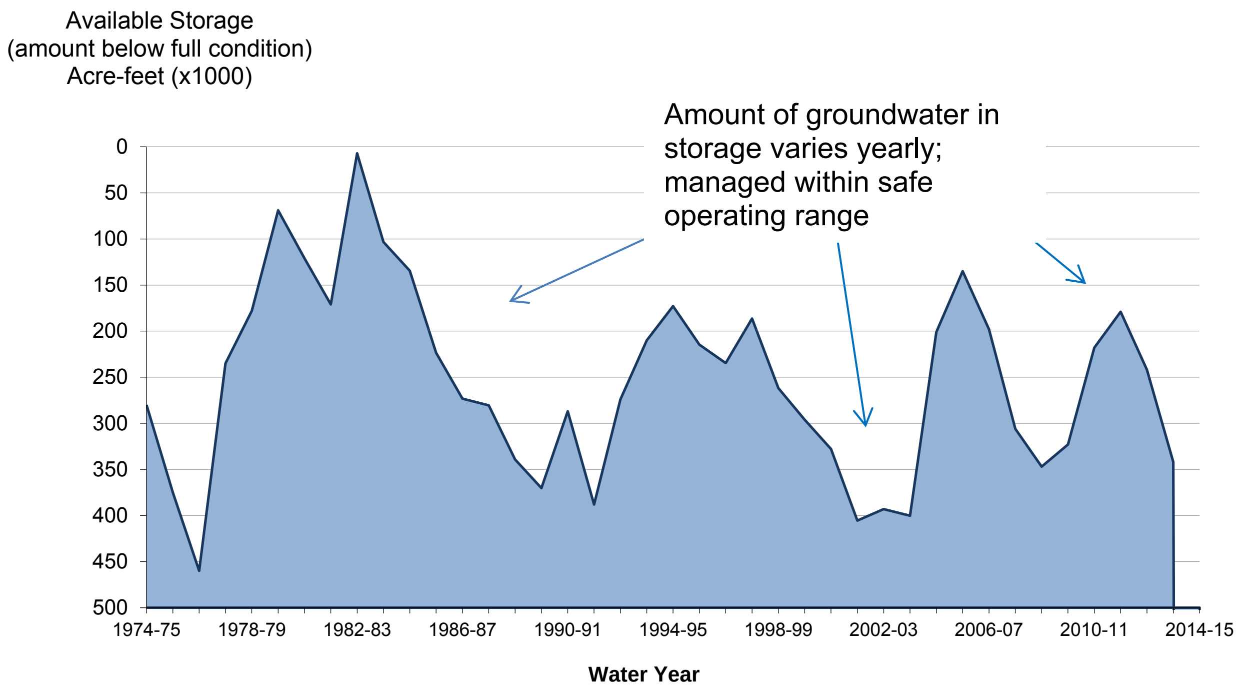


Figure ES-10: Groundwater Storage for Water Years 1974-75 to 2013-14

Each year, the District determines the optimum level of storage for the following year when it sets the BPP. This determination is affected by several factors, including the current storage level, regional water availability, and hydrologic conditions. The District manages the basin within an established operating storage range. When the basin storage approaches the lower end of the operating range, issues that become more of a concern include seawater intrusion, upwelling of amber-colored water into the Principal Aquifer from underlying aquifers, downward migration of poor-quality groundwater from the Shallow Aquifer, increased risk of land subsidence, and potential for shallow wells to become inoperable due to lower water levels (see Figure ES-11). When operating the basin at a higher storage level, the amount of energy required to pump groundwater is less but groundwater outflow to Los Angeles County may be greater.

One of OCWD's basin management objectives is to maximize groundwater recharge. This is achieved through increasing the efficiency of and expanding the District's recharge facilities and the supply of recharge water. Operation of the GWRS provides a substantial increase in supply of water available to recharge the basin. Additional District supply management programs include encouraging and using recycled water for irrigation and other non-potable uses, participating in water conservation efforts, and working with the Metropolitan Water District of Southern California and the Municipal Water District of Orange County in developing and conducting other supply augmentation projects and strategies.

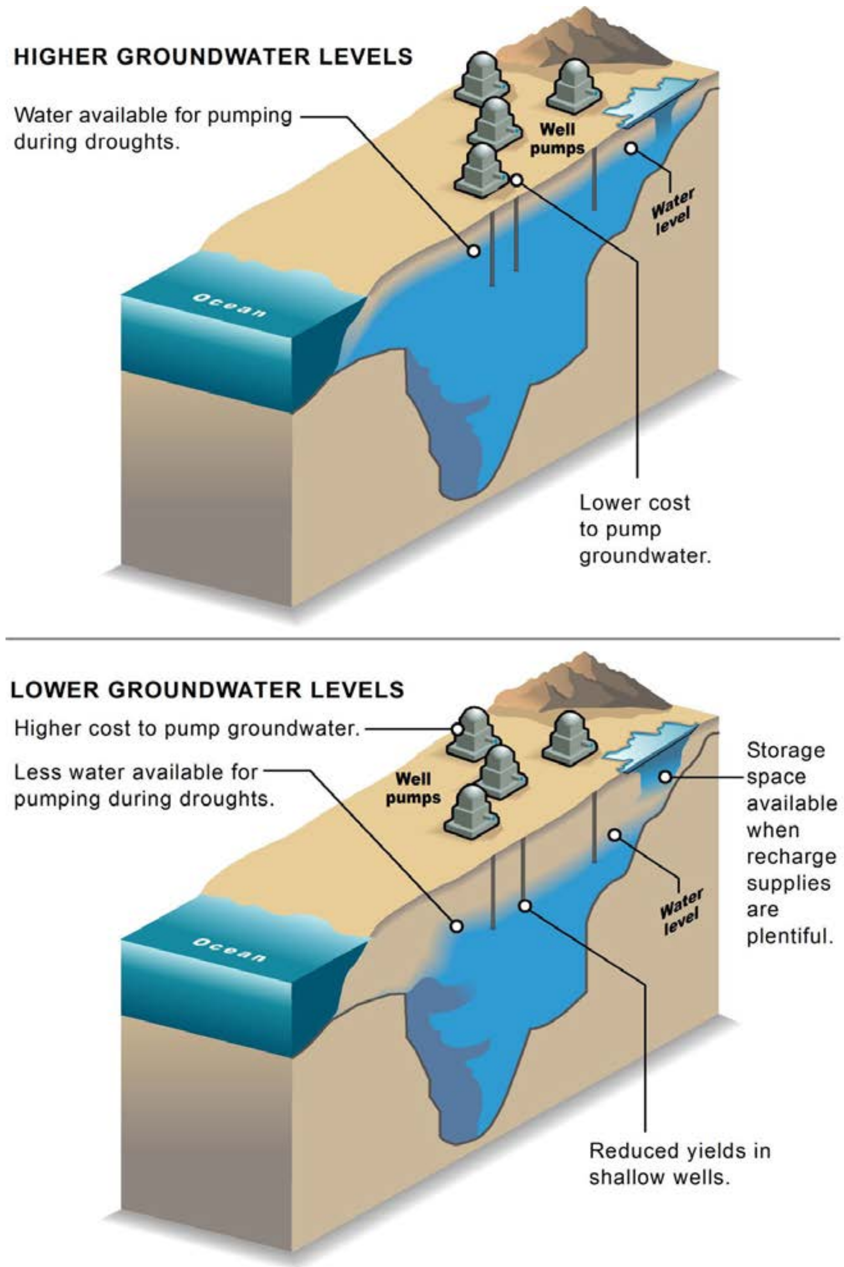


Figure ES-11: Impacts of Change in Groundwater Storage Levels

Financial Management

The District's fiscal year begins on July 1 and ends on June 30. The annual operating budget and expected revenues for FY 2014-15 were approximately $134.4 million. This includes a budget of $26 million to purchase imported water for recharge. Revenue sources include assessments to groundwater producers, property taxes, grants, and low-interest loans.

HISTORY AND GOVERNANCE

1

Recharge Facilities, downstream view of Santa Ana River with T & L Levees, 1971

The Orange County Water District, since its founding in 1933, has managed the Orange County Groundwater Basin. This section includes:

<u>History of the Orange County Water District</u>

1933: OCWD created by California legislature
1949: First purchase of imported water for groundwater recharge
1957: First off-river recharge basin purchased
1975: Talbert Seawater Barrier begins operation
2008: Groundwater Replenishment System beings operation

<u>District Governance</u>

- Board of Directors comprised of 10 members, each representing one division
- Groundwater Producers meet monthly with District staff

<u>Public Events</u>

- Groundwater Adventure Tours and GWRS Tours
- Children's Water Festival
- OC Water Summit

SECTION 1 HISTORY AND GOVERNANCE

1.1 INTRODUCTION

The Orange County Water District (OCWD, the District) is a special district formed in 1933 by an act of the California Legislature. The District manages the groundwater basin that underlies north and central Orange County. Water produced from the basin is the primary water supply for approximately 2.4 million residents living within the District's boundaries.

Figure 1-1: OCWD Board of Directors, circa 1935

Nineteen major groundwater producers, including cities, water districts, and private water companies, pump water from about 200 large-capacity wells for retail water use. There are also approximately 200 small-capacity wells that pump water from the basin. OCWD protects and manages the groundwater resource for long-term sustainability, while meeting approximately 60 to 70 percent of the water supply demand within its service area.

Since its founding, the District has grown in area from 162,676 to 243,968 acres and has experienced an increase in population from approximately 120,000 to 2.4 million people. The District has employed groundwater management techniques to increase the annual yield from the basin including operating over 1,500 acres of infiltration basins in the cities of Anaheim, Orange, and unincorporated areas of Orange County. Annual water production increased from approximately 150,000 acre-feet per year (afy) in the mid-1950s to a high of over 360,000 afy in water year 2007-08.

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 protecting the long-term sustainability of the basin.

1.2 HISTORY OF THE ORANGE COUNTY WATER DISTRICT

1800s: Population in the Santa Ana River Watershed increases rapidly as immigrants move into the region that for centuries was populated by Native Americans.

1900s: Growth of Orange County's agricultural economy creates demand for water, straining available surface and groundwater supplies. Increased water use upstream in San Bernardino and Riverside Counties results in declining flows in the Santa Ana River.

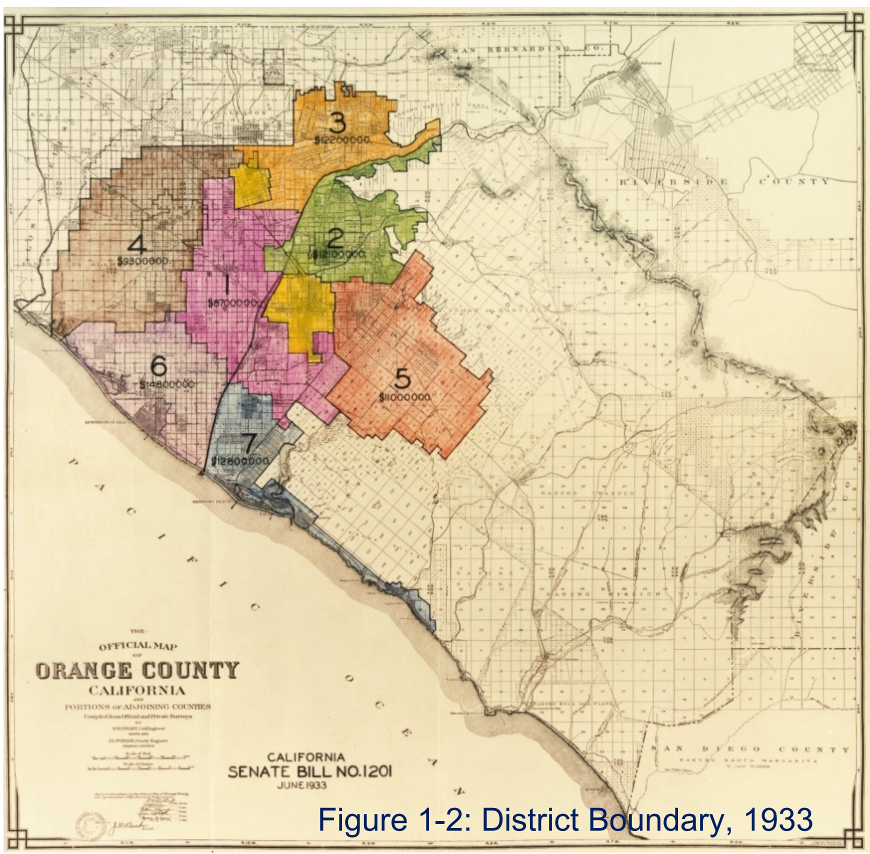


Figure 1-2: District Boundary, 1933

1932: The Irvine Company, the county's largest landowner, files suit against upper basin users to protect its rights to river flows. The Orange County Farm Bureau forms the Santa Ana Basin Water Rights Protective Association to consider options to secure adequate supplies.

June 14, 1933: California Legislature creates the Orange County Water District by special act to protect surface water rights and manage the groundwater basin. The new district joins the Irvine Company's lawsuit.

1930s: Groundwater pumping in Orange County exceeds the rate of recharge resulting in groundwater levels dropping. OCWD begins actively recharging the groundwater basin and looking for additional water supplies.

1936: OCWD begins purchasing portions of the Santa Ana River channel with the first purchase of 26 acres.

1942: The Irvine Company lawsuit is settled by setting limits on the amount of Santa Ana River water to be used for recharge in the upper basins as a means to provide Orange County with a share of this water supply.

1949: OCWD begins purchasing imported water from the Colorado River Aqueduct for groundwater recharge.

1951: OCWD initiates legal action against cities upstream of Orange County to protect rights to Santa Ana River flow. Settlement of the suit in 1957 limits use of river water to the amount used in 1946.

1954: The District Act is amended giving OCWD authority to collect a Replenishment Assessment (RA) from groundwater pumpers to purchase imported water for groundwater recharge. The amendments also enlarged the District boundaries, and required the publication of an annual engineer's report on groundwater production and basin conditions.

1956: Groundwater levels drop as much as 40 feet below sea level and seawater intrudes 3½ miles inland. Plans begin to construct seawater intrusion barriers in two areas – Alamitos Gap at the mouth of the San Gabriel River at the Orange County/Los Angeles County border and the Talbert Gap at the mouth of the Santa Ana River in Fountain Valley.

1957: OCWD purchases land and constructs Anaheim Lake, the District's first off-river recharge basin.

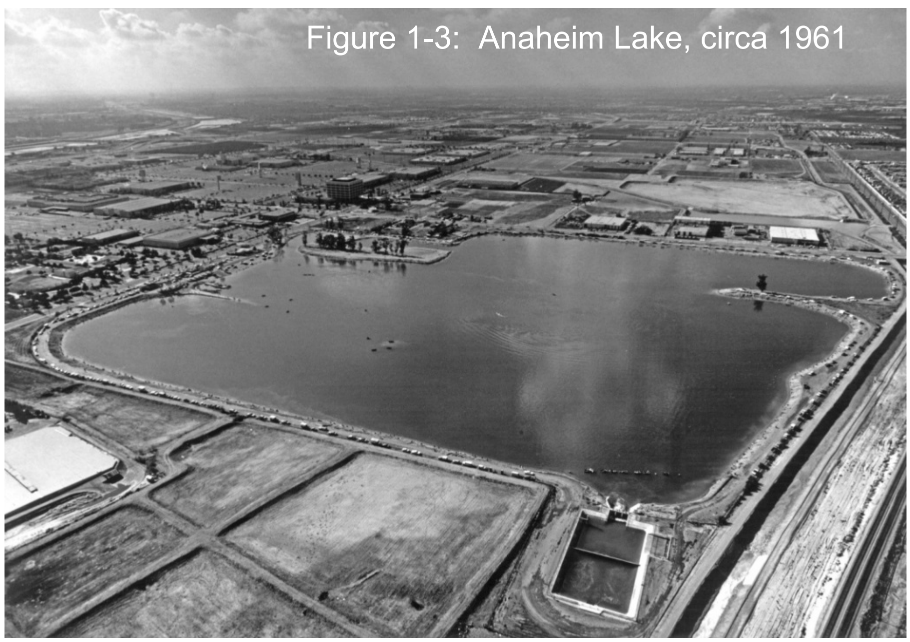


Figure 1-3: Anaheim Lake, circa 1961

1963: OCWD files a lawsuit against all upper watershed entities above Prado Dam to ensure a minimum amount of Santa Ana River water for Orange County.

1965: OCWD partners with the Los Angeles County Flood Control District to begin injecting fresh water into the Alamitos Gap to prevent saltwater intrusion.

1968: OCWD purchases land and water rights owned by Anaheim Union Water Company and the Santa Ana Valley Irrigation Company, which includes land upstream of Prado Dam that was acquired to protect Orange County's interest in Santa Ana River water.

1969: The lawsuit against upper watershed entities is settled. (Orange County Water District v. City of Chino, et al., Case no. 117628 – County of Orange). Large water districts agree to deliver at least 42,000 acre-feet of Santa Ana River baseflow to Orange County and OCWD gains the rights to all stormflows reaching Prado Dam. Parties to the judgment include Western Municipal Water District, San Bernardino Valley Municipal Water District and the Inland Empire Utilities Agency.

1969: The Basin Production Percentage and the Basin Equity Assessment are established.

1973: First water quality laboratory is constructed to analyze samples from the Santa Ana River and to begin analysis of demonstration injection wells for the planned construction of Water Factory 21.

1975: Talbert Seawater Intrusion Barrier begins operation. Control of seawater intrusion in the Talbert Gap requires six times the amount of water needed for the Alamitos Gap. Water Factory 21 is built to supply water to the Talbert Seawater Intrusion Barrier. Secondary-treated wastewater from the Orange County Sanitation District receives advanced treatment and is blended with potable water to produce a safe, reliable supply for barrier operations.

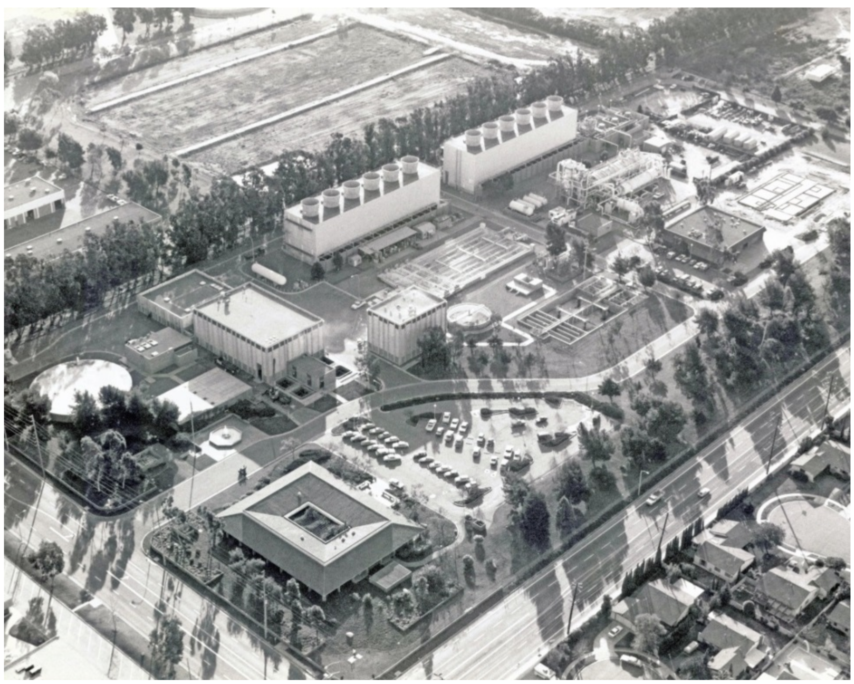


Figure 1-4: Water Factory 21, circa 1975

1991: Santiago Creek recharge project is completed, including purchase and development of Santiago Basins along Santiago Creek, a pump station at Burris Basin, and a pipeline to convey water back and forth from recharge basins along the Santa Ana River and Santiago Basins. Two rubber dams are installed on the Santa Ana River, allowing for more efficient diversion of river water to the downstream recharge facilities. The increased capture of water from the dams paid for the cost of the dams within the first year of operation.

2008: The Groundwater Replenishment System (GWRS) begins operation, replacing Water Factory 21. The GWRS is capable of producing up to 72 mgd of water for use in Talbert Barrier operations and for groundwater recharge.

2009: New Advanced Water Quality Assurance Laboratory opens to handle over 400,000 analyses of nearly 20,000 water samples each year.

2015: GWRS Initial Expansion is completed, expanding plant capacity from 72 mgd to 100 mgd of product water.

Figure 1-5: GWRS Reverse Osmosis Building

1.3 OCWD GOVERNANCE

The Orange County Water District was created by a special act of the California legislature in 1933 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)

The District is divided into 10 divisions as specified in the District Act. One director is elected or appointed from each division. The cities of Anaheim, Fullerton, and Santa Ana appoint one member each to serve on the Board. The other seven Board members are elected by voters in the respective divisions. Boundaries of the 10 divisions are shown in Figure 1-6. Appointed members of the Board serve a four-year term and may be removed at any time by a majority vote of the appointing governing body. Elected members of the board serve four-year terms and may be re-elected without limits.

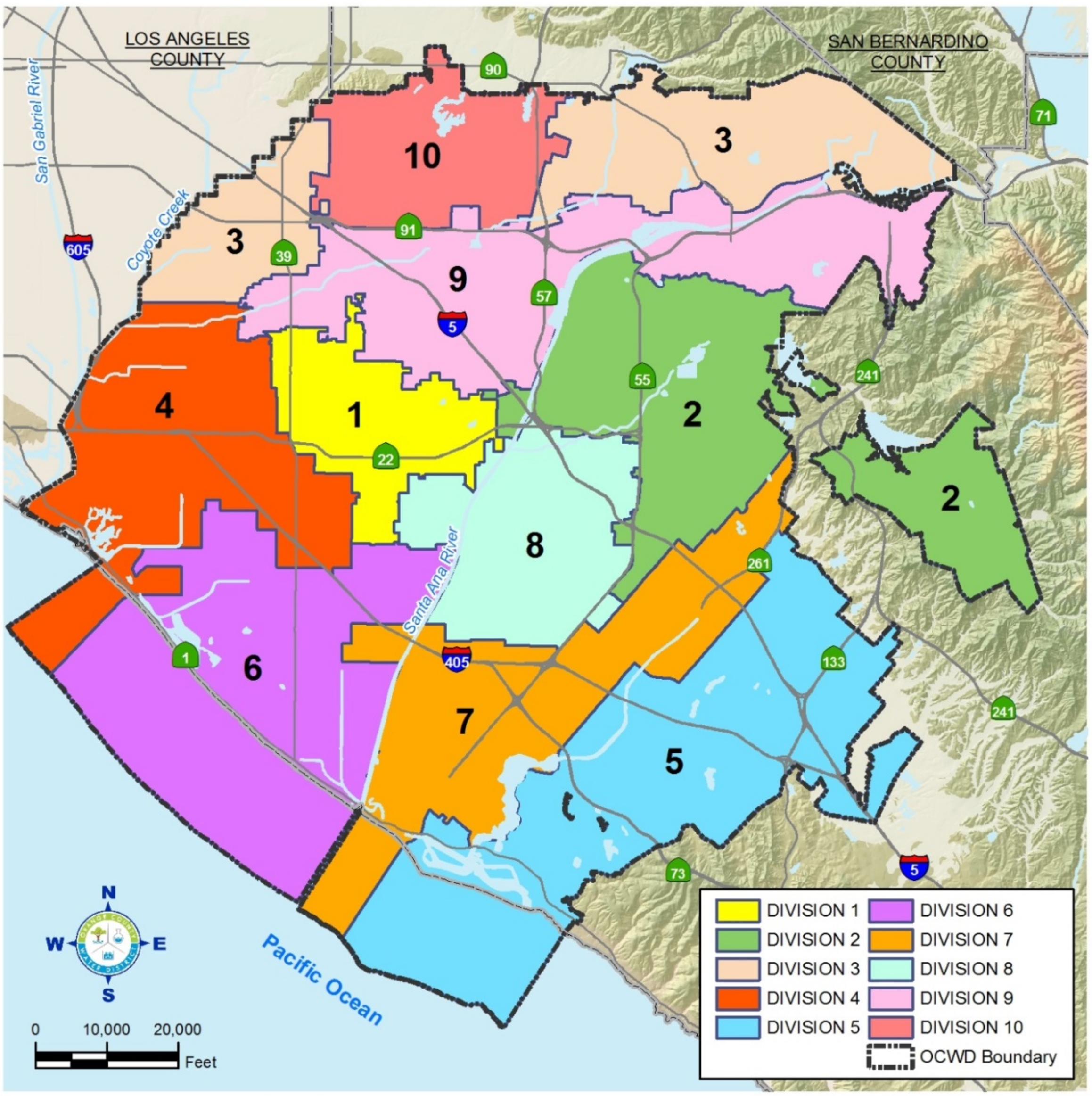


Figure 1-6: Board of Directors Service Area

The ten divisions are comprised of the following areas:

Division One:	Garden Grove, Stanton, Westminster
Division Two:	Orange, Villa Park, and parts of Tustin
Division Three:	Buena Park, La Palma, Placentia, Yorba Linda, and parts of Cypress
Division Four:	Los Alamitos, Seal Beach, and parts of Buena Park, Cypress, Garden Grove, Huntington Beach, Stanton, and Westminster
Division Five:	Parts of Irvine and Newport Beach
Division Six:	Parts of Fountain Valley and Huntington Beach
Division Seven:	Costa Mesa and parts of Fountain Valley, Irvine, Newport Beach and Tustin
Division Eight:	Santa Ana
Division Nine:	Anaheim
Division Ten:	Fullerton

The full Board of Directors, shown in Figure 1-7, meets twice a month, normally on the first and third Wednesdays of the month. Board committees also meet on a monthly basis. These committees include the Water Issues, Communication/Legislation, Administration/Finance, Property/Management and Retirement.

Figure 1-7: OCWD Board of Directors Meeting in Fountain Valley

The Groundwater Replenishment System Steering Committee, a joint committee of OCWD and Orange County Sanitation District (OCSD) meets on a quarterly basis to manage and plan operation of and expansion of the Groundwater Replenishment System. As operation of the plant is a joint venture of the two agencies, the Steering Committee discusses issues such as flow availability from the OCSD plant, operational challenges, plant expansion, source control, water quality, and others.

Section 2 of the District Act grants powers to the District as summarized below:

- To construct, purchase, lease, or otherwise acquire, and to operate and maintain necessary waterworks, water rights, spreading grounds, lands, and rights necessary to replenish the groundwater basin and augment and protect the water quality of the common water supplies of the District;
- Provide for the conjunctive use of groundwater and surface water resources within the district area;
- Store water in underground basins or reservoirs within or outside the District;
- Regulate and control the storage of water and the use of groundwater basin storage space in the basin;
- Purchase and import water into the District;
- Transport, reclaim, purify, treat, inject, extract, or otherwise manage and control water for the beneficial use of persons or property within the District and to improve and protect the quality of the groundwater supplies;
- Determine the amount and percentage of water produced from the groundwater basin within the district to the total amount of water produced within the District by all persons and operators;
- Require that persons and operators produce more or less of their total water needs from the groundwater within the District than the basin production percentage determined by the District, levy a basin equity assessment on each person and operator who produces more water from the basin, compensate persons and operators who are directed by the District to produce less than the basin production percentage;
- Provide for the protection and enhancement of the environment within and outside the District in connection with the water activities of the district; and
- To commence, maintain, intervene in, defend, and compromise, and assume the costs and expenses of all actions to prevent interference with water or water rights used within the District or diminution of the quality or pollution or contamination of the water supply of the District.

A copy of the District Act can be found at:
http://www.ocwd.com/Portals/0/Pdf/ocwd_district_act.pdf.

1.4 GROUNDWATER PRODUCERS

The local agencies that produce the majority of the groundwater from the basin are listed in Table 1-1 with geographic boundaries shown in Figure 1-8. District staff members meet monthly with 19 local, major water producers, referred to as the Producers, to discuss and evaluate important basin management issues in order to involve other affected agencies and work cooperatively where service areas or boundaries overlie the basin.

Table 1-1 Major Groundwater Producers within OCWD Boundaries

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

Generally, each year a chairman is elected to manage the Producers' meetings and represent the Producers. This monthly meeting provides a forum for the Producers to provide their input to the District 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; and
- Budgeting and considering other important policy decisions.

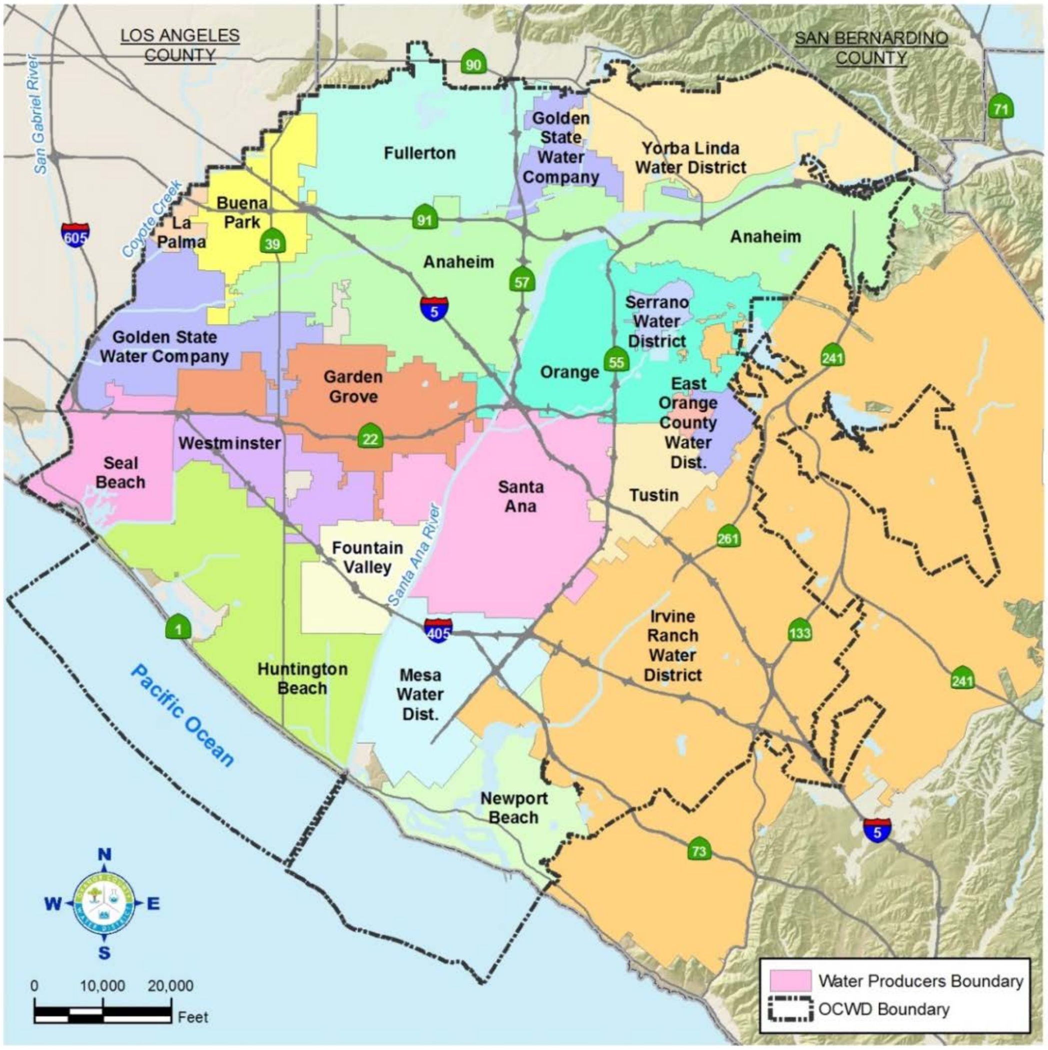


Figure 1-8: Retail Water Agencies within OCWD

1.5 PUBLIC EDUCATION AND EVENTS

Proactive community outreach and public education are central to the operation of OCWD. The District is dedicated to the creation, promotion and management of water education and conservation programs throughout Orange County. Each year, staff members give more than 70 offsite presentations to community leaders and citizens, conduct nearly 200 onsite presentations and tours of District facilities, and take an active part in community events (see Figure 1-9). The goal of OCWD's water-use efficiency and education programs, local water briefings, and outreach to organizations is to draw attention to state and local water needs and crises, teach useful and simple ways to reduce water consumption and respect this natural resource, and encourage local citizens to make life-long commitments to conserving water. The components that comprise OCWD's water-use efficiency, outreach and public education events and programs are described in this section.

Children's Water Education Festival

The Children's Water Education Festival, shown in Figure 1-9, is the largest event of its kind in the nation, serving approximately 7,000 elementary school students annually. Thanks to more than 400 volunteers and the support of the Disneyland Resort, the National Water Research Institute and OCWD's Groundwater Guardian Team, the Festival celebrated its 19th anniversary in March 2015. The two-day Festival teaches children about water and the environment through hands-on educational activities. Topics include water resources, watersheds, wildlife and natural habitats, biology, chemistry and recycling at this unique event.

The Festival has a legacy of hosting educational presenters who are experts from organizations such as National Geographic, NASA/JPL, Columbia Memorial Space Center, Wyland Foundation, California Department of Water Resources, United States Environmental Protection Agency, United States Army Corps of Engineers, UCLA, and UCI. Since inception, more than 110,000 students have attended.

Figure 1-9: Group Attending the 2015 Children's Water Education Festival

O.C. Water Hero Program

The O.C. Water Hero Program was designed to make water conservation fun while helping children and parents develop effective water-use efficiency habits that will last a lifetime. When children sign up to commit to saving 20 gallons of water per day, they will enjoy videos, games, trivia, and other incentives they can access via the website and smartphone applications. The purpose of the O.C. Water Hero Program is to raise awareness of the need to conserve water and motivate county residents to reduce their water consumption by 20 gallons per day, per person. Since its inception in 2007, nearly 20,000 Water Heroes and Superheroes have enrolled in the program. In 2015, OCWD revamped the program to upgrade the technology platform in order to increase participation.

Groundwater Guardian

The District was recognized as a Groundwater Guardian member in 1996, thereafter forming the OCWD Groundwater Guardian Team. This program is designed to empower local citizens and communities to take voluntary steps toward protecting groundwater resources. The OCWD Groundwater Guardian Team primarily supports the Children's Water Education Festival.

Social Media

Social media is a unique opportunity to provide information directly to people interested in OCWD and the topics associated with the organization. Through vehicles such as Facebook, Twitter, YouTube, Instagram and others, the District posts information of immediate importance, as well as joins the conversation on trending topics. OCWD engages in social media practice several times during a given week, primarily to followers of its Facebook and Twitter accounts.

OC Water Summit

The annual OC Water Summit, shown in Figure 1-10, teaches individuals, business, and community and civic leaders where our water comes from, and provides information about the water supply crisis and water quality challenges we face. The event, held annually since 2008, educates the public on what temporary measures are in place to address these issues as well as possible solutions to water reliability and preserving the Bay-Delta River, California's main source of water. A collaborative effort between businesses, water agencies and local governments, the OC Water Summit provides a platform for individuals in the community to work with water utilities and legislators on creating and implementing solutions that will see Orange County through future water challenges. Topics for each Summit are determined according to the water climate each year. This event is hosted in conjunction with the Municipal Water District of Orange County and the Disneyland Resort.

Figure 1-10: 2014 Orange County Water Summit

The Groundwater Adventure Tour

Nearly 150 guests attend the Groundwater Adventure Tour (see Figure 1-11) that takes place each fall. The annual event highlights Orange County Water District operations that include the Groundwater Replenishment System, the Advanced Water Quality Assurance Laboratory, Recharge Operations, and Prado Wetlands. The day's activities are designed to provide an inside look at Orange County's water supply, as well as provide a better understanding of the District's groundwater recharge operations.

Tour attendees include staff from cities, offices of elected officials, water districts, universities, state and county agencies, students, chambers of commerce members, service club members, and other stakeholders. Information is presented to attendees in a variety of formats including speeches, tours, video and question and answer sessions. OCWD executive management and supporting staff share their knowledge and facilitate activities throughout the day.

Figure 1-11: 2014 Groundwater Adventure Tour

Website

The Public Affairs Department hosts the District's website, www.ocwd.com, to provide information on an array of subjects about OCWD, its board, facilities, and its programs. It includes access to important documents and forms providing transparency and public access. In 2015, the District merged the OCWD website with a separate site that was dedicated to information about the Groundwater Replenishment System, www.gwrsystem.com . The website helps to engage the citizens of north and central Orange County and water-related agencies to learn more about OCWD's operations.

Hydrospectives Newsletter

The Hydrospectives newsletter is a monthly publication with a circulation of approximately 5,700 subscribers from the water industry, government officials and agencies, OCWD staff, and the general public. It reflects the progress and decisions of the District, its achievements and influences and information pertinent to the groundwater industry in north and central Orange

County. Each month, it offers a variety of subjects that include a message from the board president, important contributions from departments and staff, global and regional news, and celebrations and accomplishments of which OCWD is a part.

Media Coverage/Exposure

OCWD, its facilities and programs have been featured in thousands of print and broadcast stories, both mainstream and trade press, locally, nationally and internationally. The District and its Groundwater Replenishment System have been featured in National Geographic magazine, Wall Street Journal and on the 60 Minutes television program. They have also been featured in several documentaries including “Tapped – The Movie;” “Ecopolis” and “How Stuff Works” for *Discovery TV*; “Urban Evolution: The Story of Pure Water” for London’s Institution of Engineering & Technology; “America’s Infrastructure Report Card- Water” (ASCE 2009); in an episode of “Off Limits” for the *Travel Channel*; and referenced in the documentary titled “Last Call at the Oasis.”

Facility Tours and Speakers Bureau

OCWD receives hundreds of requests each year to provide tours and briefings for visitors from local colleges, water agencies, the surrounding community, and international organizations. Through its active speakers bureau program, OCWD also receives requests for representatives to go out to the community and speak to numerous organizations and schools, as well as at local, national and international conferences.

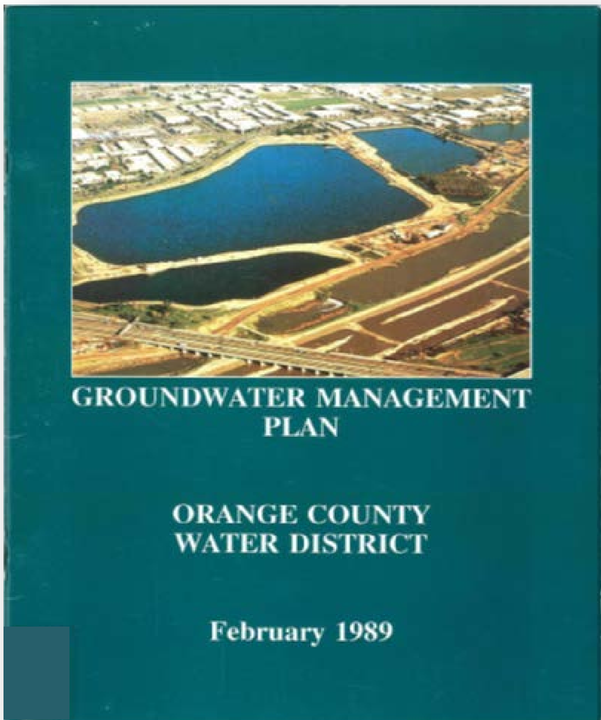
Since the GWRS came online in January 2008, more than 24,000 visitors have toured the facility. During FY 2013-14, OCWD conducted 198 public tours of the GWRS plant and the Advanced Water Quality Laboratory with a total of 3,432 participants.

OCWD is committed to proactive public outreach and education and makes every effort to accommodate requests for speakers and tours. Educating the public about advanced wastewater purification is important to garnering support for future GWRS-like projects that are being planned around the world. Knowledge about Orange County’s water supply encourages water-use efficiency efforts and educates stakeholders about the importance of protecting groundwater supplies.

Figure 1-12: OCWD Public Tour

PREPARATION OF GROUNDWATER MANAGEMENT PLAN

2



The Groundwater Management Plan is a comprehensive description of and plan for District operations. This section includes:

History of the District's Groundwater Management Plan

- First plan adopted in 1989 under authority granted by OCWD District Act
- 2015 Update will be sixth updated plan
- CA Sustainable Groundwater Management Act elements incorporated into 2015 Update

Goals established for Basin Management Objectives

- Protect and enhance groundwater quality
- Protect and increase basin sustainable yield in cost-effective manner
- Increase operational efficiency

Accomplishments 2009 to 2014

- Status of 2009 recommendations
- 19 completed projects

Recommendations for 2015 to 2020

SECTION 2 PREPARATION OF GROUNDWATER MANAGEMENT PLAN

2.1 INTRODUCTION

OCWD adopted its first *Groundwater Management Plan* (GWMP) in 1989 under authority granted by the District Act. Updates to the plan were prepared and adopted by the Board of Directors in 1990, 1994, 2004, and 2009.

The 2015 update sets forth basin management goals and objectives, describes accomplishments, explains changes in basin management, and provides information about projects completed by the District since publication of the latest update in 2009. OCWD's goals and basin management objectives were reviewed and revised as necessary reflecting the need to protect and manage the Orange County Groundwater Basin for long-term sustainability.

The District, as the groundwater basin manager, and the Producers, as the local retailers, cooperate to serve the 2.4 million residents within OCWD's boundaries. The OCWD's Board of Directors and the Producers served as the Advisory Committee for the preparation of this *Groundwater Management Plan*. The OCWD Board of Directors has the sole authority to adopt the GWMP.

Figure 2-1: Meeting of OCWD Staff with Groundwater Producers

Specific projects developed as a result of recommendations in the GWMP are separately reviewed and approved by the District's Board of Directors and processed for environmental review prior to project implementation. The GWMP describes the factors and key issues that are considered as the Board makes basin management decisions on a regular basis each year but does not commit the District to a particular program or level of groundwater production.

To encourage public participation in the development of and adoption of the GWMP update, OCWD published a notice pursuant to Section 6066 of the Government Code of the District's intention to prepare this document and invited interested individuals to participate in the preparation process. A notice was placed on OCWD's website on the main page inviting public participation.

In addition to the publicly-noticed public participation opportunities and postings on the website, the District held workshops with the Producers, shown in Figure 2-1. The Producers include cities, special districts and investor-owned utilities that produce more than 90 percent of the water pumped from the basin. The content of the GWMP was developed with input and review from the Producers by conducting workshops and seeking comments on drafts of the plan.

The California Water Code (section 10750 et seq.) describes the process for development and adoption of a groundwater management plan that includes a public participation component. As explained above, the process of adopting this plan included publicly-noticed meetings held as part of the District's regularly-scheduled board meetings and information posted on the OCWD website and the Hydrospectives newsletter. Appendix A contains copies of the public notices. Water Code Section 10753.7 and 10753.8 lists the mandatory and recommended components of a Groundwater Management Plan. A complete list of these components and their location in the OCWD's GWMP can be found in Appendix B. This plan is developed to meet the requirements of the California Water Code.

2.2 SUSTAINABLE GROUNDWATER MANAGEMENT ACT

The California Sustainable Groundwater Management Act (SB1168, AB1739, and SB1319) became law on September 16, 2014. This new law provides specific authority to establish groundwater sustainability agencies and sets forth procedures and requirements to prepare and adopt Groundwater Sustainability Plans.

The new law establishes OCWD as the exclusive local agency to manage groundwater within the District's statutory boundaries with powers to comply with the provisions of the Sustainable Groundwater Management Act (California Water Code Section 10723 (c) (1)).

California Water Code Sections 10727 (a) and 10733.6 require groundwater sustainability agencies to develop and implement groundwater sustainability plans and submit the plans to DWR for review upon adoption. Section 10733.6 also provides for the preparation of an alternative plan that includes an analysis of basin conditions demonstrating that the basin has operated within its sustainable yield over a period of at least 10 years. An alternative plan must be submitted no later than January 1, 2017.

DWR is required to adopt regulations by June 1, 2016 for evaluating groundwater sustainability plans and the implementation of plans. Regulations shall identify necessary plan components (California Water Code Sections 10727.2, 10727.4 and 10727.6). Required elements include a description of the physical setting and characteristics of the aquifer system, measurable objectives, a planning and implementation horizon, components related to management of the basin, summary of monitoring programs, monitoring protocols, and a description of how the plan may affect other plans related to water resources.

Required elements for Groundwater Sustainability Plans and additional plan elements have been incorporated into OCWD's Groundwater Management Plan. These elements are listed in Appendix B along with references to where the elements are contained in in the plan. A description of how each of the basin management objectives contributes to sustainable management of the basin can be found in Appendix C.

2.3 BASIN MANGEMENT GOALS AND OBJECTIVES

OCWD basin management goals are:

1. To protect and enhance the groundwater quality of the Orange County Groundwater Basin
2. To protect and increase the sustainable yield of the basin in a cost-effective manner
3. To increase the efficiency of OCWD operations

More specific basin management objectives set to accomplish the above mentioned goals are summarized below in Table 2-1, 2-2, and 2-3. A section reference is provided for each of the objectives with detailed explanations of how the groundwater basin is managed to achieve the objective.

Table 2-1: Basin Management Objective:

Protect and Enhance Groundwater Quality	Section Reference
Groundwater Quality	
Collect & analyze water quality samples from 400 District monitoring wells as determined by program protocols (at least annually)	4.2
Collect & analyze water quality samples from 200 drinking water wells as determined by Title 22 protocols (at least annually)	4.2
Recharge Water Supplies	
Collect & analyze water quality samples of recharge supplies (surface, recycled, imported, & ground water) according to program protocols (at least quarterly)	4.2.5 4.3
Surface Water Supplies	
Sample & analyze 2 sites on Santa Ana River in Orange County as directed by NWRI Santa Ana River Monitoring Program Expert Panel (quarterly)	4.3
Sample & analyze 12 sites in upper watershed for constituents as directed by NWRI Santa Ana River Monitoring Program Expert Panel (annually)	4.3
Contamination Prevention and Remediation	
Implement the District's Groundwater Quality Protection Policy	8.1
Evaluate & implement projects to address groundwater contamination in North Basin	8.9

Table 2-1: Basin Management Objective:

Protect and Enhance Groundwater Quality	Section Reference
& South Basin areas	
Seawater Intrusion	
Collect samples & analyze water quality from 86 wells to assess control of seawater intrusion at Talbert, Bolsa, Sunset, and Alamitos Gaps (annually)	4.2, 7
Prepare Talbert Gap area chloride concentration contour maps (every two years)	7
Operate Talbert Seawater Intrusion Barrier to (1) maintain protective groundwater elevation at well OCWD-M26 and (2) prevent landward seawater migration into the groundwater basin based on 250 mg/L chloride concentration contour	7.2
Participate in Alamitos Barrier Operations Committee to review barrier performance (at least annually)	7.3
Operate Alamitos Seawater Intrusion Barrier with Los Angeles County agencies to prevent landward seawater migration into the groundwater basin based on 250 mg/L chloride concentration contour	7.3
Increase injection or implement other measures to prevent basin degradation if significant seawater intrusion occurs	7
Wetlands & Natural Resources	
Support natural resource programs in watershed to improve water quality	9
Participate in cooperative efforts with regulators and stakeholders within watershed	4.3.3, 9
Divert 50% of Santa Ana River flow through Prado Wetlands to improve river water quality; measure flow & nitrogen removal loads (monthly)	8.5

Table 2-2: Basin Management Objective:

Protect and Increase Basin Sustainable Yield in Cost-Effective Manner	Section Reference
Collect & analyze at least 1,000 measurements of groundwater levels (at least 6 times/year)	4.2.2
Calculate change in basin storage (annually)	4.2.2
Collect production rate data from 19 large producers (monthly) & small producers (every six months)	4.2.1
Participate in state CASGEM program by reporting groundwater elevation measurements from 38 wells (annually)	4.2.4
Maintain groundwater storage within safe operating range (less than 500,000 acre-feet below full condition)	10
Set target level for total production, estimate total water demands & establish Basin Production Percentage (annually)	3.4, 10.2
Calculate total volume of water recharged (annually)	5
Report & publish, on website, total water recharged in *Water Resources Summary* (monthly)	5
Convene OCWD Recharge Enhancement Working Group (annually)	5.5.1
Evaluate potential new recharge projects using District's Recharge Facilities Model	5.5.2
Promote local infiltration of stormwater	3.3.2
Participate in cooperative efforts with regulators & stakeholders in watershed	9.2, 9.3
Collect & review ground surface elevation measurement data from Orange County Surveyor (annually)	3.6
If significant levels of subsidence occur, conduct characterization & mitigation study	3.6
Produce 90,000 afy of GWRS recycled water	6
Publish the *Engineer's Report* that includes total pumping, groundwater elevations, change in storage, & related water data (annually)	10.2

Table 2-3: Basin Management Objective:

Increase Operational Efficiency	Section Reference
Maintain Water Resources Management System database as central repository for water quality, pumping, recharge, & related water management information	4.4
Manage District's finances for long-term fiscal stability	11
Operate District programs in cost-effective & efficient manner	11
Manage natural resource programs in Santa Ana River Watershed in efficient manner	9.2
Implement efficient environmental management programs to reduce greenhouse gas emissions & use alternative energy where feasible	6.3
Use Recharge Facilities Model to evaluate cost-effectiveness of potential new recharge basins & improvements to existing facilities	5.5
Make improvements to recharge facilities to increase efficiency	5.6

The District publishes the following reports to support achievement of the above listed management goals:

- Update the *Groundwater Management Plan* every five years
- Update the *Long-Term Facilities Plan* periodically approximately every five years
- Publication of:
    - *Santa Ana River Water Quality Monitoring Report* (biannually)
    - *Engineer's Report on the Groundwater Conditions, Water Supply and Basin Utilization* (annually)
    - *Santa Ana River Watermaster Report* (annually)
    - *Groundwater Replenishment System Annual Report*
- Preparation of the *Water Resources Summary* (monthly)
- Periodic publication of *Report on Groundwater Recharge in the Orange County Groundwater Basin*

2.4 RECOMMENDATIONS AND PROJECTS COMPLETED 2009-2015

In the 2009 GWMP Update, the District adopted recommendations to continue sustainable management of the basin. Those recommendations that have been achieved are listed in Table 2-4. Recommendations yet to be completed are listed in Table 2-5. The tables indicate which of the three basin management objectives (1) protecting and enhancing water quality, (2) protecting and increasing the basin's sustainable yield, and (3) increasing the efficiency of OCWD's operations apply to each of the recommendations. Table 2-6 lists the projects completed by OCWD between 2009 and 2015.

Table 2-4: 2009 Recommendations: Completed	Water Quality	Sustainable Yield	Efficiency
Monitor groundwater elevations & water storage levels	✓	✓	
Monitor quality of groundwater & recharge water sources	✓		
Update the *Groundwater Management Plan*	✓	✓	✓
Update the *Long-Term Facilities Plan*	✓	✓	✓
Publish annually: *Santa Ana River Water Quality; Engineer's Report; Santa Ana River Watermaster Report ; GWRS Operations Annual Report*	✓	✓	✓
Publish *Report on Managed Aquifer Recharge*		✓	
Monitor water management & recycling plans in watershed	✓	✓	
Complete study on reducing sediment loads in recharge water	✓		✓
Complete GWRS Initial Expansion	✓	✓	
Increase drought preparedness by utilizing full capacity of GWRS		✓	
Develop improved tools and approaches to evaluate potential new recharge basins & proposed changes to existing operations		✓	✓
Expand removal of non-native vegetation & plant native vegetation	✓	✓	
Promote incidental recharge		✓	
Manage recharge supplies to meet/exceed MCLs & Notification Levels	✓		
Operate Prado Wetlands to reduce nitrogen loads in Santa Ana River	✓		
Publish research study on emerging constituents with MWD and NWRI	✓		

Table 2-4: 2009 Recommendations: Completed	Water Quality	Sustain-able Yield	Effic-iency
Participate in cooperative efforts with watershed stakeholders	✓	✓	
Maintain control of seawater intrusion in the Talbert Gap	✓	✓	
Open new water quality laboratory in Fountain Valley	✓		
Operate basin within safe & sustainable operating range		✓	
Set Basin Production Percentage to optimize sustainable use of groundwater			✓
Manage finances to maintain high credit ratings			✓
Maintain reserves for purchase of supplemental water supplies			✓

Table 2-5: 2009 Recommendations: On-going	Water Quality	Sustain-able Yield	Effic-ency
Complete North Basin Groundwater Protection Program	✓		
Complete South Basin Groundwater Protection Program	✓		
Address MTBE contamination	✓		
Increase allowable storage of stormwater behind Prado Dam		✓	✓
Improve performance of Alamitos Seawater Barrier; evaluate need for more injection wells; construct necessary facilities	✓	✓	

Table 2-6: Completed Projects/Accomplishments 2009-2015	Completed	Section Reference
GWRS Initial Expansion: expand capacity from 70-100 mgd	2015	8
Miraloma Basin: new basin increased recharge by approx. 30,000 afy	2012	5.6
Construction of new water quality laboratory	2009	4.5
Olive Basin Pump Station: increase infiltration by 1,600-4,800 afy	2010	5.6
Burris & Lincoln Basins Reconfiguration: remove impermeable material to increase infiltration rates	2010	5.6
Santiago Basin Pump Station: remove water stored below outlet structure; increase of recharge capacity by 5,000 afy	2012	5.6
Alamitos Barrier Flow and Transport Models to improve evaluation of seawater intrusion	2014	3.7.5, 7.3
Recharge Facilities Model: evaluate existing & proposed operations to increase operational efficiency	2009	5.2.2
Santa Ana River Armoring Study of river sediments to evaluate alternatives for improved infiltration	2010	5.5
Recharge Water Sediment Removal Feasibility Study: pilot-study of filter systems to improve percolation rates	2010	5.6
Arundo Removal and Native Plantings: remove 5,000 acres of invasive plants; increase annual water yield of 3.75 cfs/acre removed	2014	9.2.2
Least Bell's Vireo Habitat Management: increase populations in watershed	2014	9.2.1
Nesting Box Installation: 500 boxes in Prado Basin & Forebay to attract birds that eat insect pests to reduce pesticide use	2014	9.2
Regulatory approval to inject 100% recycled water at Talbert Barrier	2009	7.2
Adoption of a BPP Policy to assure long-term basin sustainability	2013	10.4.2
GWRS Plant Operational Optimization	2013	6.3
NWRI/MET/OCWD Study of constituents of emerging concern	2010	8.8
Completed testing for unregulated chemicals under the EPA UCMRI-List 1 program	2010	4.2.3

2.5 RECOMMENDATIONS FOR 2015-2020

OCWD plans for the next five years include accomplishment of the recommendations listed in Table 2-7.

Table 2-7: Recommendations for 2015-2020

PROJECT	BENEFIT TO BASIN
GWRS Final Expansion to 130 MGD	Increase recharge water supply from 100,000 to134,000 afy
Mid-Basin Injection	Increase basin recharge in area of concentrated groundwater pumping
Subsurface Recharge & Collection System	Increase recharge
Prado Basin Sediment Management Demonstration Project	Remove sediment behind dam to increase storage capacity
North Basin Groundwater Protection Program	Remediate VOC contamination
South Basin Groundwater Protection Program	Remediate VOC contamination
MTBE Investigation and Remediation	Remediate MTBE contamination
Fletcher Basin	New recharge basin
West Orange County Enhanced Pumping	Reduce groundwater flow from Orange County into Los Angeles County
La Palma Basin	New recharge basin
Prado Basin Enhanced Water Conservation	Increase allowable storage of stormwater behind Prado Dam
Increase recharge in Santiago Creek below Hart Park	Increase recharge capacity
Alamitos Barrier Improvements	Protect water quality by increasing seawater intrusion facilities
Alamitos Barrier Expansion (Landing Hill)	Expand seawater intrusion facilities
Sunset Gap Barrier/Desalter	Improve water quality by capturing and treating brackish groundwater

Table 2-7: Recommendations for 2015-2020

PROJECT	BENEFIT TO BASIN
Huntington Beach Ocean Desalination Plant	Increase water supply by up to 56,000 afy
Enhanced Recharge in SAR Below Ball Road	Increase capacity to capture and infiltrate stormwater

2.6 PLANNING AND IMPLEMENTATION HORIZONS

District management and operations incorporate a variety of planning and implementation horizons as explained below.

The *Long-Term Facilities Plan* is updated approximately every five years to evaluate a large number of potential future projects. The planning horizon for consideration of new facilities is five years. The implementation horizon for projects varies from two to 10 years, depending on size and complexity of the individual project. The 2014 plan, for example, evaluated 64 potential projects ranging from those to increase water supply, institute changes in basin management, modify recharge facilities, and increase operational efficiency. Each proposed project is considered for future study based on cost-effectiveness, amount of new water supply provided, regulatory and institutional feasibility, and other factors. The cost-effectiveness of each project that provides additional groundwater recharge is evaluated in relationship to the current and projected cost of imported water. In this sense, the cost of imported water provides a benchmark for determination of project cost effectiveness.

The District's *Groundwater Management Plan* is updated approximately every five years. This plan provides an overview of all district operations, documents accomplishments and projects built since the last updated plan was published, and establishes basin management objectives.

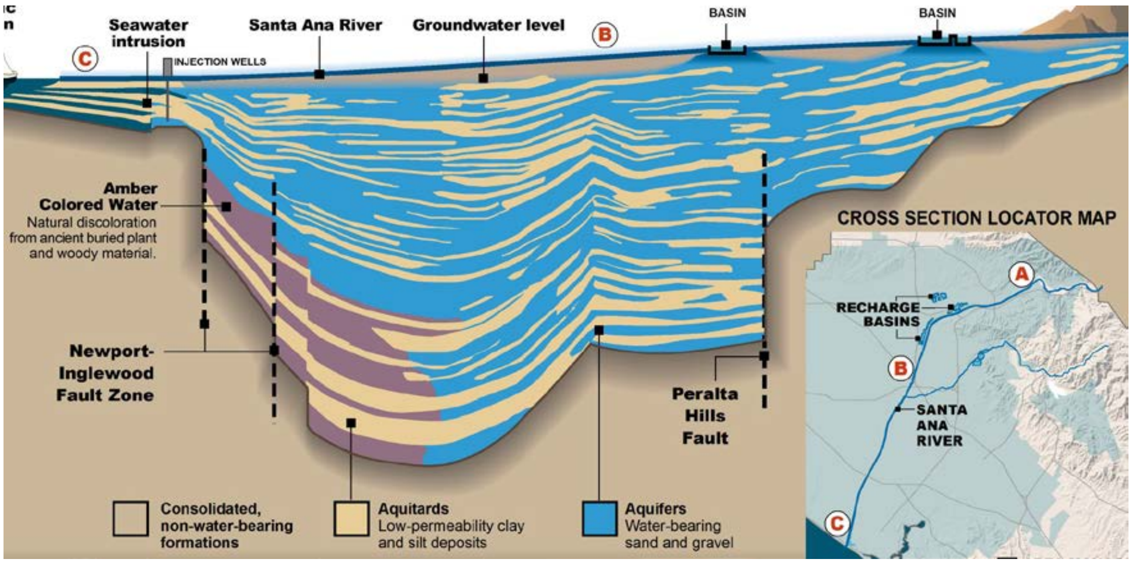
OCWD uses a variety of models and studies to assist in long-term planning. The Recharge Facilities Model, described in Section 5.5, provides the ability to simulate different water inflow scenarios, different Prado Dam conservation pool elevations and release rates, changes in basin recharge capacities, and amount of imported water recharged to evaluate the effectiveness of proposed recharge projects.

In 2014, the District completed a study projecting future Santa Ana River flows. The planning horizon for this study is approximately 50 years. This work, explained in section 5.5.3, was done primarily to support work with the U.S. Army Corps of Engineers in studying the feasibility of increasing the volume of water that can be temporarily impounded behind Prado Dam.

The planning and implementation horizon for water demand projections is dependent upon the publication of Urban Water Management Plans for cities within the boundaries of OCWD, which currently have projected demands to 2035.

BASIN HYDROGEOLOGY

3



This section describes the hydrogeology of the Orange County Groundwater Basin, also refered to as Basin 8-1.

<u>Hydrogeology</u>

- Basin covers approximately 350 square miles in north and central Orange County
- Basin divided into Forebay and Pressure Areas
- OCWD determined total basin volume
- Water budget incorporates basin inflows and outflows

<u>Groundwater in Storage</u>

- Estimated annually, based on 2007 comprehensive study
- Land subsidence potential monitored

<u>Groundwater Basin Model</u>

- Model encompasses entire basin; updated every 3-5 years
- Talbert Gap model used to assess seawater intrusion
- Alamitos Barrier model constructed in 1965; latest update in 2010

SECTION 3 BASIN HYDROGEOLOGY

3.1 DESCRIPTION OF BASIN HYDROGEOLOGY

The Orange County Groundwater Basin is located in the area designated by the California Department of Water Resources (DWR) as Basin 8-1, the "Coastal Plain of Orange County Groundwater Basin" in Bulletin 118 (DWR, 2003). Figure 3-1 displays the OCWD boundary in relation to the boundary of Basin 8-1.

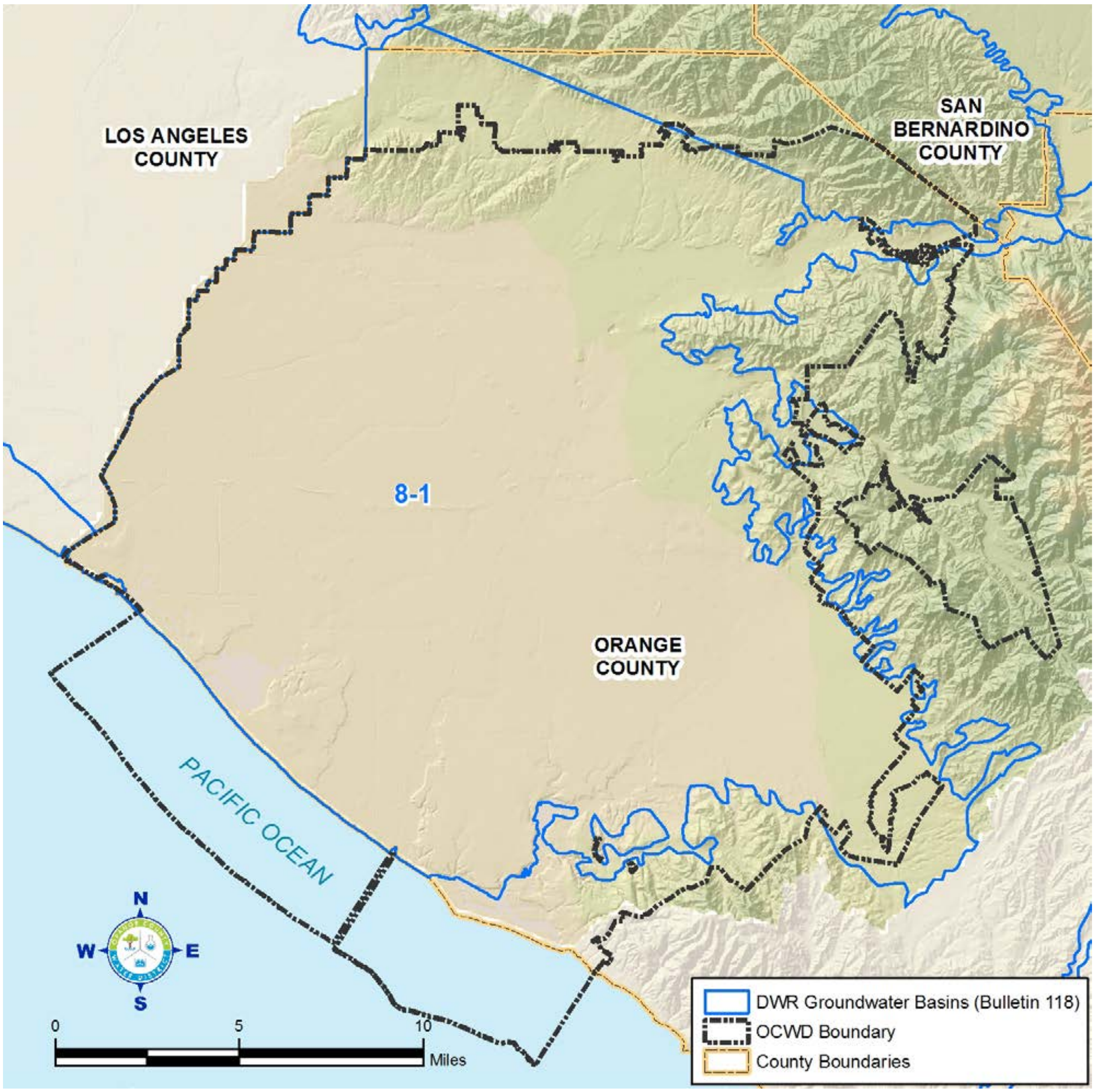


Figure 3-1: Coastal Plain of Orange County Groundwater Basin, Basin 8-1

The basin underlies north and central Orange County beneath broad lowlands known as the Tustin and Downey plains. The basin covers an area of approximately 350 square miles, bordered by the Coyote and Chino Hills to the north, the Santa Ana Mountains to the northeast, and the Pacific Ocean to the southwest. The basin boundary extends to the Orange County-Los Angeles line to the northwest, where groundwater flow is unrestricted across the county line into the Central Basin of Los Angeles County. The Newport-Inglewood fault zone forms the southwestern boundary of all but the Shallow Aquifer in the basin.

The groundwater basin formed in a synclinal, northwest-trending trough that deepens as it continues beyond the Orange-Los Angeles county line. The Newport-Inglewood fault zone, San Joaquin Hills, Coyote Hills, and Santa Ana Mountains form the uplifted margins of the syncline. The total thickness of sedimentary rocks in the basin surpasses 20,000 feet, of which only the upper 2,000 to 4,000 feet contain fresh water. In the southeastern area underlying the city of Irvine and along the basin margins, the thickness of fresh water-bearing sediments is less than 1,000 feet (Herndon and Bonsangue, 2006).

Structural folding and faulting along the basin margins, together with down warping and deposition within the basin, have occurred since Oligocene time. The Newport-Inglewood fault zone, comprising the most significant structural feature in the basin from a hydrogeologic standpoint, consists of a series of faulted blocks which are generally up thrown on the southwest side. Folding and faulting along the Newport-Inglewood fault zone have created a natural restriction to seawater intrusion into the groundwater basin (Herndon and Bonsangue, 2006).

Pleistocene or younger aquifers within the basin form a complex series of interconnected sand and gravel deposits. In coastal and central portions of the basin, these deposits are extensively separated by lower-permeability clay and silt deposits or aquitards. In the inland areas, the clay and silt deposits become thinner and more discontinuous, allowing larger quantities of groundwater to flow more easily between shallow and deeper aquifers (California Department of Water Resources, 1967). Figure 3-2 presents a geologic cross section through the basin along the Santa Ana River.

OCWD subdivided the groundwater basin into three major aquifer systems, based on geological data and vertical potentiometric head differences measured regionally at over 50 multi-depth monitoring wells, shown in Figure 3-8. The three aquifer systems, known as the Shallow, Principal, and Deep, are hydraulically connected, as groundwater is able to flow between them via leakage through the intervening aquitards or discontinuities in the aquitards.

The Shallow Aquifer system overlies the entire basin and includes the prolific Talbert Aquifer. It generally occurs from the surface to approximately 250 feet below ground surface. The majority of groundwater from the shallow aquifer is pumped by small water systems for industrial and agricultural use, although the cities of Garden Grove and Newport Beach, and the Yorba Linda Water District, operate wells that pump from the shallow aquifer for municipal use.

Over 90 percent of groundwater production occurs from wells that are screened within the Principal Aquifer system at depths between 200 and 1,300 feet. A minor amount of groundwater is pumped from the Deep Aquifer, which underlies the Principal Aquifer system and is up to 2,000 feet deep in the center of the basin. Hindering production from the Deep Aquifer system is the depth and the presence of amber colored groundwater in some areas. The treatment and use of amber colored groundwater is discussed in Section 8.6.

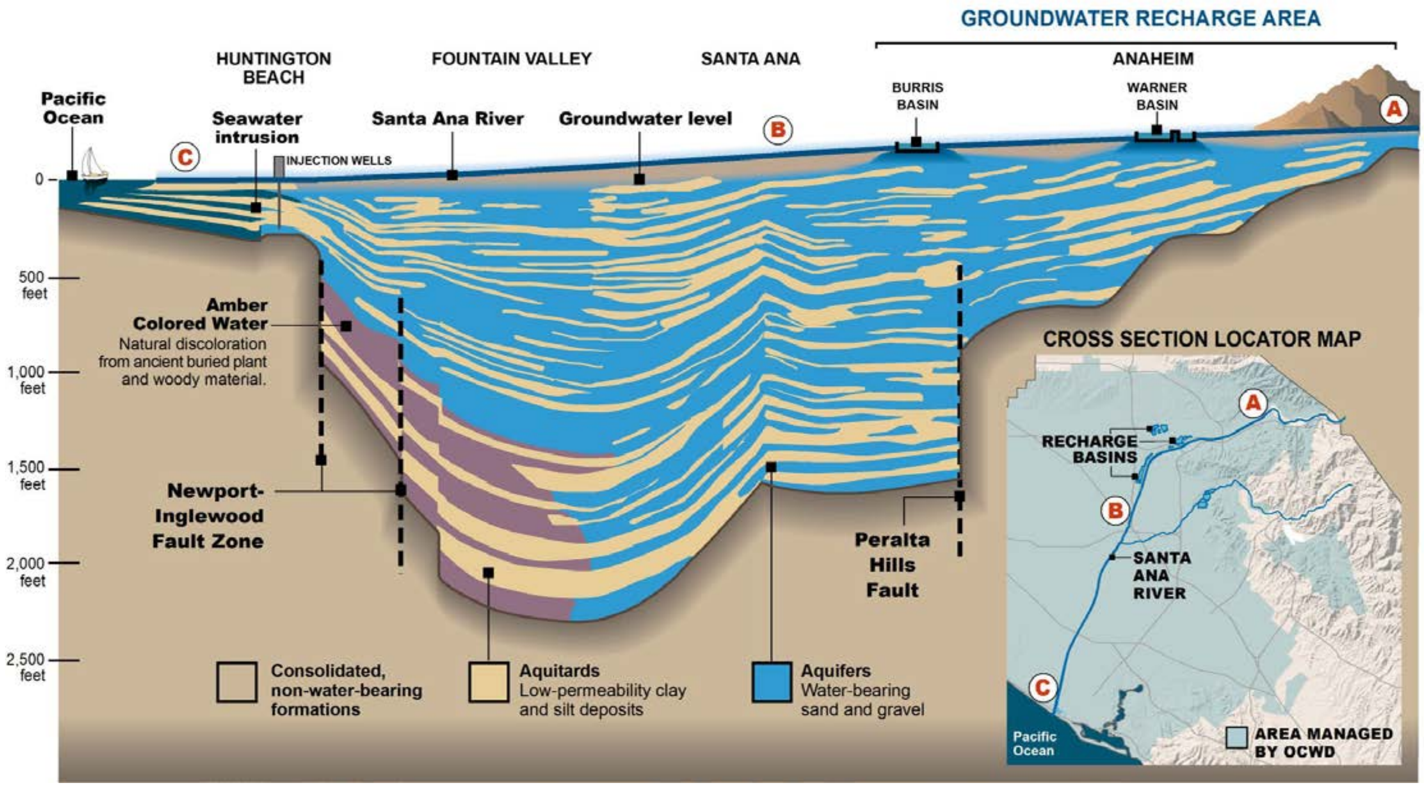


Figure 3-2: Geologic Cross-Section, Orange County Groundwater Basin

3.1.1 Forebay and Pressure Areas

The Department of Water Resources (DWR, 1934) divided the basin into two primary hydrologic divisions, the Forebay and Pressure areas, as shown in Figure 3-3. The Forebay/Pressure area boundary generally delineates the areas where surface water or shallow groundwater can or cannot move downward to the first producible aquifer in quantities significant from a water supply perspective. From a water quality perspective, the amount of vertical flow to deeper aquifers from surface water or shallow groundwater may be significant in terms of impacts of past agricultural or industrial land uses (e.g., fertilizer application and leaky underground storage tanks).

The Forebay refers to the area of intake or recharge where most of the groundwater recharge occurs. Highly-permeable sands and gravels with few and discontinuous clay and silt deposits allow direct percolation of Santa Ana River and other surface water. The Forebay area encompasses most of the cities of Anaheim, Fullerton, and Villa Park and portions of the cities of Orange and Yorba Linda.

The Pressure Area is generally defined as the area of the basin where large quantities of surface water and near-surface groundwater is impeded from percolating into the major producible aquifers by clay and silt layers at shallow depths (upper 50 feet). The Principal and Deep Aquifers in this area are under “confined” conditions (under hydrostatic pressure); the water levels of wells penetrating these aquifers exhibit large seasonal variations. Most of the central and coastal portions of the basin fall within the Pressure Area.

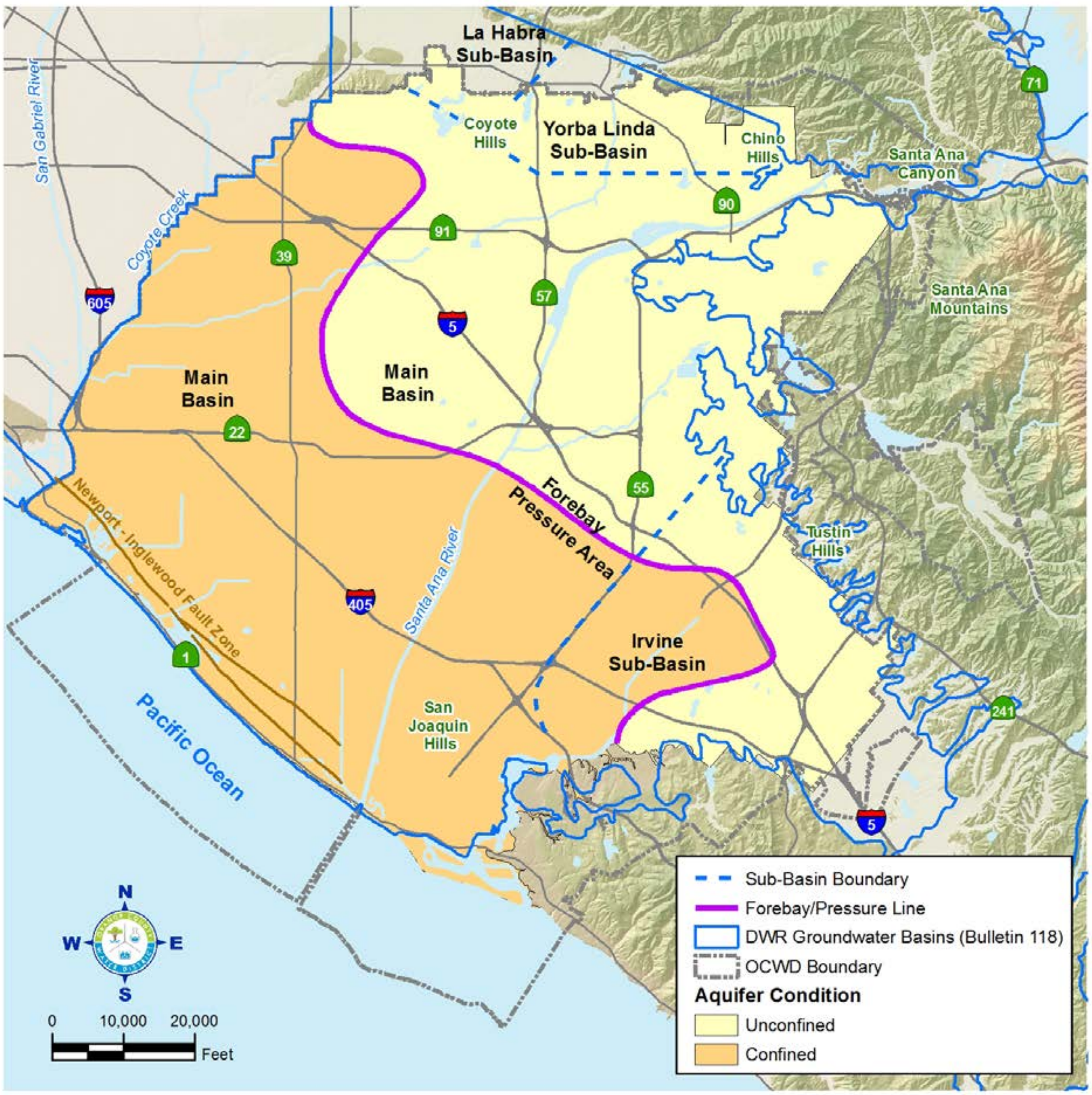


Figure 3-3: Orange County Groundwater Basin

3.1.2 Groundwater Subbasins, Mesas, and Gaps

The Orange County Groundwater Basin, as defined by DWR Bulletin 118 Basin 8-1, can be subdivided into subbasins and the coastal region can be distinguished by higher and lower elevation areas, as described in this section and shown in Figure 3-3.

Main Basin

The Main Basin is the largest sub-basin where the majority of groundwater production occurs.

Mesas and Gaps

Four relatively flat elevated areas, known as mesas, occur along the coastal boundary of the basin. The mesas were formed by ground surface uplift along the Newport Inglewood Fault Zone. Ancient meandering of the Santa Ana River carved notches through the uplifted area and left behind sand- and gravel-filled deposits beneath the lowland areas between the mesas, known as gaps (Poland et al., 1956). Groundwater in the shallow aquifers within the gaps is susceptible to seawater intrusion. The Talbert and Alamitos seawater intrusion barriers were constructed to address this problem. Locations of mesas and details of seawater barrier operations are shown in Figure 7-1.

Irvine Subbasin

The Irvine subbasin, bounded by the Santa Ana Mountains and the San Joaquin Hills, forms the southern-most portion of the basin. The Costa Mesa Freeway (State Route 55) and Newport Boulevard form the subbasin's approximate western boundary with the Main Basin. Here, the aquifers are thinner and contain more clay and silt deposits than aquifers in the main portion of the basin.

The aquifer base in the Irvine sub-basin ranges from approximately 1,000 feet deep beneath the former Marine Corps Air Station (MCAS) Tustin to less than 200 feet deep at the eastern boundary of the former MCAS El Toro. East of former MCAS El Toro, the aquifer further thins and transitions into lower-permeability sandstones and other semi-consolidated sediments, which have minor water storage and transmission capacity.

Groundwater historically flowed out of the Irvine subbasin westerly into the Main Basin since the amount of natural recharge in the area, predominantly from the Santa Ana Mountains, was typically greater than the amount of pumping (Singer, 1973; Banks, 1984). With the operation of the Irvine Desalter Project commencing in 2007, it is possible that groundwater production in the Irvine subbasin may exceed the natural replenishment from the adjacent hills and mountains, in which case groundwater would be drawn into the Irvine subbasin from the Main Basin.

Yorba Linda Subbasin

The Yorba Linda subbasin is located north of the Forebay recharge area in Anaheim, within the cities of Yorba Linda and Placentia. Due to low transmissivity and high total dissolved solids (TDS) concentrations (Mills, 1987) there is little groundwater pumped from this subbasin. Groundwater from the Yorba Linda subbasin flows southward into the Main Basin since the limited groundwater production is less than the natural replenishment from the adjacent Chino Hills.

La Habra Subbasin

The La Habra subbasin is located north of the Main Basin within the cities of La Habra and Brea. It comprises a shallow alluvial depression between the Coyote Hills and the Puente Hills. Prior to the 1950s, hundreds of wells produced water for domestic use and irrigation. The majority of these wells were abandoned due to high concentrations of nitrate, total dissolved solids, and metals and taste and odor problems. However, in recent years, the City of La Habra has explored options to increase groundwater production from this subbasin.

Hydrogeologic studies have indicated that 2,200 to 5,500 afy of groundwater flows out of the La Habra Basin in two areas: (1) southerly into the Main Basin along the Brea Creek drainage between the East and West Coyote Hills and (2) westerly into the Central Basin in Los Angeles County (James M. Montgomery, 1977; Ramsey, 1980; OCWD, 1994). The areas that lie outside the District boundaries in the northern portion of Basin 8-1, as defined in DWR Bulletin 118, are located in the La Habra subbasin.

3.1.3 Coastal Plain of Orange County: Areas outside OCWD Boundaries

The District boundaries do not encompass the entire area of Basin 8-1 as defined by DWR as shown in Figure 3-4. Areas that are outside of OCWD's boundary are shown in red highlight. These areas include (1) a northern portion of DWR Basin 8-1 located in the La Habra subbasin, a portion of which is in Los Angeles County, (2) areas along the mountain fronts at the eastern side of the basin and in the southern portion of Basin 8-1 within the Irvine subbasin, and (3) a portion of Basin 8-1 immediately downstream of Prado Dam located in Riverside and San Bernardino counties. None of the areas that are included in Basin 8-1 outside of OCWD boundaries are within the boundaries of other sustainability agencies and have not as yet been incorporated into a groundwater management plan or a groundwater sustainability plan. OCWD is coordinating with the City of La Habra, the County of Orange, Irvine Ranch Water District, and other stakeholders regarding management of these areas outside the OCWD boundary.

3.2 DETERMINATION OF TOTAL BASIN VOLUME

A vast amount of fresh water is stored within the basin, although only a fraction of this water can be removed practically using pumping wells and without causing physical damage such as seawater intrusion or the potential for land subsidence (Alley, 2006). Nonetheless, it is important to note the total volume of groundwater that is within the active flow system, i.e., within the influence of pumping and recharge operations.

OCWD used its geographic information system and the aquifer system boundaries described in Section 3.8 to calculate the total volume of each of the three major aquifer systems as well as the intervening aquitards. The total volume was calculated by multiplying the area and thickness of each hydrogeologic unit. Because groundwater fills the pore spaces that represent typically between 20 and 30 percent of the total volume, the total volume was multiplied by this porosity percentage to arrive at a total groundwater volume. Assuming the basin is completely full, based on District estimates, the total amount of fresh groundwater stored in the basin is approximately 66 million acre-feet, as shown in Table 3-1.

For comparison, DWR (1967) estimated that about 38 million acre-feet of fresh water is stored in the groundwater basin when full. DWR used a factor known as the specific yield to calculate this volume. The specific yield (typically between 10 and 20 percent) is the amount of water that can be drained by gravity from a certain volume of aquifer and reflects the soil's ability to retain and hold a significant volume of water due to capillary effects. Thus, DWR's *drainable* groundwater volume can be considered consistent with OCWD's estimate of *total* groundwater volume in the basin.

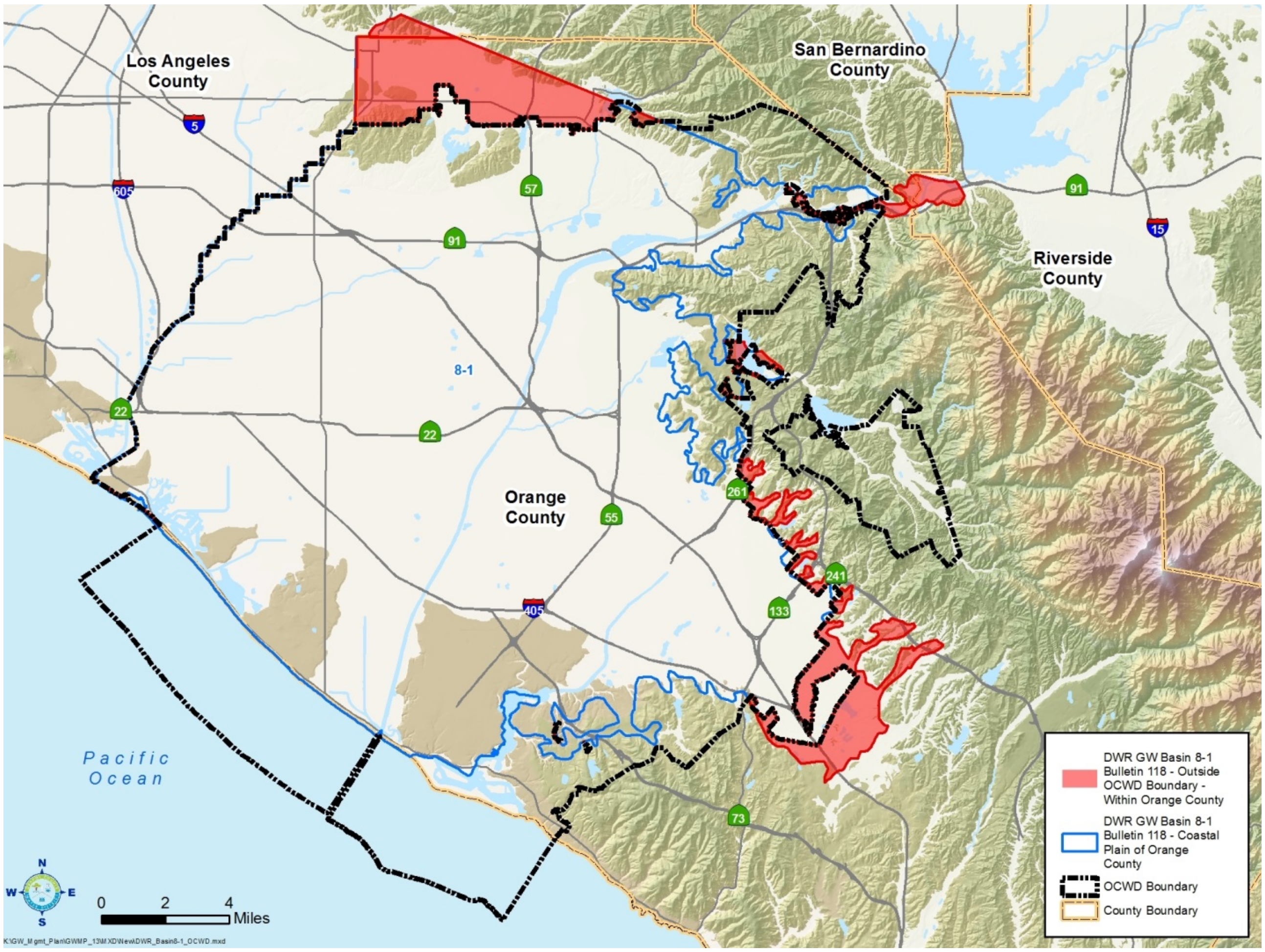


Figure 3-4: Basin 8-1 and OCWD Boundaries

Table 3-1: Estimated Basin Groundwater Storage by Hydrogeologic Unit
(Volumes in Acre-feet)

HYDROGEOLOGIC UNIT	PRESSURE AREA	FOREBAY	TOTAL
Shallow Aquifer System	3,800,000	1,200,000	5,000,000
Aquitard	900,000	200,000	1,100,000
Principal Aquifer System	24,300,000	8,600,000	32,900,000
Aquitard	1,600,000	300,000	1,900,000
Deep Aquifer System	18,800,000	6,300,000	25,100,000
TOTAL	49,400,000	16,600,000	66,000,000

Notes: (1) Volumes calculated using the 3-layer basin model surfaces with ArcInfo Workstation GRID. (2) A porosity of 0.25 was assumed for aquifer systems. (3) A porosity of 0.30 was assumed for aquitards.

3.3 WATER BUDGET

OCWD developed a hydrologic budget (inflows and outflows) for the purpose of constructing the 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 a period of several years, the basin must be maintained in an approximate balance as explained in Section 10.

Table 3-2 presents the components of an example balanced basin water budget (no annual change in storage). Note that it does not represent data for any particular year. The annual budget presented is based on the following assumptions: (1) average precipitation, (2) basin storage at 400,000 acre-feet below full, (3) recharge of 274,500 acre-feet in District facilities including surface spreading basins and seawater intrusion barrier wells, and (4) adjusted groundwater production so that total basin inflows and outflows are equal. The sources of recharge water used by the District include Santa Ana River base flow and storm flow, imported water, and GWRS recycled water. The major components of the water budget are described in the following sections.

3.3.1 Measured Recharge

Measured recharge consists of all water artificially recharged at OCWD's surface water recharge facilities and water injected in the Talbert and Alamitos Barriers. The majority of measured recharge occurs in the District's surface water system, which receives Santa Ana River base flow and storm flow, imported water and GWRS recycled water. The importance of these sources has changed over time, as shown in Figure 5-8. In recent years, GWRS and imported water have become more important as the volume of Santa Ana River base flow declines.

OCWD's Talbert Barrier is a series of injection wells that span the 2.5-mile wide Talbert Gap, between the Newport and Huntington Beach mesas. Purified water produced by the GWRS is injected into multiple aquifers; over 95 percent of the injected water flows inland and becomes part of the basin's groundwater supply.

The Alamitos Barrier is a series of wells injecting a blend of imported and recycled water into multiple aquifer zones that span the Alamitos Gap at the Los Angeles/Orange County line. Essentially all of the injected water flows inland, replenishing groundwater basins in the two counties. Inspection of groundwater contour maps indicates that roughly one-third of the Alamitos Barrier injection water remains within or flows into Orange County.

Table 3-2: Example Annual Basin Water Budget

FLOW COMPONENT	Acre-feet per Year
INFLOW	
Measured Recharge	
1. Surface recharge facilities[1]	243,000
2. Talbert Barrier injection	30,000
3. Alamitos Barrier injection, Orange County portion only	2,000
Subtotal:	**275,000**
Estimated Unmeasured or Incidental Recharge[2]	
1. Subsurface Inflow	47,000
2. Areal recharge from rainfall/irrigation	19,000
Subtotal:	**66,000**
TOTAL INFLOW:	341,000
OUTFLOW	
1. Groundwater Production	335,000
2. Subsurface Outflow	6,000
TOTAL OUTFLOW:	341,000
CHANGE IN STORAGE:	0

[1] Evaporation from surface recharge facilities is estimated to be 2,000 afy.
[2] Assuming average precipitation (14 inches/year)

3.3.2 Unmeasured Recharge

Unmeasured recharge also referred to as “incidental recharge” accounts for a significant amount of the basin’s sustainable yield. 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 in 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 3-5.

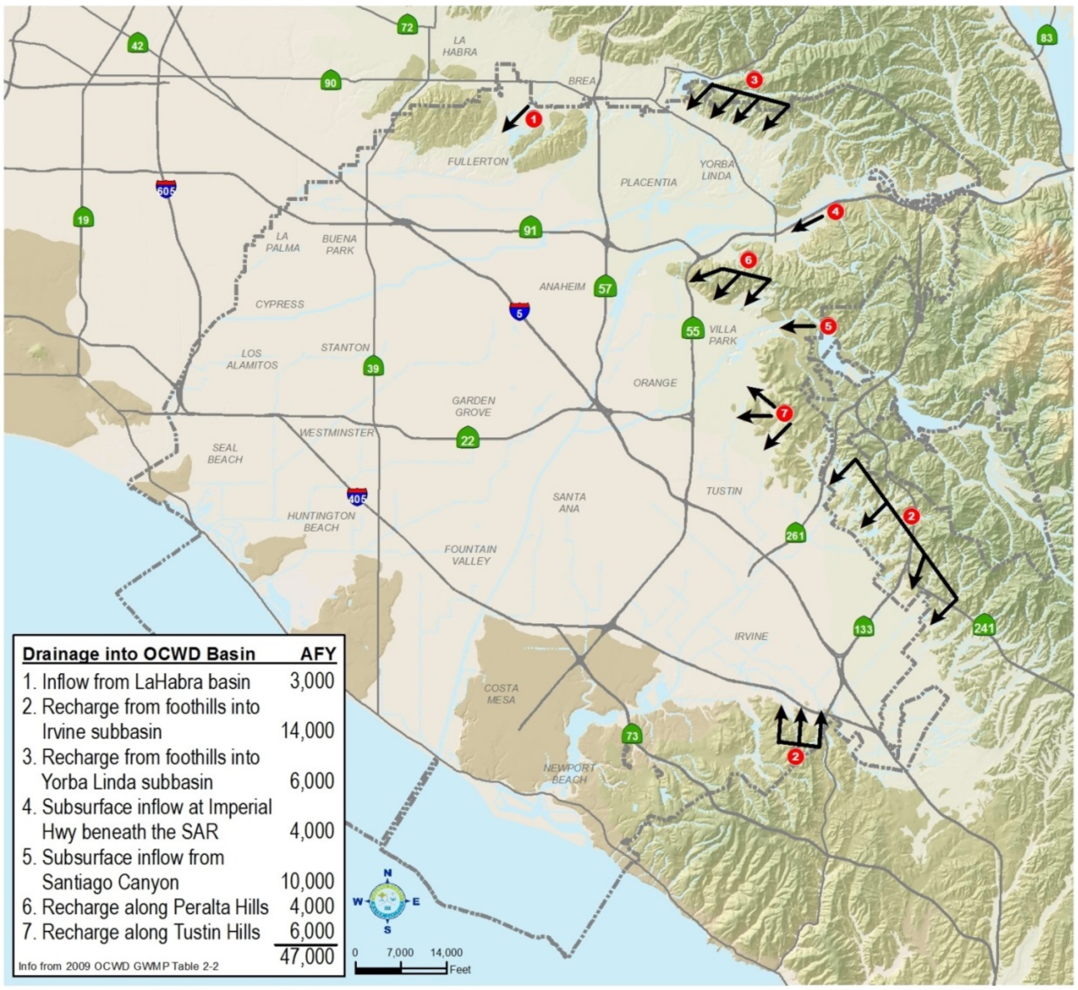


Figure 3-5: Estimated Subsurface Recharge

Total unmeasured recharge ranges between 20,000 to 160,000 afy. This number is the volume left over after all the basin inputs and outputs are accounted for. Net unmeasured or incidental recharge is the amount of incidental recharge remaining in the basin after accounting for losses to Los Angeles County. 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 afy reported by Hardt and Cordes (1971) as part of a U.S. Geological Survey (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 probably 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 over- or underestimating the total recharge volume within this error margin is considered to be minor.

3.3.3 Groundwater Production

Active wells pumping water from the basin are shown in Figure 3-6. The approximately 200 large-system wells account for an estimated 97 percent of the total basin production; 200 small production wells produce less than 25 afy. Large-capacity wells are all metered, as required by the District Act. Production data was recorded on a semi-annual basin until 1988 when the District began obtaining monthly individual well production measurements.

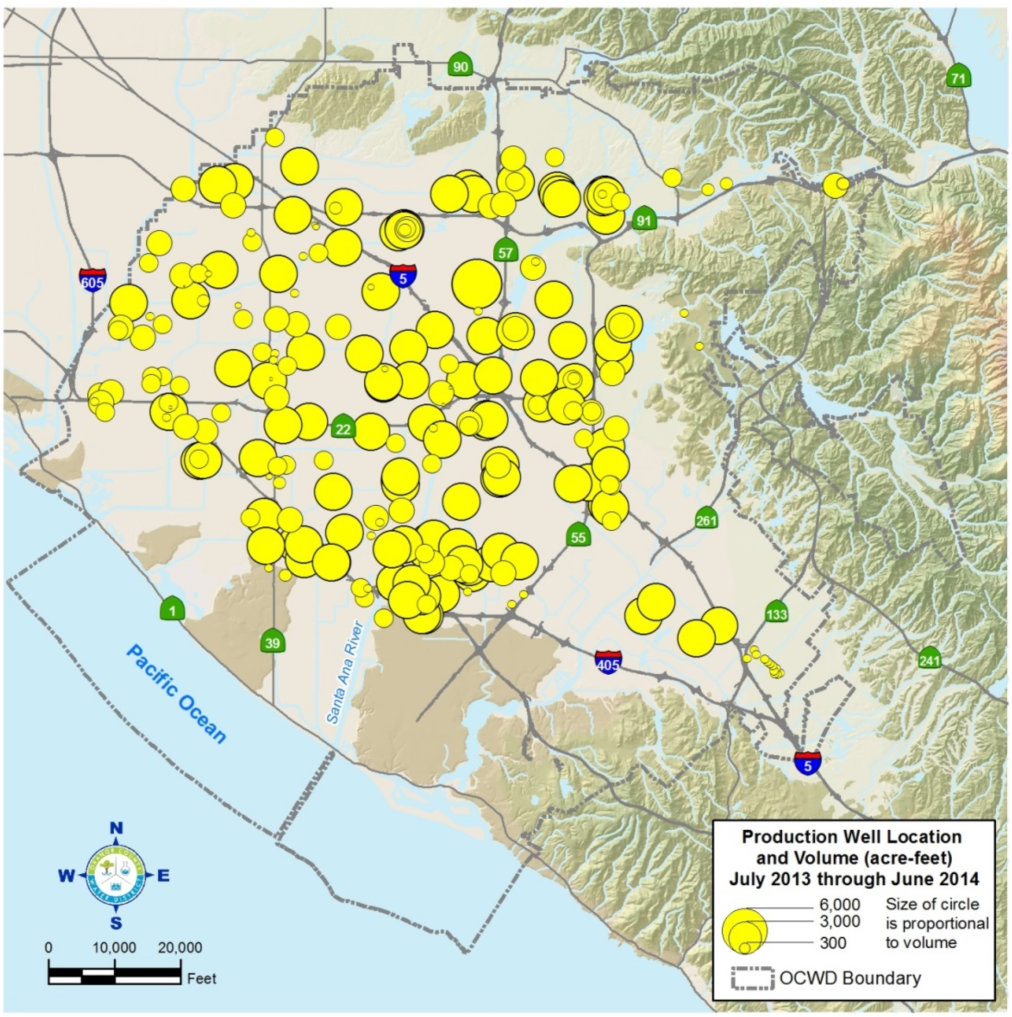


Figure 3-6: Distribution of Groundwater Production, Water Year 2013-14

3.3.4 Subsurface Outflow

Groundwater outflow from the basin across the Los Angeles/Orange County line has been estimated to range from approximately 1,000 to 14,000 afy based on groundwater elevation gradients and aquifer transmissivity (DWR, 1967; McGillicuddy, 1989). The Water Replenishment District of Southern California also has estimated underflow from Orange County to Los Angeles County within the aforementioned range.

Modeling by OCWD indicates that assuming that groundwater elevations in Los Angeles County remain constant underflow to Los Angeles County increases by approximately 7,500 afy for every 100,000 acre-feet of increased groundwater in storage in Orange County (see Figure 3-7). 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.

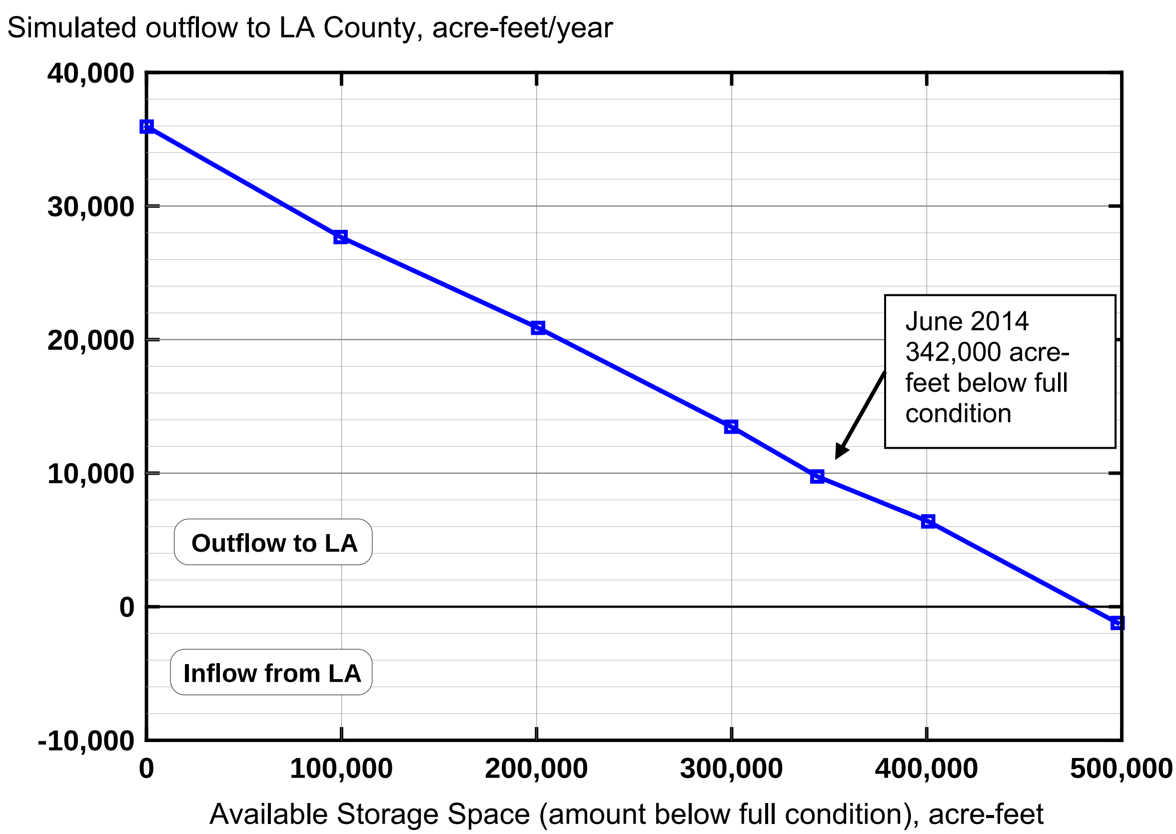


Figure 3-7: Relationship between OCWD Basin Storage and Estimated Outflow to Los Angeles County

3.3.5 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 high percolation rates (1 to 10 feet per day).

3.4 CALCULATION OF CHANGE IN GROUNDWATER STORAGE

Even though the groundwater basin contains an estimated 66 million acre-feet when full, OCWD operates the basin from a full condition to approximately 500,000 acre-feet below full to protect against irreversible seawater intrusion and land subsidence. On a short-term basis, the basin can be operated at an even lower storage level in an emergency.

The District manages storage and water levels in the groundwater basin within a safe operating range as described in Section 10. The safe operating range is defined as the upper and lower levels of groundwater storage in the basin that can be reached without causing negative or adverse impacts. In order to manage the basin within this safe operating range, OCWD calculates the amount of groundwater in storage on an annual basis.

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 safe operating range reaching a full condition in 1969, and 1983. Even though the District calculates and reports accumulated overdraft in its annual Engineers Report, “overdraft” in the traditional sense does not exist in the Orange County Groundwater Basin because the basin is operated to continuously fluctuate within the safe operating range.

The District 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 until trued up at the end of the year with the final reports of inflows and outflows. This method produces a monthly estimate of the change in groundwater storage and allows for virtually 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. The three-layer method involves creating groundwater elevation contour maps for each of the three aquifer layers (Shallow, Principal, and Deep Aquifers) in the basin, schematically represented in Figure 3-8, for conditions at the end of June of each year.

The need for this method was driven by the record-setting wet year of 2004-05, in which water levels throughout the basin approached a near-full condition. An analysis of the amount of groundwater in storage compared to the estimate using a one-layer change in storage method showed a discrepancy of 150,000 acre-feet. The discrepancy of 150,000 acre-feet in two different calculations indicated that the current condition could not be properly rectified back to the prior 1969 benchmark. This brought to light three important discoveries:

- The one-layer storage change calculation contained considerable uncertainty that when cumulatively added over tens of years led to a large discrepancy in the level of water in storage relative to 1969.
- Water level conditions in 1969 no longer represented a full basin, particularly because of change in pumping and recharge conditions.
- A more accurate storage change calculation should be based on water level changes and storage coefficients for each of the three major aquifer systems.

In February 2007, the District adopted an updated approach to defining the full basin condition and calculating storage changes. This updated approach includes:

- A new full-basin groundwater level based on the following prescribed conditions:
  - o Observed historical high water levels
  - o Present-day pumping and recharge conditions
  - o Protection from seawater intrusion
  - o Minimal potential for mounding at or near recharge basins
- Calculation of the amount of groundwater in storage in each of the three major aquifer systems.

A more detailed description of the three-layer methodology is presented in OCWD's *Report on Evaluation of Orange County Groundwater Basin Storage and Operational Strategy* (February 2007) and can be found in Appendix D.

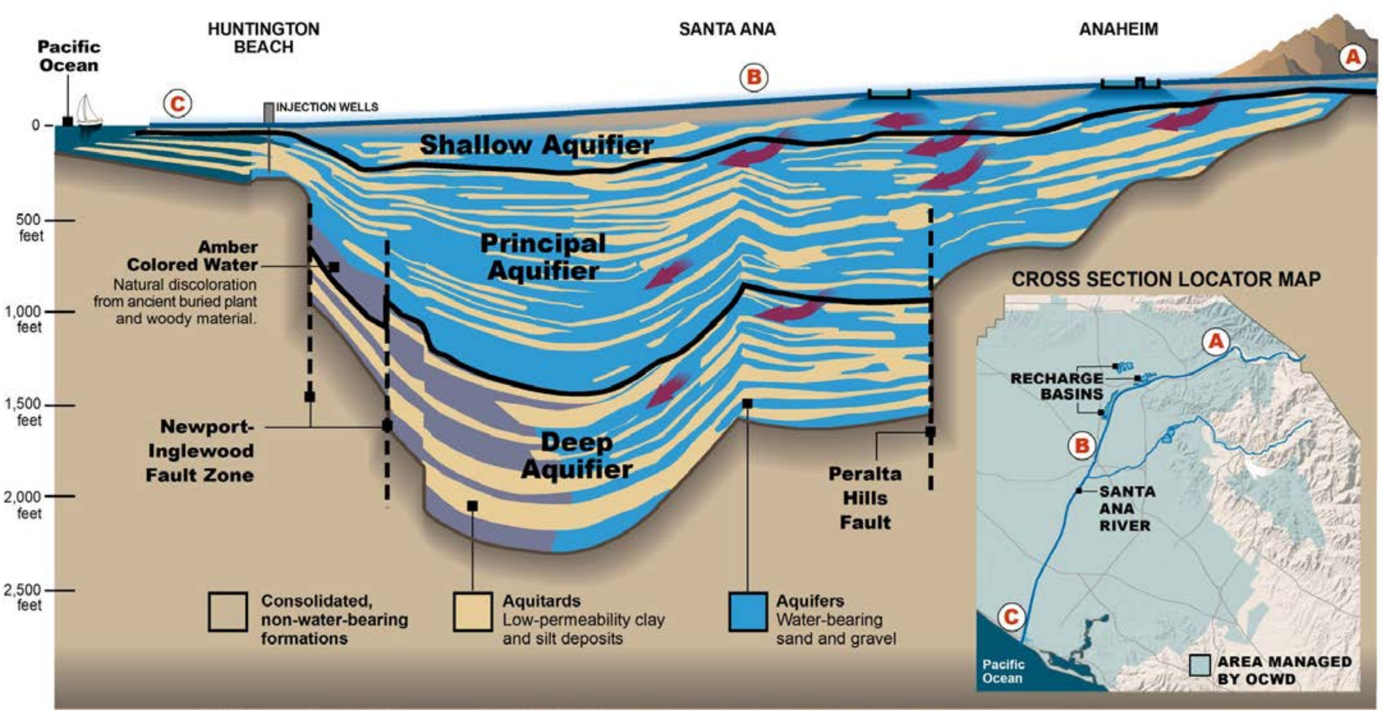


Figure 3-8: Schematic Cross-Section of the Basin Showing Three Aquifer Layers

Figure 3-9 shows the contoured water levels for the Principal Aquifer in June 2014. The maps are prepared annually and scanned and digitized into the District's GIS database. The previous year's water levels are subtracted from the current water levels to calculate change in water levels. Water level change contour maps are prepared for each of the three aquifer layers. Figure 3-10 shows the water level change for the Principal Aquifer from June 2013 to June 2014. For each of the three aquifers, the GIS is used to multiply the water level changes by a grid of aquifer storage coefficients from OCWD's calibrated groundwater flow model. This results in a storage change volume for each of the three aquifers which are totaled to provide a net annual storage change for the basin, shown in Figure 3-11. In cases where there is a calculation discrepancy between the storage changes estimated by the two methods, the unmeasured recharge value is adjusted to eliminate the difference.

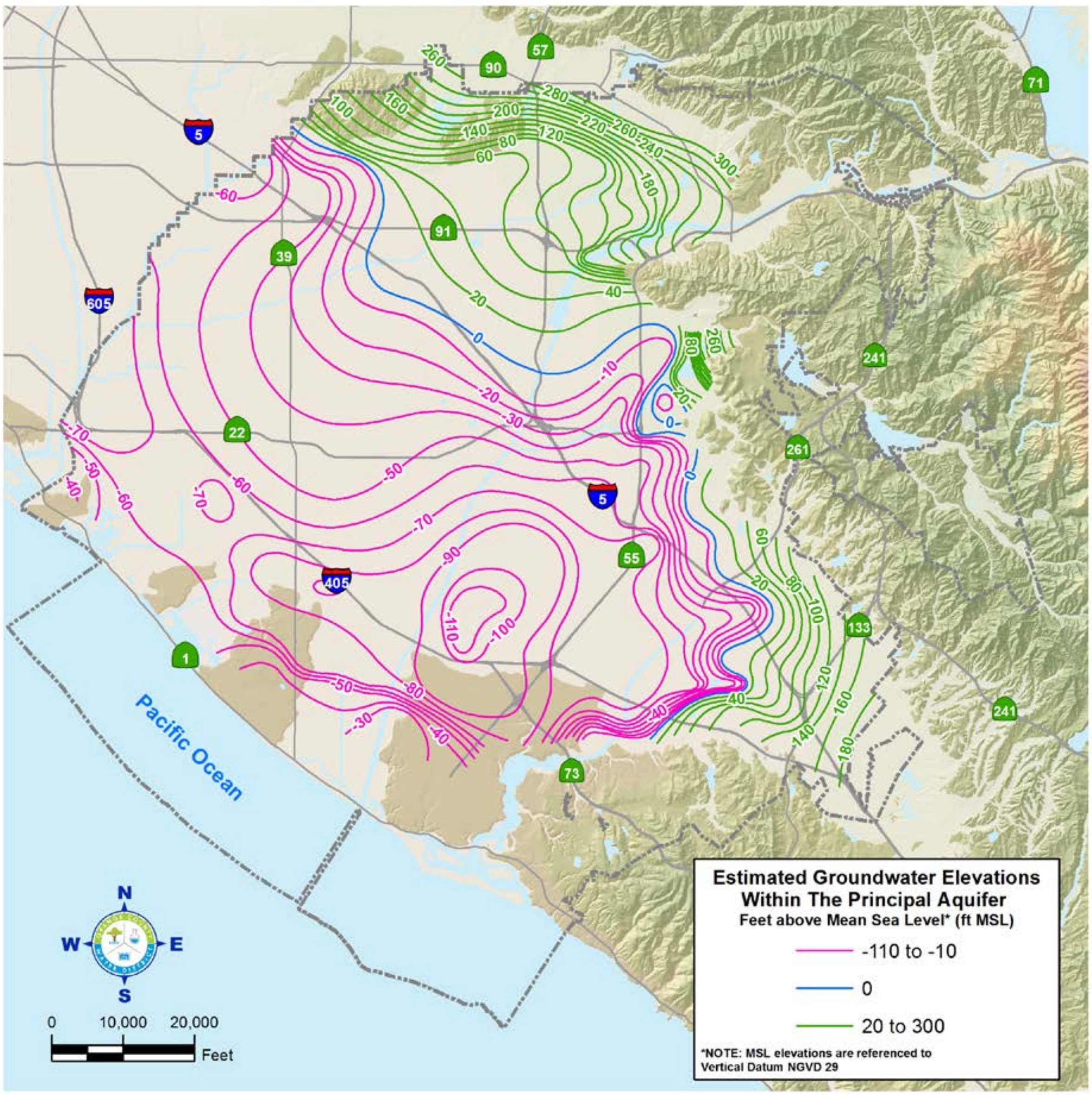


Figure 3-9: Groundwater Level Contour Map, June 2014

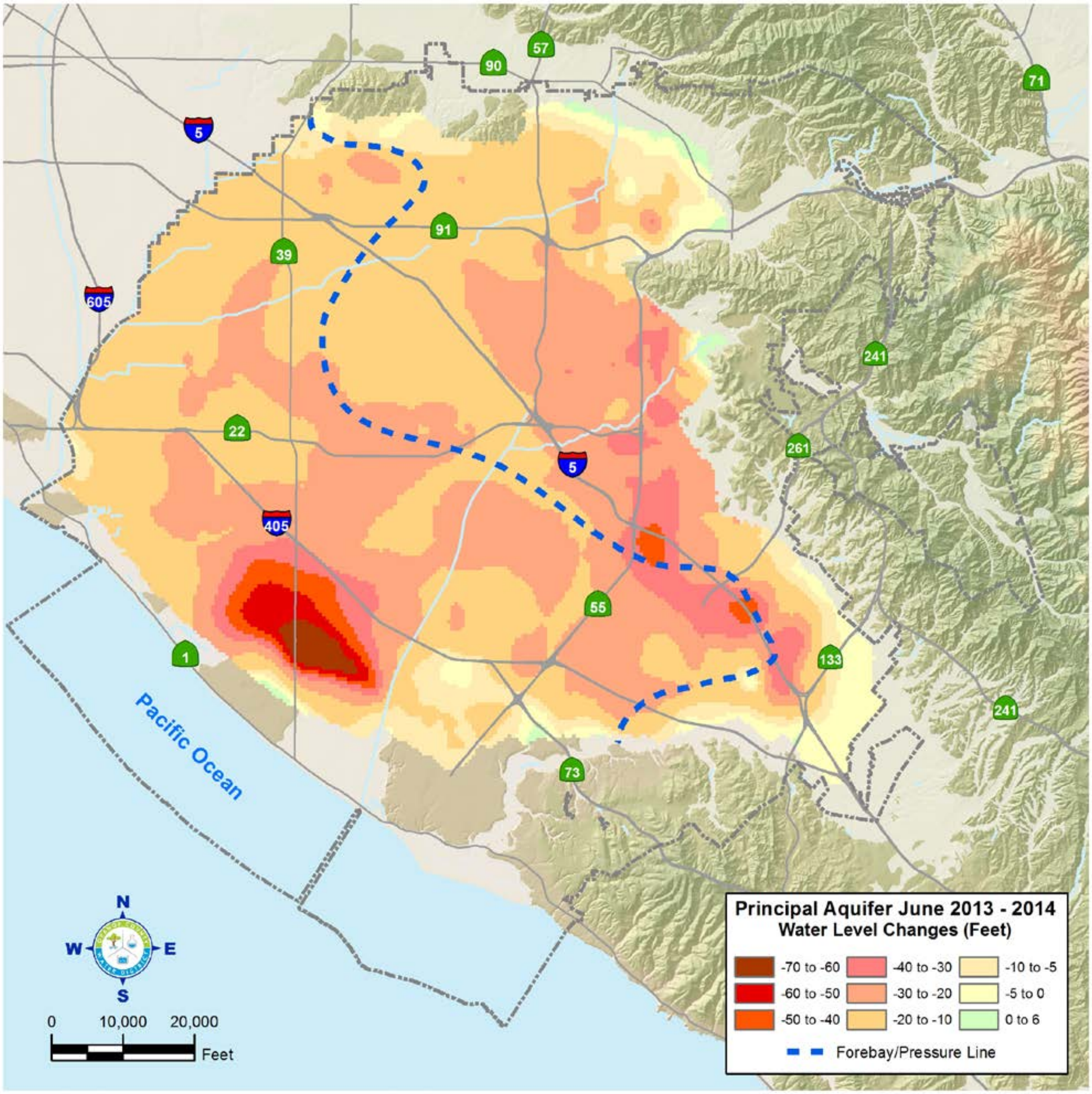


Figure 3-10: Groundwater Level Changes, June 2013-14

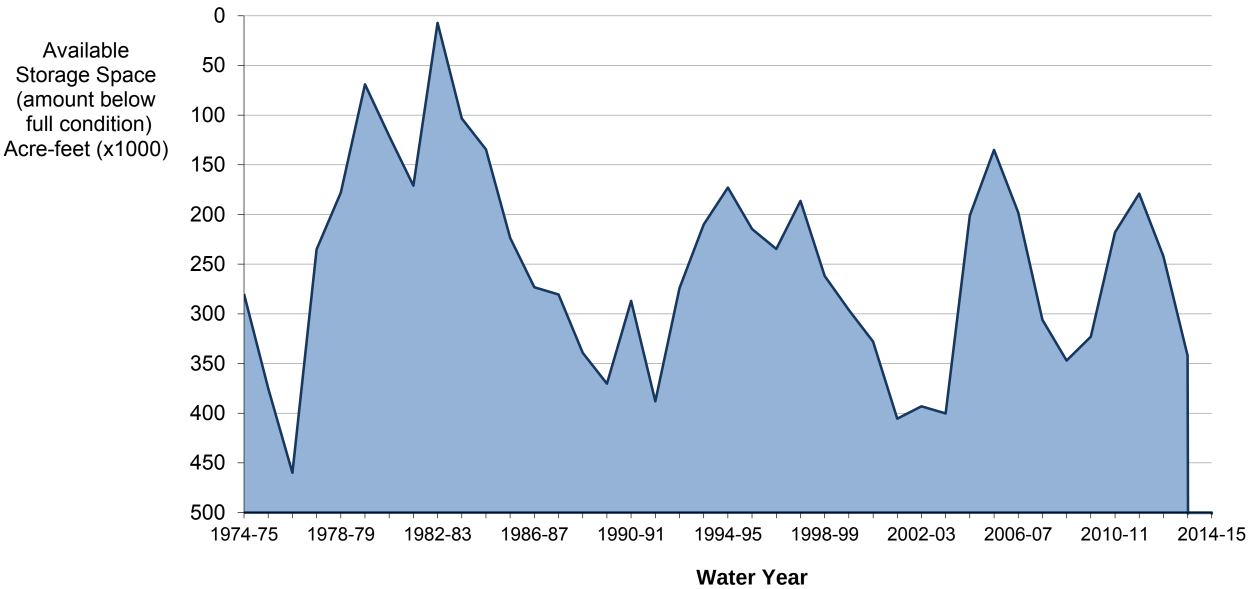


Figure 3-11: Change in Groundwater Storage, WY 1974-75 to 2013-14

3.5 ELEVATION TRENDS

The groundwater elevation profile for the Principal Aquifer following the Santa Ana River from the ocean to the Forebay in Anaheim, for 1969, 2013, and the theoretical full condition are shown in Figure 3-12. A comparison of these profiles shows that groundwater elevations in the Forebay recharge area for all three conditions are similar while in the central and coastal areas of the basin elevations in 2013 are significantly lower. The lowering of coastal area groundwater levels relative to groundwater levels further inland in the Forebay translates into a steeper hydraulic gradient, which drives greater flow from the Forebay to the coastal areas. However, the lowering of coastal water levels also increases the risk of seawater intrusion.

Groundwater elevation trends can be examined using five wells with long-term groundwater level data, the locations of which are shown in Figure 3-13. Figures 3-14 and 3-15 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 an historic high in 1994 and have generally remained high as recharge has been nearly continuous at Anaheim Lake since the late 1950s.

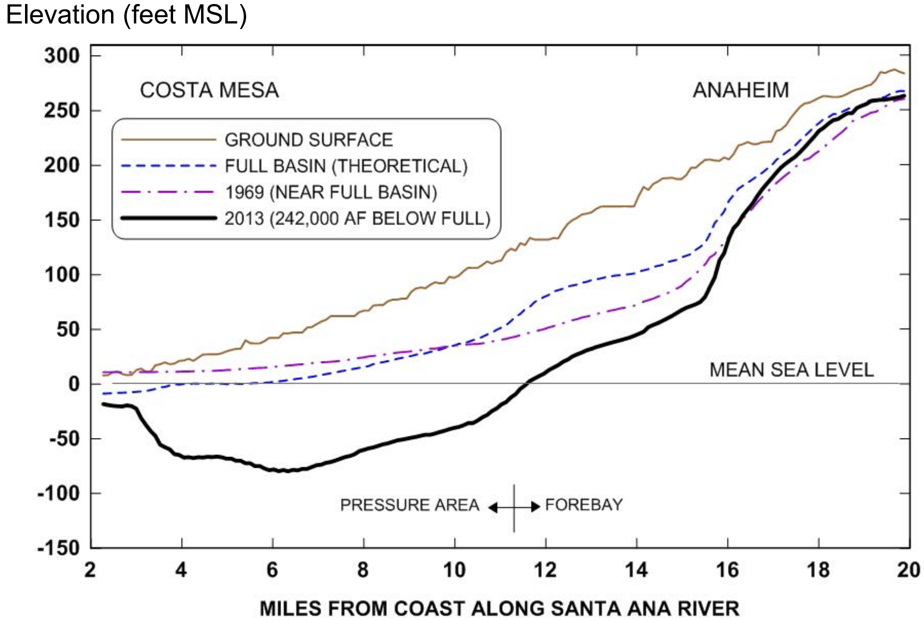


Figure 3-12: Principal Aquifer Groundwater Elevation Profiles, 1969 and 2013

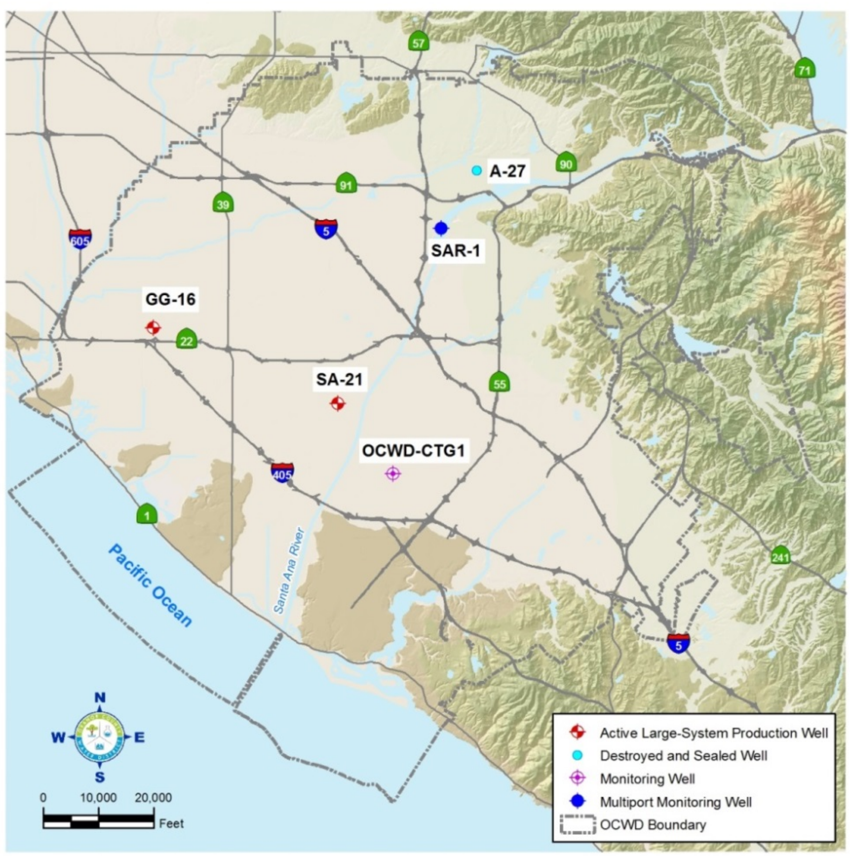
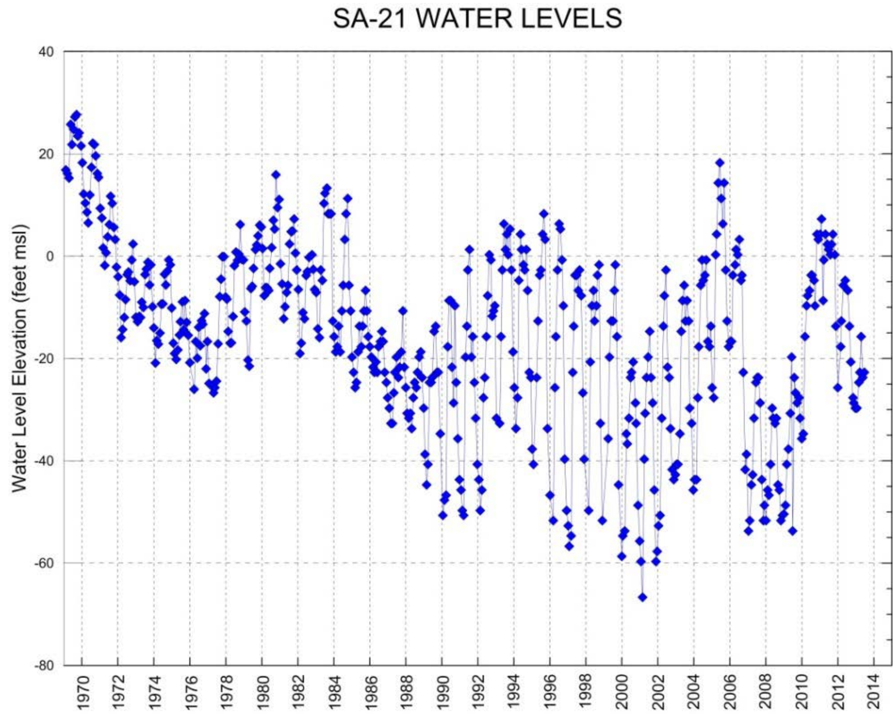


Figure 3-13: Location of Long-Term Groundwater Elevation Hydrograph



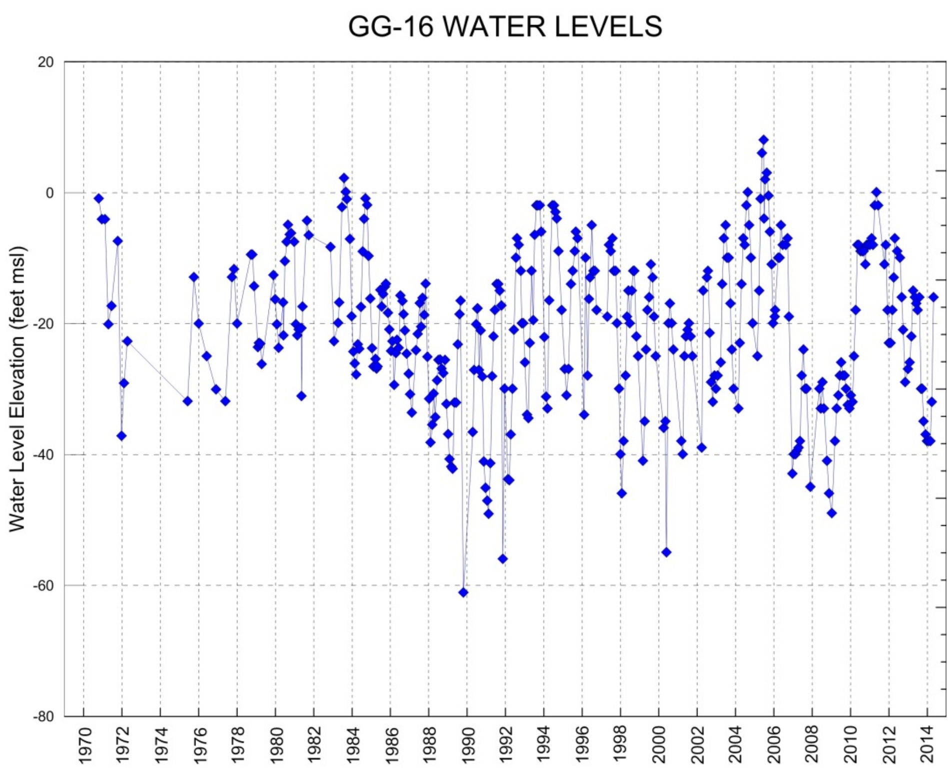


Figure 3-14: Water Level Hydrographs of Wells SA-21 and GG-16 in Pressure Area

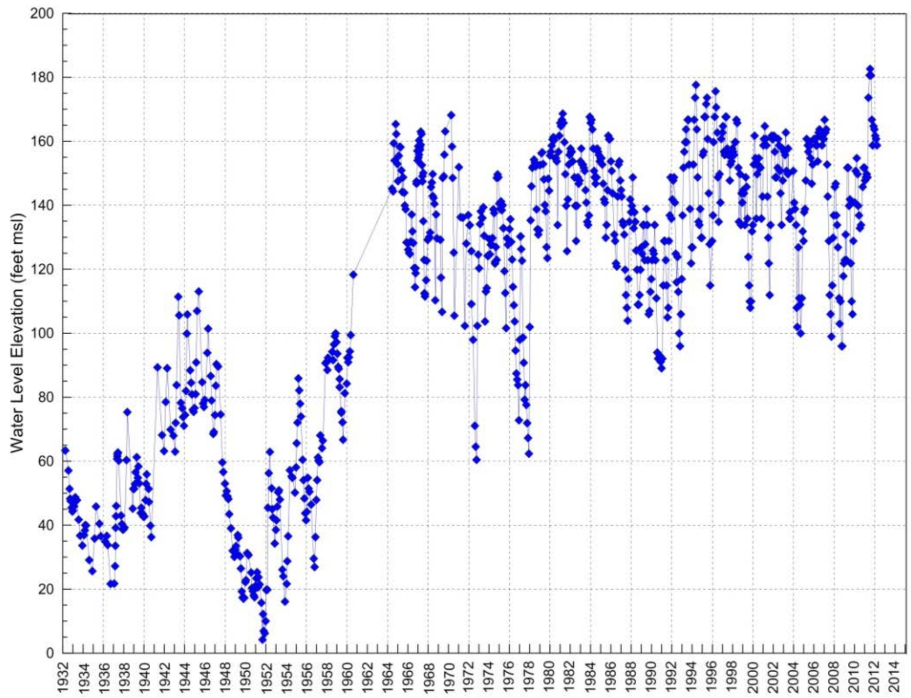


Figure 3-15: Water Level Hydrographs of Well A-27 in Forebay

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 MWD Short-Term Seasonal Storage Program by local 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 3-16 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 and the depth required to produce water from these zones.

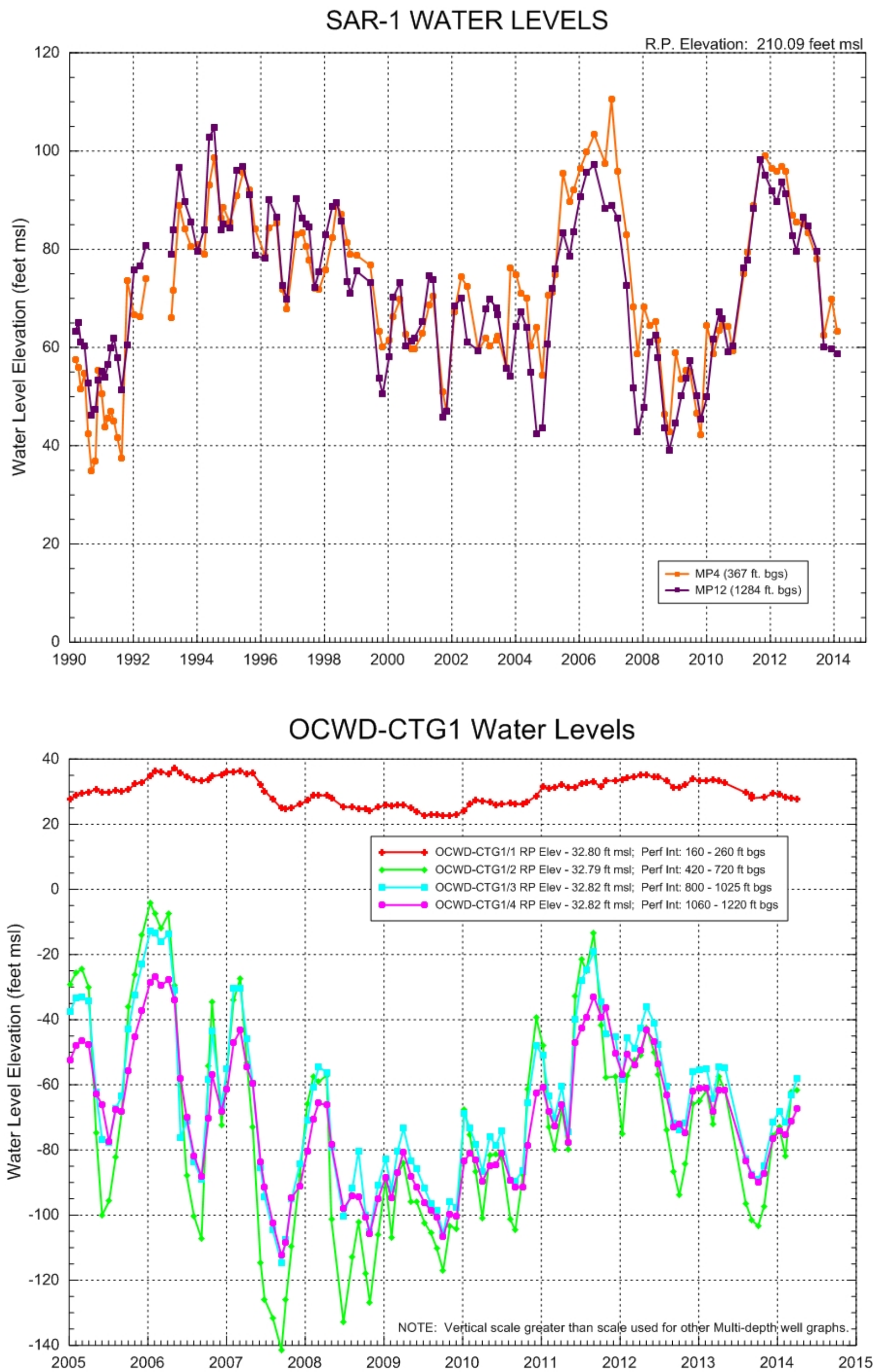


Figure 3-16: Water Level Hydrographs of Wells SAR-1 and OCWD-CTG1

3.6 LAND SUBSIDENCE

Land subsidence can be caused by a number of factors, including collapse of underground cavities, tectonic activity, natural consolidation of sediment, oxidation of organic deposits, hydrocompaction of moisture-deficient soil and sediments, development of geothermal energy, extraction of hydrocarbons from the subsurface, and extraction of groundwater.

In California, a common cause of subsidence is associated with excessive groundwater withdrawals. In the case of thick sedimentary groundwater basins comprised of alternating "confined" or "pressure" aquifers (permeable sands and gravels) and aquitards (less permeable silts and clays), the extraction of groundwater reduces the fluid pressure of the saturated pore spaces within the buried sediments. The pressure reduction in the deeper sediments allows the weight of the overlying sediments to compact the deeper sediments, particularly the clays and silts. If groundwater withdrawals cause water levels to be sustained beyond historical lows, several years or more, the incremental amount of sediment compaction can eventually manifest itself in an irreversible permanent lowering of the land surface (USGS, 1999).

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 drainage ditches drained the swamps and intercepted the shallow water table which was lowered sufficiently 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 of 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, 1978).

Subsidence due to changes in groundwater conditions in the Orange County groundwater basin is variable and does not show a pattern of widespread irreversible permanent lowering of the ground surface. Storage conditions in the groundwater basin were at historical lows in the late 1950s, but since this time OCWD has operated the groundwater basin within a storage range above the 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.

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 net withdrawal of groundwater from the basin (Bawden, 2001; 2003).

The Surveyor's office maintains more than 1,500 elevation benchmarks throughout Orange County. Periodically, the Surveyor resurveys the benchmarks to detect changes in elevation. The Surveyor maintains the survey records and makes them available to the public (http://ocpublicworks.com/survey/services/ocrtn) and provides the data to OCWD upon request. The Surveyor also maintains an Orange County Real Time Network (OCRTN) that consists of continuously operating GPS reference stations that monitor horizontal and vertical movement throughout Orange County. Figure 3-17 shows the locations of the GPS stations in Orange County.

Based on real time GPS data, the BLSA and SACY sites show the greatest range of elevation change of any of the sites in Orange County. Ground surface elevation changes at these sites from 2002 to 2014 correlate well with changes in groundwater storage, as shown on Figure 3-18. Note that this period of time includes a very wet period (2004-05) when basin groundwater storage increased significantly and a dry period (2010-2014) when basin groundwater storage decreased significantly.

In reviewing the available sources of data, it is clear that depending on the time period selected, the ground surface is rising, falling, or remaining stable. GPS data collected by the Surveyor over the past 12 years (2002-14) show that the ground surface fluctuations appear to be completely elastic, reversible, and well correlated with fluctuations in groundwater levels. These data indicate that there has not been any permanent, irreversible subsidence of the ground surface over the past 12 years.

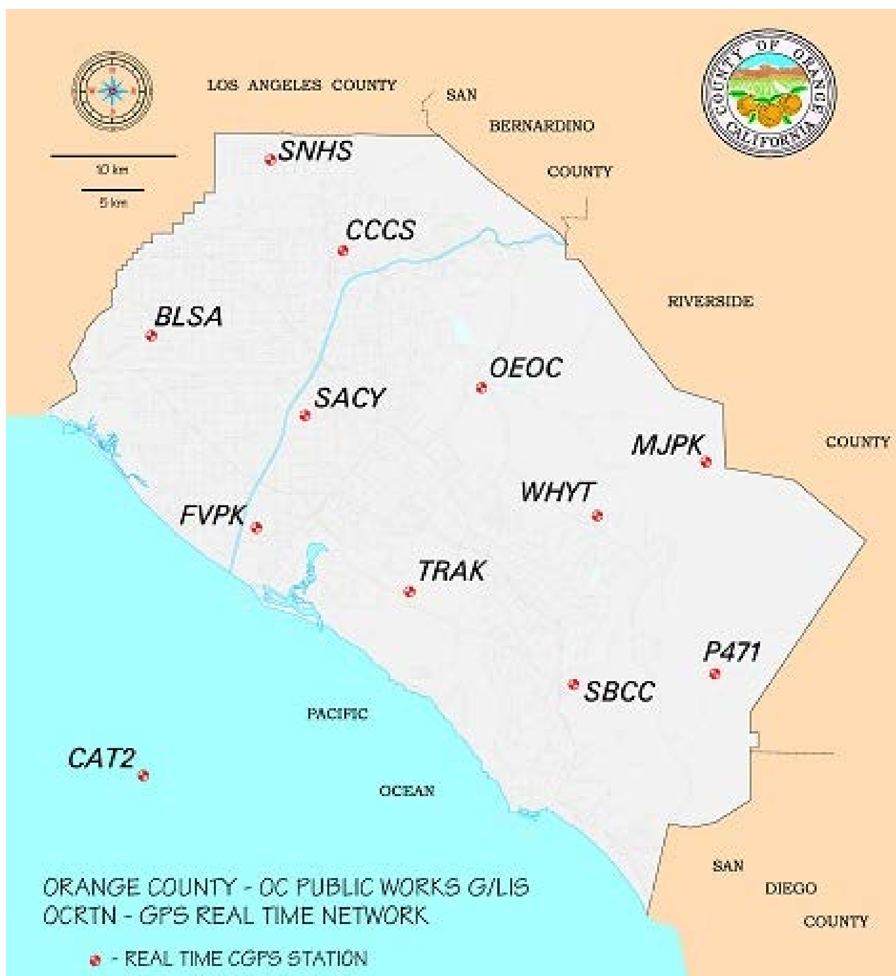


Figure 3-17: Orange County Public Works GPS Real Time Network

Finally, there is little potential for future widespread permanent, irreversible subsidence given OCWD's statutory commitment to sustainable groundwater management and policy of maintaining groundwater storage levels within a specified operating range. Nevertheless, the District annually reviews Surveyor data to evaluate ground surface fluctuations within the District'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.

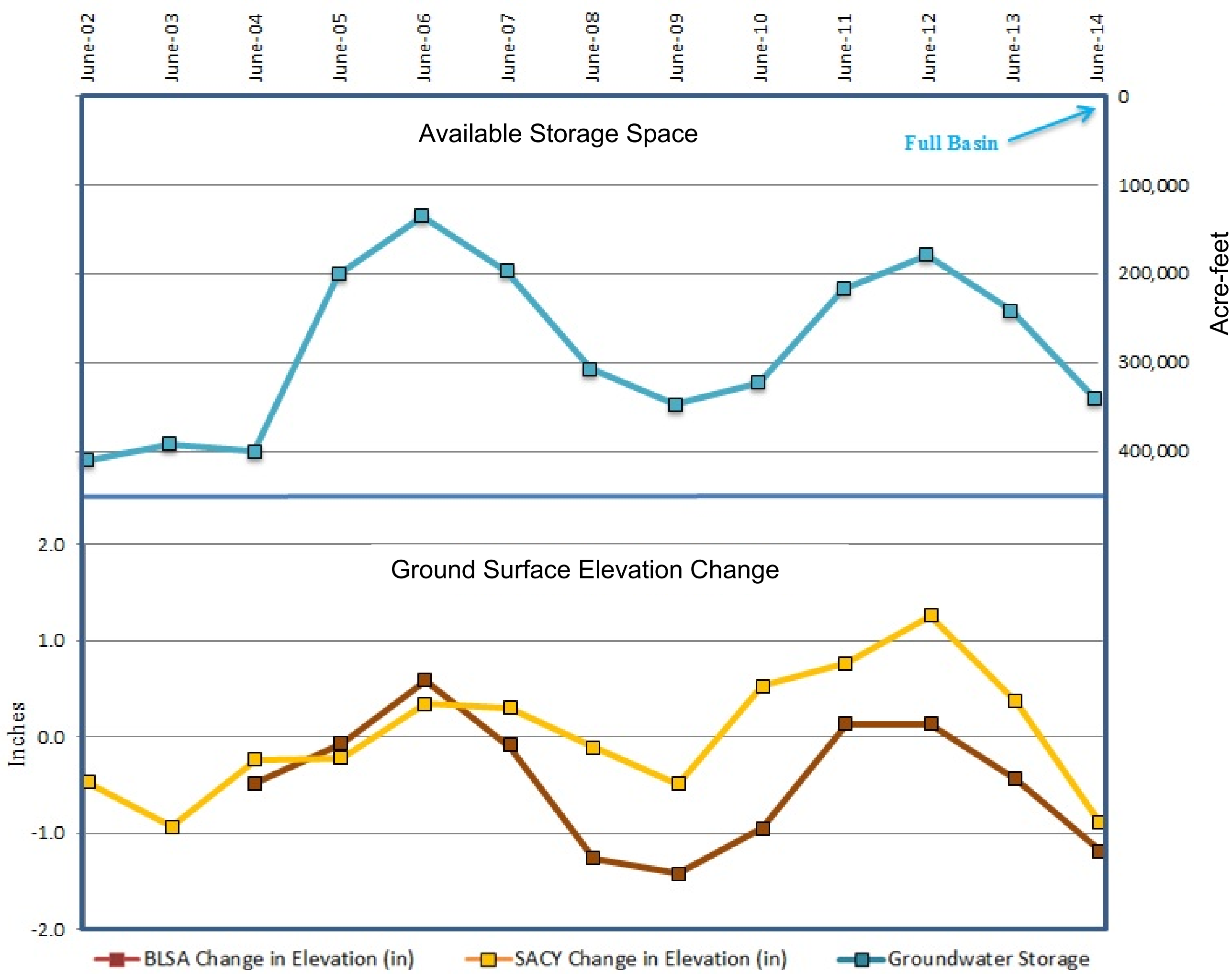


Figure 3-18: Available Storage Space in the Orange County Groundwater Basin and Ground Surface Elevation Change, 2002-2014

3.7 BASIN MODEL

OCWD's basin model encompasses the entire basin 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 3-19). As noted previously in this chapter, the county line is not a hydrogeologic boundary, i.e., groundwater freely flows through aquifers that have been correlated across the county line.

Coverage of the modeled area is accomplished with grid cells having horizontal dimensions of 500 feet by 500 feet (approximately 5.7 acres) and vertical dimensions ranging from approximately 50 to 1,800 feet, depending on the thickness of each model layer at that grid cell location. Basin aquifers and aquitards are grouped into three composite model layers thought sufficient to describe the three distinguishable flow systems corresponding to the Shallow, Principal, and Deep Aquifers. The three model layers comprise a network of over 90,000 grid cells.

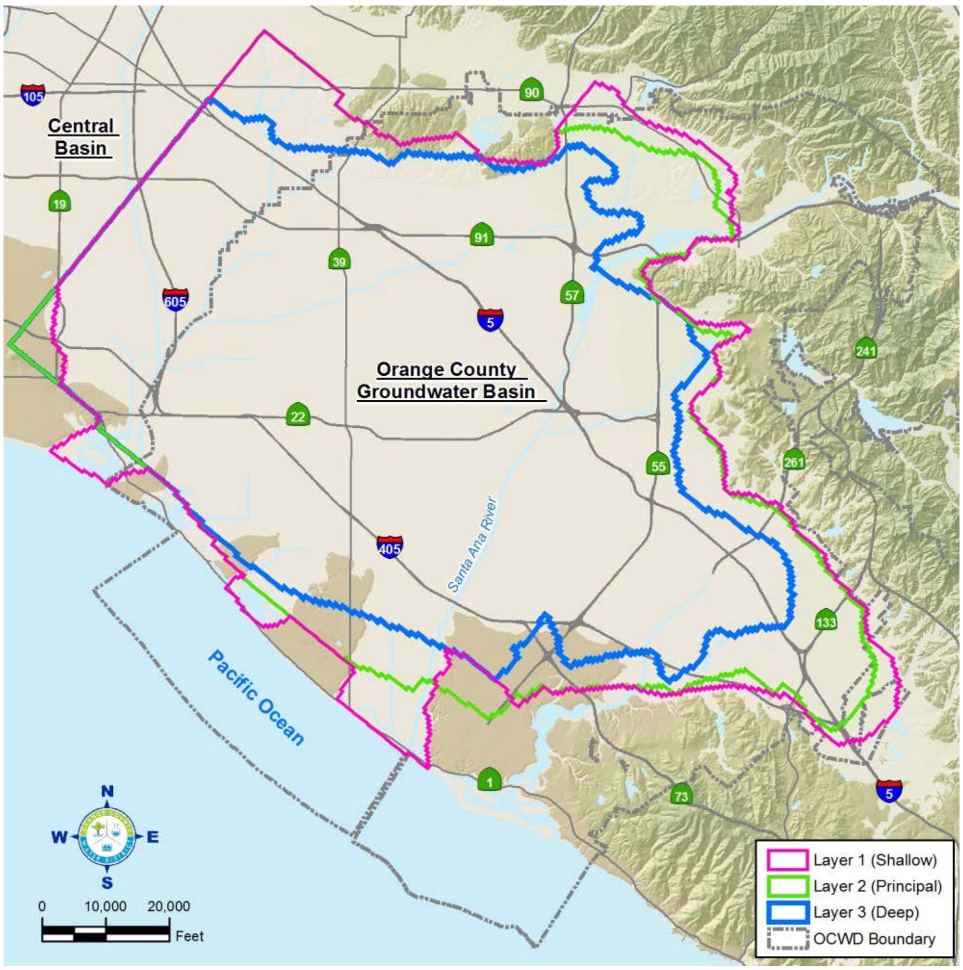


Figure 3-19: Basin Model Extent

The widely-accepted computer program, "MODFLOW," developed by the USGS, was used as the base modeling code for the mathematical model (McDonald and Harbaugh, 1988). Analogous to an off-the-shelf spreadsheet program needing data to be functional, MODFLOW requires vast amounts of input data to define the hydrogeologic conditions in the conceptual model. The types of information that must be input in digital format (data files) for each grid cell in each model layer include the following:

- Aquifer top and bottom elevations

- Aquifer lateral boundary conditions (ocean, faults, mountains)
- Aquifer hydraulic conductivity and storage coefficient/specific yield
- Initial groundwater surface elevation
- Natural and artificial recharge rates (runoff, precipitation, percolation, injection)
- Groundwater production rates for approximately 200 large system and 200 small system wells

These data originate from hand-drawn contour maps, spreadsheets, and the Water Resources Management System (WRMS) historical database. Because MODFLOW requires the input data files in a specific format, staff developed a customized database and GIS program to automate data compilation and formatting functions. These data pre-processing tasks form one of the key activities in the model development process.

Before a groundwater model can be reliably used as a predictive tool for simulating future conditions, the model must be calibrated to reach an acceptable match between simulated and actual observed conditions. The basin model was first calibrated to steady-state conditions to numerically stabilize the simulations, to make rough adjustments to the water budget terms, and to generally match regional groundwater flow patterns. Also, the steady-state calibration helped to determine the sensitivity of simulated groundwater levels to changes in incidental recharge and aquifer parameters such as hydraulic conductivity. Steady-state calibration of the basin model is documented in more detail in the *OCWD Master Plan Report* (OCWD, 1999).

Typical transient model output consists of water level elevations at each grid cell that can be plotted as a contour map for one point in time or as a time-series graph at a single location. Post-processing of model results into usable graphics is performed using a combination of semi-automated GIS and database program applications. Figure 3-20 presents a simplified schematic of the modeling process.

Model construction, calibration, and operation were built upon 12 years of effort by OCWD staff to collect, compile, digitize, and interpret hundreds of borehole geologic and geophysical logs, water level hydrographs, and water quality analyses. The process was composed of 10 main tasks comprising over 120 subtasks. The major tasks are summarized as follows:

- Finalize conceptual hydrogeologic model layers and program GIS/database applications to create properly formatted MODFLOW input data files. Over 40 geologic cross sections were used to form the basis of the vertical and lateral aquifer boundaries.
- Define model layer boundaries. The top and bottom elevations of the three aquifer system layers and intervening aquitards were hand-contoured, digitized, and overlain on the model grid to populate the model input arrays with a top and bottom elevation for each layer at every grid cell location. Model layer thickness values were then calculated using GIS.
- Develop model layer hydraulic conductivity (K) grids. Estimates of K for each layer were based on (in order of importance): available aquifer test data, well-specific capacity data, and lithologic data. In the absence of reliable aquifer test or specific capacity data for areas in Layers 1 and 3, lithology-based K estimates were calculated by assigning literature values of K

to each lithology type (e.g., sand, gravel, clay) within a model layer and then calculating an effective K value for the entire layer at that well location. Layer 2 had the most available aquifer test and specific capacity data. Therefore, a Layer 2 transmissivity contour map was prepared and digitized, and GIS was used to calculate a K surface by dividing the transmissivity grid by the aquifer thickness grid. Initial values of K were adjusted during model calibration to achieve a better match of model results with known groundwater elevations.

- Develop layer production factors for active production wells simulated in the model. Many production wells had long screened intervals that spanned at least two of the three model layers. Therefore, groundwater production for each of these wells had to be divided among each layer screened by use of layer production factors. These factors were calculated using both the relative length of screen within each model layer and the hydraulic conductivity of each layer. Well production was then multiplied by the layer factors for each individual well. For example, if a well had a screened interval equally divided across Layers 1 and 2, but the hydraulic conductivity of Layer 1 was twice that of Layer 2, then the calculated Layer 1 and 2 production factors for that well would have been one-third and two-thirds, respectively, such that when multiplied by the total production for this well, the production assigned to Layer 1 would have been twice that of Layer 2. For the current three-layer model, approximately 25 percent of the production wells in the model were screened across more than one model layer. In this context, further vertical refinement of the model (more model layers) may better represent the aquifer architecture in certain areas but may also increase the uncertainty and potential error involved in the amount of production assigned to each model layer.

- Develop basin model water budget input parameters, including groundwater production, artificial recharge, and unmeasured recharge. Groundwater production and artificial recharge volumes were applied to grid cells in which production wells or recharge facilities were located. The most uncertain component of the water budget – unmeasured or incidental recharge – was applied to the model as an average monthly volume based on estimates calculated annually for the OCWD *Engineer's Report*. Unmeasured recharge was distributed to cells throughout the model, but was mostly applied to cells along margins of the basin at the base of the hills and mountains. The underflow component of the incidental recharge represents the amount of groundwater flowing into and out of the model along open boundaries. Prescribed groundwater elevations were assigned to open boundaries along the northwest model boundary in Los Angeles County; the ocean at the Alamitos, Bolsa, and Talbert Gaps; the mouth of the Santa Ana Canyon; and the mouth of Santiago Creek Canyon. Groundwater elevations for the boundaries other than the ocean boundaries were based on historical groundwater elevation data from nearby wells. The model automatically calculated the dynamic flow across these open boundaries as part of the overall water budget.

- Develop model layer storage coefficients. Storage coefficient values for portions of model layers representing confined aquifer conditions were prepared based on available aquifer test data and were adjusted within reasonable limits based on calibration results.

- Develop vertical leakage parameters between model layers. Vertical groundwater flow between aquifer systems in the basin is generally not directly measured, yet it is one of the critically-important factors in the model's ability to represent actual basin hydraulic processes. Using geologic cross-sections and depth-specific water level and water quality data from the OCWD multi-depth monitoring well network, staff identified areas where vertical groundwater flow between the modeled aquifer systems is either likely to occur or be significantly impeded, depending on the relative abundance and continuity of lower-permeability aquitards between model layers. During model calibration, the initial parameter estimates for vertical leakage were adjusted to achieve closer matches to known vertical groundwater gradients.

- Develop groundwater contour maps for each model layer to be used for starting conditions and for visual comparison of water level patterns during calibration. Staff used observed water level data from multi-depth and other wells to prepare contour maps of each layer for November 1990 as a starting point for the calibration period. Care was taken to use wells screened within the appropriate vertical interval representing each model layer. The hand-drawn contour maps were then digitized and used as model input to represent starting conditions.
- Perform transient calibration runs. The nine-year period of November 1990 to November 1999 was selected for transient calibration, as it represented the period corresponding to the most detailed set of groundwater elevation, production, and recharge data. The transient calibration process and results are described in the next section.
- Perform various basin production and recharge scenarios using the calibrated model. Criteria for pumping and recharge, including facility locations and quantities, were developed for each scenario and input for each model run.

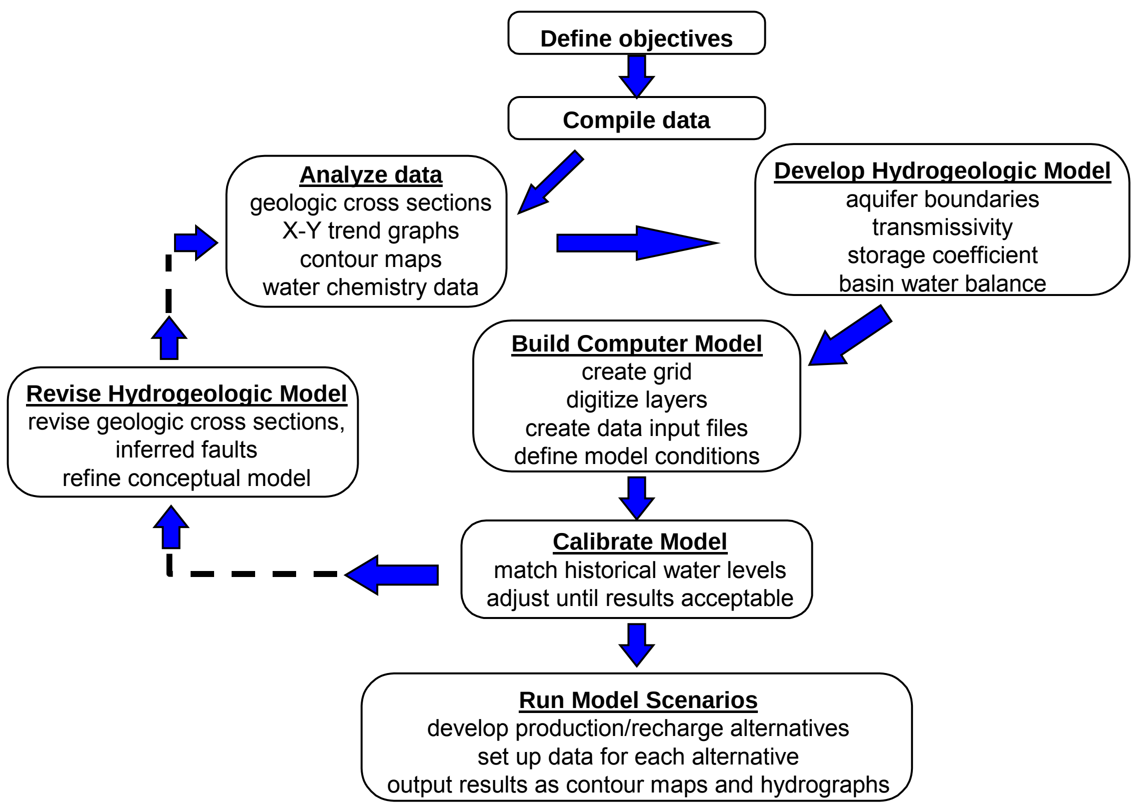


Figure 3-20: Model Development Flowchart

3.7.1 Model Calibration

Calibration of the transient basin model involved a series of simulations of the period 1990 to 1999, using monthly flow and water level data. The time period selected for calibration represents a period during which basic data required for monthly transient calibration were essentially complete (compared to pre-1990 historical records). The calibration period spans at least one “wet/dry” rainfall cycle. Monthly water level data from almost 250 target locations were used to determine if the simulated water levels adequately matched observed water levels. As shown in Figure 3-21, the calibration target points were densely distributed throughout the basin and also covered all three model layers.

After each model run, a hydrograph of observed versus simulated water levels was created and reviewed for each calibration target point. In addition, a groundwater elevation contour map for each layer was also generated from the simulated data. The simulated groundwater contours for all three layers were compared to interpreted contours of observed data (November 1997) to assess closeness of fit and to qualitatively evaluate whether the simulated gradients and overall flow patterns were consistent with the conceptual hydrogeologic model. November 1997 was chosen for the observed versus simulated contour map comparison since these hand-drawn contour maps had already been created for the prior steady state calibration step. Although November 1997 observed data were contoured for all three layers, the contour maps for Layers 1 and 3 were somewhat more generalized than for Layer 2 due to a lower density of data points (wells) in these two layers.

Depending on the results of each calibration run, model input parameters were adjusted, including hydraulic conductivity, storage coefficient, boundary conditions, and recharge distribution. Time-varying head boundaries along the Orange/Los Angeles County line were found to be extremely useful in obtaining a close fit with observed historical water levels in the northwestern portion of the model.

Fifty calibration runs were required to reach an acceptable level of calibration in which model-generated water levels were within reasonable limits of observed water level elevations during the calibration period. Figures 3-22 through 3-24 show examples of hydrographs of observed versus simulated water levels for three wells used as calibration targets.

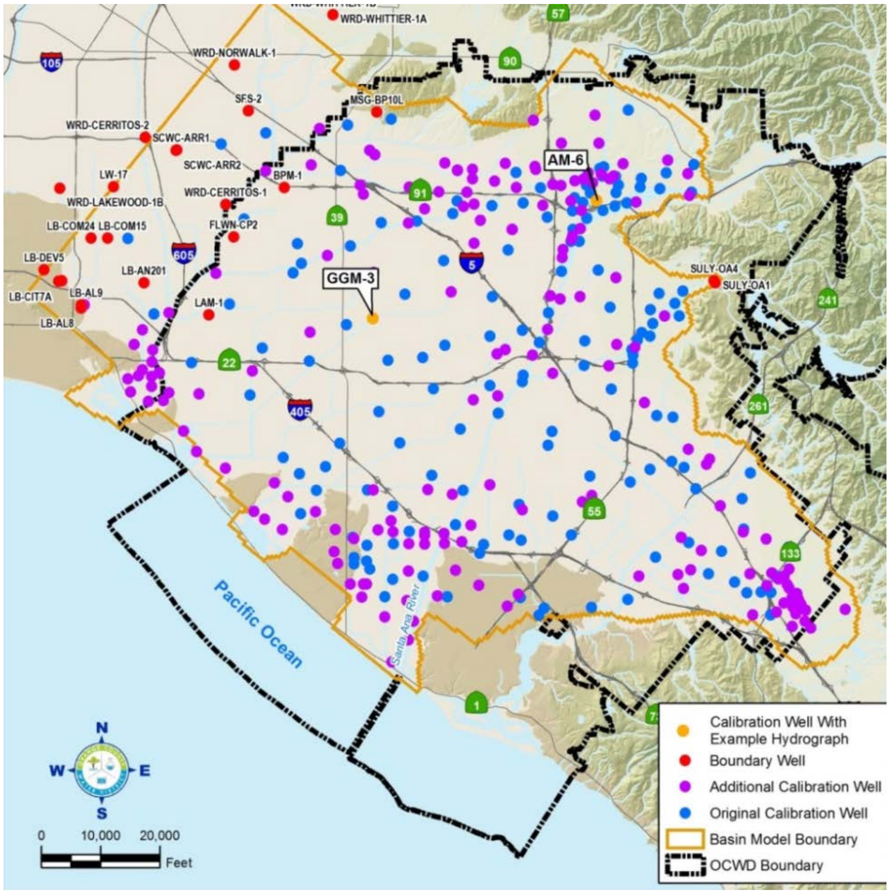


Figure 3-21: Basin Model Calibration Wells

Noteworthy findings of the model calibration process are summarized below:

- The model was most sensitive to adjustments to hydraulic conductivity and recharge distribution. In other words, minor variations in these input parameters caused significant changes in the model water level output.
- The model was less sensitive to changes in storage coefficient, requiring order-of-magnitude changes in this parameter to cause significant changes in simulated water levels, primarily affecting the amplitude of seasonal water level variations.
- The vast amount of observed historical water level data made it readily evident when the model was closely matching observed conditions.
- Incidental (unmeasured) recharge averaging approximately 70,000 afy during the 1990-1999 period appeared to be reasonable, as the model was fairly sensitive to variations in this recharge amount.
- Groundwater outflow to Los Angeles County was estimated to range between 5,000 and 12,000 afy between 1990 and 1999, most of this occurring in Layers 1 and 3.
- Groundwater flow at the Talbert Gap was inland during the entire model calibration period, indicating moderate seawater intrusion conditions. Model-derived seawater inflow ranged from 500 to 2,700 afy in the Talbert Gap and is consistent with chloride concentration trends during the

calibration period that indicated inland movement of saline groundwater in these areas.

- Model-derived groundwater inflow from the ocean at Bolsa Gap was only 100-200 afy due to the Newport-Inglewood Fault zone, which offsets the Bolsa aquifer and significantly restricts the inland migration of saline water across the fault.
- Model adjustments (mainly hydraulic conductivity and recharge) in the Santiago Basins area in Orange significantly affected simulated water levels in the coastal areas.
- Model reductions to the hydraulic conductivity of Layer 2 (Principal Aquifer) along the Peralta Hills Fault in Anaheim/Orange had the desired effect of steepening the gradient and restricting groundwater flow across the fault into the Orange area. These simulation results were consistent with observed hydrogeologic data indicating that the Peralta Hills Fault acts as a partial groundwater barrier.
- Potential unmapped faults immediately downgradient from the Santiago Basins appear to restrict groundwater flow in the Principal Aquifer, as evidenced by observed steep gradients in that area, which were reproduced by the model. As with the Peralta Hills Fault, an approximate order-of-magnitude reduction in hydraulic conductivity along these suspected faults achieved the desired effect of reproducing observed water levels with the model.

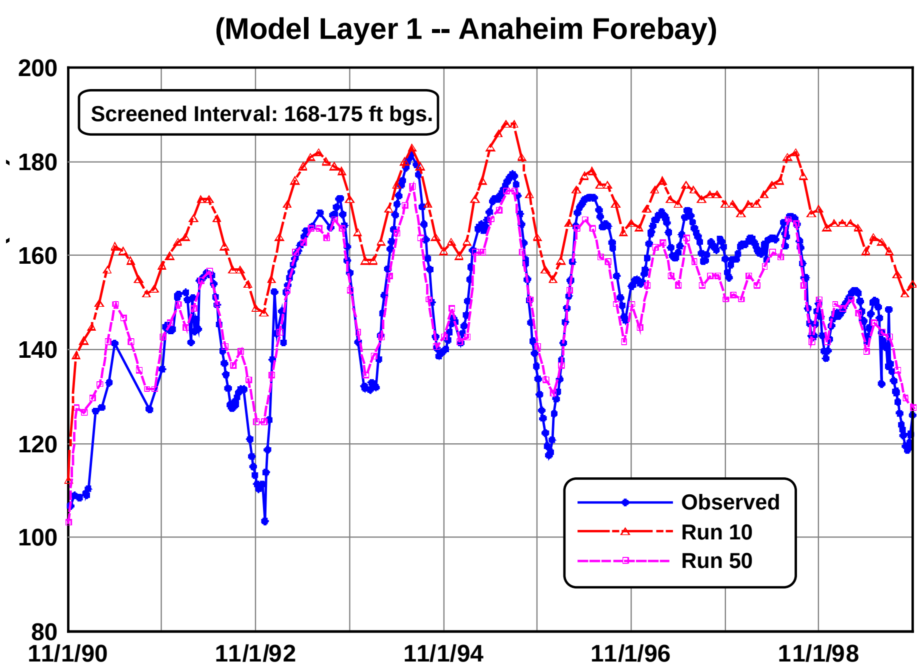


Figure 3-22: Calibration Hydrograph of Monitoring Well AM-5A

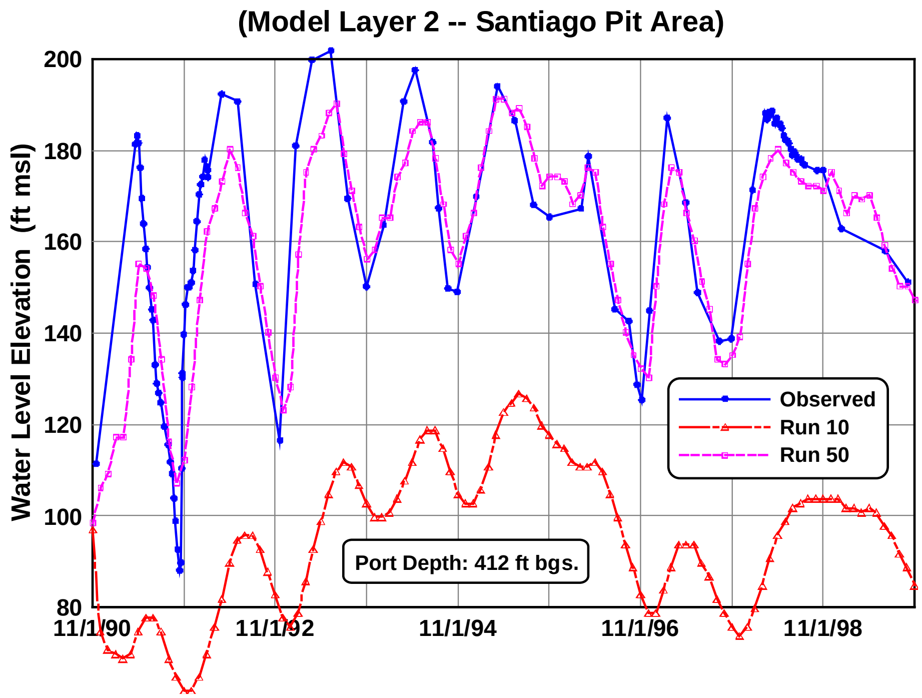


Figure 3-23: Calibration Hydrograph for Monitoring Well SC-2

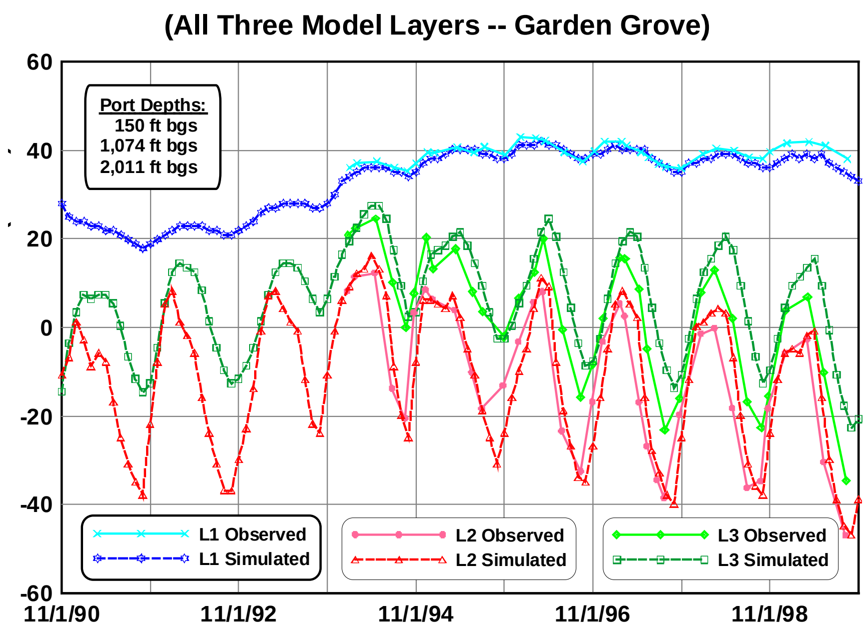


Figure 3-24: Calibration Hydrograph for Monitoring Well GGM-1

3.7.2 Model Advisory Panel

The model development and calibration process was regularly presented to and reviewed by a Model Advisory Panel. This technical panel consisted of four groundwater modeling experts who were familiar with the basin and highly qualified to provide insight and guidance during the model construction and calibration process. Twelve panel meetings were held between 1999 and 2002. The panel was tasked with providing written independent assessments of the strengths, weaknesses and overall validity and usefulness of the model in evaluating various basin management alternatives. Two memoranda were prepared: one at the completion of the steady-state model calibration and steady-state scenarios (Harley et al., 1999) and one at the completion of the transient model calibration and initial transient basin operational scenarios (Harley et al., 2001). Key conclusions and findings of the panel regarding the transient model are summarized below.

- Transient modeling has substantially improved the overall understanding of processes and conditions that determine how and why the basin reacts to pumping and recharge. This improved understanding, coupled with the model's ability to simulate existing and possible future facilities and alternative operations, significantly improves the District's potential ability to enhance and actively manage basin water resources.
- Modeling has helped verify major elements of the basin conceptual model and has been instrumental in clarifying:
    - Variations in the annual water balance
    - Hydrostratigraphy of the basin
    - Horizontal flow between basin subareas
    - The potential degree of interconnection and magnitude of vertical flow between major aquifers
    - The potential hydraulic significance of the Peralta Hills Fault in the Anaheim Forebay
    - Variations in aquifer hydraulic properties
    - The relative significance of engineered versus natural recharge and groundwater outflow within the basin
    - Numerous other issues and conditions
- The ability of the model to simulate known and projected future conditions will evolve and improve as new data become available and updated calibration runs are completed.
- Parameters used to set up the model appear to be within limits justified by known, estimated, and assumed subsurface conditions based upon available historic data.
- Initial transient calibration completed using a nine-year calibration period (1990-1999) is considered adequate to confirm the initial validity of the model for use in evaluating a variety of potential future projects and conditions.
- Areas of the basin that could benefit from future exploration, testing, monitoring, analysis and/or additional model calibration were identified.
- The model is not considered appropriate for assessing detailed local impacts related to new recharge facilities or well fields. These impacts should be assessed using more detailed local sub-models and by conducting detailed field studies.

- The model does not, nor is it intended to, address water supply availability, cost, water quality, or land subsidence.

Recommendations of the panel included suggestions that thorough documentation be prepared on model configuration and calibration and that the model calibration period be extended as new data become available.

3.7.3 Groundwater Model Update and Applications

OCWD staff update the basin groundwater model approximately every three to five years, guided by new information warranting the effort (new wells in critical areas) or by needed model evaluations using the most recent years, e.g., estimating the groundwater outflow to Los Angeles County. Major changes and improvements over the past five years include:

1. Model conversion from UNIX to PC using the Groundwater Vistas as the Graphical User Interface.

2. Extension of the model transient calibration through WY 2010-11. The new calibration period is November 1990 to June 2011 which includes a wide range of basin storage conditions as well as a wide range of hydrologic conditions.

3. Addition of several new Talbert Barrier injection wells and the addition of two new recharge basins, La Jolla and Miraloma Basins.

Typical applications of the Basin Model include estimating the effects of potential future pumping and recharge projects on groundwater levels, storage, and the water budget. The storage coefficients determined during the original Basin Model calibration are also used to estimate annual change in groundwater storage.

The Basin Model was also used in 2011 to estimate the effects of additional recharge from new Miraloma Basin on the GWRS subsurface retention time buffer area located in the Anaheim Forebay. In accordance with the CDPH Draft Groundwater Replenishment Regulations at the time of the permit's adoption, OCWD developed a six-month buffer area downgradient of Kraemer and Miller Basins using a sulfur hexafluoride (SF-6) artificial tracer test, inside which drinking water wells could not be constructed or operated (Clark, 2009). OCWD subsequently acquired the Miraloma property and developed it into a recharge basin intended primarily for GWRS water recharge. The three-layer Basin Model and the existing tracer test-determined buffer area were used to determine the necessary modifications to the Anaheim Forebay GWRS buffer area.

Two other applications of the Basin Model were related to operation of the Talbert Seawater Barrier. The first was to guide the planning, location and hydraulic effectiveness of supplemental injection wells for the Talbert Barrier during pre-GWRS planning activities. The second was to estimate the general flow paths and subsurface residence time of barrier injection water to delineate the Talbert Barrier's recycled water retention buffer area. Inside of this area new drinking water wells are not allowed, as required by the California Department of Public Health requirements contained within the original permit to operate the GWRS (RWQCB, 2004, OCWD, 2005).

3.7.4 Talbert Gap Model

Between 1999 and 2000, OCWD contracted with Camp Dresser & McKee Inc. to develop a detailed groundwater flow model of the Talbert Gap and surrounding area for the purpose of evaluating and estimating the amount and location of fresh water injection wells needed to control seawater intrusion under current and projected future basin conditions. The Talbert Gap modeling effort was undertaken as part of the design scope of work for Phase 1 of the GWRS, which included expansion of the existing Talbert Barrier. The configuration and initial calibration of the Talbert Gap Model and further model refinement and calibration were documented by Camp Dresser & McKee Inc. (2000, 2003).

Consistent with the Basin Model Advisory Panel's findings, OCWD determined that a more detailed model of the Talbert Gap was necessary to evaluate the local water level changes associated with various potential injection barrier alignments and flow rates. The Talbert model comprises an area of 85 square miles, 13 Layers (seven aquifers and six aquitards), and 509,000 grid cells (250 feet x 250 feet horizontal dimensions). Figures 2-25, 2-26 and 2-27 show the model area, Talbert Model Calibration Wells and boundary wells and layering schematic, respectively.

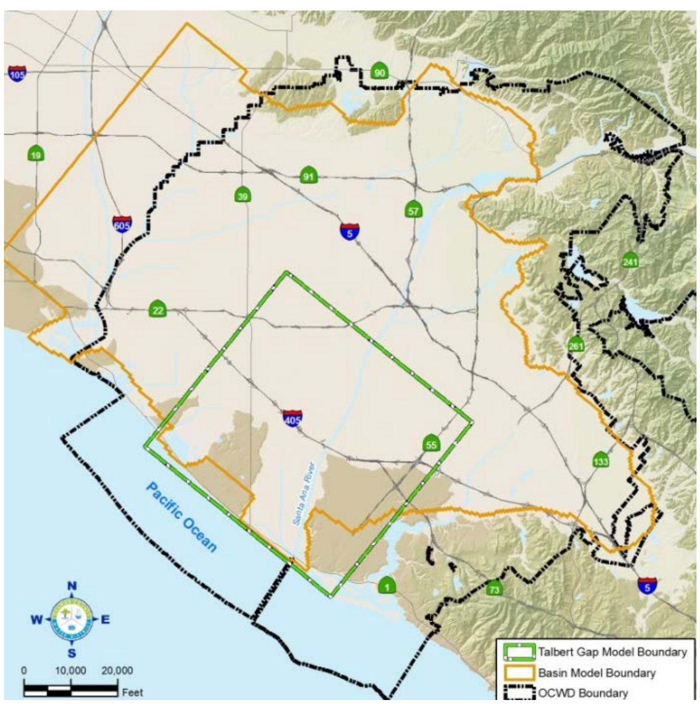


Figure 3-25: Talbert Gap Model and Basin Model Boundaries

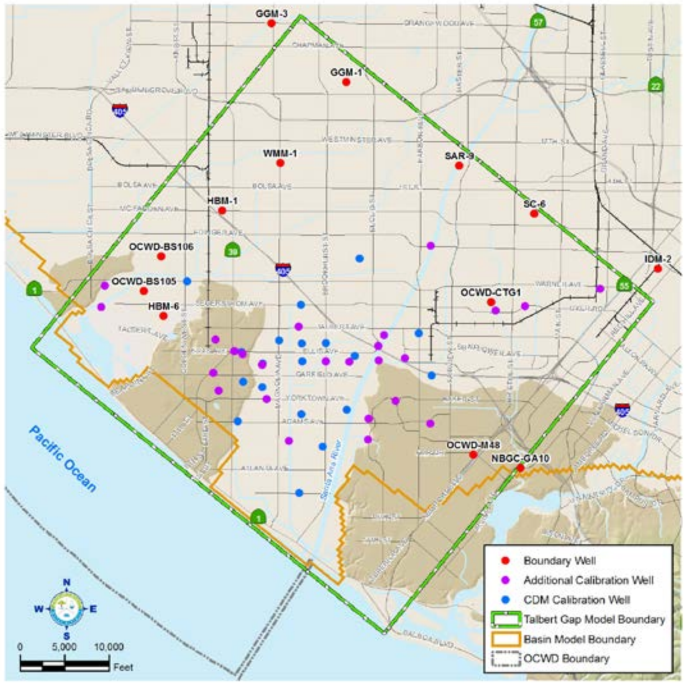


Figure 3-26: Talbert Model Calibration Wells and Boundary Wells

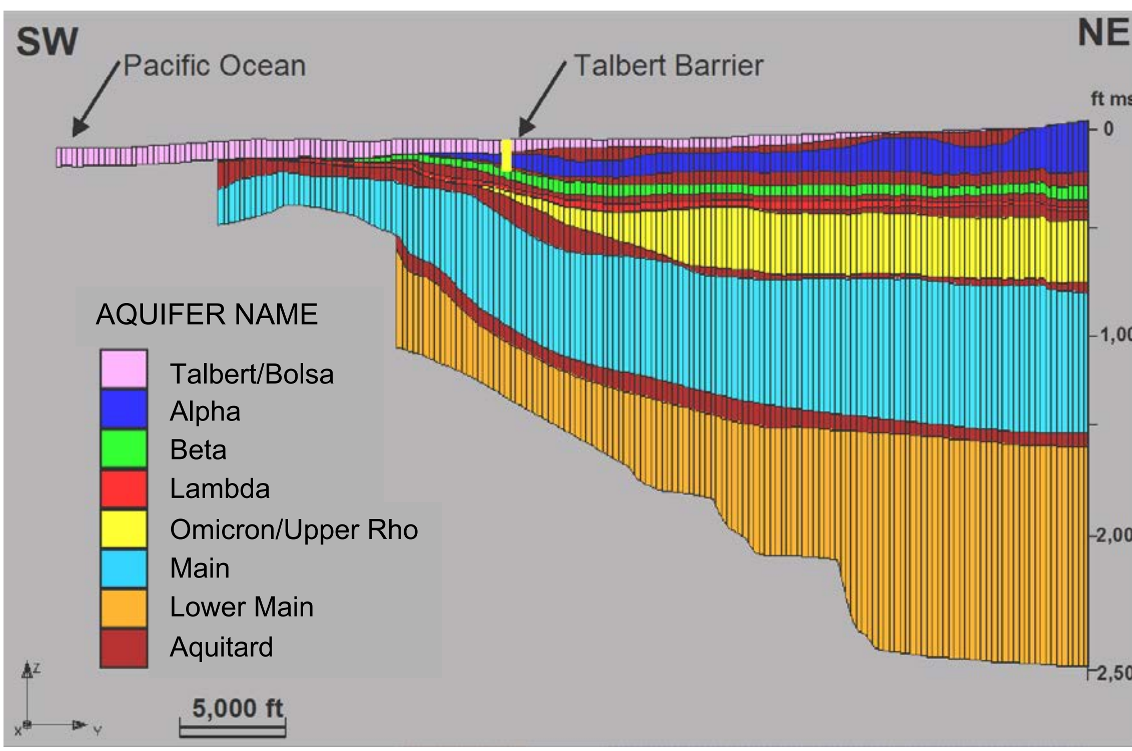


Figure 3-27: Talbert Gap Model Aquifer Layering Schematic

Key findings of the Talbert Gap groundwater model are summarized below.

- Depending on the amount of basin production, particularly near the Talbert Barrier, 30 mgd (approximately 34,000 afy) of injection will substantially raise water levels, yet may not be sufficient to fully prevent seawater intrusion in the Talbert Gap. Additional injection wells beyond those planned for Phase 1 of the GWRS might be required.

- Under projected 2020 conditions, the future Talbert Barrier may require an annual average injection rate of up to 45 mgd based on the results of existing analyses. This estimated future injection requirement will be further evaluated as additional data are collected.

- The Talbert model inland boundaries do not coincide with hydrologic or geologic features, e.g., recharge area, faults. Therefore, simulated water levels are highly influenced by the time-varying water levels specified along the boundaries. For future Talbert model predictive runs, the basin model should be used to generate water levels that can then be specified along the inland Talbert model boundaries.

- The Talbert model was less sensitive to adjustment hydraulic conductivity and storage coefficient than the basin model, primarily because of the stronger influence of the specified-head boundaries in the Talbert model.

3.7.5 Alamitos Barrier Model

The Alamitos Seawater Intrusion Barrier was constructed by OCWD and the Los Angeles County Department of Public Works (LACDPW) in 1965 to protect the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion through the Alamitos Gap. The OCWD and the Water Replenishment District of Southern California (WRD) purchase and provide the injection supply, which is primarily recycled water augmented with imported water. Barrier operations are described in Section 7.

Elevated chloride concentrations were observed inland of the barrier, especially near the southeast portion of the barrier within Orange County, which suggested that seawater intrusion was occurring through and around the barrier into the Orange County Groundwater Basin. In 2008 and 2009, OCWD identified critical data gaps and installed new monitoring wells at three sites near the Orange County portion of the barrier in order to collect data to evaluate the extent and location of possible seawater intrusion in the area.

In 2010 OCWD, WRD and LACDPW contracted with INTERA, Inc. to develop the Alamitos Barrier Flow Model (ABFM) and the Alamitos Barrier Transport Model (ABTM). These models were developed to simulate the relative differences in chloride transport, barrier performance for the existing barrier, and three selected barrier expansion configurations. The objectives of the models were to: (1) determine the existing and future potential for seawater intrusion in the Alamitos Gap and subsequent barrier expansion requirements, (2) optimize month-to-month operations of the existing barrier injection wells and (3) determine the travel time and percentage of recycled injection water reaching nearby drinking water wells to fulfill regulatory permit requirements.

The groundwater flow and solute transport models used the industry-standard computer codes MODFLOW (groundwater flow) and MT3D (solute transport). The model was constructed so that it can be operated by staff from any of the three agencies (OCWD, WRD and LACDPW) from a desktop personal computer using off-the-shelf industry-standard software and independently-run new simulations.

Key findings of the models:

1. The dominant flow direction across and around the barrier into Orange County was found to be primarily west to east, rather than wrapping around the ends of the barrier in a south to north direction, as was previously thought.
2. Per-well injection capacity is limited due to relatively low aquifer hydraulic conductivities throughout most of the Orange County portion of the barrier.
3. Additional barrier injection is required to prevent further intrusion through or around the barrier.
4. Increasing injection, along with a westerly extension of the barrier in Long Beach to the Seal Beach Fault, would likely halt further seawater intrusion into Orange County, however, cut-off plumes of elevated salinity would likely continue to migrate easterly into Orange County landward of the barrier.

A well calibrated groundwater model along with data from existing wells allowed the three agencies (OCWD, WRD, and LACDPW) to better assess and plan for necessary expansion of barrier facilities, as well as prioritize and optimize operation of the existing facilities. The models provided important new insight into the behavior of the hydrogeologic system in the vicinity of Alamitos Gap and the behavior and operation of the barrier.

One application of the model was to help evaluate the Alamitos Barrier Improvement Project, which proposed to increase the injection capacity of the Orange County portion of the Alamitos Barrier. A total of eight new injection well locations were proposed along the east portion of the barrier. At each well locations, 2 to 4 depth-specific wells were assumed to inject into a specific aquifer unit (C, B, A, or I zones).

WATER SUPPLY MONITORING

4

OCWD staff collecting sample in Santa Ana River

OCWD's comprehensive monitoring programs are conducted to safeguard the basin's water quality and to operate the basin for long-term sustainability.

<u>Monitoring programs include water quality data from over 2,000 wells</u>

- Groundwater elevations collected annually at OCWD monitoring wells
- All groundwater producers report production totals every six months
- OCWD conducts Title 22 water quality monitoring for Producers
- Additional monitoring for contamination sites and for seawater intrusion
- Recycled water monitored daily, monthly, or quarterly for general minerals, metals, organics, and microbial constituents
- Surface water monitoring includes Santa Ana River throughout the watershed

<u>Water Resources Management System</u>

- Database stores well information, historical and current data, sub-surface geology, water levels, and water quality
- Reports generated for a variety of purposes and for several agencies

<u>Water Sample Collection and Analysis</u>

- In 2014, OCWD water quality staff collected over 17,000 samples for analysis
- Most water quality samples analyzed at OCWD's Advanced Water Quality Assurance Laboratory

SECTION 4 WATER SUPPLY MONITORING

4.1 INTRODUCTION

OCWD's monitoring programs are a vital component of improving groundwater management and assuring sustainable basin management by:

- Establishing a safe and sustainable level of groundwater production;
- Monitoring coastal water quality and seawater intrusion;
- Monitoring for potential groundwater contaminants;
- Protecting the quality of surface water and recycled water used for groundwater recharge and assuring that such recharge is protective of groundwater quality; and
- Assuring that the groundwater basin is managed in full compliance with all relevant laws and regulations.

4.2 GROUNDWATER MONITORING

OCWD collects samples and analyzes water elevation and water quality data from approximately 400 District-owned monitoring wells (shown in Figure 4-1) as well as between 200 and 220 privately-owned and publically-owned large and small system drinking water wells that are part of OCWD's Title 22 program, shown in Figure 4-2. 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 4-3. 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 but is capable of being made an operating well with a minimum of effort. 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 Water Replenishment District of Southern California 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. Another example is a network of 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.

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. A comprehensive list of all wells in OCWD's database can be found in Appendix E. This list includes 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 on the data base as unknown but these wells are included because water quality or elevation data continues to be collected by the owner or operator and this data and used in a OCWD monitoring program, in groundwater modeling, or other basin program. 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 program.

The list includes wells located outside of District boundaries. These are included for a number of reasons. For example, all wells that are related to operation of the Alamitos Barrier that are located in Los Angeles County are monitored by OCWD in managing seawater intrusion along the Orange County-Los Angeles County border. Los Angeles County wells are also used to model the Orange County Groundwater Basin as groundwater flow is unrestricted across the county line. In other cases, a new well that is under construction appears on the list but the well depth and screened intervals have yet to be incorporated into the WRMS database.

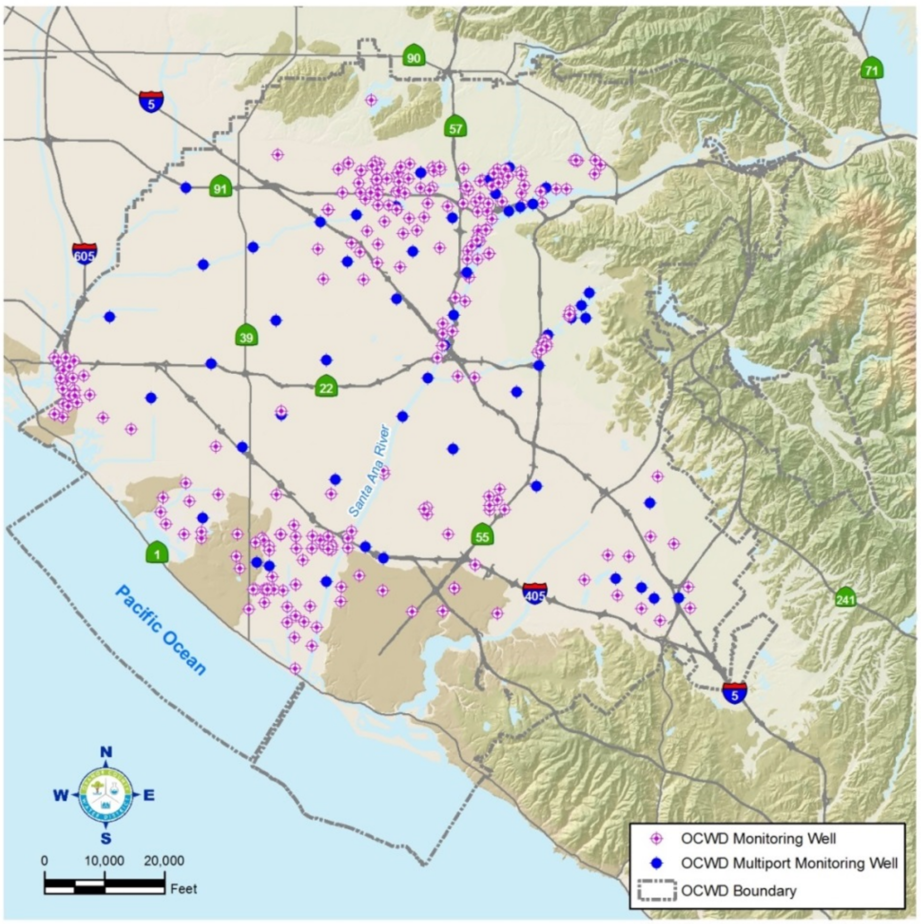


Figure 4-1: OCWD-Owned Monitoring Wells

Groundwater sampling is conducted in accordance with ASTM protocols or their functional equivalent (ASTM D4448 - 01(2013), Standard Guide for Sampling Ground-Water Monitoring Wells).

Groundwater elevation and monthly production data are used to quantify total basin pumping, evaluate seasonal groundwater level fluctuations and assess basin storage conditions.

Comprehensive water quality monitoring programs fall roughly into three categories: (1) compliance with permits and drinking water regulations, (2) basin management, and (3) projects for research and other purposes. Water quality samples and water level data are collected at frequencies necessary for short- and long-term trend analyses, for analysis of the basin as a whole and to focus on local or sub-regional investigations.

Thresholds that trigger a change in a monitoring program include (1) a recommendation by the GWRS Independent Advisory Panel (see explanation in Section 6) for resampling or increased monitoring of a particular constituent of concern; (2) a recommendation by the Independent Advisory Panel that reviews OCWD use of Santa Ana River water for groundwater recharge and related water quality; (3) a change in regulation or anticipation of a change in regulation; (4) 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; (5) 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; (6) analysis of water quality trends conducted by water quality, hydrogeology, or recycled water production staff indicate a need to change monitoring; and (7) 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 basin.

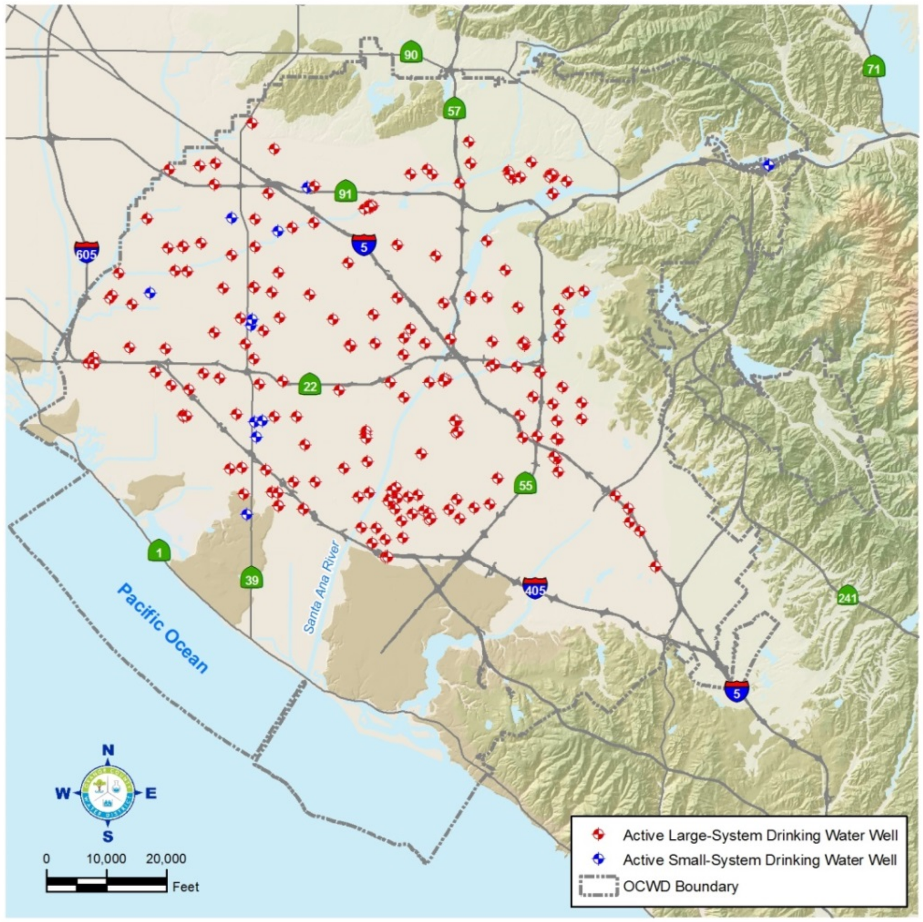


Figure 4-2: Large and Small System Drinking Water Wells in Title 22 Monitoring Program

4.2.1 Groundwater Production Monitoring

All entities that pump groundwater from the basin are required by the District Act to report production every six months and pay a Replenishment Assessment. Private individual well owners pumping less than one acre-foot a year pay an annual flat fee instead of the Replenishment Assessment and do not have to report their production.

Approximately 200 large-capacity municipal and privately-owned supply wells account for ninety-seven percent of production. Large-capacity well owners report monthly groundwater production for each of their wells. The production volumes are verified by OCWD field staff. Production data are used to manage basin storage and collect revenues.

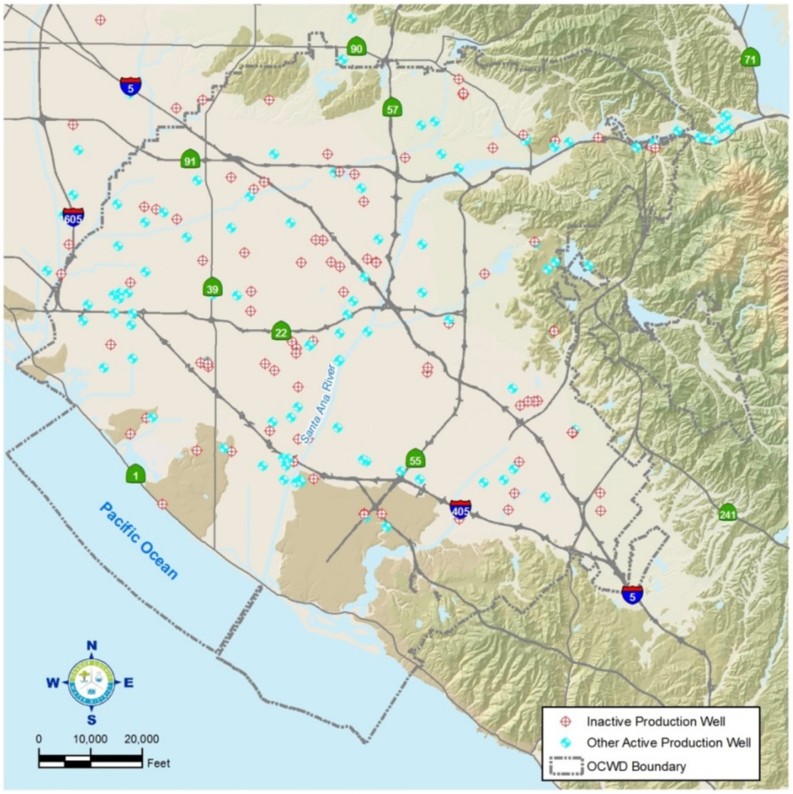


Figure 4-3: Private Domestic, Irrigation, and Industrial Wells in OCWD Monitoring Programs

4.2.2 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 some wells measured bi-weekly;
- Monitoring of municipal wells may be conducted more frequently depending on 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 the Department of Water Resources (DWR) as part of the California Statewide Groundwater

Elevation Monitoring (CASGEM) program. The CASGEM program was created by DWR in response to legislation passed in 2009 (SBx7-6). This amendment to the California Water Code required DWR to develop a statewide groundwater elevation monitoring program to track seasonal and long-term trends in groundwater elevations in California's groundwater basins. The CASGEM program aims to improve management of groundwater resources by establishing a permanent, locally-managed program of regular and systematic monitoring in all of California's alluvial groundwater basins

OCWD has been designated as the Monitoring Entity for the Orange County Groundwater Basin. A Monitoring Entity is a local agency that voluntarily takes responsibility for coordinating groundwater level monitoring and reporting for all or part of a groundwater basin. Wells monitored under the CASGEM program are listed in Appendix E. The monitoring network consists of monitoring stations distributed laterally and vertically throughout the Orange County Groundwater Basin as well as the La Habra Subbasin as shown in Figure 4-4.

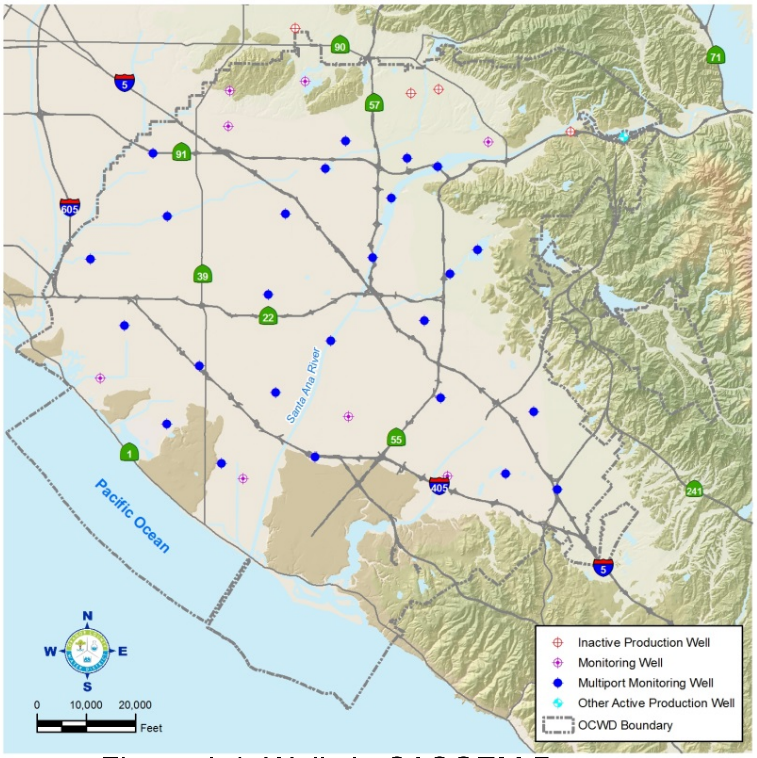


Figure 4-4: Wells in CASGEM Program

4.2.3 Water Quality Monitoring

OCWD monitors water quality in production wells on behalf of the Groundwater Producers for compliance with state and federal drinking water regulations (Figure 4-5). Samples are analyzed for more than 100 regulated and unregulated chemicals at frequencies established by regulation as shown in Table 4-1.

The total number of water samples analyzed per year varies year-to-year due to regulatory requirements, conditions in the basin and applied research and/or special study demands. In 2014, over 17,000 samples were collected by the Water Quality Department and analyzed at OCWD's state-certified Water Quality Assurance Laboratory, of which 24% were for drinking water.

Federal and State Drinking Water Standards

The Federal Safe Drinking Water Act (SDWA) directs the Environmental Protection Agency (EPA) to set health-based standards (Maximum Contaminant Levels or MCLs) for drinking water to protect public health against both naturally-occurring and man-made contaminants. EPA establishes MCLs for bacteriological, inorganic, organic, and radiological constituents. California administers and enforces the federal program and has adopted its own SDWA, which may contain more stringent state requirements. The regulations implementing the California SDWA are referred to as the Title 22 Drinking Water Standards.

Table 4-1: Monitoring of Regulated and Unregulated Chemicals

CA SWRCB Division of Drinking Water Title 22 Drinking Water: Groundwater Source Monitoring Frequency - Regulated Chemicals		
Chemical Class	**Frequency**	**Monitoring Notes**
Inorganic - General Minerals	Once every 3 years	
Inorganic - Trace Metals	Once every 3 years	
Nitrate and nitrite	Annually	New wells sampled quarterly for 1st year
Detected ≥ 50% MCL	Quarterly	
Perchlorate		New wells sampled quarterly for 1st year
Detected ≥ DLR	Quarterly	State Detection limit = 4 ppb; OCWD RDL = 2.5 ppb
Non-detect at < DLR	Once every 3 years	
Volatile organic chemicals (VOC)	Annually	New wells sampled quarterly for 1st year
Detected VOC	Quarterly	
Synthetic organic chemicals (SOC)		New wells sampled quarterly for 1st year; if non-detect, susceptibility waiver for 3 years
Simazine	Once every 3 years	Must sample 2 consecutive quarters once every 3 years
Radiological		New wells sampled quarterly for 1st year (initial screening) to determine reduced monitoring frequency for each radionuclide
Detected at > 1/2 MCL to MCL	Once every 3 years	Per radionuclide
Detected at ≥ DLR ≤ 1/2 MCL	Once every 6 years	Per radionuclide
Non-detect at < DLR	Once every 9 years	Per radionuclide
EPA and DPH Unregulated Chemicals		
CDPH : 4-Inorganic and 5-Organic chemicals	Two required GW samples: (1) Vulnerable period: May-Jun-Jul-Aug-Sep (2) 5 to 7 months before or after the sample collected in the vulnerable period. No further testing after completing the two required sampling events	Monitoring completed for existing wells in 2001- 2003; new wells tested during 1st year of operation
EPA UCMR1 - List 1: 1-Inorganic and 10-Organic chemicals		UCMR1 program completed Jan 2001 - Dec 2003
EPA UCMR1 - List 2: 13-Organic chemicals		
EPA UCMR2 - List 1: 10 Organic chemicals		UCMR2 program completed Jan 2008 - Dec 2010
EPA UCMR2 - List 2: 15 Organic chemicals		
EPA UCMR3 List 1: 7-Inorganic and 14-Organic chemicals		All water utilities serving >10,000 people. Monitoring period: Jan 2013 - Dec 2015
EPA UCMR3 List 2: 7-Organic chemicals (Hormones)		All water utilities serving population >100,000 and EPA selected systems serving <100,000 population. Monitoring period: Jan 2013 - Dec 2015

Figure 4-5: OCWD Staff Collecting Water Sample at Production Well

OCWD's water quality monitoring program for drinking water wells includes:

- Sampling of each production well (Figure 4-5) every three years (annual sampling of approximately one-third of production wells on a rotating basis) for general minerals, metals and secondary Maximum Contaminant Levels (MCLs) constituents;
- Sampling of every production well for volatile organic compounds (VOCs) and nitrates;
- Monitoring of production wells when (1) VOCs or perchlorate are detected (2) when nitrate concentrations exceed 50 percent of the primary MCL or (3) constituents exceed the secondary MCL;
- Testing for selected chemicals on the unregulated lists, chemicals with Notification Levels or new chemicals of concern at varying frequencies;
- Monitoring of newly-constructed wells for synthetic organic chemicals (SOCs) for four consecutive quarters to provide seasonal data for the California Division of Drinking Water and determining long-term monitoring frequencies; and
- Collecting and analyzing 1,161 samples in 2013 and 2014 to comply with the Federal Unregulated Contaminant Monitoring Rule Phase 3.

Monitoring for Unregulated Chemicals

EPA and the California Division of Drinking Water require monitoring for specified, unregulated chemicals. These are chemicals that do not have an established drinking water standard, but are new priority chemicals of concern. Monitoring provides information regarding their occurrence and levels detected in drinking water supply wells as the first assessment step to determine if the establishment of a standard (MCL) is necessary. Wells must be sampled twice within 12 months to comply with the unregulated chemical monitoring rules. Monitoring under the Federal Unregulated Contaminant Monitoring Rule Phase 1 and Phase 2 was completed in 2003 and 2010, respectively. Monitoring for the Federal Unregulated Contaminant Monitoring Rule Phase 3 began in January 2013 to be completed by December 2015.

4.2.4 Monitoring of Groundwater Contamination Plumes

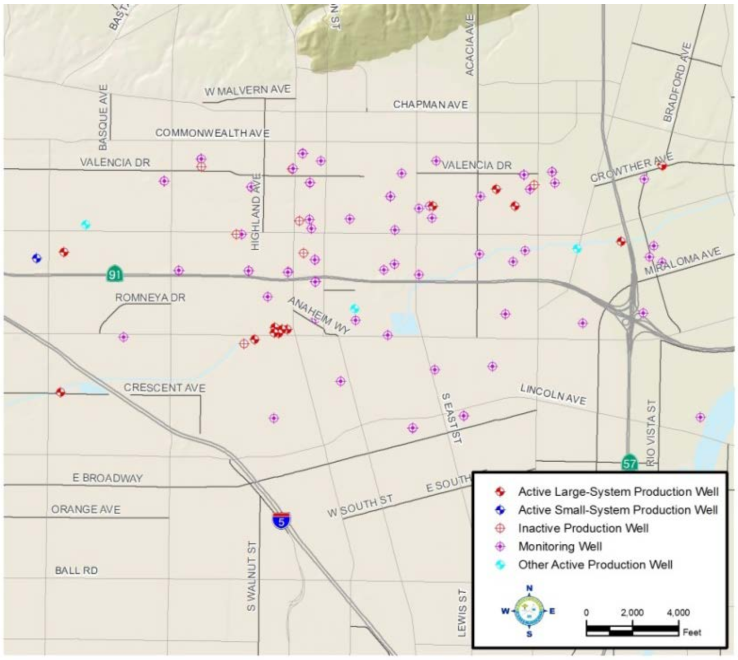


Figure 4-6: North Basin Groundwater Protection Program Monitoring Wells

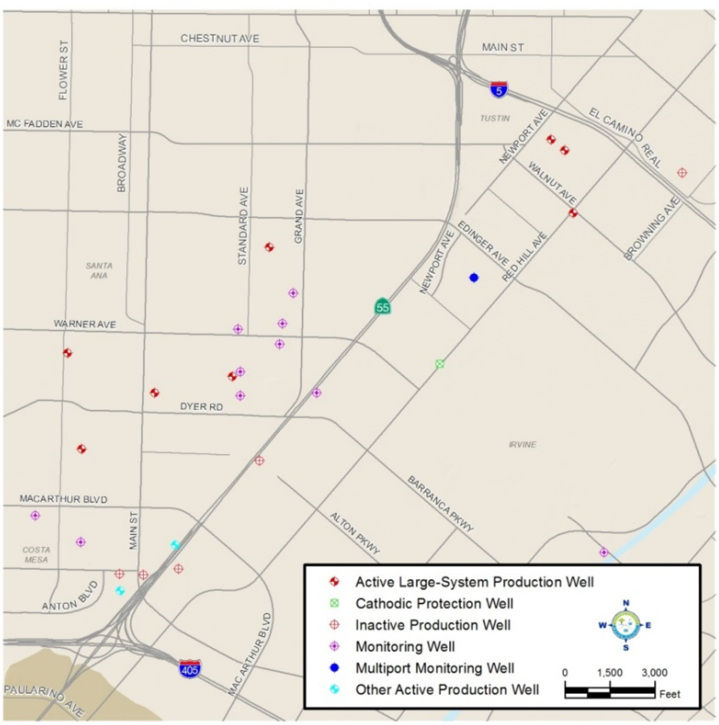


Figure 4-7: South Basin Groundwater Protection Program Monitoring Wells

In response to the discovery of VOCs in the mid-1980s, OCWD developed a comprehensive program to monitor contaminated groundwater in the basin. This extensive monitoring program led to the discovery of the former El Toro Marine Corps Air Station solvent plumes located in the City of Irvine.

Continued monitoring and installation of additional monitoring wells also resulted in the discovery of two large plumes of contaminated groundwater, one located in the north part of the basin in the Anaheim/ Fullerton area and the other located in the south part of the basin in the City of Santa Ana. Groundwater contamination in these areas is the result of industrial activities, some dating back to the 1950s and 1960s.

OCWD has and continues to work with the appropriate regulatory agencies overseeing identified sites that have contributed to groundwater contamination. OCWD has also embarked on developing projects to hydraulically contain and eventually clean up the contaminated groundwater. The northern and southern regions of contaminated groundwater are being addressed by the District's North and South Basin Groundwater Protection Programs, respectively. These projects are described in Section 8. The current groundwater monitoring networks developed for these projects are shown in Figures 4-6 and 4-7.

4.2.5 Monitoring for Seawater Intrusion

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. Over 425 monitoring and production wells are sampled semi-annually to assess water quality conditions during periods of lowest (winter) and peak production (summer).

As explained in Section 7, the Alamitos Seawater Intrusion Barrier, located along the border of Los Angeles and Orange Counties, is jointly operated by OCWD and the Los Angeles County Department of Public Works (LACDPW). LACDPW maintains and samples all barrier monitoring and injection wells including those owned by OCWD. Data is shared between the two agencies with a joint report on the status of barrier operations prepared on an annual basis.

Water levels are measured monthly in many of the coastal wells to evaluate seasonal effects of pumping and the operation of the injection barrier, as shown in Figure 4-8. A small subset of coastal wells is equipped with pressure transducers and data loggers for twice daily measurement and recording of water levels.

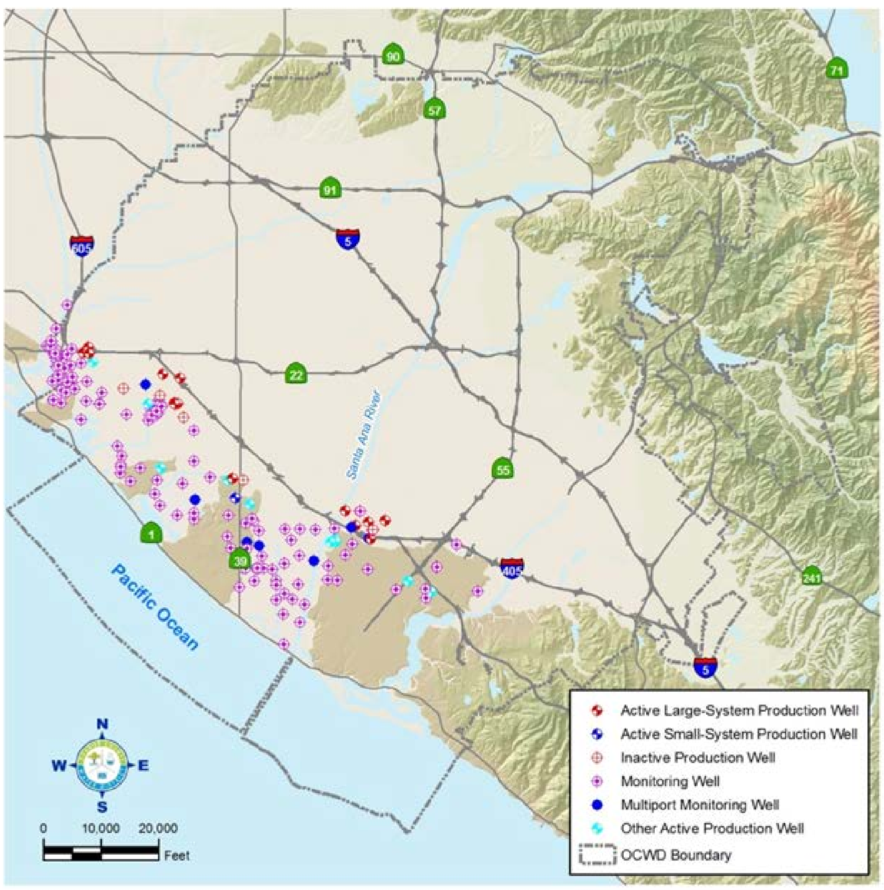


Figure 4-8: Seawater Intrusion Monitoring Wells

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 or not the freshwater mound developed by the barrier injection wells is sufficient to prevent the inland movement of saline water.

4.3 RECYCLED WATER MONITORING

Recycled water produced by the GWRS is used for injection into the Talbert Seawater Intrusion Barrier and for groundwater recharge, as described in Section 6. Use of GWRS water is regulated by the State Water Resources Control Board – Santa Ana Region and the Division of Drinking Water. 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.

GWRS product water is monitored daily, weekly, and quarterly for general minerals, metals, organics, and microbiological constituents as summarized in Table 4-2. Focused research-type testing has been conducted on organic contaminants and selected microbial species.

Table 4-2: Groundwater Replenishment System Product Water Quality Monitoring

CATEGORY	TESTING FREQUENCY
General Minerals	monthly
Nitrogen Species (NO3, NO2, NH3, Org-N)	twice weekly
TDS	weekly
Metals	quarterly
Inorganic Chemicals	quarterly
Microbial	daily
Total Organic Carbon (TOC)	daily
Non-volatile Synthetic Organic Compounds (SOCs)	quarterly
Disinfection Byproducts	quarterly
Radioactivity	quarterly
Emerging Constituents	quarterly

To comply with the permit to operate the GWRS, groundwater samples are taken from 35 monitoring wells at nine sites to monitor GWRS water after percolation or injection. Samples are also taken from additional wells downgradient and along the groundwater flow path to collect data for long-term analysis of the effect of using GWRS supply for groundwater recharge. The location of these wells is shown in Figure 4-9.

Because of the low concentration of salts in GWRS water, OCWD initiated a Metals Mobilization Study to analyze for trace metals in selected wells near and downgradient of basins used for recharge of GWRS water. The GWRS Independent Advisory Panel recommended this study to evaluate the potential of GWRS water to alter existing groundwater geochemical equilibria, such as causing metals currently bound to aquifer sediments to be released when GWRS water mixes with an aquifer matrix that is in equilibrium with the ambient groundwater.

OCWD is investigating the feasibility of injecting 100 percent GWRS water directly into the Principal Aquifer in the central part of the basin. The Mid-Basin Injection Demonstration Project consists of a test injection well (MBI-1) along with seven nearby monitoring wells (SAR-10/1-4 and SAR-11/1-3) located approximately three miles north of the Talbert Barrier, along the GWRS pipeline at the Santa Ana River and Edinger Avenue in Santa Ana.

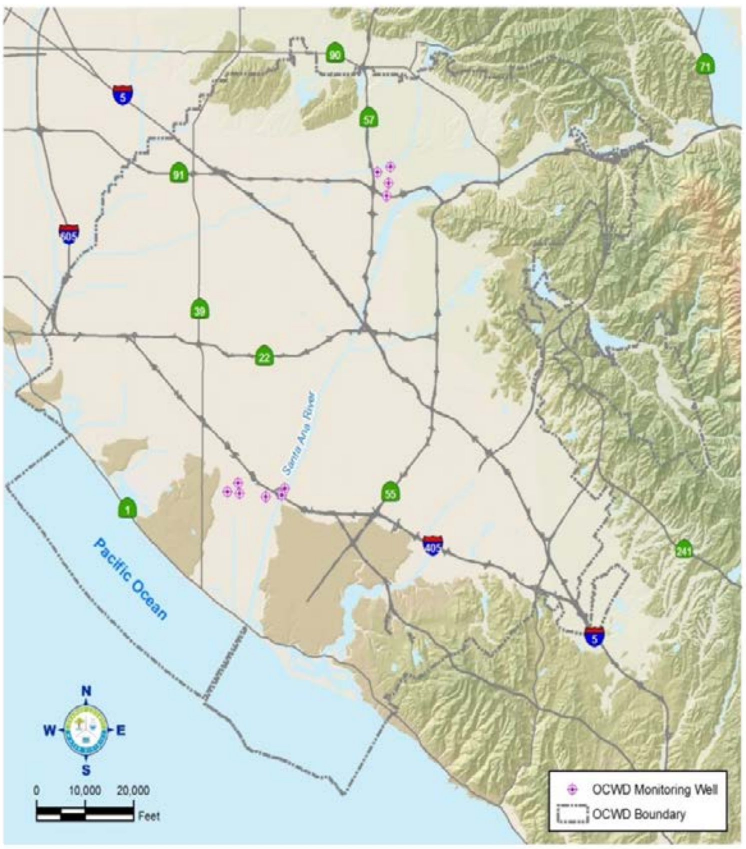


Figure 4-9: GWRS Monitoring Wells

Ambient water quality conditions are monitored in the vicinity of the demonstration project to establish a water quality baseline to evaluate the potential of metals mobilization upon injection of GWRS water and to access any other water quality changes should they occur once injection of GWRS water at the site commences. Quarterly samples are taken and analyzed for microbial, general minerals, trace metals, semi-volatile organic compounds, and radiological constituents. Data from this Mid-Basin Injection Demonstration Project will support the design and permitting of a future, full-scale project.

4.4 SURFACE WATER MONITORING

Surface water from the Santa Ana River is the predominate source of recharge supply for the groundwater basin. As a result, the quality of the surface water has a significant impact on groundwater quality. Several on-going programs monitor the condition of Santa Ana River water. Characterizing the quality of the river and its impact 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. OCWD monitoring sites along the river and its tributaries are shown in Figure 4-10.

4.4.1 Santa Ana River Monitoring

OCWD captures and recharges nearly all of the non-storm flow (base flow) in the Santa Ana River that is released through the Prado Dam, which consists predominately of tertiary-treated and disinfected wastewater discharged upstream of Prado Dam. The District assesses the long-term impacts on groundwater quality from use of this water for groundwater recharge.

Santa Ana River Water Quality and Health Study

The Santa Ana River Water Quality and Health (SARWQH) Study (OCWD, 2004) was a voluntary $10 million eight-year study that applied advanced water quality characterization methods to assess both surface water and related post-recharge groundwater quality. The multi-disciplinary study design included an examination of hydrogeology, microbiology, inorganic and organic water chemistry, toxicology and public health. The organic water chemistry component included an analysis of trace (low concentration) constituents and dissolved organic compound characterization.

Research for the SARWQH Study was conducted by scientists, researchers and water quality experts from numerous organizations, including Stanford University, Lawrence Livermore National Laboratory, USGS, Oregon State University, and Metropolitan Water District of Southern California.

At the request of OCWD, the National Water Research Institute (NWRI) conducted an independent review of the results from the SARWQH Study. NWRI assembled a group of experts in the fields of hydrogeology, water chemistry, microbiology, and the other requisite fields to form the Scientific Advisory Panel. This Panel met annually during the study to review the results and provide recommendations on future work. The results affirmed that OCWD recharge practices using Santa Ana River water are protective of public health, but that continued adaptive monitoring would be necessary. Findings from the SARWQH Study provided information necessary for the planning and permitting of other OCWD projects, such as the GWRS.

National Water Research Institute Report

The NWRI Panel concluded: “Based on the scientific data collected during the SARWQH Study, the Panel found that:

> “The SAR met all water-quality standards and guidelines that have been published for inorganic and organic contaminants in drinking water.
>
> No chemicals of wastewater origin were identified at concentrations that are of public health concern in the SAR, in water in the infiltration basins, or in nearby groundwaters.”

The constituents that were considered included non-regulated chemicals (e.g., pharmaceutically active chemicals) and contaminants of concern that arose during the course of the SARWQH study (e.g., n-Nitrosodimethylamine [NDMA]).

The unprecedented classification of the major components of DOC and the transformations that occur within these chemical classes as water moves downstream and into the aquifer provided significant new evidence to support the conclusion that the product water is suitable for potable consumption and is also becoming comparable to other sources of drinking water, such as the Colorado River, in its organic profile.” (NWRI,2004)

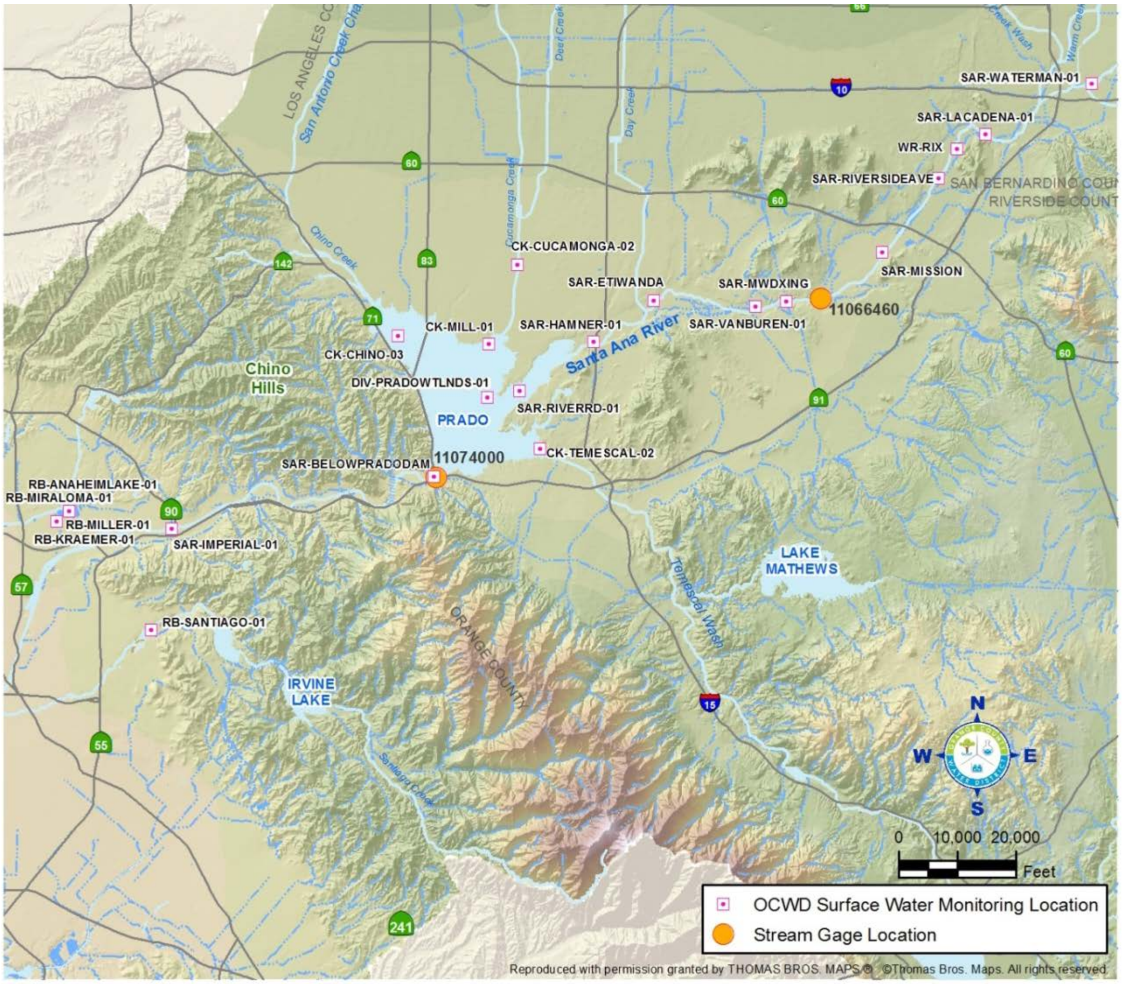


Figure 4-10: Surface Water Monitoring Locations

Santa Ana River Monitoring Program

OCWD continues to implement a comprehensive surface and groundwater monitoring program, referred to as the Santa Ana River Monitoring (SARMON) Program that includes an annual review and recommendations by the NWRI SARMON Independent Advisory Panel (IAP). Monitoring activities include sites on the Santa Ana River, Anaheim Lake, Santiago Basin and selected downgradient monitoring wells from the recharge basins to provide data on travel time and to assess water quality changes.

On-going monthly surface water monitoring of the Santa Ana River is conducted at Imperial Highway near the diversion of the river to the off-river recharge basins and at a site below Prado Dam. Sampling frequencies for selected river sites and recharge basins are shown in Table 4-3. Several points on the river and key tributaries to the river above Prado Dam, as shown in Figure 4-10 are also monitored annually for general minerals and nutrients.

Beginning 2015, the monitoring program was revised to shift monthly monitoring from Anaheim Lake to Imperial Highway. As a result of declining base flows in the Santa Ana River, more water is recharged in the riverbed and less is diverted to Anaheim Lake for percolation. Although a site on Temescal Creek is in the sampling program, it was last sampled in 2008 because the site has been dry since 2009.

Table 4-3: Surface Water Quality Sampling Frequency within Orange County

(A= annual, S= semi-annual, M = monthly, Q = quarterly)

CATEGORY	SAR Below Dam	SAR Imperial Hwy	Anaheim Lake	Miraloma/ Kraemer/ Miller Basin	Santiago Basins
General Minerals	M	M	Q	Q	M
Nutrients	M	M	Q	Q	M
Metals	Q	Q	Q	Q	Q
Microbial	M	M	Q	M	M
Volatile Organic Compounds (VOC)	Q	M	Q	Q	M
Semi-Volatile Organic Compounds (SOC)	Q	Q	Q	Q	Q
Total Organic Halides (TOX)	M	M	Q		M
Radioactivity	Q	Q	Q	Q	Q
Perchlorate	M	M	Q	Q	M
Chlorate	Q	M	Q	Q	M
NDMA Formation Potential (NDMA-FP)[1]		S			
Chemicals of Emerging Concern (CEC)[2]	Q	Q	Q	Q	Q

Notes: [1] Monitoring for NDMA-FP was conducted monthly at Imperial Highway during 2008 and quarterly between 2009-2012 at Imperial Highway and Anaheim Lake, as well as at two sites at Prado Wetlands (upstream and downstream of the wetland ponds). Since 2015, monitoring occurs at the reduced frequency indicated in the table.

[2] Samples from Imperial Highway are tested for a full suite of CECs. The other sites are tested for a reduced list of analytes.

4.4.2 Basin Monitoring Program Annual Report of Santa Ana Water Quality

The Basin Monitoring Program Task Force (Task Force) was formed in 1995 to determine and monitor the extent of and to evaluate the impact of increasing concentrations of Total Inorganic Nitrogen (TIN) and Total Dissolved Solids (TDS) in groundwater basins in the Santa Ana River Watershed (see section 9.3 for more details). As a result of this work, the Santa Ana Regional Water Quality Control Board requires that the Task Force prepare an annual report of the Santa Ana River water quality. Monitoring locations are shown in Figure 4-11.

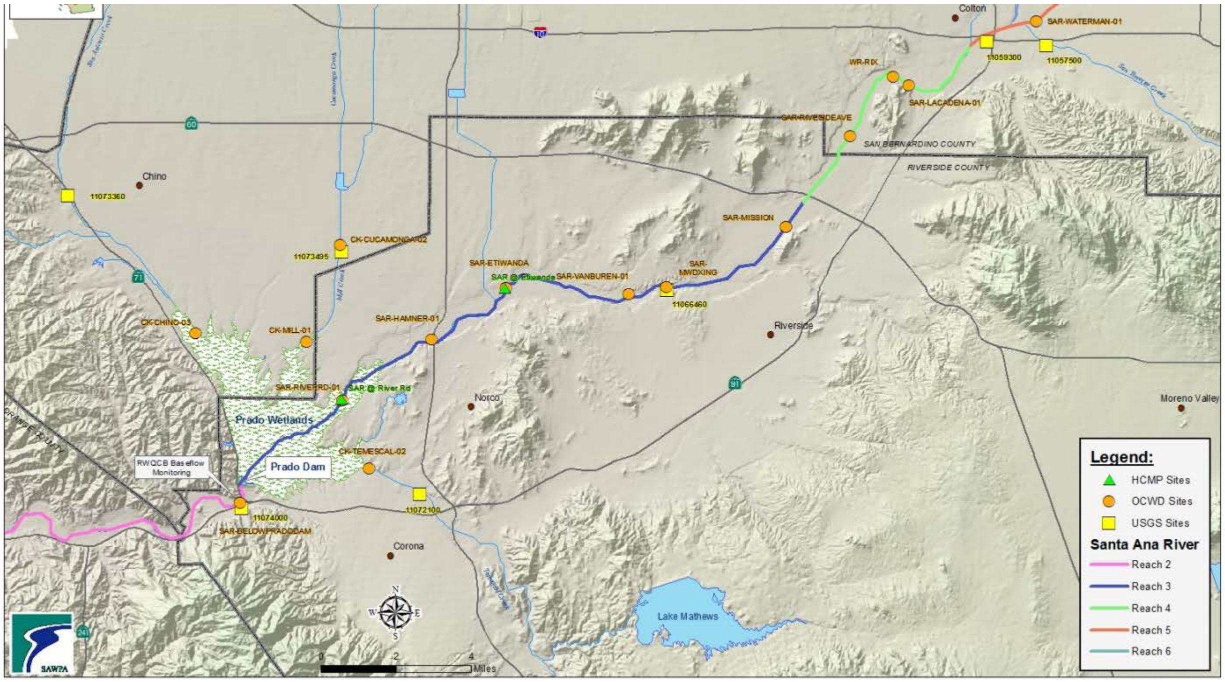


Figure 4-11: Basin Monitoring Program Task Force Monitoring Locations

4.4.3 Santa Ana River Watermaster Monitoring

The Santa Ana River Watermaster produces an annual report in fulfillment of requirements of the Stipulated Judgment in the case of Orange County Water District v. City of Chino, et.al., Case No. 117628-County of Orange, entered by the court on April 17, 1969. The Judgment settled water rights between entities in the Lower Area of the Santa Ana River Basin downstream of Prado Dam against those in the Upper Area tributary to Prado Dam. The court-appointed Watermaster Committee consists of representatives of four public entities who are responsible for fulfilling the obligations in the Judgment. These four are the Orange County Water District representing the Lower Area and San Bernardino Municipal Water District, Western Municipal Water District, and the Inland Empire Utilities Agency, representing the Upper Area.

The Watermaster annually compiles the basin hydrologic and water quality data necessary to determine compliance with the provisions of the Judgment. The data include records of stream discharge (flow) and quality for the Santa Ana River at Prado Dam and at Riverside Narrows as well as discharges for most tributaries; flow and quality of non-tributary water entering the river; rainfall records at locations in or adjacent to the watershed; and other data that may be used to support the determinations of the Watermaster.

Data collected by the USGS at two gaging stations, “Santa Ana River Below Prado” and “Santa Ana River at Metropolitan Water District Crossing” are used. Discharge data at both stations consists of computed daily mean discharges based on continuous recordings and daily maximum and minimum and mean values for electrical conductivity (EC) measured as specific conductance and twice monthly measured values for total dissolved solids.

Stream gage data collected by the USGS at the following gaging stations are also used: Santa Ana River at E Street in San Bernardino, Chino Creek at Schaefer Avenue, Cucamonga Creek near Mira Loma, and Temescal Creek in the City of Corona. Precipitation data is collected at the USGS Gilbert Street Gage in San Bernardino and by OCWD in Orange County.

4.4.4 Metropolitan Water District Imported Water

Imported water purchased by the District from the Metropolitan Water District of Southern California (MWD) is monitored for general minerals, nutrients and other selected constituents. The District may also monitor metals, volatile organics and semi-volatile organics (e.g., pesticides and herbicides). MWD performs its own comprehensive monitoring and provides data to the District upon request.

4.4.5 Prado Wetlands

Flow into and out of the District's Prado Basin wetlands are monitored to evaluate changes in water quality and to evaluate the effectiveness of the wetlands treatment. More details concerning the operation of the Prado Wetlands can be found in Section 8.5. OCWD has been monitoring the Prado Wetlands since 1998. Water samples are analyzed for field parameters, biological, inorganic, and organic constituents. Research is currently being conducted at the Prado site to evaluate alternative methods of wetlands treatment.

4.4.6 Emerging Constituents

OCWD participates in a watershed-wide Emerging Constituents Monitoring Program administered by 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. Future testing may be conducted after completion of a statewide program currently being developed by the SWRCB.

OCWD monitors 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. In addition, OCWD samples for CECs at the diversion into the Prado Wetlands once during the winter and fall and monthly from spring through summer as part of a focused study with ReNUWit (see Prado POWUP Project described in Section 4.4.7). The District also conducts a groundwater monitoring program testing for representative constituents as described in Section 8.8.

4.4.7 Special Surface Water Studies

OCWD conducts additional water quality studies as needed. Current studies are described below.

Sediment Removal Studies

One of the key impediments to maximizing the recharge capacity of the surface water system is clogging, which is primarily caused by the deposition of silts and clays in the recharge basins. An extensive research project was conducted to evaluate various methods that could be used to reduce or remove the suspended sediments from surface water prior to recharge. The two methods that were identified for additional demonstration-scale testing were Riverbed and Cloth Filtration, which are discussed in Section 5.6.

GWRS Focused Studies and Membrane Testing

These studies evaluate treatment removal efficiencies and membrane integrity assessment (new and old membranes), focusing on specific water quality assessments and may include use of external contract lab support for specific process points to aid in possibly obtaining greater removal credit for the GWRS treatment system.

Prado POWUP Project

Prado Open Water Unit Process Wetlands (POWUP) Research Project is funded by the National Science Foundation. OCWD is conducting this project with ReNUWIt (Re-inventing the Nation’s Urban Water Infrastructure) and four primary member institutions (Stanford University, UC-Berkeley, Colorado School of Mines, and New Mexico State University). OCWD’s Prado Wetlands are being used to test how wetlands treatment can be optimized with unit processes in series. The project will test the removal of pharmaceuticals and nitrates from wastewater effluent and effluent-dominated surface waters and assess the overall costs and benefits of alternative constructed wetland treatment systems.

4.5 WATER RESOURCES MANAGEMENT SYSTEM: DATABASE MANAGEMENT

Data collected by OCWD are stored in the District’s custom electronic database called the Water Resources Management System (WRMS). WRMS provides a central point of access and storage of hydrologic and hydrogeologic information. The database contains comprehensive well information, current and historical data, as well as information on sub-surface geology, water level and water quality. This database provides for subsequent retrieval and analysis of data or preparation of data reports and data submittals to other agencies. OCWD analyzes and reports data in a number of regular publications as shown in Table 4-4.

WRMS is an integrated system that is comprised of four primary components: (1) a relational database management system (RDBMS) using Oracle, (2) a geographic information system

(GIS) using ArcGIS, (3) a computer-aided drafting system (CAD) using AutoCAD, and (4) a web portal with custom applications to facilitate sharing of data between the systems and to provide an interface for users to enter, report, evaluate and analyze data.

WRMS was designed to assist Orange County Water District's engineers and scientists with the management of the groundwater basin. The foundation data set is the location and attributes of wells throughout the basin. Details about existing and historical wells, such as construction information and lithology logs, are stored in the RDBMS. Also stored in WRMS are all the historical and current time-series data, including water levels, water quality, production, and injection data associated with the wells. Additionally, the RDBMS stores information about recharge stations and percolation volumes. Typical applications include:

Aerial maps	Location of proposed new wells
Water elevation contours	Contamination plume maps
Maps of basin change in storage	Well logs
Pumping volume	Cross sections
Basin volume calculation	Well diagrams and casing details
Seawater intrusion	Time series data water level graphs
Maps of well location	Atlases and reports

WRMS provides information in the form of reports and data extraction to agencies on a regular basis, such as:

- Orange County Public Health Department
- California Department of Water Resources
- California Division of Drinking Water
- California Regional Water Quality Control Board
- California Department of Toxic Substances Control
- U.S. Environmental Protection Agency
- OCWD Groundwater Producers

The CAD applications query data stored in the WRMS assist the end-user in preparation of hydrogeologic graphics. Examples of the types of graphics include geologic cross-sections and stiff diagrams. The GIS component of WRMS provides two primary functions: production of maps and spatial analyses for planning-level studies, and as a pre- and post-processing tool for the numerical groundwater computer model of the groundwater basin. Spatial data used by the GIS includes well locations, recharge basins, water level contours, street networks, as well as additional layers, such as political boundaries. Digital aerial photography is also used for map production work.

4.6 WATER SAMPLE COLLECTION AND ANALYSIS

OCWD's laboratory, shown in Figure 4-12, is state-certified to perform bacteriological, inorganic, and organic analyses. The District utilizes state-certified contractor laboratories to analyze asbestos, dioxin and radiological samples. Analytical methods approved by the Division of

Drinking Water and the EPA are used for analyzing water quality samples for the drinking water compliance program. As new chemicals are regulated, the OCWD laboratory develops the analytical capability and becomes certified in the approved method to process compliance samples. The amount of samples analyzed is dynamic, ranging from 600 to 1,700 samples in any given month. In 2014, the lab handled nearly 20,000 samples for a total of 427,000 analytes.

Figure 4-12: OCWD Advanced Water Quality Assurance Laboratory

Water quality samples are collected in the field in accordance with approved federal and state procedures and industry-recognized quality assurance and control protocols to ensure that sampled water is representative of ambient groundwater or surface water conditions. Analyses for synthetic organic chemicals (SOCs) including tests for herbicides, pesticides, plasticizers, and other semi-volatile organics require use of 12 or more analytical methods.

Production wells that provide water for drinking water, irrigation/agriculture and industrial uses generally have well screens located in the permeable, water-bearing zones that may tap multiple aquifers. Therefore, water quality samples collected from these wells may represent water from one or more aquifers with some permeable zones providing a greater contribution than others to the overall water sample. In contrast, monitoring wells are designed and constructed with well screens placed at a specific depth and length to provide water quality at desired zones within an aquifer. Figure 4-13 illustrates the three monitoring well designs used for basin-wide water quality monitoring activities: multi-point, nested and cluster.

The multi-point well is a Westbay well design that contains a single casing with sampling ports located at specific depths in the underlying aquifers (Figure 4-14). Individual sampling points are hydraulically separated by packers. A computer-assisted sampling probe is used to collect a water sample at the desired depth. The sampling port has direct hydraulic connection between the port and the aquifer, allowing groundwater to flow into a detachable stainless steel sample container. OCWD has more than 50 multi-point wells ranging from a few hundred feet to over 2,000 feet in depth.

Sampling the nested and cluster monitoring wells may require purging of 40 to nearly 2,000 gallons of groundwater prior to sample collection. Generally, a truck equipped with one or more submersible pumps and a portable generator is used to purge and sample groundwater from these wells. Portable submersible pump and reel systems provide additional flexibility to increase the efficiency of sampling monitoring wells without dedicated pumps. One truck is outfitted with a dual system of submersible pumps and environmental hoses installed separately on hydraulic booms to sample two wells simultaneously.

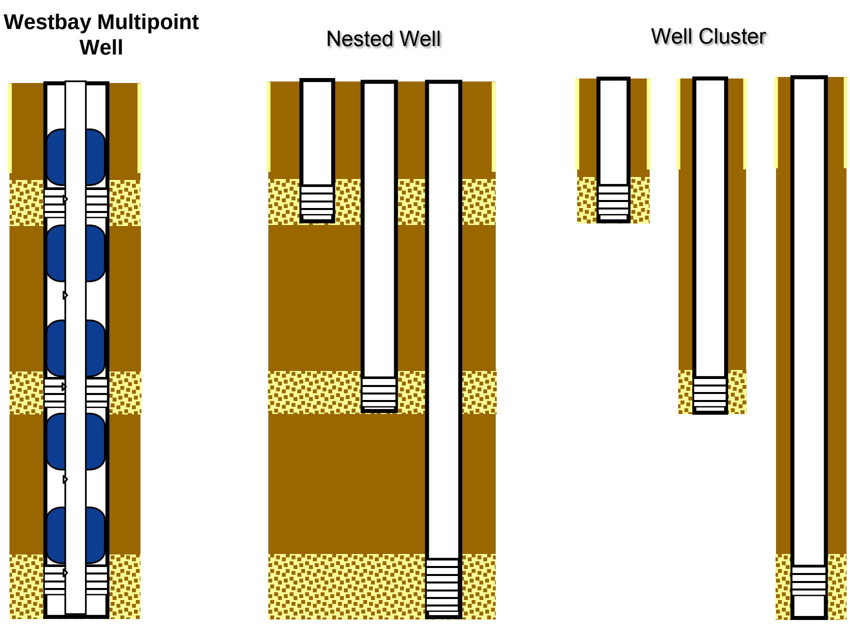


Figure 4-13: Monitoring Well Designs

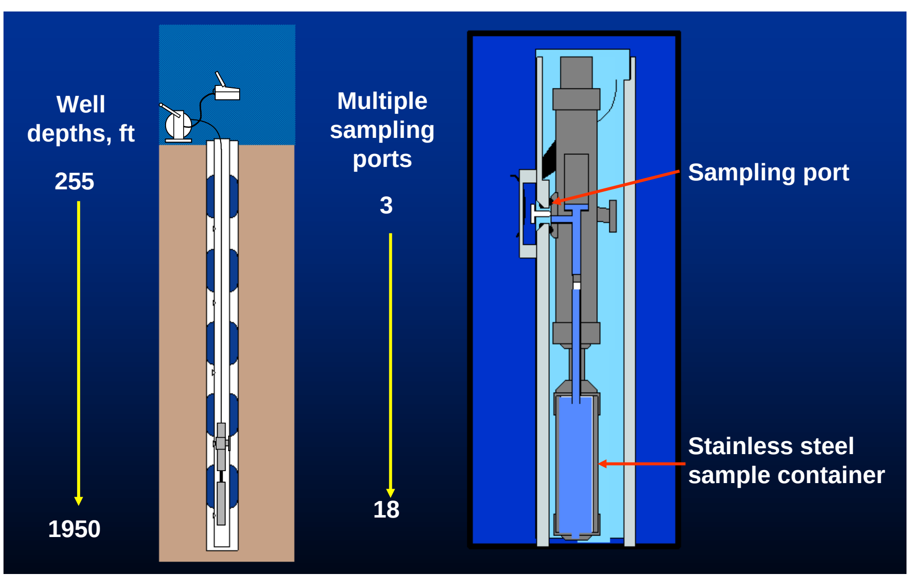


Figure 4-14: Westbay Well Schematic

4.6.1 Publication of Data

OCWD presents collected data in a number of regular publications listed in Table 4-4.

Table 4-4: OCWD Publications

Report	Publication Frequency	Contents
Engineer's Report on the Groundwater Conditions, Water Supply and Basin Utilization in the Orange County Water District	Annual	Basin hydrology, groundwater conditions, total groundwater production, groundwater levels, coastal groundwater conditions, calculation water in storage, imported water purchases; required by District Act
Santa Ana River Water Quality Monitoring Report	Annual	Surface water quality data for Santa Ana River
Groundwater Replenishment System Annual Report	Annual	Data related to the operation of the GWRS and Talbert Seawater Intrusion Barrier; required by RWQCB permit
Santa Ana River Watermaster Report	Annual	Amounts of Santa Ana River flows at Prado Dam and Riverside Narrows; required by 1969 stipulated judgment
Report on Groundwater Recharge	Periodically	Total amount of recharge to basin, including natural recharge, managed aquifer recharge, source of recharge water, & recharge facility performance

4.7 GROUNDWATER AND SURFACE WATER INTERACTIONS

Frequent and destructive flooding of the Santa Ana River in Orange County was the impetus for construction of the 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 as seen in Figure 4-15. 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 with 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 for development. Today, groundwater levels throughout Orange County are low enough that the rising and lowering of groundwater levels do not impact surface water flows or ecosystems.

From Prado Dam to Imperial Highway, the wide soft-bottomed channel supports riparian habitats. 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 data, although some infiltration may occur due to groundwater pumping in the vicinity of Green River Golf Course.

From Imperial Highway to 17th Street in Santa Ana, the river is a losing reach with surface water percolating into groundwater. 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.

Figure 4-15: Santa Ana River in Orange County,1938
Courtesy of the Anaheim Public Library

From 17th Street to near Adams Avenue in Costa Mesa, the river channel is concrete-lined for flood control with sloping concrete side levees and a concrete bottom. From Adams Avenue to the coast, the channel has 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 approximately from the ocean to the Adams Avenue Bridge.

There are no surface water bodies within the boundaries of OCWD that are dependent on groundwater. Therefore, there are no groundwater dependent ecosystems issues in the Orange County Groundwater Basin.

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 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 will threaten urban infrastructure.

MANAGEMENT AND OPERATION OF RECHARGE FACILITIES

5

Routine basin maintenance at Anaheim Lake

Management of recharge facilities to maximize groundwater recharge includes the following:

Sources of Recharge Water Supplies

- Santa Ana River
- Recycled water
- Imported water
- Precipitation

Facilities Operations

- 23 recharge facilities with storage capacity of approximately 26,000 acre-feet
- Volume of recharge estimated monthly

Recharge Studies and Evaluations

- Recharge Enhancement Working Group evaluates plans to maximize efficiency of system and develop concepts for increasing recharge capacity
- Recharge Facilities Model developed to project additional recharge for potential new projects
- Several studies evaluate future Santa Ana River flows

SECTION 5 MANAGEMENT AND OPERATION OF RECHARGE FACILITIES

5.1 HISTORY OF RECHARGE OPERATIONS

Replenishing the groundwater basin, through natural and artificial means, is essential to support pumping from the basin. Although the amount of recharge and basin pumping may not be the same each year, over the long-term recharge needs to approximately equal total pumping. Recharge water sources include water from the Santa Ana River and tributaries, imported water, and recycled water supplied by the Groundwater Replenishment System as well as incidental recharge from precipitation and subsurface inflow.

OCWD owns over 1,500 acres of land on which there are 1,067 wetted acres of recharge facilities. These facilities are located in the Forebay of the groundwater basin adjacent to the Santa Ana River (Figure 5-1) and Santiago Creek.

Managed aquifer recharge began in the 1930s, in response to declining water levels in the basin. Shortly after its formation in 1933, OCWD, in cooperation with the Orange County Flood

Figure 5-1: Santa Ana River, view upstream

Control District (OCFCD) began experimenting with methods to increase the percolation capacity of the Santa Ana River Channel. Successful experiments included removing vegetation and re-sculpting the river bank and river bottom. The District began purchasing portions of the river channel, eventually acquiring six miles of the channel in Orange County, in order to maximize the recharge of Santa Ana River water to the basin.

Recharge of imported water began in 1949 when OCWD began purchasing Colorado River water from the Metropolitan Water District of Southern California (MWD). In 1958, OCWD purchased and excavated a 64-acre site one mile from the Santa Ana River to create Anaheim Lake, OCWD's first recharge basin (Figure 5-2). Expansion of the surface water recharge system has continued to the present time; today OCWD operates a network of 25 facilities that recharge an average of over 230,000 afy. Although the surface water system provides the largest source of recharge to the basin, recharge from the seawater barriers is also an important source of recharge.

Figure 5-2: Anaheim Lake and Mini Anaheim Lake, in foreground with Miller and Kraemer Basins in background

5.2 SOURCES OF RECHARGE WATER SUPPLIES

Water supplies used to recharge the groundwater basin are listed in Table 5-1. Figure 5-3 and Table 5-2 show the average annual recharge by source between Water Years 2009-10 and 2013-14.

Table 5-1: 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
Natural 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; recharged in Kraemer, Miller, 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 Diemer Water Treatment Plant	Injected into Talbert and Alamitos Barriers

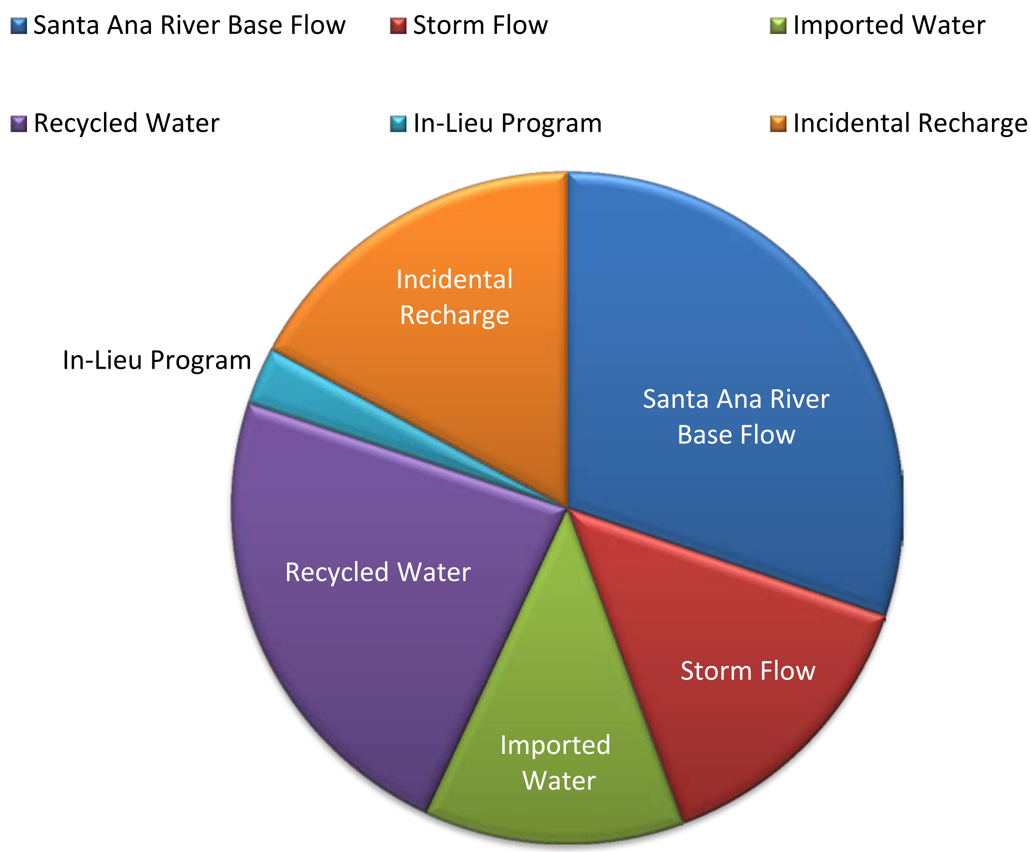


Figure 5-3: Five Year Average Recharge by Source
Water Year 2009-10 to 2013-14

Table 5-2: Annual Recharge by Source, Water Year 2009-10 to 2013-14
(acre-feet per year)

Water Year	Santa Ana River		Imported Water	Recycled Water	In lieu Recharge	Incidental Recharge	Total
	Base Flow	Storm Flow					
2009-10	103,000	59,000	22,000	67,000	0	83,000	334,000
2010-11	104,000	78,000	29,000	67,000	10,000	94,000	382,000
2011-12	95,000	32,000	42,000	72,000	31,000	27,000	299,000
2012-13	85,000	18,000	41,000	73,000	0	20,000	237,000
2013-14	65,000	25,000	53,000	66,000	0	32,000	241,000
Average	90,000	42,000	37,000	69,000	8,000	51,000	298,000
Average %	30%	14%	13%	23%	3%	17%	100%

Notes: (1) "Storm Water" includes total storm flow recharged in both the Santa Ana River and Santiago Creek, a tributary of the Santa Ana River (2) "Imported water" includes water used for Alamitos and Talbert Barriers, water purchased by and recharged by OCWD, MET CUP supply and MET CUP in lieu supply recharged in the Forebay.

5.2.1 Santa Ana River

The Santa Ana River begins in the San Bernardino Mountains and flows through the Prado Dam to Orange County, as shown in Figure 5-4. The dam was built by the U.S. Army Corps of Engineers (the Corps) in 1941 “for flood control and other purposes.”

Water from the Santa Ana River is the primary source of water used to recharge the groundwater basin. Downstream of the dam, OCWD diverts river water into recharge facilities where the water percolates into the groundwater basin. A 1969 legal settlement between OCWD and all upper watershed parties requires that a minimum of 42,000 afy of Santa Ana River base flows reach the Prado Dam. Since the 1973, base flow has exceeded the legal minimum, reaching a maximum of over 158,000 acre-feet in 1999. In July 2009, the State Water Resources Control Board approved Water Rights Permit No. 21243, which provides OCWD the right to divert and recharge up to 362,000 afy of Santa Ana River flows.

District recharge facilities are capable of recharging nearly all of the base flow. OCWD also has rights to all storm 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. Storing water behind Prado Dam significantly increases the amount of stormwater that OCWD is able to recharge into the groundwater basin.

Figure 5-4: Santa Ana River Watershed

In the 1960s, the Corps began working with OCWD to temporarily store storm water behind the dam. When rates of release through the dam are closely matched to the downstream diversion capacity, OCWD is able to maximize capture of this water supply and minimize the flow of water to the ocean. However, storing water behind the dam must be managed so as not to jeopardize the primary purpose of the dam for flood control. This is accomplished by limiting the volume of water stored behind the dam to a lower level during the storm season to maintain storage for future storm events. Outside of the storm season, the Corps allows a larger storage volume to be held behind the dam.

Agreements between OCWD and the Corps signed in 1994 and 2006 set dam operating procedures to allow temporary storage behind Prado Dam up to an elevation of 498 feet mean sea level (msl) during the flood season (October 1 – February 28), which equates to just under 10,000 acre-feet of storage. During the non-storm season, which extends from March 1 to September 30, the allowable elevation increases to an elevation of 505 feet msl, which equates to just less than 20,000 acre-feet of storage. The areas inundated behind Prado Dam and the storage for the non-storm season and storm season pools are depicted in Figure 5-5.

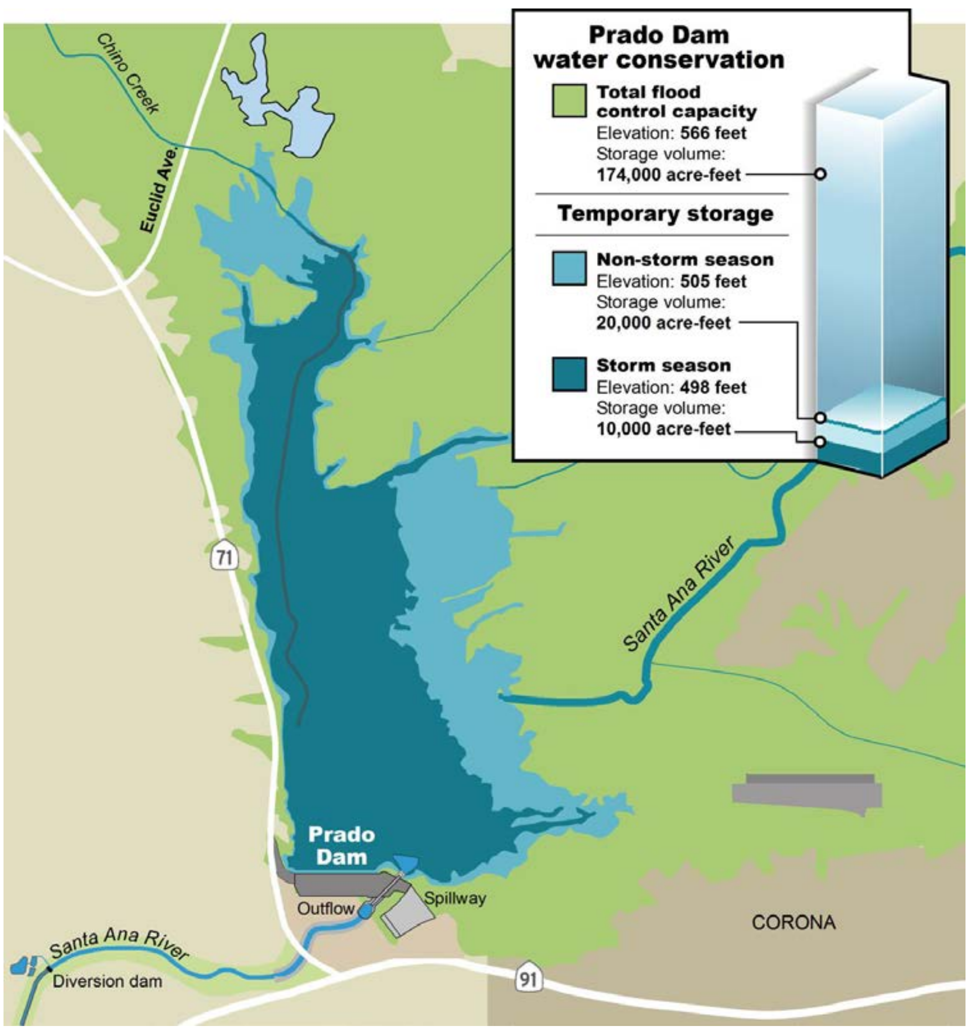


Figure 5-5: Area of Inundation and Storage Volume for Water Conservation Pools

Both the base flow and the storm flow in the Santa Ana River vary from year to year as shown in Figure 5-6**.** Recent trends show a decline in base flow, which may be a result of increased recycling, drought conditions, declining per capita water use, and changing economic conditions in the upper watershed. The volume of storm water that can be recharged into the basin is highly dependent on amount and timing of precipitation in the upper watershed, which is highly variable, as shown in Figure 5-7.

Figure 5-8 shows the amount of stormwater captured since 1936. Although storm flow averages approximately 33 percent of the total Santa Ana River flows, only approximately half of that amount is recharged by OCWD. This is primarily because most of the flows that are lost to the ocean occur during relatively brief periods of high releases from Prado Dam that exceed the District's diversion capacity. During dry years, very little water is lost to the ocean; however, in wet years, losses can be great. In water year 1997-98, for example, the District was able to capture and recharge over 74,000 acre-feet of storm flow, but was unable to capture approximately 270,000 acre-feet of storm flow.

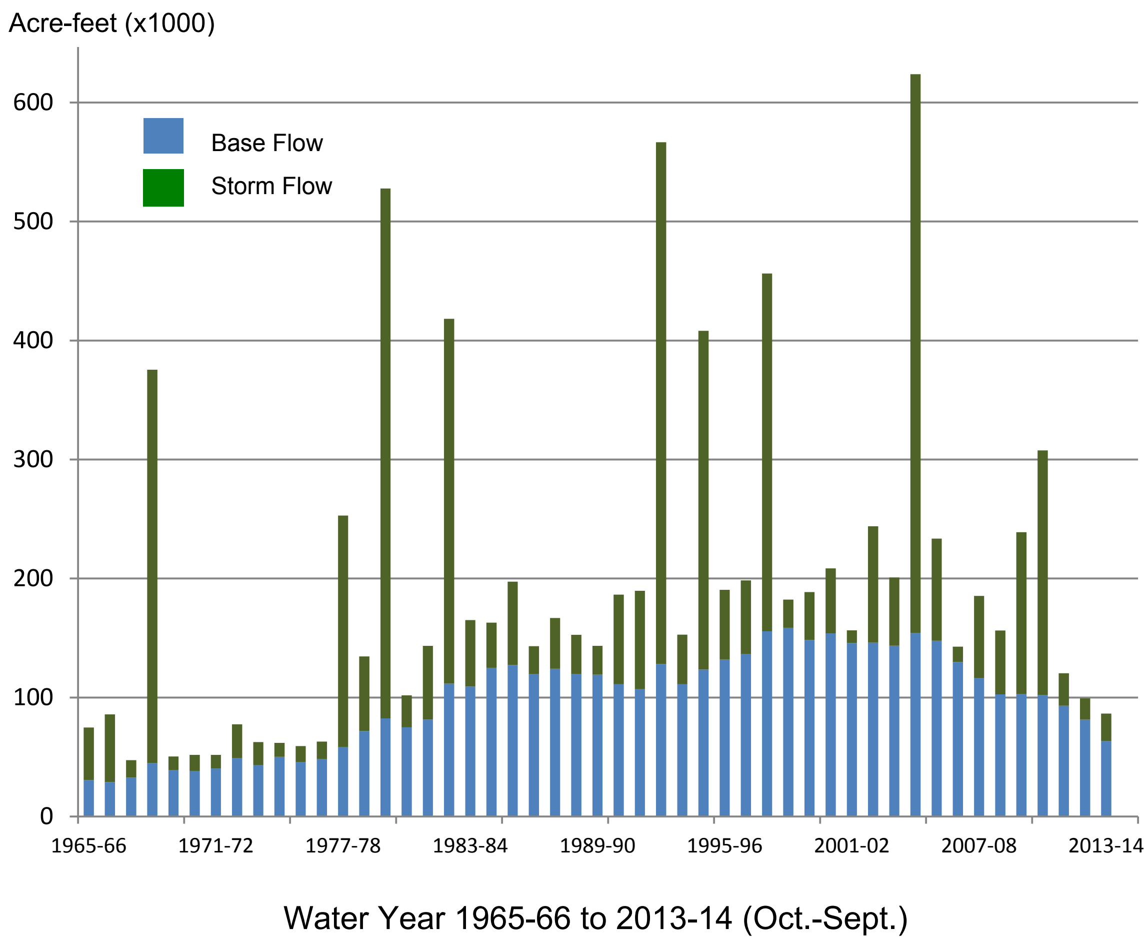


Figure 5-6: Annual Base and Storm Flow in the Santa Ana River at Prado Dam
Source: Santa Ana River Watermaster, 2014

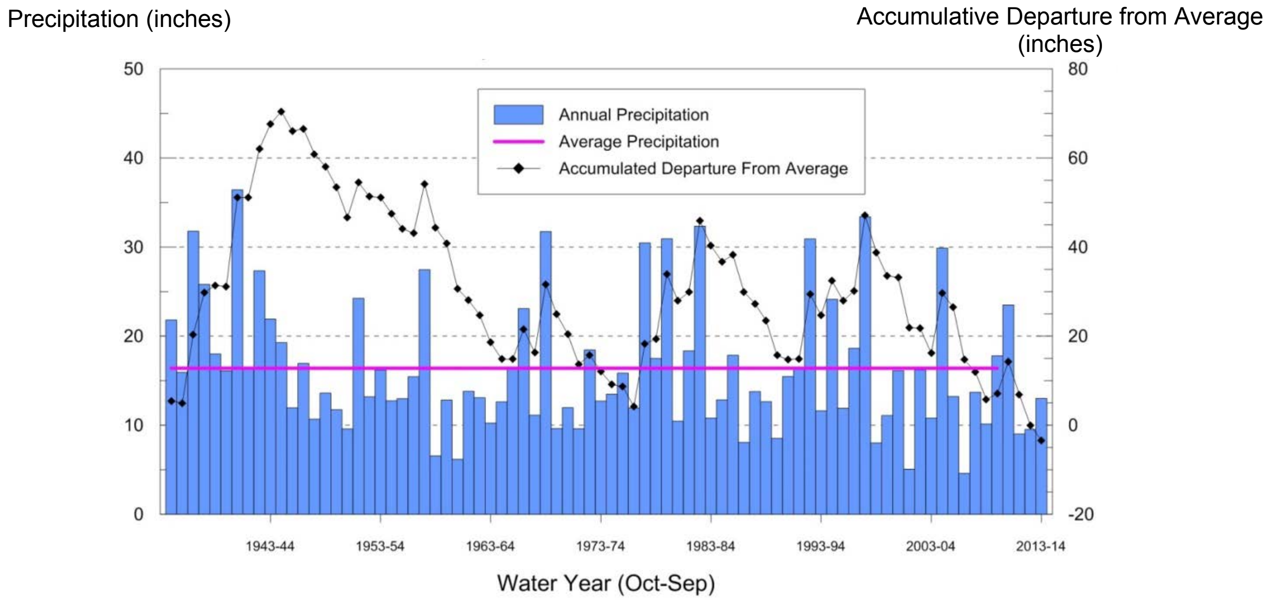


Figure 5-7: Precipitation at San Bernardino, Water Year (Oct.-Sept.) 1934-35 to 2013-14

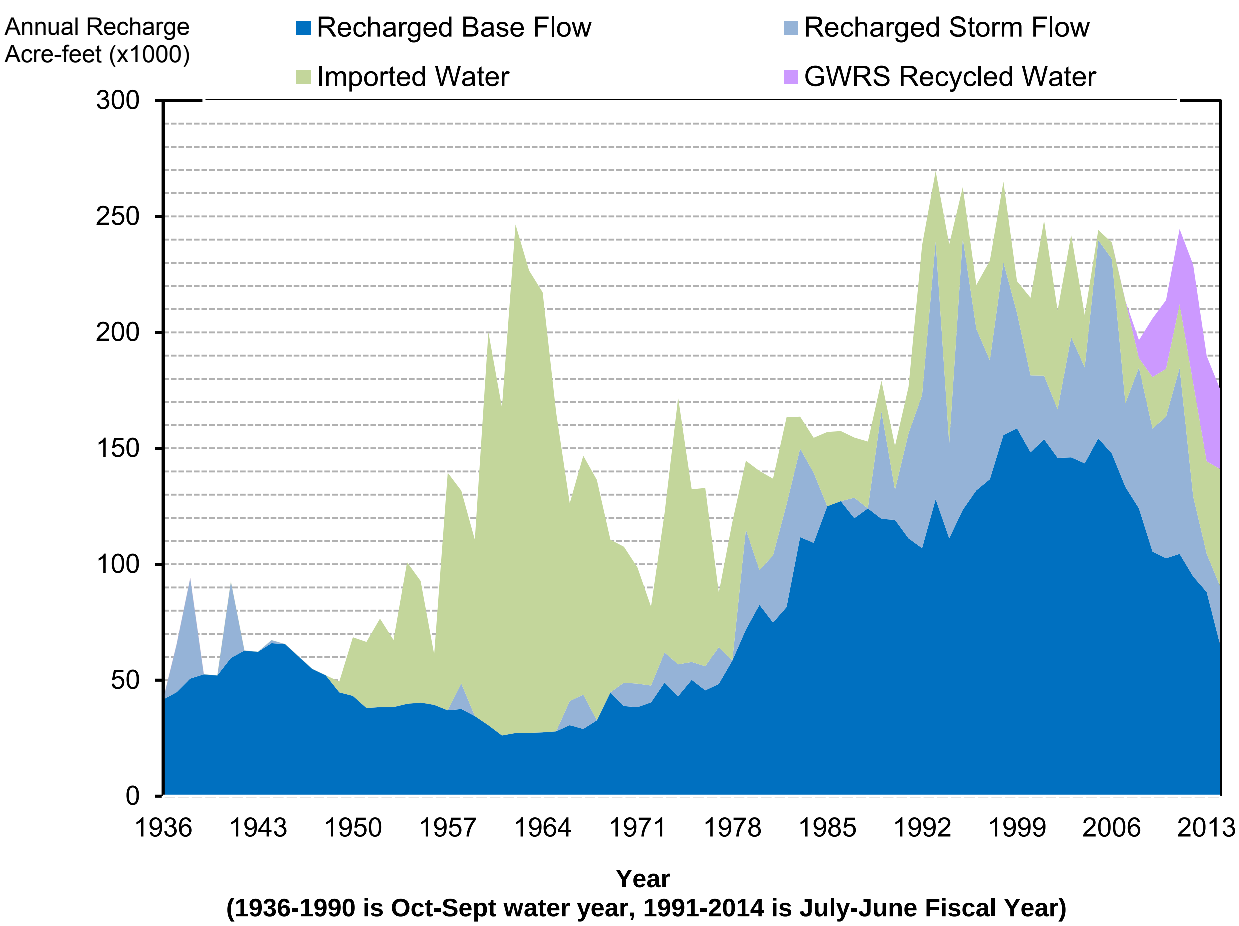


Figure 5-8: Historical Recharge in Surface Water Recharge System

5.2.2 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 as shown on Figure 5-9. Water from Santiago Creek and imported water is impounded by Santiago Dam, creating Irvine Lake, which is owned by the Irvine Ranch Water District and Serrano Water District. Downstream of Santiago Dam is Villa Park Dam, which is a flood-control facility owned and operated by the Orange County Flood Control District.

OCWD's Santiago Basins are located downstream of Villa Park Dam. These former gravel pits contain a large percentage of the storage capacity within the District's recharge system and can recharge up to approximately 125 cfs. Prior to the early 1990s, the only source of water to Santiago Basins was runoff from Santiago Creek.

In the early 1990s, the Burris Basin Pump Station and Santiago Pipeline were constructed, allowing Santa Ana River water to be pumped to Santiago Basins for recharge. Pumped water can also be diverted to the creek downstream of the basins for recharge. With completion of the Santiago Basin Pump Station in 2003, OCWD has the capacity to move water both directions in the Santiago Pipeline. This has allowed for faster draining of Santiago Basins, freeing up storage for stormwater capture and increasing the District's recharge capacity.

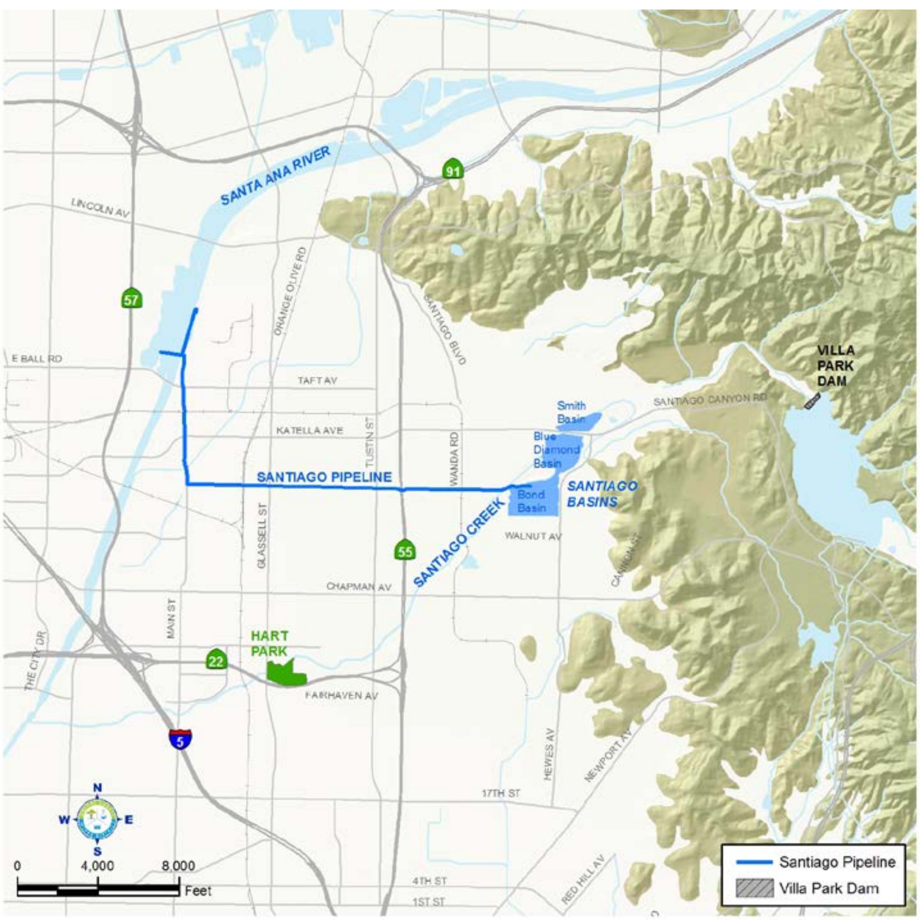


Figure 5-9: Santiago Basins and Santiago Creek

During average rainfall conditions, the District captures and recharges an estimated 50,000 to 70,000 afy of storm flow, with much of this recharge taking place in the Santiago Basins.

Some groundwater producers in the general vicinity of the Santiago Basins have low groundwater levels at their production wells when the amount of groundwater in storage declines. This occurs to some extent because the aquifer is relatively thin in the east Orange area compared to the aquifer thickness in the middle portion of the groundwater basin. OCWD seeks to recharge as much water possible in the Santiago Basins subject to various operational constraints and limitations on the amount of available recharge water.

Currently recharge in Santiago Creek is limited to the reach between Santiago Basins and Hart Park in the city of Orange. The parking lot of Hart Park occupies the creek channel, making it difficult to convey water safely through the park. The District is currently evaluating projects that will allow for the lower reach of the creek downstream of Hart Park to be used for recharge of Santa Ana River water.

5.2.3 Natural Recharge

Natural recharge, referred to in Section 3 as unmeasured or incidental recharge, is comprised of subsurface inflow from the local hills and mountains, (see Figure 3-5), 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 natural recharge cannot be directly measured, it is commonly referred to as incidental or unmeasured recharge. Each year, an estimate is made of the amount of subsurface flow that flowed across the Los Angeles-Orange County line. In general, since the Central Basin in Los Angeles County is 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. Figure 5-10 shows the amount of net incidental recharge from WY 2000-01 to 2013-14. Note the correlation between amount of precipitation and net incidental recharge.

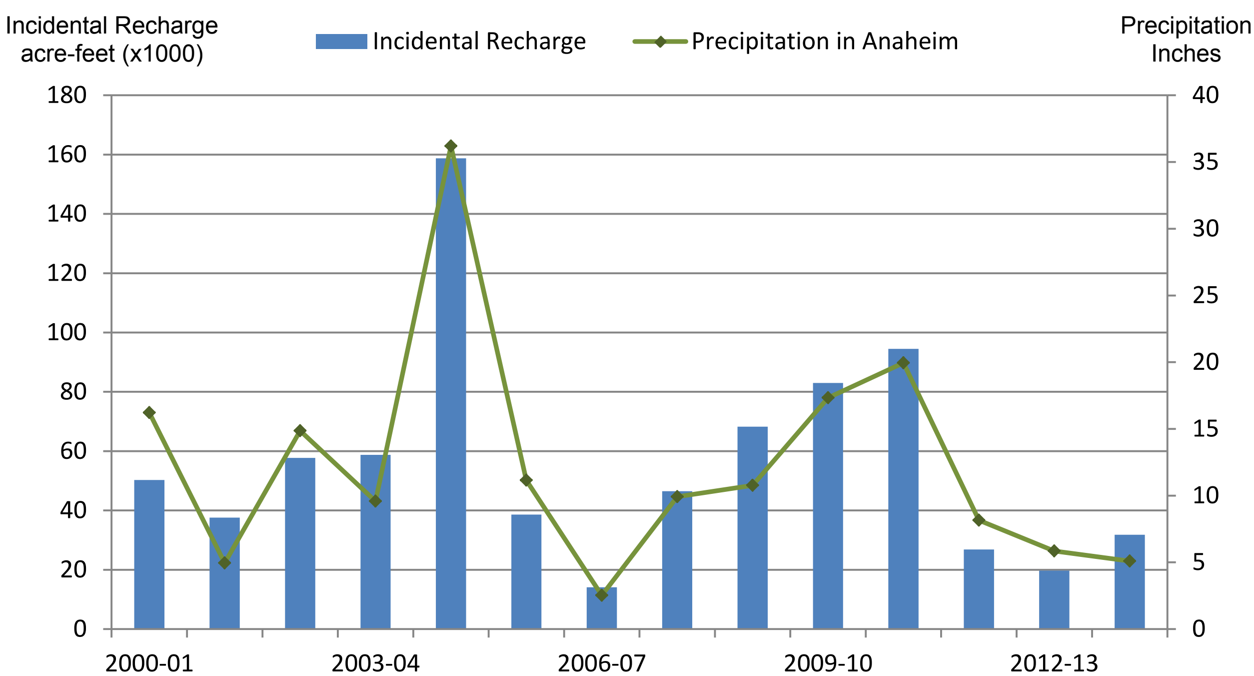


Figure 5-10: Net Incidental Recharge and Precipitation, WY 2000-01 to 2013-14

5.2.4 Recycled Water

The basin receives two sources of recycled water for recharge. The main source is the GWRS, which has capacity to produce 102,000 afy of recycled water. This water is recharged in the surface water system and the Talbert Seawater Barrier. Operation of GWRS is explained in detail in Section 6.

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 3,300 afy to approximately 9,000 afy. Only 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.

5.2.5 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). Connections OC-28, OC-11 and OC-13 supply OCWD with Colorado River Aqueduct water. Connection OC-59 supplies OCWD with State Water Project water and OC-28A supplies OCWD with a variable blend of water from these two sources.

Treated imported water was used extensively for in-lieu recharge from 1977 to 2007. During this time frame, OCWD recharged over 900,000 acre-feet of water using in-lieu recharge purchased from MWD. The MWD discontinued the in-lieu program in 2012. When the program was operational, OCWD would ask groundwater pumpers to participate by turning off their wells and take imported treated water in-lieu of pumping groundwater. OCWD would pay the pumpers the incremental additional cost of taking imported water versus groundwater to make the cost of this water equivalent to groundwater.

Control of Quagga Mussels

Quagga mussels are an invasive species that were found in 2007 in Lake Mead, a reservoir on the Colorado River. These mussels grow quickly to form massive colonies. Not only are natural ecosystems disrupted, but spread of these invasives can block water intakes causing significant disruption and damage to water distribution systems.

MWD has a *Raw Water Discharge Plan* to manage the spread of quagga mussels within the imported water system. Within Orange County, the mussels were found in Irvine Lake, Rattlesnake Reservoir, and Walnut Canyon Reservoir. Methods to control the quagga include desiccation and chlorination.

OCWD recharges Colorado River water in Anaheim Lake, Mini-Anaheim Lake, Kraemer Basin, La Jolla Basin, and Raymond Basin. To control the spread of quaggas, OCWD only uses Colorado River Water in basins that can be completely drained and desiccated. As a result of the quagga mussels, OCWD can no longer recharge Colorado River water in the Santa Ana River or any other facility that cannot be fully desiccated.

5.3 SURFACE WATER RECHARGE FACILITIES

The District's surface water recharge system is comprised of 23 facilities covering over 1,000 wetted acres and a total storage capacity of approximately 26,000 acre-feet, as listed in Table 5-3. The locations of these facilities are shown in Figure 5-11. Section 5.3.1 illustrates the operation of the recharge system. OCWD carefully tracks the amount of water being recharged in each facility on a daily basis.

Table 5-3: Area and Storage Capacities of Surface Water Recharge Facilities

FACILITY	Wetted Area (acre-feet)	Maximum Storage Capacity (acre-feet)[1]
Anaheim Lake	72	2,260
Burris Basin	120	2,670
Conrock Basin	25	1,070
Five Coves Basin: Lower	16	182
Five Coves Basin: Upper	15	164
Foster-Huckleberry Basin	21	630
Kraemer Basin	31	1,170
La Jolla Basin	6.5	26
Lincoln Basin	10	60
Little Warner Basin	11	225
Miller Basin[2]	25	300
Mini-Anaheim Lake	5	13
Miraloma Basin	9.8	63
Off-River Channel	89	N/A
Olive Basin	5.8	122
Placentia Basin[2]	9	350
Raymond Basin[2]	19	370
River View Basin	3.6	11
Santa Ana River: Imperial to Orangewood Ave.	291	N/A
Santiago Basins	187	13,720
Santiago Creek to Hart Park[3]	10	N/A
Warner Basin	70	2,620
Weir Ponds 1-4	33	252
TOTAL	1,085	26,278

Notes: (1) Maximum storage capacity is typically not achieved for most facilities due to need to reserve buffer space for system flow and level fluctuations. (2) Owned by Orange County Flood Control District. Maximum storage capacity shown is the maximum flood control storage. (3) Basin is not owned by OCWD. Owners include OCFCD, City of Orange, and MWD.

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. The monthly figures are compiled to determine yearly recharge and production totals. A monthly report from 2014 is presented in Appendix F.

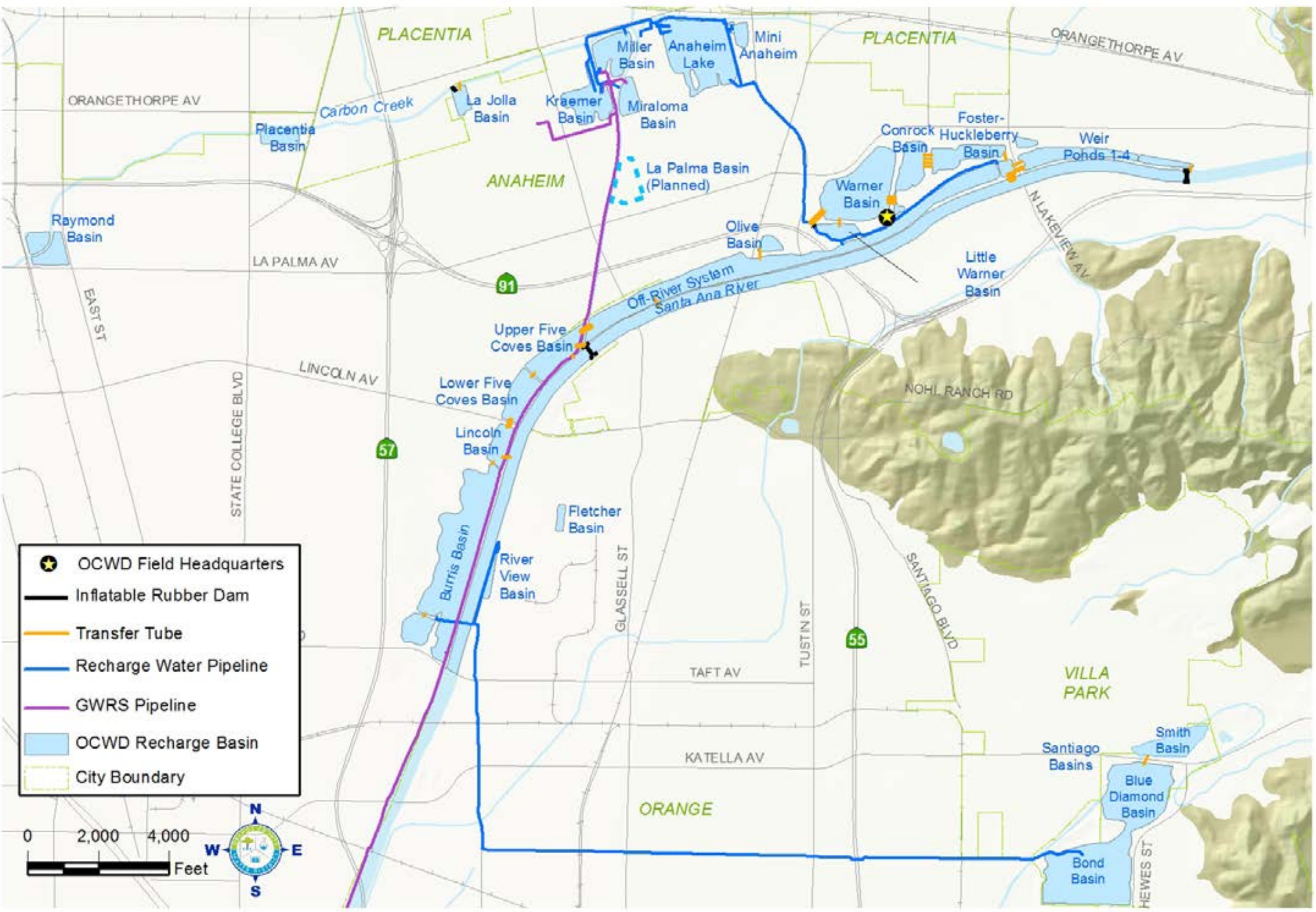


Figure 5-11: OCWD Surface Water Recharge Facilities

5.3.1 Surface Water Recharge System

Below Prado Dam

Water released at Prado Dam naturally flows downstream and percolates through the river's 300-400 foot wide unlined channel bottom that consists of sandy, permeable sediment.

OCWD actively manages recharge in an approximate 6 mile stretch of the river channel from Imperial Highway to Orangewood Avenue. This reach covers an area of over 290 acres

Santa Ana River in Anaheim

The Imperial Inflatable Dam diverts up to 500 cfs of Santa Ana River water into the recharge system. Flows are also bypassed around the dam to downstream facilities.

Imperial Rubber Dam

Weir Ponds 1, 2, 3, and 4, also referred to as the Desilting System, are used to remove sediment from Santa Ana River water.

Flows are split at Weir Pond 4 to flow either to the Warner Basin Subsystem (Foster-Huckleberry, Conrock, Warner, and Little Warner Basins) or to the Off-River Channel

Warner Basin

From Warner Basin, water is conveyed by pipeline to Anaheim Lake and then to Miller and Kraemer Basins. Water can then be conveyed in Carbon Creek to La Jolla, Placentia and Raymond Basins.

Kraemer Basin

Water conveyed into the Off-River Channel, which parallels the main river channel, percolates into the sandy channel bottom. This 200-foot wide channel is separated from the Santa Ana River by a 2.3-mile-long levee. Remaining flows can be recharged in Olive Basin or conveyed to Five Coves Basins. The Five Coves Basins can also receive water directly from the Santa Ana River diverted at the Five Coves Inflatable Dam.

From Five Coves, water flows into Lincoln and Burris Basins.

Off-River Channel

From Burris Basin, water is pumped to Santiago Basins by the Burris Basin Pump Station through the 60-inch diameter, five-mile long Santiago Pipeline. Pumped water is percolated in the Santiago Basins, (Blue Diamond Basin, Bond Basin, and Smith Basin), River View Basin and Santiago Creek. The Santiago Basins are used to recharge and store stormwater to be conveyed back to recharge basins when capacity is available.


Santiago Basin


Santiago Creek

Pumps in Burris and Santiago Basins allow for release of water into Santiago Creek for percolation.


Lower Santa Ana River

Water that remains in the Santa Ana River is managed to maximize infiltration; levees constructed in the river bed spread water across the width of the river channel. River water reaches the Pacific Ocean in Huntington Beach only when flow exceeds recharge capacity, which typically occurs only during large storm events.

Recycled water produced at the GWRS in Fountain Valley is conveyed through a 13-mile pipeline located in the west levee of the Santa Ana River to OCWD recharge basins. GWRS recycled water is primarily percolated in Kraemer, Miller and Miraloma Basins.

5.4 MAINTENANCE OF RECHARGE FACILITIES

OCWD recharge basins range in depth from 10 to 60 feet. Portions of their side-walls and bottoms are composed of natural, sandy, permeable materials that allow water to percolate into the aquifer. Percolation rates vary depending on the size and depths of the basins; rates slow significantly as fine-grained sediment particles accumulate on the basin bottoms. Most of the basins can be drained and cleaned to remove this clogging layer, thereby restoring percolation rates and increasing recharge efficiency.

Percolation rates tend to decrease with time as basins develop a thin clogging layer along the bottom. The clogging layer develops from fine grain sediment deposition and from biological growth, shown in Figure 5-12. Percolation rates are restored by mechanical removal of the clogging layer utilizing heavy equipment such as bulldozers and scrapers.

Figure 5-12: Recharge Basin showing Accumulated Clogging Layer

OCWD maximizes recharge in the Main River System by removing the clogging layer (Figure 5-13) and bulldozing a series of sand levees in the river. These levees maximize recharge by spreading the water across the width of the river to maximize the wetted surface area. Typically, water flows at a velocity sufficient to prevent the accumulation of fine sediment and biological growth. The riverbed is also cleaned naturally, when winter and spring stormflows wash out the levees and scour the bottom. When necessary, heavy equipment is used to move sediments in order to restore the high percolation rate. Sand levees remain intact until flows exceed approximately 350 cfs, at which time they erode and water flows from bank to bank in the riverbed. Although percolation is believed to remain high during these high flow conditions, rates are difficult to measure.

Figure 5-13: Bulldozer in Off-River Channel Removing Clogging Layer

5.5 RECHARGE STUDIES AND EVALUATIONS

The District has an ongoing program to continually assess potential enhancements to existing recharge facilities, evaluate new recharge methods and analyze potential new recharge facilities. The planning and implementation horizon for recharge facilities varies from a near term horizon of five to 10 years for development of specific projects to 50-year projections of the future availability of recharge water supplies, as described below.

5.5.1 Recharge Enhancement Working Group

The Recharge Enhancement Working Group is comprised of staff from multiple departments that works to maximize the efficiency of existing recharge facilities and evaluate new concepts to increase recharge capacity. Staff from recharge operations, hydrogeology, engineering, research and development, regulatory affairs, and planning departments meets on a regular basis to review new data and evaluate potential new projects.

Proposed projects under investigation are continually changing as needs and conditions change. Potential projects/concepts considered include reconfiguration of existing basins, operational improvements to increase flexibility in the management of the basins, alternative basin cleaning methods, potential sites for new basins, and control of sediment concentrations, are discussed and prioritized.

5.5.2 Computer Model of Recharge Facilities

One of the challenges the District faces in determining the value of improving existing recharge facilities, storing more water at Prado Dam and purchasing new recharge facilities is estimating the amount of additional water that could be recharged due to a potential project. Given the complexity and interconnectivity of the recharge system, a model was needed to isolate the impacts of various proposed projects in order to determine the increased recharge potential due to a specific project.

OCWD developed the Recharge Facilities Model, which is a computer model of the District's recharge system that simulates Prado Dam operations, Santa Ana River flow and each recharge facility. This model is primarily a planning tool that is used to evaluate various conditions including estimating recharge benefits if new recharge facilities are constructed, existing facilities are improved, increased storage is achieved at Prado Dam, or baseflow changes occur in the Santa Ana River. The model can be operated by District staff from a desktop computer using a graphical user interface.

The Recharge Facilities Model was completed in 2009 with the assistance of CH2M HILL and is based on GoldSim software, which is a general simulation software solution for dynamically modeling complex systems in business, engineering and science http://www.goldsim.com/Home/) (CH2M HILL, 2009).

Key features of the Recharge Facilities Model include:

- Ability to simulate different surface water inflow scenarios (e.g., high base flow, low base flow, etc.)
- Inflatable rubber dam operations (e.g., diversion rates, deflation/inflation)
- Conveyance capacity of system (e.g., pipeline and pumping capacities)
- Basin recharge capacities
- Reductions in basin capacities caused by clogging
- Maintenance thresholds that cause basins to be taken out of service and cleaned
- Different Prado Dam conservation pool elevations and release rates
- Different sedimentation levels behind Prado Dam
- Ability to add imported water to system when excess capacity is available

Output from the model includes:

- Amount of water recharged in each facility, storage at Prado Dam, release rates from Prado Dam, storage in each facility, etc.;
- Amount of water that could not be recharged and water losses to the ocean;
- Optimal amount of cleaning operations;

- Available (unused) recharge capacity; and
- Amount of imported water that can be recharged using unused capacity.

The RFM is flexible and allows for the development and simulation of a wide array of different scenarios. Figure 5-14 presents an overview of the system as it appears in GoldSim. Examples of how the model has been used to evaluate potential recharge projects include:

- Estimate of the additional amount of water available for recharge if the water conservation pool behind Prado Dam is raised to 505 msl year round (see Section 5.2.1).
- Estimate of the impact of the recent trend toward decreasing base flows in the Santa Ana River.
- Estimate of how much imported water could be purchased using unused system capacity.

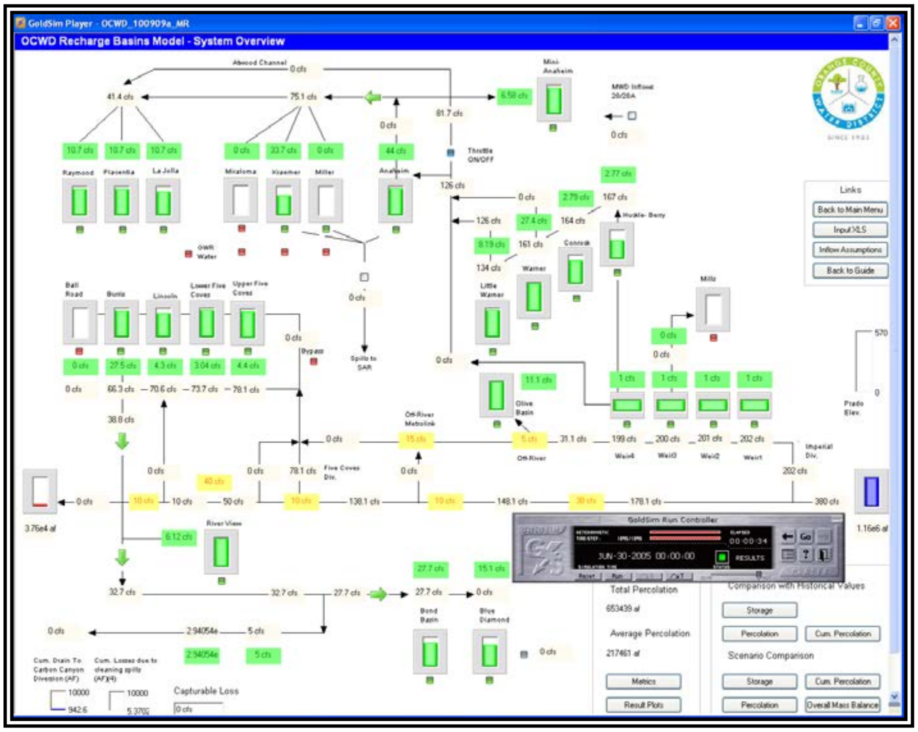


Figure 5-14: Recharge Facilities Model System Overview

5.5.3 Future Santa Ana River Flow Projections

OCWD prepares projections or works with other agencies to prepare projections of Santa Ana River flows. The results of the projections are highly variable, as explained below.

<u>OCWD Assessment of Future Santa Ana River Flows Below Prado Dam, 2006</u>

OCWD applied to the State Water Resources Control Board (SWRCB) for a permit to divert a wet-year maximum of 505,000 afy of water from the Santa Ana River at the District's diversion facilities below Prado Dam. As part of the 2006 application, the SWRCB requested that OCWD prepare a water availability assessment to confirm that the volume of water would be available in the future.

To prepare the assessment, the District used flow data collected by the Santa Ana River Watermaster which showed that more than 505,000 afy of water was recorded in the lower Santa Ana River in recent years preceding the study. Future wet-year flow estimates were developed taking into account planned upstream diversions to calculate conservative future wet-year Santa Ana River flow below Prado Dam. This assessment concluded that the requested diversion of 505,000 afy is reasonably foreseeable in future wet years downstream of Prado Dam.

The Corps Prado Basin Water Supply Feasibility Study, 2004

The Corps' report *Prado Basin Water Supply Feasibility Study Main Report and Draft Environmental Impact Statement, 2004* estimated future Santa Ana River flows to assist in evaluating the flood control and water conservation capabilities of the dam. Between 1990 and 2003 the maximum flow occurred in 1993 when the USGS gage below Prado Dam recorded a total of 571,138 acre-feet. The Corps used a 39-year hydrologic base period (federal water year 1950-1988) and Corps projected watershed conditions through 2052. These projections factored in changes in stormwater runoff due to increased urbanization in Riverside and San Bernardino counties and population projections as well as estimates of wastewater effluent discharges to the river upstream of the dam.

The Corps projected that future annual flow in the Santa Ana River at Imperial Highway will fluctuate between approximately 300,000 and 868,000 afy. These projections include a net contribution of 21,000 afy from the nine miles of the river between Prado Dam and Imperial Highway.

SAWPA Santa Ana River Flow Estimates, 2004

SAWPA produced an independent estimate of future SAR flows at Prado Dam for the period 2010 and 2025. The estimates included baseflow and stormflow for dry, average, and wet years. Stormflow estimates were based on the average historical peaks ranging from 18,300 to 340,300 afy. Estimates of wastewater discharges included reductions in discharge due to increased recycling of wastewater. Base flow projections for 2025 ranged from 197,000 afy to 222,000 afy.

OCWD/Corps Study, 2014

Projections of future Santa Ana River flows were developed for OCWD and the Corps to evaluate the feasibility of increasing the volume of water that can be stored behind Prado Dam. (WEI, 2014) An existing model developed by Wildermuth Environmental, Inc. (WEI) called the Waste Load Allocation Model (WLAM), was used to estimate non-discharge inputs contributing to river flows. The WLAM is a hydrologic simulation tool of the Santa Ana River watershed tributary to Prado Dam and was developed for the Santa Ana Watershed Project Authority (SAWPA) by WEI (WEI, 2009). WEI began development of the WLAM for SAWPA in 1994 and has improved it over time to support numerous water resources investigations.

The WLAM uses historic rainfall and stream flow along the model boundaries for the 50-year period from 1950 to 1999. The model also accounts for the contribution of rising groundwater to Santa Ana River flows. The volume of rising groundwater has decreased in recent years due to lower groundwater levels in the southern portion of the Chino Groundwater Basin. Groundwater levels in this area are expected to remain low as this is part of the basin management strategy to reduce the migration of poor quality groundwater into the Santa Ana River.

Estimated future discharges of water from wastewater treatment plants to the Santa Ana River are expected to decline due to conservation and increased recycling. This, along with reductions in rising groundwater, means that projected Santa Ana River base flows reaching Prado Dam are significantly lower than what occurred from the early 1990s to 2005.

As a result of this work, OCWD developed three Santa Ana River base flow projections:

1. High Base Flow Condition: 101,700 afy
2. Medium Base Flow Condition: 52,400 afy
3. Low Base Flow Condition: 36,000 afy

Per the 1969 Stipulated Judgment in the case of Orange County Water District v. City of Chino, et al., Case No. 117628-County of Orange, a minimum annual Santa Ana River base flow of 42,000 afy is required to reach Prado Dam. However, a system of credits in the judgment allows the Santa Ana River base flow to be as low as 34,000 afy until the credits are exhausted. Given the large credit that exists due to many years of base flow exceeding 42,000 afy, the minimum flow of 34,000 afy could be in place for many decades. Even though the minimum allowable base flow is 34,000 afy, the annual base flow simulated was 36,000 afy due to minor variations in rising groundwater produced by the WLAM.

In developing estimates of future Santa Ana River storm flows arriving at Prado Dam, land use conditions in the WLAM were reviewed. For future conditions, SCAG 2005 land use data was modified to represent future (2071) land uses. The assumptions made in modifying the 2005 land use data were: (1) already developed urban areas and surrounding mountain areas were assumed not to change; (2) dairy, poultry, intensive livestock, as well as land use classified as “other agriculture” were assumed to be developed; and, (3) vacant and undeveloped areas were also assumed to be developed by 2071. In addition, all new developed land use in 2071 was assumed to be high density residential. This analysis resulted in an increase in high density residential area of approximately 71 square miles, a decrease dairy, poultry, horse ranch, etc. areas by approximately 11 square miles, and a decrease in undeveloped areas by approximately 59 square miles.

The increased runoff generated by future land uses is offset by plans for storm water harvesting by upstream agencies. Plans were identified for future storm water harvesting from Seven Oaks Dam, diversions from the Santa Ana River and its tributaries, and on-site infiltration that would be required by the Municipal Separate Storm Sewer System (MS4) permit. To develop the lowest flow condition possible, it was assumed that projects that have reached the environmental review stage would be constructed. As a result, the average annual storm flow arriving at Prado Dam is reduced by 27,360 afy (WEI, 2014b).

Future estimates of Santa Ana River storm flow arriving at Prado Dam are presented in Table 5-4. The three Santa Ana River base flow conditions were combined with the estimated storm flow arriving at Prado Dam to develop three inflow conditions as summarized in Table 5-5.

Table 5-4: Estimated Future Santa Ana River Storm Flow Arriving at Prado Dam

STORM FLOW RUNOFF CONDITION	Average Storm Flow to Prado Basin (afy)
Current Land Uses	118,000
Future (2071) Land Uses	125,970
Future (2071) Land Uses, Maximum Storm Water Harvesting	98,610

Table 5-5: Santa Ana River Flow Conditions and Estimated Average Inflow to Prado Dam

CONDITION	DESCRIPTION	Santa Ana River Flow to Prado (afy)		Total Average Flow (afy)
		Average Base Flow	Average Storm Flow	
High	High Base Flow, Current Land Uses	101,700	118,000	219,700
Medium	Medium Base Flow, Future (2071) Land Uses	52,400	125,970	178,370
Low	Low Base Flow, Future (2071) Land Uses, Maximum Storm Water Harvesting	36,000	98,610	134,610

5.5.4 Evaluation of Potential Projects to Increase Basin Recharge

Sixteen potential recharge projects were evaluated using the Recharge Facilities Model (RFM) as part of the preparation of the District's Long-Term Facilities Plan 2014 Update. Key assumptions used in the RFM are as follows:

1. The Prado Dam conservation pool is operating at 505 feet year round. Work to raise the flood season pool from 498 to 505 feet is ongoing and is expected to be completed and implemented in the next few years.

2. All GWRS water conveyed to Anaheim, including flows from the final expansion of GWRS, will be recharged in Miraloma Basin and planned La Palma Basin. This assumption frees up the capacity of the remainder of the recharge system for Santa Ana River flows and imported water.

The approach to modeling each project was to compare the total system recharge with and without the project for each flow condition. For example, total system recharge was modeled for the high flow condition with and without a project. The difference in the recharge obtained for the entire system comparing the two runs defined the benefit of the project being modeled. This was then repeated for the medium and low flow conditions. Table 5-6 shows the additional yield produced by each potential project for the high, medium, and low flow conditions.

The RFM was also used to evaluate the loss of storm flow capture that will result as sediment continues to accumulate in the Prado Basin. Based on the historical rate of sediment accumulation of approximately 350 acre-feet per year, the storage within the conservation pool is projected to fill up within the next 50 years. When the conservation pool becomes filled with sediment, the eventual loss of storm water available for recharge will range from 30,000 to 38,000 acre-feet per year.

Table 5-6: Annual Yield of Potential Surface Water Recharge System Projects based on Recharge Facilities Model

PROJECT NAME	Santa Ana River Flow Condition (afy)		
	High	Medium	Low
Desilting Santa Ana River Flows	10	390	10
Enhanced Recharge in Santiago Creek at Grijalva Park	10	10	85
Subsurface Collection and Recharge System in Off-River and Five Coves	610	730	150
Enhanced Recharge in Santa Ana River Between Five Coves/Lincoln Ave.	10	220	20
Enhanced Recharge in Santa Ana River Below Ball Road	730	600	230
Recharge in Lower Santiago Creek	270	150	90
Five Coves Bypass Pipeline	130	10	10
Five Coves Bypass Pipeline with Lincoln Basin Rehabilitation	710	490	100
Placentia Basin Improvements	75	170	260
Raymond Basin Improvements	40	230	350
River View Basin Expansion	10	100	10

PROJECT NAME	Santa Ana River Flow Condition (afy)		
	High	Medium	Low
Additional Warner to Anaheim Lake Pipeline	10	10	30
Lakeview Pipeline	10	10	10
Warner System Modifications	210	250	10
Anaheim Lake Re-contouring	10	125	10

5.6 RECHARGE FACILITIES IMPROVEMENT PROJECTS AND STUDIES 2009-2014

The District regularly evaluates potential projects and conducts studies to improve the existing recharge facilities and build new facilities. This may include:

- Increasing the capacity to transfer water from one basin to another;
- Improving the removal of the clogging layer that forms on the bottom of basins;
- Removing shallow low-permeability silt or clay layers beneath recharge basins;
- Reconfiguring a basin to improve infiltration rates;
- Converting an underperforming basin to a new type of recharge facility; and
- Evaluating potential sites for new recharge facilities such as existing flood control facilities and sites for construction of new basins.

Recharge improvement projects and studies completed since publication of *the Groundwater Management Plan 2009 Update* include the following:

Sediment Removal Demonstration Projects

Clogging of the District's recharge facilities is caused primarily by suspended sediments in Santa Ana River water. To a limited extent, clogging is also caused by biological growth supplied by the organic carbon and nutrients in the recharge water. Recharge rates achieved when using water with little to no suspended sediment, such as imported water from the Metropolitan Water District of Southern California (MWD) and highly treated recycled water from GWRS, are two to three times greater than what is achieved with Santa Ana River water.

In an effort to maximize the recharge of storm water, the District embarked on a multi-phased Sediment Removal Study. Phase I of the study identified a number of sediment removal technologies for testing. Phase II of the study included bench-scale testing of five different treatment technologies, including:

- Flocculation-Sedimentation
- Dissolved Air Floatation (DAF)
- Ballasted Sedimentation

- Cloth Filtration (with and without chemical pre-treatment)
- Riverbed Filtration

In Phase III, research continued on two of the removal technologies: Cloth Filtration without chemical pretreatment in 2013 and Riverbed Filtration in 2014.

The Riverbed Filtration Project is located in the Off-River Channel adjacent to the main Santa Ana River Channel. This project uses the natural treatment obtained by infiltration in native sediments to remove suspended sediments. For this system, a large underground network of collection pipes were installed three-to-five feet below the surface of the Off-River channel. Water flows by gravity into these pipes and then to Olive Basin, which has been plumbed to only receive this filtered water. Initial results indicate that this method removes virtually all of the suspended sediment in the water and improves water quality in ways similar to that seen in recharge basins.

The Cloth Filter Demonstration Project is located at River View Basin. Extensive water quality testing showed that this technology was marginally effective in reducing suspended solids concentrations; however, it did not, as expected, affect other water quality parameters. Testing of the cloth filter system will continue, but the scope of water quality testing has been reduced to monitoring for turbidity and total suspended solids.

Miraloma Basin

Miraloma Basin is a new recharge basin that was placed online in 2012. OCWD acquired the former 13-acre industrial site adjacent to existing recharge basins in Anaheim as shown in Figure 5-15. Construction included excavation, demolition and hauling, construction of water supply pipelines with appurtenances for flow control and metering, a pump station, integration with OCWD supervisory control and data acquisition (SCADA) system, site improvements to facilitate operations and maintenance, as well as landscape improvements. The new 10-acre recharge basin is dedicated to recharge GWRS product water and has capacity to recharge approximately 20,000 to 30,000 afy.

Figure 5-15: Miraloma Basin

Mid-Basin Injection Demonstration Project

As the GWRS is expanded, an increased supply of recharge water will be available. In order to recharge this supply of water, the Mid-Basin Injection Project is being considered. This would involve using high-quality GWRS water for direct injection into the Principal Aquifer in the central portions of the groundwater basin. By directly injecting water into the Principal Aquifer where most of the pumping occurs, low groundwater levels due to pumping can be reduced. Also, mid-basin injection would reduce the recharge requirement in Anaheim and Orange area recharge basins, thus providing more capacity to recharge Santa Ana River and imported water. A demonstration well and two monitoring wells were constructed to evaluate the feasibility of a full-scale injection project.

Burris and Lincoln Basins Reconfiguration

Modifications to Burris and Lincoln basins were completed to improve recharge capability. Low-permeability sediments were excavated from Lincoln Basin and the northern end of Burris Basin and the conveyance channel between the two basins was reconfigured.

Santiago Basins Pump Station

A floating pump station, shown in Figure 5-16, was constructed to dewater the Santiago Basins to increase storm flow capture and percolation, to make storage available for winter season use, to provide water to the Santiago Creek for percolation, and to increase operational flexibility by pumping water back to Burris Basin when necessary. Operation of the pump station for the basins increased recharge capacity and allowed for more flexible and efficient operations.

Figure 5-16: Santiago Basins Pump Station

Olive Basin Pump Station

A dewatering pump station was constructed to allow for more frequent basin cleanings and to maintain infiltration rates. The increase in average annual recharge capacity is estimated to be 1,600 afy with maximum increase of 4,800 afy. Improvements to Olive Basin will allow the basin to be drained more rapidly for cleaning. An intake structure with a 36-inch diameter fill pipe was constructed to allow water to flow from the Off-River System into the deepest part of the basin. This decreased the amount of sediment stirred up in the basin, thereby increasing the recharge performance.

Santa Ana River Sediment Characterization Study

The Santa Ana River channel is one of the District's most productive recharge facilities, recharging approximately 100 cubic feet per second (cfs), similar to the performance of Anaheim Lake when freshly cleaned. The transport and deposition of sediment, primarily sand, is important to maintaining recharge in the river bottom. However, Prado Dam traps the majority of sand flowing down the river just upstream of Orange County causing changes in bed material composition in the river downstream.

Downstream loss of sand results in coarsening of sediment and armoring. Coarsening refers to the increase in sediment grain size, as seen in Figure 5-17, and armoring is a condition where coarser sediments eventually interlock or harden with fine sediments and form an armored layer. Both conditions cause a reduction in infiltration rates.

An OCWD investigation studied trends in the sediment characteristics in the river (Golder Associates, 2009). The results highlight the importance of addressing long-term sediment transport in the Santa Ana River. The study reached the following conclusions:

- Areas of armoring were observed in the river bed between Prado Dam and Imperial Highway, particularly in the floodplain portion of the river outside the natural low-flow channel.
- Below Imperial Highway, coarsening of sediment was observed but armoring was not observed due to OCWD maintenance activities reworking sediment with earth moving equipment.
- Continued coarsening of riverbed material and scour are expected in the river recharge reach below Imperial Highway. Coarsening may result from: 1) entrapment of sand at Prado Dam, 2) removal of fine material caused by moderate flows, and 2) deposition of coarse bed material originating from the reach between Imperial Highway and Prado Dam during high flows.
- The erosion that is expected to occur downstream of grade control and drop structures during moderate to high flows could result in additional deposited coarse material concentrating in those sections.
- The riverbed particle packing density is expected to increase as the riverbed material coarsens resulting in decreased permeability. Additionally, there is greater potential for fine-grained sediments transported by river flows to migrate to greater depth, such that they are more difficult to remove, causing a reduction in the permeability of the riverbed sediments.

Figure 5-17: Sand and Cobble Sediments in Santa Ana River Channel

GROUNDWATER REPLENISHMENT SYSTEM

6

GWRS Water Pump Station and RO Electrical Building

The Groundwater Replenishment System began operation in 2008.

<u>Overview</u>

- Produces up to 100 million gallons per day
- Recycled water used for groundwater recharge and seawater barrier operations

<u>Treatment Process</u>

- Microfiltration
- Reverse osmosis
- Ultraviolet light with hydrogen peroxide

<u>Water Quality Monitoring</u>

- Independent Advisory Panel evaluates monitoring programs
- Network of monitoring wells used to track travel times from recharge sites to production wells

SECTION 6 GROUNDWATER REPLENISHMENT SYSTEM

6.1 OVERVIEW

The Groundwater Replenishment System (GWRS) is a joint project built by OCWD and the Orange County Sanitation District (OCSD) that began operating in 2008 (see Figure 6-1). Wastewater that otherwise would be discharged to the Pacific Ocean is purified using a three-step advanced process to produce high-quality water used to control seawater intrusion and recharge the Orange County Groundwater Basin. The GWRS produces up to 100 million gallons per day (mgd) of highly-treated recycled water. The system includes three major components (1) the Advanced Water Purification Facility (AWPF), (2) the Talbert Seawater Intrusion Barrier and (3) recharge basins where GWRS water is percolated into the groundwater basin, schematically illustrated in Figure 6-2.

Secondary-treated wastewater is conveyed to OCWD from OCSD Plant No.1, located adjacent to the District's facilities in Fountain Valley. The water undergoes an advanced treatment process that includes microfiltration, reverse osmosis and advanced oxidation/disinfection with hydrogen peroxide and ultraviolet light exposure followed by de-carbonation and lime stabilization. The Full Advanced Treated (FAT) water is used for groundwater recharge, to supply the Talbert Seawater Barrier and provide recycled water for three industrial/commercial users. The AWPF produces up to 100 mgd or approximately 112,000 afy. Approximately 34% of the water is injected in the Talbert Barrier and 66% is percolated in the recharge basins. Industrial and commercial uses include cooling water for the City of Anaheim's Canyon Power Plant, recycled water for the Anaheim Regional Transportation Intermodal Center, and hydrostatic testing of new secondary treatment basins at OCSD Plant No.1.

The Talbert Seawater Intrusion Barrier consists of a series of 36 injection well sites that are supplied by pipelines from AWPF. OCWD constructed the injection barrier to form an underground hydraulic mound, or pressure ridge, to manage seawater intrusion near the coast in the Talbert Gap area. The Talbert Barrier wells also serve to replenish the groundwater basin with injection of purified, recycled water into the Main Aquifer.

In addition to supplying the Talbert Barrier, GWRS water is recharged in Kraemer, Miller and Miraloma basins, located in the city of Anaheim. Water is conveyed to these basins through a 13-mile pipeline in the west levee of the Santa Ana River through the cities of Fountain Valley, Santa Ana, Orange, and Anaheim and along the Carbon Canyon Diversion Channel. Five feet in diameter at its end point, this pipeline is capable of delivering over 80 million gallons of highly-treated recycled water to the basins each day.

Figure 6-1: Aerial View of the Groundwater Replenishment System

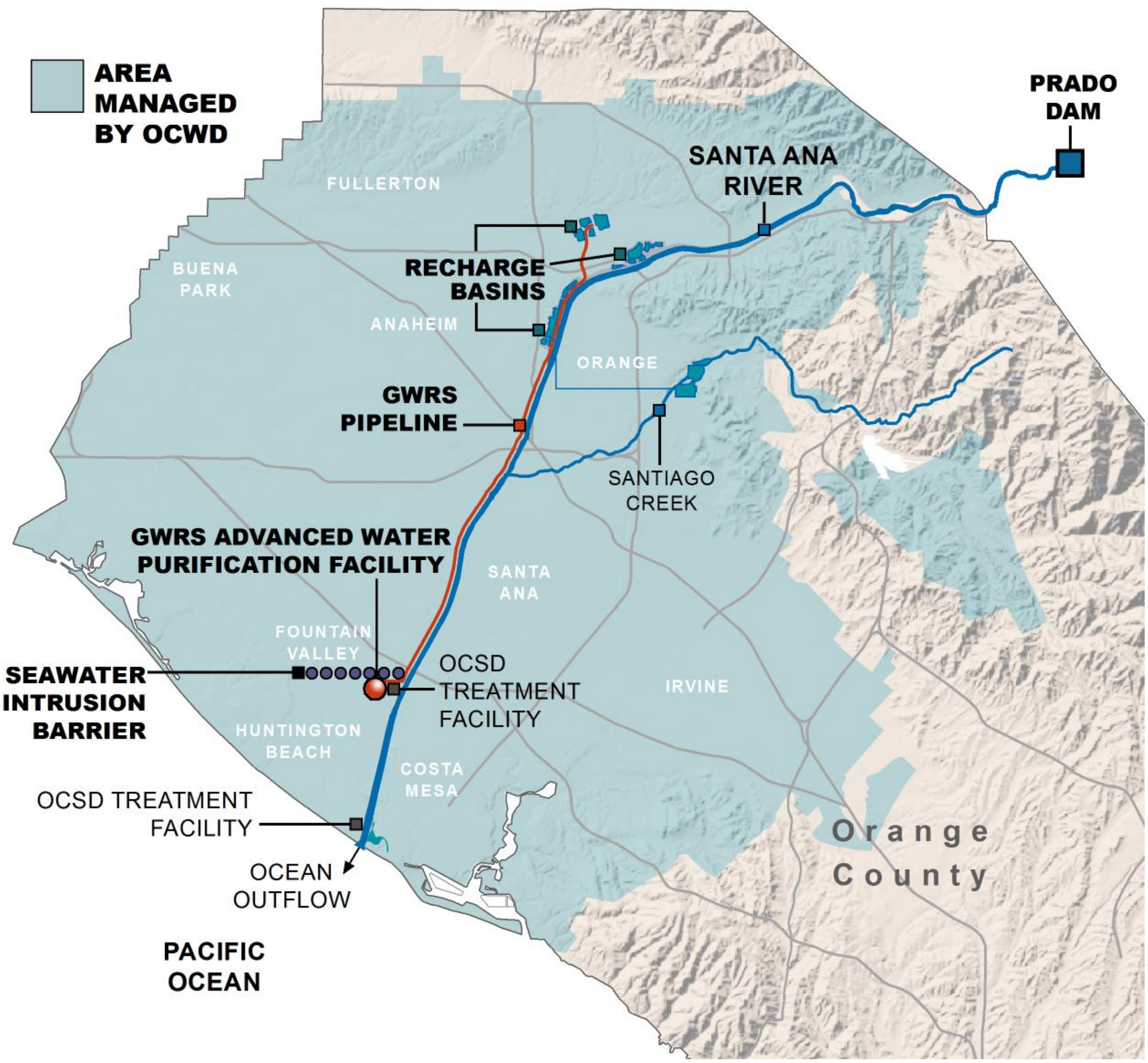


Figure 6-2: Groundwater Replenishment System Facilities

6.1.1 History

The need for a reliable water supply for the Talbert Barrier led to the construction of Water Factory 21 (WF 21) in 1975. This 15-mgd advanced water purification plant treated secondary treated wastewater from OCSD with lime clarification, ammonia stripping, re-carbonation, multimedia filtration, granular activated carbon (GAC) adsorption, and chlorination. A 5-mgd reverse osmosis (RO) demineralization plant was added to the process in 1977 to reduce total dissolved solids in the product water.

WF 21 was the first plant in the world to use RO to purify wastewater to drinking water standards. The GAC-treated water and RO-treated water were blended with groundwater and imported water to supply the injection wells and recharge the groundwater basin. Due to new water quality issues in 2000, WF-21 subsequently used only RO-treated water.

Figure 6-3: Water Factory 21, circa 1975

By the mid-1990s, OCWD needed a larger supply of water to manage seawater intrusion. Plans to build the GWRS plant coincided with OCSD's need to build a second ocean outfall to dispose of increased wastewater flows. Expanding the advanced water treatment plant, therefore, would not only increase water supplies for OCWD but would also reduce the volume of secondary-treated wastewater and provide an alternative to a second ocean outfall.

The original WF 21 ceased operations in 2004. At that time Interim Water Factory 21 (IWF 21) operated for two years while the GWRS was being built. In addition to continuing the seawater intrusion prevention effort, IWF 21 served as a training facility, enabling staff to become familiar with the treatment processes being developed for the GWRS facility. Plant modifications included the addition of microfiltration and low-pressure high-intensity ultraviolet light with hydrogen peroxide to create an advanced oxidation process. The new processes, together with the existing RO system retrofitted with thin film composite polyamide membranes, resulted in increased energy efficiency and more effective removal of contaminants. The addition of hydrogen peroxide upstream of the UV light enhanced the oxidation process and enabled the destruction of UV-resistant contaminants. In the interim between IWF 21 taken off-line until completion of GWRS in 2008, OCWD used potable water from imported sources and the City of Fountain Valley for barrier operations.

6.2 ADVANCED WATER TREATMENT PROCESS

The advanced water treatment process consists of microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide and lime treatment. This process is illustrated in Figure 6-4 and explained in more detail below.

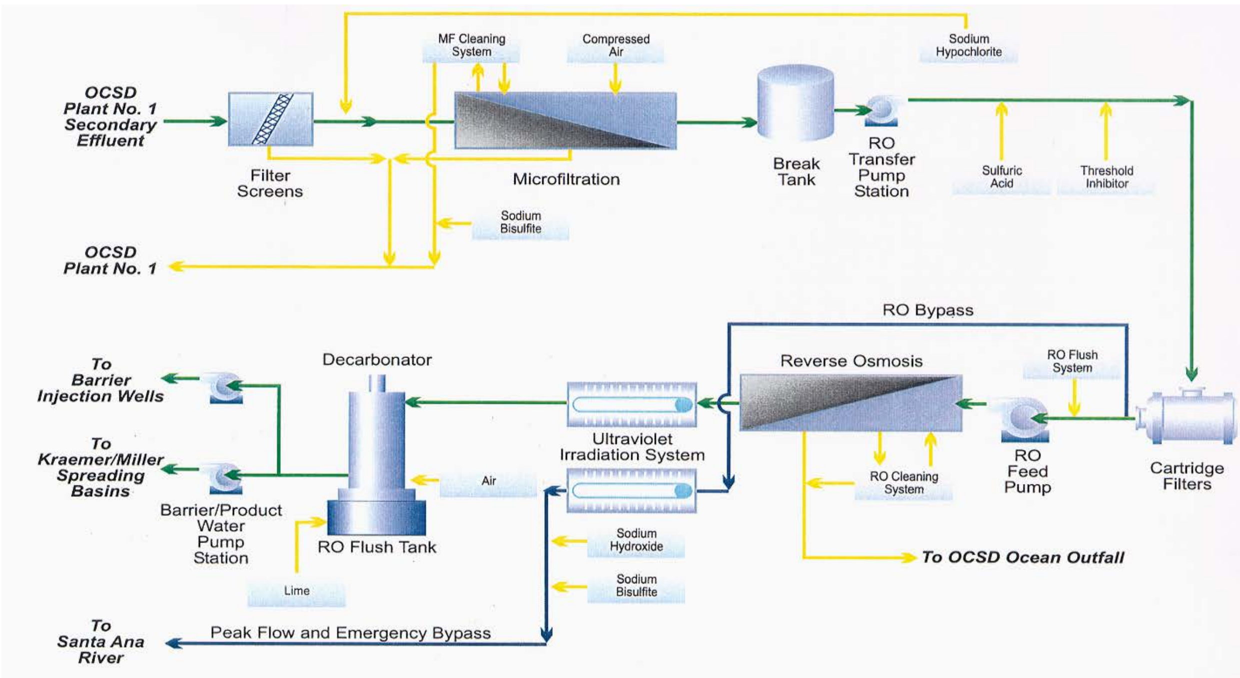


Figure 6-4: AWPF Process Flow Diagram

6.2.1 Microfiltration

Secondary-treated wastewater from the OCSD wastewater treatment plant is gravity-fed to OCWD. The effluent is fine-screened at the AWPF influent screening facility and then passes through the microfiltration (MF) process. Bundles of hollow polypropylene fibers in submerged racks remove particulate contaminants from water. Under a vacuum, water is drawn through the fibers' minute pores, each approximately 0.2 microns in diameter; suspended solids, protozoa, bacteria, and some viruses are strained out. The MF cells are regularly backwashed to clean the membranes. The MF membranes are periodically cleaned-in-place using citric acid and sodium hydroxide with a proprietary chemical to remove foulants and restore membrane performance. Waste backwash and cleaning solutions are returned to OCSD for treatment.

6.2.2 Reverse Osmosis

The MF product water advances to the next step in the process, reverse osmosis (RO). This system uses envelopes of semi-permeable polyamide membranes rolled into bundles and encased in long pressure vessels. Pressurized micro-filtered water enters at one end of each vessel and passes through the membrane to the inside of the envelope where purified product water is collected, exiting through the product water pipes.

The RO process demineralizes water and removes inorganics, organics, viruses and other contaminants. The RO process features pretreatment chemical addition using sulfuric acid and anti-scalant, cartridge filtration and high pressure feed pumps that supply the pressure vessels containing the RO membranes. Concentrate from the RO process is discharged to OCSD for disposal.

6.2.3 Ultraviolet Light with Hydrogen Peroxide and Lime Treatment

After purification with MF/RO, water is exposed to high intensity ultraviolet light (UV) and treated with hydrogen peroxide (H_2O_2) to disinfect the water and destroy remaining low molecular weight organic compounds including those that must be removed to parts per trillion levels. This process ensures that unwanted biological materials and organic chemical compounds are effectively destroyed or removed.

Post-treatment consists of de-carbonation and lime stabilization to raise the pH and add hardness and alkalinity to make the recycled water less corrosive and more stable. Excess residual carbon dioxide is removed from the RO permeate by five forced-draft decarbonators in order to stabilize the finished product water. The de-carbonation system treats about 80% of the UV disinfected recycled water while the remaining flow bypasses the decarbonators. Hydrated lime (calcium hydroxide) is added to neutralize the remaining carbon dioxide and stabilize the finished product water.

6.3 ENERGY EFFICIENT OPERATIONS

When designing and building the District's GWRS, the conservation of energy was established as a priority. Energy efficiency was built into the original GWRS plant design.

The District participated in Southern California Edison's "Efficiency by Design" grant funding program. Selection of energy efficient elements enabled OCWD to take advantage of grant funds to purchase capital equipment and realize the long-term benefits of reducing the energy load for day-to-day plant operations.

The reverse osmosis facility was designed and built with energy recovery devices that capture energy normally lost when water is released through a throttling valve from a high pressure system. It is expected that the high-tech energy recovery system will save 14 million kW hours and $ 1.3 million dollars every year for the life of the system. Another benefit of this device is its corresponding reduction in greenhouse gas emissions of 14 million pounds per year. The use of new technology energy recovery units (ERDs) in the expanded reverse osmosis system was designed to produce a significant and long-term savings in pumping costs. The ultraviolet (UV) advanced oxidation system was also selected, in part, because of its optimal energy performance characteristics.

In addition to these devices, the GWRS uses variable frequency drives on virtually all of its pumps and other rotating equipment. These computer controlled devices vary the rotational speed of the motors allowing for flow control and improved energy efficiency. Reduction in energy use for lighting is achieved by the widespread uses of skylights and open-air designs as well as new low-power designs.

The District participates in the demand response program. OCWD agrees to curtain plant operations during times of grid emergency or insufficient generation, which provides the equivalent of 11 megawatts of increased peak generation for the regional electrical system. In addition, pumping operations are shifted, when possible, to off-peak times (usually at night) to relax demand on the system during peak loads.

6.4 PLANT OPTIMIZATION AND EXPANSION

During FY 2012-2013, GWRS achieved the highest production since start-up in January 2008 with 72,691 acre-feet of FAT water produced. In contrast, during the first year of operation, the plant produced 43,500 acre-feet of recycled water. Increased production was made possible by a number of operational improvements and construction of additional facilities, as described below.

Steve Anderson Lift Station

OCSD constructed Steve Anderson Lift Station in 2009 to provide additional flow to the GWRS. The lift station diverts up to 50 mgd of raw wastewater from OCSD Plant 2 to OCSD Plant 1, boosting the amount of secondary effluent that could be conveyed to the GWRS for treatment.

Microfiltration Backwash Storage

The AWPF was designed to treat a relatively constant flow rate, but flows to the wastewater treatment plant experience low nighttime flows. To help with the diurnal flow deficit, OCWD and OCSD completed a project in 2012 to store MF backwash waste generated by the GWRS in existing OCSD's primary clarifies that are otherwise unused. MF backwash waste is stored during the day in the primary basins and pumped back into the secondary process during the low diurnal flow period at night using 10 sump pumps. These pumps are scheduled to come on at various intervals at the start of the flow deficit and are secured when OCSD's flows begin to recover in the morning. The project has helped make up about 2.4 mgd during the diurnal feed water flow deficit and has enabled the AWPF to produce closer to the design capacity.

Addition of Microfiltration Cells

The capacity of the MF process was increased in 2011 with the buildout of the existing 26 MF cells that contained 608 MF membranes with an additional 76 membranes for a total of 684 MF membranes per MF cell. This provides additional flexibility and capacity to maintain production when MF cells are down for cleaning or repairs, increasing available MF production capacity from 86 to 102.4 mgd at 89% recovery.

<u>Optimization of the RO Process</u>
Throughout 2012, research was conducted to optimize operations of the RO process through management of both biological and mineral membrane fouling. A variety of experimental laboratory cleanings were conducted to assess the effectiveness of removing mineral foulant from membranes. Experimental cleaning was performed on membrane samples and the effectiveness of cleaners in removing foulant from the membrane surface and restoring permeability was evaluated.

<u>Plant Expansion</u>
Construction of the initial expansion of GWRS was completed in 2015. This provides an additional 30 mgd of capacity and includes construction of flow equalization facilities to compensate for diurnal fluctuation in secondary treated source water from Plant No.1. The initial expansion increases total plant capacity to 100 mgd. Plans are being drawn up to construct the final expansion of GWRS, which would increase total capacity to 130 mgd.

<u>GWRS Flow Equalization Tanks</u>
Two 7.5 million gallon storage tanks (Figure 6-5) were constructed by OCWD on land owned by OCSD in Fountain Valley to provide storage of secondary-treated wastewater on a temporary basis during daily peak flow periods prior to conveyance to OCWD for advanced treatment at GWRS. Due to diurnal flow patterns of wastewater at the OCSD plant, daytime flow to the GWRS plant exceeds plant capacity while nighttime low flows result in the plant operating at below capacity. Excess flows bypass the GWRS and are discharged to the Pacific Ocean via the OCSD ocean outfall pipeline. The Flow Equalization Tanks will store wastewater when flows exceed the GWRS plant capacity and will be conveyed to the plant at night when flows drop to levels below plant capacity.

Figure 6-5: Flow Equalization Tanks

6.5 WATER QUALITY MONITORING AND REPORTING

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, 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 are used to determine travel times from recharge basins to production wells. Monitoring programs related to operation of GWRS are described in detail in Section 4.

Because of the long history of using advanced purified water at the Talbert Barrier, OCWD is permitted to use 100% GWRS water for injection into the barrier without blending with imported water or other sources as required for other seawater barrier projects in Southern California. However, blending is still required at the recharge basins with GWRS water making up no more than 75% of the blend with the balance coming from Santa Ana River storm flows and imported water.

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.

6.5.1 The Independent Advisory Panel

Performance of the GWRS plant is monitored by OCWD's research department and the Advanced Water Quality Laboratory. Annual GWRS reports are prepared by a diplomate of the American Academy of Environmental Engineering and an Independent Advisory Panel (IAP) to document ongoing scientific peer review. The IAP analyzes data in OCWD's Annual GWRS Report of plant operations as well as water quality data collected throughout the groundwater basin. The IAP is appointed and administered by the National Water Research Institute to provide credible, objective review of all aspects of GWRS by scientific and engineering experts. In addition to formal written reports, the IAP also offers suggestions for enhancing monitoring of water quality, improving the efficiency of current GWRS technologies and evaluating future projects associated with the GWRS.

6.5.2 GWRS Annual Report

A GWRS Annual Report is prepared in fulfillment of the requirements specified in the permit issued by the Santa Ana Regional Water Quality Control Board in 2008.[1] The order specifies

[1] *Producer/User Water Recycling Requirements and Monitoring and Reporting program for the Orange County Water District Interim Water Factory 21 and Groundwater Replenishment System Groundwater Recharge and Reuse at Talbert Gap Seawater Intrusion Barrier and Kraemer/Miller Basins* adopted as Order No. R8-2004-0002, Santa Ana Regional Water Quality Control Board on March 12, 2004 and the subsequent amendment Order No. R8-2008-0058 adopted on July 18, 2008.

permit requirements for the GWRS for purified recycled water for industrial uses and at the Talbert Barrier and recharge basins. The annual report contains a detailed evaluation of the operation of the entire GWRS and creates a historical record of operations of the water reclamation as well as groundwater recharge and reuse facilities.

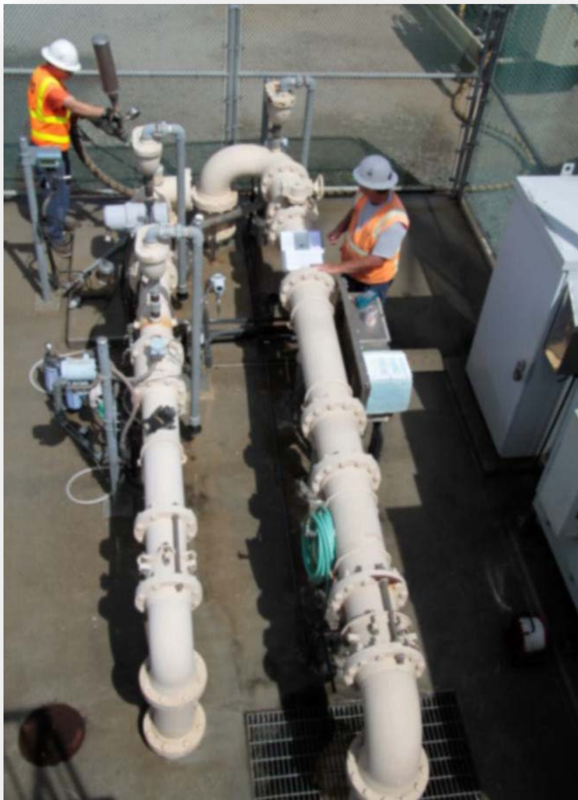
6.6 PUBLIC OUTREACH

Since the GWRS came on-line in January 2008, more than 24,000 visitors have toured the facility. During FY 2013-14, OCWD conducted 198 public tours of the GWRS plant and the Advanced Water Quality Laboratory with a total of 3,432 participants. Tour groups included 10 local high schools and 20 colleges and universities. In addition to many groups from throughout the United States, OCWD hosted tours from China, Korea, Japan, Saudi Arabia, Thailand, Australia, Switzerland, and Russia.

Figure 6-6: Group Touring the Groundwater Replenishment System

SEAWATER INTRUSION AND BARRIER MANAGEMENT

7



Routine Maintenance of Talbert Injection Wells

Monitoring and preventing the encroachment of seawater into fresh groundwater zones is a major component of sustainable basin management.

<u>Background</u>

- Coastal gaps most susceptible to seawater intrusion
- Construction of barriers began in 1960s

<u>Talbert Seawater Intrusion Barrier</u>

- 36 well sites used to inject fresh water into 4 aquifer zones
- GWRS recycled water used for barrier operation

<u>Alamitos Seawater Intrusion Barrier</u>

- Joint operation since 1964 with Los Angeles County Flood Control District
- 43 injection well and 177 active monitoring sites
- Expansion of barrier under investigation

<u>Sunset Gap Investigation</u>

- Elevated chloride levels indicate seawater intruding through gap
- Investigation underway to evaluate alternative remedies

SECTION 7 SEAWATER INTRUSION AND BARRIER MANAGEMENT

7.1 BACKGROUND

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. The susceptible locations are the Talbert, Bolsa, Sunset, and Alamitos Gaps as shown in Figure 7-1.

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; seawater intruded over three miles inland. Prior to the construction of the seawater intrusion barriers, OCWD slowed seawater intrusion by filling the basin with imported Colorado River water.

In the 1960s and 1970s, a series of injection wells at two key geologic gaps were constructed to form subsurface freshwater hydraulic barriers. These 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 with a sustainable yield of over 300,000 afy.

Figure 7-1: Coastal Gaps in Orange County

In July 2014, the District's Board of Directors adopted a policy regarding control of seawater intrusion that contained the following principles:

- Prevent degradation of the quality of the groundwater basin from seawater intrusion.
- Effectively operate and evaluate the performance of the District's 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.

In addition to the seawater barrier injection facilities, the District 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 the barriers and to identify potential areas of intrusion. OCWD measures chloride concentrations in groundwater to monitor seawater intrusion. Chloride concentrations are monitored twice a year at the coastal area monitoring wells and chloride contour maps are prepared at least every two years to delineate the extent of seawater intrusion and determine areas where it is migrating inland or being pushed seaward. The monitoring well network has been expanded and improved over time leading to new information and a greater understanding of the coastal hydrogeology and intrusion pathways. A more detailed discussion of the coastal water quality monitoring program can be found in Section 4.

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 wells. The pressure mound resulting from this injection minimizes seawater intrusion through these gaps into the basin. The District plans to expand the Alamitos Barrier with additional monitoring and injection wells and is currently expanding the monitoring well network in Sunset Gap to better delineate the nature and extent of seawater intrusion in that area as the first step towards investigating feasible remedies for Sunset Gap. In Bolsa Gap, chloride concentration trends suggest that the Newport-Inglewood Fault System sufficiently restricts inland migration of seawater intrusion into the potable aquifers.

7.2 TALBERT SEAWATER INTRUSION BARRIER

Seawater intrusion through the Talbert Gap, a 2.5-mile-wide geological feature between the Newport and Huntington Beach mesas, was documented as far back as 1925. A more detailed study of the gap was conducted by the Department of Water Resources in 1966 (DWR, 1966). Largely based on this study, OCWD constructed the initial Talbert Seawater Intrusion Barrier in 1975 with 23 injection well sites.

Over time the barrier was expanded to keep pace with increasing groundwater production in the coastal area. Chloride concentrations at OCWD monitoring wells in the 1990s showed advancing seawater intrusion in the Talbert Gap and beneath the adjacent mesas despite barrier injection operations. Today, the Talbert Barrier is composed of a series of 36 well sites that are used to inject water into multiple aquifer zones for seawater intrusion control as well as basin replenishment. The injection raises groundwater levels along the barrier alignment and thus forms a hydraulic barrier to seawater that would otherwise migrate inland toward areas of groundwater production. A list of the injection wells, injection depths, and associated aquifers can be found in Appendix E. Injection well sites are shown in Figure 7-2.

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). A permit issued by the Santa Ana Regional Water Quality Control Board in 2004 limited the percentage of recycled water at the Talbert Barrier to 75% with a minimum travel time of six months to the nearest production wells. The permitted maximum allowable recycled water contribution at the Talbert Barrier was subsequently increased to 100% in December 2009. (CA RWQCB, 2004, 2008)

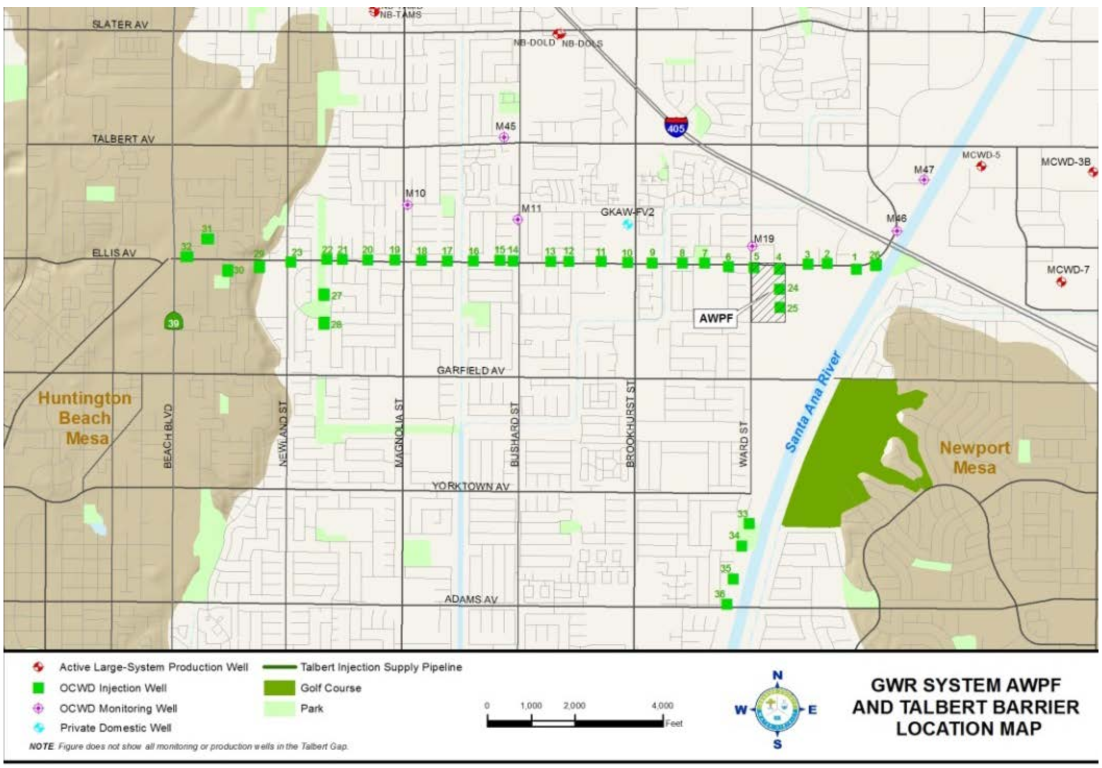


Figure 7-2: Talbert Barrier Injection Wells

The chloride concentration contours for the Talbert Gap and surrounding area shown in Figure 7-3 illustrate historical inland progression and seaward reversals of groundwater salinity due to injection operations and basin management practices. In addition to contour maps, OCWD staff prepares and reviews chloride concentration trend graphs at individual wells to identify and evaluate intrusion in specific aquifer zones over time.

In general terms, chloride concentrations are inversely related to groundwater elevations. When groundwater elevations decline below mean sea level in the area of the intrusion front, chloride concentrations generally increase and seawater intrusion worsens (see Figure 7-4).

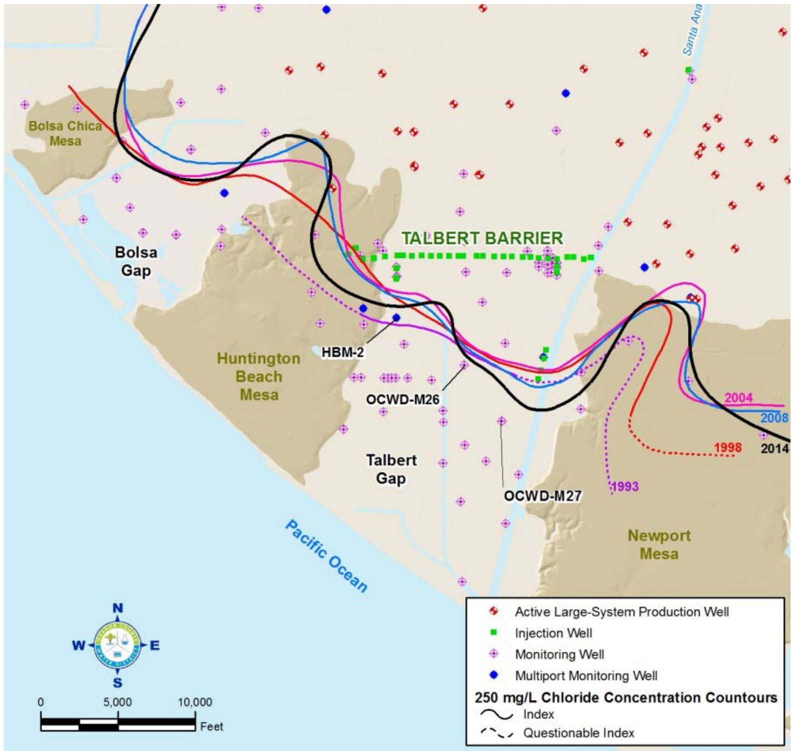


Figure 7-3: Talbert Gap 250 mg/L Chloride Concentration Contours for Selected Years

Conversely, when groundwater elevations rise and are sustained above mean sea level, chloride concentrations decrease and intrusion is pushed back seaward. This is especially evident in Figure 7-5 which shows how chloride concentrations were significantly reduced when new injection wells were turned on to raise groundwater levels.

Monitoring well OCWD-M26 is strategically located seaward of the barrier in the Talbert-Lambda mergence zone in the middle of the Talbert Gap and is screened in both the Talbert and Lambda aquifers. Therefore, OCWD-M26 is a key monitoring well for evaluating barrier injection requirements versus seawater intrusion potential. OCWD-M26 is located approximately 1,000 feet north of Adams Avenue, which approximately represents the farthest seaward line at which the goal is to achieve protective groundwater elevations of approximately 3 feet above mean sea level (ft msl).

This protective elevation is based on the Ghyben-Herzberg relation (Ghyben, 1888; Herzberg, 1901; Freeze and Cherry, 1979), which takes into account the depth of the Talbert aquifer at that location along with the density difference between saline and fresh groundwater. If this protective elevation is achieved along Adams Avenue for at least the majority of each year, then brackish water in the Talbert aquifer would be maintained slightly seaward of the mergence zone and thus prevented from migrating down into the Lambda aquifer that is tapped by inland production wells.

OCWD operates the Talbert Seawater Intrusion Barrier to (1) maintain protective groundwater elevation at well OCWD-M26 and (2) prevent landward seawater migration into the groundwater basin based on the 250 mg/L chloride concentration contour. For more detailed information on the operation of the Talbert Seawater Barrier see *GWRS 2013 Annual Report* prepared for the California Regional Water Quality Control Board, Santa Ana Region, June 16, 2014.

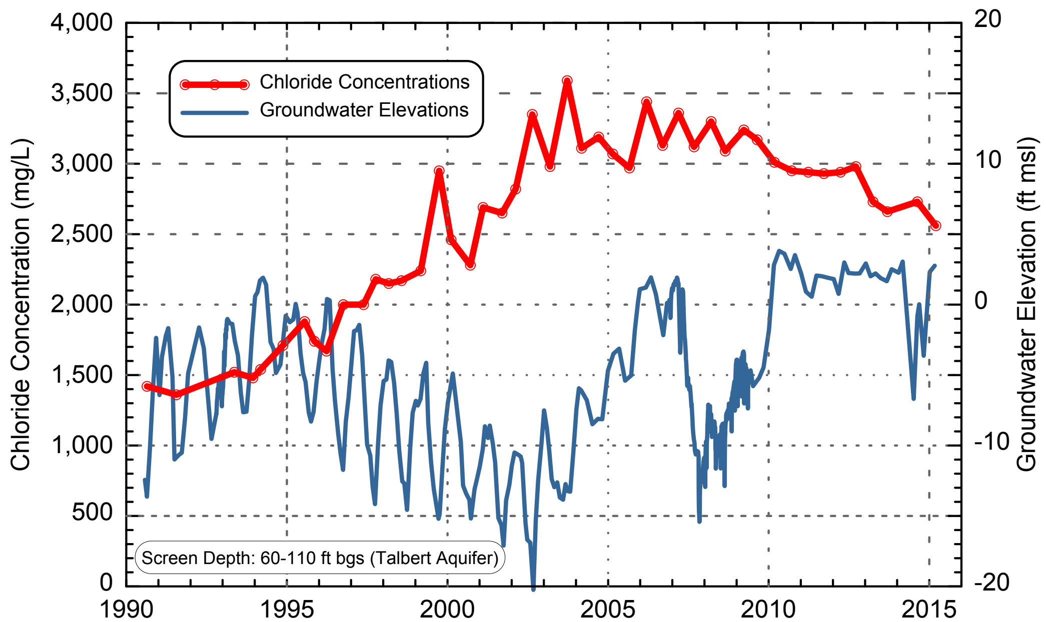


Figure 7-4: Groundwater Elevations and Chloride Concentrations at OCWD-M27

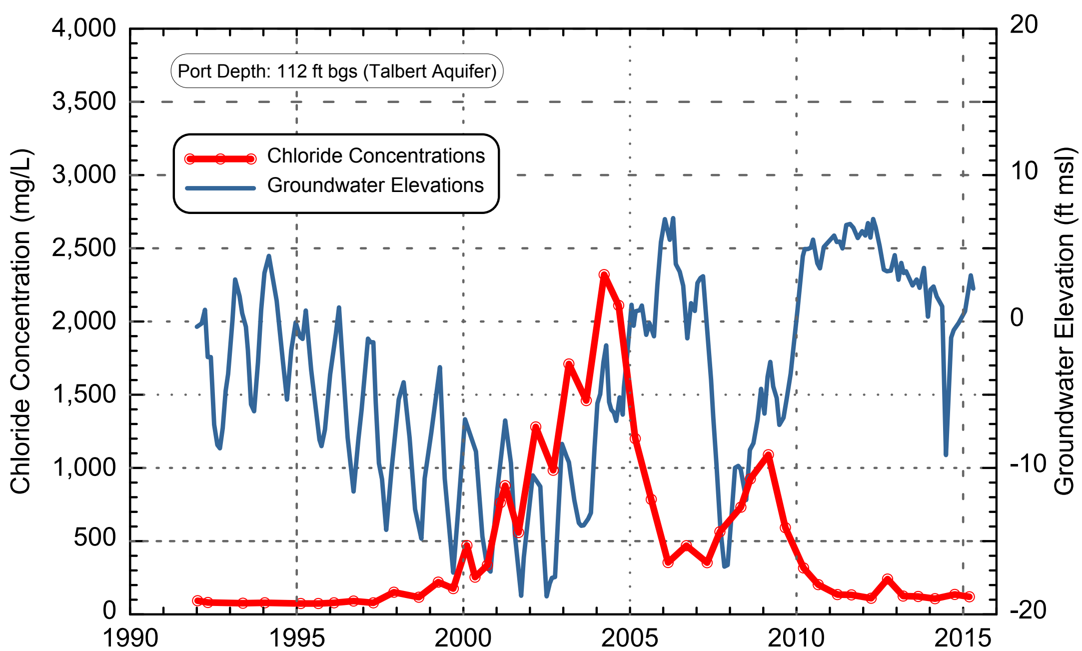


Figure 7-5: Groundwater Elevations and Chloride Concentrations at HBM-2/MP1

7.3 ALAMITOS SEAWATER INTRUSION BARRIER

The Alamitos Seawater Intrusion Barrier was constructed in 1965 to protect the Central Basin of Los Angeles County and the Orange County Groundwater Basin from seawater intrusion through the Alamitos Gap. Since the barrier alignment lies in both Los Angeles and Orange Counties, the barrier facilities are jointly owned by the Los Angeles County Flood Control District (LACFCD) and OCWD and include 43 injection wells and 177 active monitoring well sites.

Under the terms of a 1964 joint agreement, LACFCD operates and maintains the barrier, while the Water Replenishment District of Southern California (WRD) and OCWD purchase and provide the injection water supply, which currently consists of nearly 100% recycled water. WRD is under permit with the Regional Water Quality Control Board – Los Angeles Region (LARWQCB) for injection of recycled water at the Alamitos Barrier. LARWQCB permit requirements include groundwater monitoring and numerical modeling to track the recycled injection water migrating towards nearby municipal production wells in Orange County.

A list of the injection wells, injection depths and associated aquifers for wells on the Orange County side of the barrier can be found in Appendix E. All injection well sites are shown in Figure 7-6. Although OCWD owns many of the Alamitos Barrier monitoring and injection wells, all of the wells are operated, maintained and sampled by LACFCD as part of the Alamitos Barrier joint agreement described above.

OCWD funds operation of the Alamitos Seawater Intrusion Barrier with the Los Angeles County agencies to prevent landward seawater migration into the groundwater basin based on the 250 mg/L chloride concentration contour.

Over the last several years, pockets of elevated chloride concentrations have been observed inland of the barrier, especially near the southeast portion of the barrier within Orange County. Elevated chloride concentration is the parameter that the District uses to determine if the barrier is sufficiently protecting seawater intrusion from occurring. In this case, OCWD began a study to delineate the extent of seawater intrusion both through and around the Alamitos Barrier as summarized below.

- In 2008, OCWD identified critical data gaps where seawater intrusion was suspected but unconfirmed.

- Four monitoring wells were installed in 2009 at three sites near the Orange County portion of the barrier. As shown in Figure 7-6, salinity data from existing and the newly-installed wells were used to delineate the extent of seawater intrusion in this area, especially pertaining to potential migration towards nearby production wells owned and operated by the City of Seal Beach and Golden State Water Company.

- A pipeline hydraulic model of the Alamitos Barrier injection system was completed in 2009 to determine injection supply pipeline capacities under existing conditions and for potential barrier expansion alternatives.

- Groundwater level and salinity data from the new and existing monitoring wells were evaluated, in conjunction with the development and calibration of a detailed numerical groundwater flow and transport model of the Alamitos Gap area (Intera, 2010). The three agencies (OCWD, LACFCD and WRD) collaborated to develop the Alamitos Barrier Flow Model (ABFM) and Alamitos Barrier Transport Model (ABTM). The models, completed in 2013, simulate the fate and residence time of recycled water used for injection and the relative differences in chloride transport and barrier performance for the existing Alamitos Barrier and three selected barrier expansion configurations. As explained earlier, the models were used to assess and plan for necessary expansion of barrier facilities, as well as prioritize and optimize operation of the existing facilities to combat against seawater intrusion.

A future southern extension of the barrier is being investigated to halt the eastern migration of saline water into the Sunset Gap.

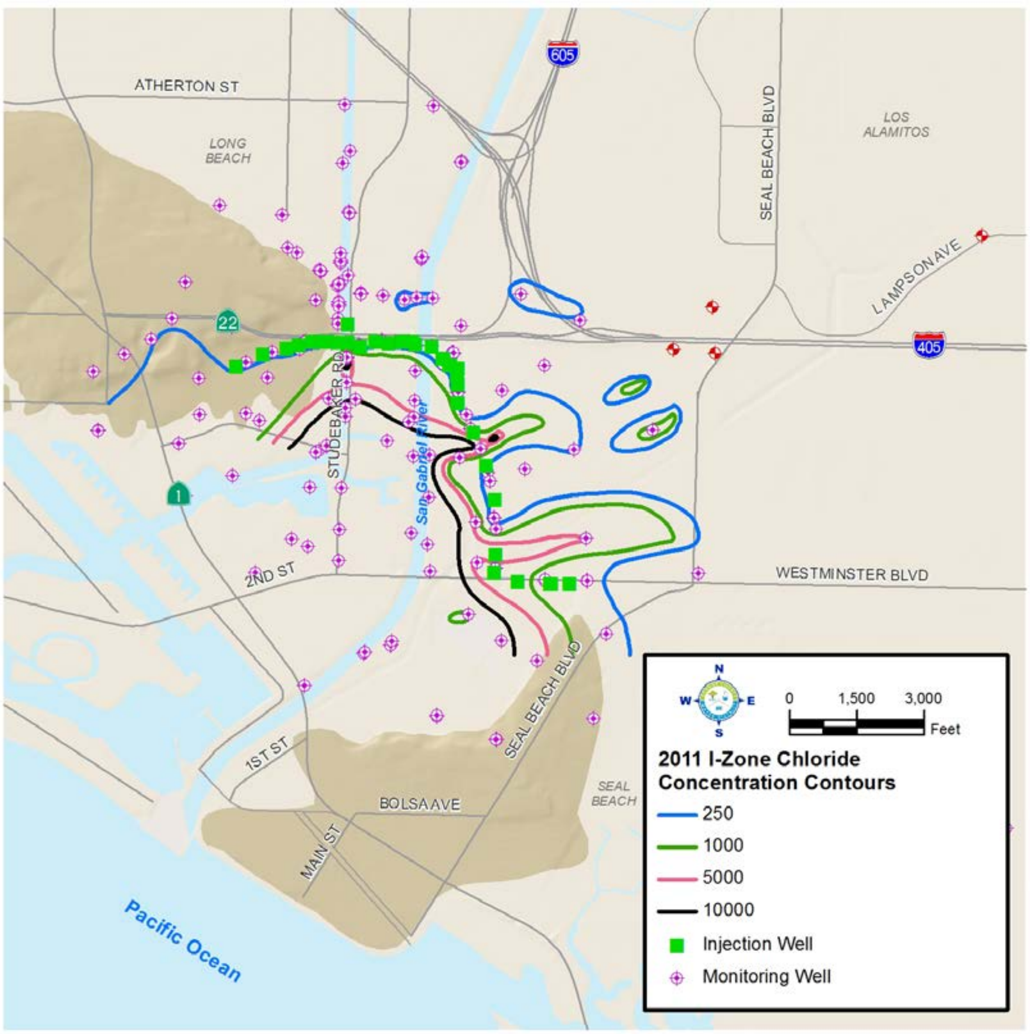


Figure 7-6: Alamitos Gap Injection and Monitoring Wells with Chloride Concentration Contours

7.4 SUNSET GAP INVESTIGATION

Basin monitoring for potential seawater intrusion in the vicinity of the Sunset Gap began in the 1950s. While the Newport-Inglewood Fault acts as the primary coastal barrier to seawater intrusion into the groundwater basin, investigations between 1959 and 1983 indicated the potential for saline water leakage across the fault, particularly in shallow aquifers and when inland groundwater levels are significantly below sea level due to pumping and decreases in groundwater storage.
The dredging of Huntington Harbor in the early 1960s was the subject of several studies regarding the potential for worsening saline intrusion in this area and the influence of tides on seawater intrusion. Conclusions of the studies as to Huntington Harbor's effect on saline intrusion were inconsistent. Studies done by DWR (1968) and USGS (1966) 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.

In 2007, the City of Huntington Beach Well No. 12 was permanently removed from service due to high salinity levels. In response, the District commissioned an electric geophysical survey in 2010 to delineate the extent and magnitude of seawater intrusion in the Sunset Gap. In 2012, two multi-depth monitoring wells, OCWD-BS10 (BS10) and OCWD-BS11 (BS11) were installed as shown in Figure 7-7 to better delineate the extent and source of the seawater intrusion.

Elevated chloride concentrations were found at both wells at a depth of approximately 230 feet, confirming seawater intrusion. Suspected pathways are from the Alamitos Gap to the west, Huntington Harbor to the south and possible leakage across the Newport-Inglewood Fault to the southwest. Construction of six multi-depth nested monitoring well sites (a total of 29 individual well casings to depths up to 1,000 feet) is underway to further delineate the extent and sources of the seawater intrusion in Sunset Gap, and to support a future feasibility study of alternatives to control the seawater intrusion. By early 2015, four of the six new monitoring well sites were constructed on the Naval Weapons Station Seal Beach as shown in Figure 7-7 (BS14, BS17, BS21, and BS22).

Strategies to control intrusion under consideration include a potential southerly extension of the Alamitos Seawater Barrier along Seal Beach Boulevard and a brackish groundwater extraction and desalination system. Such a system may be necessary and appropriate to prevent a large "plume" of elevated salinity to continue to migrate toward production wells and impact larger portions of the groundwater basin.

Figure 7-7: Sunset Gap Monitoring and Production Wells with Chloride Concentration Contour

7.5 EVALUATION OF POTENTIAL IMPACTS DUE TO CLIMATE CHANGE

The U.S. Bureau of Reclamation conducted a study in collaboration with SAWPA of the potential impacts to water resources due to climate change in the Santa Ana River Watershed. (USBR, 2013) The purpose of the study was to refine the watershed's water projections and identify potential adaptation strategies in light of projected effects of climate change. The study included the development of hydrology models and analysis of impacts focused on key areas.

Likely impacts of changing climatic conditions in the Santa Ana River Watershed include a decrease of surface water supplies, increase in temperatures, more severe flood events, and increase dependency on groundwater supplies.

Results of the study indicate that increasing temperatures will melt ice sheets and glaciers and cause thermal expansion of ocean water, increasing the volume of water in the oceans and raising sea levels. Regional mean sea level along the Southern California coast is projected to rise by 1.5 to 12 inches by 2030, 5 to 24 inches by 2050, and 16 to 66 inches by 2100. Regional sea level rise may be higher or lower than global mean sea level rise due to regional changes in atmospheric and ocean circulation patterns.

Sea level rise is likely to increase the coastal area vulnerable to flooding during storm events. OCWD conducted a study to evaluate the potential effects of projected sea level rise on coastal Orange County groundwater conditions. Two locations were selected for analysis near the Talbert and Alamitos seawater intrusion injection barriers. The study model used data from well logs, aquifer pump tests, groundwater elevation measurements, hand-drawn contour maps, geologic cross sections, water budget spreadsheets and other data stored in OCWD's Water Resources Management System database.

The Talbert Barrier would be effective at preventing seawater intrusion though the Talbert Gap under the condition of a 3-foot rise in sea level. In the case of the Alamitos Barrier, seawater intrusion throughout the gap would likely be prevented once current plans to construct additional injection wells are implemented. At both barriers, however, shallow groundwater concerns could limit injection rates and thus reduce the effectiveness of the barriers in preventing seawater intrusion under rising sea levels.

The groundwater screening tool was used to estimate changes in basin-average groundwater levels over time as a function of seven natural and anthropogenic factors that govern groundwater recharge and discharge: precipitation, local stream flow, trans-basin water imports, municipal and industrial water demands, agricultural water demand, evaporative demand from native and landscaped vegetation, and an optional exogenous input that represents groundwater management objectives that affect basin-scale groundwater levels.

WATER QUALITY PROTECTION AND MANAGEMENT

8

OCWD's Fountain Valley Laboratory

OCWD conducts a wide range of water quality programs in Orange County and throughout the watershed.

Groundwater Quality Protection

- Board-adopted policy in 1987; updated in 2014
- Well development, management and closure policies

Programs

- Salinity: measurements in groundwater, watershed-wide programs to manage salinity in surface waters
- Nitrates: measurements in groundwater; operation of Prado Wetlands to remove nitrates in Santa Ana River water
- Amber-colored groundwater: 3 facilities treat water for potable use
- Contaminants: programs to monitor MTBE, VOCs, NDMA, 1,4 Dioxane, and Perchlorate

Water Quality Improvement Projects

- North Basin Groundwater Protection Program
- South Basin Groundwater Protection Program
- Irvine and Tustin Desalters

SECTION 8 WATER QUALITY PROTECTION AND MANAGEMENT

8.1 OCWD GROUNDWATER QUALITY PROTECTION POLICY

OCWD adopted the first Groundwater Quality Protection Policy in 1987 under statutory authority granted under Section 2 of the District Act. A revised policy was adopted by the Board of Directors in 2014. The 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;
- Assist regulatory agencies in identifying sources of contamination to assure cleanup by the responsible parties;
- Support regulatory enforcement of investigation and cleanup requirements on responsible parties in accordance with law;
- Undertake investigation and cleanup projects as necessary to protect groundwater from contamination;
- Maintain consistency with the National Contingency Plan when seeking recovery of investigation and response costs;
- Negotiate with and engage in mediation with parties responsible for contamination when possible to resolve issues related to cleanup and abatement of contamination;
- Establish a Groundwater Contamination Cleanup Fund to hold proceeds received from settlement of lawsuits for each groundwater contamination case for which the District received moneys;
- Maintain surface water and groundwater quality monitoring programs and monitoring well network;
- Maintain the database system, geographic information system, and computer models to support water quality programs;
- Maintain an Emergency Response Fund to ensure adequate funds are available to contain and clean up catastrophic releases of chemicals or other substances that may contaminate surface or groundwater water;
- Coordinate with groundwater producer(s) impacted or threatened by any groundwater contamination and work to develop appropriate monitoring and remediation if necessary; and
- Encourage the beneficial use and appropriate treatment of poor-quality groundwater where the use of such groundwater will reduce the risk of impact to additional production wells, increase the operational yield of the basin and/or provide additional water quality improvements to the basin.

8.2 WELL DEVELOPMENT, MANAGEMENT, AND CLOSURE

To comply with federal Safe Drinking Water Act requirements regarding the protection of drinking water sources, the California Department of Public Health (now the Division of Drinking Water) 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 Producers in the preparation of these reports.

This program requires all well owners to prepare a drinking water source assessment and establish a source water protection program for all new wells. The source water program must include: (1) a delineation of the land area to be protected, (2) the identification of all potential sources of contamination to the well, and (3) a description of management strategies aimed at preventing groundwater contamination.

Developing management strategies to prevent, reduce, or eliminate risks of groundwater contamination is one component of the multiple barrier protection of source water. Contingency planning is an essential component of a complete DWSAP and includes developing alternate water supplies for unexpected loss of each drinking water source, by man-made or catastrophic events.

Wells constructed by the District are built to prevent the migration of surface contamination into the subsurface. This is achieved through the placement of annular well seals and surface seals during construction. Also, seals are placed within the borehole annulus between aquifers to minimize the potential for flow between aquifers.

Well construction ordinances adopted and implemented by the Orange County Health Care Agency (OCHCA) and municipalities follow state well construction standards established to protect water quality under California Water Code Section 231. Cities within OCWD district 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 the District'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.

Information on the status of wells is kept within the District's WRMS data base. Records in this data base show 606 wells that have been destroyed and properly sealed, 217 destroyed wells with inadequate information to determine if properly sealed and 948 abandoned wells.

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.

8.3 MANAGING SALINITY IN WATER SUPPLIES

Increasing salinity is a significant water quality problem in many parts of the southwestern United States and Southern California, including Orange County. Elevated salinity levels can contaminate groundwater supplies, constrain implementation of water recycling projects and cause other negative economic impacts such as the need for increased water treatment by residential, industrial, commercial users, and water utilities.

Salinity is a measure of the dissolved minerals in water that includes both Total Dissolved Solids (TDS) and nitrates. Due to differences in sources of contamination, control methods and human health effects, nitrate management will be discussed separately in Section 8.4.

High salinity and hardness limit the beneficial uses of water for domestic, industrial and agricultural applications. Hard water causes scale formation in boilers, pipes and heat-exchange equipment as well as soap scum and an increase in detergent use. This can result in the need to replace plumbing and appliances and require increased water treatment. Some industrial processes, such as computer microchip manufacturers, must have low TDS in the process water and often must treat the municipal supply prior to use. High salinity water may reduce plant growth and crop yield, and clog drip irrigation lines.

8.3.1 Regulation of Salinity in the Watershed

The U.S. EPA and the California Division of Drinking Water regulate TDS as a constituent that affects the aesthetic quality of water – notably, taste. The recommended secondary MCLs for key constituents comprising TDS are listed in Table 8-1.

Table 8-1: Secondary Drinking Water Standards for Selected Constituents

Constituent	Recommended Secondary MCL
Total Dissolved Solids (salts)	500 mg/L
Chloride	250 mg/L
Sulfate	250 mg/L

At the state level, the State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards have authority to manage TDS in water supplies. The salinity management program for the Santa Ana River Watershed was adopted by the Santa Ana Regional Water Quality Control Board (Regional Water Board) in 2004.

The salinity program is implemented by the Basin Monitoring Program Task Force, a group comprised of water districts, wastewater treatment agencies and the Regional Water Board. The task force delineated boundaries for 39 groundwater management zones in the watershed including two in Orange County as shown in Figure 8-1.

Historical ambient or baseline conditions were calculated for levels of TDS and nitrates in each management zone. These levels were adopted as water quality objectives and incorporated into the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan). The Basin Plan specifies that current ambient concentrations of TDS and nitrate must be recalculated every three years for each of the management zones.

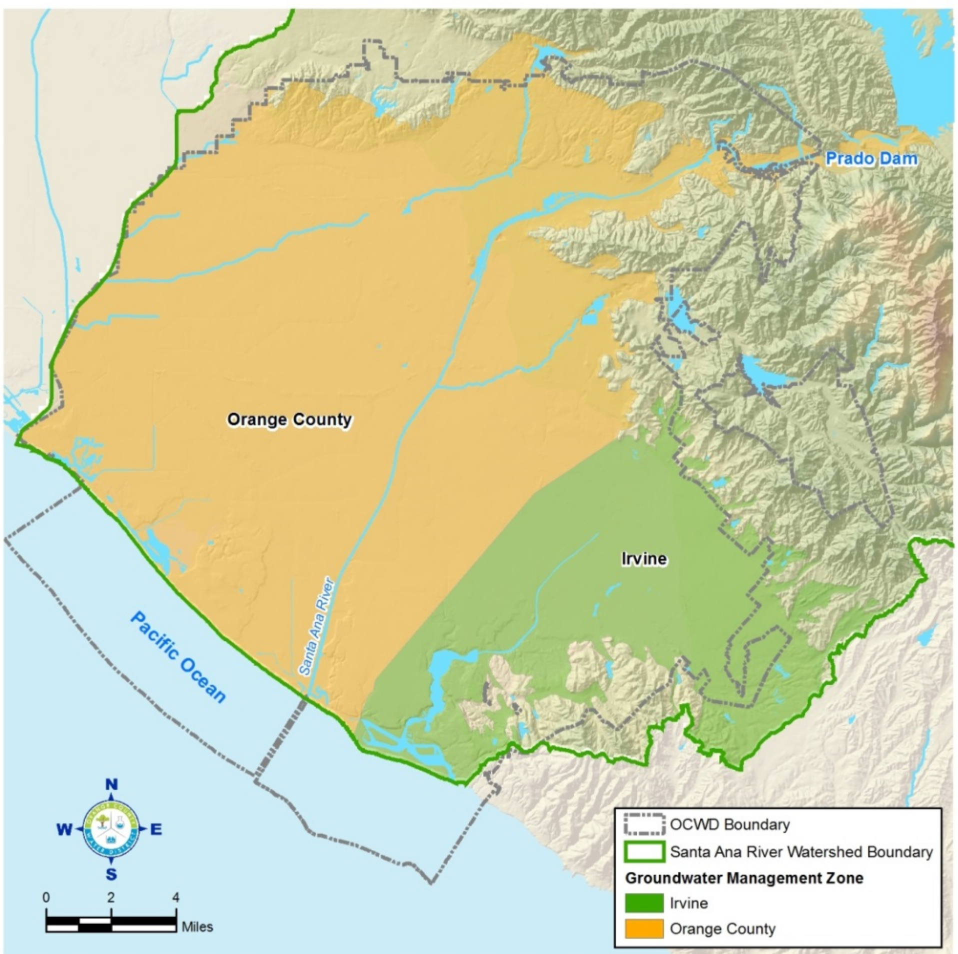


Figure 8-1: Groundwater Management Zones in Orange County

When a newly determined ambient level is equal to or greater than the established objective, that management zone does not have an “assimilative capacity.” This means that the quality of the groundwater in that zone is determined to be incapable of successfully assimilating increased loads of TDS or nitrates without degrading the water quality. Conversely, when an ambient level is lower than the established objective, that management zone has an assimilative capacity and is determined to be capable of receiving modest inputs of TDS without exceeding the water quality objective.

The water quality objectives and ambient quality levels for the two Orange County management zones are shown in Table 8-2. Comparing the ambient water quality to the TDS objectives indicates that these zones have no available assimilative capacity for TDS.

Table 8-2: TDS Water Quality Objectives for Lower Santa Ana River Basin Management Zones

Management Zone	Water Quality Objective	2012 Ambient Quality
Orange County	580 mg/L	610 mg/L
Irvine	910 mg/L	940 mg/L

(Wildermuth, 2014)

8.3.2 Managing Salinity in the Orange County Groundwater Basin

As explained in Section 4, OCWD monitors the levels of TDS in wells throughout the groundwater basin. Figure 8-2 shows the average TDS at production wells in the basin for the period of 2010 to 2014. In general, the portions of the basin with the highest TDS levels are located in Irvine, Tustin, Yorba Linda, Anaheim, and Fullerton. In addition, there is a broad area in the middle portion of the basin where the TDS generally ranges from 500 to 700 mg/L. Localized areas near the coast, where water production does not occur, contain relatively higher TDS concentrations. OCWD also monitors salinity levels in water supplies used to recharge the groundwater basin, which include Santa Ana River baseflow and stormflow, GWRS water, and imported water.

Table 8-3 presents the estimated salt inflows for the basin using average recharge volumes. TDS concentrations for the inflows were based on flow and water quality data collected by the District and the USGS. The calculation of TDS in the Talbert Barrier supply was based on TDS concentration in GWRS water while the calculation for the Alamitos Barrier assumed that injection water was a 50:50 blend of recycled water and imported water.

The flow-weighted TDS of local incidental recharge of 1,100 mg/L was calculated using estimates of the TDS concentration of each component listed in Section 3, Table 3-2. For subsurface inflow and recharge from the foothills, the TDS concentration was estimated using data from the closest nearby wells.

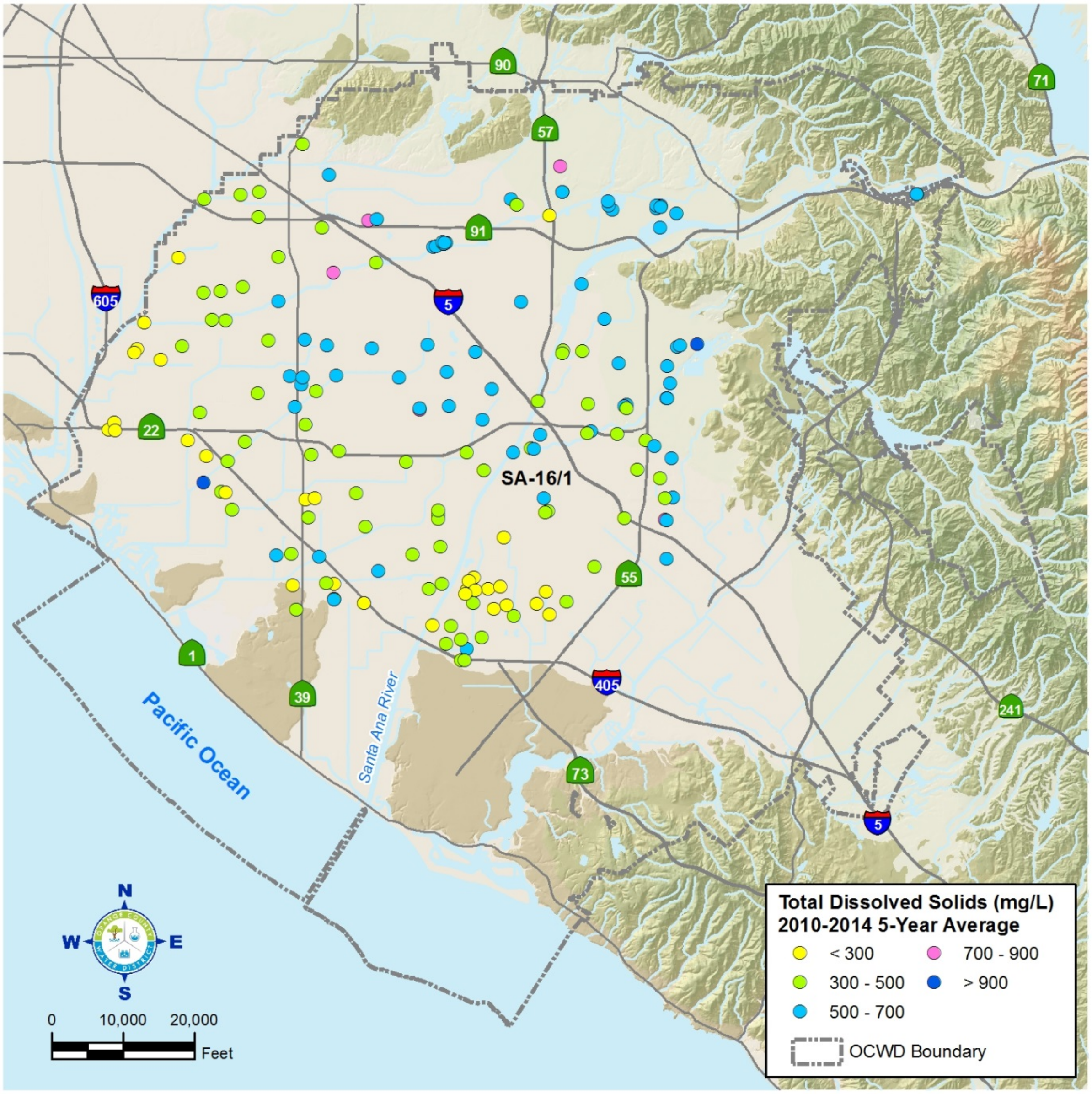


Figure 8-2: TDS in Groundwater Production Wells

As shown in Table 8-3, the District estimates that the flow-weighted average inflow TDS concentration for all water recharging the basin is 501 mg/L. It is important to note that the TDS concentration of GWRS water is approximately 50 mg/L, which is expected to decrease the overall TDS concentration in the basin over time.

Table 8-3: Salt Inflows for Orange County and Irvine Management Zones

WATER SOURCE	Inflow (afy)	TDS (mg/L)	Salt (tons/yr)
Recharged SAR Base Flow	65,000	700	62,000
Recharged SAR Storm Flow	40,000	200	11,000
GWRS Water Recharge in Anaheim	73,000	50	5,000
Unmeasured Recharge (Incidental)	66,000	1,100	99,000
Injection Barriers			
Talbert	30,000	50	2,000
Alamitos	2,000	350	1,000
Imported Water Recharged	65,000	600	53,000
TOTAL	341,000	501*	233,000

* Flow-weighted average

Figure 8-3 shows the total flow-weighted average of TDS levels of the water supply used for the Talbert Barrier. Prior to 2004, injection water was a blend of imported water, WF 21 purified water and Deep Aquifer water. Between 2004 and 2007 when WF 21 was decommissioned and the GWRS was in construction, a blend of imported water, potable water, and Deep Aquifer water was injected into the barrier. In 2007 the barrier was supplied entirely with imported water. Beginning in 2008, GWRS recycled water was used as a barrier water supply resulting in TDS concentrations in injection water quality of below 50 mg/L.

8.3.3 Septic Systems in Orange County

Another source of salinity in the basin originates from onsite wastewater treatment systems, commonly known as septic systems. There are an estimated 2,500 septic systems in operation within the boundary of OCWD. Septic systems operate by collecting wastewater in a holding tank and then allowing the liquid fraction to leach out into the underlying sediments where it becomes filtered and eventually becomes part of the groundwater supply. A properly maintained system can be effective at removing many contaminants from the wastewater but salts remain in the leachate. Septic systems are typically in older communities that were developed prior to the construction of sewer systems or located in an area some distance from existing sewers. The State and Regional Water Boards regulate the siting of new septic systems to reduce the possibility of groundwater contamination. Within Orange County, water districts and local officials work to expand sewer systems to neighborhoods without access to them in order to reduce the use of septic systems to the extent feasible and economical.

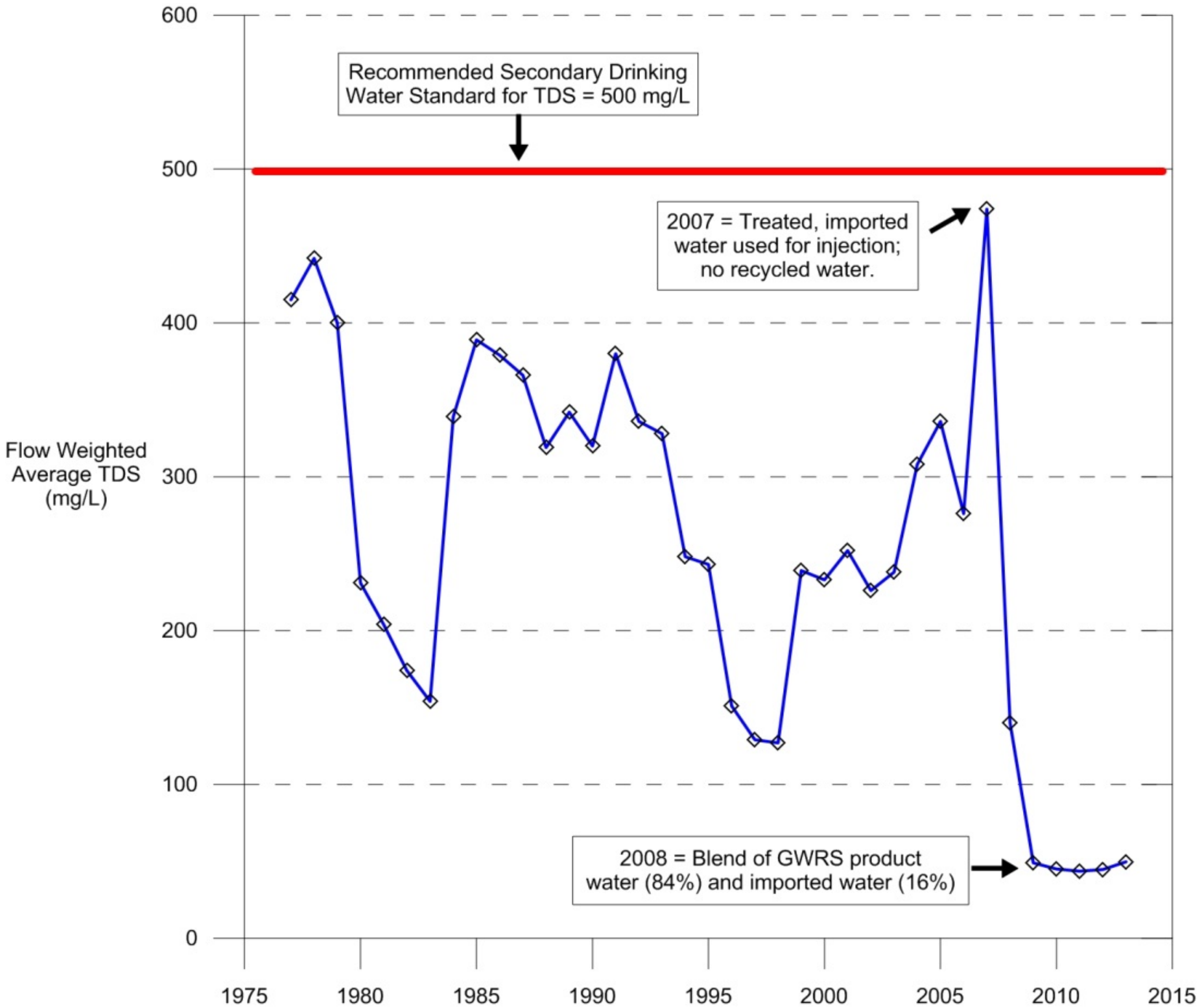


Figure 8-3: Total Flow Weighted Average TDS of All Source Waters Used for Injection at the Talbert Barrier

8.3.4. Salinity Management Projects

This section describes salinity management projects operating in the Santa Ana River Watershed.

Inland Empire Brineline and Non-Reclaimable Waste Line

Several water treatment plants that are designed to remove salts from groundwater, commonly referred to as desalters, have been built in Orange, Riverside, and San Bernardino Counties. These plants are effectively reducing the amount of salt buildup in the watershed. The Inland Empire Brine Line (IEBL), formerly called the Santa Ana Regional Interceptor (SARI), built by the Santa Ana Watershed Project Authority (SAWPA), has operated since 1975 to remove salt from the watershed by transporting industrial wastewater and brine produced by desalter operations directly to OCSD for treatment.

The other brine line in the upper watershed, the Non-Reclaimable Waste Line in the Chino Basin operated by the Inland Empire Utilities Agency (IEUA), segregates high TDS industrial wastewater and conveys this flow to Los Angeles County for treatment and disposal.

Groundwater Replenishment System

Within Orange County, the GWRS, several local and regional groundwater desalters, and seawater intrusion barriers are operating to reduce salt levels. The GWRS, described in Section 6**,** purifies wastewater that is used for groundwater recharge and for injection into the Talbert Barrier to prevent seawater intrusion.

To illustrate the benefits of replacing imported water with GWRS water for groundwater recharge, assume an equal volume of 100,000 afy of these two supplies is used for recharge. Figure 8-4 shows the tons of salt in GWRS water as compared to an equal amount of imported water using a TDS of 50 mg/L for GWRS water and TDS of 600 mg/L for imported water.

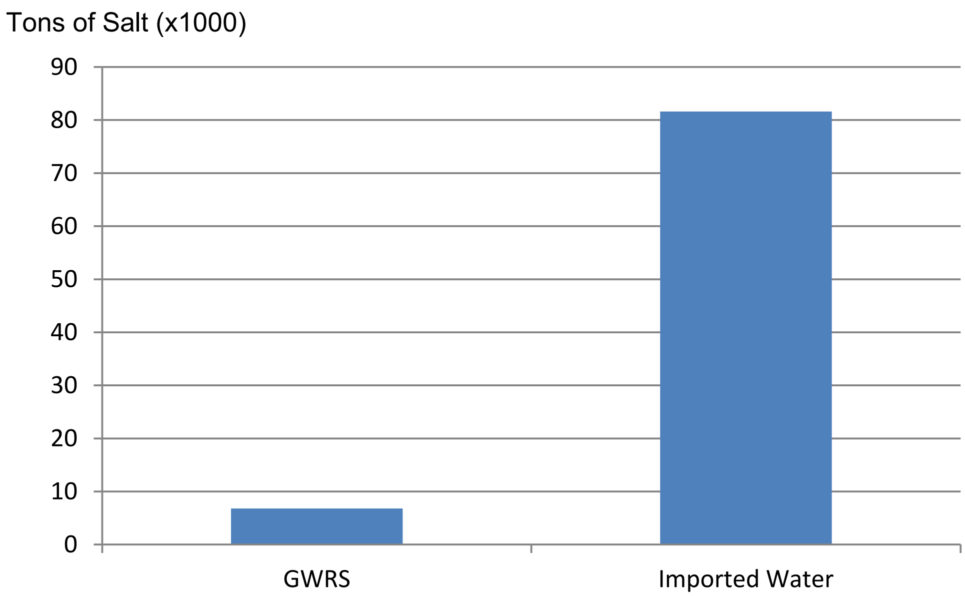


Figure 8-4: Tons of Salt in GWRS vs. Imported Water

Coastal Pumping Transfer Program

Another management tool available to OCWD to manage salinity levels in the groundwater basin is the Coastal Pumping Transfer Program (CPTP). The purpose of the CPTP is to encourage inland producers to pump more groundwater and coastal producers to pump less to raise coastal groundwater levels, which lessens the potential for seawater intrusion. Inland pumpers are encouraged to pump above the BPP without having to pay the BEA for the amount pumped above the BPP. The funds collected from the increased inland pumping are used to offset the increased cost of water paid by coastal producers who must purchase imported water. This program is cost-neutral to the producers.

Groundwater Desalters

Other salinity management projects include groundwater desalters, located in the cities of Tustin and Irvine that are pumping and treating high salinity groundwater (see Section 8.9).

Seawater Intrusion Barriers

The two seawater intrusion barriers operating within Orange County manage salinity along the coast. The Alamitos seawater intrusion barrier spans the Los Angeles/Orange County line in the Seal Beach-Long Beach area. Injection wells are supplied from a blend of recycled water from Water Replenishment District and potable supplies from MWD. OCWD's Talbert Seawater Intrusion Barrier spans the 2.5-mile-wide Talbert Gap. From 1975 until 2004, a blend of purified water from OCWD's WF 21, Deep Aquifer water, and imported potable water was injected into the barrier. Beginning in 2008, the GWRS began providing recycled water for the barrier.

8.4 MANAGEMENT OF NITRATES IN GROUNDWATER

Nitrate is one of the most common and widespread contaminants in groundwater supplies. Elevated levels of nitrate in soil and water supplies originate from fertilizer use, animal feedlots, wastewater disposal systems, and other sources. Plants and bacteria break down nitrate but excess amounts can leach into groundwater; once in the groundwater, nitrate can remain relatively stable for years.

Nitrogen is an element essential for plant growth. In the environment, it naturally converts to nitrate, a nitrogen-oxygen ion (NO_3^-) that is very soluble and mobile in water. The primary concern for human health is its conversion to nitrite (NO_2^-) in the body. Nitrite oxidizes iron in the hemoglobin of red blood cells to form methemoglobin, depriving the blood of oxygen. This is hazardous to infants as they do not yet have enzymes in their blood to counteract this process. They can suffer oxygen deficiency called methemoglobinemia, commonly known as "blue baby syndrome" named for its most noticeable symptom of bluish skin coloring. Both federal and state agencies regulate nitrate levels in water. The EPA and CDPH set the Maximum Contaminant Level (MCL) for nitrate (as nitrogen) in drinking water at 10 mg/L.

Management of nitrates is a component of the salinity management program in the Santa Ana River Watershed. Along with TDS objectives, water quality objectives for nitrates are established for each of the 39 groundwater management zones in the watershed. Water quality objectives and ambient quality levels for Orange County's management zones are shown in Table 8-4. As indicated, the main Orange County basin has a minor amount of assimilative capacity for nitrate but the Irvine Subbasin has no assimilative capacity.

Table 8-4: Nitrate-nitrogen Water Quality Objective for Lower Santa Ana River Basin Management Zones

Management Zone	Water Quality Objective	Ambient Quality
Orange County	3.4 mg/L	2.9 mg/L
Irvine	5.9 mg/L	6.7 mg/L

Source: Wildermuth Environmental (2014)

OCWD conducts an extensive program to protect the groundwater basin from nitrate contamination. The District regularly monitors nitrate levels in groundwater and works with Producers to treat individual wells when nitrate concentrations exceed safe levels.

One of the District's programs to reduce nitrate concentrations in groundwater is managing the nitrate concentration of water recharged by the District's facilities. This includes managing the quality of surface water flowing to Orange County through Prado Dam. To reduce nitrate concentrations in Santa Ana River water, OCWD operates an extensive system of wetlands in the Prado Basin as explained in Section 8.5**.**

The District tests all production wells annually for nitrate; wells with concentrations equal to or greater than 50 percent of the MCL are monitored on a quarterly basis. Areas where nitrate concentrations exceed the MCL are shown in Figure 8-5. OCWD works with the Producers to address areas of high nitrate levels. The Tustin Main Street Treatment Plant is an example of such an effort.

Within Orange County, nitrate levels in groundwater generally range from 4 to 7 mg/L in the Forebay area and from 1 to 4 mg/L in the Pressure area. Ninety-eight percent of the drinking water wells meet drinking water standards for nitrate. The two percent above MCL are treated to reduce nitrate levels prior to being served to customers.

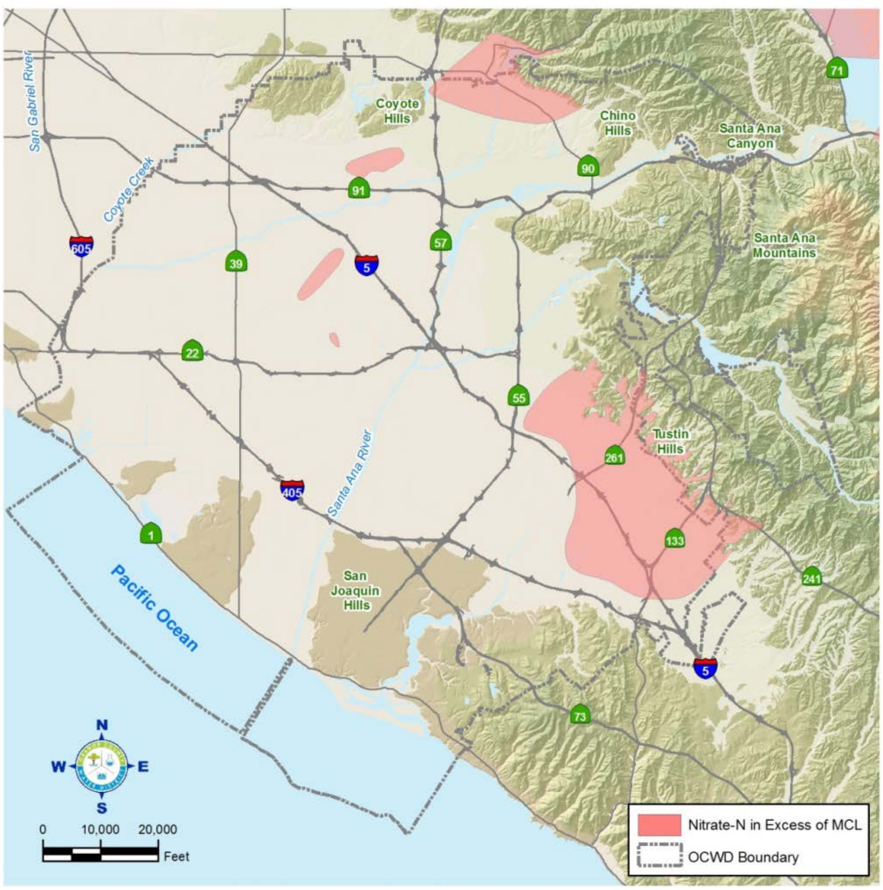


Figure 8-5: Areas with Elevated Nitrate Levels

8.5 OCWD PRADO WETLANDS

OCWD owns approximately 2,400 acres of land in the Prado Basin. As shown in Figures 8-6 and 8-7, this acreage includes the approximate 465-acre constructed Prado Wetlands, a system comprised of 50 shallow ponds. Originally, the site was used for farming barley. In the mid-1970s the fields were turned into ponds to be used for duck hunting. In 1996, OCWD modified the duck ponds and converted them to a natural water treatment system. The Prado Wetlands are designed to remove nitrogen and other pollutants from the Santa Ana River before the water is diverted from the river in Orange County to be percolated into OCWD's surface water recharge system.

OCWD diverts approximately half of the base flow of the Santa Ana River through the wetland ponds, which remove an estimated 15 to 40 tons of nitrates a month depending on the time of year. The wetlands are more effective from May through October when the water temperatures are warmer and daylight hours are longer. During summer months the wetlands reduce nitrate from nearly 10 mg/L to 1 to 2 mg/L.

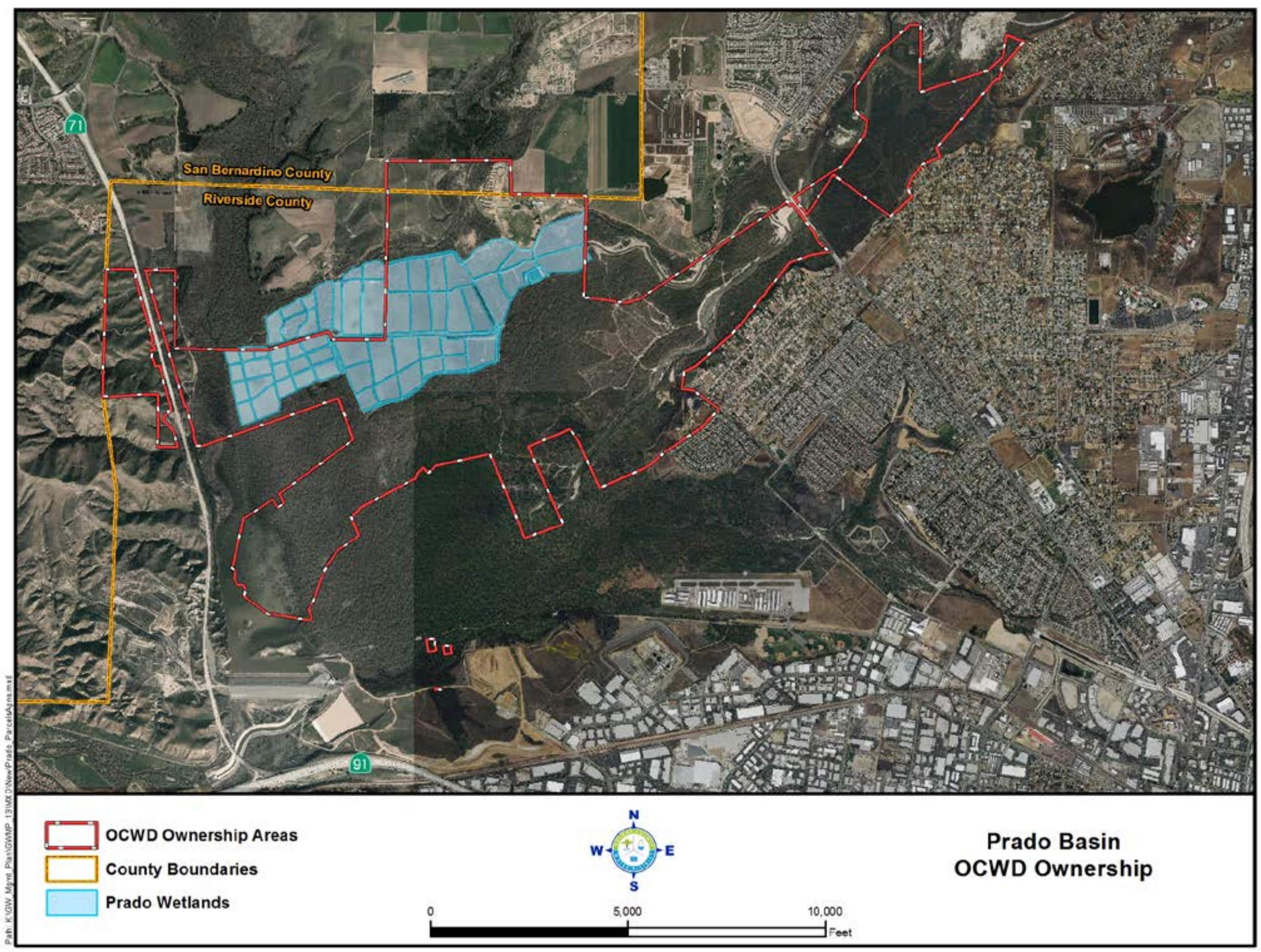


Figure 8-6: Location of Prado Wetlands

Figure 8-7: Aerial View of Prado Wetlands

Treating the water in the Prado Wetlands is an important first step in protecting the basin's groundwater quality before it reaches downstream recharge facilities in Anaheim. The majority of the baseflow (non-stormwater flow) in the Santa Ana River is comprised of treated wastewater. On an annual basis, about 50% of the SAR flow entering the Prado Basin is treated wastewater, but during summer months, treated wastewater can comprise more than 90% of the baseflow.

Wastewater contains nitrogenous compounds, other nutrients such as phosphate and complex organic compounds. In the 1990s, research demonstrated a significant change in the organic composition of water after flowing through wetland ponds. These studies suggest that wetlands play an important role in not only removing nitrate but also changing the overall organic signature of the wastewater. The diverse array of wetland processes appears to modify organic compounds from anthropogenic sources producing a matrix dominated by characteristics of natural organic material. As a result, the wetlands were found to consistently improve the quality of the river water.

Aquatic plants play a significant role in the transformation and transport of nitrogen in a wetlands system. Two important plants for nitrate removal in the Prado Wetlands are bulrush

(*Schoenoplectus californicus*) and cattail (*Typha latifolia*). These two plants take up nitrate as an essential nutrient while also providing an environment for bacterial growth. Most of the nitrate is removed at the soil/root interface through an anaerobic bacterial process called denitrification. This process transforms nitrate to nitrogen gas with no solid residue which must be disposed as is the case with treatment plant nitrate removal.

Surface water flows from the Santa Ana River are conveyed through a series of wetland ponds, shown in Figure 8-8, where the water is naturally treated by micro-organisms and wetland plants to remove nitrates and other pollutants. Once the water is treated, it is conveyed back to the Santa Ana River where it is blended with other sources of surface water in the Prado Basin, including Chino Creek, Mill Creek and Temescal Wash. The blended flows pass through Prado Dam where they are captured by OCWD facilities and recharged into the groundwater basin.

Treatment ponds are dominated by zones of emergent and submerged aquatic plants and open water of varying depth. A network of levees, concrete weirs and conveyance piping control water flow through the ponds where it undergoes sedimentation, assimilation, adsorption, and denitrification treatment processes, all of which are specifically designed to remove nitrogen and other pollutants from river water.

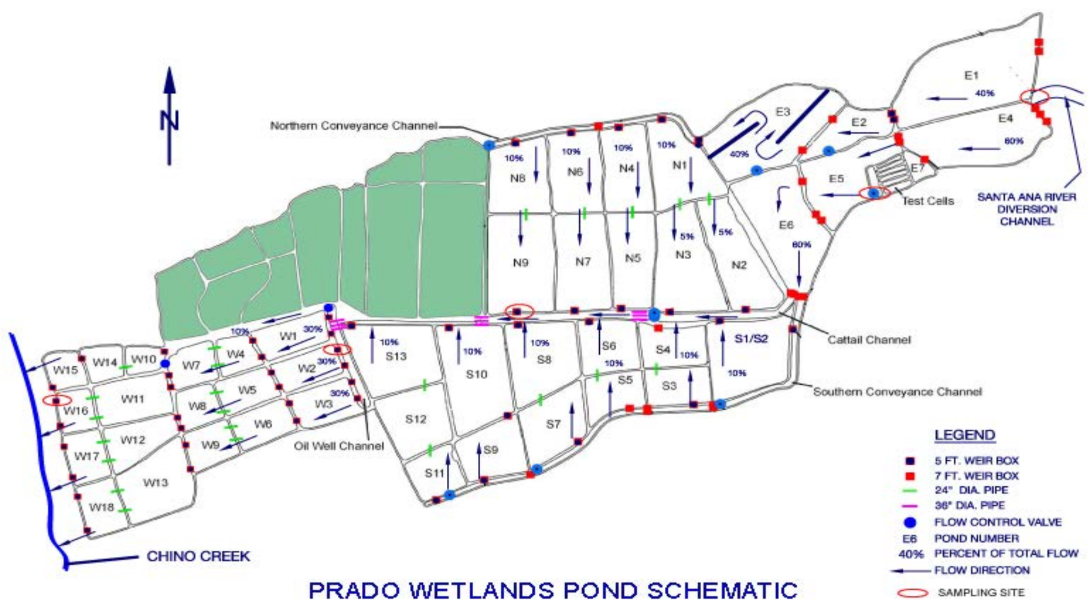


Figure 8-8: Wetlands Pond Schematic

Mitigation requirements for potential environmental impacts due to temporary storage of water behind Prado Dam include planting 10,000 mule fat plants per year, restoring riparian habitat, controlling non-native plants, managing vireo and surveying nesting sites, conducting cowbird trapping programs, and creating habitat for the Santa Ana Sucker fish, as discussed in more detail in Section 9.

8.6 AMBER-COLORED GROUNDWATER MANAGEMENT

Amber-colored water is found in the Deep Aquifer (600-2,000 feet below ground surface), as shown in Section 3, Figure 3-2 and Figure 8-9. Buried natural organic material from ancient buried plant and woody material gives the water an amber tint and a sulfur odor. Although this water is of very high quality, its color and odor produce negative aesthetic qualities that require treatment before use as drinking water.

The total volume of amber-colored groundwater is conservatively estimated to be over one million acre feet. Economic constraints pose challenges to developing this source of water due to cost of treatment to remove the color and odor. Treatment costs depend on the water quality (color and other parameters) and the type and extent of required treatment.

Another limitation to development of amber colored groundwater is the potential negative impact in other aquifer zones. Monitoring wells reveal a correlation of clear/colored zone water level fluctuations, indicating a fairly strong hydrologic connection between the two zones in some areas of the basin. Pumping amber colored water has the potential to mobilize movement of the colored water into the Principal Aquifer.

Two facilities currently treat colored groundwater in Orange County. In 2001, Mesa Water District opened its Colored Water Treatment Facility (CWTF) 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. The second facility is the Deep Aquifer Treatment System (DATS), a treatment facility operated by the Irvine Ranch Water District since 2002 that uses nano-filtration membranes. This facility purifies 7.4 mgd of amber-colored water.

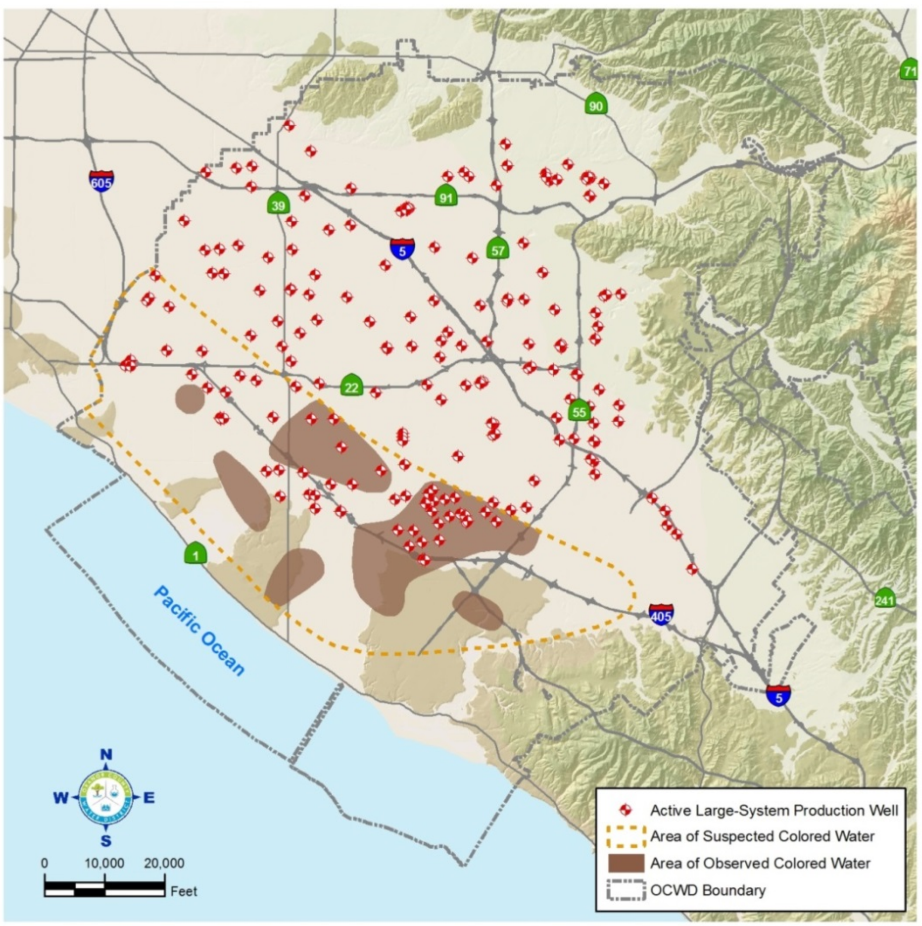


Figure 8-9: Extent of Amber-Colored Water

8.7 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. For example, the County of Orange Health Care Agency (OCHCA) regulates leaking underground fuel tanks except in cases where an individual city or the Regional Water Board is the lead agency.

OCWD does not have regulatory authority to require responsible parties to clean up pollutants that have contaminated groundwater. In some cases, the District has pursued legal action against entities that have contaminated the groundwater basin to recover the District's remediation costs. The District 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; and
- 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.

Ninety-five percent of groundwater used for drinking water supplies is pumped from the Principal Aquifer. Water from this aquifer continues to be of high quality. This section describes areas of the basin that are experiencing contamination threats, most of which occur in the Shallow Aquifer.

8.7.1 Methyl Tertiary Butyl Ether (MTBE)

During the 1980s, gasoline hydrocarbons of greatest risk to drinking water were benzene, toluene, ethylbenzene, and xylenes, collectively known as BTEX chemicals. Although leaking underground fuel tanks were identified throughout the basin, these chemicals typically were degraded by naturally-occurring aquifer microbes that allowed clean up by natural attenuation or passive bioremediation.

Unfortunately, an additive to gasoline aimed at reducing air pollution became a widespread contaminant in groundwater supplies. Methyl tertiary butyl ether (MTBE) is a synthetic, organic chemical that was added to gasoline to increase octane ratings during the phase-out of leaded gasoline. In the mid-1990s, the percentage of MTBE added to gasoline increased significantly to reduce air emissions. MTBE is a serious threat to groundwater quality as it sorbs weakly to soil and does not readily biodegrade. The greatest source of MTBE contamination comes from underground fuel tank releases.

The State of California banned the use of the additive in 2004 in response to its widespread detection in groundwater throughout the state. The Division of Drinking Water set the primary MCL for MTBE in drinking water at 13 µg/L. The secondary MCL for MTBE is 5 µg/L.

Drinking water wells in the basin are tested annually for VOC analytes including MTBE. The District continues to work with local water agencies to monitor for MTBE and other fuel-related contaminants to identify areas that may have potential underground storage tank problems and releases resulting in groundwater contamination.

8.7.2 Volatile Organic Compounds

Volatile organic compounds (VOCs) in groundwater come from a number of sources. From the late 1950s through early 1980s, VOCs were used for industrial degreasing in metals and electronics manufacturing. Other common sources include paint thinners and dry cleaning solvents.

VOC contamination is found in several locations in the basin. In 1985, contamination was discovered beneath the former El Toro Marine Corps Air Station. Monitoring wells at the site installed by the U.S. Navy and OCWD delineated a one-mile wide by three-mile long plume, comprised primarily of trichloroethylene (TCE). Beneath the site, VOC contamination was primarily found in the shallow groundwater up to 150 feet below the ground surface. Off-base, to the west, the VOC plume migrated to deeper aquifers from 200 to 600 feet deep.

Another area of VOC contamination was found in the Shallow Aquifer and portions of the Principal Aquifer in the northern portion of Orange County in the cities of Fullerton and Anaheim. The District's groundwater monitoring data indicate that the VOCs are migrating into the Principal Aquifer, which is used for drinking water supplies. Two of Fullerton's and one of Anaheim's production wells were removed from service and destroyed due to VOC contamination in the area. The North Basin Groundwater Protection Program, described in Section 8.9, was initiated in 2005 to minimize the spread of the contamination and clean up the groundwater in this portion of the basin.

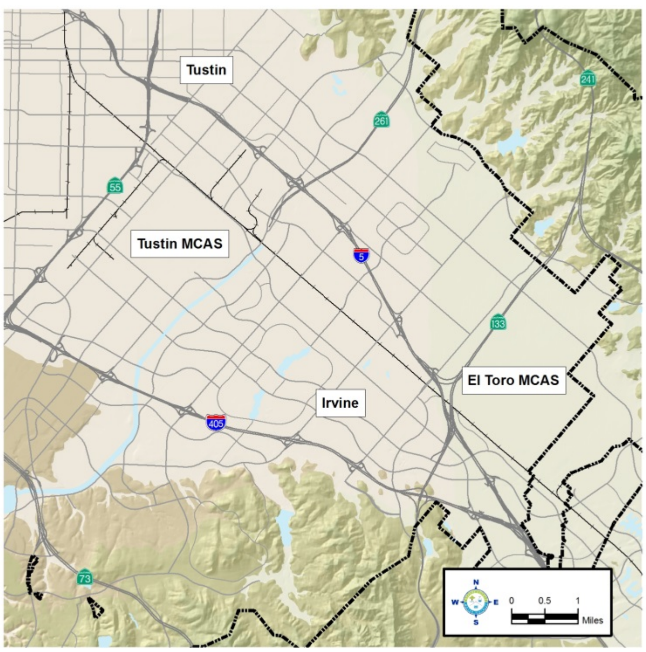


Figure 8-10: Groundwater Cleanup Projects

Elevated concentrations of perchloroethylene (PCE), TCE, and perchlorate were detected in Irvine Ranch Water District's Well No. 3, located in Santa Ana. OCWD is currently working with the Regional Water Quality Control Board and the California Department of Toxic Substances Control to require aggressive cleanup actions at nearby sites that are potential sources of the contamination. OCWD has initiated the South Basin Groundwater Protection Program described in Section 8.9 to address this area of contamination.

8.7.3 N-Nitrosodimethylamine (NDMA)

N-Nitrosodimethylamine (NDMA) is a low molecular weight compound that can occur in wastewater after disinfection of water or wastewater via chlorination and/or chloramination. It is also found in food products such as cured meat, fish, beer, milk, and tobacco smoke. The California Notification Level for NDMA is 10 nanograms per liter (ng/L) and the Response Level is 300 ng/L.

OCWD routinely monitors for NDMA in the groundwater and in water supplies used for recharge. In 2000, OCWD discovered NDMA in groundwater near the Talbert Barrier. One production well was found to have concentrations in excess of the Notification Level. OCWD installed and operated an ultraviolet light treatment system on this well to remove the NDMA beginning in 2001 until the NDMA levels at the well were consistently below the 2 ng/L analytical detection limit in 2010.

An OCSD investigation traced the contaminant to industrial wastewater dischargers that affected the water produced by WF 21 injected into the Talbert Barrier. NDMA concentrations are maintained below the Notification Level at the GWRS plant through a combination of source control measures and photolysis using ultraviolet light. As of 2012, NDMA was no longer detectable in any of the GWRS compliance monitoring wells near the Talbert Seawater Barrier. Santa Ana River water, tested at Imperial Highway, consistency has NDMA concentrations less than 2 ng/L.

Figure 8-11: Sample Analysis at OCWD Laboratory

8.7.4 1,4-Dioxane

A suspected human carcinogen, 1,4-dioxane, is used as a solvent in various industrial processes such as the manufacture of adhesive products and membranes and may be present in consumer products such as detergents, cosmetics, pharmaceuticals, and food products. In 2002, OCWD detected 1,4-dioxane in groundwater near the Talbert Barrier. A total of nine production wells were found to exceed the then California Notification Level of 3 micrograms per liter (µg/L). These wells were temporarily shut down with a loss of 34 mgd of water supply. Further investigation traced the contaminant to one industrial discharger that was discharging 1,4-dioxane into the OCSD sewer system and subsequently treated by WF 21. The discharger voluntarily ceased discharging 1,4-dioxane to the sewer, which resulted in a decline in 1,4-dioxance concentrations. Later monitoring data showed reduced 1,4-dioxane concentrations. The CDPH determined that the water was not a significant risk to health, and the wells were returned to service under the Notification Level requirements. 1,4-dioxane concentrations are maintained at the GWRS plant below the updated Notification Level of 1 µg/L through a combination of source control measures, improved reverse osmosis, and advanced oxidation using ultraviolet light and hydrogen peroxide addition.

8.7.5 Perchlorate

Sources of perchlorate in groundwater include:

- Application of fertilizer containing perchlorate;
- Water imported from the Colorado River and used for recharge or irrigation;
- Industrial or military sites that used, disposed of, or stored perchlorate that was used as an ingredient in rocket propellant, explosives, fireworks, and road flares; and
- Naturally occurring perchlorate.

The occurrence of perchlorate in Chilean fertilizer applied for agricultural purposes has been documented in various studies, for example, the discussion in the December 1, 2006 publication of the journal *Analytical Chemistry* (Foubister, 2006) and Urbansky et al (2001).

The occurrence of perchlorate in historic supplies of Colorado River water has been documented in published studies, including a 2005 National Research Council report titled "Health Implications of Perchlorate Ingestion" (National Research Council, 2006), and Urbansky et al (2001). Due to remediation efforts near Henderson, Nevada, a key source of perchlorate in Lake Mead, the concentration of perchlorate in Colorado River water has decreased in recent years (Nevada Division of Environmental Protection, 2009).

Perchlorate has been detected in groundwater at various sites in California in association with industrial or military sites (Interstate Technology & Regulatory Council, 2005). Perchlorate also has been detected in rainfall (see for example, the report published by the Interstate Technology & Regulatory Council, 2005 and Dasgupta et al (2005)).

Perchlorate has been detected at wells distributed over a large area of the groundwater basin. Based on data from 219 active production wells between 2010 and 2014 and a detection limit of 2.5 micrograms per liter, perchlorate was not detected in 84 percent of the wells. Sixteen percent of the wells had detectable concentrations of perchlorate. For those wells with detectable amounts of perchlorate, 89 percent of the wells have detected perchlorate concentrations at or below the California primary drinking water standard of 6 micrograms per liter. Four of the 219 active production wells had perchlorate concentrations greater than 6 micrograms per liter. It is important to note that water delivered for municipal purposes meets the primary drinking water standard. Groundwater from production wells that have perchlorate concentrations over the primary drinking water standard is treated to reduce the concentration below the primary drinking water standard prior to delivery for municipal usage.

The District's ongoing monitoring program is continuing to assess the distribution of perchlorate in the groundwater basin and how concentrations change through time. The District regularly reviews this information and will continue to work with the stakeholders to address this issue.

8.7.6 Selenium

Selenium is a naturally-occurring micronutrient found in soils and groundwater in the Newport Bay watershed. Selenium is essential for reproductive health and immune system function in humans, fish and wildlife. However, selenium bio-accumulates in the food chain and can result in deformities, stunted growth, reduced hatching success, and suppression of immune systems in fish and wildlife.

Prior to urban development, the Irvine Subbasin was an area of shallow groundwater that contained an area known as the Swamp of the Frogs (Cienega de Las Ranas). Runoff from local foothills over several thousands of years accumulated selenium-rich deposits in the swamp. To make this region suitable for farming, drains and channels were constructed. This mobilized selenium from sediments into the shallow groundwater drained by the channels that eventually discharge to Newport Bay.

The Nitrogen and Selenium Management Program was formed to develop and implement a work plan to address selenium and nitrate in the watershed. This stakeholder working group that includes the County of Orange, affected cities, environmental organizations, Irvine Ranch Water District, the Irvine Company and the Santa Ana Regional Water Board developed a long-term work plan to identify comprehensive point and non-point source management plans for selenium and nitrogen, identify and pilot test potential treatment technologies, and recommend an implementation plan. Management of selenium is difficult as there is no off-the-shelf treatment technology available.

8.8 CONSTITUENTS OF EMERGING CONCERN

Constituents of emerging concern (CECs) are synthetic or naturally occurring substances that are not formally regulated in water supplies or wastewater discharges but can now be detected using very sensitive analytical techniques. The newest group of constituents of emerging concern includes pharmaceuticals, personal care products and endocrine disruptors.

Pharmaceuticals and personal care products (PPCPs) include thousands of chemicals contained in consumer and health-related products such as toothpaste, drugs (prescription and over-the-counter), food supplements, fragrances, sun-screen agents, deodorants, flavoring agents, insect repellants, and inert ingredients. Important classes of high-use prescription drugs include antibiotics, hormones, beta-blockers (blood pressure medicine), analgesics (pain-killers), steroids, antiepileptic, sedatives, and lipid regulators.

Endocrine Disrupting Compounds (EDCs) are compounds that can disrupt the endocrine system. They can occur in a wide variety of products such as pesticides and pharmaceuticals.

Research investigations have documented that EDCs can interfere with the normal function of hormones that affect growth and reproduction in animals and humans. Findings of secondary sex changes, poor hatching, decreased fertility, and altered behavior have been observed in fish following exposure to EDCs.

In general, these substances have been identified as potential contaminants or were previously detected in the environment. As new laboratory methods are developed, substances can be detected at much lower concentrations. When such detection occurs before regulatory limits are established and potential environmental/aquatic and human health effects are still unknown, water suppliers and health officials face new challenges. In some cases, public awareness and concern is high because the compounds are detected but scientific-based information on potential health impacts of such low concentrations is not available.

Water quality concerns arise from the widespread use of PPCPs and EDCs. In the case of pharmaceuticals, the impacts on human health from exposure to low concentrations of these substances are well known due to studies completed during their development and regulatory approval. The effects of personal care products, EDCs, and mixtures of CEC's are less well understood. European studies in the 1990s confirmed the presence of some of these chemicals in the less than one microgram per liter range (ppb) in surface waters and groundwater and at low concentrations in wastewater treatment plant effluents.

A USGS report found detectable concentrations of hormones and PPCPs in many vulnerable waterways throughout the United States (Kolpin 2002). Due to the potential impact of EDCs on water reclamation projects, the District prioritizes monitoring of these chemicals.

OCWD's state-certified laboratory is one of a few in the state that has a program to continuously develop capabilities to analyze for new compounds. Recognizing that the state Division of Drinking Water has limited resources to focus on methods development, OCWD works on developing low detection levels for chemicals likely to be targeted for future regulation or monitoring.

OCWD advocates the following general principles as water suppliers and regulators develop programs to protect public health and the environmental from adverse effects of CECs:

- Monitoring should focus on constituents that pose the greatest risk.
- Constituents that are prevalent, persistent in the environment, and may occur in unsafe concentrations should be prioritized.
- Analytical methods to detect these constituents should be approved by the state or federal government.
- Studies to evaluate the potential risk to human health and the environment should be funded by the state or federal government.
- The state and federal government should encourage programs to educate the public on waste minimization and proper disposal of unused pharmaceuticals.

OCWD is committed to (1) track new compounds of concern; (2) research chemical occurrence and treatment; (3) communicate closely with the Division of Drinking Water on prioritizing investigation and guidance; (4) coordinate with OCSD, upper watershed wastewater dischargers and regulatory agencies to identify sources and reduce contaminant releases; and (5) inform the Producers on emerging issues. The District's program for monitoring CECs is explained in Section 4.

8.9 GROUNDWATER QUALITY IMPROVEMENT PROJECTS

This section describes specific projects that improve groundwater quality by removing TDS, nitrate, VOCs and other constituents. The location of these projects is shown in Figure 8-12.

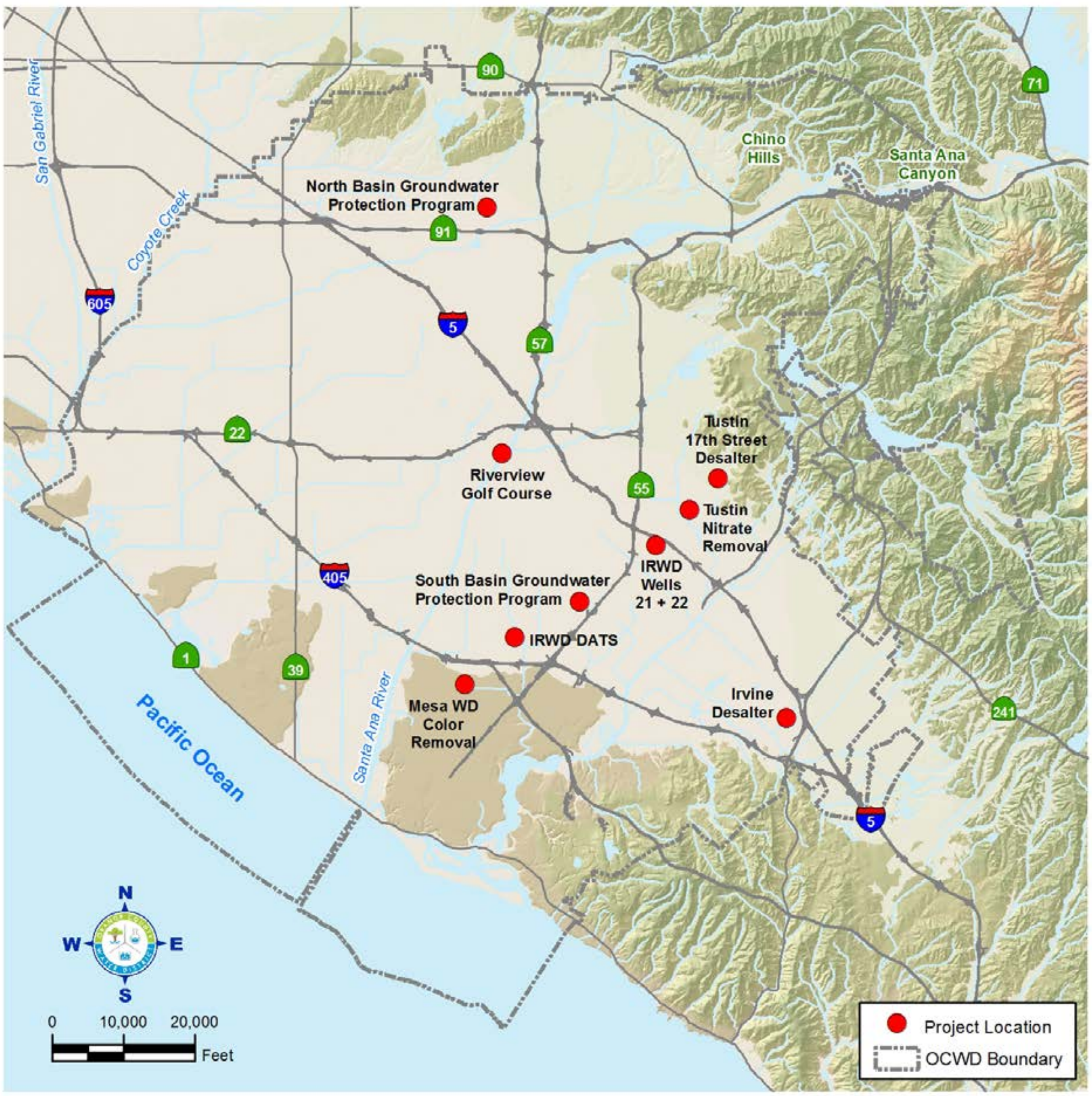


Figure 8-12: Water Quality Improvement Projects

8.9.1 North Basin Groundwater Protection Program (NBGPP)

The purpose of the North Basin Groundwater Protection Program (NBGPP) is to develop a remedial strategy to prevent VOC-contaminated groundwater in the cities of Fullerton and Anaheim from further spreading in the Shallow Aquifer and migrating vertically into the Principal Aquifer.

Groundwater contamination, shown in Figure 8-13, is primarily found in the shallow-most 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. The District is working with regulatory agencies and stakeholders to evaluate and develop effective remedies to address the contamination under the National Contingency Plan (NCP) process.

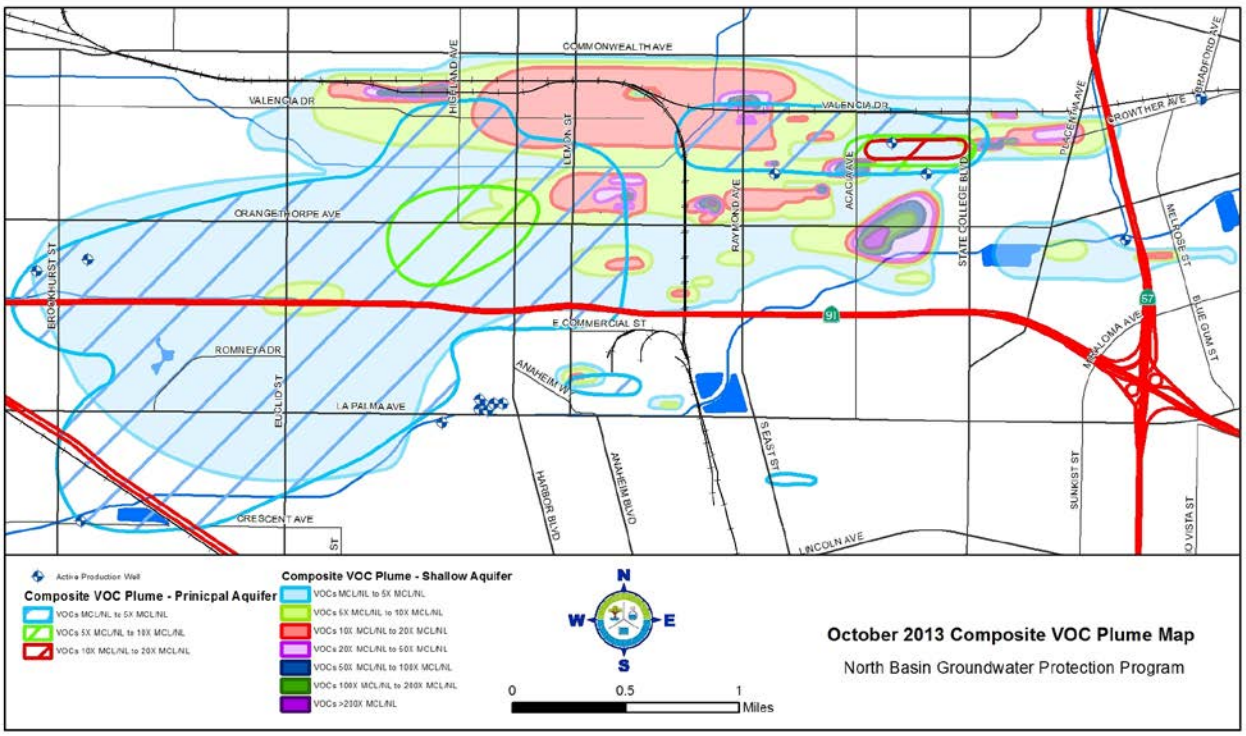


Figure 8-13: North Basin Groundwater Contamination Plume

8.9.2 South Basin Groundwater Protection Program (SBGPP)

The purpose of the South Basin Groundwater Protection Program (SBGPP) is to remediate contaminated groundwater in the southern part of the Orange County groundwater basin, shown in Figure 8-14, before it impacts additional drinking water wells and groundwater supplies. The extent of groundwater contamination from volatile organic compounds (VOCs) and perchlorate has been investigated, contamination plumes have been delineated, and the remedial program is being developed in cooperation with regulatory agencies and stakeholders following the NCP process.

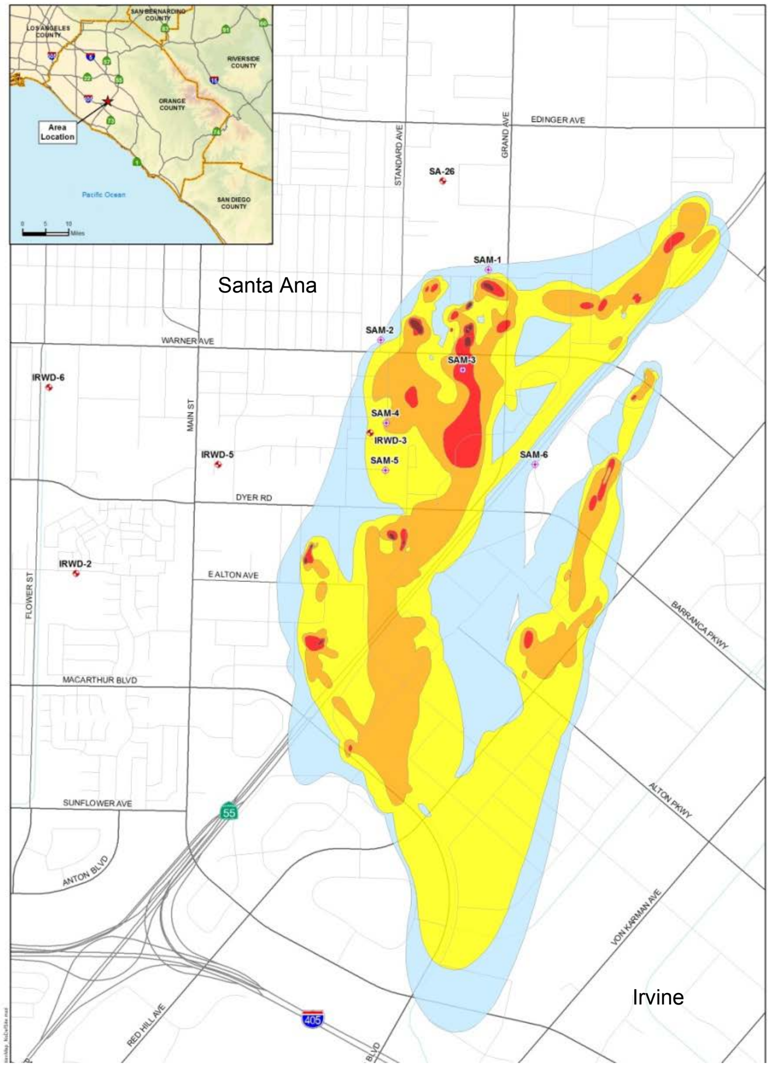


Figure 8-14: South Basin Groundwater Contamination Plume

8.9.3 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.

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). If other contaminants (e.g., excessive nitrates or TDS) are also found in groundwater with MTBE, additional treatment processes (ion exchange membranes) would also need to be included in the process train.

8.9.4 Irvine Desalter

The Irvine Desalter was built in response to the discovery in 1985 of VOCs beneath the former El Toro Marine Air Corps Station and the central area of Irvine. The plume of improperly disposed cleaning solvents migrated off base and threatened the groundwater basin. Irvine Ranch Water District and OCWD cooperated in building production wells, pipelines and two treatment plants, both of which are now owned and managed by Irvine Ranch Water District. One plant removes VOCs by air-stripping and vapor-phase carbon adsorption with the treated water used for irrigation and recycled water purposes. A second plant treats groundwater outside the plume to remove excess nitrate and TDS concentrations using RO membranes for drinking water purposes. Combined production of the Irvine Desalter wells is approximately 8,000 afy.

8.9.5 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 reverse osmosis or ion exchange treatment. The reverse osmosis 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 afy.

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 afy.

8.9.6 River View Golf Course

VOC contamination, originating from an up-gradient source, was discovered in a well owned by River View Golf Course, located in the City of Santa Ana. The well was used for drinking water but was converted to supply irrigation for the golf course due to the contamination. Continued operation of the well helps to remove VOC contamination from the basin.

8.9.7 Irvine Ranch Water District Wells 21 and 22

Water produced by Irvine Ranch Water District Wells 21 and 22 contain nitrate (measured as Nitrogen) 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 reverse osmosis treatment facility to reduce concentrations in the water before conveying to the potable supply distribution system.

Operation of the treatment facility provides 6,300 afy of drinking water and will benefit the groundwater basin by reducing the spread of impaired groundwater to other portions of the basin.

8.10 BEA EXEMPTION FOR IMPROVEMENT PROJECTS

In some cases, the District 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.

As explained in detail in Section 11, OCWD uses financial incentives to manage the level of pumping from the groundwater basin. Producers pay a Replenishment Assessment (RA) for water pumped from the basin. Each year the District sets an allowable amount of pumping and assesses an additional charge, called the BEA, on all water pumped above that limit.

OCWD uses a partial or total exemption of the BEA to compensate a qualified participating agency or 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, the District 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 8-5.

Table 8-5: Summary of BEA Exemption Projects

Project Name	Project Description	BEA Exemption Approved	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
River View Golf Course	Remove VOCs	1998	350	$50/af BEA reduction
Mesa WD Colored Water Removal	Remove Color	2000	8,700	Exemption
IRWD Wells 21 and 22	Remove nitrates	2012	7,000	Exemption

NATURAL RESOURCE AND COLLABORATIVE WATERSHED PROGRAMS 9

Natural Resources and Collaborative Programs are conducted in Orange County, Prado Basin and in the watershed upstream of Prado Dam.

Watershed Programs

- Mitigation for OCWD's water management in Prado Basin: invasive plant removal, planting of native vegetation, managing habitat for threatened and endangered birds and creating habitat for the Santa Ana Sucker

Orange County Programs

- Burris Basin Habitat Management Plan
- Nest Boxes

Collaborative Watershed Program

- Partnering with Santa Ana Watershed Association
- Participating in task forces with the Santa Ana Watershed Project Authority
- Working with Municipal Water District of Orange County
- Partnering with OC Flood Control District and OC Sanitation District

SECTION 9 NATURAL RESOURCE AND COLLABORATIVE WATERSHED PROGRAMS

9.1 OCWD NATURAL RESOURCE PROGRAMS – OVERVIEW

OCWD participates in cooperative efforts within the Santa Ana River Watershed. OCWD's natural resource programs remove invasive plants, plant native species, and manage habitat and wildlife including endangered and threatened species. These programs protect the water quality in the Santa Ana River and fulfill mitigation requirements for impacts to natural resources from District operations in the Prado Basin. OCWD's natural resource programs exceed that which is required by regulations with the belief that excellence in water management and stewardship of natural resources go hand in hand.

The Prado Dam was built by the U.S. Army Corps of Engineers (the Corps) in 1941. In the 1960s the Corps began working with OCWD to conserve water behind the dam in order to support OCWD's recharge operations as described in Section 5. OCWD's natural resource programs began in response to concerns that increased water storage behind the dam could negatively impact the Prado Basin ecosystem.

The Prado Basin, shown in Figure 9-1, contains the single largest stand of forested riparian habitat remaining in coastal Southern California, which supports an abundance and diversity of wildlife including many federal and state listed and sensitive species. OCWD owns approximately 2,150 acres of land in the Prado Basin, which includes approximately 465-acres of managed wetlands. The wetlands are operated to improve the quality of Santa Ana River water that is used downstream to recharge the Orange County Groundwater Basin.

In addition to programs in the Prado Basin, the District is a partner in watershed-wide efforts to eradicate the invasive plant *Arundo donax*, manages habitat for rare and endangered birds and conducts programs to protect the Santa Ana Sucker, an endangered fish. Wildlife protection programs within Orange County include the construction of a bird island on Burris Basin.

<u>PRADO BASIN NATURAL RESOURCES</u>

The riparian woodland provides habitat for a wide variety of wildlife species, particularly birds. The avifauna is a diverse assemblage of resident and migratory species. The raptor concentration in the Prado Basin is among the largest in Southern California. The Prado Basin also provides habitat for the federally and state listed endangered southwestern willow flycatcher (Empidonax traillii extimus), least Bell's vireo (Vireo belli pusillas) and the state listed endangered yellow-billed cuckoo (Coccyzus americanus occidentalis). However, the cuckoo has not been reported in several years. Additionally, several species designated by the California Department of Fish and Wildlife as "Birds of Special Concern" occupy habitat in the basin. These include the Cooper's hawk (Accipiter cooperi), yellow warbler (Dendroica petechia) and yellow-breasted chat (Icteria virens).

Figure 9-1: View of Prado Basin Looking East with Prado Dam in Foreground

9.2 NATURAL RESOURCE PROGRAMS IN THE WATERSHED

OCWD began actively managing habitat and natural resources in the Prado Basin in the 1980s when the District began working with the Corps to increase storage of storm water behind Prado Dam. Enhanced water conservation required planning to avoid, minimize and offset potential environmental damage. The availability of water in the Prado Basin supported wetland habitat but inundation for long periods could negatively impact habitat value.

Mitigation requirements for environmental impacts due to OCWD's ongoing operation of the Prado Wetlands and temporary storage behind Prado Dam for water conservation include planting 10,000 native plants per year, restoring riparian habitat, controlling non-native plants, managing least Bell's vireo and survey nesting sites, conducting cowbird trapping programs, and creating habitat for the Santa Ana Sucker.

A total of 19 mitigation sites are included in the Prado Mitigation Monitoring Program (Figure 9-2). To comply with mitigation requirements, OCWD prepares annual monitoring reports to document the progress of habitat restoration activities and management efforts.

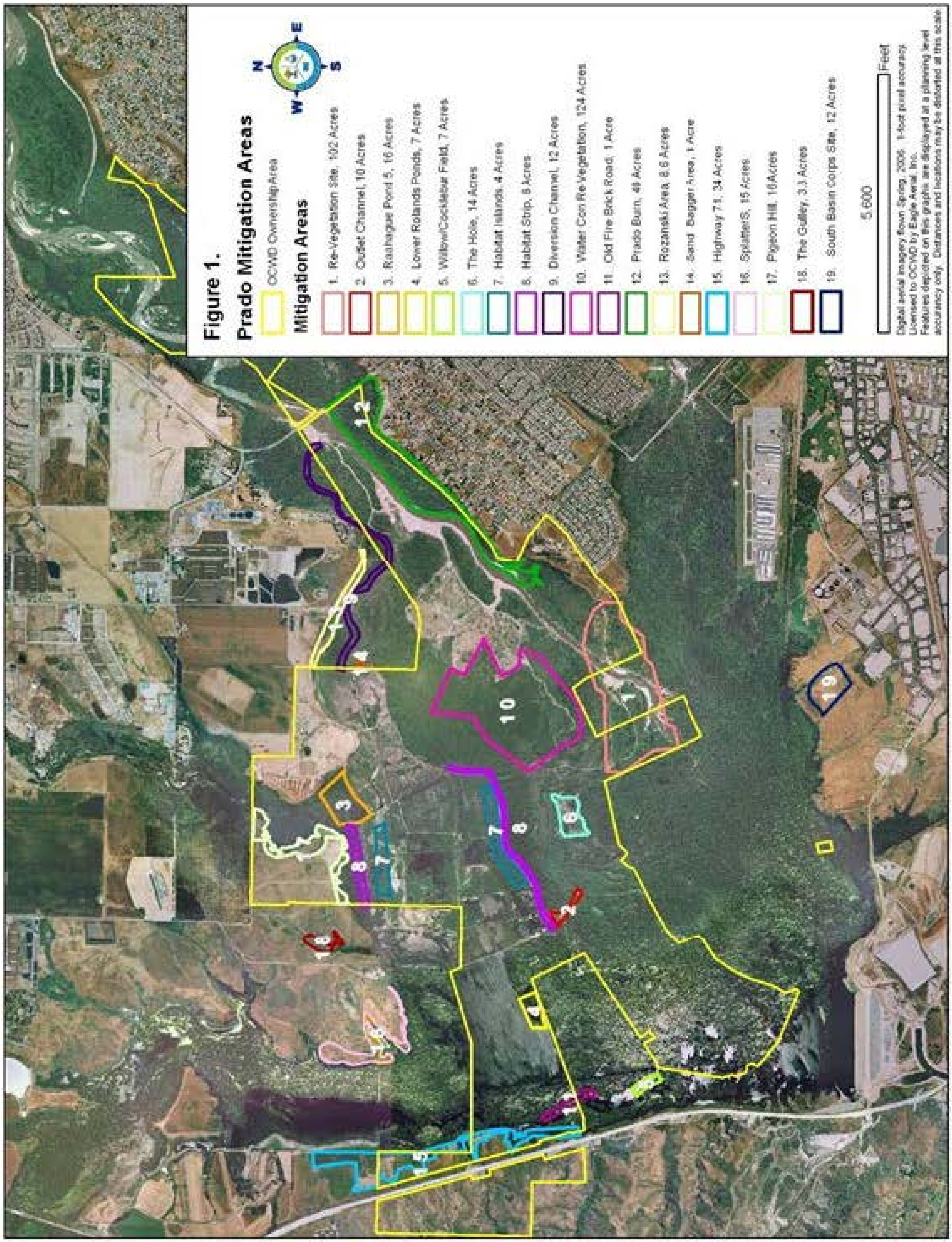


Figure 9-2: Prado Mitigation Areas

9.2.1 Least Bell's Vireo

OCWD is committed to manage habitat and monitor the populations of an endangered bird, the least Bell's vireo, shown in Figure 9-3. In 1983, there were 12 vireo territories in the Prado Basin and extirpation was imminent. OCWD signed agreements with the U.S. Fish and Wildlife Service (USFWS) and the Nature Conservancy in 1989 and 1990 to initiate and fund a vireo management program. This program was expanded with additional agreements with the Corps in 1991, 1992, 1995, 2000, and 2004. In exchange for expansion of water storage behind the dam, OCWD contributed $1.07 million to the Nature Conservancy and $1 million to the Santa Ana Watershed Association (SAWA) and made commitments to restore wildlife habitat, remove invasive plants and participate in other natural resource protection programs in the watershed. Agreements expanded to include establishing a trust fund to remove Arundo and increasing vireo monitoring and habitat protection outside of Prado Basin throughout the watershed.

Figure 9-3: Least Bell's Vireo

OCWD has created more than 800 acres of habitat for the federally and state listed endangered least Bells' vireo, the Southwestern Willow Flycatcher and many other species in the Prado Basin. In the watershed outside of the basin, OCWD has partnered in the removal of over 5,000 acres of Arundo resulting in thousands of acres of restored habitat for many wildlife species.

During the last few years, vireo populations have increased to over 400 breeding pairs out of a total of up to 600 male territories in the Prado Basin (Pike, et al. 2010). A comparison between 1983 vireo territories and 2012 territories can be seen in Figures 9-4 and 9-5. OCWD continues to plant 10,000 native riparian plants in the ground annually. Placing the plantings above potential future water conservation elevations and adjacent to occupied vireo habitat is expected to result in expansion of populations and pave the way for additional water conservation.

LEAST BELL'S VIREO

Since the initiation of efforts by OCWD in 1983, populations of the least Bell's vireo (*Vireo pusillus bellii*) has grown from 12 territories in the Prado Basin to 1,432 in the Santa Ana Watershed including 569 in Prado Basin. The vireo population in the watershed is the single largest in existence. The success of vireo recovery in the Santa Ana River Watershed and range-wide in Southern California prompted the Fish and Wildlife Service to recommend that the vireo be down-listed to threatened status. Without OCWD's success with Arundo control and vireo management, increased water conservation and reduced outflows from Prado Dam would not have been allowed.

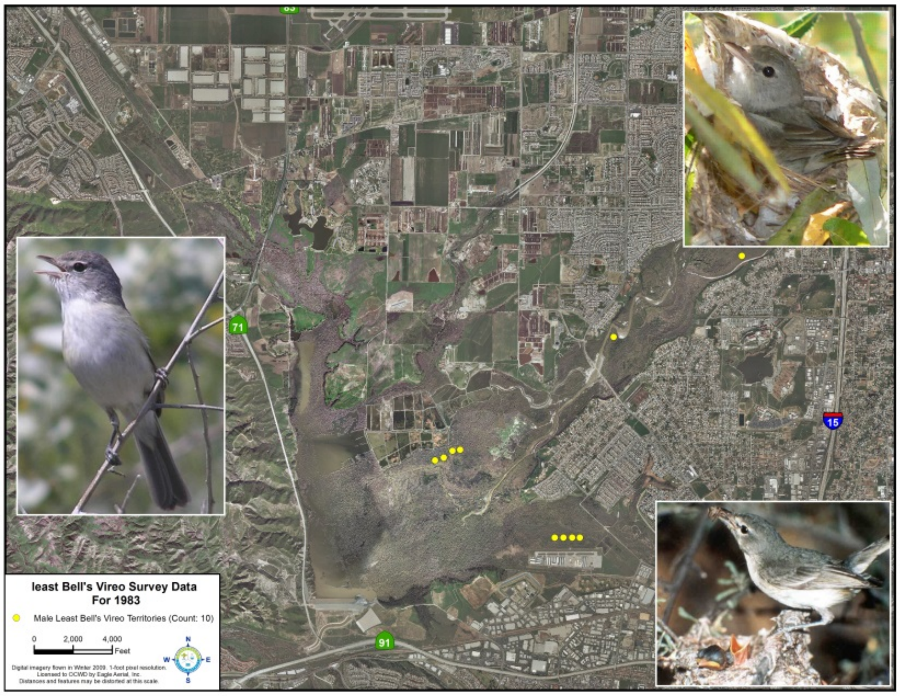


Figure 9-4: Least Bell's Vireo Survey Data 1983

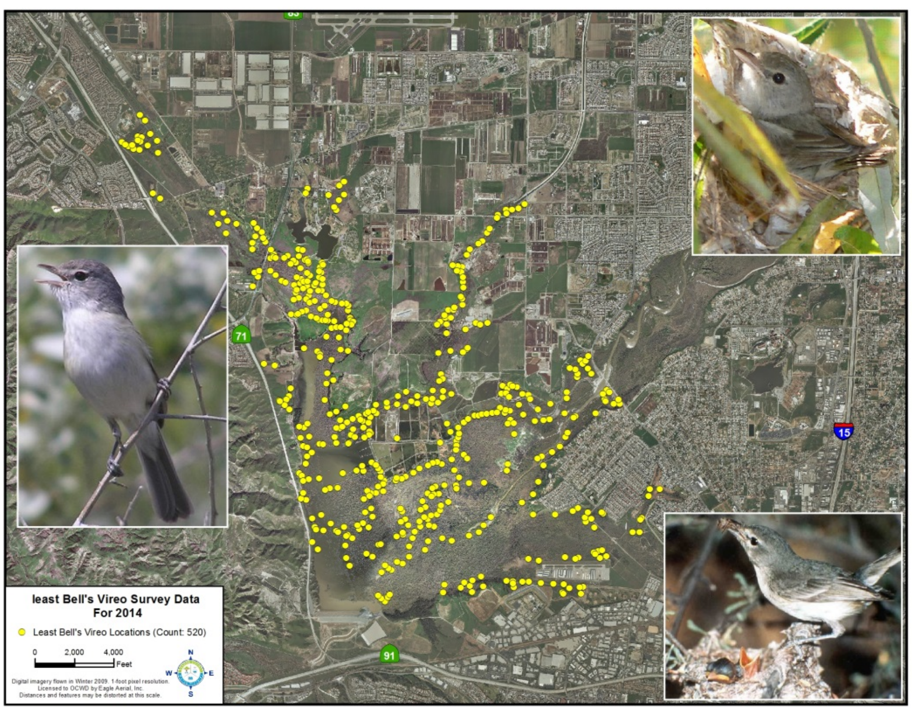


Figure 9-5: Least Bell's Vireo Survey Data 2014

9.2.2 Arundo Removal

Arundo donax, shown in Figure 9-6, is a grass species native to Europe that was purposely introduced to California in the 1820s for planting along ditches and channels to control erosion. This invasive plant spreads quickly, crowds out native vegetation and has become the dominant species along the Santa Ana River. The plant obstructs flood flows, causes expensive beach cleanups, degrades native habitat, impacts water quality, and consumes at least three times more water than native plants.

OCWD began involvement in watershed-wide Arundo control with the signing of a landmark agreement in 1995 between the Corps and U.S. Department of Interior, which allows OCWD to engage in mitigation actions in the upper watershed miles from OCWD property and the site of impact. These mitigation activities are accomplished in partnership with SAWA, a non-profit corporation run by a five member board with one representative each from the OCWD and four Resource Conservation Districts. Other partners involved in these efforts include the U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, the Corps, the Regional Water Quality Control Board, the counties, several cities, and many other individuals and organizations.

Figure 9-6: Arundo

Over 5,000 acres of Arundo have been cleared in the upper watershed and additional acres are planned to be cleared within the next five to 10 years. Removing Arundo and keeping it out has yielded a minimum of 15,000 acre-feet of water each year. The 5,000 acres of river bottom lands formerly infested by Arundo and other weeds are now under management. The entire upper watershed of the Santa Ana River and all of the major tributaries have been cleared and are under a regime of re-treatment as needed down to the vicinity of Prado Basin. The goal of control effort is to eventually eradicate Arundo and other pernicious weeds from the watershed.

Invasive Plants in the Watershed

A significant amount of the Santa Ana River Watershed, including the Prado Basin is infested with exotic vegetation. The exotic vegetation includes Giant Reed (Arundo donax), Tree-of-heaven (Ailanthus altissima), White Bladder Flower (Araujia sericifera), Pepperweed (Lepidium latifolium), Castor Bean (Ricinus communis), and Tamarisk (Tamarix ramosissima). The most prolific and abundant exotic species within the Prado Basin is Arundo. The Arundo grows rapidly and unless it is regularly treated it will grow back very quickly. Large strands of Arundo can wash downstream and re-sprout in areas where it has been removed. Until the time the Arundo is removed and managed within the upper watershed down to the Prado Basin, the basin will continue to be infested by Arundo. Arundo has caused major damage to bridges during floods, it renders water ways impenetrable, carries fire storms, destroys wildlife habitat, reduces water quality, interferes with flood control and endangered species recovery, and litters the beaches.

9.2.3 Santa Ana Sucker

The Santa Ana Sucker, shown in Figure 9-7, was common in streams of the Santa Ana Watershed and other rivers of Southern California, but has all but disappeared from areas where it was once common. Because of the marked decline in the numbers of these fish, the U.S. Fish & Wildlife Service listed the Santa Ana Sucker as threatened under the Endangered Species Act in 2004.

OCWD agreed to provide leadership in conservation efforts for the threatened Santa Ana Sucker as part of an agreement in 2006 with the California Department of Fish and Wildlife for dismissal of their protest for OCWD's petition for water rights before the State Water Resources Control Board.

Figure 9-7: Santa Ana Sucker

Suckers require cool, clear streams with rocky substrate, riffles and pools. The riffles and pools provide refuge from high velocity flows, sites for spawning fish and habitat for benthic invertebrates and plants. Presently, the majority of the Santa Ana River immediately upstream of the Prado Dam is composed of sandy substrate. The sand bottom provides minimal food resources, poor refuge from exotic predators, and no spawning opportunity.

In 2010, OCWD installed seven rock-filled gabions in the Santa Ana River above Prado Dam in Riverside County between River Road and Hamner Avenue, as shown in Figure 9-8. The gabions are designed to deflect the current, creating localized scour that expose gravel, cobbles and rocks that were buried by sand. This pilot project demonstrated the potential to create habitat for the sucker and showed that design of future, long-term habitat will require rock replenishment or anchoring to be ultimately successful.

Partnering with SAWA and other agencies, OCWD designed and implemented the only currently successful sucker habitat restoration project in the watershed. Sunnyslope Creek, a small tributary to the Santa Ana River located near Mt. Rubidoux in Riverside, was one of few known spawning sites for the threatened sucker. High flows caused a blockage in 2005 that cut off flows to the river and threatening the suckers. OCWD biologists conducted studies and began managing the creek in 2010 to restore the hydrologic connection to the river and reduce the threat from non-native predatory aquatic species. This on-going project was deemed a success beginning in 2011 when suckers in spawning condition were again detected in the creek.

The Santa Ana Sucker Conservation Team, comprised of staff from concerned public agencies from throughout the Santa Ana River Watershed have been meeting since 1998 to assess the reasons for the decline of the Santa Ana Sucker and to devise strategies for recovering the species.

Scientific studies and other cooperative efforts for Sucker conservation are being conducted by the Sucker Conservation Program. The funding partners include OCWD, Orange County Sanitation District, the County of Orange, Riverside County Flood Control and Water Conservation District, Riverside County Transportation Department, City of Riverside, Santa Ana Watershed Project Authority, and San Bernardino Flood Control District. Other active participants include the U.S. Fish & Wildlife Service, California Department of Fish & Wildlife, the Corps, and Santa Ana Regional Water Quality Control Board. Reports and other information are available online at www.sawpa.org.

Figure 9-8: Gabion in Santa Ana River Installed to Create Habitat for Santa Ana Sucker

9.2.4 Natural Resource Programs in Orange County

Burris Basin Habitat Management Plan

Reconstruction of one of the District's recharge basins, Burris Basin, necessitated the removal of existing vegetation and a small island. A comprehensive habitat management plan was developed to mitigate for habitat impacts which included construction of a floating island to provide bird habitat as shown in Figure 9-9. Non-native trees and vegetation were removed and replaced with 650 native trees, 2,900 shrubs and 1,000 mulefat plants. A small freshwater marsh habitat was created on the basin's edge with plantings of cattails, bulrush, primrose, and salt grass. A sandbar island was constructed to create habitat for the California Least Tern, a state and federal endangered species, as well as other native birds.

As a result of implementation of the Burris Basin Habitat Management Plan there is a productive 1.5 mile long riparian strip along the entire edge of the basin that in 2014 supported over 150 breeding bird territories in 2014 of 51 different species including Song Sparrows, hummingbirds, swallows, California Towhees, House Finches, Lesser Goldfinches, Mourning Doves, Northern Mockingbirds, Bushtits, Scrub Jay, Yellow Warbler, Common Yellowthroat, Ash-throated Flycatcher, and Black Phoebe.

On the nesting bird island there were 18 nesting attempts by California Least Terns, most of them successful along with Forester's Terns (210 nests, 457 eggs laid), Black Skimmers (91 nests, 228 eggs), American Avocets (58 nests, 184 eggs), Black-necked Stilt (28 nests), Killdeer (22 nests), Spotted Sandpiper (3 nests), Mallard and Gadwall (17 nests, 179 eggs), and Canada Goose (5 nests, 24 eggs), among others.

Figure 9-9: Bird Habitat Island Constructed in Burris Basin

Nest Boxes

In the 2000s, OCWD began a program to reduce use of chemical pesticides in the vicinity of the Prado Wetlands. Nest boxes were installed for birds, particularly Tree Swallows (Figure 9-10), whose food supply includes flying insect pests. Birds occupied 100% of the nest boxes resulting in nearly 5,000 Tree Swallow fledglings produced, consuming millions of midges and mosquitoes each year. This successful program was expanded to sites along the Santa Ana River in Orange County for the same purpose of reducing the use of chemical pesticides in the river. Bird nest boxes were mounted atop fences, in trees, and on metal poles.

Figure 9-10: Tree Swallows Nesting, Lower Santa Ana River, 2014

In 2014, 437 boxes were available at 14 distinct locations ranging from water storage basins, the Santa Ana River and the Orange County public bike trail adjacent to the river, one of which is shown in Figure 9-11.

Of these, 215 boxes (49%) were occupied by either Tree Swallow (*Tachycineta bicolor*) or Western Bluebird (*Sialia mexicana*). There were 182 successful Tree Swallow broods and a total of 648 fledglings produced. Bluebirds occupied 38 boxes and produced 24 successful broods and 90 confirmed fledglings.

Figure 9-11: Tree Swallow Nest Box

9.3 COLLABORATIVE WATERSHED PROGRAMS

OCWD participates in several collaborative programs with stakeholders and agencies within Orange County and the Santa Ana River Watershed. These efforts are described below.

Santa Ana Watershed Association

The Santa Ana Watershed Association (SAWA) was formed in 1997 to develop, coordinate and implement natural resource programs that support sustainable ecosystems in the upper Santa Ana River Watershed. Major areas of SAWA's focus are removal of invasive species, native habitat enhancement and the protection of endangered and threatened species. The Board of Directors of SAWA includes:

- Orange County Water District
- Inland Empire Resource Conservation District
- Riverside Corona Resource Conservation District
- San Jacinto Basin Resource Conservation District
- Elsinore-Murrieta-Anza Resource Conservation District

To conserve water behind Prado Dam, the District needs to address potential environmental impacts to habitat for endangered species. The District implements a portion of its environmental mitigation for Prado water conservation through SAWA. Conserving stormwater behind Prado Dam is very important to the District and has increased the sustainable yield of the groundwater basin.

Since 1997, SAWA has removed more than 5,000 acres of Arundo from the Santa Ana River Watershed. Past studies have indicated that this provides a net savings in water consumption by these plants of 3.75 acre-feet/year or 18,750 acre-feet of additional water in the river annually. More recent studies estimate the water savings to be much higher at 20 acre-feet/acre of Arundo removed.

Santa Ana Watershed Project Authority

The Santa Ana Watershed Project Authority (SAWPA) was first formed in 1968 as a planning agency and reformed in 1972 with a mission is to develop and maintain regional plans, programs, and projects that will protect the Santa Ana River Basin water resources. The current configuration as a joint powers authority went into effect in 1975. SAWPA's member agencies include San Bernardino Valley Municipal Water District, Inland Empire Utilities Agency, Western Municipal Water District, Eastern Municipal Water District, and OCWD. The District participates on a number of work groups that meet on a regular basis to discuss, plan, and make joint decisions on management of water resources in the Santa Ana Watershed. OCWD actively participates in the following SAWPA task forces and work groups:

SAWPA Commission

The commission, composed of Board members from SAWPA's five member agencies including OCWD, meets on a monthly basis to set policy and oversee the management of SAWPA.

Storm Water Quality Standards Task Force

The Storm Water Quality Standards Task Force was formed in 2002 to evaluate water quality standards for body contact recreation related to urban runoff and stormwater. Water and wastewater agencies, stormwater management agencies, environmental groups, and the Regional Water Board joined together to develop recommendations for updating recreational water quality standards for freshwater bodies in the watershed. This effort was initiated by the counties and cities concerned about the future cost of compliance with stormwater discharge permits. One major challenge in the region is that beneficial uses for water in flood-control channels include direct body contact recreation. Stringent bacterial standards to protect recreational use of these waters must be met even though many of the channels are concrete-lined, are fenced off, and would be unsafe for swimming during storms.

This task force collected data, evaluated water bodies for their actual and potential recreational value and prepared reports that were used to identify and document where body-contact recreation was occurring and could potentially occur. Regulatory changes were drafted and adopted that will focus water quality improvement efforts in areas of greatest recreational value.

Basin Monitoring Program Task Force

In 1995, a task force of over 20 water and wastewater resource agencies and local governments, including OCWD, initiated a study to evaluate the impacts to groundwater quality of elevated levels of Total Inorganic Nitrogen (TIN) and Total Dissolved Solids (TDS) in the watershed. Formation of the Task Force was in response to concerns by the Santa Ana Regional Water Quality Control Board (Regional Water Board) that water quality objectives for nitrogen and TDS were being exceeded in some groundwater basins in the watershed.

The Task Force completed the study and developed amendments to the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) that were adopted in 2004. This nearly 10-year effort involved collecting and analyzing data in 25 newly defined groundwater management zones in the watershed to recalculate nitrogen and TDS levels and to establish new water quality objectives.

One major challenge of this effort was developing the tools and collecting data to assess and monitor surface water and groundwater interactions. Although typically regulated and managed separately, stakeholders recognized that surface water and groundwater in the watershed are interconnected and as such protection of these resources would require a comprehensive program. Models were developed and data collected to enable an evaluation of the potential short-term and long-term impacts on water resources due to changes in land use, the quantity and quality of runoff, and point source discharges.

The Basin Plan charges the Task Force with implementing a watershed-wide TDS/Nitrogen management program. Task Force members agreed to fund and participate in a process to recalculate ambient water quality every three years in each of the 25 groundwater management zones and to compare water quality to the water quality objectives in order to measure compliance with the Basin Plan. The latest recalculation, the third since adoption of the amendment, was completed in 2014 (Wildermuth, 2014).

Salinity Management and Imported Water Recharge Workgroup

The Salinity Management and Imported Water Recharge Workgroup, in cooperation with the Regional Water Board, implements a Cooperative Agreement signed in 2008 by water agencies that use imported water for groundwater recharge. The objective of this effort was to evaluate and monitor the long-term impacts of recharging groundwater basins with imported water. The concern was using imported water supplies with relatively high salt concentrations for groundwater recharge in basins with lower salinity. In these cases, using imported water as a source to recharge had the potential to degrade groundwater quality in those basins.

The workgroup analyzes water quality data and estimates future conditions to evaluate the potential impact of recharging imported water. TDS and nitrate data are collected and analyzed to determine whether the intentional recharge of imported water may have adverse impacts on compliance with salinity objectives in the region.

Emerging Constituents Workgroup

“Emerging Constituents” (ECs) refers to a group of chemicals that are ingredients in consumer and industrial products (pharmaceuticals, personal care products, food additives, pesticides, and other common household products) that may occur at trace levels in wastewater discharges, agricultural runoff and various surface water bodies and are currently unregulated.

In 2008, a workgroup was formed with stakeholders in the watershed to develop a monitoring program to evaluate the potential impacts of emerging constituents on surface and groundwater quality from the recharge of imported water and the discharge of treated wastewater in the Santa Ana River. The group began collecting and analyzing water samples in 2010 and continued for the next three years. Future monitoring will continue when the State Water Resources Control Board finalizes plans for a state-wide EC monitoring program.

Santa Ana Sucker Conservation Team

Meeting monthly since 1998, a group of concerned public agencies from throughout the Santa Ana River Watershed has been working to determine the reasons for the decline of the Santa Ana Sucker (Catostomus santaanae) and to devise strategies for recovering the species. The U.S. Fish & Wildlife Service and the California Department of Fish & Wildlife are part of this effort.

One Water One Watershed Initiative

A large and diverse group of interested citizens and organizations participated in the development of an Integrated Regional Water Management Plan for the Santa Ana River Watershed. The title of the plan “One Water One Watershed” reflects the objective to engage in watershed-wide planning that recognizes the need for and importance of water as a shared resource for a diverse group of stakeholders and that protecting and managing this resource on the scale of the watershed is of value to all.

Municipal Water District of Orange County

The Municipal Water District of Orange County (MWDOC) is a member agency of the Metropolitan Water District of Southern California (MWD) and provides imported water to 28 retail water agencies and cities in Orange County. MWDOC also supplies untreated imported water to OCWD for use as a supplemental source of water to recharge the groundwater basin. OCWD and MWDOC meet on a monthly basis to discuss various topics, including:

- Coordinating mutual water resources planning, supply availability, and water-use efficiency (conservation) programs.
- Conducting and developing an Orange County Water Reliability Program to improve the overall water and emergency supply to Orange County.

- Evaluating ocean water desalination, water recycling and other means to increase the supply and system reliability.
- Evaluating water transfers and exchanges that would make surplus supplies from other areas available to the District.

Water Advisory Committee of Orange County

The Water Advisory Committee of Orange County (WACO) is a group of elected officials and water managers who meet on a monthly basis to provide advice to OCWD and MWDOC on water supply issues (Figure 9-12).

Figure 9-12: WACO Meeting in Fountain Valley

Groundwater Replenishment System Steering Committee

The Groundwater Replenishment System Steering Committee is a joint committee of the OCWD and the Orange County Sanitation District. Directors of the two districts meet on a monthly basis to coordinate joint operations.

Orange County Flood Control District

Three of the recharge basins used by OCWD for groundwater recharge are owned by the Orange County Flood Control District. OCWD also owns a six-mile section of the Santa Ana River that is used for conveyance of floodwater. Quarterly meetings are held to discuss joint operations and planning.

9.4 MANAGEMENT OF AREAS WITHIN BASIN 8-1 OUTSIDE OCWD BOUNDARIES

As explained in Section 3.1.3, the OCWD Groundwater Basin boundary does not encompass the entire area of Basin 8-1, as defined by DWR. The areas outside OCWD can generally be categorized as the La Habra Subbasin, the Santa Ana Canyon area, and the area within the Irvine Subbasin. In addition to considering possible DWR boundary modifications, OCWD is currently collaborating with other agencies regarding the management of these three areas are described below.

La Habra SubBasin

Groundwater in this subbasin flows in a westerly direction into Los Angeles County and in a southerly direction into the Orange County Groundwater Basin. This portion of the groundwater basin is relatively shallow and production is limited due to water quality issues. The cities of La Habra and Brea are discussing the option of preparing a Groundwater Sustainability Plan for the La Habra SubBasin and are collaborating with OCWD as appropriate.

Santa Ana Canyon

The areas in the Santa Ana Canyon outside of OCWD are located in Orange, Riverside and San Bernardino Counties. Groundwater in this area of the basin is shallow. Active production wells as shown in Figure 9-13 are owned by the County of Orange and used to irrigate the Green River Golf Course. Discussions between the three counties and OCWD regarding management of this area are ongoing.

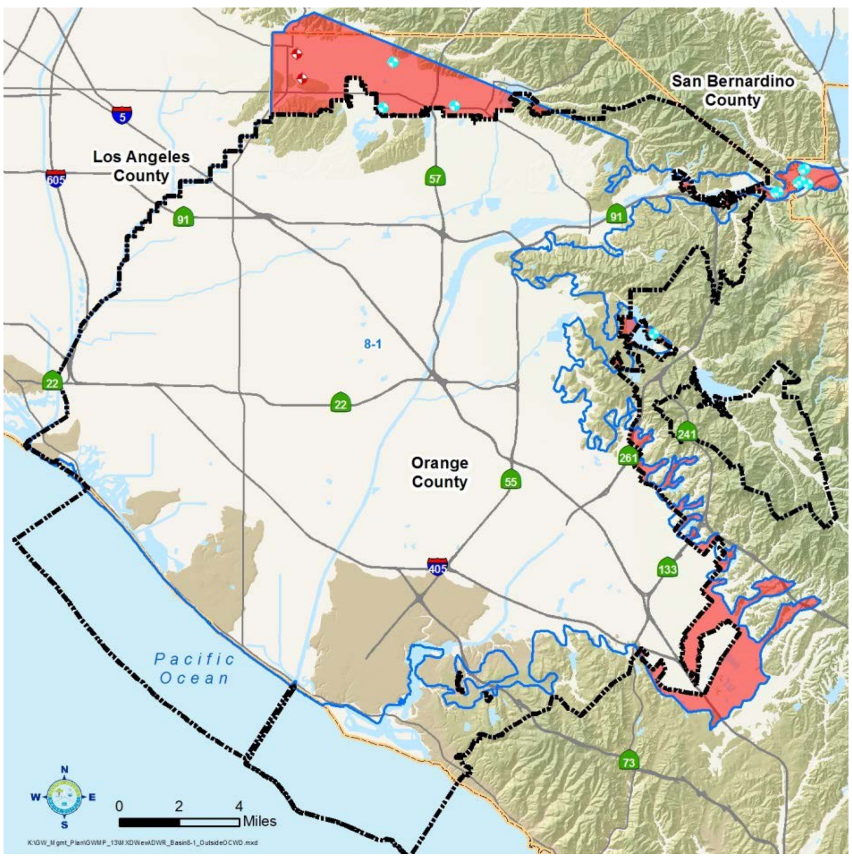


Figure 9-13: Areas Outside OCWD Boundaries

Irvine SubBasin

Groundwater resources in the Irvine Subbasin outside District boundaries are generally of poor quality and limited in supply. There are no active production wells in this portion of the basin. Irvine Ranch Water District has some inactive wells located in the City of Lake Forest that produce poor quality water in limited quantities.

9.5 ORANGE COUNTY WATER RESOURCES-RELATED PLANS

North Orange County Integrated Regional Water Management Plan

This plan was prepared by the County of Orange with the participants of a diverse group of stakeholders. The North Orange County planning area encompasses the Santa Ana River Watershed, the Lower San Gabriel River, Coyote Creek Watershed, and the Anaheim Bay-Huntington Harbour Watershed. The North Orange County Integrated Regional Watershed Management Plan was prepared in 2011 to maximize use of local water resources, to increase collaboration and to apply multiple water management strategies by implementing multi-purpose projects in the region. The plan was designed to help agencies, governments and community groups manage their water, wastewater and ecological resources and to identify potential projects to improve water quality, engage in long range water planning and obtain funding. OCWD participated in the preparation of this plan and submitted proposed projects to be considered as regional projects to augment local water supplies, protect groundwater quality and increase water supply reliability.

Central Orange County Integrated Regional and Coastal Watershed Management Plan

The Central Orange County plan was prepared in 2011 by the County of Orange and local stakeholders, including OCWD, to serve as a planning tool to effectively manage the region's water resources. The central area encompasses the entire Newport Bay Watershed and the northern portion of the adjacent Newport Coast Watershed that lies within the jurisdiction of the Santa Ana Regional Water Quality Control Board. The plan sets goals and objectives, identifies water resource projects, and discusses ways to integrate a proposed project with other projects.

One Water One Watershed (OWOW) 2.0

The Integrated Regional Watershed Management Plan for the Santa Ana Watershed is referred to as the OWOW 2.0 plan. Drafted by watershed stakeholders, including OCWD, under the direction of the Santa Ana Watershed Project Authority (SAWPA), this updated plan was adopted by the SAWPA Commission in 2014. The plan details the water resource related opportunities and constraints with the aim of developing proposed projects that provide a regional benefit, are integrated, and are proposed by more than one agency.

Municipal Water District of Orange County

Urban Water Management Plan

The Municipal Water District of Orange County (MWDOC) is a water wholesaler and regional planning agency serving 26 cities and water districts throughout Orange County, which includes OCWD's service area. MWDOC prepared its 2010 Regional Urban Water Management Plan to provide a comprehensive assessment of the region's water services, sources and supplies, including imported water, groundwater, surface water, recycled water, and wastewater. Findings and projections in the plan are used by OCWD and water retailers.

Water Reliability Report

Completed in 2015, this report assesses future demands, the reliability of the import system and need for future projects.

Orange County Municipal Stormwater Program

Municipal stormwater discharges are regulated under the federal Clean Water Act National Pollution Discharge Elimination System (NPDES) permit and in California by the State Water Resources Control Board under the California Water Code. In Orange County, this permit is issued by the Regional Water Quality Control Board to the County of Orange, as the principal permittee, and the Orange County Flood Control District and municipalities as the co-permittees. As the principal permittee, the county guides development and implements the stormwater program to ensure compliance and prevent ocean pollution.

To assist municipalities in reviewing and approving stormwater discharge permits, the county prepared a Model Water Quality Management Plan (WQMP). The document contains guidance for the preparation of individual project WQMP needed for the approval of development projects. The permit requires that new development and significant development projects manage stormwater on-site to the extent feasible using low-impact development (LID) best management practices (BMPs) with a requirement for maximizing infiltration of stormwater on the project site. To assist municipalities in implementing the stormwater program, the county prepared detailed maps showing areas where infiltration potentially is feasible and areas where infiltration is likely to be infeasible due to soil conditions, high groundwater, potential landslide areas, and areas with groundwater contamination. These maps are included as Figure XVI.2 in Appendix XVI of the Technical Guidance Document that can be found at the following link:

http://cms.ocgov.com/gov/pw/watersheds/documents/wqmp/default.asp

A permit condition requires that municipalities consult with the applicable groundwater management agency in reviewing on-site project plans that propose the utilization of infiltration LID BMPs. As such, OCWD reviews these plans within District boundaries to evaluate any potential impacts to groundwater quality due to infiltration of stormwater on particular sites.

Urban Water Management Plans

California's Urban Water Management Planning Act requires that urban water suppliers providing water for municipal purposes to more than 3,000 customers, or supplying more than 3,000 acre-feet of water annually, prepare and adopt an Urban Water Management Plan. UWMPs describe current and future water supplies and demands and must be updated every five years. OCWD utilizes the water demand forecasts from the UWMPs within District boundaries for long-range planning purposes.

Santa Ana Regional Water Quality Control Board, Santa Ana River Basin Water Quality Control Plan (Basin Plan)

The Basin Plan establishes surface and groundwater quality objectives for the Santa Ana River Basin. The water quality objectives are established to protect and enhance beneficial uses of water in the region. The basin plan identifies beneficial uses of ocean waters, bays, estuaries, tidal prisms, inland surface streams, lakes and reservoirs, wetlands, and groundwater basins, including water bodies within District boundaries.

9.6 COLLABORATION WITH FEDERAL AND STATE AGENCIES

This section summarizes the federal and state agencies that have regulatory authority over District operations and collaborate with OCWD.

9.6.1 Federal Agencies

The United States Army Corps of Engineers (the Corps) is responsible for providing flood control on the Santa Ana River and tributaries and owns and operates the Prado Dam. The Corps and OCWD have been working together for many years on water conservation programs to temporarily impound water behind Prado Dam. Based on a Memorandum of Understanding the Corps agrees to temporarily store water behind the dam and release the water at rates that allow OCWD to divert the supply into recharge facilities downstream of the dam as long as consistent with the primary purpose of the dam for flood risk management. The Corps also administers permits pursuant to Section 404 of the Clean Water Act for activities conducted within “waters of the United States.” OCWD obtains 404 permits from the Corps when District activities and project construction will impact waters of the United States.

Figure 9-14: OCWD Recharge Operations Staff

During the flood season, OCWD and staff in the Corps Reservoir Regulation section, collaborate, sometimes on a daily basis, to coordinate releases from the dam to the District’s downstream facilities.

The United States Geological Survey (USGS) operates stream gage stations in the watershed. All of these stations measure flows but some also measure water quality, such as TDS. OCWD meets annually with USGS staff to discuss the scope of the monitoring program and provides funds to maintain several of the stream gage stations on the Santa Ana River.

The United State Fish and Wildlife Service (USFWS) issues permits for OCWD projects that impact aquatic habitat and provides assistance with District programs to manage habitat for Santa Ana Suckers, least Bell's vireo, and other species. The USFWS also issues Biological Opinions that are incorporated into the MOU with the Corps on water conservation activities at Prado Dam. If any deviations from the approved plans are made, OCWD and the Corps first consults with the USFWS before any actions are taken.

The United States Environmental Protection Agency (USEPA) implements and enforces Clean Water Act and Safe Drinking Water Act programs and provides support for cleanup of contaminated groundwater.

The United States Department of Defense (DOD) is taking the lead to clean up groundwater contamination at El Toro and Tustin Marine Corps Air Stations and Seal Beach Naval Weapons Station. OCWD was heavily involved in all phases of these projects, including investigations, remedial design, alternative analysis, and monitoring.

9.6.2 State Agencies

The California Department of Fish and Wildlife manages programs to protect fish in surface waters and issues permits for OCWD projects that impact waters of the state and wetlands of the state.

The California Department of Toxic Substances Control (DTSC) oversees cleanup of contaminated groundwater sites in Orange County including remediation of the Stringfellow Acid Pits Superfund site clean-up in Riverside County that has potential to impact the Santa Ana River. OCWD regularly corresponds and collaborates with DTSC staff regarding sites that have or have the potential to impact groundwater quality.

The California Department of Water Resources (DWR) operates the State Water Project and develops the California Water Plan that serves as a guide to development and management of the State's water resources. DWR manages Integrated Regional Water Management grants and other grant programs from which OCWD has received grants for some projects. The California Statewide Groundwater Elevation Monitoring (CASGEM) program created by the California Legislature in 2009 requires the monitoring and reporting of groundwater elevation data. OCWD is the CASGEM monitoring agency for the Orange County Groundwater Basin.

The California State Water Resources Control Board (SWRCB) was established through the California Porter-Cologne Water Quality Act of 1969 and is the primary state agency responsible for water quality management in the state and as such sets statewide policy regarding water quality including regulation of recycled water projects. The SWRCB's policies are implemented by nine Regional Water Quality Control Boards. The Santa Ana Regional Water Quality Control Board regulates and manages water quality programs that include northern and central Orange County. As with DTSC, OCWD regularly engages RWQCB staff regarding sites under investigation or in remediation, the GWRS permit and other permits issued to OCWD as well as permits issued to other agencies that may impact the groundwater basin.

9.6.3 County Agencies

The Orange County Flood Control District (OCFCD) is a division of Orange County Public Works Department with responsibility to maintain the Santa Ana River levees and concrete channels in Orange County. OCFCD has agreements with OCWD to use basins owned by OCFCD for groundwater recharge and is a partner with the District in re-developing Fletcher Basin, owned by OCFCD, for use as groundwater recharge basin.

OC Environmental Services is a division of the Orange County Public Works Department responsible for coordination of watershed plans for the North, Central, and South Orange County Integrated Regional Watershed Management Plans as well as compliance with the Municipal Separate Storm Sewer System (MS4) permit for the county.

Orange County Local Area Formation Commission (OC LAFCO) is responsible for coordinating changes in local government boundaries including annexations, conducting special studies and updating sphere of influences for each city and special district within the County. LAFCO conducts municipal service reviews for all cities and special districts to look at future growth and how local agencies are planning for that growth within the municipal services and infrastructure systems.

9.6.4 Regional

The Santa Ana River Watermaster is a five-member committee appointed by the court to administer the provisions of the 1969 judgment (see Section 1.2). The SAR Watermaster is comprised of representatives from each of the parties to the judgment. The SAR Watermaster maintains a continuous accounting of stormflows and baseflows, entitlement credits and debits, and water quality data. This information is reported to the court annually for each water year. River flows recorded in the annual Watermaster Report are determined from river gages managed by the USGS.

The Metropolitan Water District of Southern California (MWD) is a consortium of 26 cities and water districts that provides drinking water to nearly 19 million people in Southern California. OCWD purchases imported water from MWD through the Municipal Water District of Orange County for recharge. OCWD and MWD have a storage agreement that allows MWD to store up to 66,000 acre-feet of water in the basin. OCWD also engages MWD regarding policies related to groundwater replenishment, local resource programs and basin storage agreements.

The Municipal Water District of Orange County (MWDOC) purchases imported water from MWD on behalf of OCWD and groundwater producers, and conducts water-use efficiency programs and provides other services to member agencies.

The Los Angeles Department of Public Works (LADPW) operates the Alamitos Seawater Intrusion Barrier under a joint agreement with OCWD. OCWD, along with LADPW, jointly manage the Alamitos Barrier and have regularly scheduled meetings to review operations and establish budget and cost-sharing.

The Water Replenishment District of Southern California (WRD) provides water to supply the Alamitos Seawater Intrusion Barrier. The WRD, along with OCWD and LADPW, participates in meetings on the operation and management of the Alamitos Barrier.

The Santa Ana Regional Water Quality Control Board (Regional Water Board) manages and enforces water quality control programs in the Santa Ana River Watershed. OCWD works closely with the Regional Water Board on a wide variety of issues.

The Orange County Sanitation District (OCSD) and OCWD jointly operate the Groundwater Replenishment System. Monthly GWRS steering committee meetings are held with OCSD.

9.7 LAND USE, DEVELOPMENT AND ENVIRONMENTAL REVIEWS

Protecting groundwater from contamination protects public health and prevents loss of valuable groundwater resources. Monitoring potential impacts from proposed new land uses and planning for future development are key management activities essential for protecting, preventing and reducing contaminant risks to drinking water supplies.

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 the District with insight on activities in the watershed that could affect water quality.

Figure 9-15: Aerial View of Orange County

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.

The Regional Board Fourth Term municipal separate storm sewer systems (MS4) permit (Order R-8-2009-0030) was adopted with specific requirements for new development and significant redevelopment to manage stormwater on-site. Low impact development (LID) is a stormwater management strategy that emphasizes conservation and use of existing site features integrated with distributed stormwater controls. The strategy is designed to mimic natural hydrologic patterns of undeveloped sites as opposed to traditional stormwater management controls. LID includes both site design and structural measures used to manage stormwater on a particular development site.

The MS4 permit requires that any new development or significant re-development project consider groundwater conditions as part of the preparation of a Project Water Quality Management Plan (WQMP).

The County of Orange prepared a Model WQMP to explain the requirements and types of analyses that are required in preparing a Conceptual/Preliminary or Project WQMP in compliance with the permit. A Technical Guidance Document (TGD) was prepared as a technical resource companion to the Model WQMP. Permit conditions require that any proposed infiltration activities be coordinated with the applicable groundwater management agency, such as the OCWD, to ensure groundwater quality is protected. Consequently, OCWD regularly reviews local development projects to evaluate any potential impacts to groundwater quality due to infiltration of stormwater on development sites within Orange County.

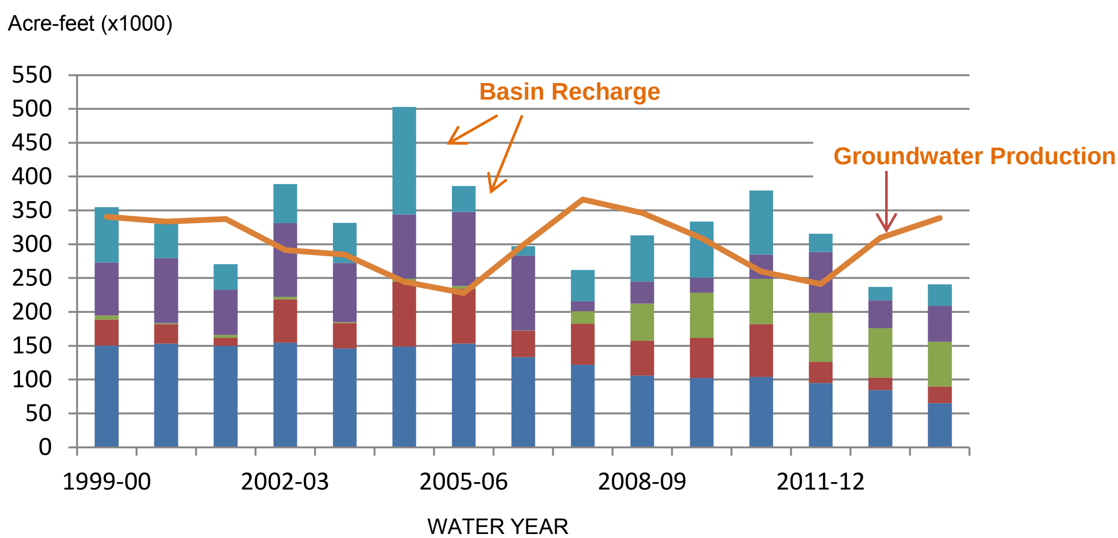
The TGD contains specific criteria to protect groundwater quality as part of local efforts to manage stormwater infiltration. The depth to seasonal high groundwater table beneath the project may preclude on-site infiltration of stormwater. In areas with known groundwater and soil pollution, infiltration may need to be avoided if it could contribute to the movement or dispersion of soil or groundwater contamination or adversely affect ongoing cleanup efforts. Potential for contamination due to infiltration is dependent on a number of factors including local hydrogeology and the chemical characteristics of the pollutants of concern. If infiltration is under consideration in areas where soil or groundwater pollutant mobilization is a concern, a site-specific analysis must be conducted to determine where infiltration-based BMPs can be used without adverse impacts.

Criteria for infiltration related to protection of groundwater quality include:

- Minimum separation between the ground surface and groundwater including guidance for calculating mounding potential
- Categorization of infiltration BMPs by relative risk of groundwater contamination
- Pollutant sources in the tributary watershed and pretreatment requirements
- Setbacks from known plumes and contaminated sites
- Guidelines for review by applicable groundwater management agencies

SUSTAINABLE BASIN MANAGEMENT

10



Maintaining balance between recharge and production over the long-term assures sustainable basin management

Sustainable Basin Management involves:

- Maintaining groundwater levels within the set basin operating range
- Balancing production and recharge
- Managing basin pumping by annually setting the Basin Production Percentage
- Maximizing recharge by increasing the efficiency of and expanding recharge facilities and the supply of recharge water
- Managing water demands in cooperation with Groundwater Producers and through programs conducted by the Municipal Water District of Orange County and the Metropolitan Water District of Southern California

SECTION 10 SUSTAINABLE BASIN MANAGEMENT

10.1 BACKGROUND

The Orange County Water District was created in 1933 in order to protect the water supplies vital for recharging the Orange County Groundwater Basis over the long-term. Water demands were growing, not only in Orange County, but also in the rest of the watershed. Groundwater production was increasing at the same time as flows in the Santa Ana River were declining.

Between the District's creation in 1933 and the 1950s, increased pumping from the basin outpaced the rate of recharge. Groundwater levels dropped and seawater intrusion into coastal areas threatened the basin's water quality. It became apparent that natural recharge and increased capture of storm flows were insufficient. Purchasing imported water for groundwater recharge was deemed necessary. However, the District's reliance on *ad valorem* taxes would not provide the resources needed to purchase of the large quantities of imported water needed to replenish the basin.

Groundwater producers agreed to a strategy of managing the basin as a common pool of water rather than allocating individual basin water rights. OCWD adopted a management plan allowing all producers to pump as much as they wanted provided they pay for the costs of replenishing the basin with imported water.

In 1954, the District Act was amended to establish a charge to pump groundwater. Each producer was required to register wells with OCWD, maintain records of amount withdrawn during the year and pay a Replenishment Assessment in proportion to the amount of extracted groundwater. The Act now included a requirement that OCWD prepare an annual Engineer's Report documenting the amount of production and replenishment achieved in the prior year, a determination of how much water could be safely pumped from the basin in the coming year and an estimate of the amount of imported water needed to maintain groundwater supplies and refill the basin.

Shortly after the Replenishment Assessment was instituted, OCWD embarked on an aggressive effort to refill the basin. From 1954 to 1964, OCWD imported and recharged a total of 1.3 million acre-feet of water.

Over time, OCWD's knowledge of the hydrogeology of the basin improved with data collected from the ever-growing number of production and monitoring wells as well as experience with operating recharge facilities and seawater intrusion barriers. One of the primary objectives continued to be managing the basin within a safe operating range.

The current policy of maintaining a groundwater storage level of between 100,000 to 500,000 acre-feet below full was established based on completion of a comprehensive hydrogeological study of the basin in 2007 (OCWD, 2007). Today, OCWD is able to support increased demands from the basin by maximizing the amount of water recharged, developing new sources of recharge water, and increasing the effectiveness of the District's recharge facilities.

10.2 BASIN OPERATING RANGE

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 narrow operating range within which the Basin can safely operate. The safe operating range is largely dictated by water quality issues, particularly seawater intrusion and the need to prevent land subsidence. The factors that are considered in determining the optimum level of basin storage are shown in Table 10-1.

Each year the District determines the optimum level of storage for the following year. Issues that are evaluated when considering the management of the basin at the lower end of the safe operating range are 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 inoperable due to lower groundwater levels. When operating the basin at a high storage level, the amount of energy required to pump groundwater is less but groundwater outflow to Los Angeles County is greater.

As explained above, OCWD does not limit pumping from the groundwater basin. Instead, basin storage and total pumping is managed using financial incentives to encourage Producers to pump an aggregate amount of water that is sustainable over the long-term. The process that determines a sustainable level of pumping considers the basin's safe operating range, basin storage conditions, water demands, and the amount of recharge water available to the District. The basin is managed to avoid groundwater elevations dropping to levels that result in negative or adverse impacts.

Negative or adverse impacts that are considered when establishing the safe operating range include chronic 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, as illustrated in Figure 10-1.

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 safe operating range for many decades. The degree to which the storage is below the full basin condition is defined in the District Act as the "accumulated overdraft."

The District's annual Engineer's Report includes a determination of the "annual overdraft" and the "accumulated overdraft as of the last day of the preceding water year," the total groundwater production, and a recommendation of the quantity of water to be purchased for replenishment. The accumulated overdraft is a calculation of the difference between groundwater production and recharge over the long-term.

Table 10-1: Benefits and Constraints of Changing Storage Levels

Available Storage Space (amount below full basin condition in acre-feet)	Benefits	Constraints
Less than 200,000	• Improve control of seawater intrusion • Lower cost to pump groundwater • Maintain stable BPP; potential to increase BPP • Increase supply of water for pumping in dry years • Decrease potential for vertical migration of poor quality water	• Increase groundwater flow to Los Angeles County • Possible impacts of high groundwater levels in local areas • Decrease opportunity to recharge basin when low-cost recharge water available
200,000 - 350,000	• Minimal to no impacts from high groundwater levels • Increase available storage capacity when recharge water available • Decrease groundwater outflow to Los Angeles County	• Reduced amount of water in storage for pumping during drought • Increase risk of seawater intrusion
350,000 to 500,000	• Minimal to no problems with high groundwater levels • Increased available storage capacity if large amount of recharge water becomes available • Further decrease in groundwater outflow to Los Angeles County	• Reduce supply of water in storage available for dry years • Increase pumping costs • Increase risk of seawater intrusion • Some production wells inoperable when groundwater levels below 400,000 acre-feet • Potential risk of increased land subsidence • Potential increased risk of vertical migration of poor quality water • Need to increase purchase of imported water • Difficult to maintain stable BPP

The available storage space is the amount of available storage space below the full basin condition. The operating range of the basin is from zero to 500,000 acre-feet below the full basin condition. Maintaining the basin storage condition on a long-term basis within this operating range prevents the basin from becoming adversely over-drafted. 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 monitoring closely and be of limited duration. In the California Water Plan Update 2013 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." (CWP, p. SC-77)[2]

Because OCWD has the means to manage basin storage within a safe operating range, and has operated the basin within this range for decades, overdraft in the traditional sense does not exist in the Orange County Groundwater Basin. For this reason, it makes more sense to refer to the storage condition of the basin, similar to the manner of describing storage in a surface water reservoir. With approximately 66,000,000 acre-feet of water in storage at the full condition, when storage levels are decreased by 200,000 acre-feet, the basin is approximately 99.7 percent full. When storage levels decrease from 200,000 to 400,000 acre-feet, the basin is 99.4 percent full. From a classical surface water reservoir perspective, the basin is almost always nearly "full."

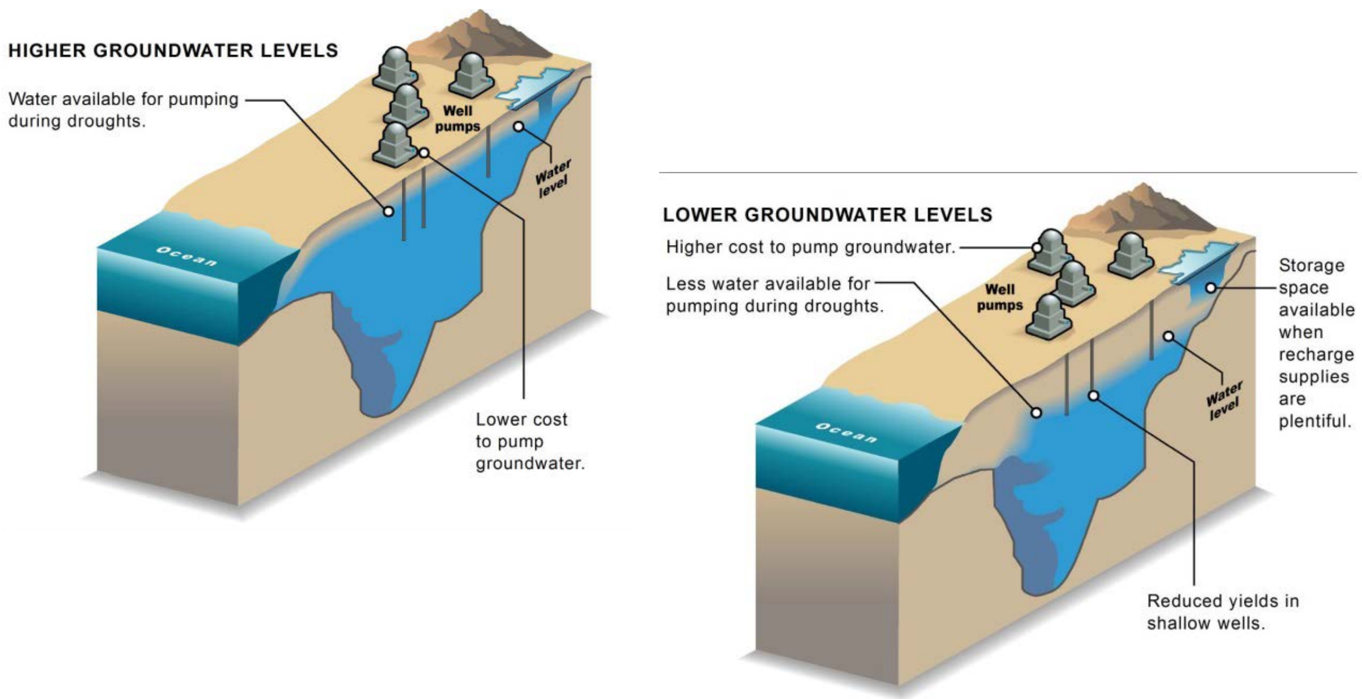


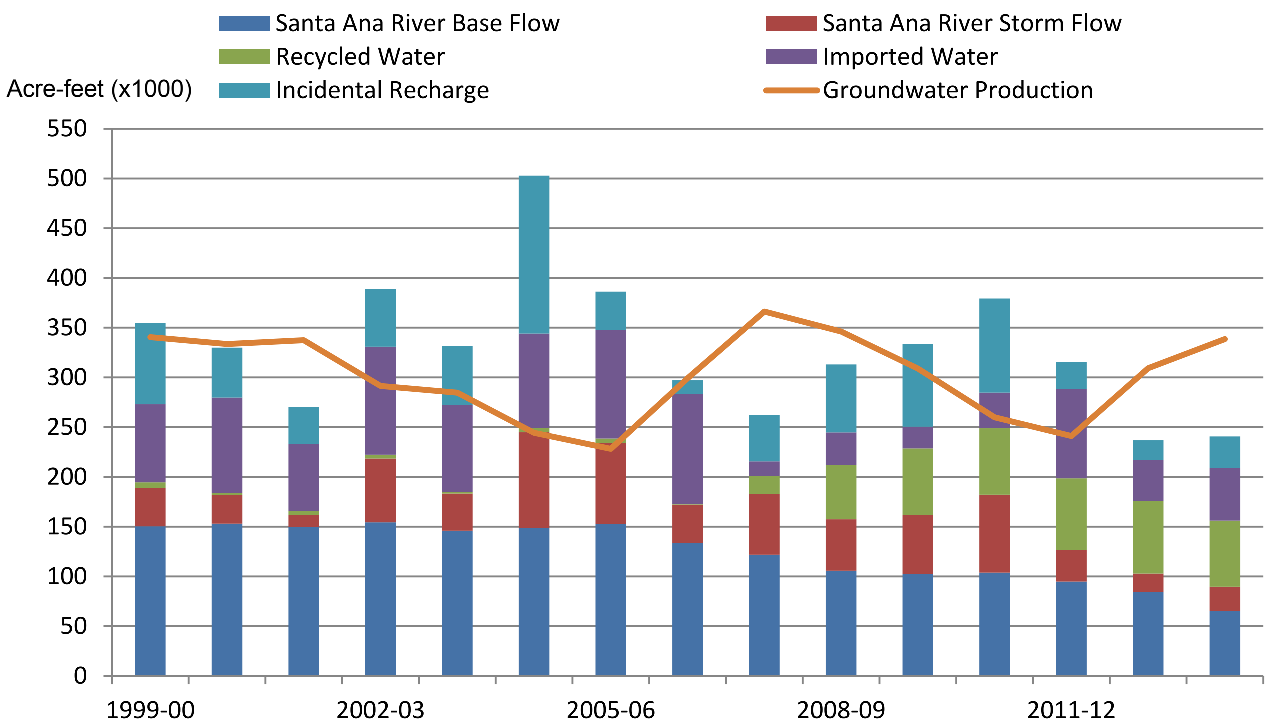
Figure 10-1: Schematic Illustration of Impacts of Changing the Amount of Groundwater in Storage

[2] This is in contrast to the traditional condition of "overdraft" as defined by the California Department of Water Resources (DWR):

> ".. the condition of a groundwater basin in which the amount of water withdrawn by pumping over the long term exceeds the amount of water that recharges the basin. Overdraft is characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years. Overdraft can lead to increased extraction costs, land subsidence, water quality degradation, and environmental impacts." (DWR, 2003) DWR Bulletin 118, Chapter 1 – California's Hidden Resource, p.29

10.3 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 one particular year, water withdrawals may exceed water recharged as long as over the course of a number of years this is balanced by years since production and water recharged exceeds withdrawals. Levels of total basin production and total water recharged since water year 1999-00 are shown in Figure 10-2 and Table 10-2.



Notes: (1) “Imported Water” includes water purchased by OCWD for recharge and water recharged under both the MWD Conjunctive Use Program (CUP) and the in-lieu program. (2) “Production” includes water produced from the basin by groundwater producers and under the MWD CUP program.

Figure 10-2: Basin Production and Recharge Sources, WY 1999-00 to 2013-14

Table 10-2: Groundwater Production and Recharge Sources (afy)

Water Year	Santa Ana River Base Flow	Santa Ana River Storm Flow	Recycled Water	Imported Water	Incidental Recharge	Groundwater Production
1999-00	150,000	39,000	6,000	78,000	82,000	341,000
2000-01	153,000	29,000	2,000	96,000	50,000	334,000
2001-02	150,000	12,000	4,000	67,000	38,000	337,000
2002-03	154,000	64,000	4,000	109,000	58,000	291,000
2003-04	146,000	37,000	2,000	88,000	59,000	285,000
2004-05	149,000	96,000	4,000	95,000	159,000	244,000
2005-06	153,000	82,000	4,000	109,000	39,000	228,000

Water Year	Santa Ana River Base Flow	Santa Ana River Storm Flow	Recycled Water	Imported Water	Incidental Recharge	Groundwater Production
2006-07	133,000	39,000	400	111,000	14,000	299,000
2007-08	122,000	61,000	18,000	15,000	46,000	366,000
2008-09	106,000	52,000	55,000	33,000	68,000	346,000
2009-10	103,000	59,000	67,000	22,000	83,000	309,000
2010-11	104,000	78,000	67,000	36,000	95,000	260,000
2011-12	95,000	32,000	72,000	90,000	27,000	241,000
2012-13	85,000	18,000	73,000	41,000	20,000	309,000
2013-14	65,000	25,000	66,000	53,000	31,000	339,000

10.4 MANAGING BASIN PUMPING

Approximately 200 large-capacity municipal supply wells account for 97 percent of basin production. Agricultural production accounts for a small amount of basin pumping. In 2014, privately owned irrigation wells produced a total of 1,298 acre-feet of water from the basin.

The primary mechanism used by OCWD to manage pumping is the Basin Production Percentage (BPP). The ability to assess the BPP and the BEA were provided to the District through an amendment to the District Act in 1969. Section 31.5 of the District 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 as well as from groundwater within the District. "

In other words, the BPP is a percentage of each Producer's water supply that comes from groundwater pumped from the basin. The BPP is set uniformly for all Producers. Groundwater production at or below the BPP is assessed the Replenishment Assessment (RA). Any production above the BPP is charged the RA plus the Basin Equity Assessment (BEA). The BEA is 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. The BEA can be increased as needed to discourage production above the BPP.

In simplified terms, the BPP is calculated by dividing groundwater production by total water demands. 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 Producers to maximize pumping and reduce their overall water supply cost. Figure 10-3 shows the history of the assigned BPP along with the actual BPP that was achieved by the Producers.

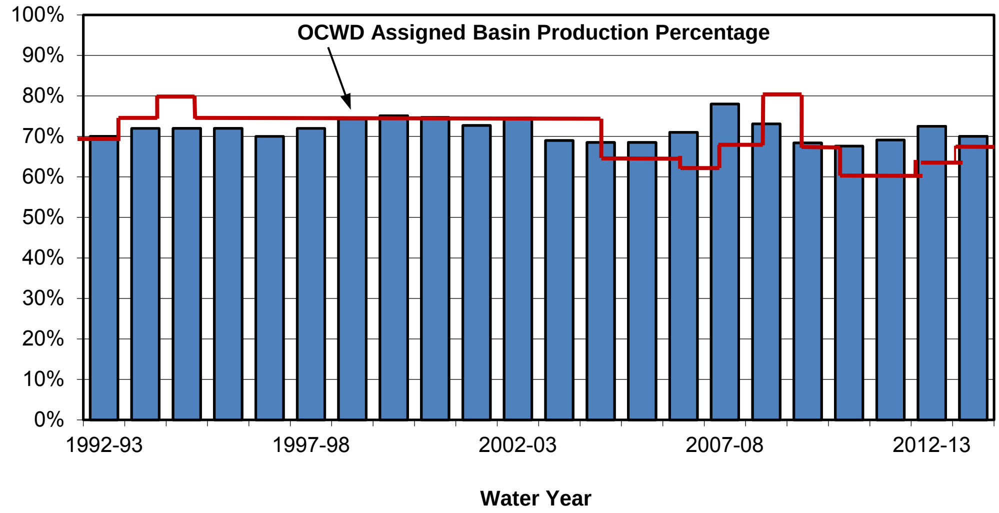


Figure 10-3: Assigned and Actual Basin Production Percentage

To change the BPP, the Board of Directors must hold a public hearing. Raising or lowering the BPP allows the District 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 Producers to purchase additional, more expensive imported water.

One example of a condition that could require a lowering of the BPP is to protect the basin from seawater intrusion. In this case, reduced pumping would allow groundwater levels to recover and seawater intrusion to be reduced.

10.4.1 Methodology for Setting the Basin Production Percentage

The formula used to estimate the BPP is shown in Figure 10-4. The formula is used as a guideline and the District's Board of Directors sets the BPP after considering the relevant information and input from the Producers and the public. To determine the BPP for a given year, the amount of water available for basin recharge must be estimated. The supplies of recharge water that are estimated are:

- Santa Ana River stormflow
- Natural incidental recharge
- Santa Ana River baseflow
- GWRS supplies
- Other supplies such as imported water and recycled water purchased for the Alamitos Barrier.

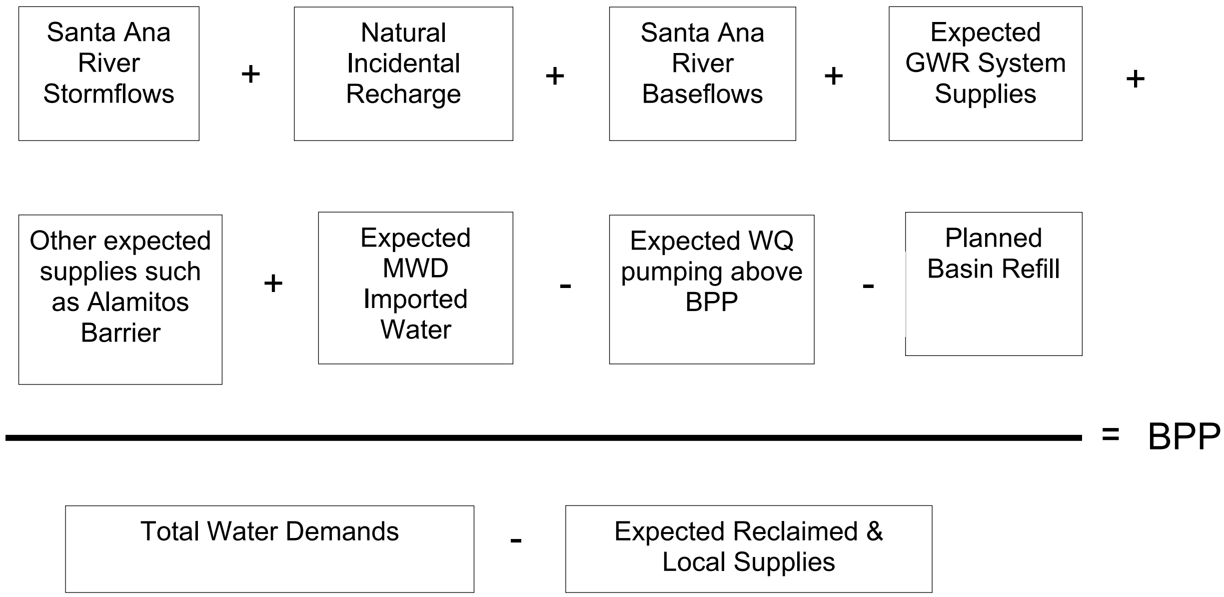


Figure 10-4: BPP Calculation

10.4.2 BPP Policy

The Board of Directors has several policy considerations that may be considered as the BPP is determined annually. For example, the Groundwater Producers generally prefer that the BPP be changed gradually, rather than abruptly changing the BPP from year-to-year. In some situations however, the Board may need to consider lowering the BPP such as in response to relatively low groundwater storage levels.

In 2013, the Board of Directors adopted a policy to establish a stable Basin Production Percentage (BPP) with the intention to work toward achieving and maintaining a 75% BPP by fiscal year 2015-16. Principles of this policy include:

- The District sets a goal for achieving a stable 75% BPP, while maintaining the same process of setting the BPP on an annual basin, with the BPP set in April of each year after holding a public hearing and based upon the public hearing testimony, presented data and reports provided at that time.
- The District would endeavor to transition to the 75% BPP between 2013 and 2015 as construction of the GWRS Initial Expansion project is completed. This project will provide an additional 31,000 acre-feet per year of water to recharge the groundwater basin.
- The District must sustainably manage the groundwater basin for future generations. If future conditions warrant, the BPP will be reduced.
- Projects and programs to achieve the 75% BPP goal will be individually reviewed and assessed for their economic viability. Economical projects and programs that could support a BPP above 75% also would be considered.

The groundwater basin's storage levels would be managed to support the 75% BPP policy. As long as the storage levels remained between 100,000 and 300,000 acre-feet from full, there would be a presumption that the BPP would not be decreased. Table 10-3 shows the management actions to be used to guide the District in setting the BPP. As the BPP is annually set in April for the following fiscal year, the change in basin storage would be estimated for the end of that current fiscal year (as of June 30th).

Table 10-3: 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

An alternative approach to managing the BPP would be to keep the groundwater basin relatively full and allow the BPP to vary more significantly, with the goal of baseloading off the MWD system during wet and near-normal years. This approach would maximize purchases of treated MWD water in wet and near-normal years and maintain groundwater in storage for future drought periods. 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. This approach would be most successful if MWD had a program to provide recharge water at a discounted rate in wet periods, such that the basin could be operated conjunctively with supplies from MWD. Availability of discounted recharge water from MWD would incentivize projects to maximize recharge capacity during wet years. If MWD does not develop a program to offer discounted recharge water, this alternative would need to be restructured.

Another approach to managing the BPP would be to keep the groundwater basin relatively full and allow the BPP to vary more significantly depending upon local hydrologic conditions, in the absence of discounted recharge water from MWD. During dry hydrologic years, less water would be recharged into the groundwater basin. The BPP would need to be lowered to maintain groundwater storage levels. Thus, the Groundwater Producers would need to purchase increased amounts of full service, treated MWD water. During locally wet hydrologic years, more local water supply water would be recharged into the groundwater basin, the BPP could be increased and the Groundwater Producers would purchase less MWD water. The BPP could annually change by over 10% under this type of operation. However the District could always ensure that the groundwater basin remained relatively full for emergency events and/or those years when imported water was being allocated.

At the beginning of 2015, the District committed to MWDOC 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 the District with managing the basin storage level within the safe operating range. The District 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.

10.4.3 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 District 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.

10.5 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 the District's recharge facilities and the supply of recharge water, as described in detail in Section 5. Construction and operation of the GWRS provides a substantial increase in supply of water available to recharge the basin. Additional District supply management programs include encouraging and using recycled water for irrigation and other non-potable uses, participating in water conservation efforts, and working with MWD and the Municipal Water District of Orange County (MWDOC) in developing and conducting other supply augmentation projects and strategies.

Use of Recycled Water for Landscape Irrigation

OCWD's Green Acres Project is a non-potable recycled water supply project that utilizes a dedicated set of pipelines to deliver irrigation and industrial water to users. Most of the recycled water is used on golf courses, greenbelts, cemeteries, and nurseries. The Green Acres Project, in operation since 1991, reduces demands on the basin by providing non-potable water for non-potable uses.

Secondary wastewater effluent from the OCSD is filtered and disinfected with chlorine to produce approximately seven mgd of irrigation and industrial water. A portion of Green Acres Project water is also supplied by Irvine Ranch Water District. The average amount of water supplied through the Green Acres Project system is 7,300 afy. Areas supplied by the recycled water are shown in Figure 10-5.

Conjunctive Use and Water Transfers

MWD purchased the right to use up to 66,000 acre-feet of storage space in the groundwater basin. The money provided by MWD was used to improve basin management facilities. The improvements contributed by MWD included the construction of eight new extraction wells and new injection wells for the Talbert Barrier. Any stored water can be extracted at a minimum of 22,000 afy.

The District reviews opportunities for additional conjunctive use projects that would store water in the basin and could potentially store water in other groundwater basins. Additionally, the District 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 and their reliability and cost effectiveness.

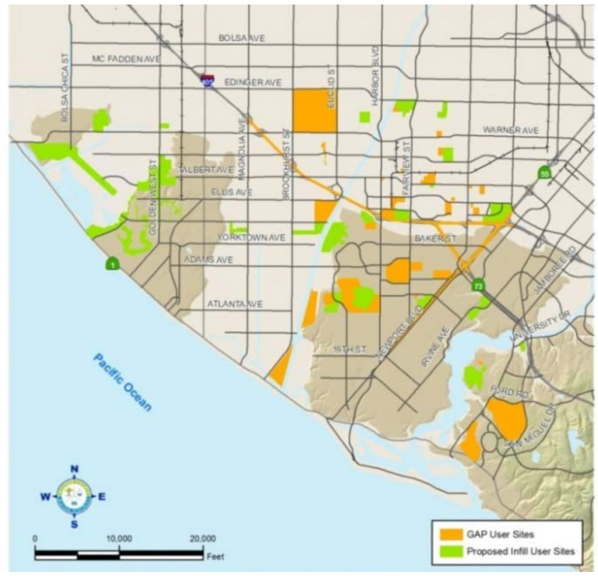


Figure 10-5: Areas Supplied by GAP Water

10.6 REMOVING IMPEDIMENTS TO CONJUNCTIVE USE

Conjunctive use is the coordinated management of surface and groundwater supplies to increase the yield of both supplies and enhance water reliability in an economic and environmentally responsible manner. Impediments to conjunctive use of surface and groundwater supplies in Orange County are outlined in Table 10-4.

Table 10-4: Conjunctive Use Impediments and Opportunities

IMPEDIMENT	OPPORTUNITIES TO REMOVE IMPEDIMENT
Declining Santa Ana River base flow reduces supply of water available to recharge groundwater basin. (flows declined from WY 1998-99 high of 158,600 acre-feet to WY 2013-14 low of 64,900 acre-feet	Operation of GWRS provides new source of recharge to replace decline in river flows. OCWD maintains water purchase reserve account for flexibility to purchase imported water in large quantities when available
Presence of Quagga Mussels in Colorado River water limits ability to recharge only in basins that can be desiccated on a regular basis to control their spread and to protect water supply infrastructure.	Recharge operations planned to use Colorado River water in basins that can readily be dewatered to control the spread of Quagga Mussels Investigate potential to treat Colorado River water for Quagga, thereby increasing locations where this water can be recharged

IMPEDIMENT	OPPORTUNITIES TO REMOVE IMPEDIMENT
Limited imported water supply increases demands on groundwater supplies & supply to recharge groundwater basin	Operation of GWRS provides new source of water to replace imported water when imported supplies are unavailable Managing the groundwater basin within operating safe yield allows for water storage in basin in wet years for use during dry years when imported water deliveries are reduced
Fine-grained sediment in Santa Ana River water causes clogging of recharge basins requiring frequent basin cleanings; basins are unavailable for infiltration when being cleaned	Cleanings scheduled to minimize chance of losing stormflows to the ocean OCWD research programs are testing methods to reduce the amount of sediment that accumulates in recharge basins, thereby increasing system recharge capacity
Flashy storms produce river flows that overwhelm recharge system; OCWD is unable to capture all stormflows, resulting in loss of potential water supply.	OCWD is working with the Corps to change operation of Prado Dam to allow increased temporary storage of stormflows behind dam to allow for greater capture in recharge basins and minimize losses to the ocean.
The MWD does not allow local groundwater to be pumped into its system.	Work with MWD to determine its requirements to pump groundwater into its system.

10.7 WATER DEMANDS

Water demands within the District's boundaries for water year (WY) 2013-14 totaled approximately 449,000 acre-feet. Total demand includes the use of groundwater, surface water from Santiago Creek and Irvine Lake, recycled water, and imported water. As shown in Figure 10-7, water demands between WY1989-90 to WY2013-14 have fluctuated between approximately 413,000 afy to 515,000 afy.

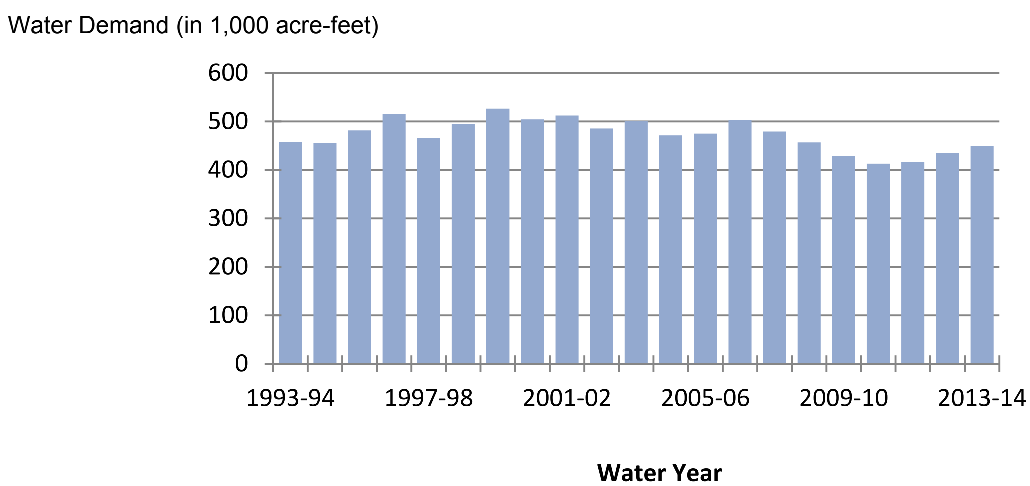


Figure 10-6: Historic Total District Water Demands

10.7.1 Projected Water Demands

Numerous factors impact water demands, such as population growth, economic conditions, conservation programs, and hydrologic conditions. Estimates of future demands are, therefore, subject to some uncertainty and need updating on a periodic basis.

Demand projections within the District's service area are based on Urban Water Management Plans (UWMP), which each Producer prepares to support their long-term resources planning to ensure that adequate supplies are available to meet existing and future water demands. Estimated future water demands within OCWD boundaries are shown in Table 10-5 with a breakdown by individual Producer's shown in Table 10-6.The California Department of Water Resources requires that the UWMP's be updated every five years. One of the key factors influencing water demand is population growth. Population within OCWD's service area is expected to increase from approximately the current 2.38 million to 2.54 million by 2035 as shown in Table 10-7.

Table 10-5: Estimated Future Water Demands in OCWD Service Area (afy)*

2015	2020	2025	2030	2035
442,048	462,805	483,563	504,321	525,079

*Projections based on annual MWDOC survey completed by each Producer

Table 10-6: Projected Total Water Demands (afy)

Fiscal Year Ending	2015	2020	2025	2030	2035
Anaheim	67,795	70,271	72,747	75,224	77,700
Buena Park	15,633	16,700	17,766	18,833	19,900
East Orange County Water District	1,045	1,059	1,073	1,086	1,100
Fountain Valley	11,438	11,120	10,801	10,483	10,165
Fullerton	29,093	30,018	30,942	31,867	32,792
Garden Grove	26,316	27,463	28,611	29,759	30,907
Golden State Water Company	28,003	29,196	30,389	31,581	32,774
Huntington Beach	30,394	31,460	32,526	33,591	34,657
Irvine Ranch Water District	63,447	69,587	75,728	81,868	88,008

Fiscal Year Ending	2015	2020	2025	2030	2035
La Palma	2,246	2,370	2,494	2,618	2,742
Mesa Water District	20,848	20,561	20,274	19,987	19,700
Newport Beach	16,509	17,001	17,492	17,983	18,474
Orange	31,723	32,471	33,218	33,966	34,713
Santa Ana	40,480	42,960	45,440	47,920	50,400
Seal Beach	3,807	4,075	4,344	4,612	4,880
Serrano Water District	3,165	3,087	3,008	2,930	2,852
Tustin	12,561	13,219	13,878	14,536	15,194
Westminster	12,477	12,442	12,407	12,372	12,337
Yorba Linda Water District	17,193	19,841	22,489	25,136	27,784
Non-Producers*	7,875	7,906	7,937	7,969	8,000
TOTAL WATER DEMAND	442,048	462,805	483,563	504,321	525,079

*Includes pumping by small system, private, domestic, irrigation, mutual water companies, and groundwater remediation systems.

Table 10-7: Projected Population within OCWD Boundaries

2015	2020	2025	2030	2035
2,376,929	2,442,790	2,487,780	2,535,627	2,539,154

Source: MWDOC and Center for Demographics Research (2014)

10.7.2 Water-Use Efficiency and Conservation Programs

Water conservation plays an important role in meeting future water demands. By implementing conservation programs, future water demand can be reduced, and less imported water will be necessary to meet the area’s water requirements.

The District cooperated with MWDOC, OCSD, and other agencies in a Low-Flush Toilet Program that subsidized the replacement of old high-volume toilets with modern low-flow toilets. The District also supported MWDOC and MWD in a Hotel/Motel Water Conservation Program to save water through minimizing water use at hotels. This program offered free laminated towel rack hangers or bed cards that encourage guests to consider using their towels and bed linens more than once during their stay.

OCWD supported MWDOC and other local agencies in a similar program aimed at restaurant water conservation. Free laminated cards were provided for restaurants to place on their tables. The cards inform patrons that water will be served only upon request. This encourages environmental awareness and water and energy conservation.

OCWD is a signatory to a Memorandum of Understanding with the California Urban Water Conservation Council (CUWCC) and prepares an annual report of the District's Best Management Practices related to water conservation and water-use efficiency.

OCWD's Green Acres Project (GAP) provides recycled water for landscape irrigation for customers in the vicinity of the District administrative offices in Fountain Valley.

The Arundo removal program is a unique water conservation program, as described in Section 9.2. Arundo is an invasive plant that spreads quickly and crowds out native vegetation. Because this plant uses significantly more water than native species, its removal along the Santa Ana River in the watershed has resulted in an additional yield of supply available for groundwater recharge. The over 4,500 acres of Arundo that have been cleared is estimated to increase yield in the river of a minimum of 15,000 acre-feet of water each year.

10.8 DROUGHT MANAGEMENT

Drought is an extended period of below-average precipitation. There is no single, official definition of the time period associated with a drought. The magnitude of a drought depends on the extent of the deviation from average precipitation, the areal extent of the below-average precipitation and other factors.

During a drought, flexibility to manage pumping from the basin becomes increasingly important. The District typically experiences a decline in the supply of recharge water (local supply of Santa Ana River water and net incidental recharge) of up to 55,000 afy or more during drought.

To the extent that the basin has water in storage that can be pumped out, the basin 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;
- Having a reserve account with sufficient funds to purchase imported water to recharge the basin when needed;
- Operating the basin at the lower storage levels in a safe manner; and
- Possessing a plan to refill the basin.

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 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 10-8.

Table 10-8: 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 District • Increases water cost for 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 • Water transfers and exchanges could be utilized to provide the increased supply of recharge water • Dependent on building and maintaining excess recharge capacity (which may be under-utilized in non-drought years)
Combination of the Above	• A combination of the approaches provides flexibility and a range of options for refilling the basin

10.9 RECORD KEEPING

District staff prepare detailed reports on a monthly basis that account for basin inflows (imported water recharged, infiltration in recharge basins, estimates of incidental recharge and evaporation, and river flow loss to the ocean) and outflows (groundwater production and storage program withdrawals); change in groundwater storage; total water demands; precipitation; GWRS production; and water levels in the area of the Talbert Seawater Intrusion Barrier. An example of a monthly report can be found in Appendix F.

FINANCIAL MANAGEMENT

11

District Headquarters in Fountain Valley

- District managed to maintain high credit ratings
- Reserves maintained to purchase imported water
- Revenues from Replenishment Assessments, Basin Equity Assessments, Property Taxes and Grants

SECTION 11 FINANCIAL MANAGEMENT

11.1 BACKGROUND

The District manages its finances to provide long-term fiscal stability. To achieve this objective OCWD:

- Manages finances to maintain high credit ratings;
- Manages District operations efficiently and effectively;
- Maintains reserves for purchase of imported water supplies when available.
- Recovers contamination cleanup costs from responsible parties when possible;
- Sets the Basin Production Percentage; and
- Sets the RA and BEA at levels that fund District activities and encourage adherence to the BPP.

The District's fiscal year (FY) begins on July 1 and ends on June 30. The annual operating budget and expected revenues for 2013-14 were approximately $134.4 million.

11.2 OPERATING EXPENSES

The District's budgeted operating expenses for FY 2014-15 are summarized in Table 11.1 and described below.

Table 11-1: FY 2014-15 Budget Operating Expenses

Expenses	Amount (in millions)
General Fund	$55.5
Total Debt Service	32.8
Water Purchases	26.3
New Equipment/ Small Projects	0.7
Retiree Health Trust	1.3
Refurbishment and Replacement Transfer	12.8
Total	$134.4

11.2.1 General Fund

The District's general fund account primarily allows the District to operate the recharge facilities in the cities of Anaheim and Orange, GWRS, the Talbert and Alamitos Seawater Intrusion Barriers, the Green Acres Project, and the Prado Wetlands. In addition, the District's Advanced Water Quality Assurance Laboratory, groundwater monitoring programs, watershed management, planning, and other miscellaneous activities are funded by this account.

11.2.2 Debt Service

The debt service budget provides for repayment of the District's debt from issues of previous bonds. OCWD has a comprehensive long-range debt program, which provides for the funding of projects necessary to increase basin production and protect water quality, while providing predictable impacts to the RA. The District holds very high credit ratings of AAA from Standard & Poor's, AAA from Fitch, along with an Aa1 rating from Moody's. Because of these excellent credit ratings, OCWD is able to borrow money at a substantially reduced cost.

11.2.3 Water Purchases

The District Act authorizes OCWD to purchase imported water for groundwater recharge to sustain groundwater pumping levels and refill the basin. As described in Section 5, imported water is purchased from MWD for recharge in the surface water recharge system. This fund provides the flexibility to purchase water when such supplies are available. The Board of Directors can allocate funds to the Water Reserve Fund so that funds may accumulate in reserve in preparation for water purchases in future years.

11.2.4 New Capital Equipment

This category includes equipment items such as laboratory equipment, vehicles, fax machines, tools, computers, and software. These items are expensed and funded using current revenues.

11.2.5 Refurbishment and Replacement Fund

OCWD has over $908 million in existing plant and fixed assets. These facilities were constructed to provide a safe and reliable water supply. The Replacement and Refurbishment Fund was established to ensure that sufficient funds are available to repair and replace existing District infrastructure, such as pumps, heavy equipment wells and water recycling facilities.

11.3 OPERATING REVENUES

Expected operating revenues for FY 2014-15 are shown in Table 12-2 and described below.

Table 11-2: FY 2014-15 Operating Revenues

Revenues	Amount (in millions)
Replenishment Assessments	$95.7
Basin Equity Assessment	1.8
Property Taxes	21.5
LRP for GAP & GWRS	8.8
Other Miscellaneous Revenue	6.6
Total	$134.4

11.3.1 Replenishment Assessments

The RA is paid for all water pumped out of the basin. The District invoices Producers for their production in July and January. The amount of revenue generated by the RA is directly related to the amount of groundwater production. The BEA is assessed annually for all groundwater production above the BPP.

11.3.2 Property Taxes

The District receives a small percentage of property taxes, also referred to as ad valorem taxes, collected in the service area. The County of Orange assesses and collects these taxes and transmits them to the District at various times during the year. This revenue source has been dedicated to the District's annual debt service expense.

11.3.3 Other Miscellaneous Revenue

Cash reserves generate interest revenues. The majority of cash reserves are invested in short-term securities. Miscellaneous revenues are primarily comprised of water sales from the Green Acres Project and loan repayments. The loan repayments originate from the Conjunctive Use Well Program in which the District loaned Producers money at low interest rates for construction of new production wells and related facilities. In addition, numerous small items such as rents, subsidies and minor fees are grouped in this account.

11.4 RESERVES

The District maintains cash reserves to ensure its financial integrity so that the basin can be successfully managed and protected. Cash reserves ensure that:

- OCWD has sufficient funds for cash flow purposes;
- Funds are available for unexpected events such as contamination issues;
- Funds are available to make necessary replacements and repairs to infrastructure;
- OCWD has access to debt programs with low interest cost;
- A financial hedge is available to manage variable rate debt; and
- Funds are available to purchase MWD water when available.

11.4.1 Reserve Policies

The District has reserve policies, which establish reserves in the following categories:

- Operating reserves
- The Replacement and Refurbishment Program
- The Toxic Cleanup Reserve
- Contingencies required by the District Act
- Bond reserve covenants

11.4.2 Operating Reserves

This reserve category helps the District maintain sufficient funds for cash flow purposes and helps sustain the District's excellent credit rating. Maintaining this reserve, which is set at 15 percent of the operating budget, is particularly important because the principal source of revenue, the RA, is only collected twice a year. Payments for significant activities, such as replenishment water purchases, are typically required on a monthly basis. The reserve provides the financial "bridge" to meet the District's financial obligations on a monthly basis.

11.4.3 Replacement and Refurbishment Program

The District maintains a Replacement and Refurbishment Fund to provide the financial resources for replacement and/or repair of the District capital assets. These assets include treatment facilities, monitoring and injection wells, and treatment facilities. The fund balance at the end of FY 2014 was approximately $ 73 million.

11.4.4 Toxic Cleanup Reserve

Funds are reserved in this account to be used in the event that a portion of the basin becomes threatened by contamination. Over two million residents in the District rely on the basin as their primary source of water. Approximately $4 million was available in this reserve fund at the end of FY 2013-14 to allow the District to respond, immediately, to contamination threats in the basin.

11.4.5 General Contingencies

Section 17.1 of the District Act requires the allocation of funds to cover annual expenditures that have not been provided for or that have been insufficiently provided for and for unappropriated requirements.

11.4.6 Debt Service Account

Restricted funds in this account have been set aside by the bonding institutions as a requirement to ensure financial solvency and to help guarantee repayment of any debt issuances. These funds cannot be used for any other purpose. The requirement varies from year to year depending on the District's debt issuance and outstanding state loans.

11.4.7 Capital Improvement Projects

Capital Improvement Projects

The District prepares a Capital Improvements Project budget to support basin production by increasing recharge capacity and operational flexibility, protecting the coastal portion of the basin, and providing water quality improvement.

12

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ACRONYMS AND ABBREVIATIONS

SECTION 12 REFERENCES

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ABBREVIATIONS AND ACRONYMS

ABFM	Alamitos Barrier Flow Model
ABTM	Alamitos Barrier Transport Model
af	acre-feet
afy	acre-feet per year
AOP	advanced oxidation processes
AWT	advanced water treatment
basin	Orange County groundwater basin
Basin Model	OCWD groundwater model
BEA	Basin Equity Assessment
BPP	Basin Production Percentage
CDFW	California Department of Fish & Wildlife
CDPH	California Department of Public Health
cfs	cubic feet per second
DATS	Deep Aquifer Treatment System
District	Orange County Water District
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 IEUA	Independent Advisory Panel Inland Empire Utilities Agency
IRWD	Irvine Ranch Water District
LACDWP	Los Angeles County Department of Power & Water
maf	million acre feet
MCAS	Marine Corps Air Station
MCL	maximum contaminant level
MWDOC	Municipal Water District of Orange County
MF	microfiltration
MODFLOW	Computer program developed by USGS
mgd	million gallons per day
mg/L	milligrams per liter
MTBE	methyl tertiary-butylether
MWD	Metropolitan Water District of Southern California
MWDOC	Municipal Water District of Orange County
NDMA	n-Nitrosodimethylamine
NF	nanofiltration
ng/L	nanograms per liter

ABBREVIATIONS AND ACRONYMS

NBGPP	North Basin Groundwater Protection Program
NO_2	nitrite
NO_3^-	Nitrate
NPDES	National Pollution Discharge Elimination System
NWRI	National Water Research Institute
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
ppb	less than one microgram per liter
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 Regional Water Quality and Health
SAWA	Santa Ana Watershed Association
SAWPA	Santa Ana Watershed Project Authority
SBGPP	South Basin Groundwater Protection Project
SDWA	Safe Drinking Water Act
SOCs	synthetic organic chemicals
SWP	State Water Project
SWRCB	State Water Resource 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

APPENDICES

Appendix A	Public Notices
Appendix B	Groundwater Management Act Mandatory and Recommended Components Sustainable Groundwater Management Act Required and Additional Plan Elements
Appendix C	Basin Management Objectives: Achievement of Sustainability for Long-Term Beneficial Uses of Groundwater
Appendix D	Report on Evaluation of Orange County Groundwater Basin Storage and Operational Strategy
Appendix E	List of Wells in OCWD Monitoring Programs
Appendix F	Monthly Water Resources Report

APPENDIX A

Public Notices

Board of Directors/Water Issues Committee Agenda, February 11, 2015

Board of Directors Meeting Minutes, February 11, 2015

Hydrospectives Newsletter, February 2015

Notice of Public Hearing and Availability of Draft Plan, Affidavit of Publication

OCWD Website screen shots of Notice of Public Hearing and Availability of Draft Plan, April 13, 2015

Board of Director's Water Issues Committee Agenda, April 15, 2015

Board of Director's Minutes, April 15, 2015

Hydrospectives Newsletter, April 2015

Producers Meeting, May, 13, 2015

Board of Director's Meeting Minutes, May 20, 2015

Comment Letter from East Orange County Water District

Comment from Irvine Ranch Water District at May 20 Public Hearing

OCWD Response to Comments

Notice of Exemption

Certification of Board Action Approving Groundwater Management Act 2015 Update

AGENDA ITEM SUBMITTAL

Meeting Date: February 11, 2015

To: Water Issues Committee
Board of Directors

From: Mike Markus

Staff Contact: G. Woodside/M. Westropp

Budgeted: N/A
Budgeted Amount: N/A
Cost Estimate: N/A
Funding Source: N/A
Program/Line Item No.: N/A
General Counsel Approval: N/A
Engineers/Feasibility Report: N/A
CEQA Compliance: Exemption to be filed upon Board receipt of final plan

Subject: OCWD GROUNDWATER MANAGEMENT PLAN UPDATE

SUMMARY

The District's Groundwater Management Plan (GWMP) was last updated in 2009. Staff proposes to prepare and adopt an update to the GWMP in 2015. Updated information concerning how the District sustainably manages the groundwater basin will be incorporated into the GWMP.

Attachment(s): Presentation

RECOMMENDATION

Informational

BACKGROUND/ANALYSIS

The District adopted its first GWMP in 1989 pursuant to authority under the District Act to manage the Orange County Groundwater Basin. Plan updates were prepared approximately every five years with the latest update adopted in 2009.

Passage of Assembly Bill 3030 in 1992 (codified in the CA Water Code Section 10750 *et. seq*.) directed the California Department of Water Resources (DWR) to oversee the preparation and adoption of groundwater management plans, listed components that must be included in those plans, and required the completion of plans for agencies to be eligible to receive grants for construction of certain groundwater projects. Although the District is not regulated by Section 10750 requirements, the OCWD Groundwater Management Plan generally includes the listed elements and maintaining this consistency has allowed the District to compete for and obtain state grants.

District staff initially planned to prepare an updated plan in 2014. This schedule was delayed in anticipation of passage of new state legislation regulating groundwater basins and the uncertainty of how this may affect required plan elements and adoption procedures.

On September 16, 2014, the Governor signed into law the California Sustainable Groundwater Management Act (SGMA).[1] This new law provides specific authority for the establishment of groundwater sustainability agencies (GSAs). Included in the law is a provision designating OCWD as the exclusive local agency to manage groundwater within the District's statutory boundaries (CA Water Code Section 10723 (c) (1)). The District, therefore, does not need to become a GSA under this new authority.

The SGMA also sets forth procedures and requirements to prepare and adopt Groundwater Sustainability Plans (GSPs). Many of the required elements specified in the SGMA are the same as or are similar to those required for Groundwater Management Plans prepared pursuant to AB3030 such as a description of the physical setting and characteristics of the aquifer system, measurable objectives, components related to management of the basin, summary of monitoring programs, and monitoring protocols. The new law specifies additional elements such as demonstration of the achievement of sustainable groundwater management and a description of how other water resource-related plans within the basin affect basin management. The Department of Water Resources is directed to adopt emergency regulations for evaluating and implementing GSPs as well as criteria for approving alternative plans by June 2016 (CA Water Code Section 10733.2).

Another provision in the newly-passed SGMA provides that instead of a GSP, an 'alternative plan' may be prepared and submitted.[2] CA Water Code Section 10733.6 provides for approval of alternative plans where there is a demonstration that such a plan meets the requirements of "sustainable groundwater management." District staff recommends preparing the OCWD's GWMP including new substantive elements required for GSPs highlighting how the District sustainably manages the groundwater basin.

Proceeding in this manner will enable OCWD to update the GWMP in a timely manner, documenting the sustainable management of the basin, and laying the foundation for submittal of this plan as an "alternative plan." It is hoped that preparation of OCWD's plan at this time will inform the process of developing GSPs in other regions of the state and may assist DWR in developing regulations specifying elements required to be included in GSPs in order to achieve sustainable groundwater management.

The proposed schedule for preparing and adopting the 2015 Update is shown on the following page.

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1 The state legislature passed three bills SB1168, AB1739, and SB1319 that combined are commonly referred to as the Sustainable Groundwater Management Act.

2 The statutory deadline for submittal of alternative plans is January 1, 2017. Alternative plans must be updated every five years.

Task	Schedule
Staff provides public notice of the intention to prepare an update to the District's GWMP	February 2015
Draft plan available for review by Board, Producers, and the public	March 2015
Deadline for receiving comments on draft plan	April 2015
Final draft plan released	May 2015
Board adopts final plan	June 2015

PRIOR RELEVANT BOARD ACTION(S)

7/15/09 M9-80: Adoption of Groundwater Management Plan 2009 Update.

MINUTES OF BOARD OF DIRECTORS MEETING
WITH WATER ISSUES COMMITTEE
ORANGE COUNTY WATER DISTRICT
February 11, 2015 @ 8 a.m.

Water Issues Committee Chair Director Sarmiento called the meeting to order in the Boardroom of the District office located in Fountain Valley, CA. The Assistant District Secretary reported quorum of the Committee.

Committee
Vincent Sarmiento
Denis Bilodeau (not present)
Dina Nguyen (arrived 8:14 a.m.)
Shawn Dewane
Philip Anthony

Alternates
Steve Sheldon (not present)
Jan Flory
Harry Sidhu (not present)
Roger Yoh (not present)
Cathy Green

OCWD Staff
Mike Markus - General Manager
Joel Kuperberg - General Counsel
Judy-Rae Karlsen - Assistant District Secretary
Darla Cirillo, Jason Dadakis, Alicia Dunkin,
Randy Fick, Roy Herndon, Adam Hutchinson,
John Kennedy, Anny Lau, Lily Sanchez,
Ben Smith, Dave Mark, Chris Olsen, Alex Vue,
Marsha Westropp, Greg Woodside, Lee Yoo

Others
Marc Marcantonio, Steve Conklin – Yorba Linda WD
Phil Lauri, Paul Shoenberger– Mesa Water District
Betsy Eglash, Howard Johnson – Brady Associates
David Holland, Jim Mott – Agilent Technologies
Don Calkins – City of Anaheim
Peer Swan – Irvine Ranch Water District
Scott Maloni – Poseidon Resources
Brian Ragland – City of Huntington Beach
Keith Lyon – Municipal Water District of Orange County
Ken Vecchiarelli - Golden State Water District
John Earl – Surf City Voice

CONSENT CALENDAR

The Consent Calendar was approved upon motion by Director Anthony, seconded by Director Flory and carried [5-0] as follows.
[Yes -Sarmiento, Dewane, Anthony, Flory, Green/No – 0]

1. Minutes of Previous Meeting

The Minutes of the Water Issues Committee meeting held January 14, 2015 are approved as presented.

2. Amendment to Agreement 538 with CH2M Hill to Update Computer Model of Recharge System and Contract Extension

Recommended for approval at February 18 Board meeting: Authorize issuance of Amendment No. 3 to Agreement No. 538 with CH2M HILL, for an amount not to exceed $24,472 for updates to the recharge facilities computer model and extending the contract to December 31, 2015.

3. Contract No. TAL-2014-1: Talbert Barrier West End Pipeline Cathodic Protection System - Publish Notice Inviting Bids

Recommended for approval at February 18 Board meeting: Authorize publication of Notice Inviting Bids for Contract No. TAL-2014-1: Talbert Barrier West End Pipeline Cathodic Protection System project.

4. Contract No. SC-2014-1, Santiago Pipeline Access Project: Ratify Change Orders and File Notice of Completion (GCI Construction, Inc.)

Recommended for approval at February 18 Board meeting: 1) Ratify issuance of Change Order No. 1 ($637) and Change Order No. 2 ($18,656) to GCI Construction, Inc.; and 2) Accept completion of work and authorize filing a Notice of Completion for Contract SC-2014-1, Santiago Pipeline Access Project.

5. Laboratory Renewal of Service Support Agreement to Cover Gas Chromatographs (GC) and Gas Chromatographs/ Mass Spectrometers (GC/MS)

Recommended for approval at February 18 Board meeting: Authorize issuance of Purchase Order to Agilent Technologies in the amount of $100,483 for a full Support Service Agreement, with prepayment option commencing March 21, 2015; to cover specified analytical systems used within the laboratory.

6. Agreements to Habitat West and Tropical Plaza Nursery for Maintenance Services on OCWD Restoration Sites in Orange County

Recommended for approval at February 18 Board meeting: Authorize issuance of Agreements to Habitat West, Inc. and Tropical Plaza Nursery Inc. for a total amount not to exceed $75,000 per year, for a three year period to provide maintenance services on habitat restoration sites in Orange County.

INFORMATIONAL ITEMS

7. OCWD Groundwater Management Plan Update

Senior Watershed Planner Marsha Westropp reported the OCWD Groundwater Management Plan (GWMP) was last updated in 2009 and staff was beginning the 2014 update, however the update was delayed in anticipation of the passage of the California Sustainable Groundwater Management Act (SGMA). She advised that as a result of that legislation passing the OCWD GWMP will include elements that are also required for Groundwater Sustainability Plans and will highlight how the District sustainably manages the groundwater basin.

Director Nguyen arrived at 8:14 a.m. during the following discussion.

8. Prado Basin Sediment Management Demonstration Project

Executive Director Greg Woodside reviewed the approach that staff has developed to bring additional information to the Board regarding the Prado Basin Sediment Management Demonstration Project and the strategy employed to reduce the project budget and secure additional grant funding and outside funding. He noted that staff will be presenting information on alternate cost saving methods for excavation/hauling, sand mining and the re-entrainment of sediment activities. Mr. Woodside advised that the project will be competitive in future rounds of grant funding decisions (Proposition 84 Round 3 and Proposition 1), therefore it would be advantageous to complete the permitting process, that

February 2015

In This Issue:

President's Message – Let's Clean it Up!

Orange County's economy thrives, in part, because of a reliable source of local water. The Orange County Water District (OCWD) is charged with managing and protecting the county's groundwater basin to ensure long-term production of clean water from our local sources at the lowest possible costs.

The groundwater basin is being threatened. In the North Basin, near the cities of Fullerton, Anaheim and Placentia, industrial contamination has seeped into the groundwater basin and has necessitated shutting down four wells. The contamination is from improper disposal of chemical solvents and other compounds from as far back as the 1950s and 1960s. The dumping has stopped but once the pollution is in the ground, it can and usually does spread. Read More...

Welcome New Board Member Roman Reyna

Santa Ana City Councilman Roman Reyna has been appointed to the Orange County Water District Board of Directors to represent Division 8—Santa Ana, effective Feb. 18, 2015. He replaces Santa Ana Mayor Pro Tem Vincent Sarmiento, Esq., who recently served a two-year term on OCWD's Board. Read More...

OC Water Summit Registration is Open

Registration is now open for the 8th annual OC Water Summit, which will take place on Friday, May 15, 2015 at the Grand Californian Hotel at the Disneyland Resort. The event draws more than 400 prominent national and state policy makers, elected officials, scientists, financial experts and business leaders. The OC Water Summit is hosted by the Orange County Water District, Disneyland Resort and the Municipal Water District of Orange County. To register as a participant or sponsor, visit the Orange Counter Water Summit.

Bill Dunivin...In His Own Words

William (Bill) R. Dunivin is a pioneer in the field of water reclamation and has dedicated his professional career, spanning 40 years, to advancing the field of water reuse and serving the public as an employee of the Orange County Water District. During his four decades of service—the longest of any OCWD employee, Bill has had direct involvement and oversight in the planning, operation and maintenance of the District's world-renowned recycling facilities.

We were curious about Bill, the changes that have taken place at OCWD over the years and Bill's observations. Read More...

Water Treatment Using Engineered Wetlands

In partnership with academic researchers from multiple university institutions, the District began a field-scale study of alternative methods for water treatment using engineered wetlands in 2013 to reduce the levels of nitrate in the Santa Ana River. At the time, nitrate from a variety of sources, including agricultural and dairy runoff as well as treated effluent from upstream water treatment plants, contributed to high levels.

Working together as the Engineering Research Center (ERC) for Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt), the National Science Foundation-supported group represents Stanford University, UC-Berkeley, Colorado School of Mines, and New Mexico State University. OCWD is a member of ReNUWIt's Industrial/Practitioner Advisory Board. The project is in its second of a three-year study. Read More...

Public Participation Sought for Groundwater Management Plan

OCWD plans to update the District's Groundwater Management Plan in 2015. This document sets forth a framework for managing the Orange County Groundwater Basin for long-term sustainability. It also allows the District to compete for and obtain state grants. This effort will update the existing plan that was adopted by the OCWD Board of Directors in 2009.

The Groundwater Management Plan sets goals and basin management objectives and describes basin hydrology, groundwater and surface water monitoring programs, operation of seawater intrusion barriers, natural resource protection programs, the Groundwater Replenishment System, and recharge operations and provides an analysis of basin conditions that demonstrates that the basin is operating within its sustainable yield. Public participation in the development of the plan is welcomed and encouraged. For more information, contact Marsha Westropp at mwestropp@ocwd.com or 714-378-8248.

2014 Tree Swallow Nesting

Tree Swallows (*Tachycineta bicolor*) are voracious consumers of flying insects within wetland and riverine systems. They typically produce large clutch sizes ranging from five to seven eggs which cause a high demand for food. Together, the adults and chicks can consume hundreds of thousands of insects during a single breeding season. This creates the potential for Tree Swallows to make a significant dent in the insect pest population. Read More...

Successful OCWD Environmental Restoration Projects

OCWD is a leader in water and natural resource management, carrying out award-winning environmental programs that also provide water supply benefits. OCWD has a reputation of providing clean, fresh water to more than 2.4 million ratepayers in north and central Orange County. The story of its responsible environmental stewardship is only beginning to be told. Read More...

1 Million Hits on YouTube

AFFIDAVIT OF PUBLICATION

STATE OF CALIFORNIA,)
) ss.
County of Orange)

I am a citizen of the United States and a resident of the County aforesaid; I am over the age of eighteen years, and not a party to or interested in the above entitled matter. I am the principal clerk of **The Orange County Register**, a newspaper of general circulation, published in the city of Santa Ana, County of Orange, and which newspaper has been adjudged to be a newspaper of general circulation by the Superior Court of the County of Orange, State of California, under the date of November 19, 1905, Case No. A-21046, that the notice, of which the annexed is a true printed copy, has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to wit:

April 13, 21, 2015

I certify (or declare) under the penalty of perjury under the laws of the State of California that the foregoing is true and correct":

Executed at Santa Ana, Orange County, California, on

Date April 21, 2015.

Angel Borten

Signature

The Orange County Register
625 N. Grand Ave.
Santa Ana, CA 92701
(714) 796-2209

PROOF OF PUBLICATION

Notice of Public Hearing
For the Purpose of Updating the Orange County Water District Groundwater Management Plan 2015

Notice is hereby given that the Orange County Water District ("District") will hold a public hearing on Wednesday, May 20, 2015 at 5:30 p.m., or as soon thereafter as the matter may be heard, in the Boardroom at the office of said District, 18700 Ward Street, Fountain Valley, California 92708.

The hearing is for the purpose of notifying the public of the intention of the District to update the District's Groundwater Management Plan and for soliciting public comments on the draft Groundwater Management Plan 2015 Update prior to adoption of the plan.

The draft plan may be viewed on the District's website, www.ocwd.com. Copies may be obtained by submitting a written request to Orange County Water District, P.O. Box 8300, Fountain Valley, CA 92728-8300 Attn: Marsha Westropp. Copies will be available at the public hearing.

The public is invited to attend the public hearing and comment on the draft plan. Written comments must be submitted by May 22, 2015. Comments may be submitted to the above post office box address, Attn: Marsha Westropp or via email at mwestropp@ocwd.com . For additional information call 714-378-8248.

The Groundwater Management Plan 2015 Update is scheduled to be considered for adoption by the District's Board of Directors at the regularly scheduled meeting of the Board of Directors to be held on June 17, 2015 at 5:30 pm. Any change to the schedule for the Board of Directors to adopt the Groundwater Management Plan 2015 Update will be posted on the District's website, www.ocwd.com.

Published: Orange County Register April 13, 21, 2015 R-552 10036126

Notice of Public Hearing
For the Purpose of Updating the Orange County Water District
Groundwater Management Plan 2015

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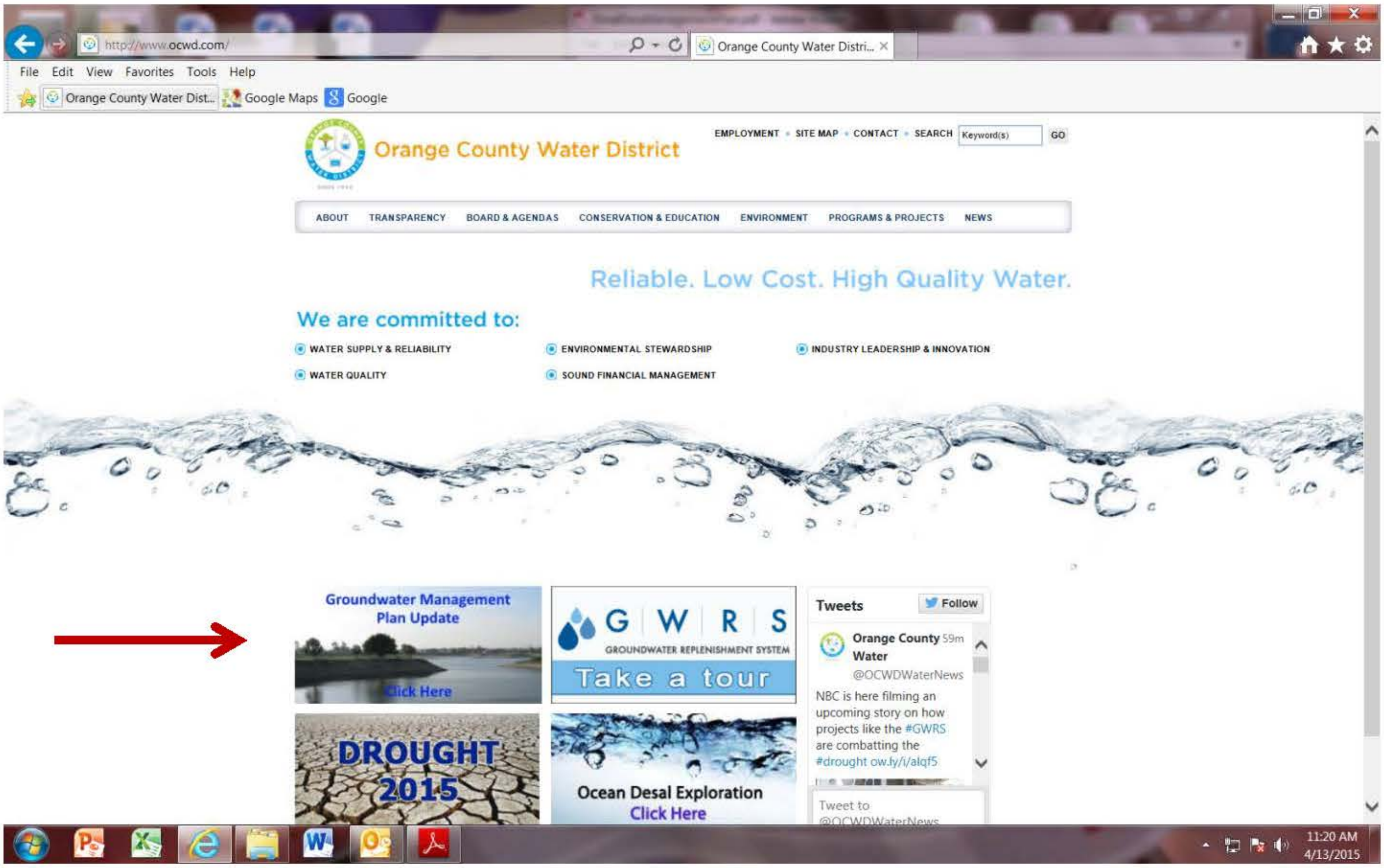
Posting of Notice on OCWD Website (April 13, 2015 to June 17, 2015)

Availability of Draft Groundwater Management Plan 2015 Update



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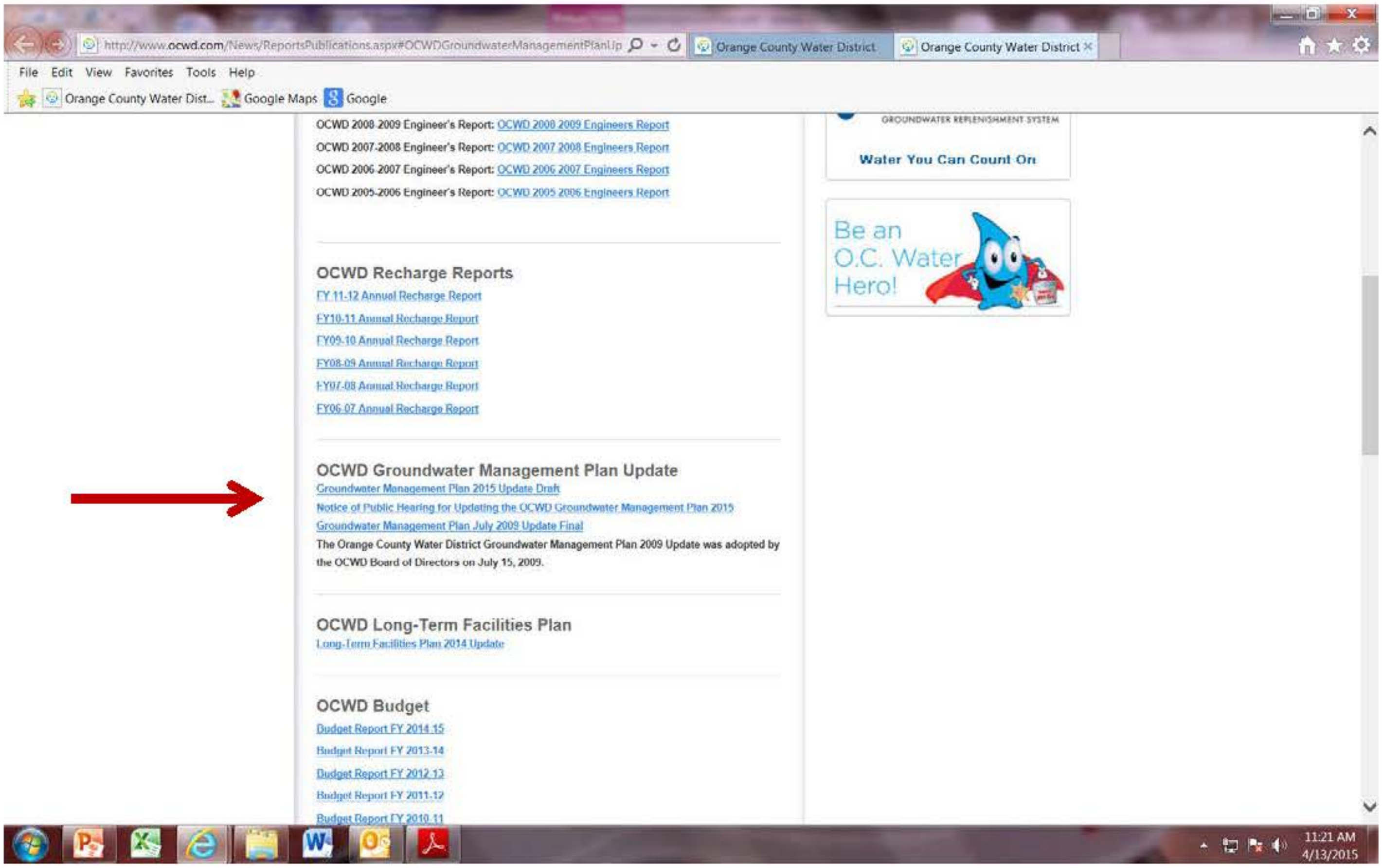

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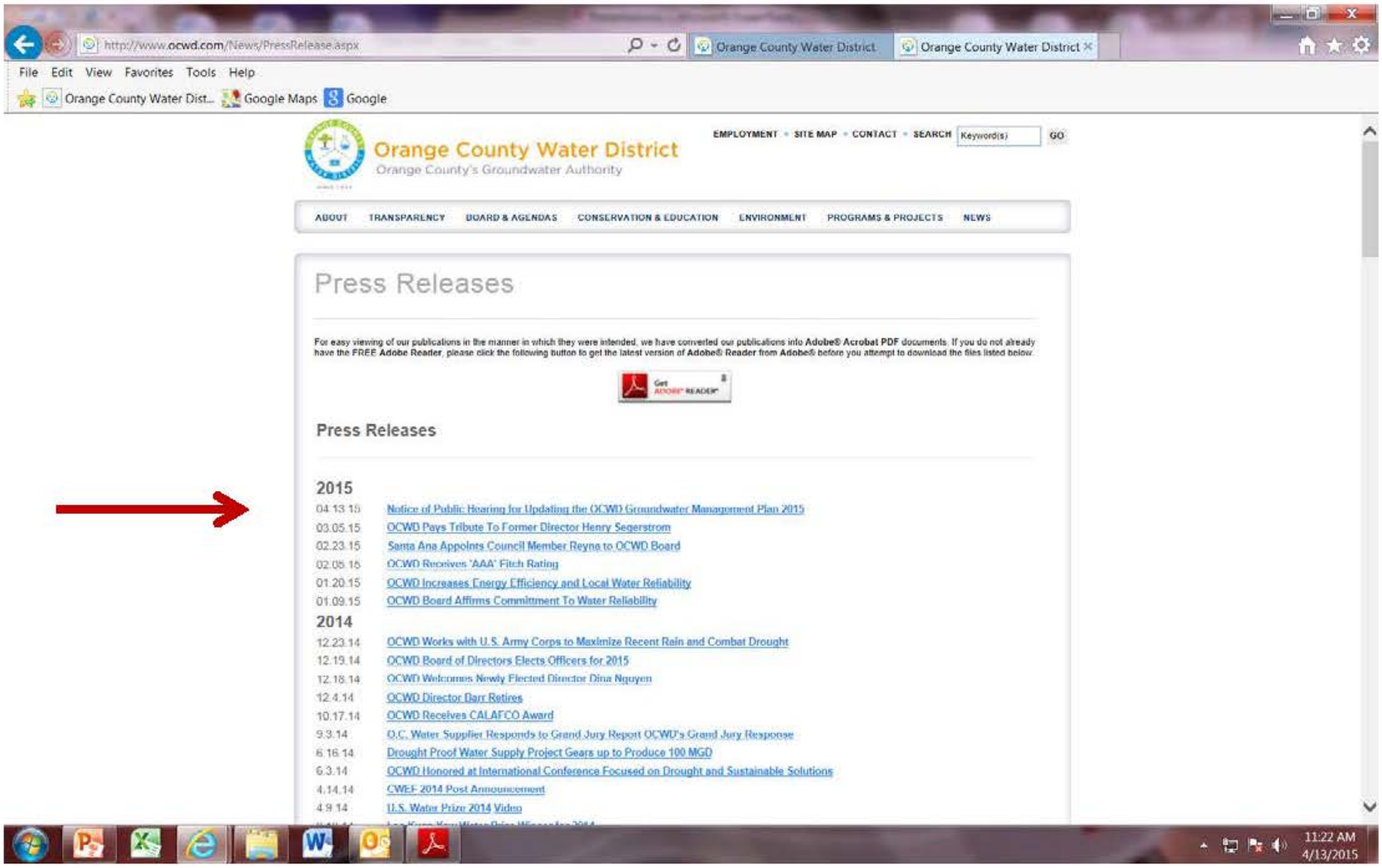

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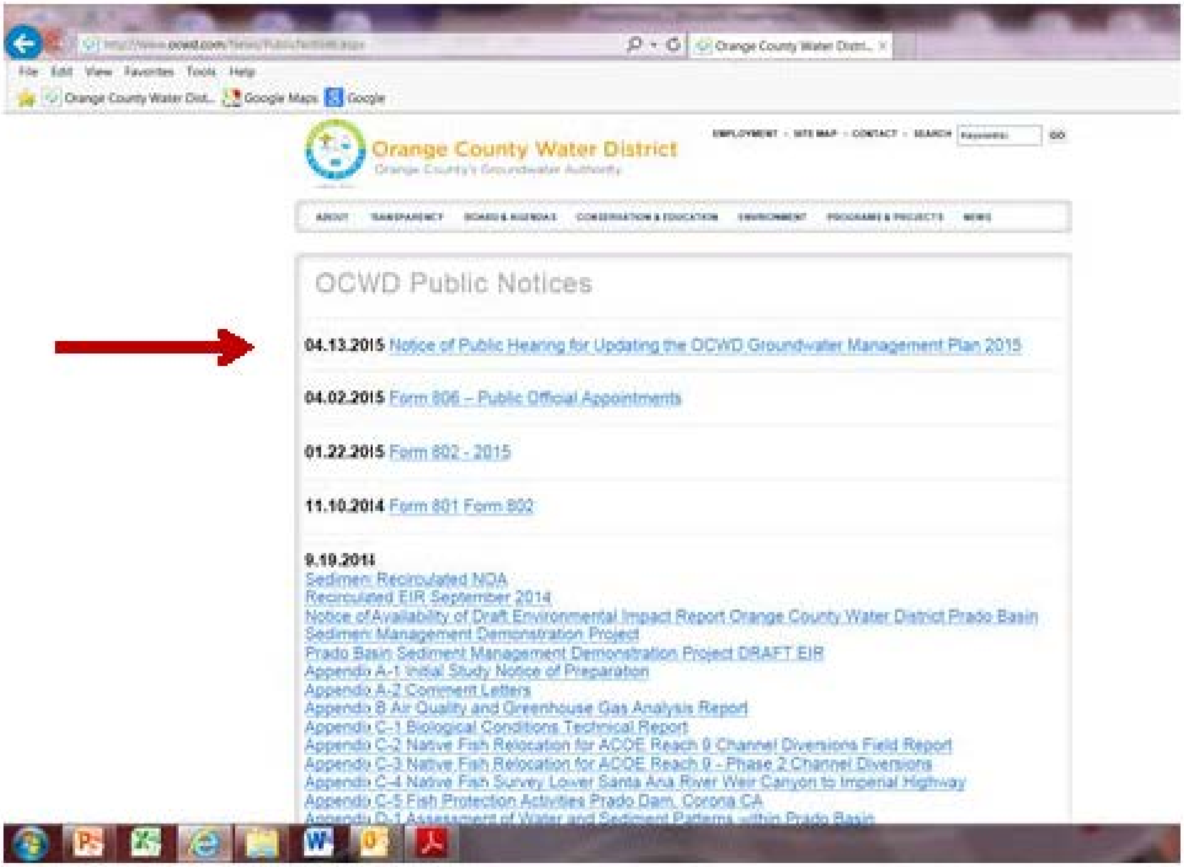


MINUTES OF MEETING
BOARD OF DIRECTORS, ORANGE COUNTY WATER DISTRICT
April 15, 2015, 5:30 p.m.

President Green called to order the April 15, 2015 regular meeting of the Orange County Water District Board of Directors at 5:30 p.m. in the Boardroom at the District office. Following the Pledge of Allegiance to the Flag, the Secretary called the roll and reported a quorum as follows.

Directors		Staff
Philip Anthony		Michael Markus, General Manager
Denis Bilodeau		Joel Kuperberg, General Counsel
Shawn Dewane		Janice Durant, District Secretary
Jan Flory		Gina Ayala, Pedro Barrera, Adrienne Campbell,
Cathy Green		Stephanie Dosier, Randy Fick,
Dina Nguyen		Roy Herndon, Bill Hunt, Judy-Rae Karlsen,
Roman Reyna		John Kennedy, Diane Pinnick, Eleanor Torres,
Stephen Sheldon		Michael Wehner, Greg Woodside,
Harry Sidhu		Nira Yamachika
Roger Yoh	(arrived 5:50 p.m.)	

Others:

Nabil Sabu – City of Santa Ana
Melody McDonald – San Bernardino Valley Municipal Water District/ACWA/JPIA
Andy Sells – Association of California Water Agencies Joint Powers Insurance Authority
Richard and Linda Armendariz – Huntington Beach residents
Jim Atkinson, Paul Shoenberger, Ethan Temianka – Mesa Water District
Steve Conklin, Bob Kiley – Yorba Linda Water District
Jose Diaz – City of Orange
Tom and Joyce Post
Ken Vecchiarelli – Golden State Water Company
Jim Dellalonga – City of Garden Grove
Brian Ragalnd – City of Huntington Beach
Bobbi Ashurst - Ratepayer
Keith Lyon – Municipal Water District of Orange County
Betsy Eglash - Brady
Peer Swan, Paul Weghorst – Irvine Ranch Water District
Vern Nelson – OJ Blog
Nick Dibs – OC Science and Engineering Fair

ASSOCIATION OF CALIFORNIA WATER AGENCIES/JOINT POWERS INSURANCE AUTHORITY (ACWA/JPIA) PRESENTATION: RETROSPECTIVE PREMIUM ADJUSTMENT STABILIZATION REFUND

ACWA/JPIA Chief Executive Officer Andy Sells and ACWA/JPIA Executive Committee member Melanie McDonald presented the District with a check in the amount of $62,638 representing a retrospective premium adjustment stabilization refund.

EMPLOYEE OF THE QUARTER AWARD

The Board presented Maintenance Technician I Pedro Barrera with the Employee of the Quarter award.

Director Sidhu returned to the meeting during discussion of the following items.

24. INFORMATIONAL ITEMS

A. Water Resources Report

There was no discussion of this item.

B. Santa Ana Watershed Project Authority Activities

Director Anthony gave a brief update on SAWPA activates.

C. OCWD Groundwater Management Plan Update

Executive Director Greg Woodside advised that the draft Groundwater Management Plan would be available for public comment until May 22, and that a public hearing has been scheduled for May 20.

D. Groundwater Producer Meeting Minutes – April 8, 2015

It was noted the minutes of this meeting were contained in tonight's packet.

E. COMMITTEE/CONFERENCE/MEETING REPORTS

► Reports on Conferences/Meetings Attended at District Expense (at which a quorum of the Board was present)

The Board reported on attendance at the following Committee meetings and noted the Minutes/Action Agendas were included in tonight's Board packet.

April 02 - Communication/Legislative Liaison Committee
April 08 - Water Issues Committee
April 09 - Administration/Finance Issues Committee
April 13 - GWRS Steering Committee

VERBAL REPORTS

Directors Bilodeau and Reyna reported on a press conference they attended today at the Hotel Fullerton where it was unveiled that they replaced 80,000 sq. ft. of grass with artificial grass for which the City of Fullerton rebated the hotel approximately $41,000.

Director Green stated the Citizens' Advisory Committee has requested the addition of another meeting. She recommended the Board extend its decision to the end of May to allow the Committee to have another meeting and submit its recommendation. Staff was directed to cancel the previously scheduled April 30 special Board meeting and reschedule it for May 14, 2014 at 5:30 p.m. to review the Poseidon Term Sheet. Director Green also advised that Public Affairs employee Becky Mudd was raising money for pediatric cancer by running a 268 mile run from Huntington Beach to the California/Arizona border. She urged the Board to contribute to her charity. Finally, Director Green stated she has a meeting with staff tomorrow with the City of Fullerton and Assemblymember Wagner.

April 2015

In This Issue:

President's Message – State Water Bond Can Help O.C. Drought Crisis

We are currently experiencing the worst California drought ever recorded in 165 years, with no end in sight. According to one NASA scientist, if we don't take measures to conserve water now, it may run out for the 38 million people, businesses and agriculture in this state.

Recently, the Governor has called for mandatory—no longer voluntary—water-use efficiency. We need to save 25 percent. What else can be done?

Luckily, the good people of the state approved the Water Quality, Supply and Infrastructure Act of 2014 (Water Bond; Proposition 1) in last year's election. Read More...

Register for the 2015 OC Water Summit

Rain today, gone tomorrow? Droughts in California are expected to occur three out of every 10 years. Without proper planning and investment in water infrastructure and policy, California's $1.9 trillion economy can come to a standstill, having devastating ripple effects on U.S. and global markets. Join us for the 8th Annual Orange County Water Summit on May 15 from 7:30 a.m. to 1:30 p.m. to set imagination, innovation and investment into motion to keep water flowing.

The annual OC Water Summit will take place at the Grand Californian Hotel at the Disneyland Resort. To register as a participant or sponsor, visit the Orange County Water Summit website. Read More...

OCWD Receives ASCE OC Flood Management Project of the Year Award

The American Society of Civil Engineers Orange County, California Branch (ASCE OC) honored the Orange County Water District's (OCWD; the District) Burris Pump Station Project, Phase 1 with the **Flood Management Project of the Year award**. More than 200 people were in attendance at its annual awards banquet as ASCE OC honored outstanding individuals and projects for 2014. A total of 35 awards were given out, including 21 project awards and 14 individual awards. Read More...

(left to right) Penny Lew, PE, OCPW and past president ASCE OC; OCWD Assistant Director of Engineering Chris Olsen, PE; and Tapas Dutta, PE, ENV SP, QSD, Harris & Associates and past president ASCE OC.

19th Annual Children's Water Education Festival a Great Success!

The 19th annual Children's Water Education Festival was a success! More than 7,000 third, fourth and fifth grade Orange County students attended the free field trip to learn about water and the environment; curriculum corresponded to California Science Standards.

The Orange County Water District's Groundwater Guardian Team, which includes OCWD, Disneyland Resort and the National Water Research Institute (NWRI), hosted the event on March 25 and 26, 2015 at the University of California, Irvine (UCI). Read More...

Groundwater Management Act 2015 Draft Ready for Public Review

The OCWD Draft Groundwater Management Act 2015 Update is available for public review and comment. The draft plan may be viewed on the District's website, www.ocwd.com. Copies may be obtained by submitting a written request to Orange County Water District, P.O. Box 8300, Fountain Valley, CA 92728-8300, Attn: Marsha Westropp. Written comments submitted to either the District's post office box or via email at mwestropp@ocwd.com will be accepted until May 22, 2015. Read More...

Celebrate 45th Annual Earth Day on April 22

Bringing the poverty, development, climate and sustainability communities together to build a broader and more inclusive global movement is the theme of this year's Earth Day on Wednesday, April 22.

Earth Day has grown from a single-day event to a year-round movement to promote sustainability. It is celebrating its 45th year in 2015. Read More...

OCWD Desal Citizens Advisory Committee Meetings Underway

The OCWD Ocean Desalination Citizens Advisory Committee (CAC), which was recently appointed by the Orange County Water District Board, gathered for two meetings and is expected to meet again on April 23 and 30. Members were shown presentations about

Agenda
GROUNDWATER PRODUCERS MEETING
Sponsored by the
ORANGE COUNTY WATER DISTRICT
(714) 378-3200
Wednesday, May 13, 2015, 9:30 a.m.

Meeting to be held at the 18700 Ward Street Fountain Valley CA

1. Mila Kleinbergs Head of Special Purpose Discharge Permit program for OCSD Discuss concept of putting Producer distribution system flushing water into OCSD Sewer System – Ken Vecchiarelli of GSWC to discuss water system operational issues.

2. Poseidon Update
    a. Term Sheet
    b. Citizens Advisory Committee
    c. May 14, 2015 OCWD Board meeting

3. Review of Draft OCWD Groundwater Management Plan

4. Annual Santa Ana River Watermaster Report

5. Groundwater Remediation Projects Update
    a. North Basin – Discuss alternatives
    b. South Basin

6. Other

The Producers' meetings are scheduled the second Wednesday of each month. The next regular monthly meeting is Wednesday, June 10, 2015 at 9:30 a.m.

MINUTES OF MEETING
BOARD OF DIRECTORS, ORANGE COUNTY WATER DISTRICT
May 20, 2015, 5:30 p.m.

President Green called to order the May 20, 2015 regular meeting of the Orange County Water District Board of Directors at 5:30 p.m. in the Boardroom at the District office. Following the Pledge of Allegiance to the Flag, the Secretary called the roll and reported a quorum as follows.

Directors		Staff
Philip Anthony		Michael Markus, General Manager
Denis Bilodeau		Jeremy Jungreis, Assistant General Counsel
Shawn Dewane		Janice Durant, District Secretary
Jan Flory		Gina Ayala, Bruce Dosier, Stephanie Dosier,
Cathy Green		Alicia Dunkin, Randy Fick, Roy Herndon,
Dina Nguyen	(not present)	Bill Hunt, Judy-Rae Karlsen, John Kennedy,
Roman Reyna		Pat Lewis, Becky Mudd, Chris Olsen,
Stephen Sheldon	(not present)	Eleanor Torres, Karen Warren, Rose Wilke,
Harry Sidhu		Greg Woodside, Nira Yamachika
Roger Yoh		

Others:
Jason and Karen Ayres – Dan Copp Crushing
Dan Copp – Dan Copp Crushing
Bob Kiley, Marc Marcantonio – Yorba Linda Water District
Ed Connor – Connor Fletcher
Dan Chase
Paul Schoenberger – Mesa Water District
Keith Lyon – Municipal Water District of Orange County
Betsy Eglash - Brady

1. Recognition of Service for Director Stephen Sheldon

This item was deferred to a later date.

2. Commemorating Becky Mudd's Run for Children's Cancer Awareness

The Board took the following action commending Public Affairs staff member Beck Mudd for her run across California to raise money for children's cancer. President Green also commended Executive Assistant Karen Warren's son, Fire Captain Mike Warren, for his recent earthquake rescue mission in Nepal.

Upon motion by Director Anthony, seconded by Director Dewane, the following resolution was unanimously carried [8-0].
Ayes: Anthony, Bilodeau, Dewane, Green, Flory, Reyna, Sidhu, Yoh
Absent: Nguyen, Sheldon

2. Public Hearing to Consider Groundwater Management Plan 2015 Update

President Green opened the Public Hearing to update the District's Groundwater Management Plan (Plan) and solicit public comments on the Plan prior to its adoption on June 17, 2015. Executive Director Greg Woodside recalled that the draft updated Plan was made available for public review on April 13, noting that the Plan has been updated periodically with the latest update adopted in 2009. He advised that the 2015 update sets forth basin management goals and objectives, describes accomplishments, presents basin management strategies, and provides information about projects completed since publication of the last update. Further, he stated the Plan also incorporates additional Plan elements required by the California Sustainable Groundwater Management Act that became law in 2014. Mr. Woodside advised that the 2015 Plan discusses the District's overall goals of managing the basin as: to protect and enhance groundwater quality, to protect and increase the sustainable yield of the basin in a cost-effective manner, and to increase the efficiency of OCWD operations. He stated the comment period for the draft plan is open until May 22, 2015 and, after the public comment period is closed, staff will respond to comments and will prepare a revised version that addresses comments received to present to the Board for approval at its June 17 Board meeting.

President Green then opened the hearing for public comment.

Irvine Ranch Water District Director Peer Swan stated that he saw no chronology in the Plan where OCWD purchased the SAVI Ranch land along the Santa Ana River which he believes to be a milestone. Secondly, he stated the basin is currently down between 300,000 – 400,000 acre-feet and he does not see where in the conjunctive use plan OCWD has been collecting the money to buy imported water when it becomes available again in order to refill the basin. He stated that the under the conjunctive use management plan, either OCWD has water in the ground or the money to buy water to fill the basin so the basin is not so overdrafted. Mr. Swan stressed that up until this year, MWD water was freely available in quantities that OCWD could have purchased enough to have a full basin at the beginning of this year.

There being no other persons wishing to present testimony, President Green declared the hearing closed.

CONSENT CALENDAR

Director Flory requested the removal of Item No. 19, *Amendment to Agreement with Parsons*, from the Consent Calendar. The balance of the Consent Calendar was then approved by Director Anthony, seconded by Director Flory and carried [8-0] as follows.
Ayes: Anthony, Bilodeau, Dewane, Green, Flory, Reyna, Sidhu, Yoh
Absent: Nguyen, Sheldon

EAST ORANGE COUNTY WATER DISTRICT

185 N Mc Pherson Road
Orange, CA 92869-3720

www.eocwd.com

Ph: (714) 538-5815
Fax: (714) 538-0334

May 20, 2015

Greg Woodside, PG CHg
Director of Planning and Natural Resources
Orange County Water District
18700 Ward Street
Fountain Valley, CA 92708

RE: **Ground Water Management Program - 2015 Update**
East Orange County Water District Comments

Dear Greg,

East Orange County Water District commends the Orange County Water District on the development of a thorough document and continued efforts to effectively manage the groundwater basin as the primary source of water for north Orange County. Our comments are presented below.

Comment 1

The Santiago Basins, which contain half of the total storage in the OCWD recharge system, have historically provided recharge to wells in our Retail Zone, and other pumpers in the area. EOCWD requests that the GWMP more strongly emphasize this condition. We also request that the Groundwater Level Changes exhibit (Fig. 3-10) be revised to reflect the reduction in water levels in our East well. During 2014, the levels dropped 20 feet and were within 25 feet of the upper perforations of the well, before Santiago basin levels and the well levels increased.

Comment 2

EOCWD requests that OCWD's recharge operations result in maximizing water levels in the Santiago basins, to maintain water levels in the EOCWD wells and those of other pumpers in the area. EOCWD supports the goal of a long term 75% BPP as stated in the GWMP.

Comment 3

Thank you for the opportunity to comment on the GWMP 2015 Update.

Respectfully submitted,

Lisa Ohlund
General Manager
East Orange County Water District

Cc: Art Valenzuela, City of Tustin
Ken Vecchiarelli, Golden State Water Company
Jose Diaz, City of Orange
Paul Cook, Irvine Ranch Water District
Jerry Vilander, Serrano Water District

Public Hearing held at Meeting of OCWD Board of Directors

May 20, 2015

Oral Comments of Peer Swan, Director, Irvine Ranch Water District

Irvine Ranch Water District Director Peer Swan stated that he saw no chronology in the Plan where OCWD purchased the SAVI Ranch, land along the Santa Ana River, which he believes to be a milestone. Secondly, he stated the basin is currently down between 300,000 – 400,000 acre-feet and he does not see where in the conjunctive use plan OCWD has been collecting the money to buy imported water when it becomes available again in order to refill the basin. He stated that part of the conjunctive use management plan is that either you have the water in the ground or the money to buy water to fill the basin so the basin is not so overdrafted. Mr. Swan stressed that up until this year MWD water was freely available in quantities that OCWD could have purchased in order to have a full basin at the beginning of this year.

Response to Comments

East Orange County Water District, Lisa Ohlund (May 20, 2015 letter)

No.	Comment	Response to Comment
1	Add text to emphasize the condition that Santiago Basins, which contain half of the total storage in the OCWD recharge system, have historically provided recharge to wells in EOCWD's Retail Zone and other pumpers in the area.	Section 5.2.2 beginning on page 5-9 has been updated to incorporate requested changes.
2	Revise the Groundwater Level Changes figure (Fig. 3-10) to reflect the reduction in water levels in the area of EOCWD East well.	Figure 3-10 has been revised to provide greater detail of water level changes in the groundwater basin.
3	EOCWD requests that OCWD's recharge operations result in maximizing water levels in the Santiago Basins.	Section 5.2.2 beginning on page 5-9 has been updated to discuss maximizing recharge in the vicinity of Santiago Basins.

Irvine Ranch Water District, Peer Swan (comments at May 20, 2015 board meeting)

No.	Comment	Response to Comment
1	Provide additional discussion concerning conjunctive use of the groundwater basin related to use of imported water to maintain groundwater elevations.	Additional language has been added to Section 10.4.2 (page 10-8), Section 10.8 (page 10-15), and Section 11.2.3 (page 11-2).
2	Add to history section the OCWD purchase of land behind Prado Dam in the 1960s.	The land purchase has been added to the history section (Section 1.2).

Orange County Water District
18700 Ward Street
Fountain Valley, CA 92708
(714) 378-3200

NOTICE OF EXEMPTION

From the Requirements of the California Environmental Quality Act (CEQA)

TO: COUNTY CLERK/County of Orange
P.O. Box 238
Santa Ana, CA 92702

FROM: Orange County Water District
Planning & Watershed Management
18700 Ward Street
Fountain Valley, CA 92708

PROJECT TITLE: Orange County Water District Groundwater Management Plan 2015 Update

APPROVAL DATE: June 17, 2015

PROJECT LOCATION: Orange County Groundwater Basin

CITY: Various **COUNTY:** Orange

DESCRIPTION OF THE PROJECT: The OCWD Groundwater Management Plan discusses the groundwater basin's physical features, OCWD facilities and monitoring and operating programs.

NAME & ADDRESS OF APPLICANT: Orange County Water District, 18700 Ward Street, Fountain Valley CA 92708

NAME OF PUBLIC AGENCY APPROVING PROJECT: Orange County Water District

EXEMPT STATUS:

- ☐ Ministerial (Sec. 15268)
- ☐ Declared Emergency (Sec. 15269 (a))
- ☐ Emergency Project (Sec. 15269(a)&(b))
- ☐ General Rule (Sec. 15061(b)(3))
- X Statutory Exemption: Section 15262
- X Categorical Exemption: Class 6 Section 15306, Class 7 Section 15307 Class 8 Section 15308

REASON(S) WHY PROJECT IS EXEMPT FROM CEQA:
The Groundwater Management Plan is an information document that discusses the Orange County Groundwater Basin and OCWD facilities and programs. The Groundwater Management Plan does not bind, commit or predispose OCWD to further consideration, approval or implementation of any potential project. Approval of the Groundwater Management Plan would not cause either a direct physical change to the environment or a reasonably foreseeable indirect physical change to the environment.

CONTACT PERSON: Marsha Westropp **TELEPHONE No:** 714 378-8248

SIGNATURE: Marsha Westropp **DATE:** June 18, 2015

TITLE: Senior Planner

CERTIFICATION OF SECRETARY

I do hereby certify that at its meeting held June 17, 2015, the Orange County Water District Board of Directors approved the following item:

FINAL DRAFT GROUNDWATER MANAGEMENT PLAN 2015 UPDATE

Adopt the Groundwater Management Plan 2015 Update; and authorize the filing of a Notice of Exemption.

IN WITNESS WHEREOF, I have executed this Certificate on June 18, 2015

Judy-Rae Karlsen, Assistant District Secretary

APPENDIX B

Groundwater Management Act Mandatory and Recommended Components

Sustainable Groundwater Management Act Required and Additional Plan Elements

Appendix B
Sustainable Groundwater Management Act
Required and Additional Plan Elements

Water Code Section	Required Plan Elements	OCWD Plan Section
10727.2(a)	Description of physical setting and characteristics of the aquifer system underlying the basin that includes the following:	
10727.2(a)(1)	Historical data	3.1; 3.4-3.7; 5.1-5.3; 7.1-7.3; 10.1-10.3
10727.2(a)(2)	Groundwater levels…………………………………… Groundwater quality…………………………………… Subsidence…………………………………………….. Groundwater-surface water interaction…………………	3.4-3.5 8.1-8.8 3.6 4.7
10727.2(a)(3)	General discussion of historical and projected water demands and supplies	10.1-10.7
10727.2(a)(4)	A map that details the area of the basin and the boundaries of the groundwater sustainability agencies that overlie the basin that have or are developing groundwater sustainability plans	Figure 3-4; 9.4; Figure 9-13
10727.2(a)(5)	A map identifying existing and potential recharge areas for the basin including identification of existing recharge areas that substantially contribute to the replenishment of the basin	3.1; 9.5; Figure 3-3; Figure 5-9; Figure 5-11
10727.2(b)(1)	Measurable objectives to achieve the sustainability goal in the basin with 20 years of implementation of the plan	2.3; Tables 2-1-2-3; Table 2-7
10727.2(b)(2)	Description of how the plan helps meet each objective and how each objective is intended to achieve sustainability for long-term beneficial uses of groundwater.	Tables 2-1, 2-2, 2-3
10727.2(c)	A planning and implementation horizon	2.6; 5.5
10727.2(d)	Components related to:	
10727.2(d)(1)	Monitoring and management of groundwater levels	3.4-3.7; 4.2.2; 10.2
10727.2(d)(2)	Monitoring and management of groundwater quality….. Groundwater quality degradation……………………… Inelastic land surface subsidence………………………. Changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater extraction………………………	4.2.3-4.2.5; Table 4-1; 6.4; 7.1-7.4; 8-1; 8.3-8.6; 4.2.4; 8.3-8.10 3.6 4.4; 5.2

Appendix B
Sustainable Groundwater Management Act
Required and Additional Plan Elements

Water Code Section	Required Plan Elements	OCWD Plan Section
10727.2(d)(3)	Mitigation of overdraft	10.1-10.8
10727.2(d)(4)	How recharge areas contribute to replenishment of the basin	5.3
10727.2(d)(5)	Description of surface water supply used for available for use for groundwater recharge or in-lieu use	5.1-5.6
10727.2(e)	Summary of type of monitoring sites, type of measurements, frequency of monitoring for each location including well depth, screened intervals, aquifer zones monitored, summary of type of well including public, irrigation, domestic, industrial, monitoring for:	
	Groundwater levels………………………………………	4.2.2
	Groundwater quality………………………………………	4.2.3; 4.2.4
	Subsidence………………………………………………..	3.6
	Stream flow………………………………………………..	4.3; 5.2.1; 5.2.2
	Precipitation………………………………………………	5.2; 5-10, Fig. 5-7
	Evaporation………………………………………………..	3.3
	Tidal influence……………………………………………..	4.2.5; 7.1-7.4
10727.2(f)	Monitoring protocols designed to detect changes in:	
	Groundwater levels………………………………………	3.4-3.7; 4.2.2; 10.2
	Groundwater quality……………………………………….	4.2.4; 4.2.6; 4.3.7; 6.4; 7.1-7.4; 8.1; 8.3- 8.6
	Inelastic surface subsidence (when applicable)………..	3-7
	Flow and quality of surface water that directly affect groundwater levels or quality or caused by groundwater extraction…………………………………	4.4; 4.7; 8.5
10727.2(g)	Description of the consideration given to the applicable county and city general plans and a description of the various adopted water resources-related plans and programs within the basin and an assessment of how the plan may affect those plans	9.3; 9.5; 9.7

Appendix B
Sustainable Groundwater Management Act
Required and Additional Plan Elements

Water Code Section	Additional Plan Elements	OCWD Plan Section
10272.4(a)	The control of saline water intrusion	4.2.6; 7.1- 7.4
10272.4(b)	Wellhead protection areas and recharge areas	8.2
10272.4(c)	Migration of contaminated groundwater	4.2.4; 8.7; 8.9
10272.4(d)	A well abandonment and well destruction program	8.2
10272.4(e)	Replenishment of groundwater extractions	5.2-5.6; 6.1-6.3; 10.1
10272.4(f)	Activities implementing, opportunities for, and removing impediments to conjunctive use or underground storage	10.6-10.8
10272.4(g)	Well construction policies	8.2
10272.4(h)	Measures addressing: Groundwater contamination clean-up…………………….. Recharge………………………………………………… Diversions to storage…………………………………… Conservation…………………………………………….. Water recycling………………………………………….. Conveyance……………………………………………… Extraction projects (note: except for contamination clean up OCWD does not have extraction projects)……………	 8.7-8.10 5.1-5.5; 6.1; 10.3 5.1-5.3 10.7.2 5.2.4; 6.1-6.6 5.1-5.3; 6.1 8.9
10272.4(i)	Efficient water management practices for the delivery of water and water conservation methods to improve the efficiency of water use	NA- section applies to agricultural water use
10272.4(j)	Efforts to develop relationships with state and federal regulatory agencies	9.6
10272.4(k)	Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity	9.5; 9.7
10272.4(l)	Impacts on groundwater dependent ecosystems	4.7

Appendix B
Mandatory and Recommended Components of a Groundwater Management Plan

Water Code Section	Mandatory Components of a GWMP	OCWD Plan Section
10753.7(a)(1)	Basin management objectives for the groundwater basin that is subject to the plan	2.3
10753.7(a)(1)	Monitoring and management of groundwater levels within the groundwater basin	3.4, 3.5, 4.2, 5.2, 5.3, 10.2-10.4
10753.7(a)(4)	Monitoring protocols that are designed to detect changes in groundwater levels	3.4, 3.5
10753.7(a)(1)	Groundwater quality degradation	8.3, 8.4, 8.7-8.9
10753.7(a)(4)	Monitoring protocols that are designed to detect groundwater quality	4.2, 4.6
10753.7(a)(1)	Inelastic land surface subsidence	3.6
10753.7(a)(4)	Monitoring protocols that are designed to detect inelastic land surface subsidence for basins for which subsidence has been identified as a potential problem	3.6
10753.7(a)(1)	Changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin	4.4, 4.7, 5.2, 5.3.3
10753.7(a)(4)	Monitoring protocols that are designed to detect flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater pumping at the basin	4.4, 4.6
10753.7(a)(2)	A plan to involve other agencies that enables the local agency to work cooperatively with other public entities whose service area or boundary overlies the groundwater basin	1.4, 1.5, 6.1, 7.3, 8.2, 8.3, 8.7, 8.9, 9.1-9.4, 9.6, 9.7
10753.7(a)(3)	A map that details the area of the groundwater basin, as defined in the department's Bulletin No. 118, and the area of the local agency, that will be subject to the plan, as well as the boundaries of other local agencies that overlie the basin in which the agency is developing a groundwater management plan	Figures 3-1, 3-4, 3.1, 3.2

Appendix B
Mandatory and Recommended Components of a Groundwater Management Plan

Water Code Section	Optional Components of a GWMP	OCWD Plan Section
10753.8(a)	The control of saline water intrusion	3.7.4, 3.7.5, 7.1-7.4
10753.8(b)	Identification and management of wellhead protection areas and recharge areas	3.1.1,Figure 3-3, 8.2, 9.5, 9.7
10753.8(c)	Regulation of the migration of contaminated groundwater	8.7, 8.9, 8.10
10753.8(d)	The administration of a well abandonment and well destruction program	8.2
10753.8(e)	Mitigation of conditions of overdraft	10.1-10.4
10753.8(f)	Replenishment of groundwater extracted by water producers	5.1-5.6
10753.8(g)	Monitoring of groundwater levels and storage	3.4, 3.5
10753.8(h)	Facilitating conjunctive use operations	5.1-5.6, 10.1-10.6
10753.8(i)	Identification of well construction policies	4.6, 8.2
10753.8(j)	The construction and operation by the local agency of groundwater contamination cleanup, recharge, storage, conservation, water recycling and extraction projects	5.1-5.6, 6.1, 6.2, 8.7-8.9
10753.8(k)	The development of relationships with state and federal regulatory agencies	4.4.2. 4.2.3, 5.2.1, 9.1-9.3
10753.8(l)	The review of land use plans and coordination with land use planning agencies to assess activities which create a reasonable risk of groundwater contamination	9.7

APPENDIX C

Basin Management Objectives:

Achievement of Sustainability for Long-Term Beneficial Uses of Groundwater

Basin Management Objectives: Achievement of Sustainability for Long-Term Beneficial Uses of Groundwater

Table 2-1: Basin Management Objective: Protect and Enhance Groundwater Quality	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
Groundwater Quality		
Collect & analyze water quality samples from 400 or more District monitoring wells as determined by program protocols (at least annually)	Discovering potential water quality problems at an early stage provides protection for groundwater used for drinking water over the long-term. Also provides data to develop programs to prevent spread of groundwater contamination.	4.2
Collect & analyze water quality samples from 200 drinking water wells as determined by Title 22 protocols (at least annually)	Comprehensive monitoring of water supplies assures quality of drinking water provided by retail agencies and continued availability of this supply of water over the long-term. Discovering potential water quality problems at an early stage provides protection for groundwater used for drinking water over the long-term.	4.2
Recharge Water Supplies		
Collect & analyze water quality samples of recharge supplies (surface, recycled, imported, & ground water) according to program protocols (at least quarterly)	Assuring the water quality of recharge sources protects the water quality of the OC Groundwater Basin resulting in the long-term availability of this local groundwater supply for use as drinking water.	4.2.5 4.3
Surface Water Supplies		
Sample & analyze 2 sites on Santa Ana River in Orange County as directed by NWRI Santa Ana River Monitoring Program Expert Panel (quarterly)	Assuring the water quality of Santa Ana river water used for recharge protects the water quality of the OC Groundwater Basin resulting in the long-term availability of this local groundwater supply for use as drinking water.	4.3

Table 2-1: Basin Management Objective: Protect and Enhance Groundwater Quality	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
Sample & analyze 12 sites in upper watershed for constituents as directed by NWRI Santa Ana River Monitoring Program Expert Panel (annually)	Assuring the water quality of Santa Ana river water used for recharge protects the water quality of the OC Groundwater Basin resulting in the long-term availability of this local groundwater supply for use as drinking water.	4.3
Contamination Prevention and Remediation		
Implement the District's Groundwater Quality Protection Policy	Discovery and remediation of groundwater contamination sites provides protection for the basin assuring use of groundwater as a source of drinking water.	8.1
Evaluate & implement projects to address groundwater contamination in North Basin & South Basin areas	Remediation of groundwater contamination sites provides protection for the basin assuring use of groundwater as a source of drinking water.	8.9
Seawater Intrusion		
Collect samples & analyze water quality from 86 wells to assess control of seawater intrusion at Talbert, Bolsa, Sunset, and Alamitos Gaps (annually)	Monitoring seawater intrusion and changing barrier operations as necessary protects the groundwater basin from migration of saline water assuring use of the basin for drinking water over the long-term.	4.2, 7
Prepare Talbert Gap area chloride concentration contour maps (every two years)	Preparing contour maps allows for assessing the effectiveness of barrier operations to assure protection of groundwater from impairment and use of the basin for drinking water over the long-term.	7
Operate Talbert Seawater Barrier to (1) maintain protective groundwater elevation at well OCWD-M26 and (2) prevent landward	Operation of the seawater barrier prevents landward movement of seawater into the groundwater basin protecting groundwater from impairment assuring	7.2

Table 2-1: Basin Management Objective: Protect and Enhance Groundwater Quality	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
seawater migration into groundwater basin based on 250 mg/L chloride concentration contour & other measurements	use of the basin for drinking water over the long-term.	
Participate in Alamitos Barrier Operations Committee to review barrier performance (at least annually)	Operation of the seawater barrier prevents landward movement of seawater into the groundwater basin protecting groundwater from impairment assuring use of the basin for drinking water over the long-term.	7.3
Operate Alamitos Barrier with Los Angeles County agencies to prevent landward seawater migration into groundwater basin based on 250 mg/L chloride concentration contour	Operation of the seawater barrier prevents landward movement of seawater into the groundwater basin protecting groundwater from impairment assuring use of the basin for drinking water over the long-term.	
Increase injection or implement other measures to prevent basin degradation if significant seawater intrusion occurs	Investigating, changing, and modifying intrusion barrier operations when necessary provides for protection of groundwater quality assuring use of the basin for drinking water over the long-term.	7
Wetlands & Natural Resources		
Support natural resource programs in watershed to improve water quality	Participating in natural resource programs, such as the least Bells vireo monitoring and management program and the Santa Ana sucker fish management program, helps maintain these native species and facilitates permitting of OCWD projects for stormwater capture and recharge.	9
Participate in cooperative efforts with regulators and stakeholders within Watershed	The purpose of the cooperative watershed programs is to maintain the quality of surface water supplies that are used for groundwater recharge. This provides protection for the quality of Santa Ana River water recharged into the	4.3.3, 9

Table 2-1: Basin Management Objective: Protect and Enhance Groundwater Quality	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
	groundwater basin and protects drinking water for the long-term.	
Divert 50% of Santa Ana River flow through Prado Wetlands to improve river water quality; measure flow & nitrogen removal loads (monthly)	Operation of Prado Wetlands results in removal of nitrates and other contaminants before the water is recharged into the groundwater basin, resulting in improved water quality of drinking water.	8.5

Table 2-2: Basin Management Objective: Protect and Increase Basin Sustainable Yield in Cost-Effective Manner	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
Collect and analyze at least 1,000 measurements of groundwater levels at least six times per year	Collecting and analyzing groundwater level data enables the District to calculate the amount of groundwater in storage every year in order to determinate the optimal groundwater production to maintain basin levels within safe operating range to assure sustainable basin management.	4.2.2
Calculate change in basin storage (annually)	Collecting groundwater level data enables the District to calculate the amount of groundwater in storage every year and determine the optimal groundwater production to maintain basin levels within safe operating range. This information guides decisions about future recharge needs and how much pumping can occur while remaining within the basin storage safe operating range.	4.2.2
Collect production rate data from 19 large producers (monthly) & small producers (every	Collecting and maintaining accurate records of amount of groundwater produced allows the District to monitor basin conditions on a monthly basis so that basin management can be re-assessed and modified if necessary to	4.2.1

Table 2-2: Basin Management Objective: Protect and Increase Basin Sustainable Yield in Cost-Effective Manner	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
six months)	protect the long-term sustainability of the basin. These data are also critical to calculating the annual water budget.	
Participate in state CASGEM program by reporting groundwater elevation measurements from 38 wells (annually)	Participating in the CASGEM program by reporting data for OC Groundwater Basin provides information on groundwater elevations.	4.2.4
Maintain groundwater storage within safe operating range (less than 500,000 acre-feet below full condition)	Maintaining groundwater storage within the safe operating range reduces the risk of seawater intrusion and irreversible land subsidence and enables OCWD to sustainably manage the basin over the long-term.	10
Set target level for total production, estimate total water demands, & establish Basin Production Percentage (BPP) (annually)	Managing annual groundwater production by setting the BPP allows for groundwater storage levels to be maintained within the safe operating range and leads to long-term sustainable management of the basin.	3.4, 10.2
Calculate total volume of water recharged (annually)	Calculating recharge totals provides data to calculate the annual water budget and allows for accurate assessment of basin conditions; this information is important to setting the BPP and thereby maintaining groundwater storage within the safe operating range.	5
Report & publish on web site total water recharged in *Water Resources Summary* (monthly)	Compiling and publishing data on a monthly basis provides ready access to information and allows stakeholders to participate in basin management and allows the District to re-assess and modify management decisions based on the most up-to-date information.	5
Convene OCWD Recharge Enhancement Working Group (annually)	The Working Group analyzes recharge operations and evaluates potential new projects to increase the efficiency of recharge facilities, thereby enabling	5.5.1

Table 2-2: Basin Management Objective: Protect and Increase Basin Sustainable Yield in Cost-Effective Manner	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
	the District to maximize recharge into the basin and the use of the basin for water supply.	
Evaluate potential new recharge projects using District's Recharge Facilities Model	The model allows the District to estimate the cost-effectiveness of potential changes to recharge operations and potential new recharge facilities and thereby pursue the most cost-effective projects to increase recharge into the basin.	5.5.2
Promote local infiltration of storm water	Local infiltration of storm water provides additional basin recharge, which helps increase the amount of pumping that can be sustained in the basin.	3.3.2
Participate in cooperative efforts with regulators & stakeholders in watershed	Cooperative efforts are aimed at improvement of water quality in the Santa Ana River, successful management of natural resources, and other benefits that allow OCWD to monitor and manage the quality and quantity of surface water supplies used to recharge the groundwater basin.	9.2, 9.3
Collect & review ground surface elevation measurement data from Orange County Surveyor (annually)	Monitoring potential land subsidence provides information so that the District's basin management measures can be modified, if necessary, to avoid unacceptable physical changes in the land surface.	3.6
If significant levels of subsidence occur, conduct characterization & mitigation study	In the event that unacceptable levels of land subsidence is found to be occurring due to changes in groundwater levels, a study to characterize such changes and determine appropriate mitigation will allow for continued production of groundwater at sustainable levels.	3.6
Produce 90,000 afy of GWRS recycled water	Producing recycled water for groundwater recharge and seawater barrier operations enables OCWD to increase the amount of pumping that can be	6

Table 2-2: Basin Management Objective: Protect and Increase Basin Sustainable Yield in Cost-Effective Manner	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
	sustained from the basin. Without the recycled water, groundwater pumping would need to be reduced.	
Publish the *Engineer's Report, that includes total pumping, groundwater elevations, change in storage, & related water data (annually)*	Compiling and publishing data on an annual basis allows all stakeholders to participate in basin management and allow the District to re-assess and modify management decisions based on the most up-to-date information.	10.2

Table 2-3: Basin Management Objective: Increase Operational Efficiency	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
Maintain Water Resources Management System database as central repository for water quality, pumping, recharge, & related water management information	Managing large amounts of historical and current data allow the District to have quick access to the data and make a variety of management decisions concerning water quality and water supply based on adequate information.	4.4
Manage District's finances for long-term fiscal stability	Maintaining fiscal stability allows the District to construct and operate necessary facilities and implement programs to protect the groundwater basin and continue sustainable management.	11
Operate District programs in cost-effective & efficient manner.	Efficient operations allow the District to construct and operate necessary facilities and implement programs to protect the groundwater basin and continue sustainable management.	11
Manage natural resource programs in Santa Ana River	Managing natural resource programs, such as the least Bells vireo	9.2

Table 2-3: Basin Management Objective: Increase Operational Efficiency	How Objective Achieves Sustainability for Long-Term Beneficial Uses of Groundwater	Section Reference
watershed in efficient manner	monitoring and management program and the Santa Ana sucker fish management program, helps maintain these native species and facilitates permitting of OCWD projects for stormwater capture and recharge.	
Implement efficient environmental management programs to reduce greenhouse gas emissions & use alternative energy where feasible	Incorporating energy efficiency programs in District operations allows for greater operational efficiency in an environmentally friendly manner.	6.3
Use Recharge Facilities Model to evaluate cost-effectiveness of potential new recharge basins & improvements to existing facilities	The model allows the District to estimate the cost-effectiveness of potential changes to recharge operations and potential new recharge facilities and thereby pursue the most cost-effective projects to increase recharge into the basin.	5.5
Make improvements to recharge facilities to increase efficiency	Efficient recharge operations helps the District maximize the amount of water recharged into the groundwater basin, which increases the amount of pumping that can be sustained.	5.6

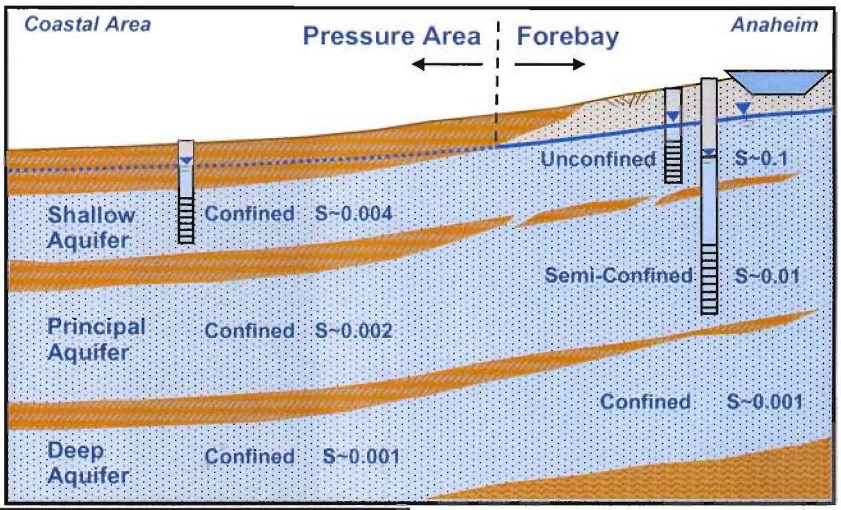
APPENDIX D

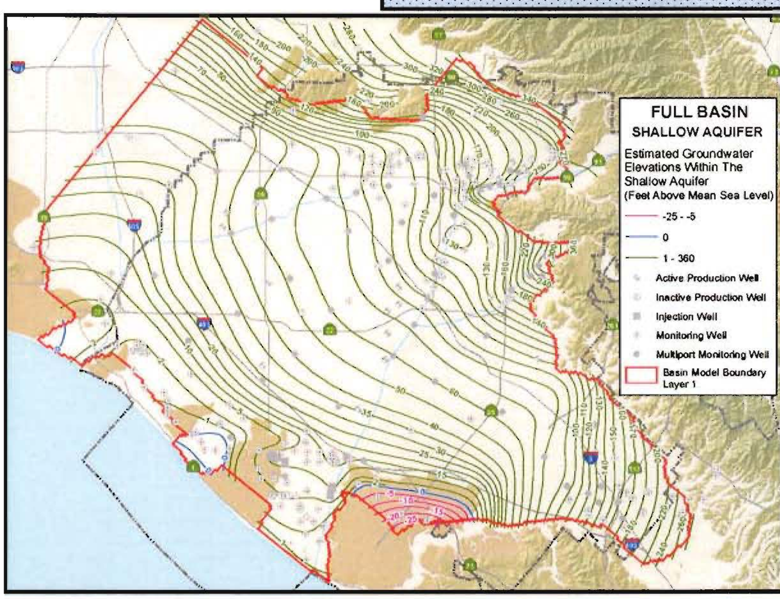
Report on Evaluation of Orange County Groundwater Basin Storage and Operational Strategy

ORANGE COUNTY WATER DISTRICT

REPORT ON

EVALUATION OF ORANGE COUNTY GROUNDWATER BASIN STORAGE AND OPERATIONAL STRATEGY





Prepared By:

Timothy J. Sovich, PE – Principal Engineer
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FEBRUARY, 2007

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Acknowledgment

Much assistance was provided by District GIS staff Dan Lee and Linda Koki, specifically with implementation and automation of the new three-layer storage change algorithm, GIS programming, mapping, and graphical support.

EXECUTIVE SUMMARY

The need for this study was largely driven by the record-setting wet year of 2004-05, in which an unprecedented storage increase of 170,000 af was estimated by OCWD staff. This led to a preliminary reassessment of the traditional storage calculation which, due to cumulative uncertainty over tens of years, could not be sufficiently rectified back to the traditional full-basin benchmark of 1969.

A new methodology has been developed, tested, and documented herein for calculating accumulated overdraft and storage change based on a three aquifer layer approach, as opposed to the previous single-layer method. Also, for calculating accumulated overdraft, a new full-basin benchmark was developed for each of the three aquifer layers, thereby replacing the traditional single-layer full benchmark of 1969. Also in this report, a basin management operational strategy is proposed that sets guidelines for planned refill or storage decrease amounts based on the level of accumulated overdraft.

The new three-layer storage change approach utilizes aquifer storage parameters supported by calibration of the District's basin-wide groundwater model ("basin model") along with actual measured water level data for each of the three aquifer systems that correspond to the three aquifer layers in the basin model: the Shallow, Principal, and Deep (colored water) aquifer systems. Traditionally, the storage change calculation was based solely on groundwater levels for the Principal aquifer, from which approximately 90 percent of basin pumping occurs.

The findings of this study are enumerated below.

1. The new three-layer storage change approach is technically feasible and provides a more accurate assessment than the traditional single-layer storage change method.

2. Using the new three-layer method, the majority of the storage change occurs in the Forebay area of the basin within the unconfined Shallow aquifer where rising or falling of the water table fills or drains empty pore space.

3. Accuracy of the storage change and accumulated overdraft estimates is dependent upon good spatial distribution of water level measurements as well as the storage coefficient values used in the calculations. Water level data for the Shallow aquifer were relatively sparse in outlying Forebay areas of the basin, leading to some uncertainty in preparing groundwater elevation contours in those areas.

4. 1969 no longer represents a truly full-basin benchmark. A new full-basin water level condition was developed based on the following prescribed conditions:

   - Observed historical high water levels
   - Present-day pumping and recharge conditions
   - Protective of seawater intrusion
   - Minimal potential for mounding at or near recharge basins

The new full-basin water levels in the Forebay area are essentially at or very near the bottom of the District's deep percolation basins (e.g., Anaheim Lake). Historical water level data from 1994 have shown that this condition is achievable without detrimental effects. Water levels slightly higher than this new full condition may be physically achievable in the Forebay area but not recommended due to the likelihood of groundwater mounding and reduced percolation in recharge basins.

5. Using the new three-layer storage change calculation in conjunction with the new full benchmark and June 2006 water levels, an accumulated overdraft of 135,000 af was calculated representing June 30, 2006. Similarly, using the new three-layer method to compare the new full water levels to those of June 2005, an accumulated overdraft of 201,000 af was calculated representing June 30, 2005. Subtracting the June 2006 accumulated overdraft from that of June 2005 yielded an annual storage increase of 66,000 af for WY 2005-06.

6. Comparing the current year's water level conditions to the full basin benchmark each successive year for calculating the basin storage will eliminate the potential for cumulative discrepancies over several years.

7. An accumulated overdraft of 500,000 af represents the lowest acceptable limit of the basin's operating range. This lower limit of 500,000 af assumes that stored MWD water (CUP and Super In-Lieu) has already been removed and is only acceptable for short durations due to drought conditions. It is not recommended to manage the basin for sustained periods at this lower limit for the following reasons:

   - Seawater intrusion likely
   - Drought supply depleted
   - Pumping levels detrimental to a handful of wells
   - Increased pumping lifts and electrical costs
   - Increased potential for color upwelling from the Deep aquifer

8. An optimal basin management target of 100,000 af of accumulated overdraft provides sufficient storage space to accommodate increased supplies from one wet year while also providing enough water in storage to offset decreased supplies during a two- to three-year drought.

9. The proposed operational strategy provides a flexible guideline to assist in determining the amount of basin refill or storage decrease for the coming water year based on using the BPP formula and considering storage goals based on current basin conditions and other factors such as water availability. This strategy is not intended to dictate a specific basin refill or storage decrease amount for a given storage condition but to provide a general guideline for the District's Board of Directors.

Based on the above findings, recommendations stemming from this study are as follows:

1. Adopt the new three-layer storage change methodology along with the associated new full-basin condition that will serve as a benchmark for calculating the basin accumulated overdraft.

2. Adopt the proposed basin operating strategy including a basin operating range spanning the new full condition to an accumulated overdraft of 500,000 af, and an optimal overdraft target of 100,000 af.

3. Include in the 2007-08 CIP budget the installation of six Shallow aquifer monitoring wells to increase accuracy of the three-layer storage change calculation.

1. INTRODUCTION

This report documents the methodology, findings, and recommendations of the basin storage and overdraft evaluation completed by District staff between May 2006 and January 2007.

Prior to this study, an unusually large annual increase in basin storage of 170,000 af was estimated for WY 2004-05, which was a record-setting wet year. During that year, water levels throughout the basin rose approximately 30 feet overall, and as much as 60 feet in the Santiago recharge area which receives significant storm runoff from Villa Park Dam releases during extremely wet years.

The estimated storage increase for WY 2004-05 was so large that it caused staff to re-examine the storage calculation. Also, the large water level rise during that year raised concern that the basin could be approaching a near-full condition, leading staff to compare 2005 water levels throughout the basin to 1969 in which the basin was historically considered full. This analysis showed that the basin may have had only 40,000 af less groundwater in storage in November 2005 as compared to the 1969 benchmark. However, the traditional method of cumulatively adding the annual storage change each year to the previous year's accumulated overdraft led to an accumulated overdraft of approximately 190,000 af for November 2005.

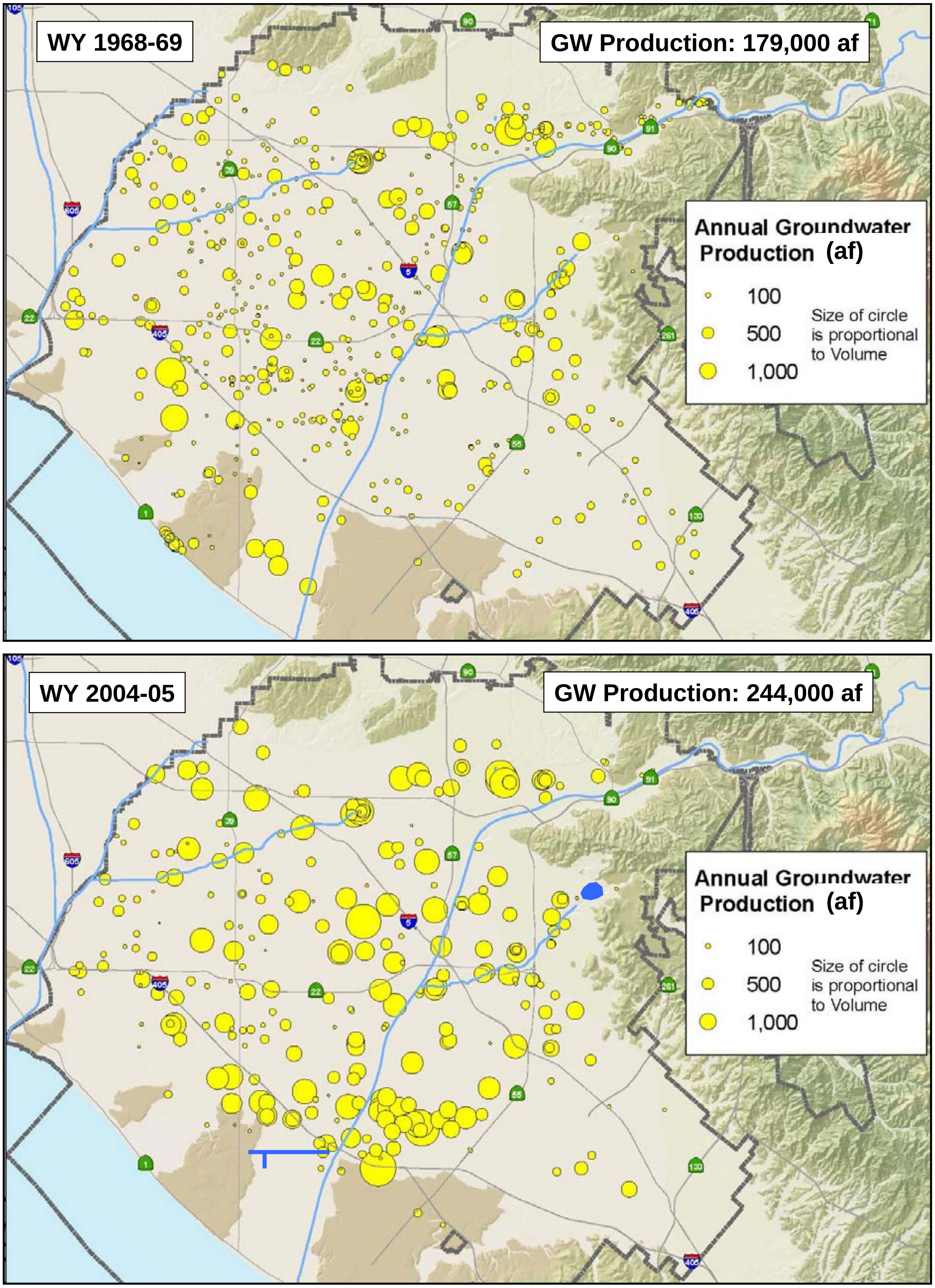
The discrepancy of 150,000 af in the two different 2005 overdraft calculations indicated that the current condition could not be properly rectified back to the 1969 benchmark. This dilemma provided the main impetus for the study documented herein and brought to light two important discoveries:

- The traditional storage change calculation contains considerable uncertainty that, when cumulatively added over tens of years, led to a large discrepancy in the accumulated overdraft relative to 1969.

- 1969 water level conditions no longer represent a full basin, primarily because of the different pumping and recharge conditions that exist today.

Figure 1-1 shows the distribution of groundwater production for WY 1968-69 (upper map) and WY 2004-05 (lower map). Each circle or "dot" represents an active production well for that year, with the size of each dot being proportional to each well's annual production. Total basin production for WY 2004-05 was only 179,000 af, whereas by WY 2004-05 it had increased to 244,000 af and would have been 70,000 af greater if not for supplemental imported water taken in-lieu of groundwater. By comparing the two production dot maps, heavy increases in pumping are evident in the coastal area since 1969, primarily due to MCWD and IRWD's Dyer Road Well Field (DRWF).

Figure 1-1. Groundwater Pumping Distribution: WY 1968-69 and WY 2004-05



In addition to changes in the amount and distribution of pumping since 1969, OCWD managed recharge operations have increased substantially such that much more water is recharged today as compared to 1969. In addition to increased Santa Ana River flows and new recharge basins being put into service in the Anaheim and Orange Forebay areas, new and improved cleaning methods have been implemented to enhance percolation rates, thus increasing the annual volume of water that is recharged annually.

Table 1-1 below summarizes the major pumping and recharge differences between WY 1968-69 and WY 2004-05.

Table 1-1. Pumping and Recharge Conditions: WY 1968-69 vs. WY 2004-05

	WY 1968-69	**WY 2004-05**
Pumping	Total Pumping: 179,000 af	Total Pumping: 244,000 af
	Agricultural Pumping: 34,000 af	Agricultural Pumping: 3,400 af
	No DRWF	In-Lieu: 70,000 af
	No MCWD municipal wells	Increased coastal pumping
	No Newport Beach wells	Less Irvine pumping
Recharge	No Talbert Barrier	Enhanced Talbert Barrier
	No Santiago Pits or Creek	Enhanced percolation rates
	No Kraemer or Miller Basins	Basin Cleaning Vehicle
	No Burris Pit or Five Coves	Riverview Basin

Since 1969, the largest pumping increases have been in the coastal area while the largest recharge increases have been in the inland Forebay area. Therefore, this redistribution along with increased utilization of the groundwater basin has led to a steeper groundwater gradient or "tilt" from the inland Forebay down to the coast. Because of this increased basin tilt under present conditions, water levels higher than 1969 can be maintained in the Forebay area without exceeding 1969 water levels in the coastal area. Because higher Forebay water levels translate into more basin storage, 1969 no longer represents a full basin condition by today's standards. In other words, a modern-day full condition could likely accommodate higher water levels than 1969 in the Forebay area, as schematically illustrated in Figure 1-2.

A review of historical water level data indicates that many wells in the Anaheim area experienced higher water levels in 1994 than in 1969. Figure 1-3 shows historical water levels for City of Anaheim Well A-27, indicating that in 1994 water levels at that location (adjacent to the south side of Anaheim Lake) were 5-10 feet higher than in 1969.

Figure 1-2. Schematic of Groundwater Level Profiles Across the Basin

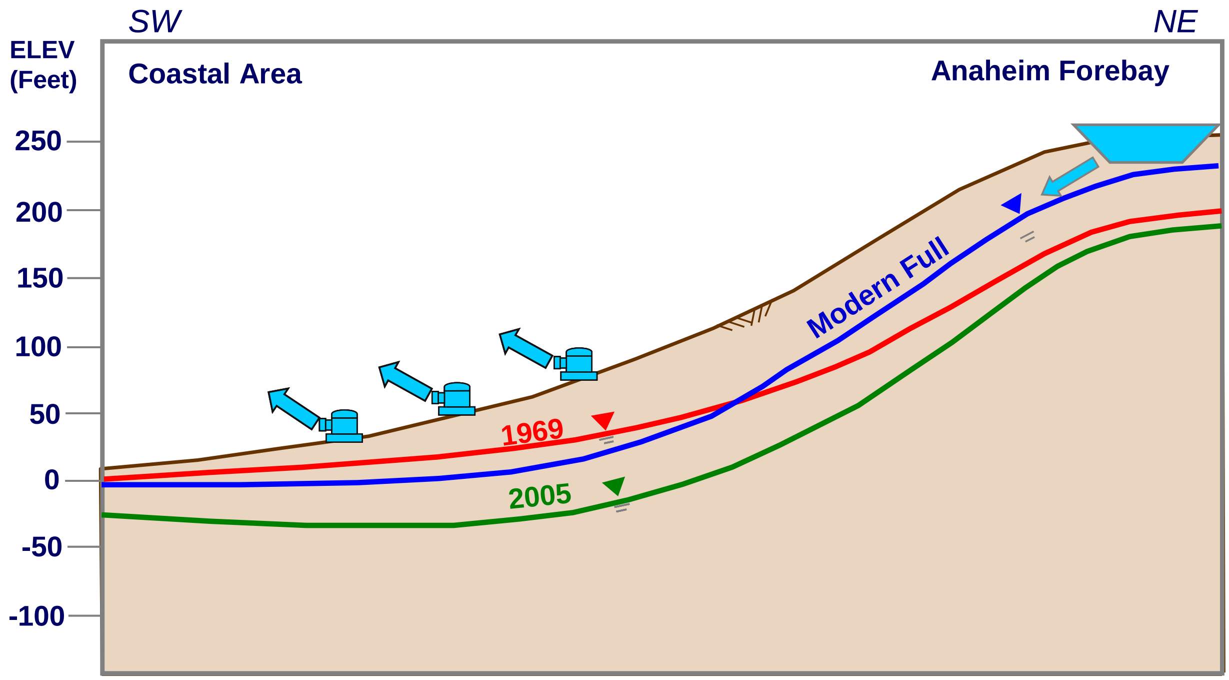
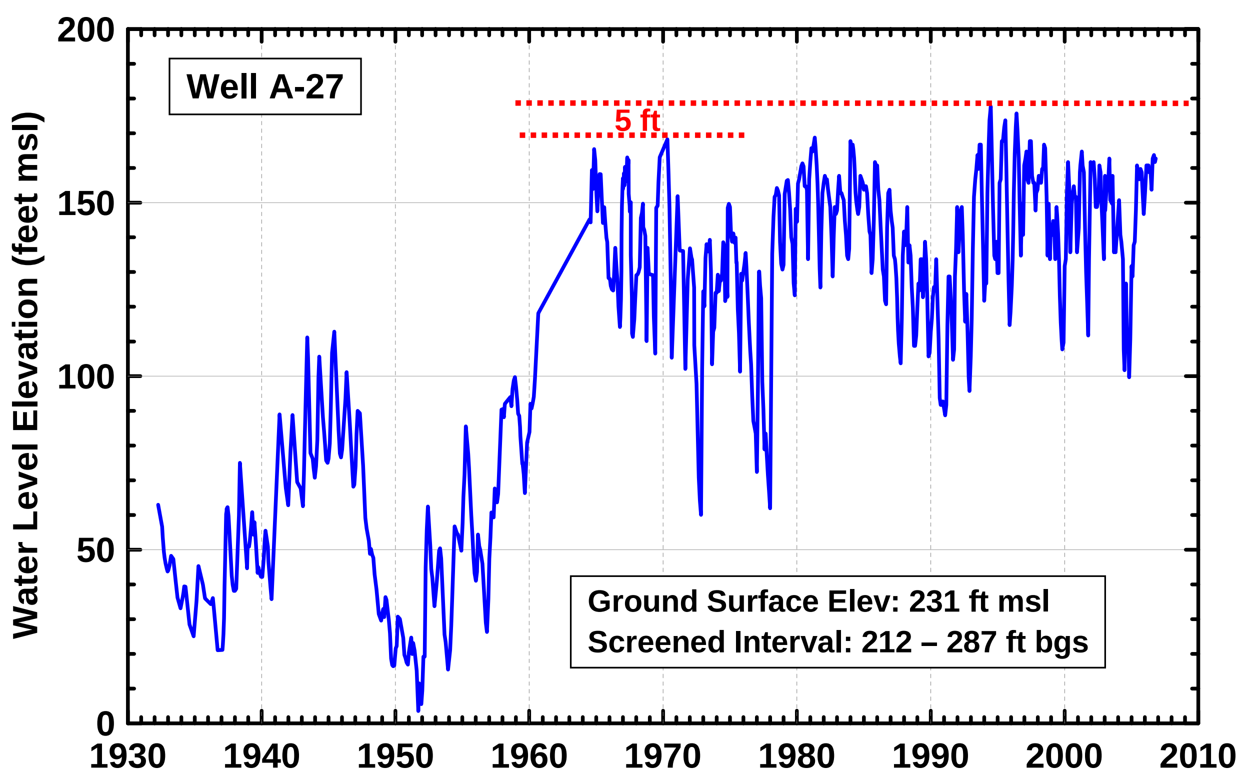


Figure 1-3. Water Level Hydrograph for City of Anaheim Well 27



2. STUDY OBJECTIVES AND WORK PLAN

Objectives of this study were three-fold:

1. Reassess and recommend modifications as necessary to staff's traditional method for calculating the annual storage change and the accumulated overdraft.

2. Develop a technically-sound full basin water level condition that takes into account current basin management practices. This new full condition would replace 1969 and become the new full benchmark used to calculate the accumulated overdraft or available storage in current and upcoming years.

3. Determine an appropriate basin storage operating range and management goal for long-term basin management purposes.

The District Board of Directors approved staff's work plan in April 2006, and work commenced shortly thereafter. All work was completed by the District's Hydrogeology Department, with oversight, direction, and review provided by District management. At the request of the Board, monthly project updates were given at the Water Issues Committee meetings as well as the monthly groundwater producers meetings to facilitate the producers' involvement in the process.

The scope of work laid out in the work plan was generally followed. Initially, it was considered that conducting basin model simulations may be beneficial in validating project results. However, after making significant progress in developing a new storage change methodology and new full basin benchmark, it became evident that it was more appropriate to use aquifer parameters and specific knowledge gained from development of the basin model rather than running new model simulations per se. As such, findings enumerated in this report were based on actual water levels observed in the field coupled with a methodology based on aquifer structure and hydraulic parameters defined during development of the basin model.

3. STORAGE CHANGE CALCULATION METHODOLOGY

In this section, the District's traditional storage change calculation is described along with its inherent limitations, followed by a discussion of the development of a new storage change calculation approach and comparison with the traditional method. But first, a conceptual explanation of aquifer storage is explained below.

3.1 Aquifer Storage Concept

Aquifers not only transmit groundwater but also provide storage volume, sometimes being referred to as "underground reservoirs." However, unlike surface water reservoirs, approximately 70 to 80 percent of the aquifer's volume is occupied by the porous medium, typically consisting of various gradations of sand and gravel as well as silts and clays. This leaves only 20 to 30 percent of the aquifer's total volume remaining as void space that groundwater can occupy. This percentage of void or pore space is referred to as *porosity*.

Over large areas and depths, the void space within aquifers can occupy huge amounts of water. Within the Orange County groundwater basin, which spans over 300 square miles and is over 2,000 feet deep in some areas, District staff have estimated that approximately 66 million acre-feet of water lies in storage. Unfortunately, the vast majority of this water cannot be feasibly drained from the basin without incurring detrimental impacts.

Excessive long-term pumping of basin aquifers without continual replenishment would lead to a lowering of water levels and a reduction in pore pressure, which would lead to seawater intrusion and irreversible compaction of the aquifer, resulting in subsidence of the land surface. The recommended "drainable" storage volume of the basin (without requiring concurrent replenishment) is 500,000 af acre-feet as discussed in Section 6.

The parameter used to define the storage capacity of an aquifer is known as the *storage coefficient (S)*. Unlike the porosity which is a measure of the entire void space regardless of whether or not it contains water, the storage coefficient is a measure of how much water can effectively be drained or squeezed out of the saturated pore space. The storage coefficient is defined as the volume of water yielded per unit horizontal area and per unit drop of water table (unconfined aquifers) or piezometric surface (confined aquifers).

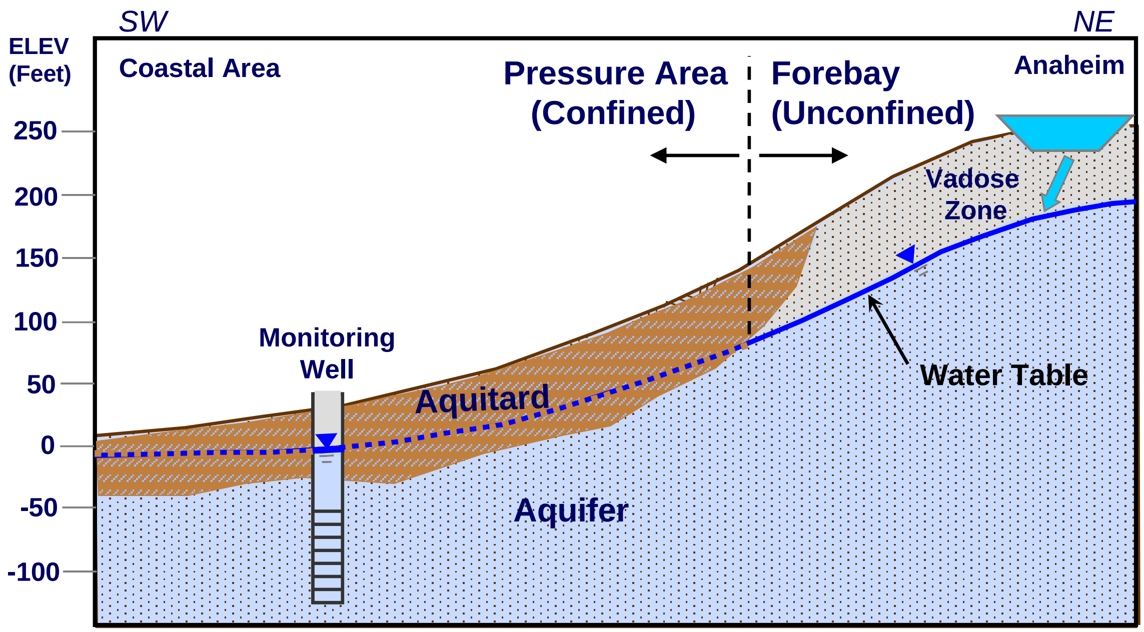
3.2 Confined and Unconfined Aquifers

A confined aquifer is an aquifer that is confined between two aquitards, which are typically clay or silt layers with low permeability. The water in a confined aquifer cannot freely rise above the overlying clay layer and is under confining pressure. When a well is drilled through the overlying clay layer down into the aquifer, the pressure in the confined aquifer causes the water to rise inside the well (see Figure 3-1) to a level higher than the overlying aquitard. Therefore, water levels measured in wells within confined aquifers – referred to as piezometric levels – may rise and fall but the confined aquifer remains saturated. In a confined aquifer, water is added to or removed from storage primarily through the rearrangement of the unconsolidated sediments via compression or decompression; the compressibility of water contributes significantly less to the storage process. A relatively large piezometric level change in a confined aquifer represents very little change in storage within that aquifer. Storage coefficients for a confined aquifer typically range from 0.01 to as low as 0.00005.

An unconfined aquifer is an aquifer in which the water table forms the upper boundary and there is no confining layer above it (see Figure 3-1). That is, the water table can freely rise or fall. Pore space is either filled or drained when the water table rises or falls. Therefore, a unit rise or decline in the water table in an unconfined aquifer represents a relatively large storage volume. For an equivalent water level rise, an unconfined aquifer would exhibit at least 100 times greater storage increase than a confined aquifer. Storage coefficients for unconfined aquifers typically range from 0.01 to 0.3, also referred to as *specific yield*.

In the Orange County groundwater basin, the Shallow aquifer is confined in the coastal and mid-basin areas, commonly referred to as the Pressure Area. The overlying aquitard in the Pressure area thins further inland until it is generally gone. This inland area is referred to as the Forebay area. Since few continuous aquitards exist between the water table and ground surface, it is the "intake" area of the basin where surface water can percolate down to the water table and recharge the aquifers (see Figure 3-1).

Figure 3-1. Forebay and Pressure Area Schematic Profile



3.3 Traditional Storage Change Calculation Method

<u>Water Level Change Method</u>

Traditionally, the storage change calculation was based solely on the water level changes occurring in the Principal aquifer, which is the main production zone in the basin from which approximately 90 percent of basin pumping occurs. Dating back to the 1940s, District staff have prepared a November groundwater contour map of Principal aquifer water levels. By comparing the November contour map to that of the previous year, the annual water level change was then determined. The water level change was then multiplied by a set of storage coefficient values and by the area of the basin to obtain the resulting groundwater storage change for that year. Then, the annual storage change was added to the accumulated overdraft from the previous year to obtain the current accumulated overdraft.

Over the years, the overall approach has remained relatively the same, but several refinements were made along the way. In the 1970s, a FORTRAN computer program was developed, referred to as the "Randall Model," which partially automated the storage change calculation by subdividing the basin into quarter-mile grid cells. The Randall Model computed the storage change calculation grid cell by grid cell. Although this process was somewhat automated, the water level maps had to be manually interpolated to obtain the average water level change for each quarter-mile grid cell. The storage coefficient values for each quarter-mile grid cell were referred to as "Randall" coefficients and are shown in Appendix 1. No documentation exists as to how these storage coefficient values were developed, but they were likely based on review of old well logs throughout the basin.

In the early 1990s, with improvements in computer hardware and software, District staff were able to further automate the traditional storage change calculation by using geographical information system (GIS) software to subdivide the basin into smaller, more refined grid cells. By digitizing the hand-drawn water level contour maps into the computer, the water level change at each refined grid cell could be computed without any manual interpolation. However, the overall approach remained the same and still used the same Randall storage coefficient values.

Over the last two years, an additional refinement included preparing an end-of-June water level contour map in addition to the annual November contour map. Although the November maps provide a good midpoint between the summer-high and winter-low water level conditions, the June maps coincided better with the District's water year and fiscal year (July 1 through June 30) for the annual storage change calculation.

Water Budget Method

For the past 10 to 15 years, the annual storage change calculated using the traditional water level method has been checked using a water budget method (inflows minus outflows equal the change in storage). Therefore, the water budget method uses measured groundwater production and recharge data along with a rainfall-based estimate of incidental recharge (unmeasured recharge less underflow to LA County).

The water budget method provides a good check of the storage change estimate from the water level method but is based on an assumed (unmeasured) amount of incidental recharge. In most years, the two methods agree rather closely, and the storage change value from the water level method is generally used. The incidental recharge is then adjusted in the water budget method to exactly match the chosen storage change.

Limitations of the Traditional Storage Change Method

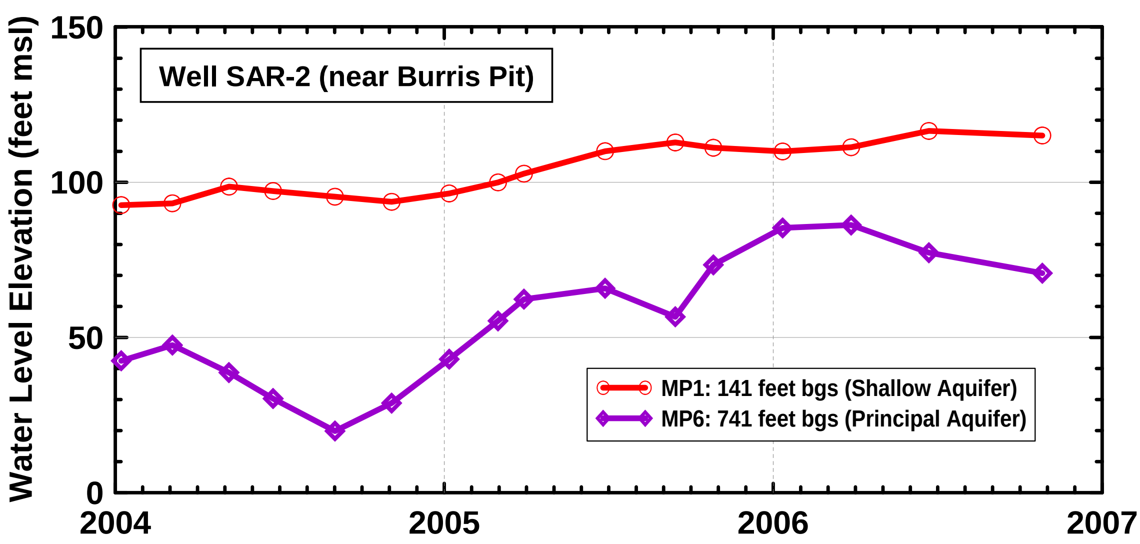
Although the traditional water level and water budget methods yield similar storage change results in most years, there are some anomalous years in which the two estimates are significantly different. In such years, typically very wet or very dry years, professional judgment must be exercised in determining the official change in storage. This can introduce significant uncertainty into the annual storage change estimate for those years, causing a cumulative effect after several years, which is why the current accumulated overdraft cannot be rectified back to 1969 as discussed in Section 1.

The biggest limitation of the traditional method is that it only uses the water level change in the Principal aquifer. Although most groundwater production is from the Principal aquifer, most of the storage change occurs in the Shallow aquifer where it is unconfined in the Forebay area of the basin. Where the Shallow aquifer is unconfined, large storage changes can occur due to the rising or falling of the water table which respectively fills or drains empty pore space, as was discussed in Section 3.2.

The Randall storage coefficients used in the traditional method are consistent with those of an unconfined aquifer in the Forebay area and thus are considered as being representative of the Shallow aquifer. Therefore, the traditional method uses Principal aquifer water levels as a surrogate for the Shallow aquifer, assuming that these two aquifers behave identically in the Forebay area. This is largely true in the Anaheim Lake area near the District's facilities, but in other portions of the Forebay, the Shallow and Principal aquifers often behave differently from one another, as shown in Figure 3-2. This indicates that these two aquifers are partially hydraulically separated by aquitards in portions of the Forebay and behave differently rather than as a single unconfined aquifer as the traditional method had assumed.

It should be pointed out that in earlier years, depth-specific water level data such as that presented in Figure 3-2 was simply not available to discern hydraulic differences between various aquifer zones, and in some areas of the Forebay, there are no noticeable vertical hydraulic differences. It has only been in the last few years through the use of the District's monitoring well network and development of the basin model that a better understanding of the basin has been gained.

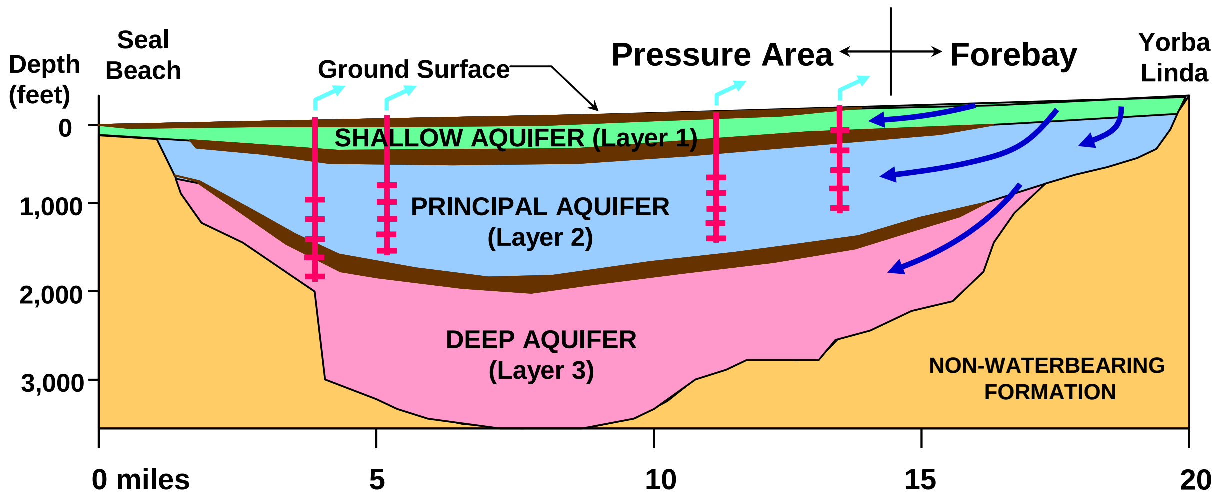
Figure 3-2. Water Level Hydrograph for OCWD Monitoring Well SAR-2



3.4 New Three-Layer Storage Change Approach

The new three-layer storage change approach uses all three aquifer systems of the basin: the Shallow, Principal, and Deep aquifer systems (see Figure 3-3). The Shallow aquifer generally ranges no deeper than approximately 250 feet below ground surface and overlies the Principal aquifer, which is generally over 1,000 feet thick throughout much of the basin and supports over 90 percent of basin pumping. The Deep aquifer contains colored water in the coastal area and is more than 2,000 feet deep throughout much of the basin. These three aquifer systems, from shallow to deep, are also referred to as aquifer layers 1, 2, and 3.

Figure 3-3. Schematic Cross-Section of the Basin Showing Three Aquifer Layers



<u>Methodology</u>

The new three-layer storage change approach is based largely on the aquifer configuration, structure, and storage coefficient parameter values defined during development of the basin model. Unlike the traditional method, all three of the basin's aquifer systems are included in this new methodology. Furthermore, the storage coefficient values used in this new method are specific to each aquifer layer and were refined during dynamic or transient calibration of the basin model until the resulting model-generated water levels achieved a close match with observed water level data throughout the basin.

The basic formula used to calculate the change in storage is very similar to the traditional method, but now must be carried out for each of the three aquifer layers. The storage change equation is defined as

Storage Change = (Water Level Change) x (storage coefficient) x (horizontal area)

The storage change for each of the three aquifer layers is thereby calculated and the results of all three summed to get the total storage change in the basin.

Figure 3-4 shows a schematic cross-section illustrating the three aquifer layers of the basin and how they differ in terms of their respective storage coefficient (S) values. Whereas the traditional method had presumed that the Forebay area behaved entirely as one large unconfined aquifer without any intervening clay layers, our current understanding of the basin is that only the Shallow aquifer in the Forebay area is truly unconfined. As was discussed in Sections 3.1 and 3.2, the majority of the storage change in the basin occurs specifically in the Shallow aquifer within the Forebay area where the rising or falling unconfined water table respectively fills or drains empty pore space. Shallow aquifer storage coefficient values in the Forebay area are approximately 0.1, but in some specific Forebay locations can be as high as 0.25, which is approximately equivalent to the porosity of the sediments at the water table/vadose zone interface.

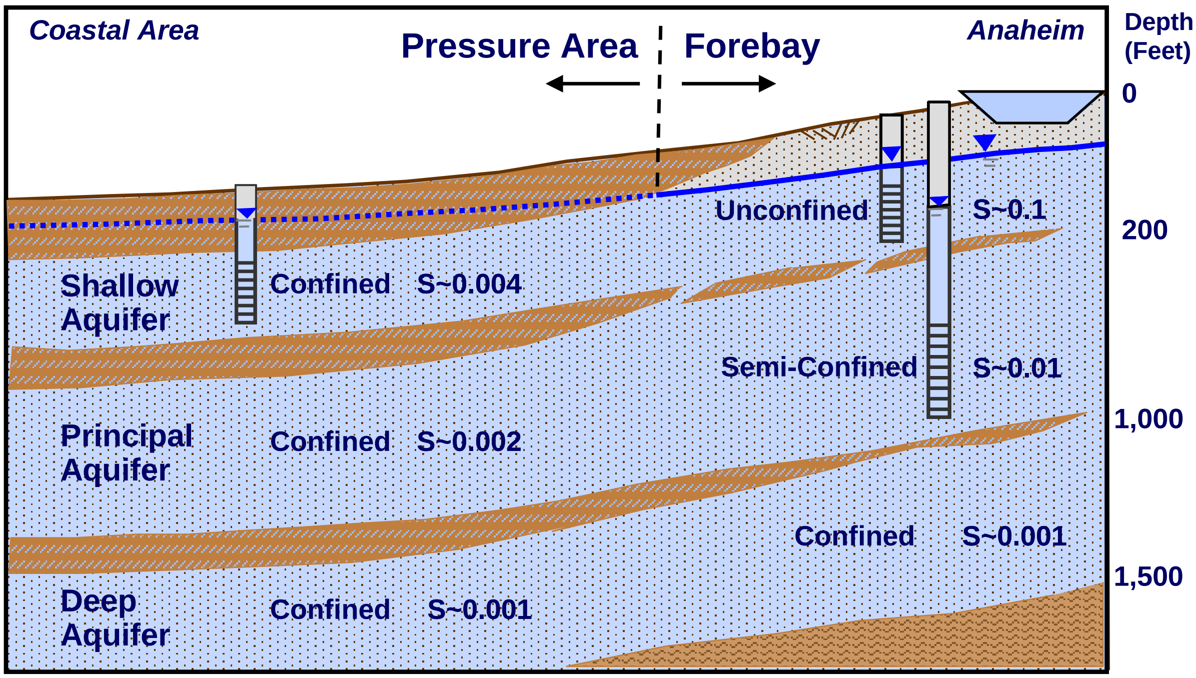
Figure 3-4 illustrates how the Shallow aquifer is confined in the Pressure area of the basin. By definition, the Pressure area ends where the water level drops below the elevation of the overlying aquitard and/or where the aquitard no longer exists. In the Pressure area, the Shallow aquifer storage coefficient values are approximately 0.004, or approximately 25 times smaller than in the unconfined Forebay area. This means that for a given water level change in the Pressure area, the resulting change in storage would be 25 times less than for that same water level change observed in the unconfined Forebay area.

As shown in Figure 3-4, the Principal aquifer is largely separated from the overlying Shallow aquifer by an extensive aquitard in the coastal and mid-basin areas. In the inland Forebay area, this intervening aquitard becomes intermittent but does not vanish completely, causing some hydraulic separation from the Shallow aquifer while still allowing large amounts of water to migrate downward into the Principal aquifer. As schematically shown in Figure 3-4, Principal aquifer water levels frequently differ from those in the Shallow aquifer due to the hydraulic separation, as was also shown in Figure 3-2 for multi-depth monitoring well SAR-2 near Burris Basin, where observed water levels in the Principal aquifer are noticeably lower than in the Shallow aquifer. The Principal aquifer is thus considered to be semi-confined in the Forebay area, with storage coefficient values of approximately 0.01, which is at least 10 times less than in the unconfined Shallow aquifer.

The Deep aquifer is generally confined throughout the entire basin and is separated from the overlying Principal aquifer by an extensive aquitard that thins somewhat in the Forebay area but remains laterally extensive. Therefore, since water level changes in the Deep aquifer represent pressure responses and thus do not involve filling or draining of pore space, storage coefficient values are typically small at approximately 0.001 throughout the entire basin.

The storage coefficient values shown in Figure 3-4 and discussed above are typical values for each of the three aquifer layers. The actual storage coefficients used in the storage change calculation not only vary for each aquifer layer but also vary spatially across the basin in both the Pressure and Forebay areas. From the basin model calibration, the different storage coefficient values within each aquifer layer are subdivided into detailed zones. For reference, these zonal storage coefficient maps are included in Appendix 2. These storage coefficient values in the Forebay area of the Shallow aquifer are generally consistent with the Randall coefficients traditionally used.

Figure 3-4. Schematic cross-section showing storage coefficients (S) values



The other component of the storage change formula not yet discussed is the water level change. To obtain the water level change involves constructing water level contour maps for each of the three aquifer layers, both for the previous and current year.

Preparation of the water level contour maps for each aquifer layer requires a considerable level of interpretation of the actual data points as well as interpolation between data points. The reported water level data is not always 100 percent accurate and must be reviewed on a well-by-well basis as the contour map is being constructed. Reasons for disqualifying or adjusting observed water level data during the contouring process may include:

- A static water level from a production well may have been measured only minutes after shutting off the well pump;
- Erroneous water level field measurement (e.g., bad equipment);

- Water level measurement taken too early or too late (for the June and November contour maps, attempt to measure all water levels within a two-week window);
- Wells are screened at different depths and some wells are screened across multiple aquifers such that water level data not entirely representative of any one aquifer layer being contoured.

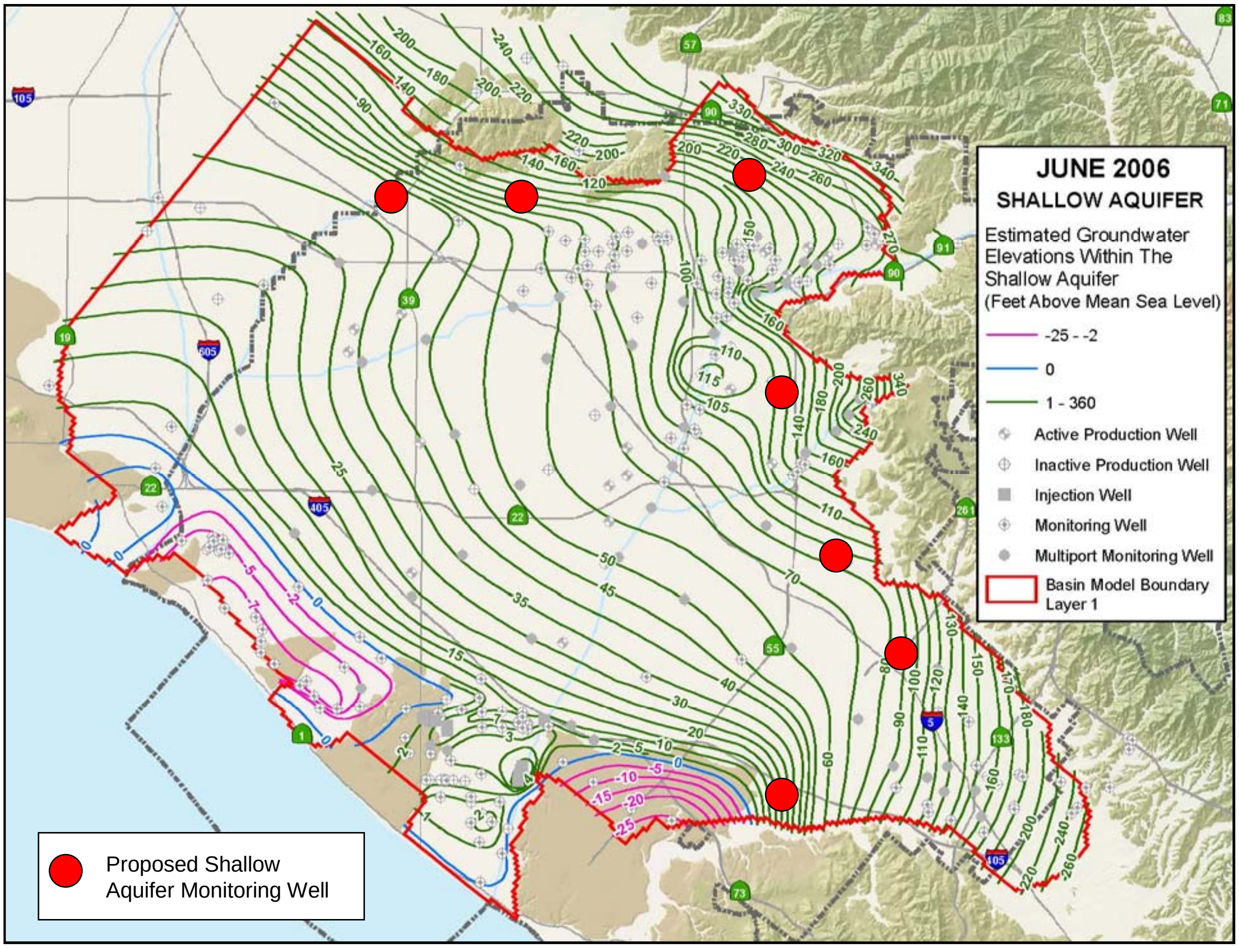
In addition to the above reasons for screening the observed water level data points, extreme care and consistency must be exercised from one year to the next when contouring and interpolating between data points, especially in sparse areas lacking sufficient data to definitively define the shape of the contours. Barring any new wells or data, water levels should be similarly interpreted in these areas from year to year so that false storage changes are not artificially created. Knowledge of the aquifer's characteristics, presence of geologic faults, regional flow regime, and vertical relationship with the other aquifers have proven useful in determining the contour patterns in a given area.

Of the three aquifer layers, the Principal aquifer has the best water level data coverage thanks to more than 200 large system production wells monitored by each respective groundwater producer, as well as District monitoring wells throughout the basin. Historically, this predominance of available water level data for the Principal aquifer and lack thereof for the Shallow and Deep aquifers is a likely reason that the traditional storage change method only considered the water level change in the Principal aquifer.

Much more water level data exists today for the Shallow aquifer than in the past, primarily due to the District's network of monitoring wells, many of which monitor multiple aquifer zones at one well site, helping to decipher the vertical relationship between the Shallow and deeper aquifers and their degree of hydraulic connection. Since the majority of the storage change in the basin occurs in the unconfined portion of the Shallow aquifer within the Forebay area, the constructed water level contours are of utmost importance in those inland areas. Unfortunately, data is sparse in a few of these outlying areas of the basin. Therefore, to increase the accuracy of the Shallow aquifer contour maps and thus the accuracy of the storage calculation, approximately six new shallow monitoring wells are recommended to fill data gaps in the areas of Buena Park, Costa Mesa, Fullerton, Orange, Irvine, and Yorba Linda. Figure 3-5 shows the approximate desired locations for these six proposed wells.

Figure 3-5 also shows the water level contours for the Shallow aquifer for June 2006. Just as for the other two aquifer layers, these contours where hand drawn based on observed water level data from wells screened in the Shallow aquifer (shown in light gray in Figure 3-5). The hand-drawn contours were then digitized into the computer for calculation purposes. Note that the contours were drawn out to the boundary of the basin model layer 1 which extends into LA County, but during the storage calculation process the LA County portion is excluded.

Figure 3-5. June 2006 Shallow Aquifer Groundwater Elevations and Proposed Wells



<u>GIS Application for Three-Layer Storage Change Calculation</u>

A new GIS application was developed and programmed to automate the new three-layer storage change calculation utilizing the digitized water level contour maps for each aquifer layer as well as the storage coefficient values from the basin model.

The new GIS application consists of a series of steps governed by programs written in the AML scripting language within the Arc/Info environment. A detailed description of these steps, along with all the AML codes written for this application, is included in Appendix 4.

The digitized water level contours are converted into GIS compatible files (grids) at the same refined resolution as the basin model input parameters, essentially subdividing the entire basin into 500-foot square grid cells. The GIS application then carries out the storage change formula one grid cell at a time for each aquifer layer, calculating the water level change between the two years in question and multiplying by the storage coefficient and horizontal area of the grid cell. Then, the storage change of all grid cells is summed for each layer. The total change in storage is then the corresponding sum of all three aquifer layers.

When calculating the storage change at each grid cell, the GIS application must check to determine if the conditions are confined or unconfined. Generally, the Principal and Deep aquifers are typically confined, but the Shallow aquifer is confined in the Pressure area and unconfined in the Forebay area, with the dividing line between these two areas being dependent upon the actual water level elevations at that time. If the water level is above the top of the aquifer layer (per the basin model layer elevations), then a confined storage coefficient is used for that grid cell; otherwise, if the water level is below the top of that aquifer layer, then a larger unconfined storage coefficient is used. To further complicate matters, the water level change in question from Year 1 to Year 2 may cause a given grid cell in the Shallow aquifer to switch from confined under Year 1 conditions to unconfined under the Year 2 conditions, or vice versa. The GIS application handles this type of condition by subdividing the water level change into two components: a confined portion and an unconfined portion. This is illustrated in the sketch and “pseudo-code” algorithm that was written for this application prior to formal programming of the GIS application (Appendix 4).

The new GIS application for the three-layer storage change calculation was thoroughly tested and necessary refinements were made to the AML codes. Water level change and storage change calculations were hand checked and verified at individual grid cells having both confined and unconfined conditions. Also, the storage change results for each aquifer layer were verified to be identical in magnitude but opposite in sign if switching the order of what is predefined as Year 1 or Year 2. For example, if the storage change from Year 1 to Year 2 was calculated to be 10,000 af, then the storage change from Year 2 to Year 1 calculates to be exactly -10,000 af.

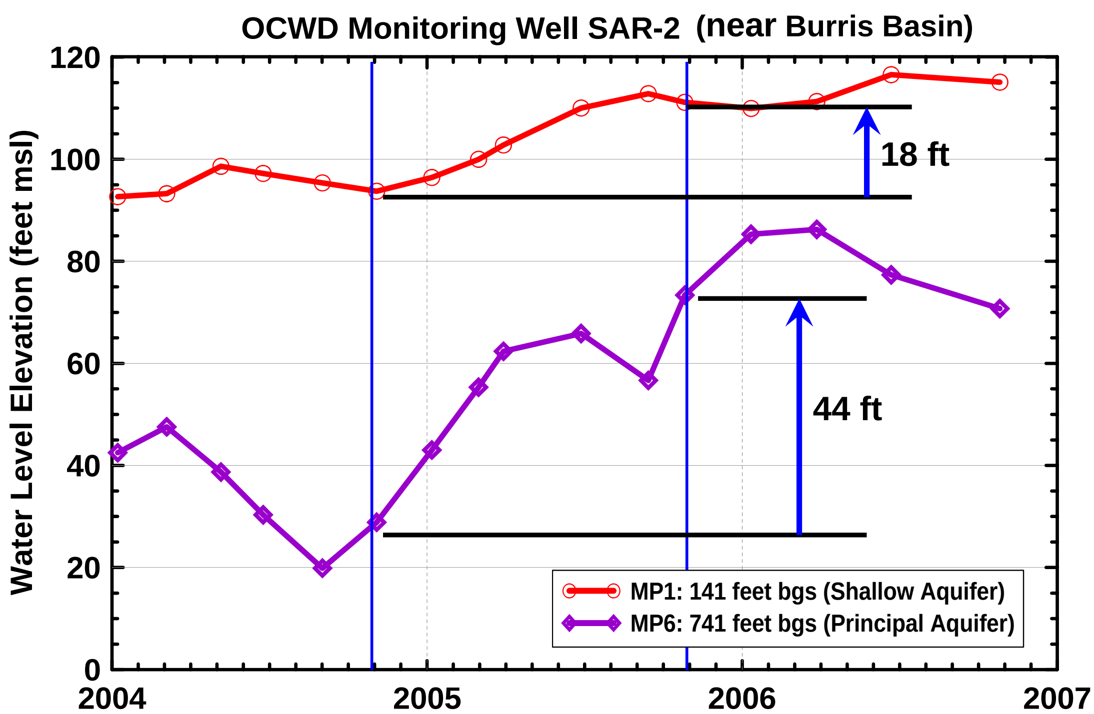
Testing the Three-Layer Method vs. the Traditional Method

Test Case 1 compared the new three-layer storage change calculation to the traditional method using the annual period November 2004 to November 2005. This first test case represented an extremely wet year with record-setting rainfall and a huge storage change of +187,000 af using the traditional method with the existing November contour maps of the Principal aquifer. Using the new three-layer approach led to a storage change of +147,000 af for the same period.

The rather large discrepancy of 40,000 af in Test Case 1 is primarily due to the inaccuracy of the traditional method presumption that Principal aquifer water levels behave identically to Shallow aquifer water levels in the Forebay area. As was shown in previous sections, this is not always the case and was especially not the case during 2004-05 when the Principal aquifer rose much more than the Shallow aquifer in most Forebay locations.

Figure 3-6 shows water levels for multi-depth monitoring well SAR-2 near Burris Basin in the Anaheim Forebay area. Notice that the water level change from November 2004 to November 2005 in the Principal aquifer zone was more than double that for the Shallow aquifer zone at that location. Since this was the case throughout much of the Forebay area, the traditional method overestimated the storage change by using Principal aquifer water levels as a surrogate for the Shallow aquifer.

Figure 3-6. November 2004-05 Water Level Change at Monitoring Well SAR-2

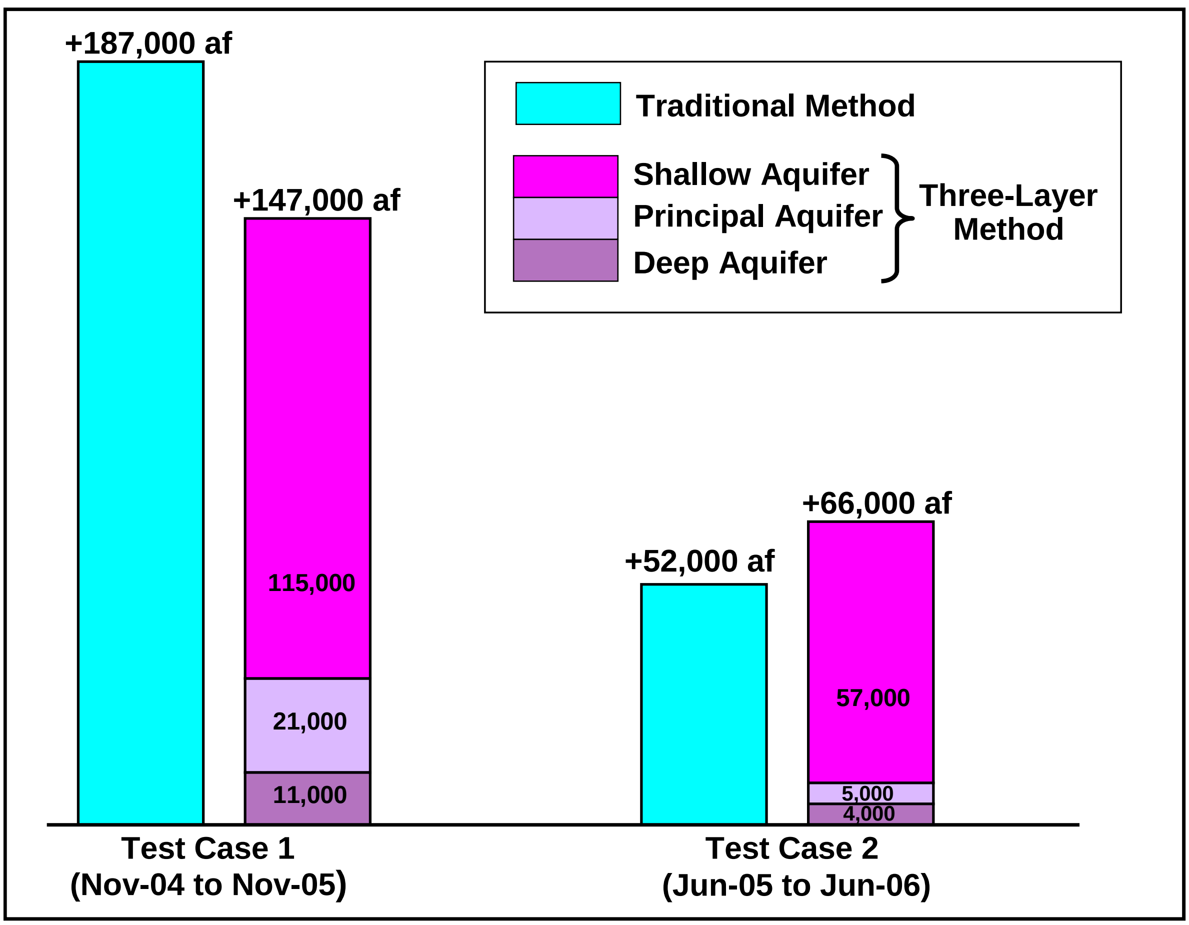


Test Case 2 compared the new three-layer method to the traditional method for the most recent water year, June 2005 through June 2006. This water year was chosen because it not only represented the most recent conditions but it was also an approximately average rainfall year in contrast to the extremely wet year in Test Case 1. As was mentioned in previous sections, care was exercised to maintain consistency of how the water level data was interpreted and hand contoured for both of these years to prevent any false or "manufactured" water level changes between the two conditions.

For Test Case 2, the traditional method yielded a storage change of +52,000 af, whereas the new three-layer method yielded a slightly higher storage change of +66,000 af. The two methods yielded much closer results for this average hydrology year, indicating that the traditional method is at least "in the ballpark" during more typical years when water levels are not as drastically rising or falling. In these closer-to-average years, the traditional method presumption that Principal aquifer water levels behave similarly to the Shallow aquifer is not grossly inaccurate. However, since the new three-layer approach is more comprehensive and utilizes all three aquifer layers, it represents a technical improvement upon the traditional method and is the preferred approach.

Figure 3-7 summarizes the results from both test cases 1 and 2 and schematically shows the storage change per aquifer layer for the three-layer method. As expected and as was discussed in earlier sections, the majority of the storage change occurred in the Shallow aquifer. The majority of basin pumping (over 200,000 afy) occurs from the Principal aquifer, which is continuously being fed by the Shallow aquifer, which in turn is being fed by the District's recharge activities (typically over 200,000 afy). If basin pumping exceeds total recharge over a given year, then the Principal aquifer draws more water out of the Shallow aquifer than what is coming in from recharge, resulting in an annual storage decrease in the Shallow aquifer. Conversely, if recharge exceeds basin pumping over the course of a year (especially in a wet year), then more recharge is entering the Shallow aquifer than what is flowing down into the Principal aquifer, causing Shallow aquifer water levels to rise and a resulting storage increase.

Figure 3-7. Summary of Traditional vs. Three-Layer Storage Change Results

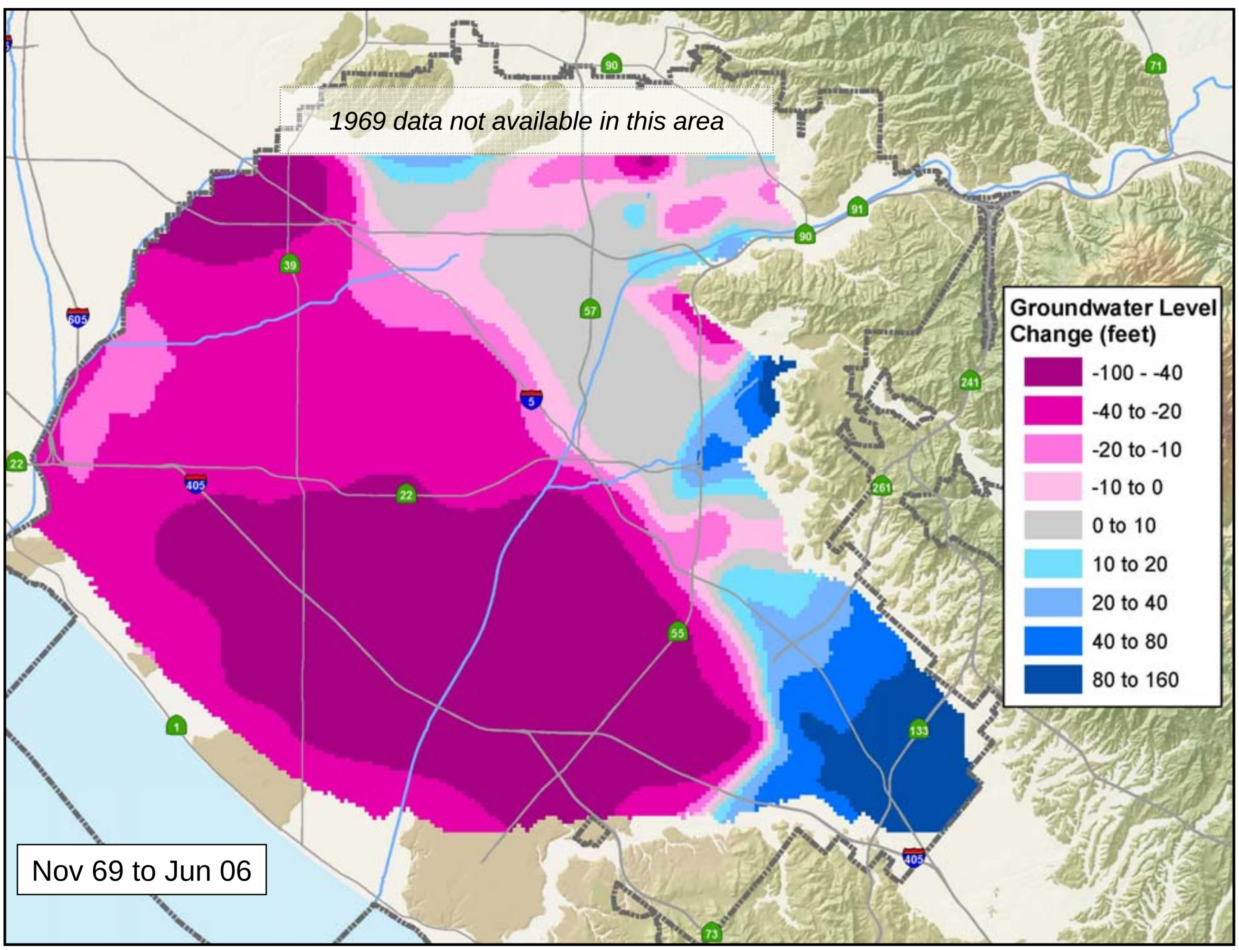


4. NEW FULL BASIN BENCHMARK

Since a new three-layer method was developed and tested for calculating the change in storage, a new full basin benchmark must be defined for all three aquifer layers so that the accumulated overdraft can ultimately be calculated.

In Section 1, it was shown that 1969 water levels no longer represented a full basin given the significantly different pumping and recharge conditions that exist today. In fact comparing the November 1969 water level contour map to the recent June 2006 Principal aquifer contour map shows that in much of the Forebay area, Principal aquifer water levels are already higher in June 2006 than they were in November 1969 when the basin had historically been considered full (see Figure 4-1). The Irvine Forebay area was over 80 feet higher in June 2006 than 1969 due to reduced agricultural pumping over the years. As was discussed in Section 1, because of increased utilization of the groundwater basin, i.e., increased pumping and recharge, higher Forebay water levels can be achieved while coastal water levels remain lower, resulting in a steeper basin gradient.

Figure 4-1. Principal Aquifer Water Level Change: November 1969 to June 2006



4.1 Assumptions and Methodology

A water level contour map representing a reasonable full condition was developed for the Shallow, Principal, and Deep aquifers. The resulting full water levels represent a "snapshot" of a peak high water level condition throughout the basin that could possibly be exceeded but with potentially detrimental impacts.

Defining how high basin water levels can rise before being considered full was largely based on a comprehensive review of relatively recent historical high basin conditions that occurred approximately in 1994 and 2006. The high basin conditions that occurred in 1969 and 1983 were briefly reviewed but were deemed of less direct value since basin pumping and recharge patterns were significantly different then.

Much of the groundwater basin achieved historical highs during 1994, with the coastal area peaking in the winter and the Forebay area in late spring or early summer. A similar lag in the seasonal timing of the coastal and Forebay area water level peak was observed during the recent high condition of 2006. Typically after a very wet winter, surplus storm runoff impounded behind Prado Dam is still being released for OCWD recharge operations well into the summer months, thus increasing Forebay recharge amounts, which in turn raise Forebay water levels at a time when coastal water levels are already beginning to decline in response to summer pumping. However, also during wet years, MWD has surplus water; thus, taking additional imported water in-lieu of groundwater pumping can extend into the summer months, which would prevent or delay coastal water levels from declining. Therefore, for the purposes here of defining a basin-wide full condition, it is assumed that water levels can concurrently peak to a full condition throughout the basin.

The full condition that was developed for all three aquifer layers represents the highest achievable water levels throughout the basin under realistic present-day operating conditions without incurring any regional-scale detrimental impacts. In general, coastal water levels were assumed to be at or very near the 1994 and 2006 winter highs, whereas the Forebay area was assumed to be at or slightly above the 1994 and June 2006 highs. In so doing, the full basin coastal water levels were high enough to be protective against seawater intrusion but not unnecessarily high to where shallow groundwater seepage could become an issue. In the Forebay area, full basin water levels were generally well below ground surface and at or near the bottom of deep recharge basins (as occurred in June 1994). Therefore, in the Forebay area, water levels any higher than this full condition may be physically possible but would likely impact recharge operations and lead to considerable mounding problems.

Other assumptions that define the new full basin condition are enumerated below.

1. Full basin flow patterns (shape of the water level contours) are representative of present-day pumping and recharge conditions (except where specifically noted) and thus are largely based on and consistent with actual water level contour maps constructed for the recent high conditions of January 2006 and June 2006.

2. Water levels in the Irvine Sub-basin were at historical highs during 2006 because of the extremely wet year 2004-05 and reduced Irvine Company agricultural pumping. The new full condition in the Irvine Sub-basin is thus based on this recent high condition, which inherently then excludes the Irvine Desalter Project (IDP). The IDP will significantly lower Irvine area water levels for many years to come, but the regional drawdown and resulting water levels in that area are uncertain and may take several years to stabilize. Previous basin model scenarios including IDP pumping estimated that approximately 50,000 af of storage decline in the Irvine Sub-basin could occur after 20 years of full-scale IDP pumping. With this in mind, the new full condition will not likely be achievable in the Irvine Sub-basin after the IDP goes on-line.

3. Based on the earlier assumption that this new full condition is protective against seawater intrusion, full basin water levels in the MCWD area were based on the historical high of 1994 rather than the somewhat lower water levels during the 2006 high condition. The 1994 water levels in the MCWD area were higher than in 2006 because the MCWD colored water project was not yet active in 1994. Therefore, the new full basin water levels in that immediate area inherently assume no MCWD colored water project (i.e., no pumping from Well MCWD-6) in order to define a condition sufficiently protective against seawater intrusion.

4. Full basin water levels in the immediate area of the Talbert Barrier were adjusted slightly higher than recent high conditions to account for the GWR Phase 1 barrier expansion soon to be on-line. Some of these new injection wells, including the four wells along the Santa Ana River just north of Adams Avenue, are already on-line and thus the observed water level rise due to these wells was used in the full basin condition.

5. Full basin water levels were raised slightly higher than either of the historical highs of 1994 or 2006 in areas where other near-term recharge projects are already planned, including La Jolla Basin and Santiago Creek recharge enhancements. However, especially in the case of Santiago Creek, full basin water levels were kept sufficiently below ground surface and known landfill elevations.

4.2 Shallow Aquifer Full Basin Water Level Map

Full basin water levels for the Shallow aquifer were based largely on the historical high water levels observed in 1994 and 2006. Only wells with a screened interval generally in the range from 100 to 250 feet below ground surface (depending on the specific area) were used to ensure that these wells were representative of the Shallow aquifer. This depth restriction excludes most large system production wells. Therefore, the majority of wells used to construct the Shallow aquifer full basin water level map were District monitoring wells, along with some small system and domestic wells having sufficient water level histories. Fortunately, the majority of the District's monitoring wells were constructed early enough so as to catch the 1994 high-basin condition.

Prior to this study, Shallow aquifer water levels were not regularly contoured, but Shallow aquifer contour maps (basin model layer 1) had been constructed during basin model development and much was learned about the hydraulic characteristics and flow patterns of the Shallow aquifer. Subsequently for testing the new three-layer storage change method described in Section 3, water level contour maps were constructed for all three aquifer layers using observed data for both June 2005 and June 2006. Fortunately, June 2006 also represented a high-basin condition from which to use as a base for making adjustments up to the new full condition.

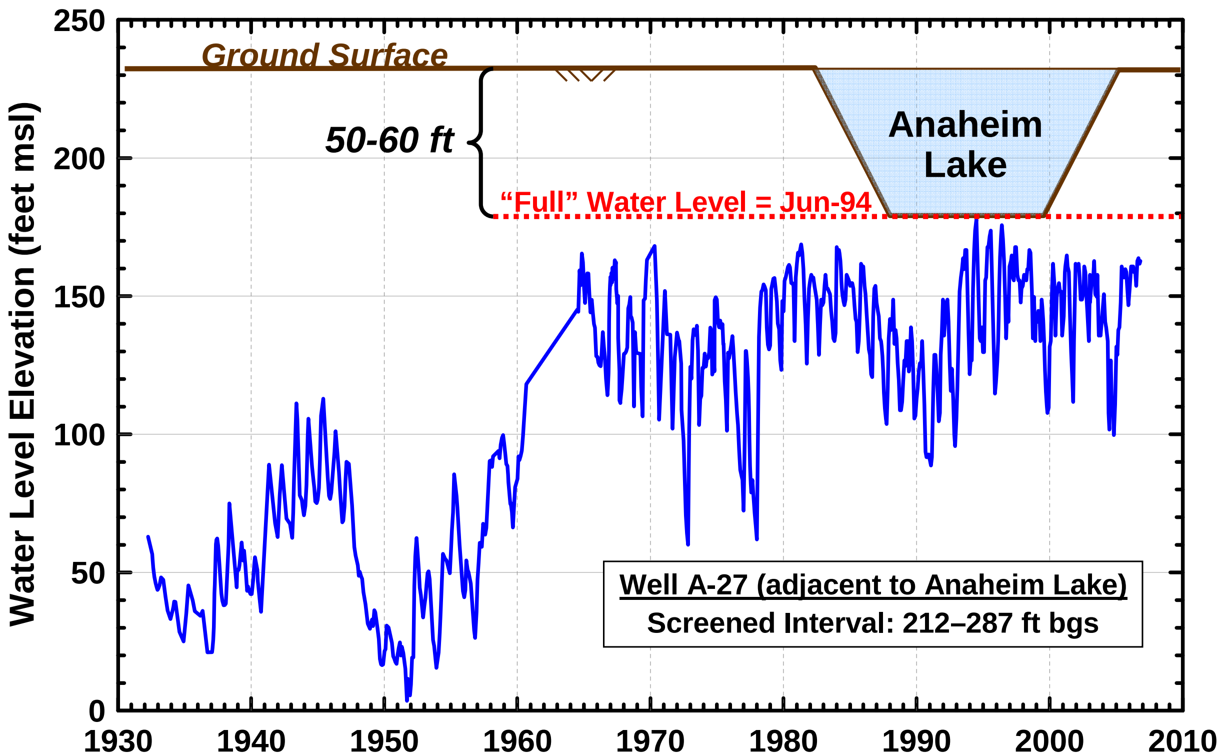
In the coastal and mid-basin areas, high water levels that peaked in January 2006 were generally adhered to and used for the full condition in those areas. This represented a condition high enough to be protective of seawater intrusion, but anything appreciably higher could potentially result in shallow groundwater seepage problems in low-lying areas. In the immediate area surrounding portions of the Talbert Barrier, the observed January 2006 water levels were adjusted upward approximately 5 feet to account for increased injection from new GWRS Phase 1 injection wells. In the area surrounding the GWRS treatment plant site where considerable construction dewatering was occurring during January 2006, full water levels were based on earlier historical highs that were nearly 15 feet higher than January 2006 in this immediate area.

In the Forebay area, full basin water levels were generally set from 0 to 15 feet above the higher of the two historical peaks that occurred in June 1994 and June 2006. The magnitude of the upward adjustment between 0 and 15 feet depended on conditions at each well location and was most significantly influenced by the relative depth of the water table from ground surface. Since relatively little pumping occurs from the Shallow aquifer, the unconfined water table in the Forebay area is largely considered to be a subdued reflection of topography, with the exception of directly beneath recharge basins where the Shallow aquifer water table tends to rise in response to percolation. From analysis of the Forebay historical highs (June 1994 and/or June 2006), Shallow aquifer water levels generally peak at an elevation that corresponds to a depth of approximately 50 to 60 feet below ground surface. Therefore, when setting the full basin water level elevations at various well points and especially in areas where little or no data existed, the 50- to 60-foot depth to water rule of thumb was generally maintained.

Since the majority of the storage change in the basin occurs in the Shallow aquifer within the Forebay area, the full basin water level condition in this area is crucial. A discussion of the full basin Shallow aquifer water level adjustments for specific regions of the Forebay is described below.

At Anaheim Lake and Kraemer Basin, full basin water levels were set at June 1994 observed levels with no upward adjustment since these levels were essentially at or even a couple feet above the deepest portion of Anaheim Lake, which is approximately 50 to 60 feet deep (see Figure 4-2), which is consistent with the depth to water rule of thumb mentioned above. Water levels any higher at this location, if even achievable, would likely impede percolation from these basins and thus would not be desirable.

Figure 4-2. Full Basin Water Level at Anaheim Well 27



At Santiago Pits, full basin water levels were set at the historical high of March 1993 (just slightly higher than June 1994) with no upward adjustment. This same identical high was reached but not exceeded more recently in June 2005 after the extremely wet winter of 2004-05. Having the observed water levels peak at the same exact same level in 1993 and 2005 may likely indicate that this repeatable historical high may represent the highest physically achievable water level for this area.

In the Anaheim/Fullerton area west of the District's spreading grounds, full basin water levels were set 10 to 15 feet higher than the new historical high of June 2006. Water levels in June 2006 exceeded the previous historical high of June 1994 and appear to still be on an upward trend. The upward adjustment of 10 to 15 feet from the June 2006 observed condition once again brought the water table up to approximately 50-60 feet from ground surface.

Along the Santa Ana River downstream of Lincoln Avenue, full basin water levels were set 5 to 10 feet higher than the new historical high of June 2006, which exceeded the previous high of June 1994 in this area as well. The upward adjustment of 5 to 10 feet above the historical high once again brought the full condition up as shallow as 40-50 feet from ground surface, likely being influenced by the recharge from the Santa Ana River and Burris Basin. This full level also corresponds approximately to the bottom elevation of Burris Basin, analogous to the full level adjacent to Anaheim Lake.

In the Irvine Forebay area, full basin water levels were set within 5 feet of the historical high, which either occurred in 1994, 1999, or 2006 depending on the exact location within this general area. Recall from the previous section that this new full condition is prior to full-scale IDP pumping. Although the majority of IDP pumping will be from the Principal aquifer, Shallow aquifer water levels will likely also decline.

Finally, in the mid-basin Pressure area, full condition water levels were modestly adjusted upward 5 to 10 feet from the new historical high of June 2006, which again significantly exceeded the previous high of June 1994. This slight upward adjustment maintains a reasonable gradient from the coast to the upwardly adjusted full water levels in the Anaheim Forebay area.

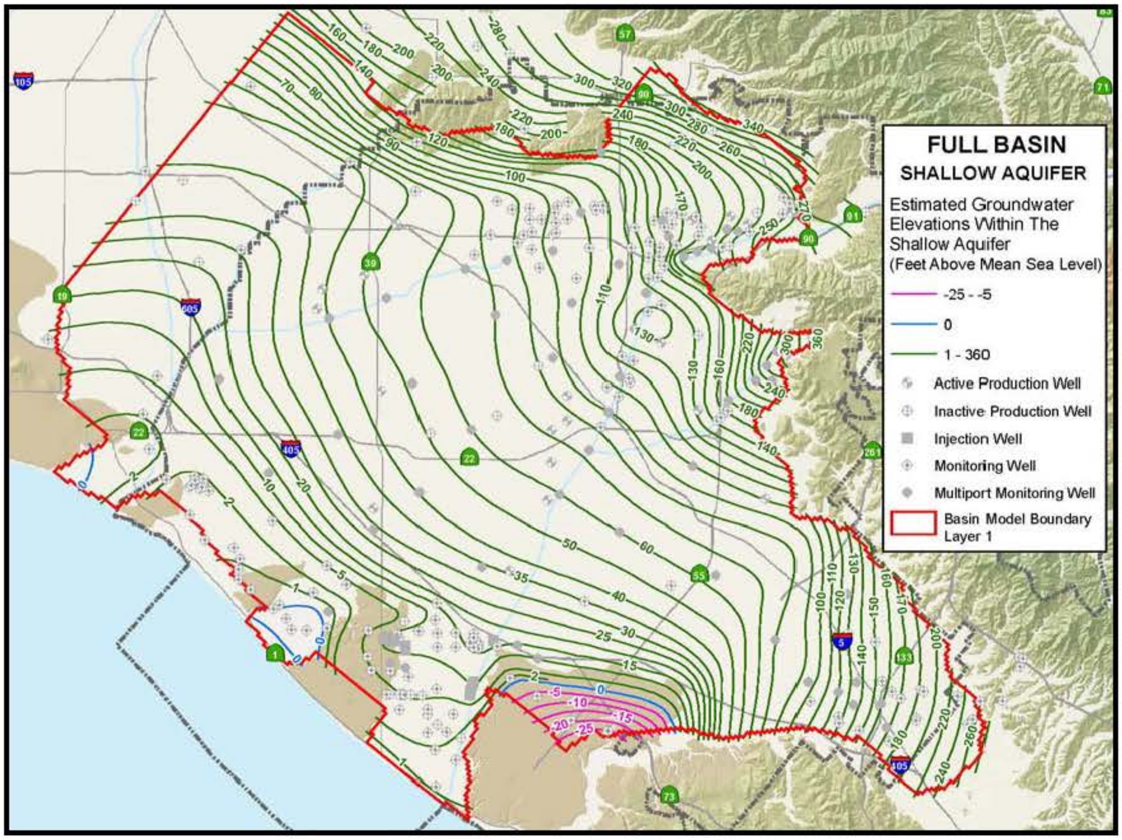
After making all the full condition water level adjustments at monitoring well points in the various areas described, the resulting full water levels were plotted on a map and hand contoured similarly to the observed water levels of June 2006. In fact, the June 2006 contour map was used as a guide or backdrop on the light table while contouring the full condition to ensure consistency, especially in outlying areas lacking data.

Figure 4-3 shows the resulting full water level contour map constructed for the Shallow aquifer. Also shown for reference is the June 2006 Shallow aquifer contour map directly below it. Note the similarity in the shape of the contours between the two maps. The various well points screened in the Shallow aquifer that were used for constructing these contour maps are shown in light gray. The red boundary represents the basin model layer 1 boundary which represents the extent of the Shallow aquifer along the mountain fronts where the aquifer terminates and on the western boundary represents an arbitrary cutoff 5 miles into LA County. Contouring the water levels slightly into LA County adds confidence to the shape of the contours in west Orange County and at least qualitatively indicates the direction of flow across the county line.

Figure 4-4 shows the same two Shallow aquifer water level conditions (Full and June 2006), but in units of depth to water below ground surface rather than elevation. As was discussed above, notice that much of the Forebay area is within the 40 feet below ground surface or greater range since the Shallow aquifer water levels generally follow ground surface topography where the aquifer is unconfined (Forebay), except near recharge facilities where the depth to water is more shallow due to percolation raising the water table.

The depth to water also becomes shallower in the Pressure area of the basin where the Shallow aquifer is confined. However, these “water levels” are actually pressure or piezometric levels since the water is confined or trapped below the overlying aquitard. Water can only rise to this elevation if a well is drilled through the aquitard down into this aquifer or if the aquitard is thin or discontinuous. Notice that there is a large area in Irvine where the piezometric level is actually above ground surface in both the observed June 2006 and Full condition. This area has historically experienced artesian conditions when basin levels are relatively high.

Figure 4-3. Shallow Aquifer Groundwater Contours: Full Basin and June 2006



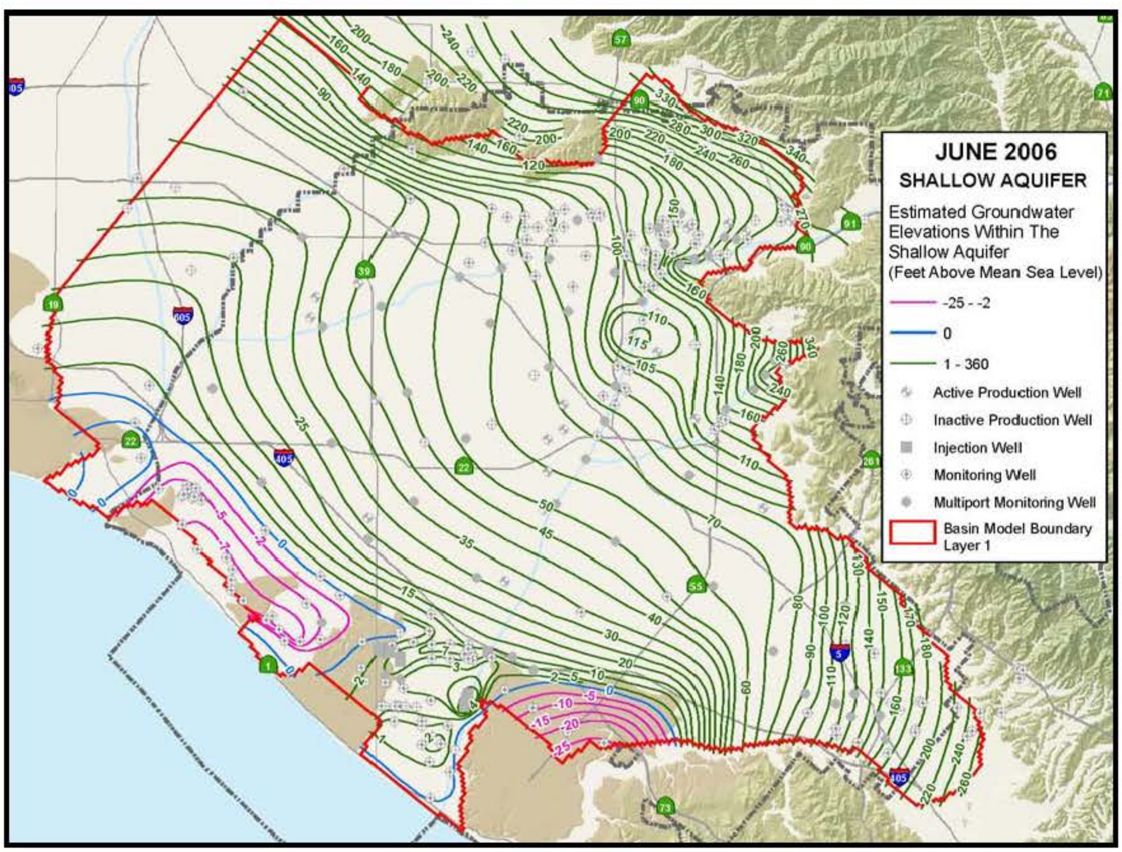
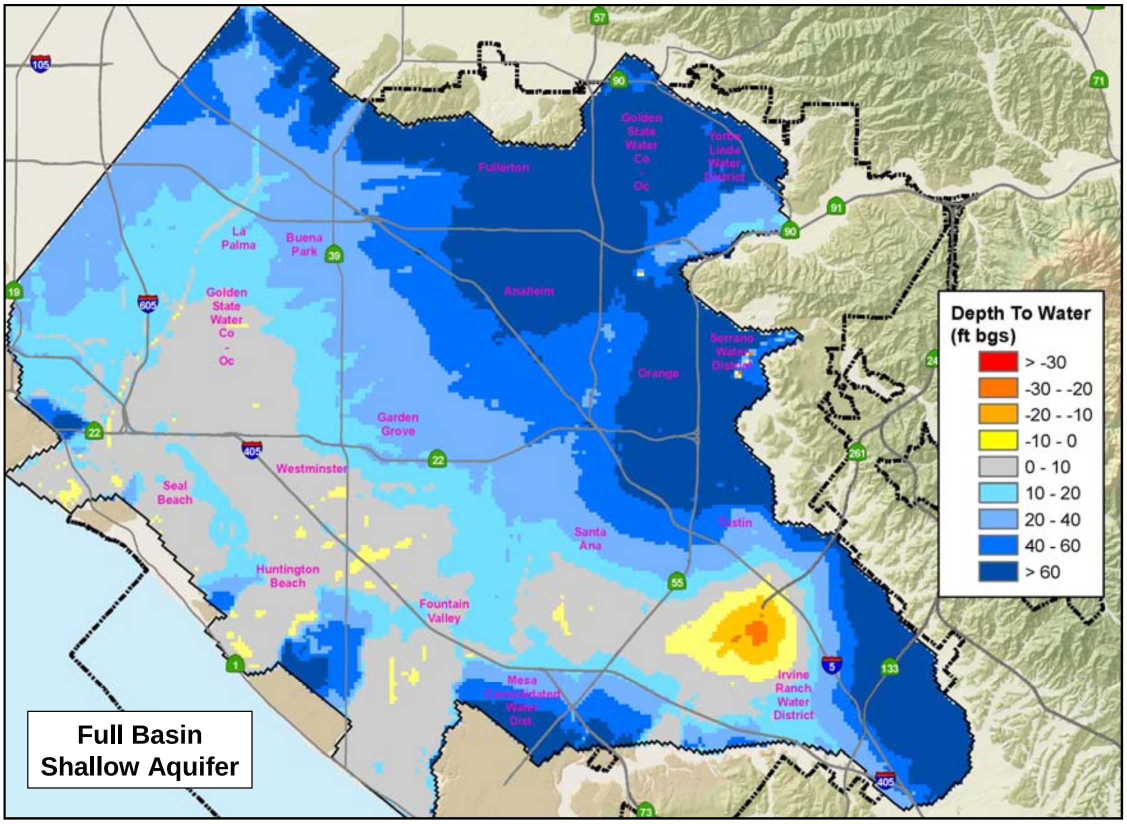
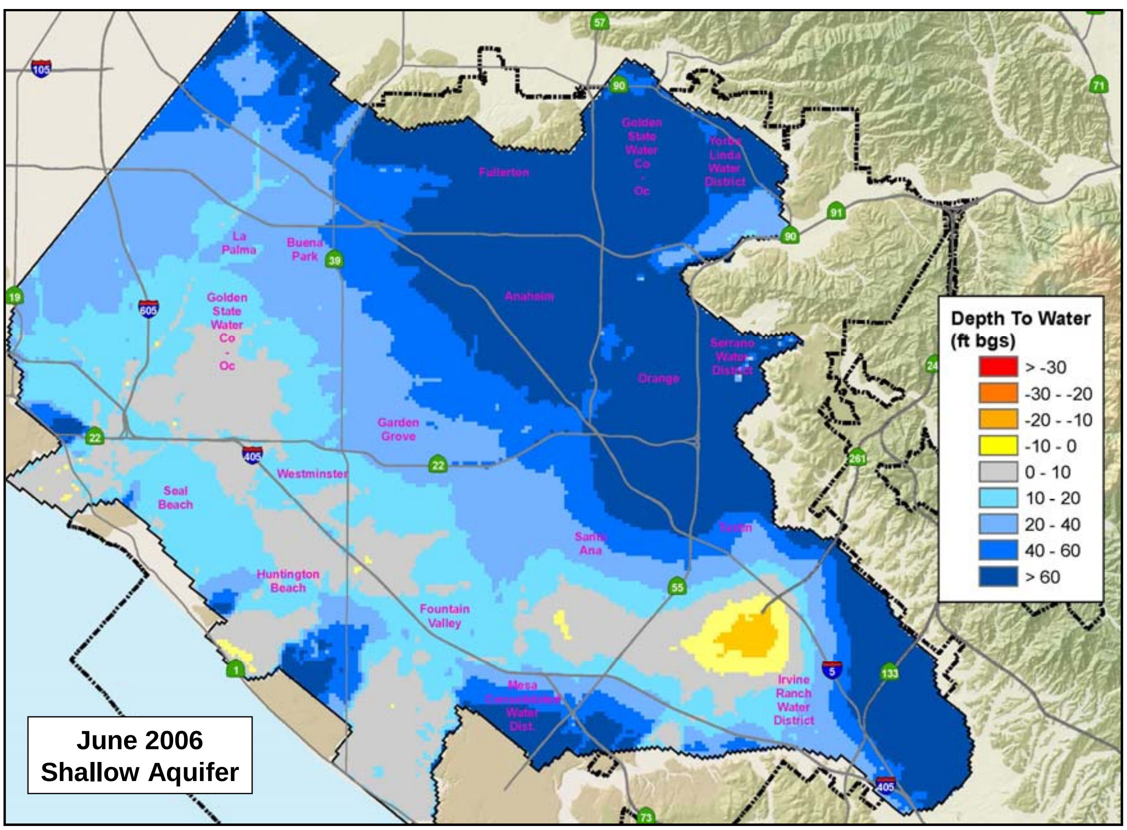


Figure 4-4. Shallow Aquifer Depth to Water: Full Basin and June 2006





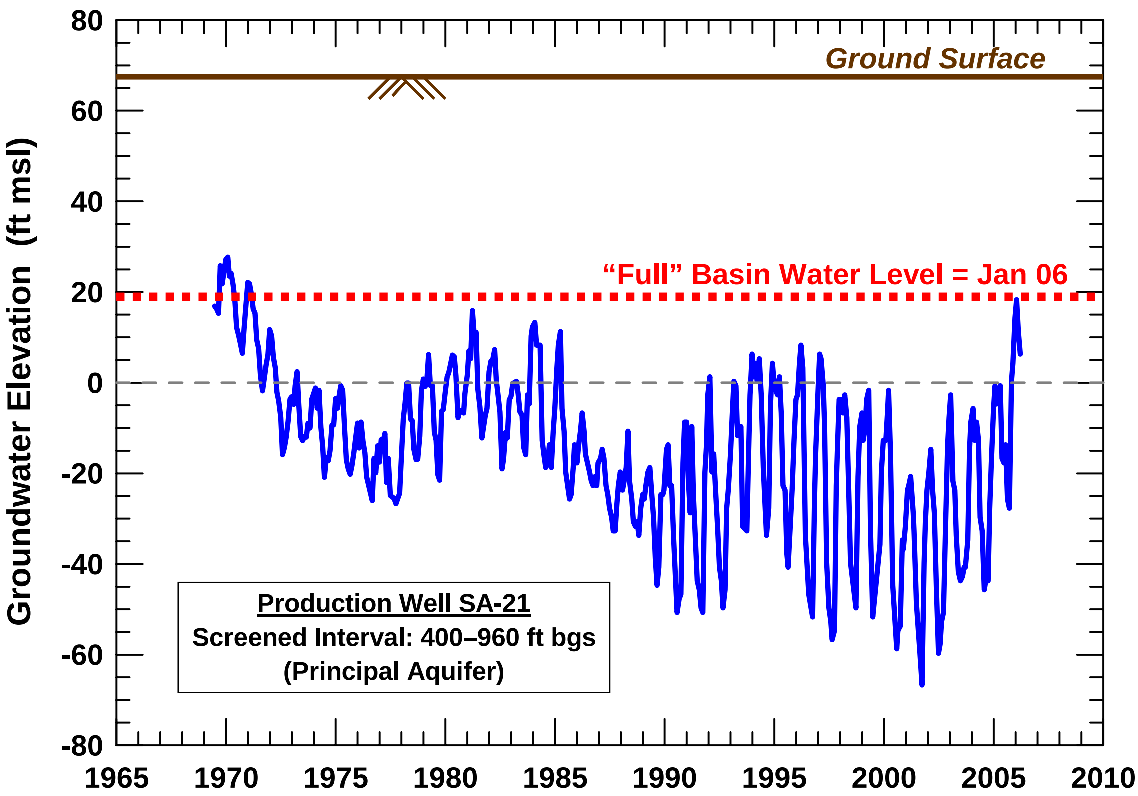
4.3 Principal Aquifer Full Basin Water Level Map

As with the Shallow aquifer, full basin water levels for the Principal aquifer were also based on the historical high water levels observed in 1994 and 2006. Wells with a screened interval generally within a range between 300 to 1,000 feet below ground surface (depending on the specific area) were used to represent the Principal aquifer. This depth interval includes most large system production wells, which along with District monitoring wells, were used to construct the Principal aquifer full basin water level map.

Prior to developing the full basin condition for the Principal aquifer, the high-basin water level condition of January 2006 was analyzed and contoured to determine the flow patterns and contour shapes for a most recent, near-full, actual condition. In subsequent months, observed water levels in the Forebay area increased further to a new historical high in June 2006, whereas in the coastal area January 2006 remained a historical high.

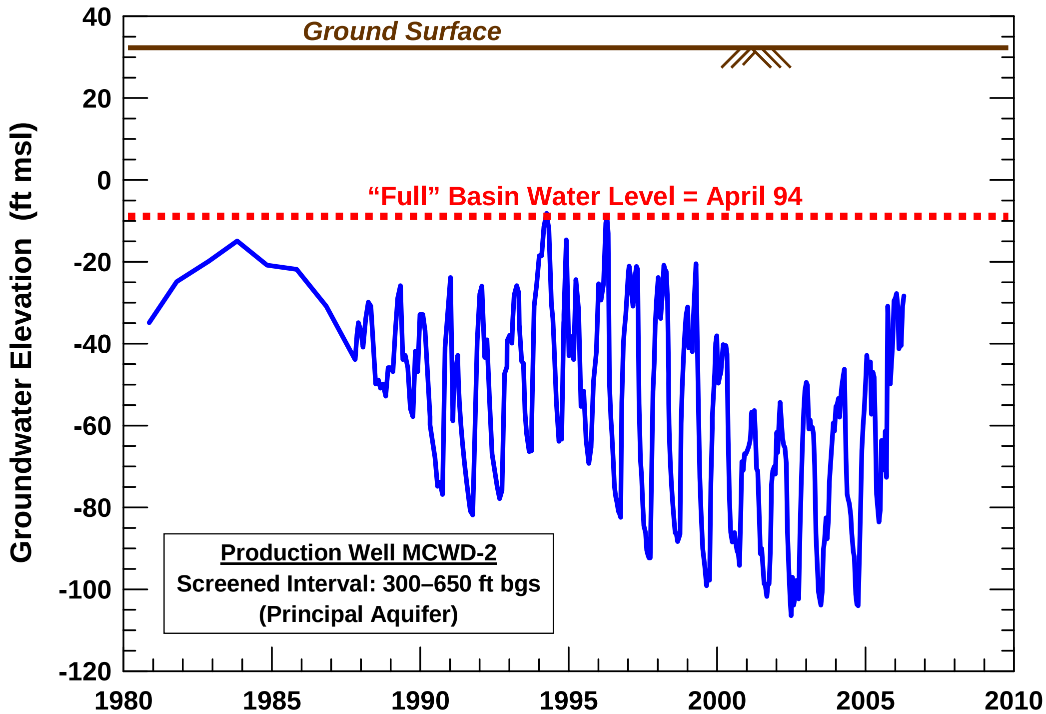
In the coastal area, full basin water levels were generally set at or within 5 feet of the observed peak January 2006 water levels, as was also done for the Shallow aquifer. In fact, this was the case for the majority of the Pressure area, where January 2006 water levels were noticeably higher than the previous high of 1994 (see Figure 4-5).

Figure 4-5. Full Basin Water Level at Santa Ana Well 21



The exception to using January 2006 water levels for the full condition in the Pressure area was in the MCWD area where the high condition of April 1994 was used. At this location, January 2006 water levels were 15 to 20 feet lower than April 1994 because of current pumping from the MCWD colored water project that did not exist in 1994. As was mentioned in the Section 4.1 assumptions, since the full condition must be sufficiently high in the coastal area to be protective of seawater intrusion, the older but higher April 1994 water levels were used in this area for the full condition even though it is not representative of present-day pumping in this immediate area (see Figure 4-6).

Figure 4-6. Full Basin Water Level at Mesa Consolidated Water District Well 2

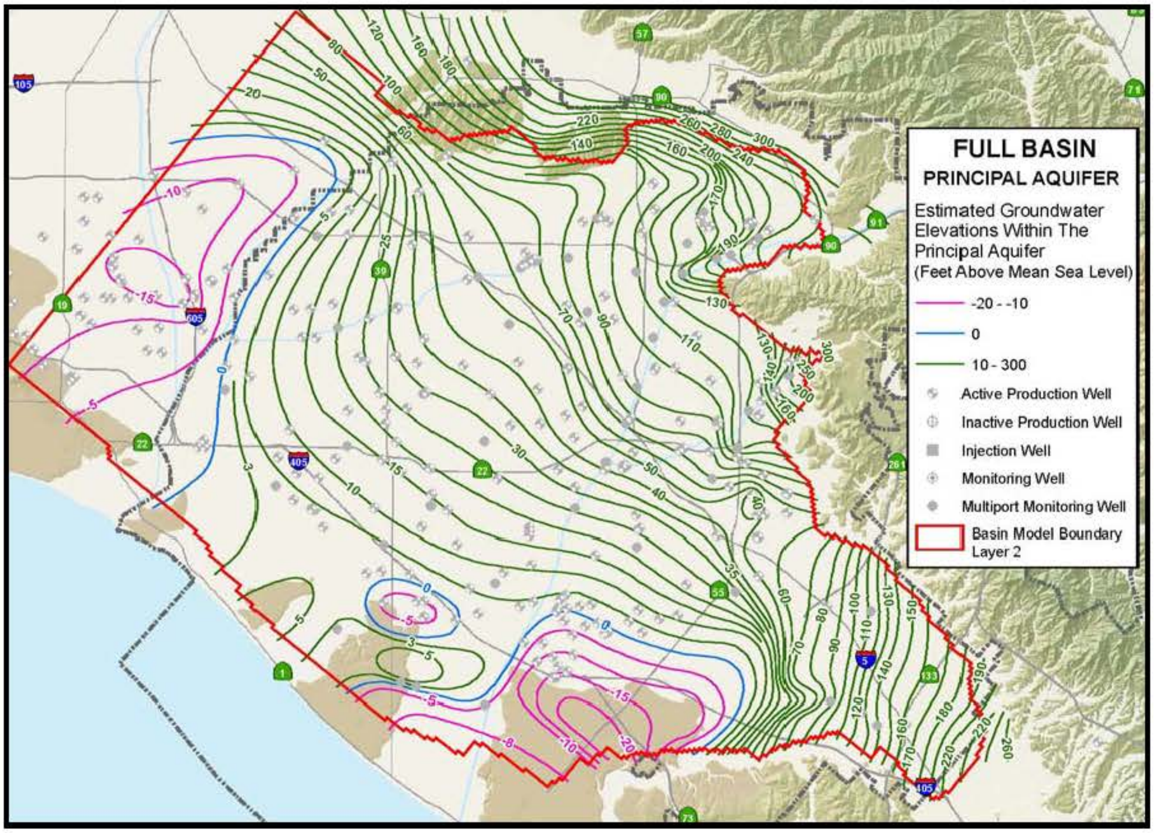


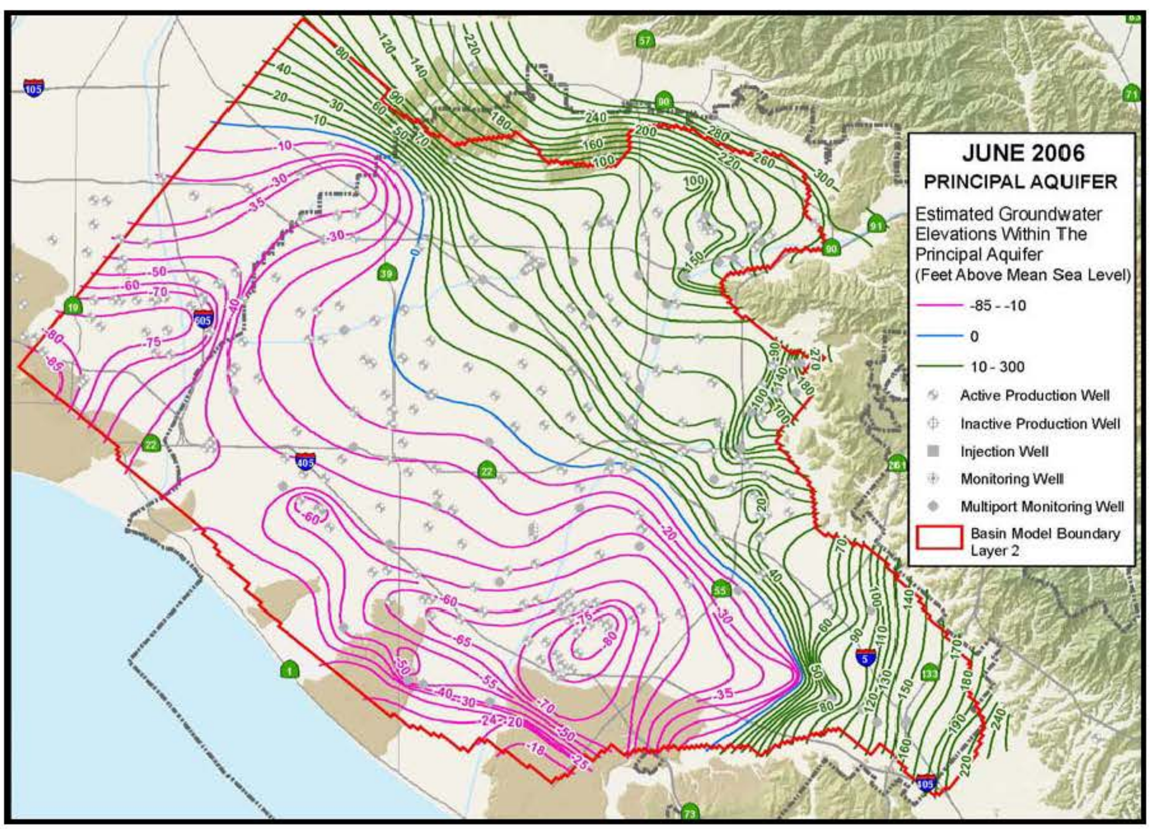
Throughout most of the Irvine Sub-basin, January 2006 represented a historical high similar to the rest of the Pressure area. Thus, full basin water levels in Irvine were also set within 5 feet of observed January 2006 levels. However, in north Irvine near the Santa Ana mountain front, 1999 water levels were used since they were nearly 15 feet higher than January 2006 in that immediate area.

In the Anaheim and Orange Forebay areas, full basin water levels were generally set at or within 5 feet of the historical high that occurred during March through June of 1994 depending on the exact location. For the majority of the Forebay area, 1994 still represented a historical high for the Principal aquifer, higher than January or June 2006.

Although the full water levels were based on different historical highs in different areas of the basin (coastal vs. inland), resulting gradients and flow patterns were reasonable and similar to those contoured for the observed data of June 2006 (see Figure 4.7).

Figure 4-7. Principal Aquifer Groundwater Contours: Full Basin and June 2006





4.4 Deep Aquifer Full Basin Water Level Map

For the Deep aquifer, the main data source for developing the full basin condition was water level data from the District's deep multi-port monitoring (Westbay) well network. Approximately two-thirds of these 56 wells were sufficiently deep and in appropriate locations overlying the Deep aquifer. Depending on the specific location, the monitoring ports of these wells that tap the Deep aquifer generally range from approximately 1,500 to 2,000 feet below ground surface.

In addition to the District's deep monitoring wells, a few other scattered well points that tap the Deep aquifer were used, such as two deep monitoring wells owned by the Water Replenishment District in LA County (very close to the county line).

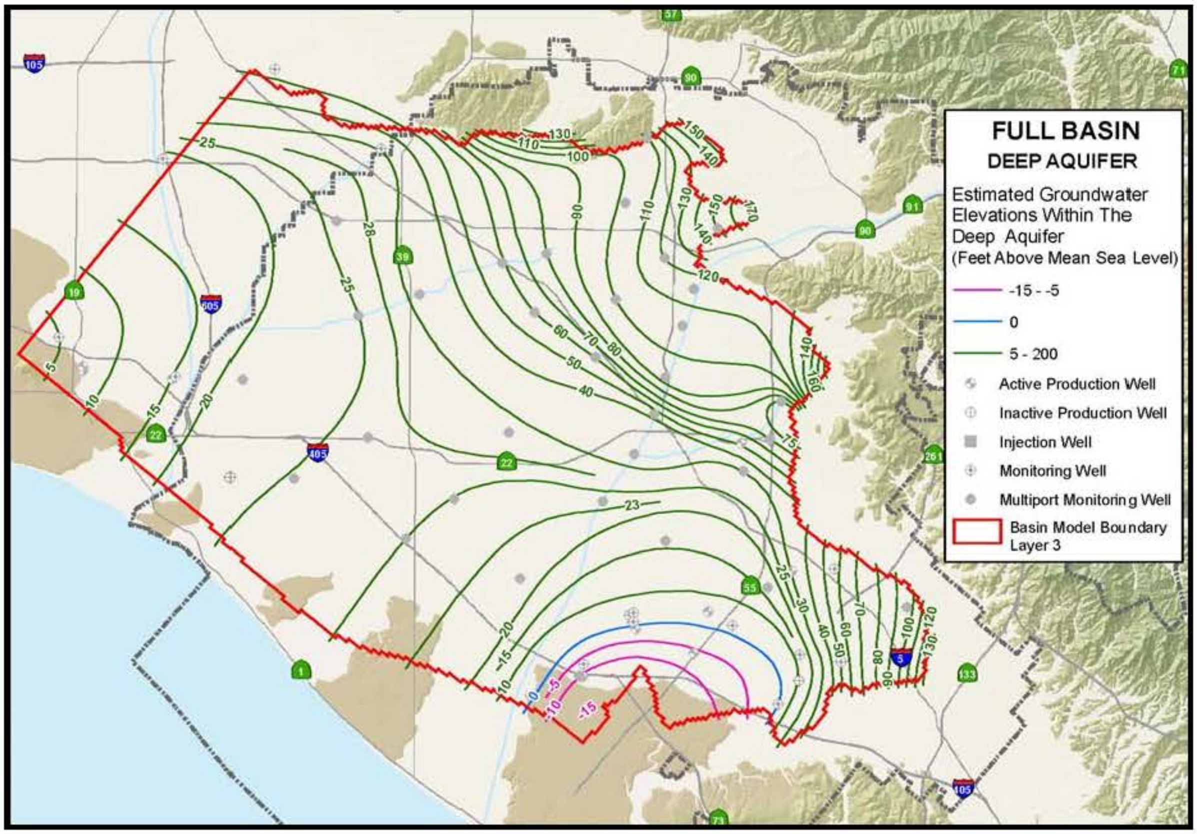
The new full condition for the Deep aquifer was predominantly based on the historical high that occurred in 1994. Throughout the basin, the recent June 2006 Deep aquifer water levels were still well below the historical high of 1994, likely due to the IRWD Deep Aquifer Treatment System (DATS) Project which began pumping approximately 8,000 afy of colored water in December 2001 from this otherwise little-used zone. Also, there was no MCWD colored water project yet in 1994. Fortunately, most of the District's deep monitoring wells are old enough to have captured the historical high condition of 1994.

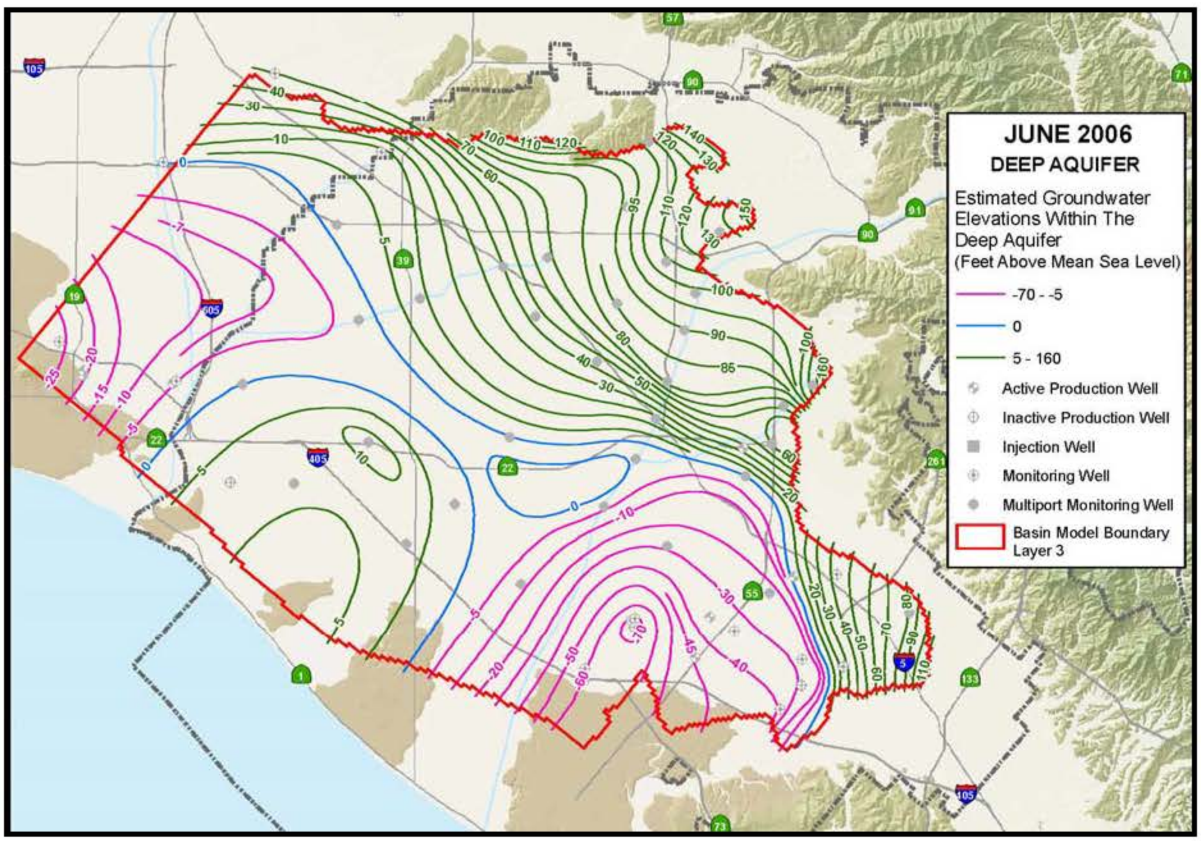
It is somewhat speculative as to how high the piezometric level of the Deep aquifer can rise. Therefore, full water levels were conservatively adjusted only 0 to 5 feet higher than the observed historical peak that occurred April to June of 1994. In so doing, the observed vertical piezometric head difference between the overlying Principal aquifer and the Deep aquifer was maintained. Throughout most of the basin, Deep aquifer piezometric levels typically ranged from 10 to 30 feet higher than the more heavily pumped Principal aquifer, except in the furthest inland locations near the mountain front and near recharge facilities where the Deep aquifer levels are actually lower than the Principal aquifer due to being more vertically removed from surficial recharge.

While contouring the resulting Deep aquifer full basin piezometric levels (also referred to as water levels for simplicity), the Principal aquifer full condition contour map was used as a backdrop on the light table to ensure that the Deep aquifer full contours maintained the vertical head difference discussed above. Also, in areas lacking data, the contours were drawn with similar patterns as those predicted during basin model calibration.

Figure 4-8 shows the resulting contour maps for both the new full condition and also June 2006 for comparison. The contour shapes are quite similar for both maps except in the area near the aforementioned DATS wells. The Full map assumes no DATS pumping since it was based on the historical high water levels of 1994, whereas the June 2006 map shows a relatively deep pumping depression in that immediate area. However, due to the confined nature of the Deep aquifer, the storage coefficients of this zone are very small (see Appendix 2) and thus even a relatively large water level difference leads to a small storage change.

Figure 4-8. Deep Aquifer Groundwater Contours: Full Basin and June 2006





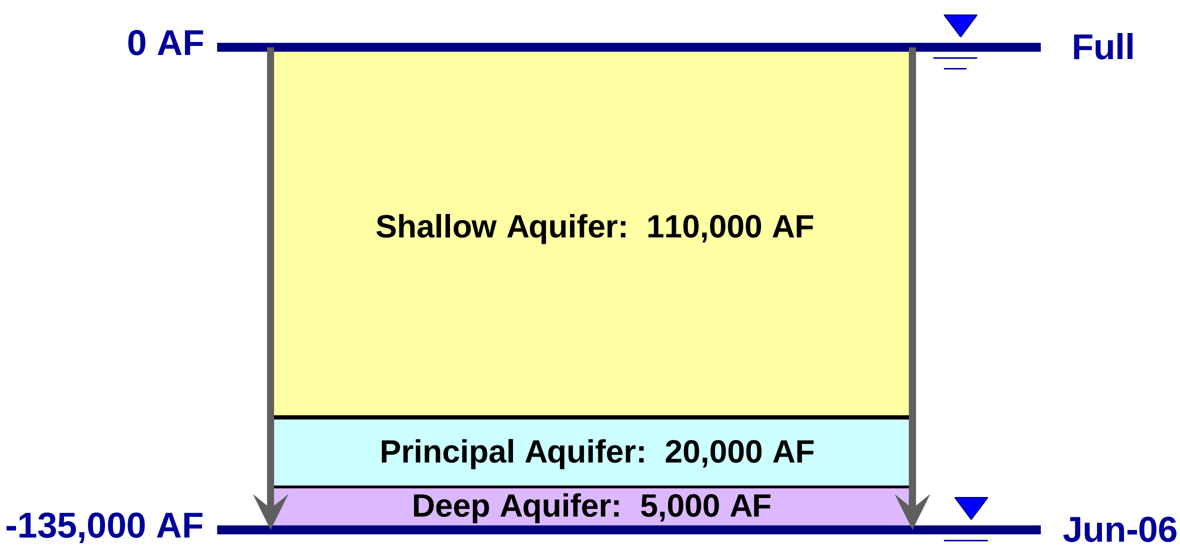
5. ACCUMULATED OVERDRAFT FROM NEW FULL CONDITION

The accumulated overdraft is the amount of storage capacity below full, sometimes referred to as dewatered storage or available storage capacity. In various literature, overdraft often has a negative connotation implying that a basin is in a steady state of decline or has been drawn-down below some critical threshold to where negative impacts such as subsidence and seawater intrusion begin to occur. In this report, use of the term "accumulated overdraft," which is defined in the District Act, is not intended to have any negative connotation and is strictly used as a measure of available basin storage below the new full benchmark or zero-overdraft condition established in Section 4.

5.1 Accumulated Overdraft as of June 30, 2006

The new three-layer storage change methodology was used to calculate the accumulated overdraft for June 2006. Three groundwater contour maps (one for each aquifer layer) representing June 30, 2006 had already been constructed for testing the new three-layer approach described in Section 3. For the storage change calculation, Year 1 was set to the new full water level condition and Year 2 was set to the June 2006 water level condition. The resulting change in storage from the new full condition to June 2006 was -135,000 af, or in other words, the accumulated overdraft as of June 30, 2006 was 135,000 af below the new full benchmark. The breakdown per aquifer layer is schematically shown below in Figure 5-1.

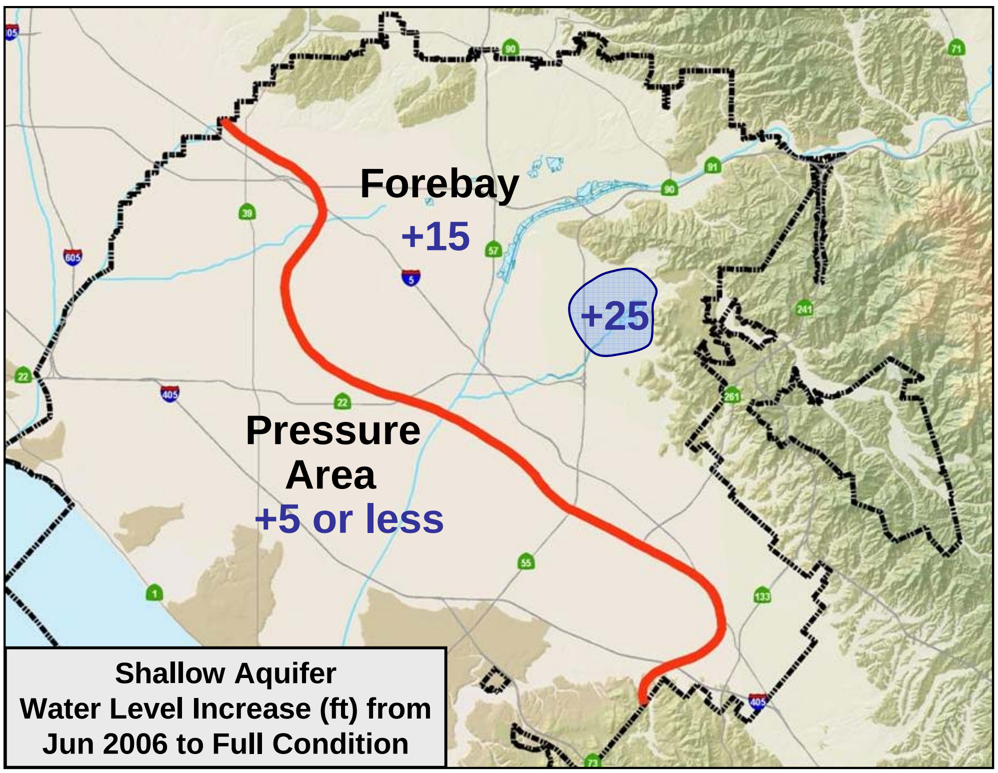
Figure 5-1. Three-Layer Accumulated Overdraft for June 2006



To put the Shallow aquifer storage change from the full condition (110,000 af) into perspective, Shallow aquifer water levels in most of the Forebay area were approximately 15 feet higher in the full condition as compared to June 2006 (Figure 5-2). In the coastal area, full water levels were only about 5 feet higher than June 2006. And since much more storage change occurs in the Forebay than the Pressure area per foot of water level change, nearly all of the Shallow aquifer storage change from full to June 2006 occurred in the Forebay area. Therefore, in general, a 15-foot Shallow aquifer water level change throughout the Forebay caused approximately 100,000 af of storage change.

Detailed water level change maps for June 2006 to the new full condition for all three aquifer layers are shown in Appendix 3.

Figure 5-2. Average Shallow Aquifer Water Level Difference from June 2006 to Full



5.2 Accumulated Overdraft as of June 30, 2005

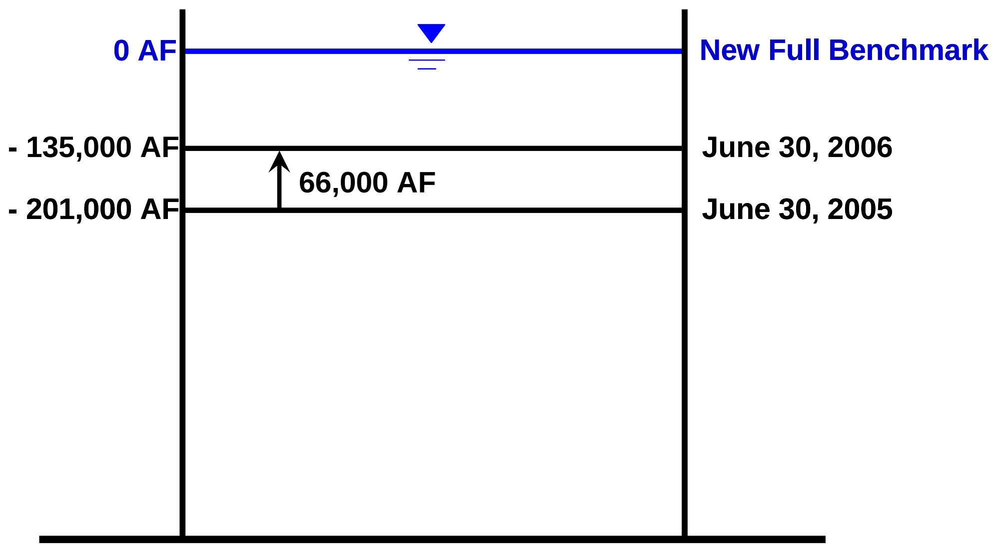
Using the new three-layer storage change method, the accumulated overdraft was calculated for June 2005 by directly comparing to the new full benchmark once again. In the storage change calculation, Year 1 was set to the new full water level condition and Year 2 was set to the June 2005 water level condition. The resulting total change in storage from the new full to June 2005 was -201,000 af, or in other words, the accumulated overdraft was 201,000 af below the new full benchmark.

The June 30, 2005 accumulated overdraft for each aquifer layer was as follows:

Shallow aquifer:	166,000 af
Principal aquifer:	25,000 af
Deep aquifer:	10,000 af
Total:	201,000 af

The difference between the June 2005 and June 2006 accumulated overdraft was 66,000 af, which represents the annual increase in storage from July 1, 2005 through June 30, 2006 (see figure 5-3). As a check, this storage change of 66,000 af was exactly the same as that calculated directly using the new three-layer method with Year 1 as June 2005 and Year 2 as June 2006 (see previous Figure 3-7). Therefore, this confirmed that the new three-layer approach yields exactly the same results summing the annual storage change over multiple years or calculating the storage change using the start and end of the multiple year period. In addition, the new method has been shown to yield the same identical storage change, but opposite in sign, when reversing the order of Year 1 vs. Year 2.

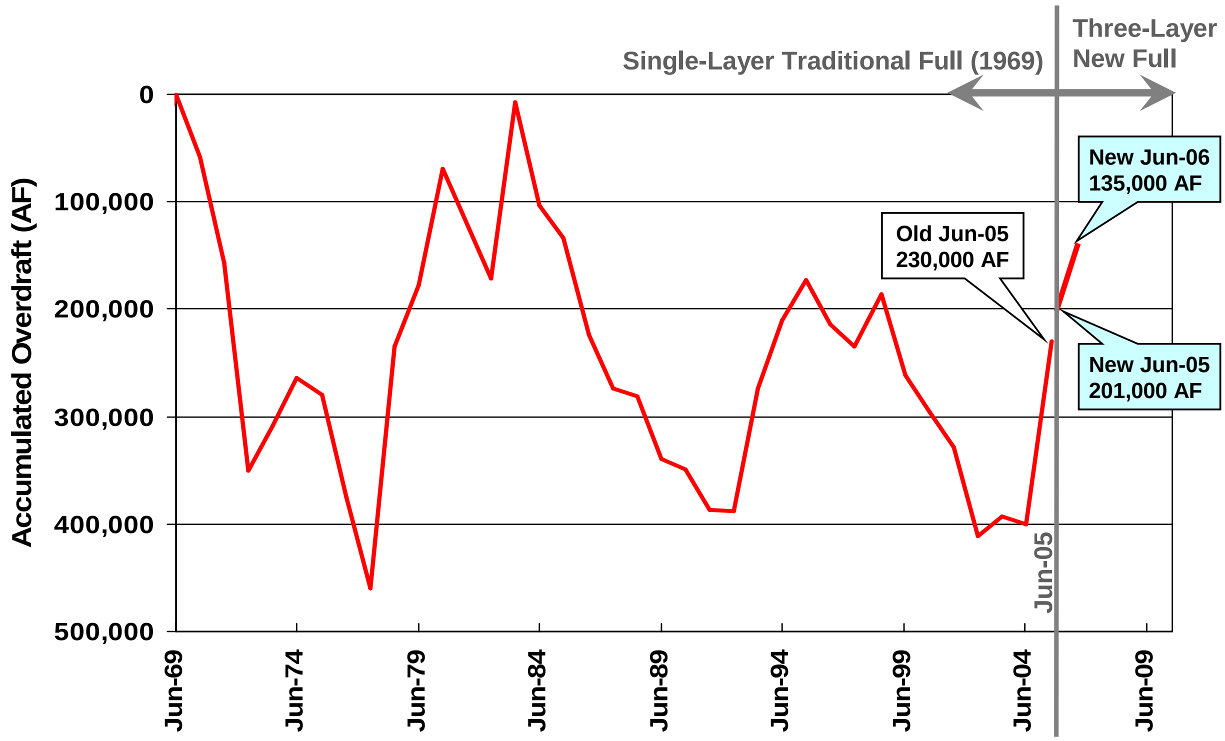
Figure 5-3. Accumulated Overdraft Schematic for June 2005 and June 2006



5.3 Historical vs. New Accumulated Overdraft Estimates

The new accumulated overdraft estimate of 201,000 af for June 2005 is 29,000 af less than the traditional method estimate of 230,000 af published in the 2004-05 OCWD Engineer's Report. This discrepancy is relatively minor when considering the major differences between the traditional single-layer and new three-layer storage change methods and also their two corresponding different full basin benchmarks. Since the historical accumulated overdraft levels are all relative to the 1969 condition as being the zero-overdraft benchmark, the two new accumulated overdraft estimates for June 2005 and June 2006 are plotted on the same familiar historical overdraft graph in Figure 5-4. However, this graph has been divided at the June 2005 line due to the two different zero-overdraft benchmarks of 1969 water levels and the new full condition.

Figure 5-4. Historical and New Accumulated Overdraft



5.4 Implementation of New Three-Layer Storage Change Method

To prevent or minimize any accumulation of potential discrepancy from year to year when implementing this new storage change method, it is important to follow the steps enumerated below.

1. Hand-contour water levels collected on or about June 30 for each of the three aquifer layers, maintaining consistency with how the water level data is interpreted from year to year, unless new well data in a specific area causes a different interpretation.

2. Use the GIS to calculate the water level change and corresponding storage change from the three-layer full benchmark to the current June condition. The resulting storage change below the full condition represents the accumulated overdraft for June of that year.

3. Subtract the previous year's accumulated overdraft from the current year to obtain the annual change in storage for that water year.

4. This step is a quality control check. Use the three-layer storage change method once again to calculate the water level change and storage change from the previous June (Year 1) to the current June (Year 2). This storage change should exactly equal the storage change calculated in Step 3.

5. Calculate incidental recharge for that water year by inputting the annual storage change estimate from Step 3 or 4 (if they are the same) into the water budget method described in Section 3.3. The resulting incidental recharge should be reasonable given the annual rainfall for the year in question; otherwise, additional error checking should be done for the water budget terms as well as the input data for the storage change calculation. It should be pointed out though that incidental recharge is not solely a function of rainfall because the flow across the LA County line – along with all other unknown inflows and outflows – is lumped into the incidental recharge term. That being said, incidental recharge for a somewhat typical year with average rainfall is thought to be approximately 60,000 afy but could vary by upwards of 20,000 af based on changes in outflow to LA County, which unfortunately is difficult to quantify.

6. The water budget method should not be used to determine or adjust the official storage change estimate calculated using the new three-layer method. It can be used to calculate preliminary monthly storage change estimates (using assumed incidental recharge) prior to performing the annual three-layer storage calculation. However, the annual storage change and accumulated overdraft official record for that year should be the exact value from the three-layer storage method steps above. This will prevent an accumulation of unknown discrepancy when rectifying back to previous years.

6. BASIN OPERATING RANGE AND STRATEGY

The level of accumulated overdraft in the basin, both for the current and upcoming year, affects important basin management decisions, including determining imported water needs and setting the Basin Pumping Percentage (BPP), both of which have major financial effects on the District and groundwater producers. Therefore, it is crucial to have an operational strategy to ensure that the basin is managed within acceptable overdraft limits to prevent detrimental impacts to the basin while also striving to maximize water reliability and financial efficiency.

In the discussion that follows, all storage and overdraft conditions are defined for June 30 of a given year, which is the ending date of the water year (July 1 through June 30) and thus the date represented by the June annual contour maps used for the storage change calculation. Seasonal fluctuations in water levels and basin storage occur throughout the water year and are tracked monthly for reporting purposes, and are used, along with the end-of-year accumulated overdraft, in making management decisions.

6.1 Basin Operating Range and Optimal Target

The operating range of the basin is considered to be the maximum allowable storage range without incurring detrimental impacts. The upper limit of the operating range is defined by the new full basin condition, which represents the zero-overdraft benchmark. 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 af overdraft and represents the lowest acceptable level in the basin, not the lowest achievable. This level also assumes that all MWD water stored in the basin (e.g., Conjuctive Use Storage Project and Super In-Lieu) has already been withdrawn. Although it is considered to be generally acceptable to allow the basin to decline to 500,000 af overdraft for brief periods due to severe drought conditions and lack of supplemental imported water supplies, 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:

- Seawater intrusion likely
- Drought supply depleted
- Pumping levels detrimental to a handful of wells
- Increased pumping lifts and electrical costs
- Increased potential for color upwelling from the Deep aquifer

Of course, detrimental impacts like those listed above do not suddenly happen when the overdraft gets down to exactly 500,000 af; rather, they occur incrementally, or the potential for their occurrence grows as the basin declines to lower levels. However, basin model computer simulations indicate that many of these detrimental impacts become evident at an overdraft of approximately 500,000 af. For example, at 500,000 af overdraft, model-simulated water levels in the Talbert Gap area were marginally low and not protective of seawater intrusion, even with the increased injection from GWRS Phase 1. Furthermore, worst case basin model runs at 700,000 af overdraft indicated seawater intrusion becoming even worse and considerably more production wells being impacted by low pumping levels. Thus, an accumulated overdraft level of 700,000 af did not appear to be acceptable, not even for short durations. At overdraft levels significantly below 500,000 af overdraft, the potential for land subsidence could also become an issue.

Based on historical hydrology and recharge water availability, an accumulated overdraft of 100,000 af best represents an optimal basin management target. This optimal target level provides sufficient storage space to accommodate anticipated recharge from a single wet year while also providing water in storage for at least 2 or 3 consecutive years of drought.

Table 6-1 shows that basin storage could increase by as much as 100,000 af in a somewhat typical wet year based on predicted increased supplies. The Captured Santa Ana River Flows and Natural Incidental Recharge terms were both based on an average of four historical wet years: 1992-93, 1994-95, 1997-98, and 2004-05. Based on historical rainfall records for the Orange County area, wet years typically do not occur back-to-back. Therefore, the optimal overdraft target of 100,000 af provides the storage capacity to capture the increased supplies from this one typically wet year.

Table 6-1. Anticipated Supply Increases for a Typical Wet Year

Increased Supplies (Above Average Annual Amounts)	1 Year (AF)
Captured Santa Ana River Flows *	50,000
Natural Incidental Recharge *	30,000
Reduced Demand (Pumping)	20,000
**Potential Storage Increase ** **	**100,000**

***** Average of four wet years: 92-93, 94-95, 97-98, 04-05
****** Assumes no mid-year BPP change

Table 6-2 shows that basin storage could decrease by approximately 90,000 af in a dry year based on reduced supplies. However, unlike wet years, historical rainfall records for this area show that dry years often occur for 2 or 3 consecutive years. Therefore, the 90,000 af of reduced supplies in a dry year could result in a 270,000 af decrease in basin storage after 3 consecutive years of drought. Assuming the basin to be at the optimal target of 100,000 af going into a three-year drought, the accumulated overdraft at the end of the drought would be 370,000 af, which is still within the acceptable operating range.

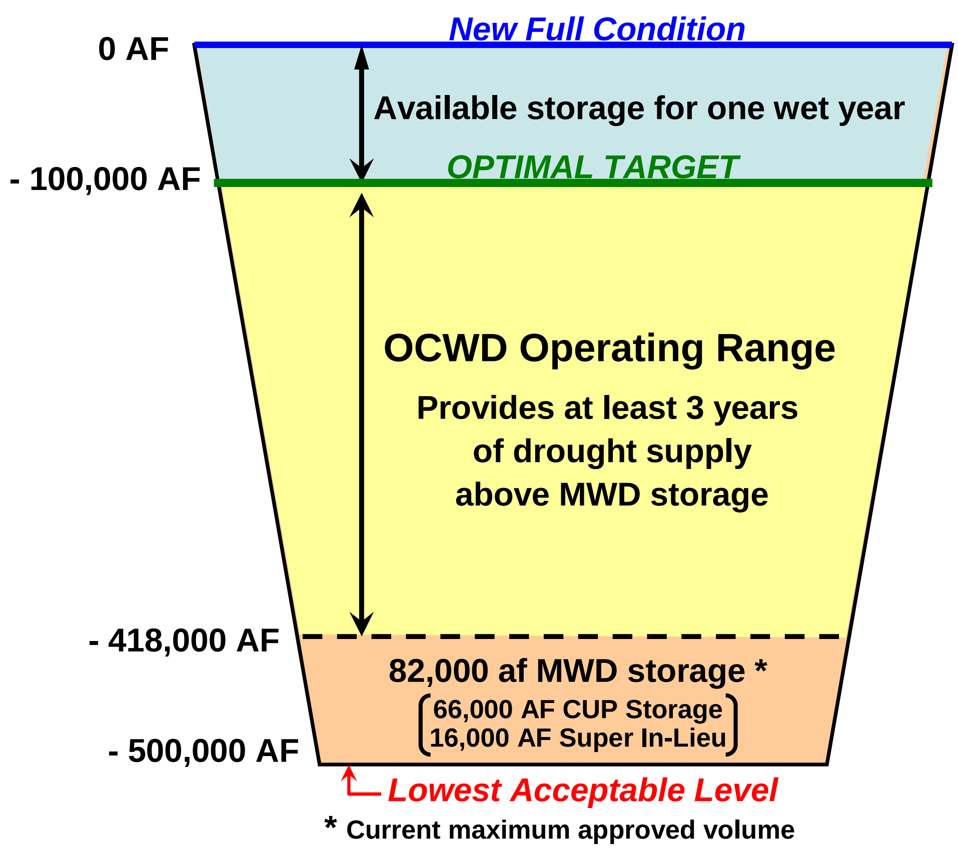
Table 6-2. Anticipated Supply Reductions for Typical Dry Years

Reduced Supplies (From Average Annual Amounts)	1 Year (AF)	3 Years (AF)
MWD Replenishment Water	-30,000	-90,000
Santa Ana River Flows	-40,000	-120,000
Natural Incidental Recharge	-20,000	-60,000
Total Potential Storage Change*	**-90,000**	**-270,000**

* Assumes no mid-year BPP change

Figure 6-1 schematically illustrates the various overdraft levels discussed above in relation to one another; namely, the new full benchmark, the optimal overdraft target of 100,000 af, and the lower limit of the operating range at 500,000 af accumulated overdraft.

Figure 6-1. Strategic Basin Operating Levels and Optimal Target



6.2 Basin Management Operational Strategy

The primary "tool" for managing the basin is the Basin Production Percentage (BPP). Each year in April, the District's Board of Directors sets the BPP for the upcoming water year. In addition to purchasing replenishment water, adjusting the BPP allows the District to effectively increase or decrease basin storage. Figure 6-2 shows the formula used to calculate the BPP each year. Only the two terms highlighted in blue and red in the BPP formula are adjustable at the District's discretion, namely the planned amount of recharge (including replenishment water purchases) and the planned amount of basin refill or storage decrease for the coming year.

The amount of recharge planned and budgeted for the coming year may be limited by factors outside the District's control, such as the availability of imported water for either direct replenishment or In-Lieu. For example, following statewide wet years, MWD may offer incentives (financial or otherwise) for local water agencies to take additional amounts of surplus imported water, whereas during a long-term statewide drought the surplus imported water may simply not be available.

Figure 6-2. BPP Formula

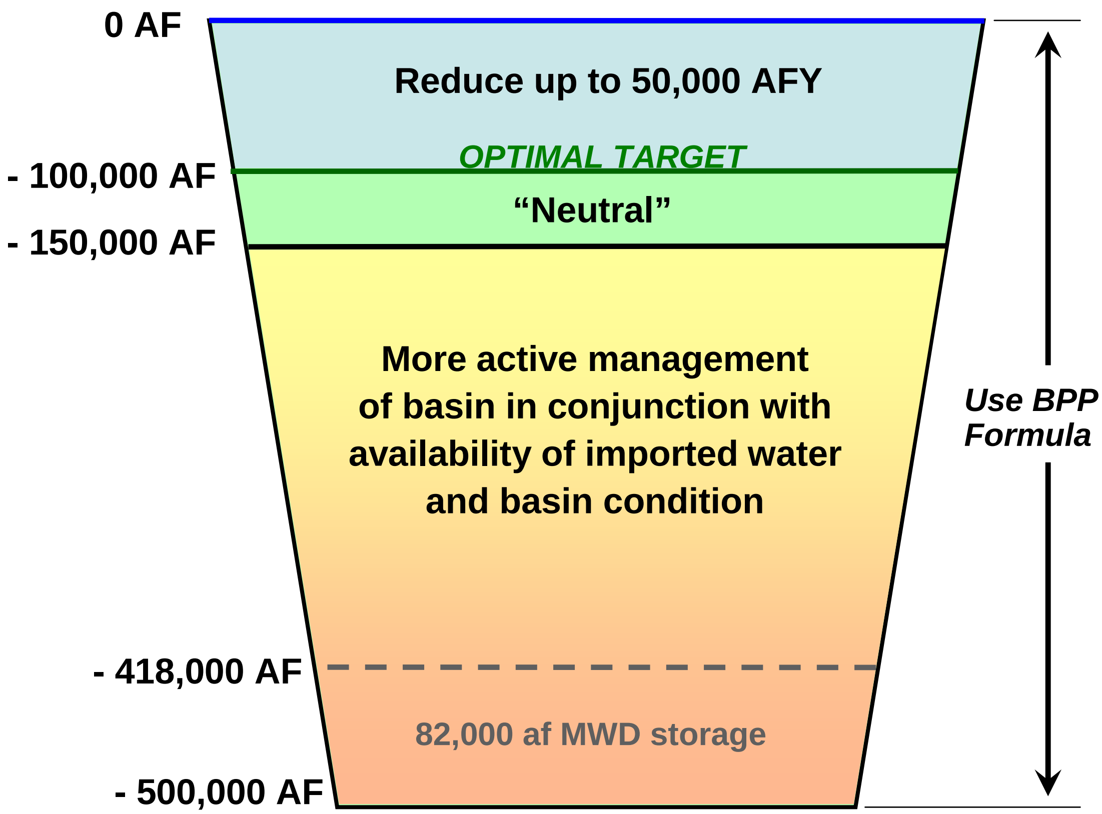
$$\text{BPP} = \frac{\text{Water Recharged} - \text{Basin Refill or Decrease} - \text{Water Quality Improvement Projects (Pumping Above BPP)}}{\text{Last Calendar Year's Total Water Demand} - \text{Reclaimed \& Local Supplies}}$$

The planned amount of basin refill or storage decrease for the coming year is within the District's control but is also considered within the context of financial impacts to both the District and the groundwater producers. Therefore, unless the basin is near the bottom of the acceptable operating range or close to being full, a moderate amount of basin refill or decrease would typically be proposed that aims to move toward the optimal overdraft target. If the basin is already at or near the 100,000 af overdraft target, then a neutral stance can be taken that attempts to balance basin production and recharge with no planned storage change.

Figure 6-3 schematically illustrates the generalized basin refill or storage decrease strategy based on the accumulated overdraft. When the basin is higher than the optimal overdraft target and nearly full, the amount of planned storage decrease of up to 50,000 af for the coming year may be recommended. This may be accomplished by a combination of raising the BPP and reducing replenishment purchases.

The proposed operational strategy illustrated in Figure 6-3 provides a flexible guideline to assist in determining the amount of basin refill or storage decrease for the coming water year based on using the BPP formula and considering storage goals based on current basin conditions and other factors such as water availability. This strategy is not intended to dictate a specific basin refill or storage decrease amount for a given storage condition but to provide a general guideline for the District's Board of Directors.

Figure 6-3. Basin Management Operational Strategy



7. FINDINGS

Findings of this study are enumerated below.

1. The new three-layer storage change approach is technically feasible and provides a more accurate assessment than the traditional single-layer storage change method.

2. Using the new three-layer method, the majority of the storage change occurs in the Forebay area of the basin within the unconfined Shallow aquifer where rising or falling of the water table fills or drains empty pore space.

3. Accuracy of the storage change and accumulated overdraft estimates is dependent upon good spatial distribution of water level measurements as well as the storage coefficient values used in the calculations. Water level data for the Shallow aquifer were relatively sparse in outlying Forebay areas of the basin, leading to some uncertainty in preparing groundwater elevation contours in those areas.

4. 1969 no longer represents a truly full-basin benchmark. A new full-basin water level condition was developed based on the following prescribed conditions:

   - Observed historical high water levels
   - Present-day pumping and recharge conditions
   - Protective of seawater intrusion
   - Minimal potential for mounding at or near recharge basins

   The new full-basin water levels in the Forebay area are essentially at or very near the bottom of the District's deep percolation basins (e.g., Anaheim Lake). Historical water level data from 1994 have shown that this condition is achievable without detrimental effects. Water levels slightly higher than this new full condition may be physically achievable in the Forebay area but not recommended due to the likelihood of groundwater mounding and reduced percolation in recharge basins.

5. Using the new three-layer storage change calculation in conjunction with the new full benchmark and June 2006 water levels, an accumulated overdraft of 135,000 af was calculated representing June 30, 2006. Similarly, using the new three-layer method to compare the new full water levels to those of June 2005, an accumulated overdraft of 201,000 af was calculated representing June 30, 2005. Subtracting the June 2006 accumulated overdraft from that of June 2005 yielded an annual storage increase of 66,000 af for WY 2005-06.

6. Comparing the current year's water level conditions to the full basin benchmark each successive year for calculating the basin storage will eliminate the potential for cumulative discrepancies over several years.

7. An accumulated overdraft of 500,000 af represents the lowest acceptable limit of the basin's operating range. This lower limit of 500,000 af assumes that stored MWD water (CUP and Super In-Lieu) has already been removed and is only acceptable for short durations due to drought conditions. It is not recommended to manage the basin for sustained periods at this lower limit for the following reasons:

   - Seawater intrusion likely
   - Drought supply depleted
   - Pumping levels detrimental to a handful of wells
   - Increased pumping lifts and electrical costs
   - Increased potential for color upwelling from the Deep aquifer

8. An optimal basin management target of 100,000 af of accumulated overdraft provides sufficient storage space to accommodate increased supplies from one wet year while also providing enough water in storage to offset decreased supplies during a two- to three-year drought.

9. The proposed operational strategy provides a flexible guideline to assist in determining the amount of basin refill or storage decrease for the coming water year based on using the BPP formula and considering storage goals based on current basin conditions and other factors such as water availability. This strategy is not intended to dictate a specific basin refill or storage decrease amount for a given storage condition but to provide a general guideline for the District's Board of Directors.

8. RECOMMENDATIONS

Based on the findings of this study are the following recommendations:

1. Adopt the new three-layer storage change methodology along with the associated new full-basin condition that will serve as a benchmark for calculating the basin accumulated overdraft.

2. Adopt the proposed basin operating strategy including a basin operating range spanning the new full condition to an accumulated overdraft of 500,000 af, and an optimal overdraft target of 100,000 af.

3. Include in the 2007-08 CIP budget the installation of six Shallow aquifer monitoring wells to increase accuracy of the three-layer storage change calculation.

9. BIBLIOGRAPHY

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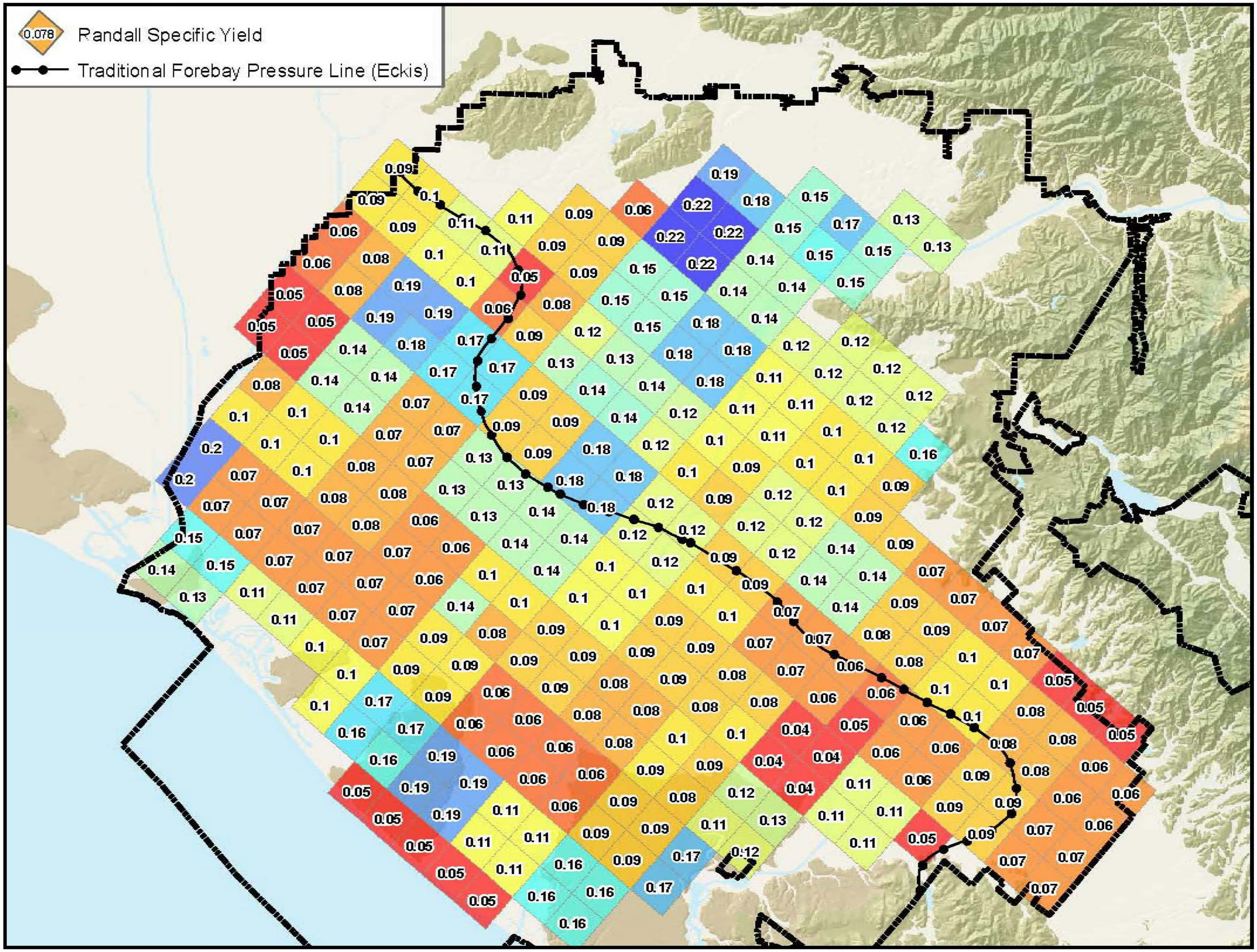
APPENDIX 1

"Randall" Specific Yield Values

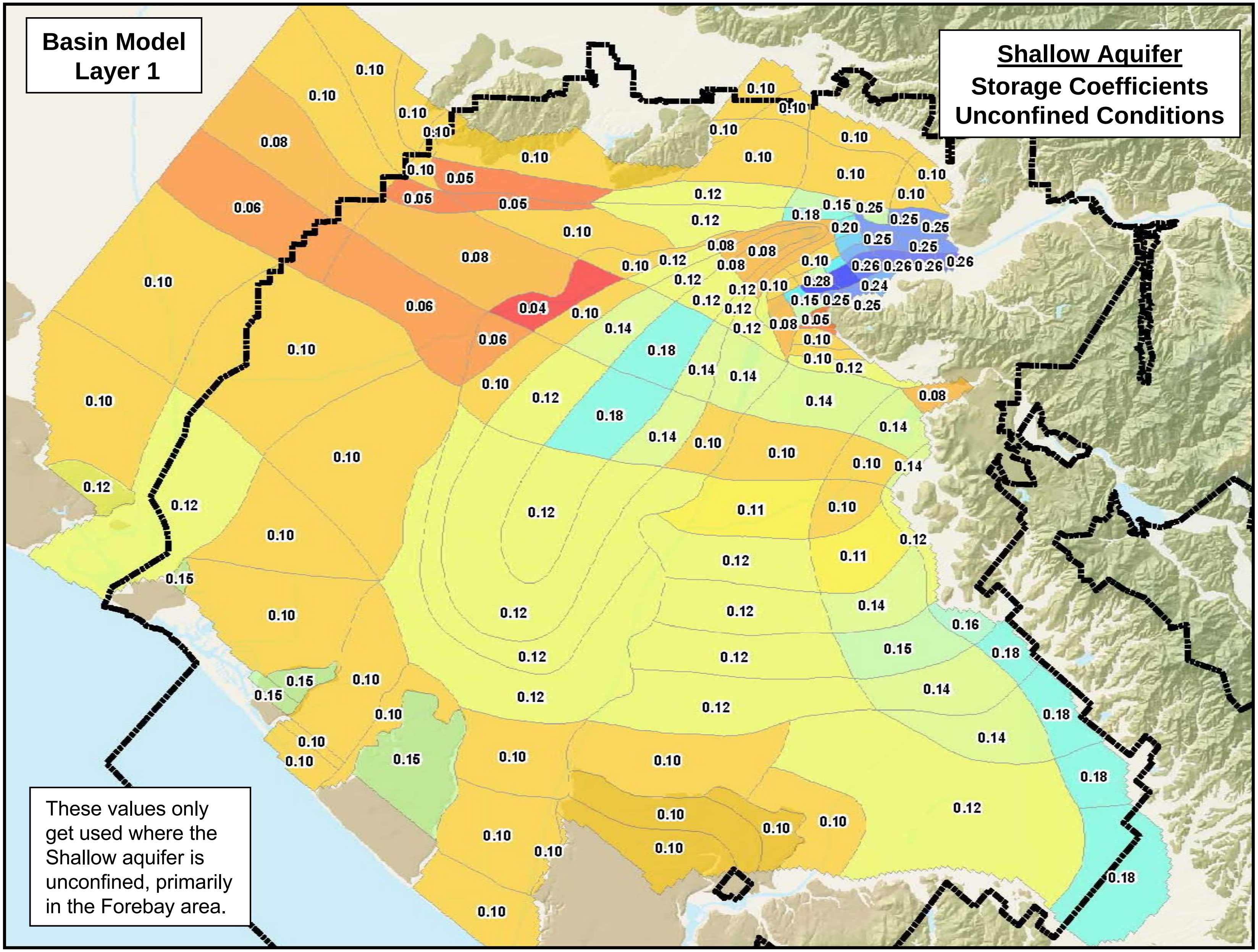
From Traditional Storage Change Method

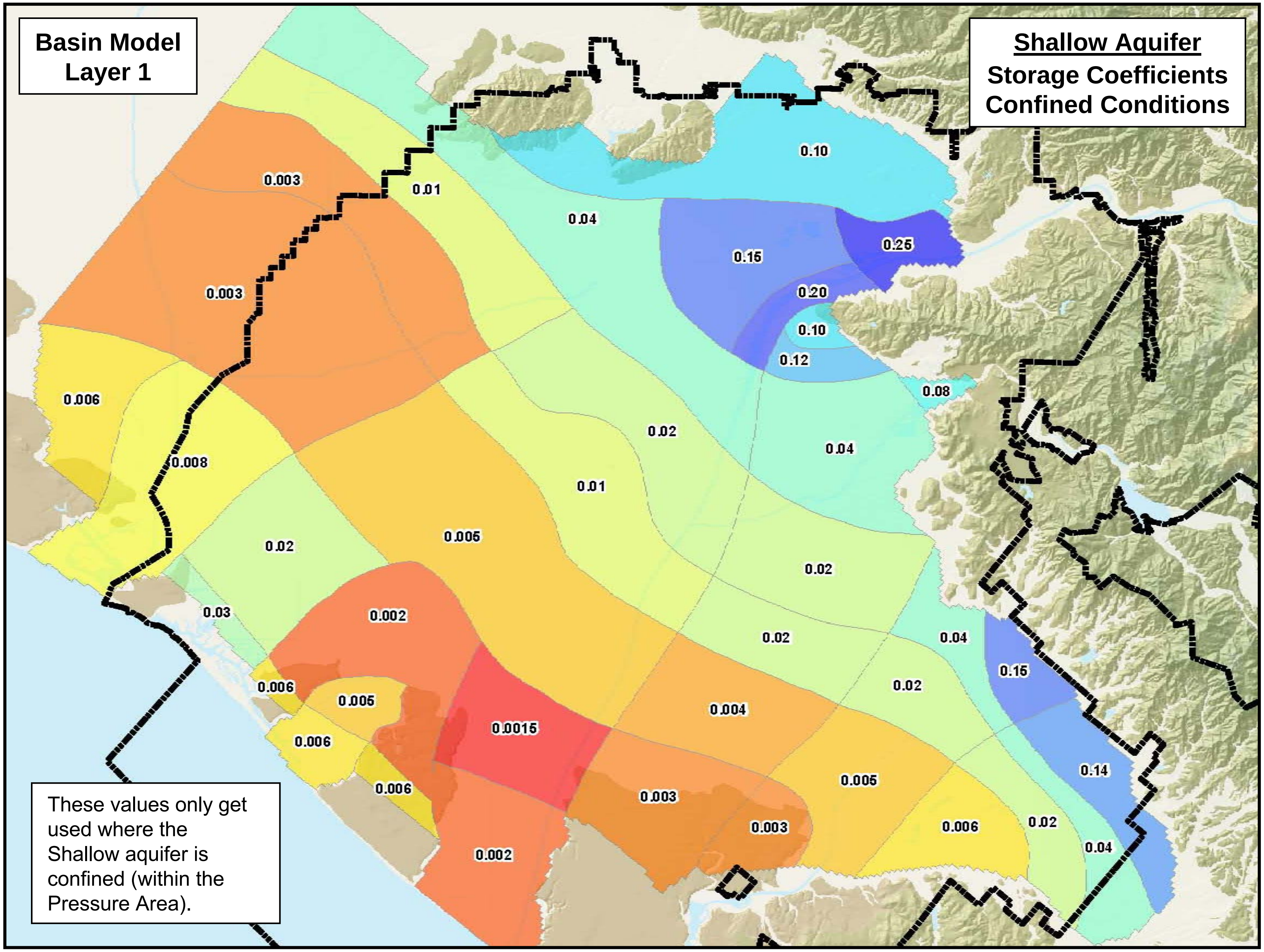

0.078
Randall Specific Yield
Traditional Forebay Pressure Line (Eckis)

APPENDIX 2

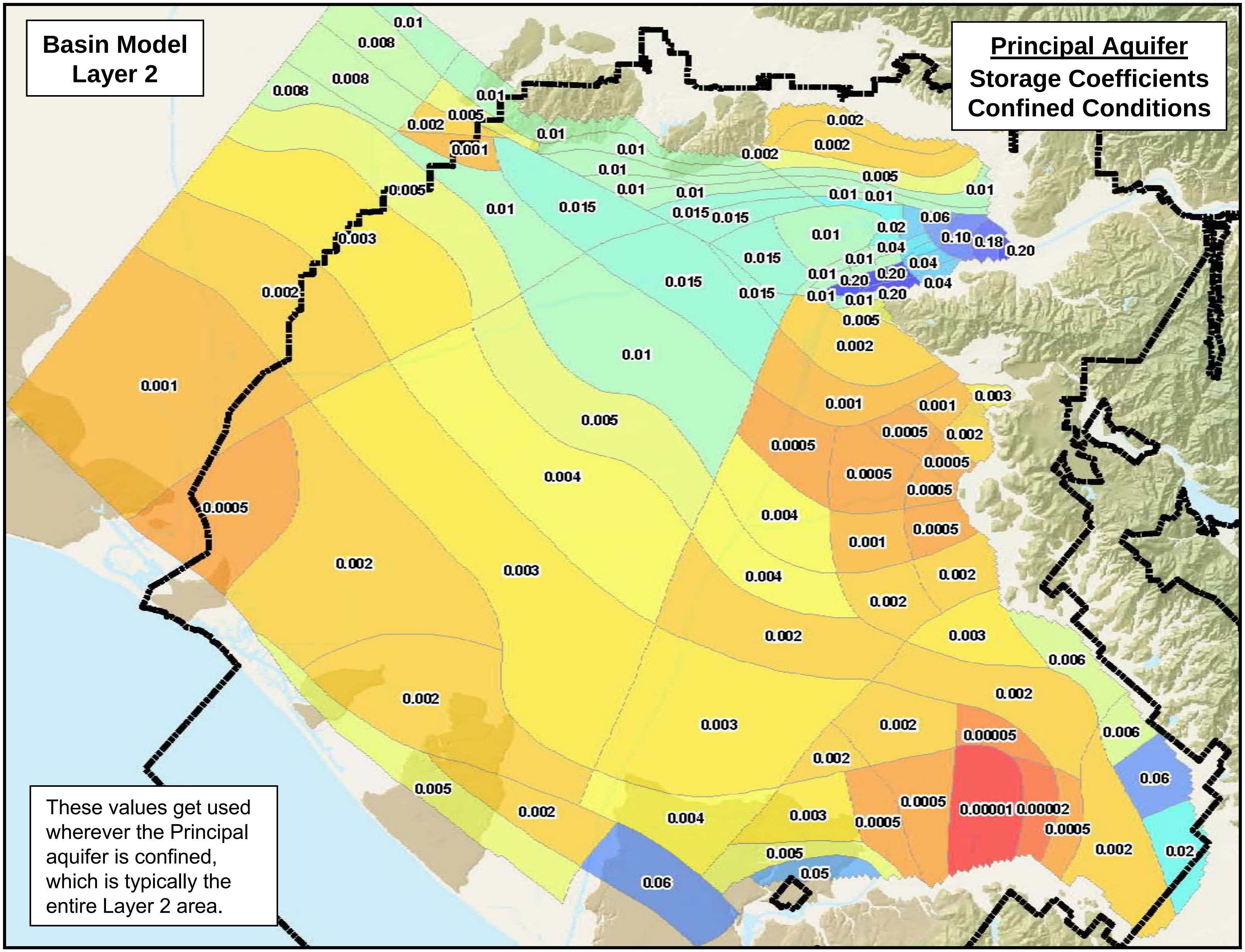
Basin Model Storage Coefficient Values

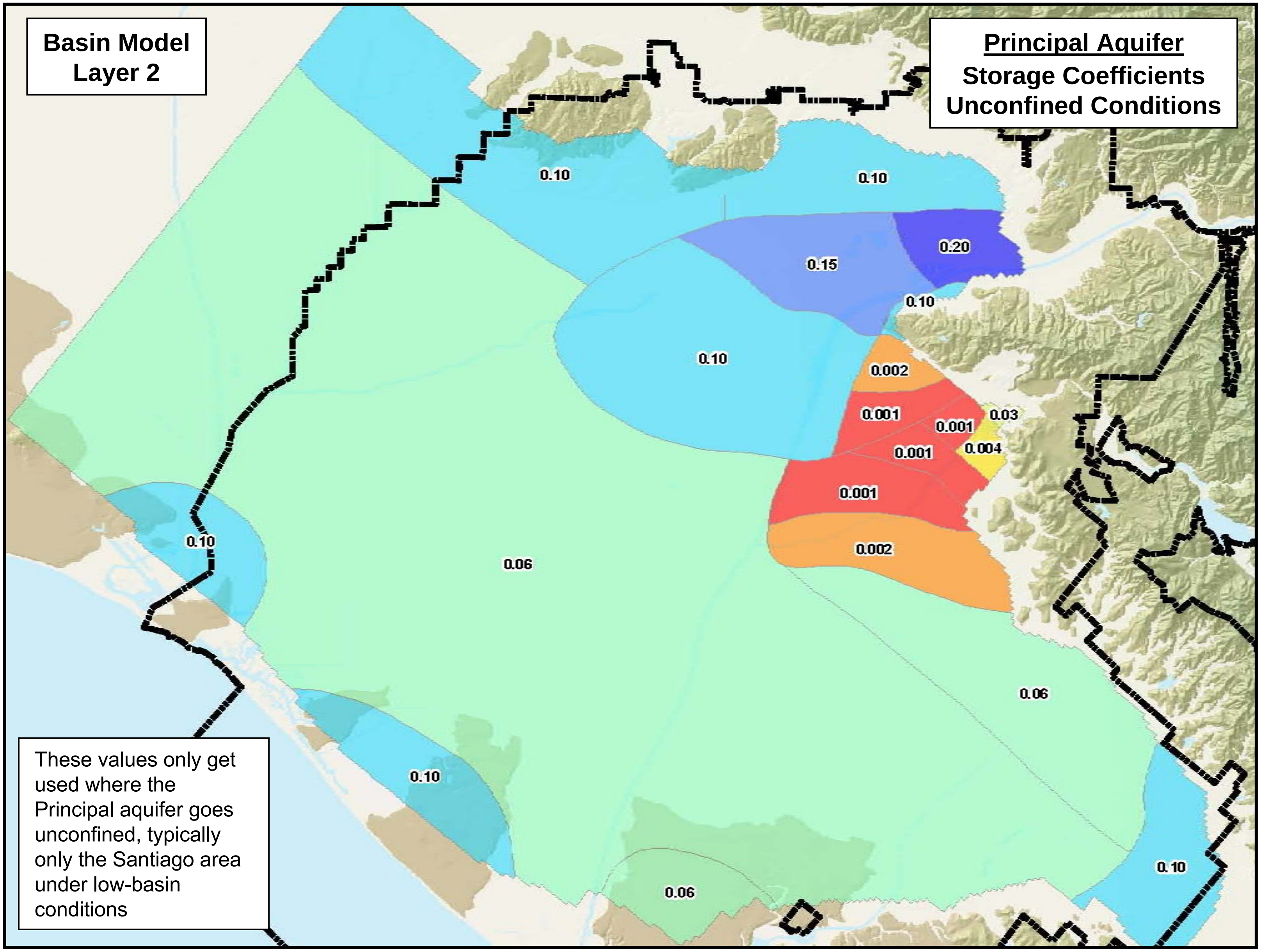
For Three-Layer Storage Change Method


Basin Model
Layer 1
Shallow Aquifer
Storage Coefficients
Unconfined Conditions
These values only get used where the Shallow aquifer is unconfined, primarily in the Forebay area.

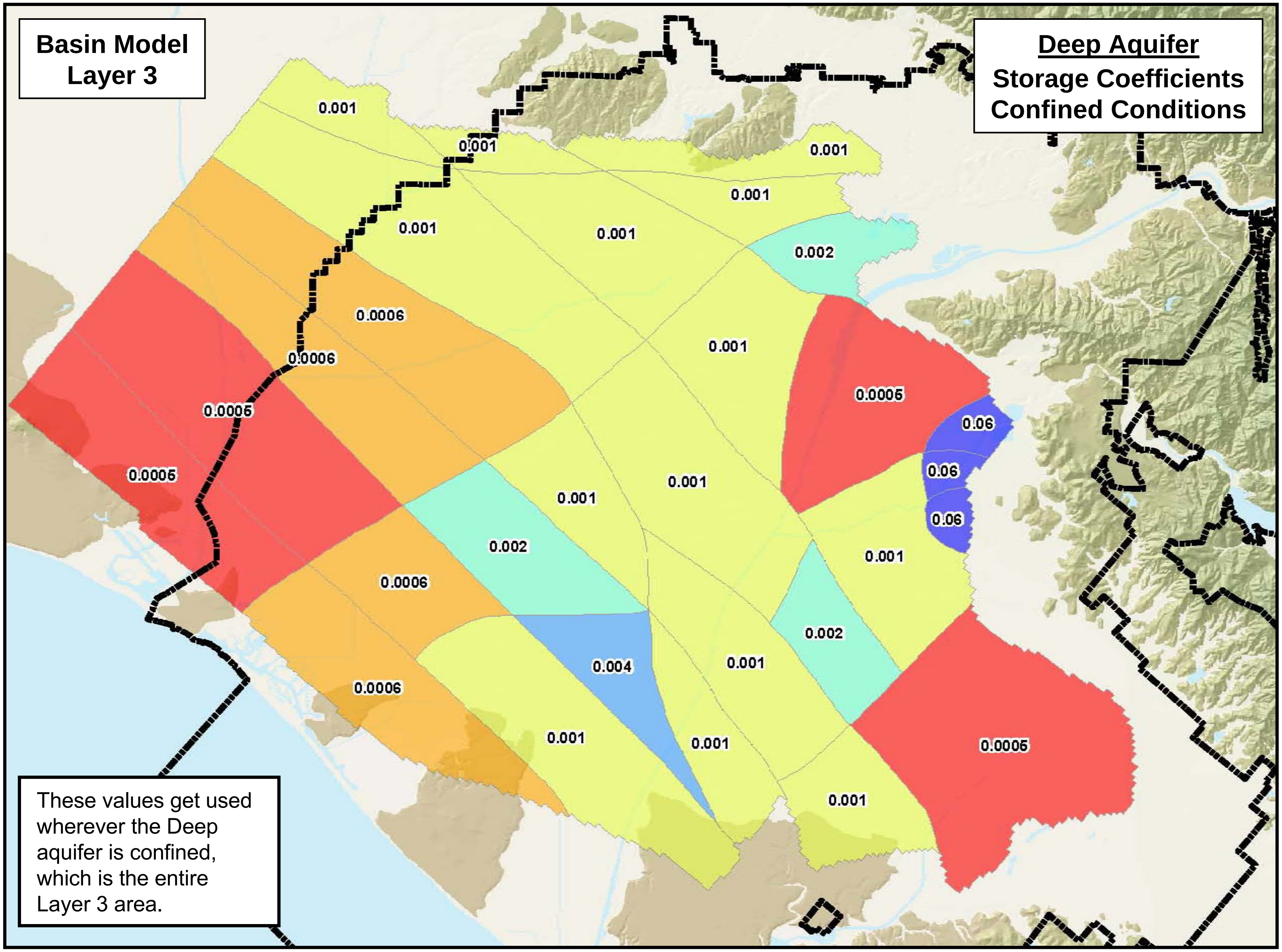


Basin Model Layer 1
Shallow Aquifer
Storage Coefficients Confined Conditions
0.003
0.01
0.04
0.10
0.15
0.25
0.003
0.20
0.10
0.12
0.08
0.006
0.02
0.008
0.04
0.01
0.02
0.005
0.02
0.03
0.002
0.02
0.04
0.006
0.15
0.005
0.02
0.004
0.0015
0.006
0.14
0.005
0.006
0.003
0.003
0.006
0.02
0.002
0.04
These values only get used where the Shallow aquifer is confined (within the Pressure Area).

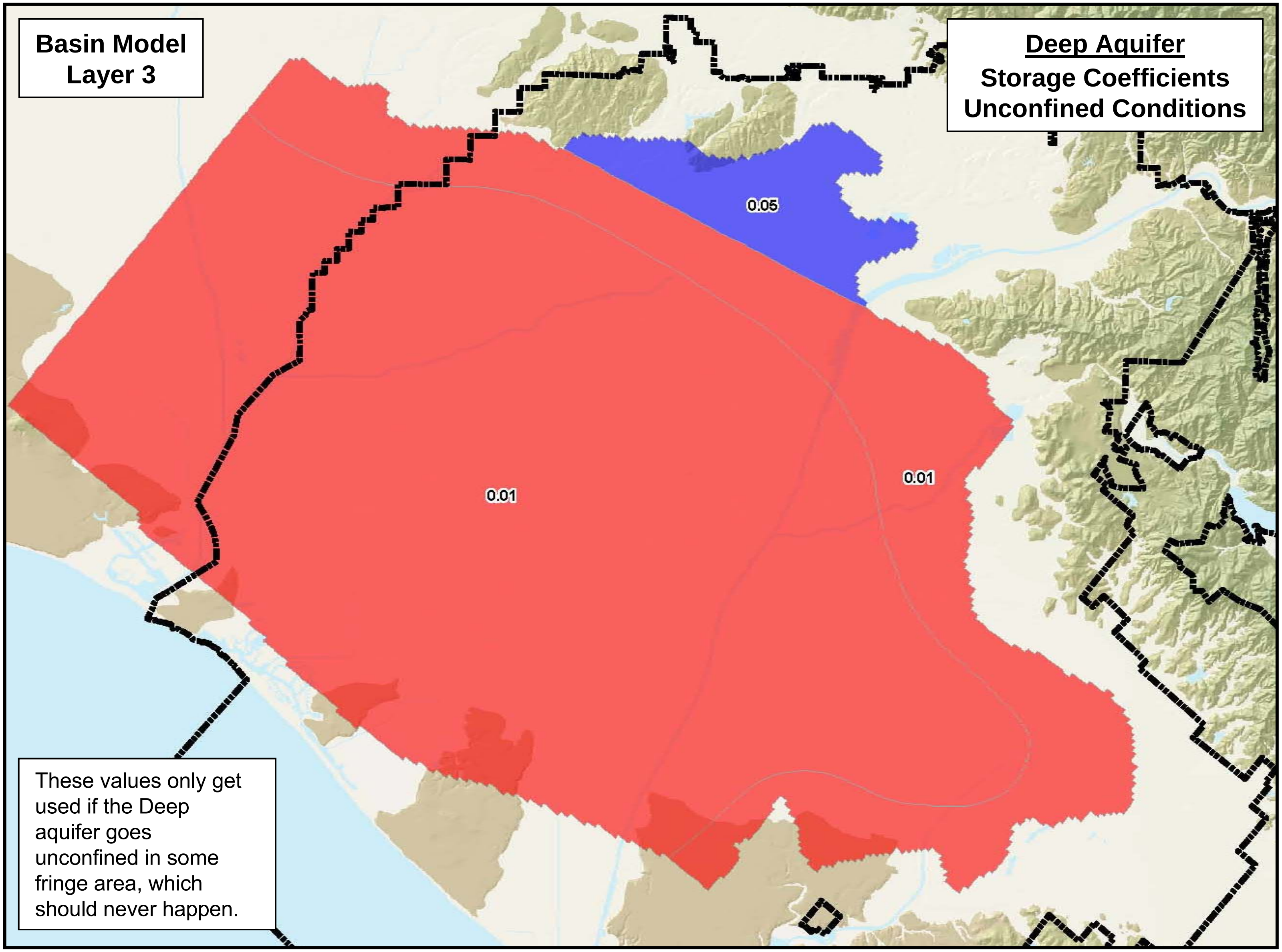

Basin Model
Layer 2
Principal Aquifer
Storage Coefficients
Confined Conditions
These values get used wherever the Principal aquifer is confined, which is typically the entire Layer 2 area.



Basin Model
Layer 2
Principal Aquifer
Storage Coefficients
Unconfined Conditions
0.10
0.10
0.20
0.15
0.10
0.10
0.002
0.001
0.03
0.001
0.004
0.001
0.001
0.10
0.06
0.002
0.06
0.10
0.10
0.06
These values only get used where the Principal aquifer goes unconfined, typically only the Santiago area under low-basin conditions



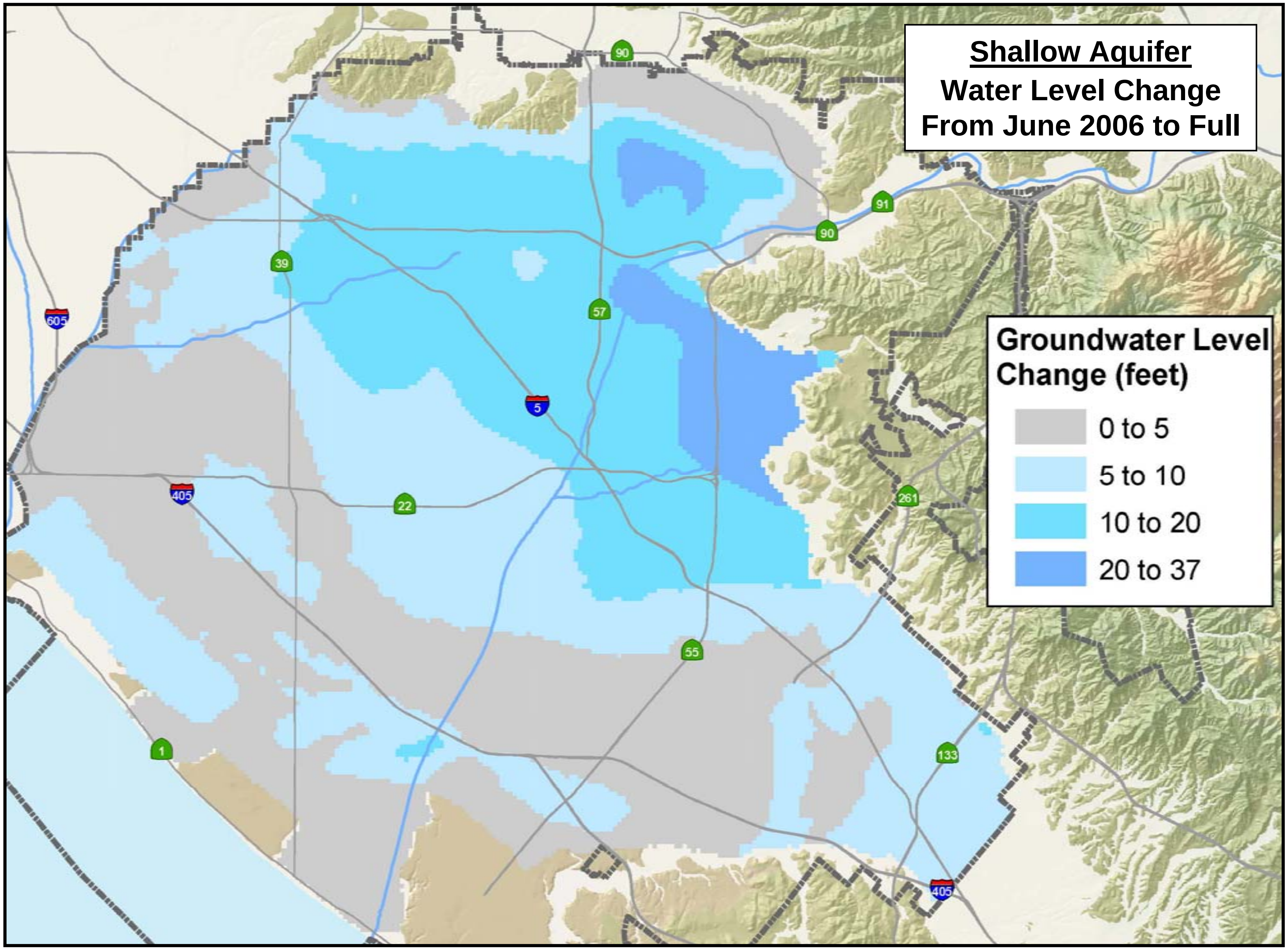
Basin Model
Layer 3
Deep Aquifer
Storage Coefficients
Confined Conditions
0.001
0.001
0.001
0.001
0.001
0.001
0.002
0.0006
0.0006
0.001
0.0005
0.0005
0.0005
0.06
0.06
0.06
0.001
0.001
0.002
0.0006
0.001
0.002
0.004
0.001
0.0006
0.001
0.001
0.0005
0.001
These values get used wherever the Deep aquifer is confined, which is the entire Layer 3 area.

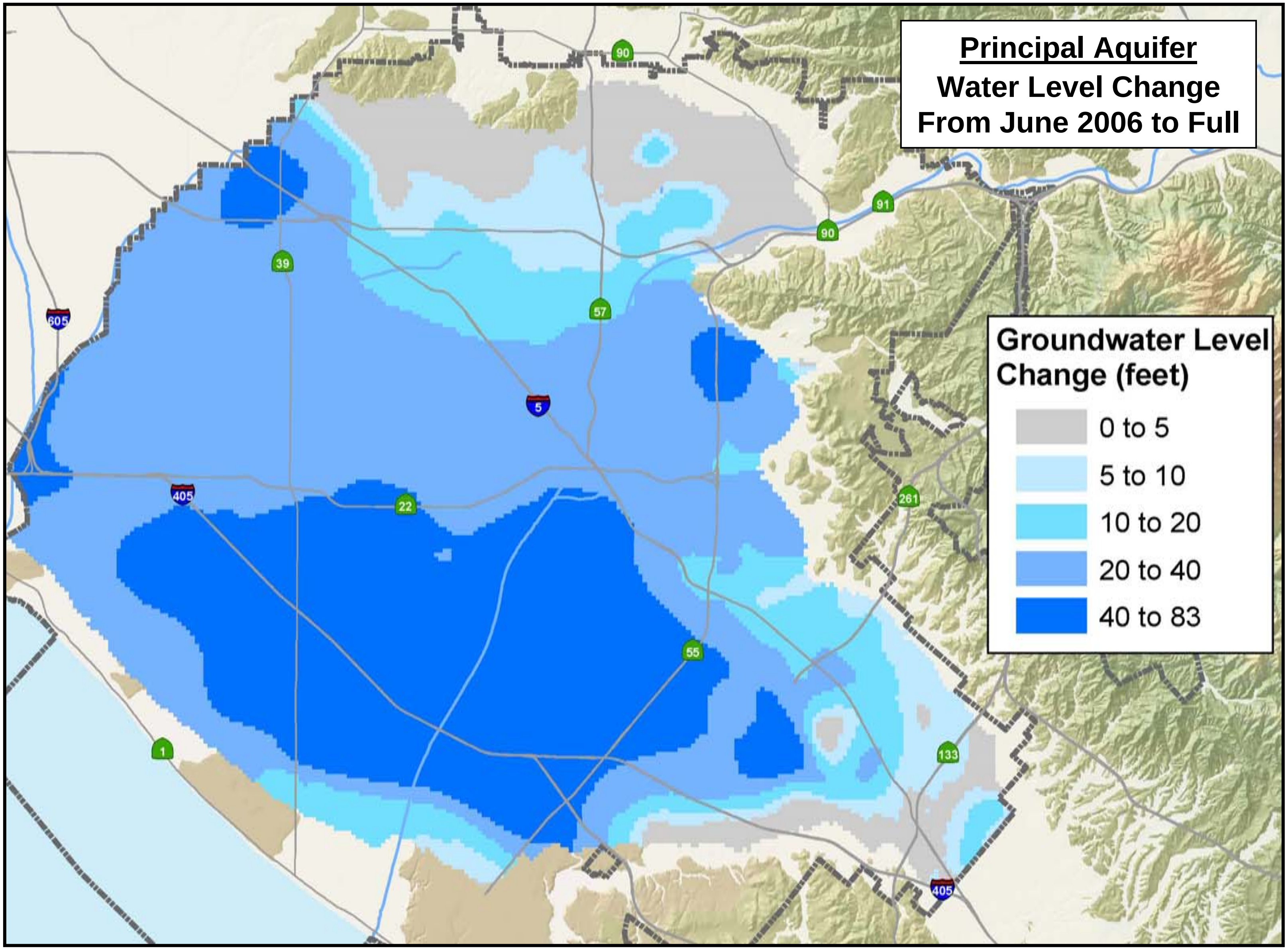

Basin Model
Layer 3
Deep Aquifer
Storage Coefficients
Unconfined Conditions
0.05
0.01
0.01
These values only get used if the Deep aquifer goes unconfined in some fringe area, which should never happen.

APPENDIX 3

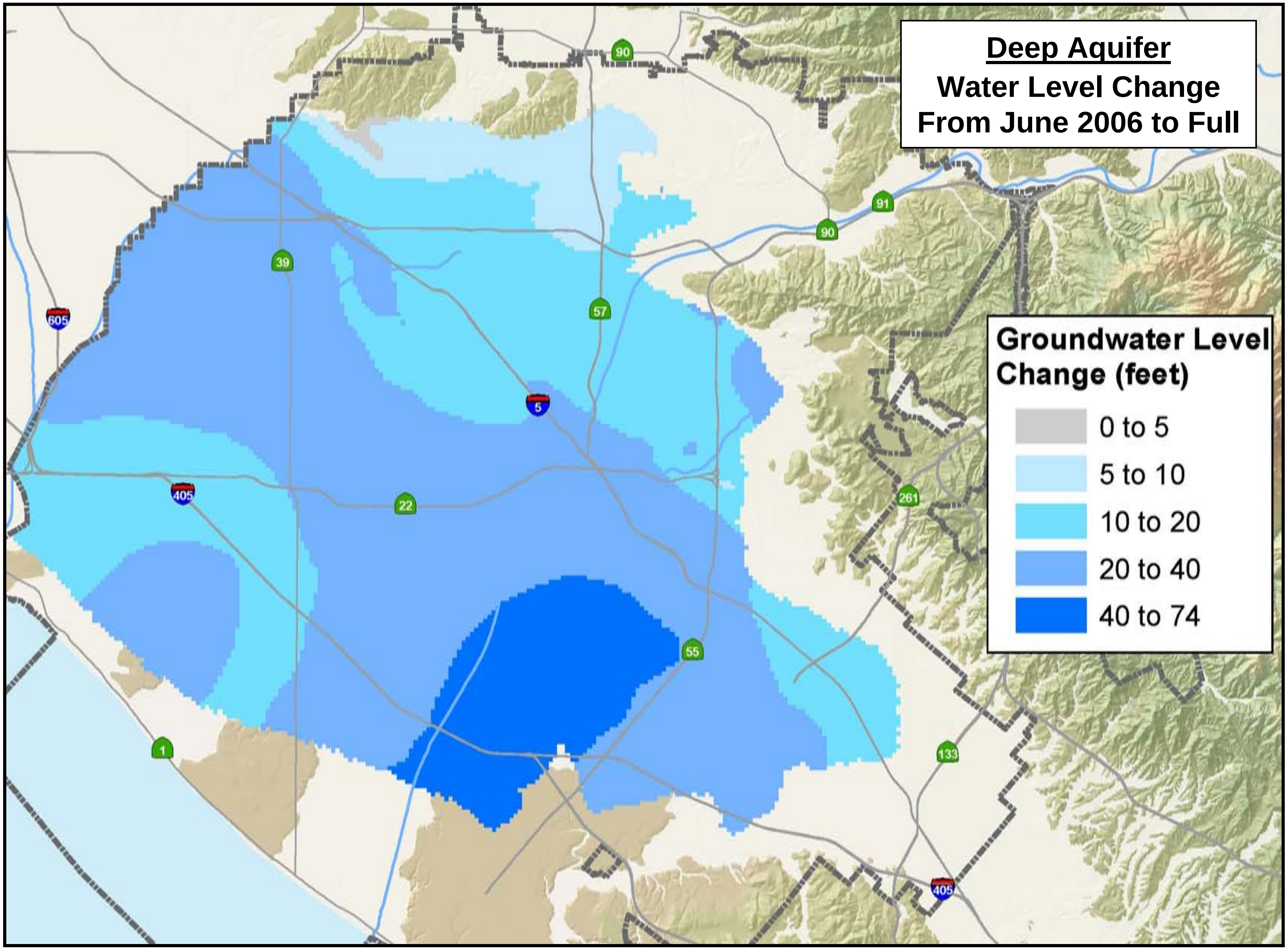
Water Level Change Maps

For June 2006 to the New Full Condition


Shallow Aquifer
Water Level Change
From June 2006 to Full
Groundwater Level Change (feet)
0 to 5
5 to 10
10 to 20
20 to 37
90
91
90
39
605
57
5
405
22
261
55
133
1
405



Principal Aquifer
Water Level Change
From June 2006 to Full
Groundwater Level Change (feet)
0 to 5
5 to 10
10 to 20
20 to 40
40 to 83
90
91
39
57
605
5
405
22
261
55
133
1


Deep Aquifer
Water Level Change
From June 2006 to Full
Groundwater Level Change (feet)
0 to 5
5 to 10
10 to 20
20 to 40
40 to 74
90
91
39
57
605
5
405
22
261
55
1
133

APPENDIX E

List of Wells in OCWD Monitoring Programs

List of Wells in OCWD Monitoring Programs

KEY

Aquifer Zone: S=Shallow Aquifer, P=Principal Aquifer, D= Deep Aquifer

Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
ABC-KISCH	ABC SCHOOL DIST.	0		0	0	Inactive Production		2
ABC-MESCH	ABC SCHOOL DIST.	0		0	0	Other Active Production		2
ABC-TETZL	ABC SCHOOL DIST.	0		0	0	Other Active Production		2
W-5470	ABC SCHOOL DIST.	282		190	240	Inactive Production		2
ACP-I03	AC PRODUCTIONUCTS	460		370	450	Injection		4
ACP-P01	AC PRODUCTIONUCTS	200		90	140	Inactive Production		2,3
ACP-P02	AC PRODUCTIONUCTS	190		100	180	Other Active Production		2
AVCC-P	ALTA VISTA COUNTRY CLUB	438		0	0	Other Active Production		2,3
AVCC-P2	ALTA VISTA COUNTRY CLUB	803		210	770	Other Active Production	P	2,3
A-14	ANAHEIM	450		309	425	Inactive Production	P	2,8
A-36	ANAHEIM	818		651	796	Inactive Production	P	2,7
A-39	ANAHEIM	1493		540	1280	Active Large Production	P	2,7
A-40	ANAHEIM	1308		505	1220	Active Large Production	P	2,7
A-41	ANAHEIM	1532		437	1450	Active Large Production	P	2,7
A-42	ANAHEIM	1260		430	1180	Active Large Production	P	2,7
A-43	ANAHEIM	1400		530	1210	Active Large Production	P	2,7
A-44	ANAHEIM	1155		450	1130	Active Large Production	P	2,7
A-45	ANAHEIM	1430		455	1410	Active Large Production	P	2,7
A-46	ANAHEIM	1565		599	1529	Active Large Production	P	2,7
A-47	ANAHEIM	1500		482	1375	Active Large Production	P	2,7,8
A-48	ANAHEIM	1450		932	1344	Active Large Production	P	2,7
A-49	ANAHEIM	1498		580	1450	Active Large Production	P	2,7,8
A-51	ANAHEIM	1310		525	965	Active Large Production	P	2,7
A-52	ANAHEIM	1210		570	1066	Active Large Production	P	2,7
A-53	ANAHEIM	1350		945	1270	Active Large Production	P	2,7
A-54	ANAHEIM	0		680	1480	Active Large Production	P	2,7
A-55	ANAHEIM	1340		370	1300	Active Large Production	P	2,7
A-56	ANAHEIM	1600		725	1300	Active Large Production	P	2,7
A-58	ANAHEIM	1218		400	930	Inactive Production		2,7
ADEV-AM1	ANAHEIM	157		110	150	Monitoring		1
A-DMGC	ANAHEIM	500		430	482	Other Active Production	P	2,3
A-YARD-MW1	ANAHEIM	112		85	109	Monitoring		1
A-YARD-MW2	ANAHEIM	111		86	110	Monitoring		1
W-15896	ANAHEIM MOTEL, LIMITED	200		0	0	Inactive Production		2,3
ANGE-O	ANGELICA HEALTHCARE SERVICES	670		186	639	Other Active Production		2,3
AET-RMW10	ARCO/TOSCO/EQUIVA	129		127	128	Monitoring		1
AET-RMW14	ARCO/TOSCO/EQUIVA	197		195	196	Monitoring		1
AET-RMW15	ARCO/TOSCO/EQUIVA	142		140	141	Monitoring		1
AET-RMW16	ARCO/TOSCO/EQUIVA	200		189	190	Monitoring		1
AET-RMW17	ARCO/TOSCO/EQUIVA	218		217	218	Monitoring		1
AET-RMW2	ARCO/TOSCO/EQUIVA	199		196	197	Monitoring		1
AET-RMW20	ARCO/TOSCO/EQUIVA	100		98	99	Monitoring		1
AET-RMW23	ARCO/TOSCO/EQUIVA	124		119	120	Monitoring		1
AET-RMW3	ARCO/TOSCO/EQUIVA	200		194	195	Monitoring		1
AET-RMW5	ARCO/TOSCO/EQUIVA	200		195	196	Monitoring		1
AET-RMW6	ARCO/TOSCO/EQUIVA	184		116	117	Monitoring		1
AET-RMW7	ARCO/TOSCO/EQUIVA	113		108	109	Monitoring		1
AET-RMW8	ARCO/TOSCO/EQUIVA	98		94	95	Monitoring		1
AET-RMW9	ARCO/TOSCO/EQUIVA	112		107	108	Monitoring		1
ARMD-LA3	ARMED FORCES RESERVE CENTER	965		333	363	Inactive Production		2
ARMD-LARA	ARMED FORCES RESERVE CENTER	0		0	0	Inactive Production		2
AR-PUMP	ARTESIA	217		0	0	Other Active Production		2,3
W-14107	ARTESIA ICE CO.	51		0	0	Inactive Production		2,3
ARCO-FBH11	ATLANTIC RICHFIELD CO.	62		50	62	Monitoring		1
ARCO-FBH12	ATLANTIC RICHFIELD CO.	75		55	75	Monitoring		1
ARCO-FBH14	ATLANTIC RICHFIELD CO.	75		0	0	Monitoring		1
ARCO-FBH17	ATLANTIC RICHFIELD CO.	140		124	139	Monitoring		1
ARCO-FBH5	ATLANTIC RICHFIELD CO.	75		0	0	Monitoring		1
ARCO-FBH6	ATLANTIC RICHFIELD CO.	80		48	80	Monitoring		1
ARCO-T2209	ATLANTIC RICHFIELD CO.	150		82	143	Injection		4
BF-BF1	BELLFLOWER	1200		574	1160	Active Large Production		2
PEER-17	BELLFLOWER MUNICIPAL WATER CO.	1030		610	1012	Active Small Production		2
PEER-2	BELLFLOWER MUNICIPAL WATER CO.	204		162	177	Active Large Production		2
PEER-7	BELLFLOWER MUNICIPAL WATER CO.	108		0	0	Active Small Production		2
PEER-8	BELLFLOWER MUNICIPAL WATER CO.	174		113	153	Other Active Production		2
FUJI-FV	BERUMEN FARMS	170		0	0	Other Active Production		2,3
FUJI-WM	BERUMEN FARMS	150		0	0	Inactive Production		2,3

List of Wells in OCWD Monitoring Programs

KEY

Aquifer Zone: S=Shallow Aquifer, P=Principal Aquifer, D= Deep Aquifer

Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
BOE-EW101	BOEING CO.	77		57	77	Other Active Production	S	2
BOE-EW102	BOEING CO.	87		62	82	Other Active Production	S	2
BOE-EW103	BOEING CO.	85		63	83	Other Active Production	S	2
BOE-EW104	BOEING CO.	83		57	82	Other Active Production	S	2
BOE-MW16	BOEING CO.	297		260	280	Monitoring		1,6
BOE-MW17	BOEING CO.	298		255	275	Monitoring		1,6
BOE-MW19A	BOEING CO.	173		153	173	Monitoring		1,6
BOE-MW20S	BOEING CO.	84		59	80	Monitoring	S	1
BOE-MW21S	BOEING CO.	81		59	79	Monitoring	S	1
BOE-MW27A	BOEING CO.	172		139	159	Monitoring		1,6
BOE-MW31S	BOEING CO.	92		78	88	Monitoring	S	1
BOE-MW34	BOEING CO.	278		252	267	Monitoring		1,6
BOE-MW37A	BOEING CO.	172		135	165	Monitoring		1,6
BOE-MW38A	BOEING CO.	170		135	165	Monitoring		1,6
BOE-MW41A	BOEING CO.	177		149	169	Monitoring		1,6
BOE-MW42A	BOEING CO.	173		140	170	Monitoring		1,6
BOE-MW57A	BOEING CO.	172		150	170	Monitoring		1,6
BOE-MW58A	BOEING CO.	175		150	170	Monitoring		1,6
BOE-MW59B	BOEING CO.	268		240	250	Monitoring		1,6
BOE-MW60A	BOEING CO.	172		150	170	Monitoring		1,6
BOE-MW61A	BOEING CO.	172		150	170	Monitoring		1,6
BOE-MW72A	BOEING CO.	132		112	127	Monitoring		1,6
BOE-MW73A	BOEING CO.	137		113	133	Monitoring		1,6
BOE-MW75	BOEING CO.	227		202	222	Monitoring		1,6
BOE-MW95A	BOEING CO.	172		135	165	Monitoring		1,6
BOE-MW96A	BOEING CO.	175		150	170	Monitoring		1,6
BOE-MW97A	BOEING CO.	215		170	175	Monitoring		1,6
BOE-MW98A	BOEING CO.	215		169	174	Monitoring		1,6
BOE-MW99A	BOEING CO.	210		146	166	Monitoring		1,6
BOTT-C	BOTT TRACT MUTUAL WATER CO.	150		0	0	Other Active Production		2,3
LB-NLB10	BOY SCOUTS OF AMERICA	378		357	374	Monitoring		1
BR-1	BREA	500		78	115	Other Active Production		2,3
BROS-WM	BRORS OF ST.PATRICK	106		98	105	Other Active Production		2
BP-BALL	BUENA PARK	890		260	870	Active Large Production	P	2,7
BP-BOIS	BUENA PARK	1505		475	1355	Active Large Production	P	2,7
BP-CABA	BUENA PARK	1430		250	1010	Active Large Production	P	2,7
BP-FREE	BUENA PARK	1000		260	1000	Active Large Production	P	2,7
BP-HOLD	BUENA PARK	1020		250	1000	Active Large Production	P	2,7
BP-KNOT	BUENA PARK	1020		260	1000	Active Large Production	P	2,7
BP-LIND	BUENA PARK	1410		470	1221	Active Large Production	P	2,7
BP-SM	BUENA PARK	1038		308	1038	Active Large Production	P	2,7
OCWD-BGO10	CA STATE LANDS COMMISSION	110		80	100	Monitoring		1
SLC-MW1	CA STATE LANDS COMMISSION	25		5	25	Monitoring		1
SLC-MW10	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW11	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW12	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW13	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW14	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW15	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW16	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW2	CA STATE LANDS COMMISSION	25		5	25	Monitoring		1
SLC-MW3	CA STATE LANDS COMMISSION	25		5	25	Monitoring		1
SLC-MW4	CA STATE LANDS COMMISSION	25		5	25	Monitoring		1
SLC-MW5	CA STATE LANDS COMMISSION	25		5	25	Monitoring		1
SLC-MW6	CA STATE LANDS COMMISSION	25		5	25	Monitoring		1
SLC-MW7	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW8	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-MW9	CA STATE LANDS COMMISSION	32		10	30	Monitoring		1
SLC-P10	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P11	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P13	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P14	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P15	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P16	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P17	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P18	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P19	CA STATE LANDS COMMISSION	40		5	20	Monitoring		1

List of Wells in OCWD Monitoring Programs

KEY

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Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
SLC-P20	CA STATE LANDS COMMISSION	25		5	10	Monitoring		1
SLC-P21	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P22	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P23	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P24	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P25	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P26	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P27	CA STATE LANDS COMMISSION	40		5	20	Monitoring		1
SLC-P29	CA STATE LANDS COMMISSION	25		6	21	Monitoring		1
SLC-P30	CA STATE LANDS COMMISSION	46		22	37	Monitoring		1
SLC-P31	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P32	CA STATE LANDS COMMISSION	25		8	23	Monitoring		1
SLC-P33	CA STATE LANDS COMMISSION	40		6	21	Monitoring		1
SLC-P34	CA STATE LANDS COMMISSION	40		6	21	Monitoring		1
SLC-P35	CA STATE LANDS COMMISSION	40		7	22	Monitoring		1
SLC-P36	CA STATE LANDS COMMISSION	40		6	21	Monitoring		1
SLC-P4	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
SLC-P5	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P6	CA STATE LANDS COMMISSION	25		5	15	Monitoring		1
SLC-P9	CA STATE LANDS COMMISSION	25		5	20	Monitoring		1
CIFM-CH	CA. INSTITUE FOR MEN - CHINO	239		122	226	Other Active Production		2
CIFM-CH1A	CA. INSTITUE FOR MEN - CHINO	529		0	0	Other Active Production		2
CSF-1	CA. STATE UNIV., FULLERTON	842		130	726	Multiport Monitoring	S/P/D	1
FPRK-YLE	CANYON RV PARK	98		60	84	Active Small Production	S	2,7
FPRK-YLW	CANYON RV PARK	98		48	80	Active Small Production	S	2,7
CARD-O	CARDINAL MANAGEMENT	70		0	0	Other Active Production		2,3
MKSSN-A	CCDA WATERS, LLC	800		635	755	Other Active Production		2,3
CE-C1	CERRITOS	1035		295	976	Active Large Production		2
CE-C2	CERRITOS	1050		280	980	Active Large Production		2
CE-C4	CERRITOS	1030		305	955	Active Large Production		2
CHEV-HBP4	CHEVRON U.S.A. - LA HABRA	680		490	640	Inactive Production		2,3
CHEV-NOR4	CHEVRON U.S.A. - LA HABRA	1023		990	1005	Inactive Production		2,3
W-18110	CHEVRON U.S.A.-HUNTINGTON BCH.	116		85	115	Monitoring		1
PLMP-YL	CITY OIL CORP	77		0	0	Inactive Production		2,3
CCOL-C	COMMUNITY COLLEGE DIST.	395		365	395	Other Active Production		2,3
COMM-LP	COMMUNITY WATER ASSOC.	0		0	0	Inactive Production		2
CNXT-NBEI1	CONEXANT SYSTEMS, INC.	100		60	100	Inactive Production		2
CNXT-NBEI2	CONEXANT SYSTEMS, INC.	100		60	100	Inactive Production		2
CNXT-NBEI3	CONEXANT SYSTEMS, INC.	100		60	100	Inactive Production		2
CNXT-NBEI4A	CONEXANT SYSTEMS, INC.	104		65	100	Inactive Production		2
CNXT-NBES1	CONEXANT SYSTEMS, INC.	43		22	42	Inactive Production		2
CNXT-NBES2	CONEXANT SYSTEMS, INC.	45		21	41	Inactive Production		2
CNXT-NBES3A	CONEXANT SYSTEMS, INC.	46		24	44	Inactive Production		2
CNXT-NBES4B	CONEXANT SYSTEMS, INC.	47		23	43	Inactive Production		2
CNXT-NBES5A	CONEXANT SYSTEMS, INC.	42		20	40	Inactive Production		2
CNXT-NBES6	CONEXANT SYSTEMS, INC.	45		25	40	Inactive Production		2
CNXT-NBI17	CONEXANT SYSTEMS, INC.	105		0	0	Injection		4
CNXT-NBMW27	CONEXANT SYSTEMS, INC.	40		10	40	Monitoring		1
CNXT-NBMW28	CONEXANT SYSTEMS, INC.	82		60	82	Monitoring		1
CNXT-NBMW29	CONEXANT SYSTEMS, INC.	42		21	40	Monitoring		1
CNXT-NBMW30	CONEXANT SYSTEMS, INC.	42		21	42	Monitoring		1
CNXT-NBRI1	CONEXANT SYSTEMS, INC.	105		77	102	Injection		4
CNXT-NBRI2	CONEXANT SYSTEMS, INC.	115		75	110	Injection		4
CNXT-NBRI3	CONEXANT SYSTEMS, INC.	122		75	115	Injection		4
CNXT-NBRI4	CONEXANT SYSTEMS, INC.	97		0	0	Injection		4
CO-16	CORONA	850		415	755	Active Large Production		2
CMW-CO	CORONITA MUTUAL WATER CO.	270		126	234	Other Active Production		2
MCWD-GC	COSTA MESA	225		195	215	Monitoring		1,6
W-3799	COSTA MESA SCHOOL DIST.	297		0	0	Inactive Production		2,3
CCC-LA1	COTTONWOOD CHRISTIAN CENTER	340		140	310	Other Active Production		2
MRCF-GG	CROSBY WATER SYSTEM	240		0	0	Other Active Production		2
MBF-FM2	CT STORAGE - FULLERTON, LLC	135		110	134	Monitoring		1,8
MBF-FM3	CT STORAGE - FULLERTON, LLC	135		110	134	Monitoring		1,8
FJC-LAK2	CYPRESS GC LLC/CYPRESS GOLF CL	620		300	570	Other Active Production	P	2,3
W-18698	DEGUSSA FLAVOR & FRUIT SYSTEMS	90		70	90	Monitoring		1
OCWD-BS103	DEPT. OF WATER RESOURCES	484		184	205	Monitoring	S	1,6
OCWD-BS105	DEPT. OF WATER RESOURCES	394		150	197	Monitoring	S	1,6

List of Wells in OCWD Monitoring Programs

KEY

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
OCWD-BS106	DEPT. OF WATER RESOURCES	556		213	255	Monitoring	S	1,6
OCWD-BS107	DEPT. OF WATER RESOURCES	738		398	441	Monitoring		1,6
OCWD-BS111	DEPT. OF WATER RESOURCES	483		184	205	Monitoring		1,6
OCWD-BSO1A	DEPT. OF WATER RESOURCES	500		245	335	Monitoring		1
OCWD-BSO1B	DEPT. OF WATER RESOURCES	500		80	104	Monitoring		1
OCWD-BSO4	DEPT. OF WATER RESOURCES	700		268	498	Monitoring		1
OCWD-BSO6A	DEPT. OF WATER RESOURCES	150		85	135	Monitoring		1,6
OCWD-BSO6B	DEPT. OF WATER RESOURCES	305		235	295	Monitoring		1,6
OCWD-BSO9A	DEPT. OF WATER RESOURCES	445		195	285	Monitoring	S	1,6
OCWD-BSO9B	DEPT. OF WATER RESOURCES	624		520	615	Monitoring	P	1,6
OCWD-BSO9C	DEPT. OF WATER RESOURCES	450		340	435	Monitoring		1,6
OCWD-SA10	DEPT. OF WATER RESOURCES	483		300	330	Monitoring	S/P	1,6
OCWD-SA12	DEPT. OF WATER RESOURCES	715		305	325	Monitoring	S	1
OCWD-SA3	DEPT. OF WATER RESOURCES	401		100	160	Monitoring	S	1,6
OCWD-SA5	DEPT. OF WATER RESOURCES	401		273	312	Monitoring	P	1,6
DICE-SA2	DIAMONITORINGD ICE CORP	1003		330	990	Inactive Production		2,3
SSPG-O	DS WATERS OF AMERICA, INC.	270		250	270	Inactive Production		2
EOCW-E	EAST ORANGE COUNTY WATER DIST.	504		324	450	Active Large Production	P	2,7
EOCW-W	EAST ORANGE COUNTY WATER DIST.	800		315	450	Active Large Production	P	2,7
LKVG-YL	EASTLAKE VILLAGE HOA	124		50	124	Other Active Production		2,3
ESWA-4	EASTSIDE WATER ASSOC.	560		240	520	Active Small Production		2,7
EDGW-SA	EDINGER WATER ASSOC.	308		0	0	Inactive Production		2
EMA-FVRI	ENVIRONMENTAL MGMT AGENCY	0		0	0	Other Active Production		2,3
ALEN-GG	EUCHARISTIC MISSIONARIES	252		0	0	Other Active Production		2
SAKH-A	F S NURSERY	383		0	0	Other Active Production		2,3
FAIR-SA	FAIRHAVEN MEMORIAL PARK	427		0	0	Inactive Production		2,3
FAIR-SA3	FAIRHAVEN MEMORIAL PARK	520		250	500	Other Active Production		2,3
FAA-LA1	FEDERAL AVAIATION ADMIN.	0		0	0	Other Active Production		2,3
FLWN-CQ2	FOREST LAWN	590		160	560	Other Active Production		2,3
FV-10	FOUNTAIN VALLEY	1100		460	980	Active Large Production	P	2,7
FV-11	FOUNTAIN VALLEY	1027		440	950	Active Large Production	P	2,7
FV-12	FOUNTAIN VALLEY	1230		340	1070	Active Large Production	P	2,7
FV-6	FOUNTAIN VALLEY	1150		370	1110	Active Large Production	P	2,7
FV-8	FOUNTAIN VALLEY	920		312	844	Active Large Production	P	2,7
FV-9	FOUNTAIN VALLEY	1114		415	1070	Active Large Production	P	2,7
W-3791	FOUNTAIN VALLEY	0		0	0	Inactive Production		2
F-10	FULLERTON	1350		460	1290	Active Large Production	P	2,7,8
F-3A	FULLERTON	1295		580	1280	Active Large Production	P	2,7,8
F-4	FULLERTON	415		315	405	Active Large Production	P	2,7,8
F-5	FULLERTON	440		350	400	Active Large Production	P	2,7,8
F-6	FULLERTON	430		340	401	Active Large Production	P	2,7,8
F-7	FULLERTON	434		300	410	Active Large Production	P	2,7,8
F-8	FULLERTON	458		324	402	Active Large Production	P	2,7,8
F-AIRP	FULLERTON	1135		435	1080	Active Large Production	P	2,7
F-CHRI2	FULLERTON	1350		520	1330	Active Large Production	P	2,7,8
F-COYO2	FULLERTON	1517		309	919	Inactive Production	P	2
F-KIM1A	FULLERTON	1243		500	1225	Active Large Production	P	2,7,8
F-KIM2	FULLERTON	652		320	626	Active Large Production	P	2,7,8
GG-16	GARDEN GROVE	1000		304	864	Active Large Production	P	2,7
GG-19	GARDEN GROVE	942		818	892	Active Large Production	P	2,7
GG-20	GARDEN GROVE	960		360	912	Active Large Production	P	2,7
GG-21	GARDEN GROVE	1187		428	1080	Active Large Production	P	2,7
GG-22	GARDEN GROVE	1040		416	1020	Active Large Production	P	2,7
GG-23	GARDEN GROVE	860		474	835	Active Large Production	P	2,7
GG-25	GARDEN GROVE	987		442	850	Active Large Production	P	2,7
GG-26	GARDEN GROVE	1120		470	1060	Active Large Production	P	2,7
GG-27	GARDEN GROVE	1215		520	1160	Active Large Production	P	2,7
GG-28	GARDEN GROVE	328		130	240	Active Large Production	S	2,7
GG-29	GARDEN GROVE	1140		465	1110	Active Large Production	P	2,7
GG-30	GARDEN GROVE	1205		390	1146	Active Large Production	P	2,7
GG-31	GARDEN GROVE	1462		739	1373	Active Large Production	P	2,7
WWGC-SAK3	GARDEN GROVE	206		149	170	Other Active Production	S	2,3
WWGC-SAK4	GARDEN GROVE	272		150	249	Other Active Production		2,3
W-15829	GARDEN GROVE UNIF. SCH. DIST.	209		0	0	Inactive Production		2,3
W-4220	GENERAL SERVICE ADMIN.	900		264	887	Inactive Production		2
W-4224	GENERAL SERVICE ADMIN.	602		378	438	Inactive Production		2,3
W-4226	GENERAL SERVICE ADMIN.	586		271	372	Inactive Production		2,3

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
W-4856	GENERAL SERVICE ADMIN.	804		247	427	Inactive Production		2
GSWC-HGC6	GOLDEN STATE WATER CO - LA	1295		180	1170	Active Large Production		2
SCWC-ARR1	GOLDEN STATE WATER CO - LA	1026		919	965	Active Small Production		2
SCWC-HGC3	GOLDEN STATE WATER CO - LA	860		110	852	Inactive Production		2
SCWC-HGC4	GOLDEN STATE WATER CO - LA	861		110	856	Inactive Production		2
SCWC-HGCAR	GOLDEN STATE WATER CO - LA	570		121	327	Inactive Production		2
SCWC-HGJ4	GOLDEN STATE WATER CO - LA	890		530	710	Active Large Production		2
SCWC-LKHAW	GOLDEN STATE WATER CO - LA	822		200	796	Active Large Production		2
SCWC-LKMA	GOLDEN STATE WATER CO - LA	885		215	830	Active Large Production		2
SCWC-NWDAC1	GOLDEN STATE WATER CO - LA	380		0	0	Other Active Production		2
SCWC-NWIMP1	GOLDEN STATE WATER CO - LA	0		0	0	Other Active Production		2
SCWC-NWIMP2	GOLDEN STATE WATER CO - LA	399		0	0	Other Active Production		2
SCWC-NWIMP3	GOLDEN STATE WATER CO - LA	890		0	890	Other Active Production		2
W-17720	GOLDEN STATE WATER CO - LA	0		0	0	Other Active Production		2
GSWC-POR1	GOLDEN STATE WATER CO - OC	1129		350	895	Active Large Production	P	2,7
GSWC-SCL5	GOLDEN STATE WATER CO - OC	1416		700	1000	Active Large Production	P	2,7
RHWC-E	GOLDEN STATE WATER CO - OC	945		410	920	Active Large Production	P	2,7
RHWC-W2	GOLDEN STATE WATER CO - OC	954		474	753	Active Large Production	P	2,7
SCWC-CBAL	GOLDEN STATE WATER CO - OC	990		200	770	Active Large Production	P	2,7
SCWC-CSC	GOLDEN STATE WATER CO - OC	600		526	556	Active Large Production	P	2,7
SCWC-CVV	GOLDEN STATE WATER CO - OC	670		524	645	Active Large Production	P	2,7
SCWC-CVV2	GOLDEN STATE WATER CO - OC	1010		480	981	Active Large Production	P	2,7
SCWC-LABL2	GOLDEN STATE WATER CO - OC	708		460	690	Active Large Production	P	2,7
SCWC-LAC3	GOLDEN STATE WATER CO - OC	632		346	593	Active Large Production	P	2,7
SCWC-LAFL	GOLDEN STATE WATER CO - OC	720		300	680	Active Large Production	P	2,7
SCWC-LAHO	GOLDEN STATE WATER CO - OC	520		386	486	Active Large Production	P	2,7
SCWC-LAYT	GOLDEN STATE WATER CO - OC	812		250	800	Active Large Production	P	2,6,7
SCWC-PBF3	GOLDEN STATE WATER CO - OC	496		220	475	Active Large Production	P	2,7,8
SCWC-PBF4	GOLDEN STATE WATER CO - OC	550		275	520	Active Large Production	P	2,7,8
SCWC-PLJ2	GOLDEN STATE WATER CO - OC	505		402	492	Active Large Production	P	2,7,8
SCWC-PRU	GOLDEN STATE WATER CO - OC	837		430	790	Active Large Production	P	2,7
SCWC-SBCH	GOLDEN STATE WATER CO - OC	600		200	570	Active Large Production	P	2,7
SCWC-SCL4	GOLDEN STATE WATER CO - OC	530		294	488	Active Large Production	P	2,7
SCWC-SDAL	GOLDEN STATE WATER CO - OC	562		500	542	Active Large Production	P	2,7
SCWC-SLON	GOLDEN STATE WATER CO - OC	778		0	0	Active Large Production	P	2,7
SCWC-SORG	GOLDEN STATE WATER CO - OC	302		242	286	Active Large Production	P	2,7
SCWC-SSHR	GOLDEN STATE WATER CO - OC	618		520	580	Active Large Production	P	2,7
SCWC-SSYC	GOLDEN STATE WATER CO - OC	568		500	546	Active Large Production	P	2,7
SCWC-YLCO2	GOLDEN STATE WATER CO - OC	504		100	480	Inactive Production		2
GWRC-SFS8	GOLDEN WEST REFINING CO.	0		0	0	Other Active Production		2
GOOD-HB	GOOD SHEPHERD CEMETERY	244		180	218	Other Active Production		2,3,6
ETCH-AL2	GOODWIN MUTUAL WATER CO.	200		85	185	Inactive Production	S	2,3
GRV-RSIR	GREEN RIVER VILLIAGE	85		50	82	Other Active Production		2,3
HALD-BP	HALDOR PLACE MUTUAL WATER	265		0	0	Inactive Production		2
HMEM-COS	HARBOR LAWN MEMORIAL PARK	280		190	200	Monitoring		1,6
HOLY-A	HOLY CROSS CEMETERY	365		334	364	Other Active Production	P	2,3
HOUS-F	HOUSTON AVE. WATER	156		0	0	Other Active Production		2
W-14801	HUGHES AIRCRAFT CO.	155		135	155	Monitoring		1
W-14803	HUGHES AIRCRAFT CO.	165		144	164	Monitoring		1
HB-1	HUNTINGTON BEACH	306		258	297	Inactive Production		2,6
HB-10	HUNTINGTON BEACH	1000		232	942	Active Large Production	P	2,7
HB-12	HUNTINGTON BEACH	807		265	740	Inactive Production		2,6
HB-13	HUNTINGTON BEACH	860		280	810	Active Large Production	P	2,6,7
HB-3A	HUNTINGTON BEACH	738		370	640	Active Large Production	P	2,6,7
HB-4	HUNTINGTON BEACH	826		252	804	Active Large Production	P	2,6,7
HB-5	HUNTINGTON BEACH	830		223	800	Active Large Production	P	2,7
HB-6	HUNTINGTON BEACH	876		246	810	Active Large Production	P	2,7
HB-7	HUNTINGTON BEACH	930		263	879	Active Large Production	P	2,6,7
HB-8	HUNTINGTON BEACH	1172		256	704	Inactive Production	P	2
HB-9	HUNTINGTON BEACH	1010		556	996	Active Large Production	P	2,7
HB-MEA2	HUNTINGTON BEACH	537		480	510	Or Active Production	P	2,3
W-15104	HUNTINGTON BEACH CO.	130		90	125	Inactive Production		2
W-15819	HUNTINGTON BEACH CO.	181		0	0	Inactive Production		2
W-15821	HUNTINGTON BEACH CO.	155		0	0	Inactive Production		2
W-15823	HUNTINGTON BEACH CO.	123		0	0	Inactive Production		2
HUNT-P13	HUNTINGTON CONDO ASSOC.	9		0	9	Monitoring		1
HUNT-P14	HUNTINGTON CONDO ASSOC.	10		0	10	Monitoring		1

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
HUNT-P7	HUNTINGTON CONDO ASSOC.	19		4	20	Monitoring		1
OCWD-HH2	HUNTINGTON HARBOUR CORP	150		130	140	Monitoring	S	1,6
OCWD-HH3	HUNTINGTON HARBOUR CORP	150		133	143	Monitoring	S	1,6
OCWD-HH4	HUNTINGTON HARBOUR CORP	145		130	140	Monitoring	S	1,6
OCWD-HH5	HUNTINGTON HARBOUR CORP	138		102	112	Monitoring	S	1,6
OCWD-HH6A	HUNTINGTON HARBOUR CORP	55		40	50	Monitoring		1,6
OCWD-HH6B	HUNTINGTON HARBOUR CORP	110		90	100	Monitoring	S	1,6,10
OCWD-HH6C	HUNTINGTON HARBOUR CORP	202		170	180	Monitoring		1,6
HYNS-S1	HYNES ESTATES, INC.	250		0	0	Active Small Production		2,7
HYNS-S2	HYNES ESTATES, INC.	182		162	182	Active Small Production	S	2,7
IWMD-LVM2	INTERGRATED WASTE MGMT. DIST.	248		223	243	Monitoring		1
IWMD-LVM3	INTERGRATED WASTE MGMT. DIST.	253		223	253	Monitoring		1
IWMD-LVM4	INTERGRATED WASTE MGMT. DIST.	247		206	246	Monitoring		1
IWMD-RPM3	INTERGRATED WASTE MGMT. DIST.	101		76	101	Monitoring		1
IWMD-RPM5	INTERGRATED WASTE MGMT. DIST.	102		70	100	Monitoring		1
TIC-108	IRVINE CO.	1045		200	960	Inactive Production	P	2,3
TIC-194	IRVINE CO.	822		562	726	Monitoring	P/D	1,9
TIC-25	IRVINE CO.	790		666	760	Monitoring	P/D	1,10
TIC-50	IRVINE CO.	1488		475	1070	Monitoring		1
TIC-61	IRVINE CO.	762		240	695	Inactive Production	P	2,3
TIC-80	IRVINE CO.	1553		415	1300	Monitoring		1
TIC-99	IRVINE CO.	692		346	650	Monitoring	P	1
W-285	IRVINE CO.	93		37	84	Inactive Production		2,3
ET-1	IRVINE RANCH WATER DIST.	520		220	490	Other Active Production	P	2,3
ET-2	IRVINE RANCH WATER DIST.	1120		280	1080	Other Active Production	P	2,3
IRWD-1	IRVINE RANCH WATER DIST.	2020		410	860	Active Large Production	P	2,7
IRWD-10	IRVINE RANCH WATER DIST.	1040		419	940	Active Large Production	P	2,7
IRWD-107R	IRVINE RANCH WATER DIST.	1060		275	1000	Active Large Production	P	2,7
IRWD-11	IRVINE RANCH WATER DIST.	1300		410	870	Active Large Production	P	2,7
IRWD-110	IRVINE RANCH WATER DIST.	1070		555	1015	Active Large Production	P	2,7
IRWD-115R	IRVINE RANCH WATER DIST.	1136		290	1080	Active Large Production		2,7
IRWD-12	IRVINE RANCH WATER DIST.	1424		580	1040	Active Large Production	P	2,7
IRWD-13	IRVINE RANCH WATER DIST.	1170		410	980	Active Large Production	P	2,7
IRWD-14	IRVINE RANCH WATER DIST.	1015		470	970	Active Large Production	P	2,7
IRWD-15	IRVINE RANCH WATER DIST.	1085		470	990	Active Large Production	P	2,7
IRWD-16	IRVINE RANCH WATER DIST.	1010		406	807	Active Large Production	P	2,7
IRWD-17	IRVINE RANCH WATER DIST.	1019		504	960	Active Large Production	P	2,7
IRWD-18	IRVINE RANCH WATER DIST.	1120		390	1080	Active Large Production	P	2,7
IRWD-2	IRVINE RANCH WATER DIST.	1450		385	855	Active Large Production	P	2,7,9
IRWD-21	IRVINE RANCH WATER DIST.	1223		290	970	Active Large Production	P	2,7,9
IRWD-22	IRVINE RANCH WATER DIST.	1220		300	970	Active Large Production	P	2,7,9
IRWD-3	IRVINE RANCH WATER DIST.	1309		484	1250	Active Large Production	P	2,7,9
IRWD-4	IRVINE RANCH WATER DIST.	1146		440	910	Active Large Production	P	2,7
IRWD-5	IRVINE RANCH WATER DIST.	1075		554	1028	Active Large Production	P	2,7,9
IRWD-52	IRVINE RANCH WATER DIST.	1400		635	1290	Inactive Production		2,7,9
IRWD-6	IRVINE RANCH WATER DIST.	1175		499	1124	Active Large Production	P	2,7,9
IRWD-7	IRVINE RANCH WATER DIST.	2731		359	660	Active Large Production	P	2,7
IRWD-72	IRVINE RANCH WATER DIST.	1192		254	1151	Other Active Production	P	2,3
IRWD-76	IRVINE RANCH WATER DIST.	1055		450	900	Active Large Production	P	2,7
IRWD-77	IRVINE RANCH WATER DIST.	1000		330	980	Active Large Production	P	2,7
IRWD-78R	IRVINE RANCH WATER DIST.	1010		250	730	Other Active Production	P	2,3
IRWD-98	IRVINE RANCH WATER DIST.	355		115	343	Inactive Production	P	2,3
IRWD-C8	IRVINE RANCH WATER DIST.	2065		1080	1982	Active Large Production	D	2,7
IRWD-C9	IRVINE RANCH WATER DIST.	2106		1055	1930	Active Large Production	D	2,7
IRWD-LA1	IRVINE RANCH WATER DIST.	800		200	790	Inactive Production		2
IRWD-LA3	IRVINE RANCH WATER DIST.	800		0	0	Inactive Production		2
IRWD-LA4	IRVINE RANCH WATER DIST.	810		350	790	Inactive Production		2
IRWD-LA5	IRVINE RANCH WATER DIST.	820		350	780	Inactive Production		2
IRWD-LA7	IRVINE RANCH WATER DIST.	1000		430	980	Inactive Production		2
IRWD-LF2	IRVINE RANCH WATER DIST.	808		280	640	Active Large Production		2
IRWD-MICH10	IRVINE RANCH WATER DIST.	0		0	0	Other Active Production		2
IRWD-MICH2	IRVINE RANCH WATER DIST.	0		30	50	Other Active Production		2
IRWD-MICH3	IRVINE RANCH WATER DIST.	0		30	50	Other Active Production		2
IRWD-MICH4	IRVINE RANCH WATER DIST.	0		17	67	Other Active Production		2
IRWD-MICH5	IRVINE RANCH WATER DIST.	0		17	67	Other Active Production		2
IRWD-MICH6	IRVINE RANCH WATER DIST.	0		40	70	Other Active Production		2
IRWD-MICH7	IRVINE RANCH WATER DIST.	0		40	70	Other Active Production		2

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
IRWD-MICH8	IRVINE RANCH WATER DIST.	0		40	70	Other Active Production		2
IRWD-MICH9	IRVINE RANCH WATER DIST.	0		17	67	Other Active Production		2
IRWD-OPA1	IRVINE RANCH WATER DIST.	1000		390	750	Inactive Production		2,7
TIC-106	IRVINE RANCH WATER DIST.	725		405	715	Other Active Production	P	2,3
TIC-109	IRVINE RANCH WATER DIST.	1145		240	1120	Inactive Production	P	2,3
TIC-112	IRVINE RANCH WATER DIST.	1141		240	1100	Inactive Production	P	2,3
TIC-114	IRVINE RANCH WATER DIST.	1000		300	960	Inactive Production	P	2,3
TIC-55	IRVINE RANCH WATER DIST.	746		300	497	Inactive Production		2,3
TIC-82	IRVINE RANCH WATER DIST.	1145		410	1002	Monitoring	P	1
W-14556	IRVINE RANCH WATER DIST.	0		17	67	Inactive Production		2
ITO-LA	ITO-OZAWA FARMS	860		70	710	Other Active Production		2,3
ITO-LAG3	ITO-OZAWA FARMS	800		170	780	Other Active Production		2,3
JLAW-HB	JANUARY & ELLIS LAW	135		0	0	Inactive Production		2
SAKI-FV	JKS-SF, LLC	450		304	438	Inactive Production		2,3
SULY-OA1	JMI PROPERTIES/SANTIAGO PRTNRS	120		0	0	Other Active Production		2,3
SULY-OA4	JMI PROPERTIES/SANTIAGO PRTNRS	130		0	0	Inactive Production	S	2,3
JWC-NWLEF	JUNIOR WATER CO.	480		416	426	Other Active Production		2
JWC-NWTAD	JUNIOR WATER CO.	614		361	587	Other Active Production		2
W-15825	KAREN STREET WATER CO.	100		0	0	Inactive Production		2
GKAW-FV2	KAWAGUCHI ENTERPRISES û LP	125		120	125	Other Active Production		2
MKAW-FV	KAWAGUCHI ENTERPRISES û LP	225		185	225	Other Active Production	S	2
KAYO-GG	KAYANO FARMS	0		0	0	Inactive Production		2,3
GARD-A	KINDRED COMMUNITY CHURCH	35		0	0	Other Active Production		2,3
KINGK-CE2	KING KELLY MARMILADE CO. INC.	0		0	0	Other Active Production		2
W-18116	KLEINFELDER & ASSOCIATES	250		238	248	Monitoring		1
W-18118	KLEINFELDER & ASSOCIATES	187		176	186	Monitoring		1
W-18120	KLEINFELDER & ASSOCIATES	255		243	253	Monitoring		1
KNOT-BP	KNOTT'S BERRY FARM	447		0	0	Other Active Production		2,3
KNOT-BPBS	KNOTT'S BERRY FARM	730		430	630	Active Small Production	P	2,7
W-14871	KOLL REAL ESTATE	600		0	0	Inactive Production		2,3
LH-2A	LA HABRA	1000		460	950	Active Large Production		2
LH-FS192	LA HABRA	1403		880	1210	Inactive Production		2,10
LH-LBPW	LA HABRA	1000		544	870	Active Large Production		2
LH-PPW	LA HABRA	1290		770	990	Inactive Production		2
LMP-MW	LA HABRA HEIGHTS WATER CO.	593		540	560	Monitoring		1
HALL-O	LA LINDA LLC	280		0	0	Inactive Production		2
LP-CITY	LA PALMA	1516		290	1415	Active Large Production	P	2,7
LP-WALK	LA PALMA	1020		489	919	Active Large Production	P	2,7
LMA-I	LAKES MASTER ASSOC.	0		0	0	Other Active Production		2,3
LW-10	LAKEWOOD	1148		448	471	Active Large Production		2
LW-13A	LAKEWOOD	1120		620	940	Active Large Production		2
LW-15A	LAKEWOOD	1050		470	1030	Active Large Production		2
LW-17	LAKEWOOD	1134		1064	1121	Active Large Production		2
LW-18	LAKEWOOD	1108		1041	1069	Active Large Production		2
LW-22	LAKEWOOD	1500		440	1060	Active Large Production		2
LW-27	LAKEWOOD	990		490	950	Active Large Production		2
LW-2A	LAKEWOOD	656		612	637	Active Large Production		2
LW-4	LAKEWOOD	716		367	388	Active Large Production		2
LW-6	LAKEWOOD	602		224	306	Other Active Production		2,3
LW-8	LAKEWOOD	405		352	380	Active Small Production		2
W-17351	LAKEWOOD	0		0	0	Inactive Production		2
LWPC-LWP1	LAKEWOOD WATER & POWER CO.	870		488	835	Other Active Production		2
LIBM-HB	LIBERTY PARK WATER ASSOC.	160		0	0	Active Small Production		2,6,7
LMC-EW1	LOCKHEED MARTIN CORP.	62		40	60	Other Active Production		2
LMC-EW2	LOCKHEED MARTIN CORP.	62		40	60	Other Active Production		2
LMC-EW3	LOCKHEED MARTIN CORP.	90		58	78	Other Active Production		2
LB-1017	LONG BEACH	875		140	540	Other Active Production		2,3
LB-1017B	LONG BEACH	675		0	0	Monitoring		1
LB-AL13	LONG BEACH	1030		559	902	Active Large Production		2
LB-AL8	LONG BEACH	982		515	978	Active Large Production		2
LB-AL9	LONG BEACH	1152		804	1130	Active Large Production		2
LB-AN201	LONG BEACH	854		507	838	Active Large Production		2
LB-AN204	LONG BEACH	1186		1124	1146	Other Active Production		2,3
LB-AN206	LONG BEACH	1170		300	471	Inactive Production		2
LB-AN26	LONG BEACH	610		364	590	Inactive Production		2
LB-CIT10	LONG BEACH	1020		300	988	Active Large Production		2
LB-CIT7A	LONG BEACH	950		300	898	Active Large Production		2

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
LB-CIT8	LONG BEACH	1516		310	1039	Active Small Production		2
LB-CIT9	LONG BEACH	850		300	808	Active Large Production		2
LB-COM10	LONG BEACH	900		540	685	Active Large Production		2
LB-COM13	LONG BEACH	1634		310	1539	Active Large Production		2
LB-COM14	LONG BEACH	1110		302	1072	Active Large Production		2
LB-COM15	LONG BEACH	1120		303	1008	Active Large Production		2
LB-COM16	LONG BEACH	1023		300	988	Active Large Production		2
LB-COM17	LONG BEACH	1030		300	988	Active Large Production		2
LB-COM18	LONG BEACH	0		303	988	Active Large Production		2
LB-COM19	LONG BEACH	1700		605	1640	Active Large Production		2
LB-COM20	LONG BEACH	1500		602	1240	Active Large Production		2
LB-COM21	LONG BEACH	1691		640	1370	Active Large Production		2
LB-COM22	LONG BEACH	1512		490	1160	Active Large Production		2
LB-COM23	LONG BEACH	1513		480	1020	Active Large Production		2
LB-COM24	LONG BEACH	1500		540	1411	Active Large Production		2
LB-COM25	LONG BEACH	1508		540	900	Active Large Production		2
LB-COM6A	LONG BEACH	1012		412	980	Monitoring		1
LB-DEV1	LONG BEACH	1017		959	1017	Active Large Production		2
LB-DEV2	LONG BEACH	684		390	684	Inactive Production		2
LB-DEV4	LONG BEACH	1004		400	972	Inactive Production		2
LB-DEV5	LONG BEACH	1016		267	990	Active Large Production		2
LB-DEV9	LONG BEACH	1030		260	1030	Active Large Production		2
LB-NLB11	LONG BEACH	2000		412	1431	Active Large Production		2
LB-NLB12	LONG BEACH	1058		300	1000	Active Large Production		2
LB-NLB4	LONG BEACH	1160		972	1142	Active Large Production		2
LB-NLB8	LONG BEACH	1180		1050	1100	Active Large Production		2
LB-NLB9	LONG BEACH	800		445	720	Active Large Production		2
LB-WIL1A	LONG BEACH	1370		272	1351	Active Large Production		2
LB-WS1A	LONG BEACH	1100		272	1078	Active Large Production		2
W-11412	LONG BEACH	639		458	630	Inactive Production		2,3
W-11460	LONG BEACH	994		0	0	Inactive Production		2
LART-CR2	LOS ALAMITOS RACE TRACT	0		0	0	Active Small Production		2,7
LAC-32LP8X	LOS ANGELES COUNTY	120		105	115	Monitoring		1
LAC-32LP8Z	LOS ANGELES COUNTY	945		325	335	Monitoring		1
LAC-32S9	LOS ANGELES COUNTY	885		189	199	Monitoring		1
LAC-32TP25	LOS ANGELES COUNTY	945		252	262	Monitoring		1
LAC-32U15	LOS ANGELES COUNTY	141		117	133	Monitoring		1
LAC-32V22	LOS ANGELES COUNTY	151		120	135	Monitoring		1
LAC-32VP10	LOS ANGELES COUNTY	210		145	180	Monitoring		1
LAC-32X11	LOS ANGELES COUNTY	196		135	165	Monitoring		1
LAC-32YP43	LOS ANGELES COUNTY	55		42	52	Monitoring		1
LAC-32ZP5	LOS ANGELES COUNTY	155		93	133	Monitoring		1
LAC-33D01	LOS ANGELES COUNTY	453		215	275	Monitoring		1
LAC-33D24	LOS ANGELES COUNTY	750		315	325	Monitoring		1
LAC-33DP22	LOS ANGELES COUNTY	825		210	220	Monitoring		1
LAC-33G	LOS ANGELES COUNTY	119		43	103	Injection		4
LAC-33G36	LOS ANGELES COUNTY	525		338	348	Monitoring		1
LAC-33G9	LOS ANGELES COUNTY	147		120	140	Monitoring		1
LAC-33GJ	LOS ANGELES COUNTY	140		52	115	Monitoring		1
LAC-33HP13	LOS ANGELES COUNTY	123		88	103	Monitoring		1
LAC-33J	LOS ANGELES COUNTY	134		66	126	Injection		4
LAC-33JL	LOS ANGELES COUNTY	147		52	137	Monitoring		1
LAC-33KP42	LOS ANGELES COUNTY	86		63	73	Monitoring		1
LAC-33L	LOS ANGELES COUNTY	144		56	136	Injection		4
LAC-33L23	LOS ANGELES COUNTY	405		349	359	Monitoring		1
LAC-33L30	LOS ANGELES COUNTY	73		50	65	Monitoring		1
LAC-33N	LOS ANGELES COUNTY	164		58	148	Injection		4
LAC-33N21	LOS ANGELES COUNTY	497		460	485	Monitoring		1
LAC-33NQ	LOS ANGELES COUNTY	177		60	160	Monitoring		1
LAC-33Q	LOS ANGELES COUNTY	174		69	164	Injection		4
LAC-33Q1	LOS ANGELES COUNTY	58		28	44	Injection		4
LAC-33Q15V	LOS ANGELES COUNTY	232		210	220	Monitoring		1
LAC-33Q15W	LOS ANGELES COUNTY	296		273	283	Monitoring		1
LAC-33Q15X	LOS ANGELES COUNTY	390		346	356	Monitoring		1
LAC-33Q9	LOS ANGELES COUNTY	223		115	145	Monitoring		1
LAC-33S	LOS ANGELES COUNTY	207		73	194	Injection		4
LAC-33S1	LOS ANGELES COUNTY	63		25	45	Injection		4

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
LAC-33S18U	LOS ANGELES COUNTY	101		73	83	Monitoring		1
LAC-33S18V	LOS ANGELES COUNTY	295		231	241	Monitoring		1
LAC-33S18W	LOS ANGELES COUNTY	300		273	283	Monitoring		1
LAC-33S18X	LOS ANGELES COUNTY	405		357	367	Monitoring		1
LAC-33S20	LOS ANGELES COUNTY	514		476	486	Monitoring		1
LAC-33S40	LOS ANGELES COUNTY	527		477	507	Monitoring		1
LAC-33S43	LOS ANGELES COUNTY	615		341	362	Monitoring		1
LAC-33S52	LOS ANGELES COUNTY	393		290	350	Monitoring		1
LAC-33ST	LOS ANGELES COUNTY	195		140	185	Monitoring		1
LAC-33T	LOS ANGELES COUNTY	214		89	199	Injection		4
LAC-33T125	LOS ANGELES COUNTY	487		426	466	Monitoring		1
LAC-33T13U	LOS ANGELES COUNTY	87		63	73	Monitoring		1
LAC-33T13V	LOS ANGELES COUNTY	237		210	220	Monitoring		1
LAC-33T13W	LOS ANGELES COUNTY	294		273	283	Monitoring		1
LAC-33T13X	LOS ANGELES COUNTY	405		336	346	Monitoring		1
LAC-33T15	LOS ANGELES COUNTY	420		341	351	Monitoring		1
LAC-33T29U	LOS ANGELES COUNTY	83		63	73	Monitoring		1
LAC-33T29X	LOS ANGELES COUNTY	405		357	367	Monitoring		1
LAC-33T29Z	LOS ANGELES COUNTY	1926		664	705	Monitoring		1
LAC-33T3	LOS ANGELES COUNTY	141		45	90	Monitoring		1
LAC-33T4	LOS ANGELES COUNTY	330		281	306	Monitoring		1
LAC-33T9U	LOS ANGELES COUNTY	50		25	40	Monitoring		1
LAC-33T9V	LOS ANGELES COUNTY	190		133	158	Monitoring		1
LAC-33T9W	LOS ANGELES COUNTY	200		179	189	Monitoring		1
LAC-33T9X	LOS ANGELES COUNTY	885		273	283	Monitoring		1
LAC-33T9Y	LOS ANGELES COUNTY	400		378	388	Monitoring		1
LAC-33TP13U	LOS ANGELES COUNTY	79		46	66	Monitoring		1
LAC-33TP24U	LOS ANGELES COUNTY	55		30	43	Monitoring		1
LAC-33TP24Y	LOS ANGELES COUNTY	109		63	88	Monitoring		1
LAC-33U	LOS ANGELES COUNTY	254		98	238	Injection		4
LAC-33U11V	LOS ANGELES COUNTY	210		194	204	Monitoring		1
LAC-33U11W	LOS ANGELES COUNTY	295		273	283	Monitoring		1
LAC-33U11X	LOS ANGELES COUNTY	405		357	367	Monitoring		1
LAC-33U3	LOS ANGELES COUNTY	143		70	125	Injection		4
LAC-33UP05	LOS ANGELES COUNTY	83		63	73	Monitoring		1
LAC-33UP34	LOS ANGELES COUNTY	61		53	60	Monitoring		1
LAC-33UP3X	LOS ANGELES COUNTY	120		94	105	Monitoring		1
LAC-33UP3Y	LOS ANGELES COUNTY	169		151	161	Monitoring		1
LAC-33UP3Z	LOS ANGELES COUNTY	1720		378	399	Monitoring		1
LAC-33UV	LOS ANGELES COUNTY	308		213	262	Monitoring		1
LAC-33V	LOS ANGELES COUNTY	294		119	269	Injection		4
LAC-33VP14U1	LOS ANGELES COUNTY	27		23	27	Monitoring		1
LAC-33VP14U2	LOS ANGELES COUNTY	84		79	83	Monitoring		1
LAC-33VP14U3	LOS ANGELES COUNTY	50		40	50	Monitoring		1
LAC-33VP15P	LOS ANGELES COUNTY	100		57	82	Other Active Production		2
LAC-33VP22Z1	LOS ANGELES COUNTY	150		127	137	Monitoring		1
LAC-33VP22Z2	LOS ANGELES COUNTY	780		255	265	Monitoring		1
LAC-33VP46	LOS ANGELES COUNTY	80		61	71	Monitoring		1
LAC-33VP8	LOS ANGELES COUNTY	163		105	145	Monitoring		1
LAC-33W	LOS ANGELES COUNTY	420		120	390	Injection		4
LAC-33W11	LOS ANGELES COUNTY	508		427	482	Monitoring		1,6
LAC-33W54	LOS ANGELES COUNTY	83		40	70	Monitoring		1
LAC-33WP14	LOS ANGELES COUNTY	108		57	87	Monitoring		1
LAC-33WP17	LOS ANGELES COUNTY	78		45	65	Monitoring		1
LAC-33WX	LOS ANGELES COUNTY	448		379	423	Monitoring		1
LAC-33WXU	LOS ANGELES COUNTY	74		45	60	Monitoring		1
LAC-33X	LOS ANGELES COUNTY	452		170	430	Injection		4
LAC-33X10	LOS ANGELES COUNTY	517		425	475	Monitoring		1,6
LAC-33X20U	LOS ANGELES COUNTY	110		85	95	Monitoring		1,6
LAC-33X20W	LOS ANGELES COUNTY	325		294	304	Monitoring		1,6
LAC-33X20X	LOS ANGELES COUNTY	415		377	387	Monitoring		1,6
LAC-33X20Y	LOS ANGELES COUNTY	645		483	493	Monitoring		1,6
LAC-33XY	LOS ANGELES COUNTY	475		409	451	Monitoring		1
LAC-33Y	LOS ANGELES COUNTY	475		218	457	Injection		4
LAC-33Y10	LOS ANGELES COUNTY	125		75	115	Monitoring		1,6
LAC-33Y42U	LOS ANGELES COUNTY	105		89	95	Monitoring		1,6
LAC-33Y42X	LOS ANGELES COUNTY	660		362	372	Monitoring		1,6

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
LAC-33YP35	LOS ANGELES COUNTY	103		73	83	Monitoring		1
LAC-33YZ	LOS ANGELES COUNTY	467		408	451	Monitoring		1
LAC-33Z	LOS ANGELES COUNTY	484		206	461	Injection		4
LAC-33Z2	LOS ANGELES COUNTY	499		310	444	Injection		4
LAC-33ZP1T	LOS ANGELES COUNTY	146		116	135	Monitoring		1
LAC-33ZP1U	LOS ANGELES COUNTY	90		62	85	Monitoring		1
LAC-33ZP1X	LOS ANGELES COUNTY	360		336	346	Monitoring		1
LAC-34D	LOS ANGELES COUNTY	494		219	474	Injection		4
LAC-34D01	LOS ANGELES COUNTY	83		73	83	Monitoring		1
LAC-34DG	LOS ANGELES COUNTY	477		405	450	Monitoring		1,6
LAC-34DP6	LOS ANGELES COUNTY	477		415	445	Monitoring		1
LAC-34EP13	LOS ANGELES COUNTY	363		305	335	Monitoring		1
LAC-34EP23	LOS ANGELES COUNTY	108		48	88	Monitoring		1
LAC-34EP48	LOS ANGELES COUNTY	735		255	265	Monitoring		1
LAC-34EV	LOS ANGELES COUNTY	288		145	250	Injection		4
LAC-34EY	LOS ANGELES COUNTY	488		410	455	Injection		4
LAC-34F	LOS ANGELES COUNTY	487		410	450	Injection		4
LAC-34F5T	LOS ANGELES COUNTY	185		140	170	Monitoring		1,6
LAC-34F5V	LOS ANGELES COUNTY	242		195	225	Monitoring		1
LAC-34F5W	LOS ANGELES COUNTY	288		235	275	Monitoring		1
LAC-34F5X	LOS ANGELES COUNTY	372		300	360	Monitoring		1
LAC-34F5Y	LOS ANGELES COUNTY	482		415	455	Monitoring		1
LAC-34FP13V	LOS ANGELES COUNTY	120		95	105	Monitoring		1
LAC-34FP13X	LOS ANGELES COUNTY	315		193	203	Monitoring		1
LAC-34FP40	LOS ANGELES COUNTY	68		45	55	Monitoring		1
LAC-34FX	LOS ANGELES COUNTY	489		410	450	Injection		4
LAC-34G	LOS ANGELES COUNTY	475		285	350	Injection		4
LAC-34G2V	LOS ANGELES COUNTY	280		140	250	Injection		4
LAC-34G2Y	LOS ANGELES COUNTY	489		405	445	Injection		4
LAC-34GH	LOS ANGELES COUNTY	479		415	455	Monitoring		1,6
LAC-34H	LOS ANGELES COUNTY	490		405	445	Injection		4
LAC-34HJX	LOS ANGELES COUNTY	368		315	345	Monitoring		1
LAC-34HJY	LOS ANGELES COUNTY	503		410	440	Monitoring		1,6
LAC-34HP17	LOS ANGELES COUNTY	90		55	75	Monitoring		1
LAC-34HP17P	LOS ANGELES COUNTY	95		51	76	Other Active Production		2
LAC-34HP18P	LOS ANGELES COUNTY	206		145	175	Other Active Production		2
LAC-34J	LOS ANGELES COUNTY	456		270	315	Injection		4
LAC-34JL	LOS ANGELES COUNTY	440		385	420	Monitoring		1,6
LAC-34JP12	LOS ANGELES COUNTY	109		43	93	Monitoring		1
LAC-34L	LOS ANGELES COUNTY	420		146	400	Injection		4
LAC-34LP1U	LOS ANGELES COUNTY	88		67	77	Monitoring		1
LAC-34LP1V	LOS ANGELES COUNTY	210		166	176	Monitoring		1
LAC-34LP1Z	LOS ANGELES COUNTY	900		609	619	Monitoring		1
LAC-34NP16	LOS ANGELES COUNTY	0		41	71	Monitoring		1
LAC-34QP22	LOS ANGELES COUNTY	91		55	80	Monitoring		1
LAC-34SP22P	LOS ANGELES COUNTY	95		52	77	Other Active Production		2
LAC-34VP18	LOS ANGELES COUNTY	85		48	73	Monitoring		1
LAC-35SP24U	LOS ANGELES COUNTY	83		59	69	Monitoring		1
LAC-35SP24Z1	LOS ANGELES COUNTY	180		157	167	Monitoring		1
LAC-35SP24Z2	LOS ANGELES COUNTY	825		210	220	Monitoring		1
LAC-35VP32Z1	LOS ANGELES COUNTY	213		189	199	Monitoring		1
LAC-35VP32Z2	LOS ANGELES COUNTY	855		483	493	Monitoring		1
LAC-36WP80	LOS ANGELES COUNTY	870		293	303	Monitoring		1
LAC-PZ1	LOS ANGELES COUNTY	16		10	16	Monitoring		1
LAC-PZ2	LOS ANGELES COUNTY	14		0	0	Monitoring		1
LAC-PZ3	LOS ANGELES COUNTY	16		0	0	Monitoring		1
LAC-PZ4	LOS ANGELES COUNTY	25		14	22	Monitoring		1
LAC-PZ5	LOS ANGELES COUNTY	64		33	49	Monitoring		1
LXMS-A	LYON CHRISTMAS TREE FARMS	240		0	0	Inactive Production		2,3
MAGM-GG	MAGNOLIA MEMORIAL PARK	168		0	0	Other Active Production		2,3
MNEE-A	MALLONEE	400		0	0	Inactive Production		2,3
HMW-01	MANHEIM CA (COX ENTERPRISES)	75		55	75	Monitoring	S	1
HMW-02	MANHEIM CA (COX ENTERPRISES)	72		52	72	Monitoring		1
HMW-03	MANHEIM CA (COX ENTERPRISES)	50		30	50	Monitoring		1
HMW-04	MANHEIM CA (COX ENTERPRISES)	47		27	47	Monitoring		1
W-3789	MARDEN SUSCO PIPE SUPPLY CO.	0		0	0	Inactive Production		2
USMC-01MW101	MARINE CORPS AIR STATION	159		118	148	Monitoring		1

List of Wells in OCWD Monitoring Programs

KEY

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Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
USMC-01MW102	MARINE CORPS AIR STATION	142		95	135	Monitoring		1
USMC-01MW201	MARINE CORPS AIR STATION	77		27	57	Monitoring		1
USMC-02NEW01	MARINE CORPS AIR STATION	143		115	135	Monitoring		1
USMC-02NEW07	MARINE CORPS AIR STATION	150		103	143	Monitoring		1
USMC-02NEW11	MARINE CORPS AIR STATION	81		45	65	Monitoring		1
USMC-02NEW12	MARINE CORPS AIR STATION	256		209	249	Monitoring		1
USMC-02NEW13	MARINE CORPS AIR STATION	107		60	100	Monitoring		1
USMC-02NEW14	MARINE CORPS AIR STATION	111		40	105	Monitoring		1
USMC-02NEW15	MARINE CORPS AIR STATION	70		25	65	Monitoring		1
USMC-02NEW16	MARINE CORPS AIR STATION	70		25	65	Monitoring		1
USMC-02NEW2	MARINE CORPS AIR STATION	105		75	95	Monitoring		1
USMC-02NEW8A	MARINE CORPS AIR STATION	111		84	104	Monitoring		1
USMC-02UGMW25	MARINE CORPS AIR STATION	84		55	75	Monitoring		1
USMC-05NEW1	MARINE CORPS AIR STATION	210		163	203	Monitoring		1
USMC-16MPE1	MARINE CORPS AIR STATION	194		146	191	Monitoring		1
USMC-16MW1	MARINE CORPS AIR STATION	183		155	180	Monitoring		1
USMC-16MW10	MARINE CORPS AIR STATION	199		165	195	Monitoring		1
USMC-16MW11	MARINE CORPS AIR STATION	182		160	180	Monitoring	S	1
USMC-16MW12	MARINE CORPS AIR STATION	180		160	180	Monitoring		1
USMC-16MW13	MARINE CORPS AIR STATION	181		160	180	Monitoring		1
USMC-16MW14	MARINE CORPS AIR STATION	199		185	195	Monitoring		1
USMC-16MW15	MARINE CORPS AIR STATION	182		160	180	Monitoring		1
USMC-16MW16	MARINE CORPS AIR STATION	201		190	200	Monitoring		1
USMC-16MW2	MARINE CORPS AIR STATION	185		153	178	Monitoring	S	1
USMC-16MW3	MARINE CORPS AIR STATION	185		158	183	Monitoring		1
USMC-16MW4	MARINE CORPS AIR STATION	196		155	190	Monitoring		1
USMC-16MW5	MARINE CORPS AIR STATION	196		155	190	Monitoring		1
USMC-16MW7	MARINE CORPS AIR STATION	194		145	190	Monitoring		1
USMC-16MW8	MARINE CORPS AIR STATION	189		165	183	Monitoring		1
USMC-16MW9	MARINE CORPS AIR STATION	187		165	183	Monitoring		1
USMC-17NEW1	MARINE CORPS AIR STATION	233		186	226	Monitoring		1
USMC-17NEW2	MARINE CORPS AIR STATION	131		83	123	Monitoring		1
USMC-24EX10	MARINE CORPS AIR STATION	165		115	160	Monitoring		1
USMC-24EX11	MARINE CORPS AIR STATION	222		135	180	Monitoring		1
USMC-24EX12A	MARINE CORPS AIR STATION	252		115	160	Monitoring		1
USMC-24EX12B	MARINE CORPS AIR STATION	225		165	210	Monitoring		1
USMC-24EX12C	MARINE CORPS AIR STATION	272		220	260	Monitoring		1
USMC-24EX13A	MARINE CORPS AIR STATION	172		110	160	Monitoring		1
USMC-24EX13B	MARINE CORPS AIR STATION	213		165	205	Monitoring		1
USMC-24EX13C	MARINE CORPS AIR STATION	282		230	270	Monitoring		1
USMC-24EX14	MARINE CORPS AIR STATION	195		115	185	Monitoring		1
USMC-24EX2	MARINE CORPS AIR STATION	215		109	209	Other Active Production		2
USMC-24EX20B	MARINE CORPS AIR STATION	210		107	205	Other Active Production		2
USMC-24EX3	MARINE CORPS AIR STATION	186		0	0	Monitoring		1
USMC-24EX30B1	MARINE CORPS AIR STATION	158		105	150	Monitoring		1
USMC-24EX30B2	MARINE CORPS AIR STATION	156		105	150	Monitoring		1
USMC-24EX30B3	MARINE CORPS AIR STATION	182		170	175	Monitoring		1
USMC-24EX4	MARINE CORPS AIR STATION	195		104	190	Other Active Production		2
USMC-24EX40B2	MARINE CORPS AIR STATION	156		106	106	Monitoring		1
USMC-24EX5	MARINE CORPS AIR STATION	160		104	154	Other Active Production		2
USMC-24EX50B1	MARINE CORPS AIR STATION	156		105	150	Monitoring		1
USMC-24EX50B2	MARINE CORPS AIR STATION	156		105	150	Monitoring		1
USMC-24EX6	MARINE CORPS AIR STATION	178		0	0	Monitoring		1
USMC-24EX60B1	MARINE CORPS AIR STATION	160		106	151	Monitoring		1
USMC-24EX60B2	MARINE CORPS AIR STATION	158		105	150	Monitoring		1
USMC-24EX60B3	MARINE CORPS AIR STATION	225		218	223	Monitoring		1
USMC-24EX9	MARINE CORPS AIR STATION	214		120	200	Monitoring		1
USMC-24IN03	MARINE CORPS AIR STATION	169		91	160	Injection		4
USMC-24IN20B1	MARINE CORPS AIR STATION	300		194	271	Injection		4
USMC-24MW10AB	MARINE CORPS AIR STATION	143		130	140	Monitoring	S	1
USMC-24MW10CD	MARINE CORPS AIR STATION	245		230	240	Monitoring		1
USMC-24MW11AB	MARINE CORPS AIR STATION	145		130	140	Monitoring	S	1
USMC-24MW11CD	MARINE CORPS AIR STATION	240		210	220	Monitoring		1
USMC-24MW12AB	MARINE CORPS AIR STATION	140		127	137	Monitoring	S	1
USMC-24MW12CD	MARINE CORPS AIR STATION	231		203	213	Monitoring		1
USMC-24MW13AB	MARINE CORPS AIR STATION	124		111	121	Monitoring	S	1
USMC-24MW13CD	MARINE CORPS AIR STATION	228		212	222	Monitoring		1

List of Wells in OCWD Monitoring Programs

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				Screened Interval (ft.bgs)				
Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Top	Bottom	Type of Well	Aquifer Zone	Program
USMC-24MW14AB	MARINE CORPS AIR STATION	129		115	125	Monitoring	S	1
USMC-24MW14CD	MARINE CORPS AIR STATION	223		211	221	Monitoring		1
USMC-24MW15AB	MARINE CORPS AIR STATION	137		125	135	Monitoring	S	1
USMC-24MW15CD	MARINE CORPS AIR STATION	236		220	230	Monitoring		1
USMC-24MW16	MARINE CORPS AIR STATION	340		80	300	Multiport Monitoring		1
USMC-24MW17	MARINE CORPS AIR STATION	340		75	310	Multiport Monitoring		1
USMC-24MW5	MARINE CORPS AIR STATION	181		140	168	Monitoring		1
USMC-24MW6	MARINE CORPS AIR STATION	195		170	190	Monitoring		1
USMC-24MW7	MARINE CORPS AIR STATION	208		120	200	Monitoring		1
USMC-24MW8	MARINE CORPS AIR STATION	380		105	350	Multiport Monitoring		1
USMC-24MW9AB	MARINE CORPS AIR STATION	151		140	150	Monitoring	S	1
USMC-24MW9CD	MARINE CORPS AIR STATION	243		230	240	Monitoring		1
USMC-24NEW1	MARINE CORPS AIR STATION	260		225	245	Monitoring		1
USMC-24NEW4	MARINE CORPS AIR STATION	160		108	148	Monitoring	S	1
USMC-24NEW5	MARINE CORPS AIR STATION	262		230	250	Monitoring		1
USMC-24NEW6	MARINE CORPS AIR STATION	193		165	185	Monitoring		1
USMC-24NEW7	MARINE CORPS AIR STATION	174		118	158	Monitoring		1
USMC-24NEW8	MARINE CORPS AIR STATION	170		122	162	Monitoring	S	1
USMC-DW135	MARINE CORPS AIR STATION	135		115	135	Monitoring	S	1
USMC-DW250	MARINE CORPS AIR STATION	254		215	250	Monitoring		1
USMC-DW350	MARINE CORPS AIR STATION	353		310	350	Monitoring		1
USMC-DW450	MARINE CORPS AIR STATION	454		414	450	Monitoring		1
USMC-DW540	MARINE CORPS AIR STATION	541		490	540	Monitoring		1
USMC-MP06	MARINE CORPS AIR STATION	500		105	455	Multiport Monitoring		1
USMC-MP08	MARINE CORPS AIR STATION	500		61	449	Multiport Monitoring		1
USMC-MP09	MARINE CORPS AIR STATION	500		59	463	Multiport Monitoring		1
USMC-MP10	MARINE CORPS AIR STATION	1202		218	1011	Multiport Monitoring		1
USMC-MW01A	MARINE CORPS AIR STATION	500		466	486	Monitoring		1
USMC-MW01B	MARINE CORPS AIR STATION	421		396	416	Monitoring		1
USMC-MW01C	MARINE CORPS AIR STATION	358		330	350	Monitoring		1
USMC-MW01D	MARINE CORPS AIR STATION	270		242	262	Monitoring		1
USMC-MW01E	MARINE CORPS AIR STATION	233		205	225	Monitoring		1
USMC-MW02A	MARINE CORPS AIR STATION	500		462	482	Monitoring		1
USMC-MW02C	MARINE CORPS AIR STATION	386		358	378	Monitoring		1
USMC-MW02D	MARINE CORPS AIR STATION	319		294	314	Monitoring		1
USMC-MW02E	MARINE CORPS AIR STATION	253		198	233	Monitoring		1
USMC-MW03A	MARINE CORPS AIR STATION	471		370	390	Monitoring		1
USMC-MW03B	MARINE CORPS AIR STATION	310		280	300	Monitoring		1
USMC-MW03C	MARINE CORPS AIR STATION	250		222	242	Monitoring		1
USMC-MW03E	MARINE CORPS AIR STATION	172		124	164	Monitoring	S	1
USMC-MW04A	MARINE CORPS AIR STATION	421		286	306	Monitoring		1
USMC-MW04B	MARINE CORPS AIR STATION	421		190	210	Monitoring		1
USMC-MW05A	MARINE CORPS AIR STATION	500		462	482	Monitoring		1
USMC-MW05B	MARINE CORPS AIR STATION	364		321	341	Monitoring		1
USMC-MW05C	MARINE CORPS AIR STATION	500		225	245	Monitoring		1
USMC-MW05D	MARINE CORPS AIR STATION	147		83	133	Monitoring		1
USMC-MW05E	MARINE CORPS AIR STATION	160		80	130	Monitoring		1
USMC-MW07	MARINE CORPS AIR STATION	90		25	65	Monitoring		1
USMC-MW100	MARINE CORPS AIR STATION	179		131	171	Monitoring		1
USMC-MW100A	MARINE CORPS AIR STATION	138		93	132	Monitoring		1
USMC-MW101	MARINE CORPS AIR STATION	140		90	130	Monitoring		1
USMC-MW101A	MARINE CORPS AIR STATION	105		68	98	Monitoring		1
USMC-MW103	MARINE CORPS AIR STATION	499		395	495	Monitoring		1
USMC-MW19A	MARINE CORPS AIR STATION	500		448	468	Monitoring		1
USMC-MW19B	MARINE CORPS AIR STATION	425		400	420	Monitoring		1
USMC-MW19C	MARINE CORPS AIR STATION	500		257	277	Monitoring		1
USMC-MW19D	MARINE CORPS AIR STATION	500		150	170	Monitoring	S	1
USMC-MW19E	MARINE CORPS AIR STATION	148		98	138	Monitoring		1
USMC-MW23	MARINE CORPS AIR STATION	115		64	104	Monitoring	S	1
USMC-MW24	MARINE CORPS AIR STATION	80		51	71	Monitoring		1
USMC-MW25	MARINE CORPS AIR STATION	84		55	75	Monitoring		1
USMC-MW29	MARINE CORPS AIR STATION	120		95	135	Monitoring		1
USMC-MW29A	MARINE CORPS AIR STATION	115		75	100	Monitoring		1
USMC-MW31	MARINE CORPS AIR STATION	153		105	145	Monitoring	S	1
USMC-MW37	MARINE CORPS AIR STATION	137		89	130	Monitoring		1
USMC-MW39	MARINE CORPS AIR STATION	276		230	270	Monitoring		1
USMC-MW398-01	MARINE CORPS AIR STATION	231		198	228	Monitoring		1

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
USMC-MW398-02	MARINE CORPS AIR STATION	231		199	229	Monitoring		1
USMC-MW398-03	MARINE CORPS AIR STATION	242		208	238	Monitoring		1
USMC-MW398-04	MARINE CORPS AIR STATION	232		201	231	Monitoring		1
USMC-MW398-05	MARINE CORPS AIR STATION	230		197	227	Monitoring		1
USMC-MW398-06	MARINE CORPS AIR STATION	228		196	226	Monitoring		1
USMC-MW398-08	MARINE CORPS AIR STATION	233		200	230	Monitoring		1
USMC-MW398-09	MARINE CORPS AIR STATION	242		190	240	Monitoring		1
USMC-MW398-10	MARINE CORPS AIR STATION	260		200	250	Monitoring		1
USMC-MW398-11	MARINE CORPS AIR STATION	267		200	250	Monitoring		1
USMC-MW398-12	MARINE CORPS AIR STATION	7		190	240	Monitoring		1
USMC-MW398-13	MARINE CORPS AIR STATION	245		193	243	Monitoring		1
USMC-MW398-13D	MARINE CORPS AIR STATION	301		251	301	Monitoring		1
USMC-MW398-14	MARINE CORPS AIR STATION	242		192	242	Monitoring		1
USMC-MW398-15	MARINE CORPS AIR STATION	249		199	249	Monitoring		1
USMC-MW398-16	MARINE CORPS AIR STATION	247		194	244	Monitoring		1
USMC-MW398-17	MARINE CORPS AIR STATION	241		189	239	Monitoring		1
USMC-MW398-18	MARINE CORPS AIR STATION	267		194	244	Monitoring		1
USMC-MW398-19	MARINE CORPS AIR STATION	252		202	252	Monitoring		1
USMC-MW398-20	MARINE CORPS AIR STATION	253		201	251	Monitoring		1
USMC-MW398-21	MARINE CORPS AIR STATION	254		193	243	Monitoring		1
USMC-MW398-22	MARINE CORPS AIR STATION	162		120	160	Monitoring		1
USMC-MW398-23	MARINE CORPS AIR STATION	160		120	160	Monitoring		1
USMC-MW398-24	MARINE CORPS AIR STATION	162		120	160	Monitoring		1
USMC-MW398-25	MARINE CORPS AIR STATION	254		201	251	Monitoring		1
USMC-MW398-26	MARINE CORPS AIR STATION	253		202	252	Monitoring		1
USMC-MW398-27	MARINE CORPS AIR STATION	0		202	252	Monitoring		1
USMC-MW40	MARINE CORPS AIR STATION	275		220	260	Monitoring		1
USMC-MW41	MARINE CORPS AIR STATION	228		182	222	Monitoring		1
USMC-MW41A	MARINE CORPS AIR STATION	194		145	185	Monitoring		1
USMC-MW43	MARINE CORPS AIR STATION	200		150	190	Monitoring		1
USMC-MW43B	MARINE CORPS AIR STATION	143		100	141	Monitoring		1
USMC-MW45	MARINE CORPS AIR STATION	169		117	157	Monitoring		1
USMC-MW47	MARINE CORPS AIR STATION	169		116	156	Monitoring		1
USMC-MW48	MARINE CORPS AIR STATION	140		95	135	Monitoring		1
USMC-MW48A	MARINE CORPS AIR STATION	111		74	104	Monitoring		1
USMC-MW50	MARINE CORPS AIR STATION	168		120	160	Monitoring		1
USMC-MW51	MARINE CORPS AIR STATION	172		125	165	Monitoring		1
USMC-MW52	MARINE CORPS AIR STATION	228		182	222	Monitoring		1
USMC-MW56	MARINE CORPS AIR STATION	140		92	132	Monitoring		1
USMC-MW57	MARINE CORPS AIR STATION	93		63	83	Monitoring		1
USMC-MW58	MARINE CORPS AIR STATION	86		69	89	Monitoring		1
USMC-MW59	MARINE CORPS AIR STATION	99		69	89	Monitoring		1
USMC-MW63	MARINE CORPS AIR STATION	281		235	237	Monitoring		1
USMC-MW64	MARINE CORPS AIR STATION	294		245	285	Monitoring		1
USMC-MW64A	MARINE CORPS AIR STATION	255		210	250	Monitoring		1
USMC-MW65X	MARINE CORPS AIR STATION	279		230	270	Monitoring		1
USMC-MW65XA	MARINE CORPS AIR STATION	249		201	236	Monitoring		1
USMC-MW66	MARINE CORPS AIR STATION	305		250	290	Monitoring		1
USMC-MW66A	MARINE CORPS AIR STATION	235		190	230	Monitoring		1
USMC-MW67	MARINE CORPS AIR STATION	245		187	227	Monitoring		1
USMC-MW67A	MARINE CORPS AIR STATION	195		150	190	Monitoring		1
USMC-MW68	MARINE CORPS AIR STATION	308		190	210	Monitoring		1
USMC-MW68A	MARINE CORPS AIR STATION	194		147	187	Monitoring		1
USMC-MW70	MARINE CORPS AIR STATION	172		125	165	Monitoring		1
USMC-MW71	MARINE CORPS AIR STATION	163		115	155	Monitoring		1
USMC-MW72	MARINE CORPS AIR STATION	159		90	130	Monitoring		1
USMC-MW73	MARINE CORPS AIR STATION	140		90	130	Monitoring		1
USMC-MW74	MARINE CORPS AIR STATION	140		90	130	Monitoring		1
USMC-MW75	MARINE CORPS AIR STATION	150		114	154	Monitoring		1
USMC-MW77	MARINE CORPS AIR STATION	145		150	170	Monitoring	S	1
USMC-MW79	MARINE CORPS AIR STATION	166		118	158	Monitoring		1
USMC-MW81	MARINE CORPS AIR STATION	223		176	216	Monitoring		1
USMC-MW82	MARINE CORPS AIR STATION	270		235	255	Monitoring		1
USMC-MW90	MARINE CORPS AIR STATION	145		95	135	Monitoring		1
USMC-MW91	MARINE CORPS AIR STATION	160		110	150	Monitoring		1
USMC-PS1	MARINE CORPS AIR STATION	123		102	122	Monitoring		1
USMC-PS2	MARINE CORPS AIR STATION	135		103	133	Monitoring		1

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
USMC-PS3	MARINE CORPS AIR STATION	123		102	122	Monitoring		1
USMC-PS3A	MARINE CORPS AIR STATION	111		70	105	Monitoring		1
USMC-PS4	MARINE CORPS AIR STATION	123		98	118	Monitoring		1
USMC-PS5	MARINE CORPS AIR STATION	124		106	126	Monitoring	S	1
USMC-PS6	MARINE CORPS AIR STATION	155		130	150	Monitoring		1
USMC-PS7	MARINE CORPS AIR STATION	129		106	126	Monitoring		1
USMC-PS8	MARINE CORPS AIR STATION	145		125	145	Monitoring	S	1
USMC-RW1	MARINE CORPS AIR STATION	504		430	470	Monitoring		1
USMC-RW2	MARINE CORPS AIR STATION	475		270	310	Monitoring		1
USMC-RW3	MARINE CORPS AIR STATION	403		370	390	Monitoring		1
USMC-RW4	MARINE CORPS AIR STATION	86		65	85	Monitoring		1
USMC-SGU1	MARINE CORPS AIR STATION	217		96	206	Other Active Production		2
USMC-SGU10	MARINE CORPS AIR STATION	230		99	199	Other Active Production		2
USMC-SGU11	MARINE CORPS AIR STATION	231		106	216	Other Active Production		2
USMC-SGU12	MARINE CORPS AIR STATION	228		99	219	Other Active Production		2
USMC-SGU13	MARINE CORPS AIR STATION	228		98	218	Other Active Production		2
USMC-SGU14	MARINE CORPS AIR STATION	237		106	226	Other Active Production		2
USMC-SGU15	MARINE CORPS AIR STATION	229		99	219	Other Active Production		2
USMC-SGU16	MARINE CORPS AIR STATION	236		105	185	Other Active Production		2
USMC-SGU17	MARINE CORPS AIR STATION	236		105	180	Other Active Production		2
USMC-SGU18	MARINE CORPS AIR STATION	235		106	226	Other Active Production		2
USMC-SGU19	MARINE CORPS AIR STATION	246		111	231	Other Active Production		2
USMC-SGU2	MARINE CORPS AIR STATION	219		100	170	Other Active Production		2
USMC-SGU20	MARINE CORPS AIR STATION	239		111	231	Other Active Production		2
USMC-SGU21	MARINE CORPS AIR STATION	234		104	194	Other Active Production		2
USMC-SGU22	MARINE CORPS AIR STATION	227		99	219	Other Active Production		2
USMC-SGU23	MARINE CORPS AIR STATION	230		99	219	Other Active Production		2
USMC-SGU24	MARINE CORPS AIR STATION	234		99	224	Other Active Production		2
USMC-SGU25	MARINE CORPS AIR STATION	235		99	224	Other Active Production		2
USMC-SGU26	MARINE CORPS AIR STATION	235		160	225	Other Active Production		2
USMC-SGU27	MARINE CORPS AIR STATION	165		90	155	Other Active Production		2
USMC-SGU28	MARINE CORPS AIR STATION	220		146	211	Other Active Production		2
USMC-SGU29	MARINE CORPS AIR STATION	155		81	146	Other Active Production		2
USMC-SGU3	MARINE CORPS AIR STATION	225		99	114	Other Active Production		2
USMC-SGU30	MARINE CORPS AIR STATION	230		151	221	Other Active Production		2
USMC-SGU31	MARINE CORPS AIR STATION	149		70	140	Other Active Production		2
USMC-SGU32	MARINE CORPS AIR STATION	217		140	205	Other Active Production		2
USMC-SGU33	MARINE CORPS AIR STATION	154		70	145	Other Active Production		2
USMC-SGU34	MARINE CORPS AIR STATION	220		145	210	Other Active Production		2
USMC-SGU35	MARINE CORPS AIR STATION	155		75	145	Other Active Production		2
USMC-SGU36	MARINE CORPS AIR STATION	250		90	240	Other Active Production		2
USMC-SGU37	MARINE CORPS AIR STATION	250		90	240	Other Active Production		2
USMC-SGU38	MARINE CORPS AIR STATION	250		95	240	Other Active Production		2
USMC-SGU39	MARINE CORPS AIR STATION	200		90	190	Other Active Production		2
USMC-SGU4	MARINE CORPS AIR STATION	219		99	209	Other Active Production		2
USMC-SGU5	MARINE CORPS AIR STATION	215		96	206	Other Active Production		2
USMC-SGU6	MARINE CORPS AIR STATION	228		100	200	Other Active Production		2
USMC-SGU7	MARINE CORPS AIR STATION	230		104	224	Other Active Production		2
USMC-SGU8	MARINE CORPS AIR STATION	231		100	210	Other Active Production		2
USMC-SGU9	MARINE CORPS AIR STATION	228		98	218	Other Active Production		2
USMC-TF1MW1	MARINE CORPS AIR STATION	150		109	149	Monitoring		1
USMC-TF2MW1	MARINE CORPS AIR STATION	164		120	160	Monitoring		1
USMC-TF2MW4	MARINE CORPS AIR STATION	161		120	160	Monitoring		1
MSG-BP10L	MCCOLL SITE GROUP	274		247	257	Monitoring	S	1,10
MKSSN-SA	MCKESSON WATER PRODUCTION. CO.	272		160	260	Other Active Production		2,3
W-2048	MEL MACK CO.	358		112	150	Inactive Production		2
ABBY-A	MELROSE ABBEY FUNERAL CENTER	250		0	0	Other Active Production		2,3
MVCC-COSD1	MESA VERDE COUNTRY CLUB	200		0	0	Other Active Production		2,3,6
MVCC-COSD2	MESA VERDE COUNTRY CLUB	462		200	450	Other Active Production	P	2,3,6
MVCC-COSD3	MESA VERDE COUNTRY CLUB	460		200	450	Other Active Production	P	2,3,6
MCWD-11	MESA WATER DIST.	1060		330	1000	Active Large Production	P	2,7
MCWD-1B	MESA WATER DIST.	612		305	580	Active Large Production	P	2,6,7
MCWD-2	MESA WATER DIST.	670		300	650	Monitoring	P	1
MCWD-3B	MESA WATER DIST.	610		242	572	Active Large Production	P	2,6,7
MCWD-3BM	MESA WATER DIST.	1006		880	920	Monitoring	P	1,6
MCWD-5	MESA WATER DIST.	980		400	940	Active Large Production	P	2,6,7
MCWD-6	MESA WATER DIST.	1093		310	1025	Active Large Production	P	2,6,7

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
MCWD-7	MESA WATER DIST.	830		363	753	Active Large Production	P	2,6,7
MCWD-8	MESA WATER DIST.	626		300	572	Inactive Production	P	2,6,7
MCWD-8M	MESA WATER DIST.	1000		870	880	Monitoring	P	1,6
MCWD-9	MESA WATER DIST.	625		350	580	Active Large Production	P	2,6,7
W-12133	METROPOLITAN WATER DIST.	400		0	0	Cathodic Protection		9
MIDC-2	MIDWAY CITY MUTUAL WATER CO.	420		228	420	Active Small Production		2,7
MISQ-FV	MILE SQUARE PARK	300		0	0	Other Active Production		2,3
W-11192	MONITORINGTANA LAND CO.	981		870	916	Inactive Production		2
W-14809	MUTUAL WATER CO.	225		0	0	Inactive Production		2,3
W-14811	MUTUAL WATER CO.	265		0	0	Inactive Production		2,3
NATR-TW1	NATURE CONSERVANCY	150		20	150	Other Active Production		2,3
NVLR-LAG1	NAVAL RECREATION STATION	546		478	524	Other Active Production		2,3
NVLR-LAH1	NAVAL RECREATION STATION	836		0	0	Other Active Production		2,3
NVLR-LAN1	NAVAL RECREATION STATION	634		580	620	Inactive Production		2,3
NVLW-4010	NAVAL WEAPONS STATION	59		45	55	Monitoring		1
NVLW-4012	NAVAL WEAPONS STATION	59		45	55	Monitoring		1
NVLW-4013	NAVAL WEAPONS STATION	58		45	55	Monitoring		1
NVLW-4014	NAVAL WEAPONS STATION	59		30	40	Monitoring		1
NVLW-4016	NAVAL WEAPONS STATION	58		42	52	Monitoring		1
NVLW-4018	NAVAL WEAPONS STATION	62		50	60	Monitoring		1
NVLW-4020	NAVAL WEAPONS STATION	62		50	60	Monitoring		1
NVLW-4021	NAVAL WEAPONS STATION	62		51	61	Monitoring		1
NVLW-7001	NAVAL WEAPONS STATION	33		20	30	Monitoring		1
NVLW-7002	NAVAL WEAPONS STATION	32		20	30	Monitoring		1
NVLW-7003	NAVAL WEAPONS STATION	32		20	30	Monitoring		1
NVLW-7004	NAVAL WEAPONS STATION	62		49	59	Monitoring		1
NVLW-7005	NAVAL WEAPONS STATION	62		50	60	Monitoring		1
NVLW-7006	NAVAL WEAPONS STATION	62		50	60	Monitoring		1
NVLW-7007	NAVAL WEAPONS STATION	62		50	60	Monitoring		1
NVLW-7008	NAVAL WEAPONS STATION	111		96	105	Monitoring	S	1
NVLW-7009	NAVAL WEAPONS STATION	175		160	169	Monitoring		1
NVLW-7010	NAVAL WEAPONS STATION	41		30	40	Monitoring		1
NVLW-7011	NAVAL WEAPONS STATION	102		80	100	Monitoring	S	1
NVLW-7012	NAVAL WEAPONS STATION	115		100	110	Monitoring		1
NVLW-7013	NAVAL WEAPONS STATION	108		95	105	Monitoring	S	1
NVLW-7014	NAVAL WEAPONS STATION	187		160	170	Monitoring		1
NVLW-7015	NAVAL WEAPONS STATION	179		161	170	Monitoring		1
NVLW-7016	NAVAL WEAPONS STATION	110		95	105	Monitoring	S	1
NVLW-7017	NAVAL WEAPONS STATION	42		30	40	Monitoring		1
NVLW-7018	NAVAL WEAPONS STATION	102		80	100	Monitoring	S	1
NVLW-7019	NAVAL WEAPONS STATION	42		30	40	Monitoring		1
NVLW-7020	NAVAL WEAPONS STATION	0		19	29	Monitoring		1
NVLW-7021	NAVAL WEAPONS STATION	172		150	170	Monitoring		1
NVLW-7022	NAVAL WEAPONS STATION	32		20	30	Monitoring		1
NVLW-7023	NAVAL WEAPONS STATION	132		110	130	Monitoring		1
NVLW-7024	NAVAL WEAPONS STATION	27		15	25	Monitoring		1
NVLW-7025	NAVAL WEAPONS STATION	62		50	60	Monitoring	S	1
NVLW-7027	NAVAL WEAPONS STATION	36		26	36	Monitoring		1
NVLW-7028	NAVAL WEAPONS STATION	62		50	60	Monitoring	S	1
NVLW-7031	NAVAL WEAPONS STATION	145		130	140	Monitoring		1
NVLW-7032	NAVAL WEAPONS STATION	110		95	105	Monitoring		1
NVLW-7033	NAVAL WEAPONS STATION	170		155	165	Monitoring		1
NVLW-7034	NAVAL WEAPONS STATION	60		46	56	Monitoring		1
NVLW-7035	NAVAL WEAPONS STATION	103		90	100	Monitoring	S	1
NVLW-7036	NAVAL WEAPONS STATION	170		150	160	Monitoring		1
NVLW-7037	NAVAL WEAPONS STATION	112		89	109	Monitoring		1
NVLW-7038	NAVAL WEAPONS STATION	102		80	100	Monitoring	S	1
NVLW-7039	NAVAL WEAPONS STATION	159		143	153	Monitoring		1
NVLW-7040	NAVAL WEAPONS STATION	160		140	150	Monitoring		1
NVLW-7041	NAVAL WEAPONS STATION	146		133	143	Monitoring	S	1
NVLW-7042	NAVAL WEAPONS STATION	151		136	146	Monitoring	S	1
NVLW-7043	NAVAL WEAPONS STATION	150		136	146	Monitoring	S	1
NVLW-7044	NAVAL WEAPONS STATION	158		123	143	Monitoring	S	1
NVLW-7045	NAVAL WEAPONS STATION	157		135	155	Monitoring	S	1
NVLW-7046	NAVAL WEAPONS STATION	107		85	105	Monitoring		1
NVLW-70POC02	NAVAL WEAPONS STATION	0		190	201	Monitoring		1,6
NVLW-70POC03	NAVAL WEAPONS STATION	205		190	200	Monitoring		1,6

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				Screened Interval (ft.bgs)				
Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Top	Bottom	Type of Well	Aquifer Zone	Program
NVLW-70POC04	NAVAL WEAPONS STATION	210		195	206	Monitoring		1,6
NVLW-EW7001	NAVAL WEAPONS STATION	33		20	30	Inactive Production		2
NVLW-EW7003	NAVAL WEAPONS STATION	130		95	120	Inactive Production		2
NVLW-RDO1	NAVAL WEAPONS STATION	110		65	105	Monitoring		1
NVLW-RDO2	NAVAL WEAPONS STATION	110		65	105	Monitoring		1
NVLW-RDO3A	NAVAL WEAPONS STATION	31		20	30	Monitoring		1
NVLW-RDO3B	NAVAL WEAPONS STATION	107		65	105	Monitoring		1
NVLW-RDO4	NAVAL WEAPONS STATION	112		65	105	Monitoring		1
NVLW-RDO5	NAVAL WEAPONS STATION	107		65	105	Monitoring		1
NVLW-RDO6A	NAVAL WEAPONS STATION	109		95	105	Monitoring		1
NVLW-RDO6B	NAVAL WEAPONS STATION	145		130	140	Monitoring		1
NVLW-SB2	NAVAL WEAPONS STATION	424		207	407	Inactive Production		2,3,6
NVLW-SB6	NAVAL WEAPONS STATION	802		548	655	Inactive Production	P	2
BYNT-YLSE	NEFF RANCH, LTD	90		34	70	Other Active Production		2,3
NB-DOLD	NEWPORT BEACH	824		399	729	Active Large Production	P	2,7
NB-DOLS	NEWPORT BEACH	385		201	356	Active Large Production	P	2,7
NB-TAMD	NEWPORT BEACH	758		395	690	Active Large Production	P	2,7
NB-TAMS	NEWPORT BEACH	390		170	360	Active Large Production	P	2,7
NBGC-GA10	NEWPORT BEACH GOLF COURSE	65		32	62	Monitoring	S	1,6
NBGC-MW2	NEWPORT BEACH GOLF COURSE	65		35	65	Monitoring		1
NBGC-MW3	NEWPORT BEACH GOLF COURSE	65		35	65	Monitoring		1
NBGC-NB	NEWPORT BEACH GOLF COURSE	498		192	218	Other Active Production		2,3,6
NDW-1	NIAGARA DRINKING WATER	510		270	500	Inactive Production		2,9
COCA-A	NOR-CAL BEVERAGE CO. INC.	654		0	0	Inactive Production		2,3,8
NCS-NO2	NORCO COMMUNITY SERVICES	114		47	114	Other Active Production		2
GRGC-CO1	O.C. FLOOD CONTROL DIST.	96		34	67	Other Active Production		2,3
GRGC-COR1	O.C. FLOOD CONTROL DIST.	92		34	61	Other Active Production		2,3
GRGC-YL14	O.C. FLOOD CONTROL DIST.	0		0	0	Other Active Production		2,3
GRGC-YL15	O.C. FLOOD CONTROL DIST.	0		0	0	Other Active Production		2,3
GRGC-YL16	O.C. FLOOD CONTROL DIST.	0		0	0	Other Active Production		2,3
GRGC-YL4	O.C. FLOOD CONTROL DIST.	0		0	0	Other Active Production		2,3
GRGC-YL9	O.C. FLOOD CONTROL DIST.	0		0	0	Other Active Production		2,3
GRGC-YLA1	O.C. FLOOD CONTROL DIST.	0		0	0	Other Active Production		2,3
W-3763	O.C. FLOOD CONTROL DIST.	610		144	385	Inactive Production		2
W-629	O.C. FLOOD CONTROL DIST.	267		81	256	Monitoring		1
W-638	O.C. FLOOD CONTROL DIST.	176		71	162	Monitoring		1
VECT-GG	O.C. VECTOR CNT. DIST.	224		0	0	Other Active Production		2,3
BSOA-I	OC COUNCIL BOY SCOUTS/ANAHEIM	0		100	200	Other Active Production		2,3
W-19059	OC WASTE MANAGEMENT	60		27	57	Monitoring		1
OVWC-HB	OCEAN VIEW MUTUAL WATER	180		0	0	Inactive Production		2,6
ABS-1	OCWD	286	MP1	25	35	Multiport Monitoring	P	1
ABS-1	OCWD	286	MP2	75	85	Multiport Monitoring	P	1
ABS-1	OCWD	286	MP3	255	265	Multiport Monitoring	P	1
ABS-2	OCWD	180		155	165	Monitoring	S	1
AM-1	OCWD	140		97	115	Monitoring	S	1
AM-10	OCWD	300		217	235	Monitoring	S	1
AM-11	OCWD	278		218	240	Monitoring	P	1
AM-12	OCWD	299		210	225	Monitoring	S	1
AM-13	OCWD	279		252	270	Monitoring	P	1
AM-14	OCWD	321		297	315	Monitoring	P	1,8
AM-15	OCWD	320		300	317	Monitoring	P	1,8
AM-15A	OCWD	231		214	220	Monitoring	S	1,8
AM-16	OCWD	320		300	315	Monitoring	P	1,8
AM-16A	OCWD	227		215	222	Monitoring		1,8
AM-17	OCWD	320		290	308	Monitoring	P	1,8
AM-18	OCWD	320		291	309	Monitoring	P	1,8
AM-18A	OCWD	232		208	215	Monitoring		1,8
AM-19	OCWD	240		217	225	Monitoring		1
AM-19A	OCWD	127		115	123	Monitoring	S	1
AM-2	OCWD	160		87	100	Monitoring	S	1
AM-20	OCWD	397		361	379	Monitoring	P	1
AM-20A	OCWD	268		250	258	Monitoring		1
AM-21	OCWD	269		250	258	Monitoring		1
AM-21A	OCWD	179		157	165	Monitoring	S	1
AM-22	OCWD	356		339	353	Monitoring	P	1,8
AM-22A	OCWD	239		216	224	Monitoring		1,8
AM-23	OCWD	351		330	347	Monitoring	P	1,8

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
AM-24	OCWD	378		335	350	Monitoring	P	1,8
AM-24A	OCWD	305		279	294	Monitoring		1,8
AM-25	OCWD	365		340	358	Monitoring	P	1,8
AM-25A	OCWD	217		188	195	Monitoring	S	1,8
AM-26	OCWD	388		377	383	Monitoring	P	1
AM-27	OCWD	337		287	305	Monitoring	P	1
AM-28	OCWD	398		358	376	Monitoring		1
AM-29	OCWD	365		340	358	Monitoring	P	1,8
AM-29A	OCWD	96		75	95	Monitoring		1,8
AM-3	OCWD	115		91	107	Monitoring	S	1,10
AM-30	OCWD	375		349	367	Monitoring	P	1,8
AM-30A	OCWD	398		152	159	Monitoring	S	1,8
AM-31	OCWD	358		335	353	Monitoring	P	1,8
AM-31A	OCWD	360		162	170	Monitoring	S	1,8
AM-32	OCWD	398		335	353	Monitoring	P	1,8
AM-33	OCWD	378		354	372	Monitoring	P	1,8
AM-33A	OCWD	238		206	221	Monitoring		1,8
AM-34	OCWD	354		317	335	Monitoring	P	1
AM-34A	OCWD	271		252	260	Monitoring		1
AM-35	OCWD	400		332	350	Monitoring	P	1
AM-36	OCWD	398		369	387	Monitoring	P	1
AM-37	OCWD	378		349	367	Monitoring	P	1
AM-38	OCWD	358		316	334	Monitoring	P	1
AM-39	OCWD	192		168	188	Monitoring		1,8
AM-39A	OCWD	140		115	135	Monitoring	S	1,8
AM-4	OCWD	300		187	205	Monitoring	S	1
AM-40	OCWD	193		175	190	Monitoring		1,8
AM-40A	OCWD	168		145	165	Monitoring	S	1,8
AM-41	OCWD	200		190	200	Monitoring		1,8
AM-41A	OCWD	167		156	166	Monitoring	S	1,8
AM-42	OCWD	198		180	190	Monitoring		1,8
AM-42A	OCWD	135		115	130	Monitoring	S	1,8
AM-43	OCWD	100		80	100	Monitoring		1
AM-44	OCWD	162		140	160	Monitoring	S	1
AM-44A	OCWD	90		78	88	Monitoring		1
AM-45	OCWD	133		102	132	Monitoring	S	1,8
AM-46	OCWD	130		94	124	Monitoring	S	1
AM-47	OCWD	290		227	242	Monitoring	P	1,8
AM-47A	OCWD	170		160	170	Monitoring	S	1,8
AM-48	OCWD	312		270	300	Monitoring	P	1,8
AM-48A	OCWD	152		116	146	Monitoring	S	1,8
AM-49	OCWD	160		120	150	Monitoring	S	1,8
AM-5	OCWD	250		230	245	Monitoring	P	1
AM-50	OCWD	170		140	150	Monitoring	S	1
AM-51	OCWD	130		105	125	Monitoring	S	1
AM-51A	OCWD	80		50	70	Monitoring		1
AM-5A	OCWD	182		168	175	Monitoring	S	1
AM-6	OCWD	300		232	250	Monitoring	P	1
AM-7	OCWD	296		210	225	Monitoring	S	1
AM-8	OCWD	300		268	285	Monitoring	S	1,8
AM-9	OCWD	317		285	303	Monitoring	S	1,8
AMD-1	OCWD	1511	MP1	104	114	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP2	135	145	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP3	180	190	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP4	246	256	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP5	330	340	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP6	384	394	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP7	524	534	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP8	760	770	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP8	1038	1048	Multiport Monitoring	S/P/D	1,10
AMD-1	OCWD	1511	MP10	1390	1400	Multiport Monitoring	S/P/D	1,10
AMD-10	OCWD	1510		934	954	Monitoring	P	1
AMD-11	OCWD	1510		906	926	Monitoring	P	1
AMD-12	OCWD	1020		940	960	Monitoring	P	1
AMD-2	OCWD	1508	MP1	156	166	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP2	260	270	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP3	384	394	Multiport Monitoring	S/P/D	1

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
AMD-2	OCWD	1508	MP4	510	520	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP5	658	668	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP6	820	830	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP7	1012	1022	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP8	1150	1160	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP9	1290	1300	Multiport Monitoring	S/P/D	1
AMD-2	OCWD	1508	MP10	1440	1450	Multiport Monitoring	S/P/D	1
AMD-3	OCWD	1416	MP1	66	76	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP2	134	144	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP3	210	220	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP4	360	370	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP5	480	490	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP6	570	580	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP7	820	830	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP8	920	930	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP9	1170	1180	Multiport Monitoring	S/P	1,8,10
AMD-3	OCWD	1416	MP10	1282	1292	Multiport Monitoring	S/P	1,8,10
AMD-4	OCWD	1515	MP1	204	214	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP2	295	305	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP3	380	390	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP4	560	570	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP5	700	710	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP6	790	800	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP7	935	945	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP8	1055	1065	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP9	1120	1130	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP10	1265	1275	Multiport Monitoring	S/P/D	1,8
AMD-4	OCWD	1515	MP11	1405	1415	Multiport Monitoring	S/P/D	1,8
AMD-5	OCWD	1495	MP1	100	110	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP2	200	210	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP3	300	310	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP4	414	424	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP5	495	505	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP6	640	650	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP7	750	760	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP8	920	930	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP9	1025	1035	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP10	1210	1220	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP11	1320	1330	Multiport Monitoring	S/P/D	1
AMD-5	OCWD	1495	MP12	1420	1430	Multiport Monitoring	S/P/D	1
AMD-6	OCWD	1528	MP1	110	120	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP2	150	160	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP3	220	230	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP4	275	285	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP5	370	380	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP6	495	505	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP7	620	630	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP8	710	720	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP9	790	800	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP10	900	910	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP11	1090	1100	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP12	1260	1270	Multiport Monitoring	S/P	1
AMD-6	OCWD	1528	MP13	1405	1415	Multiport Monitoring	S/P	1
AMD-7	OCWD	1520	MP1	120	130	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP2	220	230	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP3	270	280	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP4	310	320	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP5	370	380	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP6	470	480	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP7	578	588	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP8	690	700	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP9	805	815	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP10	930	940	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP11	1070	1080	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP12	1165	1175	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP13	1295	1305	Multiport Monitoring	S/P/D	1,10
AMD-7	OCWD	1520	MP14	1420	1430	Multiport Monitoring	S/P/D	1,10

List of Wells in OCWD Monitoring Programs

KEY

Aquifer Zone: S=Shallow Aquifer, P=Principal Aquifer, D= Deep Aquifer

Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
AMD-8	OCWD	2080	MP1	78	88	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	P2	178	188	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP3	314	324	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP4	524	534	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP5	660	670	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP6	760	770	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP7	856	866	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP8	1000	1010	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP9	1160	1170	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP10	1286	1296	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP11	1450	1460	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP12	1564	1574	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP13	1760	1770	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP14	1944	1954	Multiport Monitoring	S/P/D	1
AMD-8	OCWD	2080	MP15	2010	2020	Multiport Monitoring	S/P/D	1
AMD-9	OCWD	1163		896	916	Monitoring	S/P	1
BPM-1	OCWD	2211	MP1	128	138	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP2	248	258	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP3	456	466	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP4	612	622	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP5	776	786	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP6	886	896	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP7	1036	1046	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP8	1264	1274	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP9	1388	1398	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP10	1498	1508	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP11	1684	1694	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP12	1800	1810	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP13	1930	1940	Multiport Monitoring	S/P/D	1,10
BPM-1	OCWD	2211	MP14	2105	2115	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP1	180	190	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP2	336	346	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP3	494	504	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP4	580	590	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP5	774	784	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP6	900	910	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP7	1024	1034	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP8	1240	1250	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP9	1364	1374	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP10	1490	1500	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP11	1610	1620	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP12	1760	1770	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP13	1928	1938	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP14	2070	2080	Multiport Monitoring	S/P/D	1,10
BPM-2	OCWD	2227	MP15	2170	2180	Multiport Monitoring	S/P/D	1,10
CB-1	OCWD	1543	MP1	76	86	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP2	140	150	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP3	440	450	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP4	659	669	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP5	870	880	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP6	1050	1060	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP7	1190	1200	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP8	1329	1339	Multiport Monitoring	S/P/D	1,8
CB-1	OCWD	1543	MP9	1460	1470	Multiport Monitoring	S/P/D	1,8
COSM-1	OCWD	2000	MP1	90	100	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP2	152	162	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP3	270	280	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP4	350	360	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP5	450	460	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP6	540	550	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP7	620	630	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP8	720	730	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP9	850	860	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP10	980	990	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP11	1100	1110	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP12	1212	1222	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP13	1432	1442	Multiport Monitoring	S/P/D	1,6,10

List of Wells in OCWD Monitoring Programs

KEY

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Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
COSM-1	OCWD	2000	MP14	1594	1604	Multiport Monitoring	S/P/D	1,6,10
COSM-1	OCWD	2000	MP15	1760	1770	Multiport Monitoring	S/P/D	1,6,10
COSM-2	OCWD	1142	MP1	58	68	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP2	113	123	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP3	198	208	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP4	307	317	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP5	406	416	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP6	540	550	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP7	649	659	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP8	757	767	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP9	886	896	Multiport Monitoring	S/P	1,6
COSM-2	OCWD	1142	MP10	1051	1061	Multiport Monitoring	S/P	1,6
FFS-1	OCWD	1490	MP1	180	190	Multiport Monitoring	S/P/D	1,8,10
FFS-1	OCWD	1490	MP2	360	370	Multiport Monitoring	S/P/D	1,8,10
FFS-1	OCWD	1490	MP3	529	539	Multiport Monitoring	S/P/D	1,8,10
FFS-1	OCWD	1490	MP4	819	829	Multiport Monitoring	S/P/D	1,8,10
FFS-1	OCWD	1490	MP5	1059	1069	Multiport Monitoring	S/P/D	1,8,10
FFS-1	OCWD	1490	MP6	1159	1169	Multiport Monitoring	S/P/D	1,8,10
FFS-1	OCWD	1490	MP7	1299	1309	Multiport Monitoring	S/P/D	1,8,10
FFS-1	OCWD	1490	MP7	1419	1429	Multiport Monitoring	S/P/D	1,8,10
FM-1	OCWD	359		348	356	Monitoring	P	1,8
FM-10	OCWD	250		215	235	Monitoring	P	1,8
FM-10A	OCWD	183		151	171	Monitoring	S	1,8
FM-11	OCWD	280		236	256	Monitoring	P	1,8
FM-11A	OCWD	162		134	154	Monitoring	S	1,8
FM-12	OCWD	241		206	226	Monitoring	P	1,8
FM-12A	OCWD	162		135	155	Monitoring	S	1,8
FM-13	OCWD	243		210	230	Monitoring	P	1,8
FM-13A	OCWD	173		140	160	Monitoring	S	1,8
FM-14	OCWD	277		234	254	Monitoring	P	1,8
FM-14A	OCWD	182		147	167	Monitoring	S	1,8
FM-15	OCWD	261		218	238	Monitoring	P	1,8
FM-15A	OCWD	160		120	140	Monitoring	S	1,8
FM-16	OCWD	282		248	268	Monitoring	P	1,8
FM-16A	OCWD	160		125	145	Monitoring	S	1,8
FM-17	OCWD	280		250	270	Monitoring	P	1,8
FM-18	OCWD	367		224	244	Monitoring	P	1,8
FM-18A	OCWD	160		121	151	Monitoring	S	1,8
FM-19A	OCWD	145		115	135	Monitoring	S	1,8
FM-19B	OCWD	270		230	260	Monitoring		1,8
FM-19C	OCWD	399		365	385	Monitoring	P	1,8
FM-1A	OCWD	197		164	172	Monitoring	S	1,8
FM-2	OCWD	352		320	338	Monitoring	P	1,8
FM-20	OCWD	290		221	241	Monitoring	P	1,8
FM-20A	OCWD	160		130	150	Monitoring	S	1,8
FM-21	OCWD	286		260	270	Monitoring	P	1,8
FM-21A	OCWD	169		140	160	Monitoring	S	1,8
FM-22	OCWD	290		242	262	Monitoring	P	1,8
FM-22A	OCWD	180		150	170	Monitoring	S	1,8
FM-23	OCWD	290		234	249	Monitoring	P	1,8
FM-23A	OCWD	155		128	143	Monitoring	S	1,8
FM-24	OCWD	302		271	291	Monitoring	P	1,8
FM-24A	OCWD	200		154	174	Monitoring	S	1,8
FM-25	OCWD	160		132	152	Monitoring	S	1,8
FM-26	OCWD	155		145	155	Monitoring	S	1,8
FM-27	OCWD	125		105	125	Monitoring	S	1,8
FM-2A	OCWD	237		226	234	Monitoring		1,8
FM-3	OCWD	298		257	263	Monitoring	P	1,8
FM-4	OCWD	355		327	345	Monitoring	P	1,8
FM-4A	OCWD	170		142	160	Monitoring	S	1,8
FM-5	OCWD	142		121	141	Monitoring	S	1,8
FM-6	OCWD	405		150	310	Monitoring	S	1,10
FM-7	OCWD	205		187	197	Monitoring		1,8
FM-7A	OCWD	172		160	170	Monitoring	S	1,8
FM-8	OCWD	150		114	134	Monitoring	S	1,8
FM-9	OCWD	260		220	240	Monitoring	P	1,8
FM-9A	OCWD	240		166	186	Monitoring	S	1,8

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
FVM-1	OCWD	2000	MP1	134	145	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP3	172	182	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP3	220	230	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP4	360	370	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP5	450	460	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP6	500	510	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP7	560	570	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP8	630	640	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP9	810	820	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP10	894	904	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP11	1000	1010	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP12	1120	1130	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP13	1175	1185	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP14	1230	1240	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP15	1320	1330	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP16	1492	1502	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP17	1582	1592	Multiport Monitoring	S/P/D	1,10
FVM-1	OCWD	2000	MP18	1834	1844	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP1	150	160	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP2	300	310	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP3	464	474	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP4	550	560	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP5	740	750	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP6	825	835	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP7	950	960	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP8	1070	1080	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP9	1260	1270	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP10	1515	1525	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP11	1650	1660	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP12	1768	1778	Multiport Monitoring	S/P/D	1,10
GGM-1	OCWD	2086	MP13	2008	2018	Multiport Monitoring	S/P/D	1,10
GGM-2	OCWD	2057	MP1	212	222	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP2	294	304	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP3	460	470	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP4	715	725	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP5	950	960	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP6	1045	1055	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP7	1145	1155	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP8	1250	1260	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP	1485	1495	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP10	1625	1635	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP11	1740	1750	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP12	1900	1910	Multiport Monitoring	S/P/D	1
GGM-2	OCWD	2057	MP13	1990	2000	Multiport Monitoring	S/P/D	1
GGM-3	OCWD	2020	MP1	195	205	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP2	310	320	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP3	545	555	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP4	640	650	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP5	837	847	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP6	1004	1014	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP7	1104	1114	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP8	1274	1284	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP9	1539	1549	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP10	1680	1690	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP11	1780	1790	Multiport Monitoring	S/P	1
GGM-3	OCWD	2020	MP12	1950	1960	Multiport Monitoring	S/P	1
HBM-1	OCWD	2013	MP1	90	100	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP2	190	200	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP3	320	330	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP4	482	492	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP5	560	570	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP6	700	710	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP7	920	930	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP8	1034	1044	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP9	1126	1136	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP10	1348	1358	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP11	1460	1470	Multiport Monitoring	S/P/D	1,10

List of Wells in OCWD Monitoring Programs

KEY

Aquifer Zone: S=Shallow Aquifer, P=Principal Aquifer, D= Deep Aquifer

Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
HBM-1	OCWD	2013	MP12	1540	1550	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP13	1640	1650	Multiport Monitoring	S/P/D	1,10
HBM-1	OCWD	2013	MP14	1930	1940	Multiport Monitoring	S/P/D	1,10
HBM-2	OCWD	1010	MP1	110	120	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP2	160	170	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP3	245	255	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP4	305	315	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP5	360	370	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP6	445	455	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP7	520	530	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP8	570	580	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP9	675	685	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP10	735	745	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP11	845	855	Multiport Monitoring	S/P	1,6,10
HBM-2	OCWD	1010	MP12	925	935	Multiport Monitoring	S/P	1,6,10
HBM-4	OCWD	830	MP1	75	85	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP2	120	130	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP3	180	190	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP4	230	240	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP5	295	305	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP6	350	360	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP7	415	425	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP8	550	560	Multiport Monitoring	S/P	1,6
HBM-4	OCWD	830	MP9	690	700	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP3	70	90	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP1	70	90	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP2	70	90	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP4	125	135	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP5	170	180	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP6	215	225	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP7	245	255	Multiport Monitoring	S/P	1,6
HBM-5	OCWD	1019	MP8	270	280	Multiport Monitoring	S/P	1,6
HBM-6	OCWD	800	MP1	52	62	Multiport Monitoring	S/P	1,6,10
HBM-6	OCWD	800	MP2	84	94	Multiport Monitoring	S/P	1,6,10
HBM-6	OCWD	800	MP3	108	118	Multiport Monitoring	S/P	1,6,10
HBM-6	OCWD	800	MP4	214	224	Multiport Monitoring	S/P	1,6,10
HBM-6	OCWD	800	MP5	263	273	Multiport Monitoring	S/P	1,6,10
HBM-6	OCWD	800	MP6	294	304	Multiport Monitoring	S/P	1,6,10
HBM-6	OCWD	800	MP7	506	516	Multiport Monitoring	S/P	1,6,10
HBM-6	OCWD	800	MP8	576	586	Multiport Monitoring	S/P	1,6,10
IDM-1	OCWD	1123	MP1	85	95	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP2	270	280	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP3	335	345	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP4	435	445	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP5	630	640	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP6	700	710	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP7	760	770	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP8	875	885	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP9	990	1000	Multiport Monitoring	S/P/D	1,10
IDM-1	OCWD	1123	MP10	1050	1060	Multiport Monitoring	S/P/D	1,10
IDM-2	OCWD	1487	MP1	126	136	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP2	234	244	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP3	284	294	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP4	352	362	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP5	492	502	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP6	612	622	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP7	710	720	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP8	886	896	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP9	1050	1060	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	MP10	1178	1188	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	M0-11	1256	1266	Multiport Monitoring	S/P/D	1,9,10
IDM-2	OCWD	1487	M012	1400	1410	Multiport Monitoring	S/P/D	1,9,10
IDM-3	OCWD	704		652	672	Monitoring	S/P	1
IDM-4	OCWD	726		654	674	Monitoring	S/P	1
IDP-1	OCWD	708		121	681	Injection		4
IDP-2R	OCWD	680		300	340	Monitoring	S/P	1
IDP-3	OCWD	602		125	505	Monitoring		1

List of Wells in OCWD Monitoring Programs

KEY

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
KBS-1	OCWD	244		209	219	Monitoring	S/P	1
KBS-2	OCWD	303	MP1	96	106	Multiport Monitoring	S/P	1
KBS-2	OCWD	303	MP2	210	220	Multiport Monitoring	S/P	1
KBS-3	OCWD	92		80	90	Monitoring		1
KBS-4	OCWD	160		138	158	Monitoring	S	1
KBS-4A	OCWD	92		80	90	Monitoring		1
LAM-1	OCWD	2211	MP1	70	80	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP2	220	230	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP3	270	280	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP4	470	480	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP5	570	580	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP6	830	840	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP7	992	1002	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP8	1070	1080	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP9	1150	1160	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP10	1250	1260	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP11	1494	1504	Multiport Monitoring	S/P/D	1,10
LAM-1	OCWD	2211	MP12	1610	1620	Multiport Monitoring	S/P/D	1,10
MBI-1	OCWD	1239		530	1190	Injection		4,5
MCAS-1	OCWD	620	MP1	60	70	Multiport Monitoring	S/P	1
MCAS-1	OCWD	620	MP2	150	160	Multiport Monitoring	S/P	1
MCAS-1	OCWD	620	MP3	210	220	Multiport Monitoring	S/P	1
MCAS-1	OCWD	620	MP4	270	280	Multiport Monitoring	S/P	1
MCAS-1	OCWD	620	MP5	330	340	Multiport Monitoring	S/P	1
MCAS-1	OCWD	620	MP6	450	460	Multiport Monitoring	S/P	1
MCAS-1	OCWD	620	MP7	540	550	Multiport Monitoring	S/P	1
MCAS-10	OCWD	389		347	377	Monitoring	P	1
MCAS-2	OCWD	680	MP1	40	50	Multiport Monitoring	S/P	1
MCAS-2	OCWD	680	MP2	130	140	Multiport Monitoring	S/P	1
MCAS-2	OCWD	680	MP3	200	210	Multiport Monitoring	S/P	1
MCAS-2	OCWD	680	MP4	370	380	Multiport Monitoring	S/P	1
MCAS-2	OCWD	680	MP5	420	430	Multiport Monitoring	S/P	1
MCAS-2	OCWD	680	MP6	490	500	Multiport Monitoring	S/P	1
MCAS-2	OCWD	680	MP7	550	560	Multiport Monitoring	S/P	1
MCAS-2	OCWD	680	MP8	620	630	Multiport Monitoring	S/P	1
MCAS-3	OCWD	603	MP1	80	90	Multiport Monitoring	S/P	1,10
MCAS-3	OCWD	603	MP2	160	170	Multiport Monitoring	S/P	1,10
MCAS-3	OCWD	603	MP3	220	230	Multiport Monitoring	S/P	1,10
MCAS-3	OCWD	603	MP4	340	350	Multiport Monitoring	S/P	1,10
MCAS-3	OCWD	603	MP5	420	430	Multiport Monitoring	S/P	1,10
MCAS-3	OCWD	603	MP6	490	500	Multiport Monitoring	S/P	1,10
MCAS-4	OCWD	317		181	238	Monitoring	S/P	1
MCAS-5A	OCWD	159		120	130	Monitoring	S	1
MCAS-6	OCWD	455		167	222	Monitoring	S	1
MCAS-7	OCWD	1297	MP1	90	100	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP2	190	200	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP3	350	360	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP4	440	450	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP5	510	520	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP6	800	810	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP7	910	920	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP8	980	990	Multiport Monitoring	S/P	1,10
MCAS-7	OCWD	1297	MP9	1100	1110	Multiport Monitoring	S/P	1,10
MCAS-8	OCWD	437		392	410	Monitoring	P	1
MCAS-9	OCWD	450		372	445	Monitoring	P	1
MSP-10P	OCWD	59		40	50	Monitoring		1
MSP-10T	OCWD	211		70	140	Monitoring		1
OCWD-33Z11	OCWD	527		435	485	Monitoring		1,6
OCWD-34F10	OCWD	490		420	460	Monitoring		1,6
OCWD-34H25	OCWD	490		410	465	Monitoring		1
OCWD-34H5	OCWD	480		405	455	Monitoring		1,6
OCWD-34L10	OCWD	478		405	450	Monitoring		1,6
OCWD-34LS	OCWD	400		340	380	Monitoring		1,6
OCWD-34N21	OCWD	494		424	464	Monitoring		1,6
OCWD-34NP7	OCWD	312		225	300	Monitoring		1,6
OCWD-34S	OCWD	380		312	347	Injection		4
OCWD-34T01	OCWD	375		290	345	Monitoring		1,6

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
OCWD-34U8	OCWD	424		359	384	Monitoring		1,6
OCWD-34V	OCWD	320		260	300	Injection		4
OCWD-34V20	OCWD	456		387	417	Monitoring		1,6
OCWD-34VZX	OCWD	199		147	177	Monitoring		1,6
OCWD-34VZY	OCWD	265		215	235	Monitoring		1,6
OCWD-34WP5	OCWD	212		165	180	Monitoring		1,6
OCWD-34X40	OCWD	450		333	358	Monitoring	S	1,6
OCWD-34Z	OCWD	191		110	150	Injection		4
OCWD-35DP5	OCWD	130		92	107	Monitoring		1,6
OCWD-35E01X	OCWD	98		65	85	Monitoring		1,6
OCWD-35E01Y	OCWD	343		105	125	Monitoring		1,6
OCWD-35F	OCWD	168		80	115	Injection		4
OCWD-35F20	OCWD	300		235	265	Monitoring		1,6
OCWD-35FP21	OCWD	85		36	71	Monitoring		1,6
OCWD-35G	OCWD	182		80	145	Injection		4
OCWD-35H11	OCWD	230		200	220	Monitoring	S	1,6
OCWD-35H12	OCWD	300		137	147	Monitoring		1,6
OCWD-35H1X	OCWD	257		131	171	Injection		4
OCWD-35H1Y	OCWD	271		215	237	Injection		4
OCWD-35H2	OCWD	260		112	241	Injection		4
OCWD-35J1	OCWD	271		190	240	Monitoring		1,6
OCWD-35J1Y	OCWD	378		264	294	Monitoring		1,6
OCWD-35K1	OCWD	275		193	243	Monitoring		1,6
OCWD-35K1V	OCWD	112		90	110	Monitoring		1,6
OCWD-35K1Y	OCWD	395		366	386	Monitoring		1,6
OCWD-35KP12	OCWD	87		47	67	Monitoring		1
OCWD-35N01	OCWD	101		80	85	Monitoring	S	1,6
OCWD-35T9	OCWD	1020		390	411	Monitoring		1,6
OCWD-36FP14Z1	OCWD	150		115	125	Monitoring		1,6
OCWD-36FP14Z2	OCWD	705		357	367	Monitoring		1,6
OCWD-36FP1X	OCWD	160		136	146	Monitoring		1
OCWD-36FP1Z	OCWD	1020		504	514	Monitoring	P	1,6
OCWD-7	OCWD	48		28	48	Monitoring		1
OCWD-AIR1	OCWD	1518		1375	1460	Monitoring	S/P	1,10
OCWD-ALK	OCWD	320		217	317	Other Active Production		2,3
OCWD-AN1	OCWD	115		35	115	Monitoring		1
OCWD-AN2	OCWD	119		35	115	Monitoring		1
OCWD-BESS	OCWD	302		172	189	Other Active Production	S	2,3
OCWD-BIO1	OCWD	124		25	115	Inactive Production	S	2
OCWD-BP1	OCWD	40		20	40	Monitoring		1
OCWD-BP2	OCWD	70		50	70	Monitoring		1
OCWD-BP3	OCWD	205		185	205	Monitoring	S	1
OCWD-BP4	OCWD	180		140	180	Monitoring	S	1
OCWD-BP5	OCWD	240		147	167	Monitoring	S	1
OCWD-BP6	OCWD	245		148	168	Monitoring	S	1
OCWD-BP7	OCWD	270		148	168	Monitoring	S	1
OCWD-BS10	OCWD	906		595	605	Monitoring	S/P	1,6
OCWD-BS103A	OCWD	16		10	15	Monitoring		1,6
OCWD-BS105A	OCWD	12		6	11	Monitoring		1,6
OCWD-BS11	OCWD	741		580	590	Monitoring	S/P	1,6
OCWD-BS15	OCWD	105		60	70	Monitoring		1,6
OCWD-BS16	OCWD	95		60	80	Monitoring	S	1,6
OCWD-BS16A	OCWD	24		16	21	Monitoring		1,6
OCWD-BS18	OCWD	95		72	82	Monitoring	S	1,6
OCWD-BS18A	OCWD	17		11	16	Monitoring		1,6
OCWD-BS19	OCWD	100		63	83	Monitoring	S	1,6
OCWD-BS20A	OCWD	27		6	11	Monitoring		1
OCWD-BS20B	OCWD	85		71	81	Monitoring	S	1,6
OCWD-BS21	OCWD	0		0	0	Monitoring	S	1,6
OCWD-CTG1	OCWD	1330		1060	1220	Monitoring	S/P/D	1,10
OCWD-CTG5	OCWD	1600		1040	1120	Monitoring	P/D	1
OCWD-CTK1	OCWD	1444		1260	1315	Monitoring	P/D	1
OCWD-D1	OCWD	926		780	880	Other Active Production	P	2,3
OCWD-D3	OCWD	1050		560	1000	Other Active Production	P	2,3
OCWD-D4	OCWD	1033		531	979	Other Active Production	P	2,3
OCWD-D5	OCWD	1050		597	1005	Inactive Production		2,3
OCWD-EW1	OCWD	324		160	295	Inactive Production		2,8

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
OCWD-EW2	OCWD	230		130	196	Inactive Production	S	2,8
OCWD-EW2A	OCWD	207		122	188	Inactive Production	S	2,8
OCWD-EW3	OCWD	270		150	249	Inactive Production		2,8
OCWD-EW3A	OCWD	0		0	0	Inactive Production	S	2,8
OCWD-EW4	OCWD	275		130	255	Inactive Production	S	2,8
OCWD-FBM1	OCWD	140		38	138	Monitoring	S	1
OCWD-FBM2	OCWD	140		39	139	Monitoring	S	1
OCWD-FBR1	OCWD	100		30	90	Injection		4
OCWD-FC1	OCWD	185		165	185	Monitoring	P	1
OCWD-FC2	OCWD	115		95	115	Monitoring	S	1
OCWD-FH1	OCWD	140		120	140	Monitoring	S	1
OCWD-GA1	OCWD	45		30	40	Monitoring		1
OCWD-GA2	OCWD	45		30	40	Monitoring	S	1,6
OCWD-GA3	OCWD	45		30	40	Monitoring		1
OCWD-GA4	OCWD	45		30	40	Monitoring		1
OCWD-GA5	OCWD	45		30	40	Monitoring		1
OCWD-GA6	OCWD	45		30	40	Monitoring		1
OCWD-GA7	OCWD	45		30	40	Monitoring		1,9
OCWD-GA9	OCWD	30		19	29	Monitoring		1
OCWD-HBM5A	OCWD	22		16	21	Monitoring		1
OCWD-HBM6A	OCWD	17		11	16	Monitoring		1
OCWD-I1	OCWD	407		365	400	Injection		4
OCWD-I10	OCWD	330		305	330	Injection		4
OCWD-I11	OCWD	310		200	225	Injection		4
OCWD-I12	OCWD	320		290	310	Injection		4
OCWD-I13	OCWD	315		280	305	Injection		4
OCWD-I14	OCWD	310		265	300	Injection		4
OCWD-I15	OCWD	295		262	285	Injection		4
OCWD-I16	OCWD	308		245	285	Injection		4
OCWD-I17	OCWD	309		250	275	Injection		4
OCWD-I18	OCWD	315		260	275	Injection		4
OCWD-I19	OCWD	292		235	270	Injection		4
OCWD-I2	OCWD	402		350	390	Injection		4
OCWD-I20	OCWD	275		240	265	Injection		4
OCWD-I21	OCWD	265		230	250	Injection		4
OCWD-I22	OCWD	306		250	275	Injection		4
OCWD-I23	OCWD	325		215	255	Injection		4
OCWD-I24	OCWD	720		420	605	Injection	P	4
OCWD-I25	OCWD	662		120	320	Injection		4
OCWD-I26A	OCWD	220		60	195	Injection	S	4
OCWD-I26B	OCWD	430		271	400	Injection		4
OCWD-I26C	OCWD	697		476	660	Injection	P	4
OCWD-I27A	OCWD	171		78	148	Injection	S	4
OCWD-I27B	OCWD	280		211	261	Injection		4
OCWD-I27C	OCWD	592		355	420	Injection	P	4
OCWD-I27M1	OCWD	23		17	22	Monitoring		1
OCWD-I28A	OCWD	163		80	140	Injection	S	4
OCWD-I28B	OCWD	258		185	235	Injection		4
OCWD-I28C	OCWD	698		360	460	Injection	P	4
OCWD-I28M1	OCWD	24		19	24	Monitoring		1
OCWD-I29A	OCWD	156		90	120	Injection	S	4
OCWD-I29B	OCWD	275		200	250	Injection		4
OCWD-I29C	OCWD	515		365	475	Injection	P	4
OCWD-I3	OCWD	380		340	380	Injection		4
OCWD-I30A	OCWD	187		95	160	Injection	S	4
OCWD-I30B	OCWD	322		230	295	Injection		4
OCWD-I30C	OCWD	708		425	650	Injection	P	4
OCWD-I31A	OCWD	192		90	165	Injection	S	4
OCWD-I31B	OCWD	321		235	295	Injection		4
OCWD-I31C	OCWD	688		440	590	Injection	P	4
OCWD-I32A	OCWD	181		90	155	Injection	S	4
OCWD-I32B	OCWD	326		226	295	Injection		4
OCWD-I32C	OCWD	703		425	670	Injection	P	4
OCWD-I33A	OCWD	183		61	156	Injection	S	4
OCWD-I34A	OCWD	160		60	135	Injection	S	4
OCWD-I35A	OCWD	155		60	115	Injection	S	4

List of Wells in OCWD Monitoring Programs

KEY

Aquifer Zone: S=Shallow Aquifer, P=Principal Aquifer, D= Deep Aquifer

Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
OCWD-I36A	OCWD	143		60	110	Injection	S	4
OCWD-I4	OCWD	360		330	355	Injection		4
OCWD-I5	OCWD	365		320	345	Injection		4
OCWD-I6	OCWD	355		315	335	Injection		4
OCWD-I7	OCWD	345		315	336	Injection		4
OCWD-I8	OCWD	335		300	325	Injection		4
OCWD-I9	OCWD	340		300	330	Injection		4
OCWD-KB1	OCWD	200		180	200	Monitoring	S	1
OCWD-LB1	OCWD	177		148	168	Monitoring	S	1
OCWD-LB2	OCWD	65		15	30	Monitoring		1
OCWD-LB3	OCWD	175		145	165	Monitoring	S	1
OCWD-LB4	OCWD	130		78	88	Monitoring	S	1
OCWD-LV1	OCWD	155		135	155	Monitoring	S	1
OCWD-M1	OCWD	123		75	110	Monitoring	S	1,6
OCWD-M10	OCWD	336		280	305	Monitoring	S	1
OCWD-M10A	OCWD	17		11	16	Monitoring		1
OCWD-M11	OCWD	310		260	290	Monitoring	S	1
OCWD-M12	OCWD	400		330	350	Monitoring	S	1
OCWD-M13	OCWD	400		360	395	Monitoring	S	1
OCWD-M13A	OCWD	21		16	21	Monitoring		1
OCWD-M14A	OCWD	360		200	300	Monitoring	S	1
OCWD-M14B	OCWD	360		320	340	Monitoring		1
OCWD-M15A	OCWD	340		195	290	Monitoring	S	1
OCWD-M15B	OCWD	340		310	335	Monitoring		1
OCWD-M16	OCWD	337		295	315	Monitoring	S	1
OCWD-M17A	OCWD	360		330	345	Monitoring	S	1
OCWD-M17B	OCWD	360		210	305	Monitoring		1
OCWD-M18	OCWD	358		310	335	Monitoring		1
OCWD-M19	OCWD	285		215	265	Monitoring	S	1
OCWD-M2	OCWD	162		85	150	Monitoring	S	1,6
OCWD-M20	OCWD	278		255	270	Monitoring	S	1
OCWD-M21	OCWD	355		320	340	Monitoring	S	1
OCWD-M22	OCWD	348		230	270	Monitoring	S	1
OCWD-M23A	OCWD	337		190	260	Monitoring		1
OCWD-M23B	OCWD	337		295	320	Monitoring		1
OCWD-M24	OCWD	330		290	310	Monitoring	S	1
OCWD-M25	OCWD	200		65	185	Monitoring	S	1,6
OCWD-M26	OCWD	151		70	135	Monitoring	S	1,6,10
OCWD-M26A	OCWD	16		11	16	Monitoring		1,6
OCWD-M27	OCWD	127		60	110	Monitoring	S	1,6
OCWD-M27A	OCWD	22		11	16	Monitoring		1,6
OCWD-M28	OCWD	161		80	145	Monitoring	S	1,6
OCWD-M2A	OCWD	25		17	22	Monitoring		1
OCWD-M30	OCWD	128		90	110	Monitoring	S	1,6
OCWD-M31	OCWD	180		82	162	Monitoring	S	1,6
OCWD-M36	OCWD	340		290	300	Monitoring	S	1,6
OCWD-M37	OCWD	368		338	348	Monitoring	S	1,6
OCWD-M38	OCWD	700		516	526	Monitoring	S/P	1,6
OCWD-M39	OCWD	622		250	270	Monitoring	P	1,6
OCWD-M4	OCWD	352		295	330	Monitoring	S	1,6
OCWD-M40	OCWD	900		330	520	Monitoring	S/P	1,6
OCWD-M41	OCWD	450		370	390	Monitoring	S/P	1,6
OCWD-M42	OCWD	645		608	628	Monitoring	S/P	1,6
OCWD-M43	OCWD	695		520	540	Monitoring	P	1,6
OCWD-M44	OCWD	502		295	305	Monitoring	S/P	1,6
OCWD-M44A	OCWD	125		100	125	Monitoring		1,6
OCWD-M45	OCWD	1014		780	790	Monitoring	S/P	1
OCWD-M46	OCWD	1035		890	910	Monitoring	P	1
OCWD-M46A	OCWD	391		350	370	Monitoring		1
OCWD-M47	OCWD	1010		940	960	Monitoring	P	1
OCWD-M48	OCWD	505		470	480	Monitoring	S/P	1,6
OCWD-M49A	OCWD	24		16	21	Monitoring		1,6
OCWD-M49B	OCWD	85		56	81	Monitoring		1,6
OCWD-M5	OCWD	325		285	305	Monitoring	S	1,6
OCWD-M50	OCWD	25		16	21	Monitoring		1,6
OCWD-M51A	OCWD	43		28	38	Monitoring		1,6
OCWD-M51B	OCWD	130		75	105	Monitoring		1,6

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
OCWD-M52A	OCWD	61		46	56	Monitoring		1,6
OCWD-M52B	OCWD	150		120	140	Monitoring		1,6
OCWD-M52C	OCWD	237		210	230	Monitoring	P	1,6
OCWD-M52D	OCWD	460		330	350	Monitoring	P	1,6
OCWD-M53A	OCWD	38		22	32	Monitoring		1,6
OCWD-M53B	OCWD	132		115	125	Monitoring	S	1,6
OCWD-M53C	OCWD	229		208	218	Monitoring		1,6
OCWD-M54B	OCWD	150		105	125	Monitoring		1,6
OCWD-M6A	OCWD	305		260	285	Monitoring	S	1,6
OCWD-M6B	OCWD	305		185	235	Monitoring		1,6
OCWD-M7A	OCWD	293		190	220	Monitoring	S	1,6
OCWD-M7B	OCWD	293		240	260	Monitoring		1,6
OCWD-M8	OCWD	346		275	310	Monitoring	S	1,6
OCWD-M9	OCWD	311		250	295	Monitoring	S	1,6
OCWD-MRSH	OCWD	540		199	219	Monitoring	P	1,6
OCWD-P1	OCWD	197		64	179	Monitoring	S	1,6
OCWD-P10	OCWD	150		90	130	Monitoring	S	1,6
OCWD-P2	OCWD	186		56	174	Monitoring	S	1
OCWD-P3	OCWD	181		66	166	Monitoring	S	1,6
OCWD-P4	OCWD	163		70	150	Monitoring	S	1,6
OCWD-P6	OCWD	178		85	150	Monitoring	S	1,6
OCWD-P7	OCWD	149		80	135	Monitoring	S	1,6
OCWD-PD3A	OCWD	11		4	9	Monitoring		1
OCWD-PD3B	OCWD	22		15	20	Monitoring		1
OCWD-PD6A	OCWD	10		3	8	Monitoring		1
OCWD-PD6B	OCWD	22		15	20	Monitoring		1
OCWD-PDE4	OCWD	0		30	213	Monitoring		1
OCWD-PDHQ	OCWD	180		100	180	Other Active Production		2
OCWD-PZ6	OCWD	32		10	30	Monitoring		1
OCWD-PZ8	OCWD	32		10	30	Monitoring		1
OCWD-RVW1	OCWD	80		67	77	Monitoring	S	1
OCWD-RVW1A	OCWD	50		39	49	Monitoring		1
OCWD-SA22R	OCWD	350		310	330	Monitoring	S/P	1,6
OCWD-T2	OCWD	380		300	360	Monitoring	S/P	1,6
OCWD-T3	OCWD	180		110	170	Monitoring	S	1,6
OCWD-T4	OCWD	178		68	168	Monitoring	S	1,6
OCWD-T5	OCWD	396		285	295	Monitoring	S	1,6
OCWD-W1	OCWD	398		0	0	Monitoring		1
OCWD-YLR1	OCWD	51		35	40	Monitoring	S	1
OCWD-YLR2	OCWD	51		32	37	Monitoring	S	1
OCWD-YLR3	OCWD	51		31	36	Monitoring	S	1
OM-1	OCWD	245		217	235	Monitoring		1
OM-2	OCWD	250		211	219	Monitoring		1
OM-2A	OCWD	135		118	125	Monitoring	S	1
OM-4	OCWD	253		221	230	Monitoring		1
OM-4A	OCWD	122		112	117	Monitoring	S	1
OM-6	OCWD	251		196	204	Monitoring		1
OM-8	OCWD	320		285	293	Monitoring		1
OM-8A	OCWD	180		156	164	Monitoring	S	1
SAM-1	OCWD	215		191	196	Monitoring	S	1,9
SAM-2	OCWD	220		204	214	Monitoring	S	1,9
SAM-3	OCWD	225		198	208	Monitoring	S	1,9
SAM-4	OCWD	210		185	195	Monitoring	S	1,9
SAM-5	OCWD	205		182	192	Monitoring	S	1,9
SAM-6	OCWD	205		176	186	Monitoring	S	1,9
SAR-1	OCWD	1530	MP1	150	170	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP2	290	300	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP3	320	330	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP4	360	370	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP5	510	530	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP6	580	590	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP7	820	840	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP8	890	900	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP9	910	920	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP10	1010	1020	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP11	1110	1120	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP12	1280	1290	Multiport Monitoring	S/P/D	1,10

List of Wells in OCWD Monitoring Programs

KEY

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
SAR-1	OCWD	1530	MP13	1370	1380	Multiport Monitoring	S/P/D	1,10
SAR-1	OCWD	1530	MP14	1441	1451	Multiport Monitoring	S/P/D	1,10
SAR-10	OCWD	1150		1100	1115	Monitoring	P	1,5
SAR-11	OCWD	1214		1100	1110	Monitoring	P	1,5
SAR-2	OCWD	1520	MP1	140	150	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP2	270	280	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP3	310	320	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP4	470	480	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP5	610	620	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP6	740	750	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP7	880	890	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP8	980	990	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP9	1020	1030	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP10	1100	1110	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP11	1230	1240	Multiport Monitoring	S/P/D	1
SAR-2	OCWD	1520	MP12	1350	1360	Multiport Monitoring	S/P/D	1
SAR-3	OCWD	1494	MP1	160	170	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP2	230	240	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP3	410	420	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP4	510	520	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP5	640	650	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP6	770	780	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP7	950	960	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP8	1070	1080	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP9	1195	1205	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP10	1265	1275	Multiport Monitoring	S/P/D	1,10
SAR-3	OCWD	1494	MP11	1390	1400	Multiport Monitoring	S/P/D	1,10
SAR-4	OCWD	1520	MP1	115	125	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP2	320	330	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP3	470	480	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP4	590	600	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP5	730	740	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP6	860	870	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP7	970	980	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP8	1060	1070	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP9	1160	1170	Multiport Monitoring	S/P/D	1
SAR-4	OCWD	1520	MP10	1395	1405	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP1	80	90	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP2	170	180	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP3	360	370	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP4	616	626	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP5	760	770	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP6	940	950	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP7	1080	1090	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP8	1190	1200	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP9	1290	1300	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP10	1540	1550	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP11	1730	1740	Multiport Monitoring	S/P/D	1
SAR-5	OCWD	1964	MP12	1820	1830	Multiport Monitoring	S/P/D	1
SAR-6	OCWD	1574	MP1	200	210	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP2	360	370	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP3	470	480	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP4	574	584	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP5	700	710	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP6	780	790	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP7	1080	1090	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP8	1180	1190	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP9	1270	1280	Multiport Monitoring	P	1
SAR-6	OCWD	1574	MP10	1500	1510	Multiport Monitoring	P	1
SAR-7	OCWD	1483	MP1	110	120	Multiport Monitoring	S/P	1
SAR-7	OCWD	1483	MP2	170	180	Multiport Monitoring	S/P	1
SAR-7	OCWD	1483	MP3	310	320	Multiport Monitoring	S/P	1
SAR-7	OCWD	1483	MP4	440	450	Multiport Monitoring	S/P	1
SAR-7	OCWD	1483	MP5	604	614	Multiport Monitoring	S/P	1
SAR-7	OCWD	1483	MP6	740	750	Multiport Monitoring	S/P	1
SAR-7	OCWD	1483	MP7	856	866	Multiport Monitoring	S/P	1
SAR-7	OCWD	1483	MP8	1190	1200	Multiport Monitoring	S/P	1

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
SAR-7	OCWD	1483	MP9	1350	1360	Multiport Monitoring	S/P	1
SAR-8	OCWD	267	MP1	34	44	Multiport Monitoring	S	1
SAR-8	OCWD	267	MP2	84	94	Multiport Monitoring	S	1
SAR-8	OCWD	267	MP3	150	160	Multiport Monitoring	S	1
SAR-9	OCWD	2008	MP1	148	160	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP2	236	248	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP3	406	418	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP4	488	500	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP5	604	616	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP6	724	736	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP7	872	884	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP8	1068	1080	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP9	1258	1270	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP10	1473	1484	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP11	1567	1578	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP12	1719	1730	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP13	1815	1826	Multiport Monitoring	S/P/D	1,10
SAR-9	OCWD	2008	MP14	1889	1900	Multiport Monitoring	S/P/D	1,10
SBM-1	OCWD	2023	MP1	74	84	Multiport Monitoring	S/P/D	1,6,10
SBM-1	OCWD	2023	MP2	144	154	Multiport Monitoring	S/P/D	1,6,10
SBM-1	OCWD	2023	MP3	240	250	Multiport Monitoring	S/P/D	1,6,10
SBM-1	OCWD	2023	MP4	370	380	Multiport Monitoring	S/P/D	1,6,10
SBM-1	OCWD	2023	MP5	510	520	Multiport Monitoring	S/P/D	1,6,10
SBM-1	OCWD	2023	MP6	696	706	Multiport Monitoring	S/P/D	1,6,10
SBM-1	OCWD	2023	MP7	910	920	Multiport Monitoring	S/P/D	1,6,10
SBM-1	OCWD	2023	MP8	1250	1260	Multiport Monitoring	S/P/D	1,6,10
SC-1	OCWD	720	MP1	44	54	Multiport Monitoring	S/P	1
SC-1	OCWD	720	MP2	90	100	Multiport Monitoring	S/P	1
SC-1	OCWD	720	MP3	150	160	Multiport Monitoring	S/P	1
SC-1	OCWD	720	MP4	194	204	Multiport Monitoring	S/P	1
SC-1	OCWD	720	MP5	294	304	Multiport Monitoring	S/P	1
SC-1	OCWD	720	MP6	390	400	Multiport Monitoring	S/P	1
SC-2	OCWD	879	MP1	46	56	Multiport Monitoring	S/P	1
SC-2	OCWD	879	MP2	94	104	Multiport Monitoring	S/P	1
SC-2	OCWD	879	MP3	146	156	Multiport Monitoring	S/P	1
SC-2	OCWD	879	MP4	190	200	Multiport Monitoring	S/P	1
SC-2	OCWD	879	MP5	248	258	Multiport Monitoring	S/P	1
SC-2	OCWD	879	MP6	300	310	Multiport Monitoring	S/P	1
SC-3	OCWD	1500	MP1	224	234	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP2	410	420	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP3	576	586	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP4	710	720	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP5	1018	1028	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP6	1150	1160	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP7	1230	1240	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP8	1370	1380	Multiport Monitoring	P/D	1
SC-3	OCWD	1500	MP9	1460	1470	Multiport Monitoring	P/D	1
SC-4	OCWD	1498	MP1	100	111	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP2	198	209	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP3	268	279	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP4	391	402	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP5	482	493	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP6	572	583	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP7	658	669	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP8	827	838	Multiport Monitoring	S/P/D	1,10
SC-4	OCWD	1498	MP9	1078	1089	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP1	123	133	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP2	196	206	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP3	290	300	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP4	468	478	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP5	667	677	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP6	804	814	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP7	932	942	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP8	1020	1030	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP9	1234	1244	Multiport Monitoring	S/P/D	1,10
SC-5	OCWD	1500	MP10	1426	1436	Multiport Monitoring	S/P/D	1,10
SC-6	OCWD	2213	MP1	90	100	Multiport Monitoring	S/P/D	1

List of Wells in OCWD Monitoring Programs

KEY

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
SC-6	OCWD	2213	MP2	200	210	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP3	300	310	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP4	540	550	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP5	785	795	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP6	960	970	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP7	1120	1130	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP8	1325	1335	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP9	1460	1470	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP10	1540	1550	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP11	1680	1690	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP12	1890	1900	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP13	2025	2035	Multiport Monitoring	S/P/D	1
SC-6	OCWD	2213	MP14	2115	2125	Multiport Monitoring	S/P/D	1
SCS-1	OCWD	313	MP1	24	34	Multiport Monitoring	S/P	1
SCS-1	OCWD	313	MP2	90	100	Multiport Monitoring	S/P	1
SCS-1	OCWD	313	MP3	142	152	Multiport Monitoring	S/P	1
SCS-1	OCWD	313	MP4	178	188	Multiport Monitoring	S/P	1
SCS-1	OCWD	313	MP5	220	230	Multiport Monitoring	S/P	1
SCS-1	OCWD	313	MP6	295	305	Multiport Monitoring	S/P	1
SCS-10	OCWD	230		206	216	Monitoring		1
SCS-11	OCWD	405		384	394	Monitoring	S	1
SCS-12	OCWD	405		275	285	Monitoring	S	1
SCS-13	OCWD	200		180	190	Monitoring		1
SCS-2	OCWD	401	MP1	134	145	Multiport Monitoring	S/P	1,10
SCS-2	OCWD	401	MP2	174	185	Multiport Monitoring	S/P	1,10
SCS-2	OCWD	401	MP3	212	223	Multiport Monitoring	S/P	1,10
SCS-2	OCWD	401	MP4	260	270	Multiport Monitoring	S/P	1,10
SCS-2	OCWD	401	MP5	325	335	Multiport Monitoring	S/P	1,10
SCS-3	OCWD	52		31	42	Monitoring		1
SCS-4	OCWD	50		21	32	Monitoring		1
SCS-5	OCWD	51		22	43	Monitoring		1
SCS-6	OCWD	154		147	153	Monitoring	S	1
SCS-7	OCWD	142		125	141	Monitoring	S	1
SCS-8	OCWD	130		108	129	Monitoring	S	1
SCS-9	OCWD	205		153	173	Monitoring	S	1
SCS-B1	OCWD	43		18	43	Monitoring		1
SCS-B2	OCWD	29		19	29	Monitoring		1
SCS-B3	OCWD	26		16	26	Monitoring		1
TIC-67	OCWD	902		245	900	Monitoring	P	1
W-14659	OCWD	27		12	27	Monitoring		1
WBS-2A	OCWD	177	MP1	50	60	Multiport Monitoring	S	1
WBS-2A	OCWD	177	MP2	90	100	Multiport Monitoring	S	1
WBS-2A	OCWD	177	MP3	135	145	Multiport Monitoring	S	1
WBS-3R	OCWD	256	MP1	75	85	Monitoring	S	1
WBS-3R	OCWD	256	MP2	215	225	Monitoring	S	1
WBS-4	OCWD	295		55	220	Multiport Monitoring	S/P	1,10
WMM-1	OCWD	2015	MP1	109	119	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP2	359	369	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP3	480	490	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP4	600	610	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP5	740	750	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP6	810	820	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP7	889	899	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP8	980	990	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP9	1060	1070	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP10	1210	1220	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP11	1309	1319	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP12	1364	1374	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP13	1430	1440	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP14	1565	1575	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP15	1619	1629	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP16	1740	1750	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP17	1800	1810	Multiport Monitoring	S/P/D	1
WMM-1	OCWD	2015	MP18	1940	1950	Multiport Monitoring	S/P/D	1
O-1	ORANGE	500		236	416	Inactive Production		2
O-15	ORANGE	506		200	492	Active Large Production	P	2,7
O-18	ORANGE	714		372	574	Active Large Production	P	2,7

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
O-19	ORANGE	1060		444	1014	Active Large Production	P	2,7
O-20	ORANGE	1210		400	1130	Active Large Production	P	2,7
O-21	ORANGE	1366		482	1252	Active Large Production	P	2,7
O-22	ORANGE	1282		342	802	Active Large Production	P	2,7
O-23	ORANGE	958		370	640	Active Large Production	P	2,7
O-24	ORANGE	826		420	800	Active Large Production	P	2,7
O-25	ORANGE	993		430	885	Active Large Production	P	2,7
O-26	ORANGE	1210		460	1170	Active Large Production	P	2,7
O-27	ORANGE	960		425	890	Inactive Production		2,7
O-3	ORANGE	216		207	216	Active Large Production		2,7
O-4	ORANGE	726		280	711	Active Large Production	P	2,7
O-5	ORANGE	751		156	723	Active Large Production		2,7
O-8	ORANGE	870		570	850	Active Large Production	P	2,7
O-9	ORANGE	910		546	888	Active Large Production	P	2,7
OASI-SA	ORANGE COAST PLUMBING	326		226	288	Inactive Production		2
EMA-AH5	ORANGE COUNTY	84		0	0	Other Active Production		2,3
TIC-73	ORANGE COUNTY	926		324	915	Inactive Production		2,3
CEM2-A	ORANGE COUNTY CEMETERY DIST.	401		0	0	Other Active Production		2,3,8
NVLW-SB	ORANGE COUNTY PRODUCTIONUCE LLC	430		200	420	Other Active Production		2,3
RUIZ-5A1	ORANGE COUNTY PRODUCTIONUCE LLC	0		0	0	Other Active Production		2,3
RUIZ-5A3	ORANGE COUNTY PRODUCTIONUCE LLC	425		210	390	Other Active Production		2,3
RUIZ-6F1	ORANGE COUNTY PRODUCTIONUCE LLC	426		210	390	Other Active Production		2,3,6
OWOD-GG	ORANGEWOOD ACADEMY	180		159	179	Other Active Production	S	2,3
PSCI-AM14	PACIFIC SCIENTIFIC	118		93	113	Other Active Production		2
PSCI-AM21	PACIFIC SCIENTIFIC	116		95	116	Other Active Production		2
PSCI-AM22	PACIFIC SCIENTIFIC	119		99	119	Other Active Production		2
PSCI-AM25	PACIFIC SCIENTIFIC	115		69	114	Other Active Production		2
PSCI-AM26	PACIFIC SCIENTIFIC	120		69	114	Other Active Production		2
PSCI-AM31	PACIFIC SCIENTIFIC	114		68	113	Other Active Production		2
PSCI-AM32R	PACIFIC SCIENTIFIC	116		70	115	Monitoring		1
PSCI-AM33	PACIFIC SCIENTIFIC	115		7	114	Other Active Production		2
PSCI-AM34	PACIFIC SCIENTIFIC	114		102	112	Other Active Production		2
PSCI-AM35	PACIFIC SCIENTIFIC	115		7	112	Other Active Production		2
PSCI-AM36	PACIFIC SCIENTIFIC	115		9	114	Other Active Production		2
PSCI-AM37	PACIFIC SCIENTIFIC	114		102	112	Or Active Production		2
PSCI-AM38	PACIFIC SCIENTIFIC	114		69	113	Or Active Production		2
PSCI-AM39	PACIFIC SCIENTIFIC	115		69	113	Or Active Production		2
PSCI-AM40	PACIFIC SCIENTIFIC	127		109	124	Monitoring		1
PSCI-AM41	PACIFIC SCIENTIFIC	116		109	114	Monitoring		1
PSCI-AM6	PACIFIC SCIENTIFIC	115		103	113	Monitoring		1
PSCI-AT1	PACIFIC SCIENTIFIC	146		129	144	Monitoring		1
PAGE-F	PAGE AVE. MUTUAL WATER CO.	378		186	364	Active Small Production		2,7,8
PLMW-A	PALM MUTUAL WATER CO.	280		0	0	Inactive Production		2,3
PLMD-HB	PALMDALE-CEDAR WATER ASSOC.	180		0	0	Inactive Production		2
PUSD-LB	PARAMOUNT UNIFIED SCHOOL DIST.	155		126	139	Other Active Production		2
W-3767	PARK STANTON PLACE	131		0	0	Inactive Production		2,3
PWC-29H	PARK WATER CO.	462		388	409	Inactive Production		2
PWC-6G	PARK WATER CO.	854		421	807	Other Active Production		2
W-15063	PARKVIEW MUTUAL WATER CO.	250		0	0	Inactive Production		2
PAUL-COS	PAULARINO WATER ASSOC.	450		0	0	Inactive Production		2
PINE-O	PINE WATER CO.	0		0	0	Inactive Production		2
PIRT-HB	PIRATE WATER CO.	156		0	0	Other Active Production		2,6
W-17527	POWERLINE OIL CO.	0		0	0	Inactive Production		2,3
SNDR-SA	PRIVATE	1030		930	990	Other Active Production	D	2,3,9
SHAF-WM	PRIVATE	125		0	0	Other Active Production		2
ANDR-A	PRIVATE	82		0	0	Other Active Production		2
ANNA-O	PRIVATE	0		0	0	Other Active Production		2
ARAK-WM	PRIVATE	0		0	0	Other Active Production		2
BLSO-SA	PRIVATE	100		0	0	Inactive Production		2,3
BOIS-A	PRIVATE	235		0	0	Other Active Production		2
BSBY-GG	PRIVATE	148		0	0	Other Active Production		2
BXBY-SB	PRIVATE	305		150	290	Other Active Production		2,3
CALL-FV	PRIVATE	214		0	0	Other Active Production		2,3
CO-8	PRIVATE	221		0	0	Other Active Production		2,3
CO-9	PRIVATE	250		144	234	Other Active Production		2,3
COOP-SA	PRIVATE	138		0	0	Inactive Production		2
COUR-HBB2	PRIVATE	138		0	0	Inactive Production		2

List of Wells in OCWD Monitoring Programs

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
COUR-HBB3	PRIVATE	226		120	216	Inactive Production		2,3
CREST-BR	PRIVATE	530		187	523	Other Active Production		2,3
CULBK-CE1	PRIVATE	0		0	0	Other Active Production		2
DAVI-O	PRIVATE	185		0	0	Other Active Production		2
DETT-BP	PRIVATE	0		0	0	Inactive Production		2
DOSS-BP	PRIVATE	0		0	0	Inactive Production		2
ECKH-A	PRIVATE	260		0	0	Or Active Production		2
ENCS-GG	PRIVATE	155		0	0	Inactive Production		2,3
FAVI-C	PRIVATE	130		0	0	Inactive Production		2
GHAV-GG	PRIVATE	200		168	188	Other Active Production	S	2,3
GORD-LW	PRIVATE	0		0	0	Other Active Production		2
GRNT-CE	PRIVATE	0		0	0	Other Active Production		2
HNCK-C	PRIVATE	90		0	0	Inactive Production		2,3
HOWD-A	PRIVATE	217		0	0	Inactive Production		2
HTCH-WM	PRIVATE	120		0	0	Inactive Production		2
HUNTZ-SA	PRIVATE	146		100	145	Other Active Production		2,3
ICHI-HB	PRIVATE	128		0	0	Other Active Production		2
JAME-CO	PRIVATE	376		192	250	Other Active Production		2
KNAS-S	PRIVATE	205		0	0	Other Active Production		2
KUBO-FV	PRIVATE	133		122	132	Other Active Production		2
LCRO-FV	PRIVATE	0		0	0	Other Active Production		2
MCGA-A	PRIVATE	0		0	0	Other Active Production		2
MCGN-BP1	PRIVATE	260		50	255	Other Active Production	S	2
MKSN-WM	PRIVATE	137		127	137	Inactive Production		2
MONITORINGG-O	PRIVATE	480		80	480	Other Active Production		2,3
MONITORINGT-A	PRIVATE	110		0	0	Other Active Production		2
MSER-A	PRIVATE	100		0	0	Other Active Production		2
MSSM-A	PRIVATE	135		0	0	Inactive Production		2
NAKM-A	PRIVATE	120		0	0	Inactive Production		2
NAKT-BP	PRIVATE	110		0	0	Other Active Production		2
NESL-GG	PRIVATE	0		0	0	Other Active Production		2
NORT-A	PRIVATE	0		0	0	Inactive Production		2
NVLW-SB3	PRIVATE	680		0	0	Other Active Production	P	2,3
PEAR-GG	PRIVATE	143		0	0	Inactive Production		2
PEIR-A	PRIVATE	137		0	0	Inactive Production		2
PTCK-SA	PRIVATE	300		0	0	Inactive Production		2,3
PURS-SB	PRIVATE	252		0	0	Other Active Production		2,3,6
RMW-SFS	PRIVATE	540		0	0	Other Active Production		2
RWLM-GG	PRIVATE	132		0	0	Other Active Production		2
SAND-BP	PRIVATE	70		0	0	Inactive Production		2
SANZ-C	PRIVATE	84		76	83	Other Active Production	S	2
SCHN-GG	PRIVATE	144		0	0	Other Active Production		2
SINC-C	PRIVATE	130		0	0	Inactive Production		2
SWAN-C	PRIVATE	185		0	0	Inactive Production		2
TAOR-A	PRIVATE	254		0	0	Inactive Production		2
VGNA-A	PRIVATE	165		0	0	Inactive Production		2,3
W-10699	PRIVATE	141		0	0	Inactive Production		2
W-10894	PRIVATE	365		357	364	Inactive Production		2
W-11104	PRIVATE	320		230	300	Inactive Production		2
W-12745	PRIVATE	270		0	0	Inactive Production		2
W-12753	PRIVATE	250		0	0	Inactive Production		2
W-12791	PRIVATE	80		0	0	Inactive Production		2
W-12819	PRIVATE	0		0	0	Inactive Production		2
W-1311	PRIVATE	345		0	345	Inactive Production		2
W-13112	PRIVATE	935		701	933	Inactive Production		2
W-13118	PRIVATE	600		343	575	Inactive Production		2,3
W-13207	PRIVATE	260		0	0	Inactive Production		2
W-13285	PRIVATE	130		0	0	Inactive Production		2
W-14805	PRIVATE	170		0	0	Inactive Production		2,3
W-15791	PRIVATE	0		0	0	Inactive Production		2,3
W-15793	PRIVATE	0		0	0	Inactive Production		2,3
W-15803	PRIVATE	0		0	0	Inactive Production		2,3
W-15817	PRIVATE	158		0	0	Inactive Production		2
W-15857	PRIVATE	100		0	0	Inactive Production		2
W-15880	PRIVATE	97		0	0	Inactive Production		2,3
W-15962	PRIVATE	450		0	0	Inactive Production		2,3
W-16004	PRIVATE	165		0	0	Inactive Production		2

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
W-18700	PRIVATE	300		200	300	Other Active Production		2,3
W-19049	PRIVATE	340		60	260	Other Active Production		2,3
W-19051	PRIVATE	430		180	400	Other Active Production		2,3
W-19053	PRIVATE	440		360	440	Other Active Production		2
W-19055	PRIVATE	360		140	360	Other Active Production		2,3
W-20906	PRIVATE	0		0	0	Inactive Production		2,3
W-2268	PRIVATE	226		140	190	Inactive Production	S	2,3
W-2447	PRIVATE	180		157	178	Inactive Production	S	2,3
W-3063	PRIVATE	310		292	300	Inactive Production		2,3
W-376	PRIVATE	370		290	370	Inactive Production		2
W-3765	PRIVATE	0		0	0	Inactive Production		2
W-3795	PRIVATE	0		0	0	Inactive Production		2,3
W-428	PRIVATE	311		0	0	Inactive Production		2,10
W-432	PRIVATE	300		117	137	Inactive Production	S	2,10
W-5304	PRIVATE	0		0	0	Inactive Production		2
W-5306	PRIVATE	292		0	0	Inactive Production		2
W-615	PRIVATE	374		188	364	Inactive Production		2,3
W-6523	PRIVATE	175		0	0	Inactive Production		2
W-702	PRIVATE	324		294	318	Inactive Production		2,3
W-7040	PRIVATE	192		0	0	Inactive Production		2,3
W-7046	PRIVATE	257		0	0	Inactive Production	S	2
W-830	PRIVATE	200		191	200	Inactive Production		2
W-856	PRIVATE	406		271	401	Inactive Production		2
W-860	PRIVATE	348		0	0	Inactive Production		2
W-9172	PRIVATE	98		50	97	Inactive Production		2
W-9180	PRIVATE	200		0	0	Inactive Production		2
WALL-A	PRIVATE	45		16	45	Other Active Production		2
WARN-WHNY	PRIVATE	0		0	0	Inactive Production		2,3
WLMS-A	PRIVATE	0		0	0	Other Active Production		2
WMIL-WM	PRIVATE	300		260	300	Inactive Production		2
WMIL-WM2	PRIVATE	650		150	640	Other Active Production		2
WRNE-WTOM	PRIVATE	0		0	0	Other Active Production		2
NOBL-O	R.J. NOBLE CO.	476		290	474	Other Active Production	P	2
FURU-HB	RAINBOW DISPOSAL	150		0	0	Other Active Production		2,6
W-4152	RAINBOW DISPOSAL	202		142	178	Inactive Production		2
RAY-MW06	RAYON CO.	191		150	190	Monitoring		1
RAY-MW09	RAYON CO.	194		152	192	Monitoring		1
RAY-MW16	RAYON CO.	180		149	179	Monitoring		1
RAY-MW17	RAYON CO.	204		173	193	Monitoring		1
RAY-MW21	RAYON CO.	238		212	232	Monitoring		1
RAY-MW23	RAYON CO.	236		215	235	Monitoring		1
RAY-MW24	RAYON CO.	338		310	330	Monitoring	D	1
RAY-MW25	RAYON CO.	805		449	480	Monitoring	D	1
RAY-MW26	RAYON CO.	805		459	499	Monitoring	P	1
RAY-MW27	RAYON CO.	550		475	515	Monitoring	P	1
RAY-MW28	RAYON CO.	425		335	375	Monitoring	P	1
RAY-MW29	RAYON CO.	266		200	240	Monitoring	P	1
RAY-MW30	RAYON CO.	635		596	616	Monitoring	P	1
RAY-MW31	RAYON CO.	1100		946	996	Monitoring	P	1
RAY-MW32	RAYON CO.	1153		1070	1100	Monitoring	P/D	1
RAY-MW33	RAYON CO.	1080		980	1020	Monitoring	P	1
RAY-MW34A	RAYON CO.	290		220	280	Monitoring		1
RAY-MW34B	RAYON CO.	540		486	536	Monitoring	P	1
RAY-MW34C	RAYON CO.	709		556	576	Monitoring	P	1
RAY-MW35	RAYON CO.	1104		990	1040	Monitoring	P	1
RAY-MW36	RAYON CO.	1030		934	994	Monitoring	P	1
RAY-MW37	RAYON CO.	916		770	820	Monitoring	P	1
RAY-MW39	RAYON CO.	1080		982	1012	Monitoring	P	1
RAY-MW40	RAYON CO.	1040		930	970	Monitoring	P	1
RAY-P07	RAYON CO.	117		108	130	Monitoring	S	1
RAY-P09	RAYON CO.	130		110	130	Monitoring	S	1
RIDG-O	RIDGELINE PERATIONS, INC.	63		55	60	Inactive Production		2
RVGC-SA	RIVER VIEW GOLF	300		156	216	Other Active Production		2,3
ROBSN-YL1	ROBERTSON READY MIX	67		21	65	Inactive Production		2,3
RCA-AR	ROMAN CATHOLIC ARCHBISHOP-LA	0		0	0	Other Active Production		2
W-8813	S FARGO BANK, INC.	13		3	13	Monitoring		1
SAKI-SAJ3	SAKIOKA & SONS, ROY K.	463		0	0	Other Active Production		2,3,9

List of Wells in OCWD Monitoring Programs

KEY

Aquifer Zone: S=Shallow Aquifer, P=Principal Aquifer, D= Deep Aquifer

Program: 1) monitoring well, 2) production well, 3) irrigation or industrial well, 4) injection well, 5) Mid-Basin Injection well, 6) seawater intrusion monitoring well, 7) well monitored by OCWD for Title 22 compliance, 8) North Basin Groundwater Protection Program wells, 9) South Basin Groundwater Protection Program wells, 10) wells in CASGEM monitoring program

Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
SAKI-SAJ1	SAKIOKA FARMS	187		0	0	Inactive Production		2,9
SA-16	SANTA ANA	978		305	950	Active Large Production	P	2,7
SA-18	SANTA ANA	654		245	623	Active Large Production	P	2,7
SA-20	SANTA ANA	981		390	940	Active Large Production	P	2,7
SA-21	SANTA ANA	986		400	960	Active Large Production	P	2,7
SA-24	SANTA ANA	688		352	654	Active Large Production	P	2,7
SA-26	SANTA ANA	1186		330	1140	Active Large Production	P	2,7,9
SA-27	SANTA ANA	1152		396	1140	Active Large Production	P	2,7
SA-28	SANTA ANA	1200		250	980	Active Large Production	P	2,7
SA-29	SANTA ANA	1090		450	1050	Active Large Production	P	2,7
SA-30	SANTA ANA	989		440	900	Active Large Production	P	2,7
SA-31	SANTA ANA	1310		465	1240	Active Large Production	P	2,7
SA-32	SANTA ANA	1060		307	1030	Inactive Production	P	2,7
SA-33	SANTA ANA	1080		425	935	Active Large Production	P	2,7
SA-34	SANTA ANA	1000		370	520	Active Large Production	P	2,7
SA-35	SANTA ANA	1520		429	1480	Active Large Production	P	2,7
SA-36	SANTA ANA	1510		570	1290	Active Large Production	P	2,7
SA-37	SANTA ANA	1560		348	1480	Active Large Production	P	2,7
SA-38	SANTA ANA	1510		400	1270	Active Large Production	P	2,7
SA-39	SANTA ANA	1350		590	1290	Active Large Production	P	2,7
SA-40	SANTA ANA	1335		550	1305	Active Large Production	P	2,7
SA-41	SANTA ANA	1010		525	978	Active Large Production	P	2,7
SA-7	SANTA ANA	960		426	907	Inactive Production		2
W-12903	SANTA ANA	423		0	0	Inactive Production		2
SACC-SA	SANTA ANA COUNTRY CLUB	536		205	406	Other Active Production	P	2,3,6
SAVI-16	SANTA ANA VALLEY IRRIGATION CO	752		262	825	Inactive Production		2,3
SFE-2	SANTA FE ENERGY CO.	294		0	0	Inactive Production		2,3
SFE-3	SANTA FE ENERGY CO.	205		0	0	Inactive Production		2,3
SFE-4	SANTA FE ENERGY CO.	180		0	0	Inactive Production		2,3
SFS-12	SANTA FE SPRINGS	1556		940	1430	Active Large Production		2
SFS-2	SANTA FE SPRINGS	1250		336	1218	Other Active Production		2,3
SAVS-ASC	SAVANNA SCHOOL DIST.	1301		0	0	Other Active Production		2,3
SB-BC	SEAL BEACH	1050		370	1020	Active Large Production	P	2,7
SB-BEV	SEAL BEACH	920		400	800	Active Large Production	P	2,6,7
SB-LAM	SEAL BEACH	1200		360	1170	Active Large Production	P	2,7
SB-LEI	SEAL BEACH	840		420	840	Active Large Production	P	2,6,7
SID-3	SERRANO WATER DIST.	604		296	584	Active Large Production	P	2,7
SID-4	SERRANO WATER DIST.	650		290	520	Active Large Production	P	2,7
SWD-5	SERRANO WATER DIST.	750		310	720	Active Large Production	P	2,7
SCC-D1	SERVICE CHEMICAL	124		113	123	Monitoring		1,9
W-15094	SHELL OIL CO.	104		58	95	Inactive Production		2
W-15098	SHELL OIL CO.	350		0	0	Inactive Production		2
W-15100	SHELL OIL CO.	115		80	115	Inactive Production		2
W-2507	SHELL OIL CO.	437		230	340	Inactive Production		2
W-2523	SHELL OIL CO.	115		70	100	Inactive Production		2
W-2505	SIGNAL OIL AND GAS	121		76	104	Inactive Production		2,3
W-9170	SIGNAL OIL AND GAS	92		80	90	Inactive Production		2
RODE-A	SILICON SALVAGE	218		178	208	Other Active Production	S	2
SILV-YL	SILVERADO CONSTRUCTORS	78		40	66	Other Active Production	S	2,3,10
W-3783	SO. CA EDISON	458		0	0	Inactive Production		2,9
SMWC-BF4	SOMERSET MUTUAL WATER CO.	1070		0	0	Other Active Production		2
SMWC-BFFWR	SOMERSET MUTUAL WATER CO.	1076		0	0	Active Small Production		2
W-13380	SOMERSET MUTUAL WATER CO.	875		0	0	Inactive Production		2
FOND-A	SOURCE REFRIGERATION	250		0	0	Inactive Production		2
MIYA-BP	SOURN CA EDISON	400		0	0	Inactive Production		2,3
SCE-DASUB	SOURN CA EDISON	0		0	0	Other Active Production		2
SCE-LBDM	SOURN CA EDISON	366		100	347	Inactive Production		2,3
SCE-LBSG	SOURN CA EDISON	340		190	340	Inactive Production		2,3
SCE-YLCS	SOURN CA EDISON	104		5	103	Inactive Production	S	2,3,10
TIC-127	SOURN CA EDISON	134		0	0	Monitoring	S	1
TIC-140	SOURN CA EDISON	787		0	0	Monitoring		1
W-13195	SOURN CA EDISON	527		0	0	Inactive Production		2,3
W-15807	SOURN CA EDISON	150		0	0	Inactive Production		2,3
W-15874	SOURN CA EDISON	188		0	0	Inactive Production		2
SCGC-I	SOURN CA GAS CO.	300		0	0	Other Active Production		2,3
SCGC-O	SOURN CA GAS CO.	405		0	0	Other Active Production		2,3
W-11198	SOURN SERVICE CO., LTD.	952		716	948	Other Active Production		2,3

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
SCSH-SA1	SOUTH COAST SHORE HOA	450		280	430	Other Active Production		2,3
SMID-D4	SOUTH MIDWAY CITY WATER CO.	142		0	0	Inactive Production		2
SMID-D5	SOUTH MIDWAY CITY WATER CO.	630		300	600	Active Small Production		2,7
SPRK-SA	SPARKLETTS DRINKING WATER CORP	246		154	212	Other Active Production		2,3
W-8292	SPRAYON PRODUCTIONUCTS	105		80	98	Monitoring		1
W-8294	SPRAYON PRODUCTIONUCTS	101		80	100	Monitoring		1
W-8296	SPRAYON PRODUCTIONUCTS	99		70	90	Monitoring		1
W-3801	STATE OF CA	725		254	407	Inactive Production		2,3
STEP-A	STEPAN CO.	275		210	275	Other Active Production		2,3,8
SWS-26B7	SUBURBAN WATER SYSTEMS	820		0	0	Inactive Production		2,3
SWS-409W3	SUBURBAN WATER SYSTEMS	1460		540	1420	Active Large Production		2
SWS-410W1	SUBURBAN WATER SYSTEMS	1312		617	1237	Other Active Production		2
ANGS-HBM3	TERMO PETROLEUM	1510		146	1440	Multiport Monitoring		1
TEX-W1	TEXACO, INC.	30		5	30	Monitoring		1
W-8805	TEXACO, INC.	45		15	45	Monitoring		1
W-8807	TEXACO, INC.	45		15	45	Monitoring		1
W-8809	TEXACO, INC.	45		15	45	Monitoring		1
W-8811	TEXACO, INC.	45		15	45	Monitoring		1
W-8815	TEXACO, INC.	35		25	35	Monitoring		1
W-18289	TOSCO MARKETING CO.	150		120	150	Monitoring		1
W-18291	TOSCO MARKETING CO.	140		105	140	Monitoring		1
W-18293	TOSCO MARKETING CO.	140		105	140	Monitoring		1
T868-S1	TRACT 868 MUTUAL WATER CO.	200		0	0	Inactive Production		2
T868-S2	TRACT 868 MUTUAL WATER CO.	0		0	0	Inactive Production		2
TREE-SA	TREESWEET PRODUCTIONUCT CO.	416		150	398	Inactive Production		2,3
TLLC-F2	TRUE LOVE LURAN CHURCH	350		190	350	Other Active Production		2,3,8
T-17S1	TUSTIN	375		200	311	Inactive Production		2
T-17S2	TUSTIN	1003		310	490	Inactive Production		2
T-17S4	TUSTIN	520		200	480	Active Large Production	P	2,7
T-BENE	TUSTIN	627		290	590	Inactive Production	P	2
T-COLU	TUSTIN	1470		560	1160	Active Large Production	P	2,7
T-ED	TUSTIN	1492		500	840	Inactive Production		2,7
T-LIVI	TUSTIN	617		300	617	Inactive Production		2
T-MS3	TUSTIN	630		300	630	Active Large Production	P	2,7
T-MS4	TUSTIN	1180		330	880	Active Large Production	P	2,7
T-NEWP	TUSTIN	375		234	267	Active Large Production	S	2,7
T-PANK	TUSTIN	614		323	614	Inactive Production	P	2,9
T-PAS	TUSTIN	1260		440	1225	Active Large Production	P	2,7
T-PROS	TUSTIN	630		270	630	Active Large Production	P	2,7
T-TUST	TUSTIN	827		306	776	Active Large Production	P	2,7
T-VNBG	TUSTIN	1129		480	900	Active Large Production	P	2,7
T-WALN	TUSTIN	1191		397	995	Active Large Production	P	2,7,9
T-YORB	TUSTIN	863		385	850	Inactive Production	P	2
USGS-NAWQA1	U.S. GEOLOGICAL SURVEY	24		14	24	Monitoring		1
USGS-NAWQA10	U.S. GEOLOGICAL SURVEY	24		14	19	Monitoring		1
USGS-NAWQA11	U.S. GEOLOGICAL SURVEY	49		39	44	Monitoring		1
USGS-NAWQA12	U.S. GEOLOGICAL SURVEY	24		14	19	Monitoring		1
USGS-NAWQA13	U.S. GEOLOGICAL SURVEY	34		24	29	Monitoring		1
USGS-NAWQA14	U.S. GEOLOGICAL SURVEY	74		69	74	Monitoring		1
USGS-NAWQA15	U.S. GEOLOGICAL SURVEY	39		29	34	Monitoring		1
USGS-NAWQA16	U.S. GEOLOGICAL SURVEY	44		34	39	Monitoring		1
USGS-NAWQA17	U.S. GEOLOGICAL SURVEY	19		9	14	Monitoring		1
USGS-NAWQA18	U.S. GEOLOGICAL SURVEY	29		19	24	Monitoring		1
USGS-NAWQA19	U.S. GEOLOGICAL SURVEY	19		9	14	Monitoring		1
USGS-NAWQA2	U.S. GEOLOGICAL SURVEY	21		10	15	Monitoring		1
USGS-NAWQA20	U.S. GEOLOGICAL SURVEY	0		14	19	Monitoring		1
USGS-NAWQA21	U.S. GEOLOGICAL SURVEY	24		14	19	Monitoring		1
USGS-NAWQA22	U.S. GEOLOGICAL SURVEY	144		134	139	Monitoring		1
USGS-NAWQA23	U.S. GEOLOGICAL SURVEY	34		24	29	Monitoring		1
USGS-NAWQA24	U.S. GEOLOGICAL SURVEY	49		34	39	Monitoring		1
USGS-NAWQA25	U.S. GEOLOGICAL SURVEY	19		9	19	Monitoring		1
USGS-NAWQA26	U.S. GEOLOGICAL SURVEY	29		19	24	Monitoring		1
USGS-NAWQA27	U.S. GEOLOGICAL SURVEY	19		9	19	Monitoring		1
USGS-NAWQA28	U.S. GEOLOGICAL SURVEY	19		9	19	Monitoring		1
USGS-NAWQA29	U.S. GEOLOGICAL SURVEY	19		9	19	Monitoring		1
USGS-NAWQA3	U.S. GEOLOGICAL SURVEY	21		12	17	Monitoring		1
USGS-NAWQA30	U.S. GEOLOGICAL SURVEY	19		9	19	Monitoring		1

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
USGS-NAWQA31	U.S. GEOLOGICAL SURVEY	24		14	19	Monitoring		1
USGS-NAWQA4	U.S. GEOLOGICAL SURVEY	24		14	19	Monitoring		1
USGS-NAWQA5	U.S. GEOLOGICAL SURVEY	20		10	15	Monitoring		1
USGS-NAWQA5	U.S. GEOLOGICAL SURVEY	20		10	15	Monitoring		9
USGS-NAWQA6	U.S. GEOLOGICAL SURVEY	20		10	15	Monitoring		1
USGS-NAWQA7	U.S. GEOLOGICAL SURVEY	29		19	24	Monitoring		1
USGS-NAWQA8	U.S. GEOLOGICAL SURVEY	23		13	18	Monitoring		1
USGS-NAWQA9	U.S. GEOLOGICAL SURVEY	29		19	24	Monitoring		1
UOC-B8	UNION OIL CO.	79		60	75	Inactive Production		2,3
UOC-B9	UNION OIL CO.	79		60	75	Inactive Production		2,3
COS-PLAZ	UNKNOWN	779		0	0	Monitoring	P	1
W-14764	UNKNOWN	0		0	0	Inactive Production		2
W-18102	UNKNOWN	130		110	130	Monitoring		1
W-3629	UNKNOWN	162		0	0	Inactive Production		2,3
W-8298	UNKNOWN	115		0	0	Monitoring		1
W-8300	UNKNOWN	85		0	0	Monitoring		1
W-8304	UNKNOWN	49		0	0	Monitoring		1
W-8306	UNKNOWN	85		0	0	Monitoring		1
W-8308	UNKNOWN	182		0	0	Monitoring		1
W-18607	UNOCAL BIRCH HILLS	130		25	130	Other Active Production		2
W-18609	UNOCAL BIRCH HILLS	0		25	120	Monitoring		1
W-18611	UNOCAL BIRCH HILLS	120		25	120	Monitoring		1
W-18613	UNOCAL BIRCH HILLS	120		45	120	Injection		4
W-18615	UNOCAL BIRCH HILLS	120		45	120	Injection		4
W-18617	UNOCAL BIRCH HILLS	120		45	120	Injection		4
W-18637	UNOCAL BIRCH HILLS	120		45	120	Injection		4
W-18639	UNOCAL BIRCH HILLS	120		45	120	Injection		4
W-18641	UNOCAL BIRCH HILLS	120		45	120	Injection		4
MTSN-SA	VERSAILLES ON LAKE APT	914		0	0	Other Active Production		2,3
CRES-A	VICTORY BAPTIST CHURCH	541		485	525	Active Small Production		2,7
A1-HB	VILLAGE NURSERIES	305		188	300	Other Active Production		2,3
W-13235	VIRGINIA COUNTRY CLUB	1285		915	1010	Monitoring		1
CATH-S	W. CARINE ST. MUT. WTR. CO.	170		0	0	Other Active Production		2,3
DISN-AE1	WALT DISNEY PRODUCTIONS	400		0	0	Inactive Production		2,3
DISN-AH1	WALT DISNEY PRODUCTIONS	0		0	0	Inactive Production		2,3
FUJS-A	WALT DISNEY PRODUCTIONS	642		446	628	Inactive Production		2,3
W-846	WALT DISNEY PRODUCTIONS	325		0	0	Inactive Production		2
WRD-CERRITOS-1	WATER REPLENISHMENT DIST.	1221		1155	1175	Monitoring		1
WRD-CERRITOS-2	WATER REPLENISHMENT DIST.	1504		1350	1370	Monitoring		1
WRD-LAKEWOOD-1A	WATER REPLENISHMENT DIST.	1020		989	1009	Monitoring		1
WRD-LAKEWOOD-1B	WATER REPLENISHMENT DIST.	172		140	160	Monitoring		1
WRD-LAKEWOOD-2	WATER REPLENISHMENT DIST.	2160		1960	2000	Monitoring		1
WRD-LAMIRADA-1	WATER REPLENISHMENT DIST.	1257		1130	1150	Monitoring		1
WRD-LONGBEACH-1	WATER REPLENISHMENT DIST.	1495		1430	1450	Monitoring		1,6
WRD-LONGBEACH-6	WATER REPLENISHMENT DIST.	1550		1490	1510	Monitoring		1
WRD-LONGBEACH-8	WATER REPLENISHMENT DIST.	1515		1435	1455	Monitoring		1
WRD-NORWALK-1	WATER REPLENISHMENT DIST.	1432		1400	1420	Monitoring		1
WRD-NORWALK-2	WATER REPLENISHMENT DIST.	1502		1460	1480	Monitoring		1
WRD-SEALBEACH-1	WATER REPLENISHMENT DIST.	1505		1345	1365	Monitoring	S/P/D	1,6
WRD-WHITTIER-1A	WATER REPLENISHMENT DIST.	1298		1180	1200	Monitoring		1
WRD-WHITTIER-1B	WATER REPLENISHMENT DIST.	640		600	620	Monitoring		1
WM-107A	WESTMINSTER	1040		350	980	Active Large Production	P	2,7
WM-11	WESTMINSTER	820		325	790	Active Large Production	P	2,7
WM-125	WESTMINSTER	930		374	860	Active Large Production	P	2,6,7
WM-3	WESTMINSTER	365		285	365	Active Large Production	P	2,7
WM-4	WESTMINSTER	1209		345	1125	Active Large Production	P	2,7
WM-6	WESTMINSTER	694		176	660	Active Large Production		2,7
WM-75A	WESTMINSTER	1041		410	996	Active Large Production	P	2,7
WM-RES1	WESTMINSTER	920		390	880	Active Large Production	P	2,7
WM-RES2	WESTMINSTER	960		340	937	Active Large Production	P	2,6,7
WM-SC4	WESTMINSTER	454		425	454	Active Large Production	P	2,7
WMEM-WE	WESTMINSTER MEMORIAL PARK	149		0	0	Inactive Production		2,3
WMEM-WPAR	WESTMINSTER MEMORIAL PARK	614		140	599	Inactive Production		2,3
WMEM-WW	WESTMINSTER MEMORIAL PARK	488		95	442	Other Active Production		2,3
WHS-CHS40	WHITTIER UNION H.S. DIST.	836		0	0	Inactive Production		2
WHS-SH550	WHITTIER UNION H.S. DIST.	804		228	780	Active Small Production		2
W-14807	WILLIAM LYON CO	490		0	0	Inactive Production		2

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Well Name	Well Owner	Bore Depth (ft. bgs)	Casing Sequence	Screened Interval (ft.bgs) Top	Bottom	Type of Well	Aquifer Zone	Program
WOOD-INLK	WOODBRIDGE VILL HOMEOWNER ASSN	910		370	890	Inactive Production	P	2,3
WOOD-ISLK	WOODBRIDGE VILL HOMEOWNER ASSN	845		210	800	Inactive Production	P	2,3
YLCC-35C2	YORBA LINDA COUNTRY CLUB	425		388	404	Inactive Production		2,3
YLCC-35C4	YORBA LINDA COUNTRY CLUB	510		188	472	Other Active Production		2,3
YLCC-35F3	YORBA LINDA COUNTRY CLUB	460		130	450	Other Active Production		2,3
YLWD-1	YORBA LINDA WATER DIST.	427		90	340	Active Large Production		2,7
YLWD-10	YORBA LINDA WATER DIST.	465		90	406	Active Large Production		2,7
YLWD-11	YORBA LINDA WATER DIST.	547		149	514	Active Large Production		2,7
YLWD-12	YORBA LINDA WATER DIST.	544		80	498	Active Large Production		2,7
YLWD-15	YORBA LINDA WATER DIST.	213		133	198	Active Large Production	S	2,7
YLWD-18	YORBA LINDA WATER DIST.	1050		250	570	Active Large Production	P	2,7
YLWD-19	YORBA LINDA WATER DIST.	611		280	581	Active Large Production	P	2,7
YLWD-20	YORBA LINDA WATER DIST.	600		225	570	Active Large Production	P	2,7
YLWD-5	YORBA LINDA WATER DIST.	395		90	340	Active Large Production		2,7
YLWD-7	YORBA LINDA WATER DIST.	361		137	259	Active Large Production		2,7

APPENDIX F

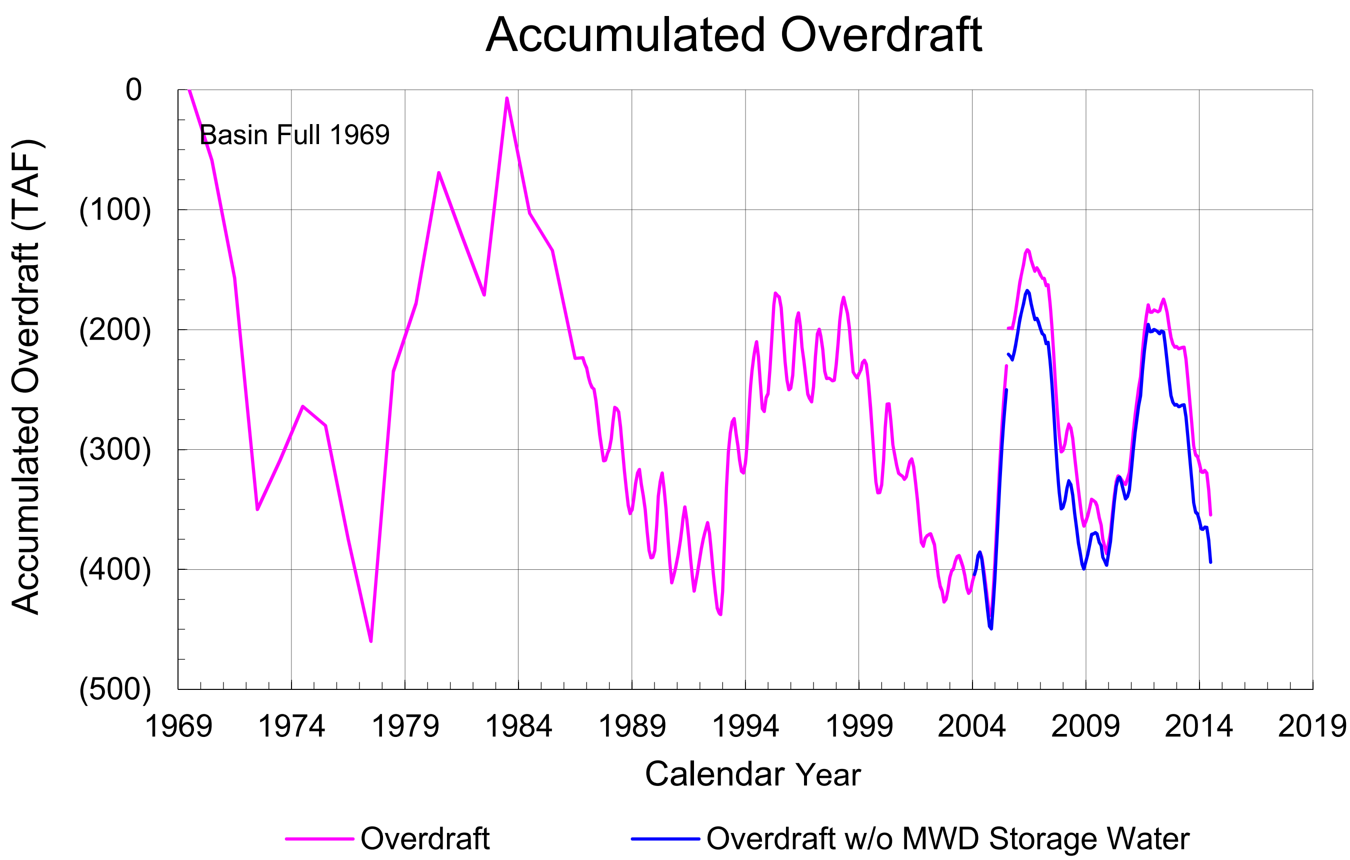
Monthly Water Resources Report

WATER RESOURCES SUMMARY

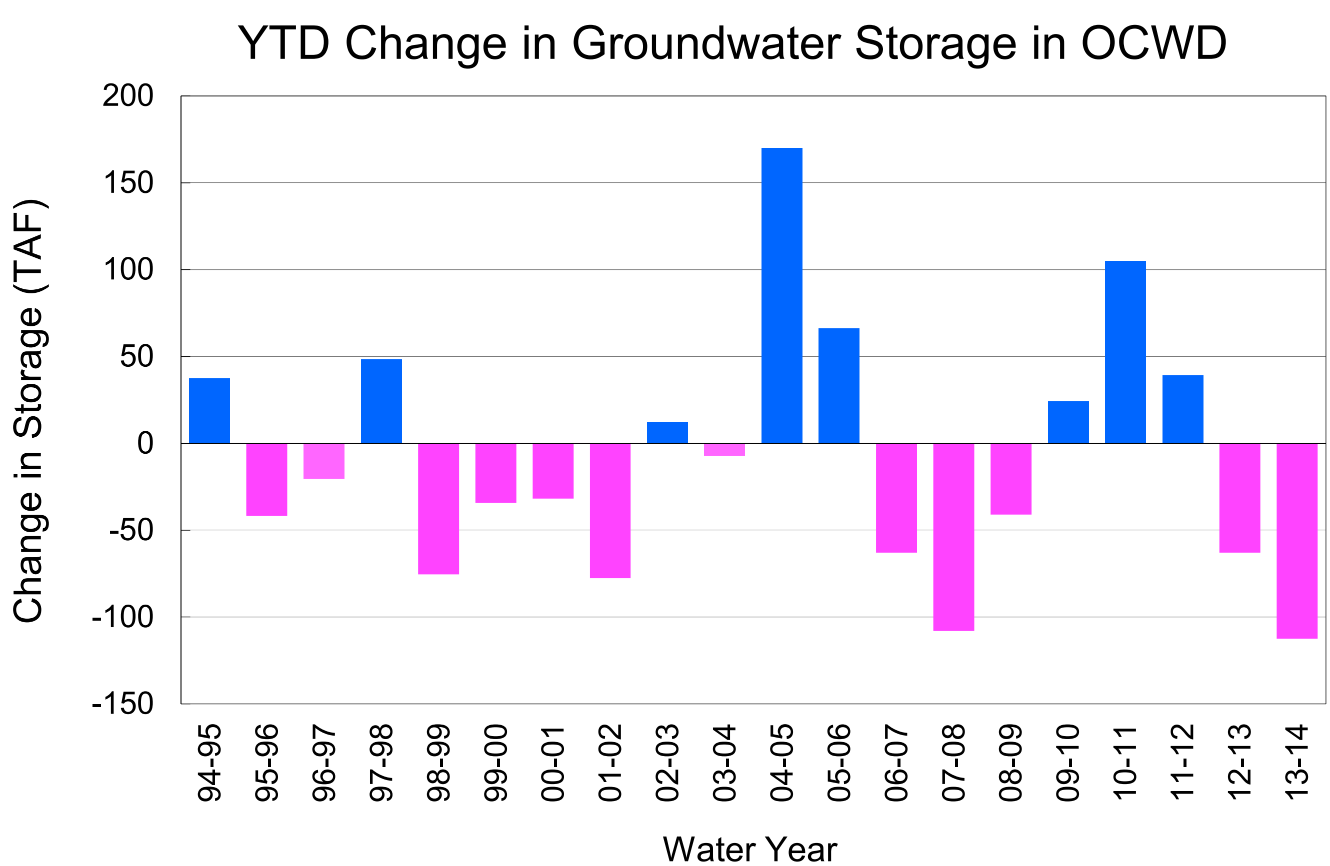
June 2014

INFLOWS & OUTFLOWS (acre-feet)	Total for Month	Year to Date - This Year	Year to Date - Last Year
BASIN SUPPLIES			
Water Purchases from MWD (excludes In Lieu)	3,890	50,701	24,356
Water into MWD Storage Account (excludes In Lieu)	0	0	15,571
SAR & Santiago Creek Flows	5,788	90,335	115,065
(accounts for storage to/from recharge facilities)			
GWRS Water to Forebay	610	34,263	45,422
GWRS Water to Talbert Barrier	606	31,900	27,205
OC-44 Water to Talbert Barrier	0	6	4
Alamitos Barrier Water	0	2,140	1,722
Incidental Recharge (estimated)	1,650	19,800	19,698
Evaporation from Recharge Basins	(263)	(2,407)	(2,309)
River Flow Lost to Ocean	0	(500)	(440)
Total Groundwater Recharge	12,280	226,238	246,294
WATER PRODUCTION			
Groundwater Production	30,759	331,156	309,295
MWD Storage Program Withdrawals	2,376	7,634	0
Total Groundwater Production	33,136	338,789	309,295
BASIN BALANCE			
Change in Groundwater Storage	(20,855)	(112,552)	(63,001)
Change in Groundwater Storage excluding MWD Stored Water	(18,479)	(104,918)	(78,572)
Accumulated Overdraft	------	354,552	242,000
Accumulated Overdraft excluding MWD Storage	------	394,189	289,902
IN LIEU WATER			
OCWD In Lieu Purchases	0	0	0
MWD In Lieu Storage	0	0	0
Total In Lieu	0	0	0
OTHER KEY INFORMATION			
1. MWD Water Deliveries to Producers	7,874	97,059	111,098
2. Basin Production Percentage	75.0%	76.0%	73.6%
3. Total Water Demand	42,549	451,867	436,275
4. Total GWRS Production	1,216	66,163	72,627
5. Green Acres Project Water	517	5,071	6,540
6. SAR Water Quality			
- Total Dissolved Solids (TDS) of SAR below Prado Dam (ppm)	724	------	710
- Total Nitrogen of SAR below Prado Dam (ppm)	4.6	------	4.3
7. Month-End Water Storage Behind Prado Dam	0	------	1
8. Month-End Water Storage in Recharge Facilities	10,151	------	8,322
9. Water Storage Change in Recharge Facilities	(2,028)	1,829	(10,168)
10. Total Artificial Recharge	10,632	206,438	226,597
11. Monthly Mean Temperature at Santa Ana Fire Station (°F)	71.4	------	70.1
12. Rainfall at FHQ (inches)	0.00	5.09	5.85

7/10/2014



Accumulated Overdraft
Accumulated Overdraft (TAF)
0
(100)
(200)
(300)
(400)
(500)
Basin Full 1969
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014
2019
Calendar Year
Overdraft
Overdraft w/o MWD Storage Water



YTD Change in Groundwater Storage in OCWD
Change in Storage (TAF)
200
150
100
50
0
-50
-100
-150
94-95
95-96
96-97
97-98
98-99
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
09-10
10-11
11-12
12-13
13-14
Water Year

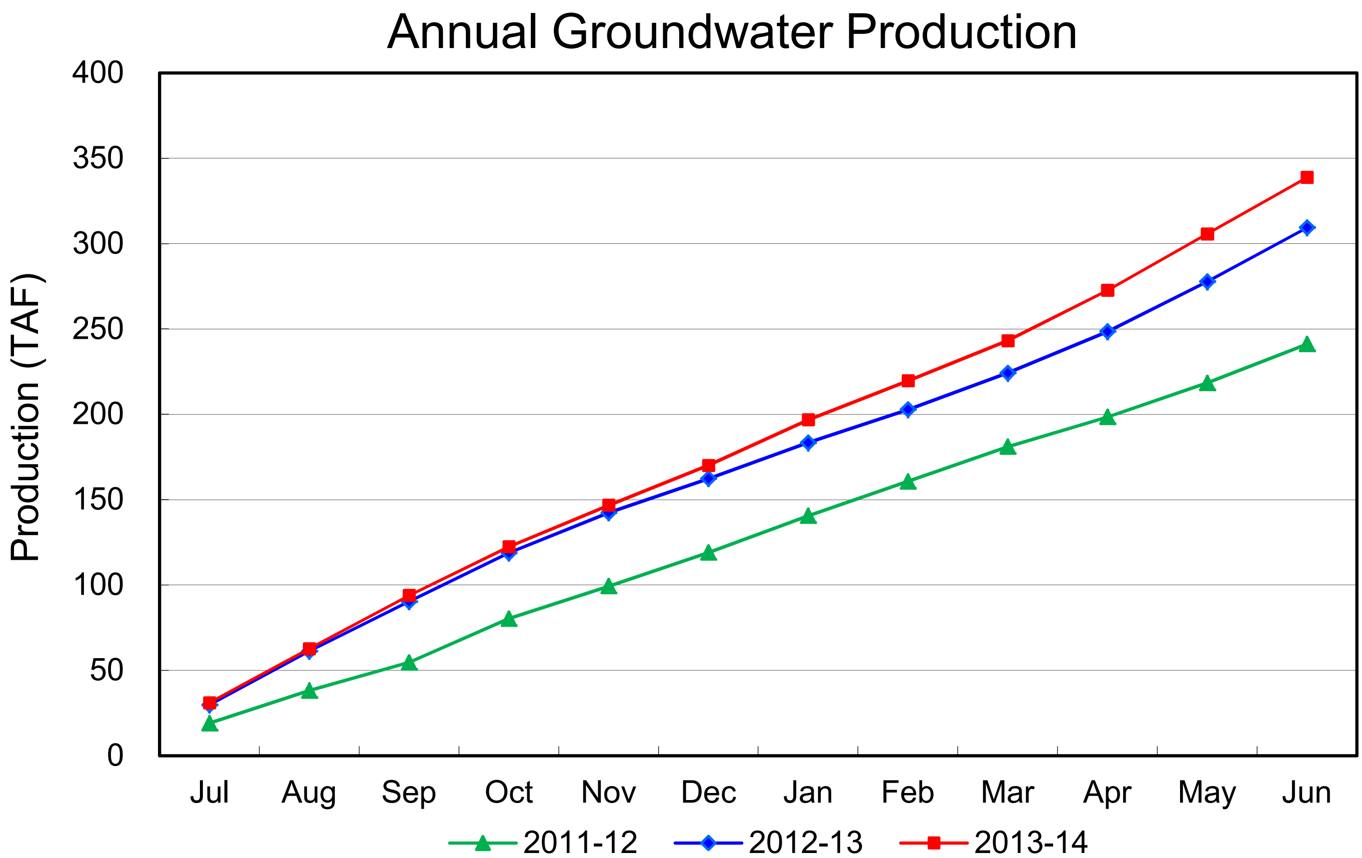
PRODUCERS WATER USAGE SUMMARY

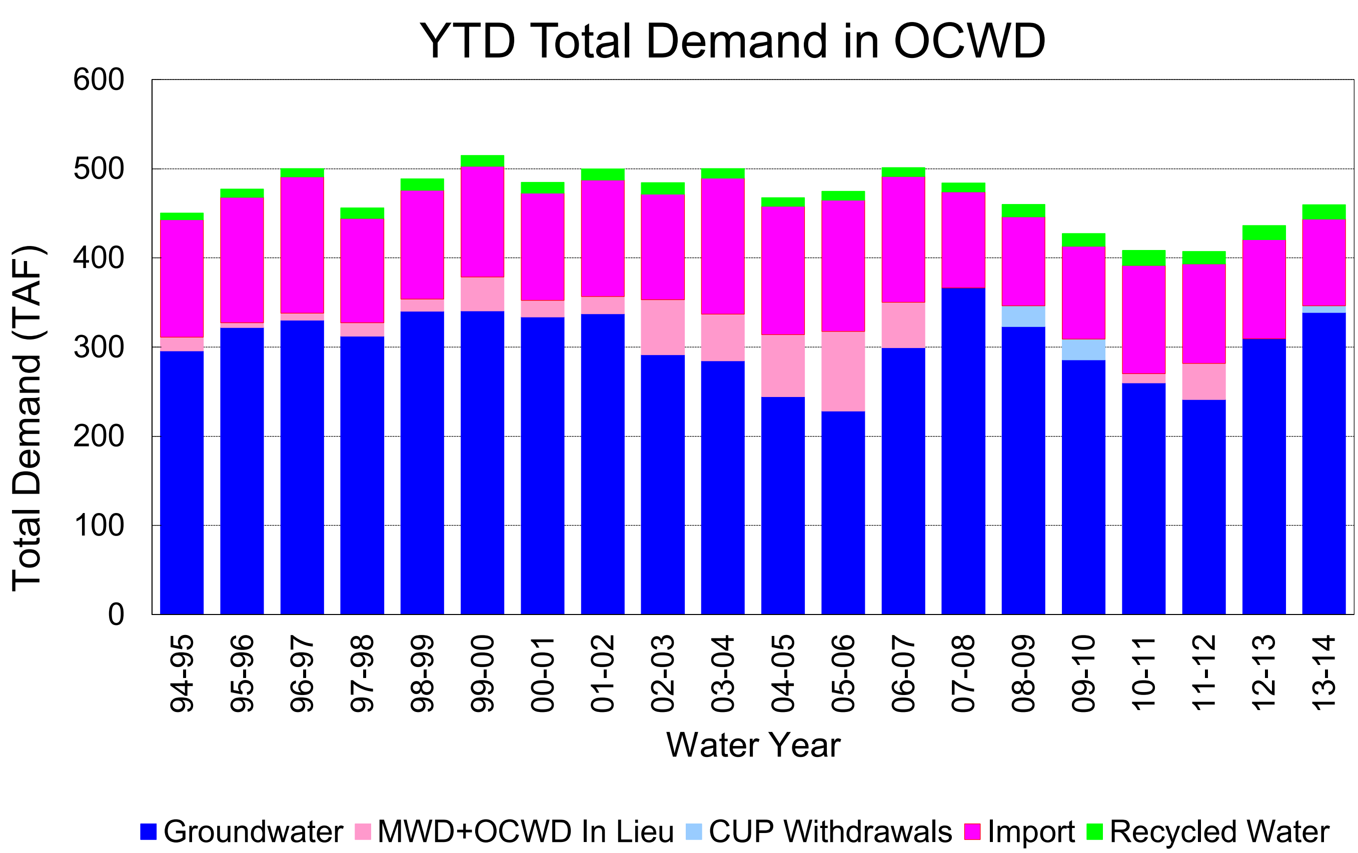
June 2014

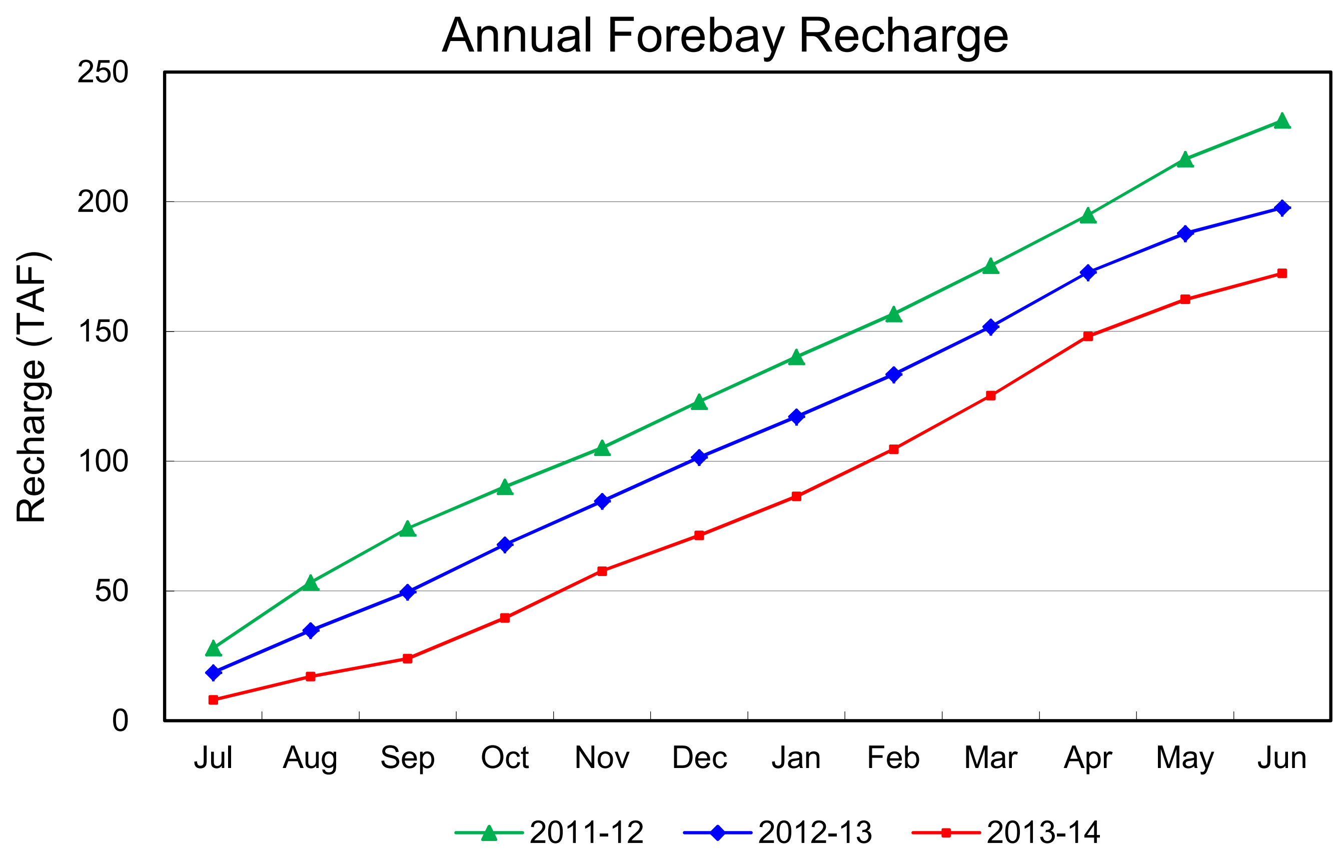
(AF except BPP)

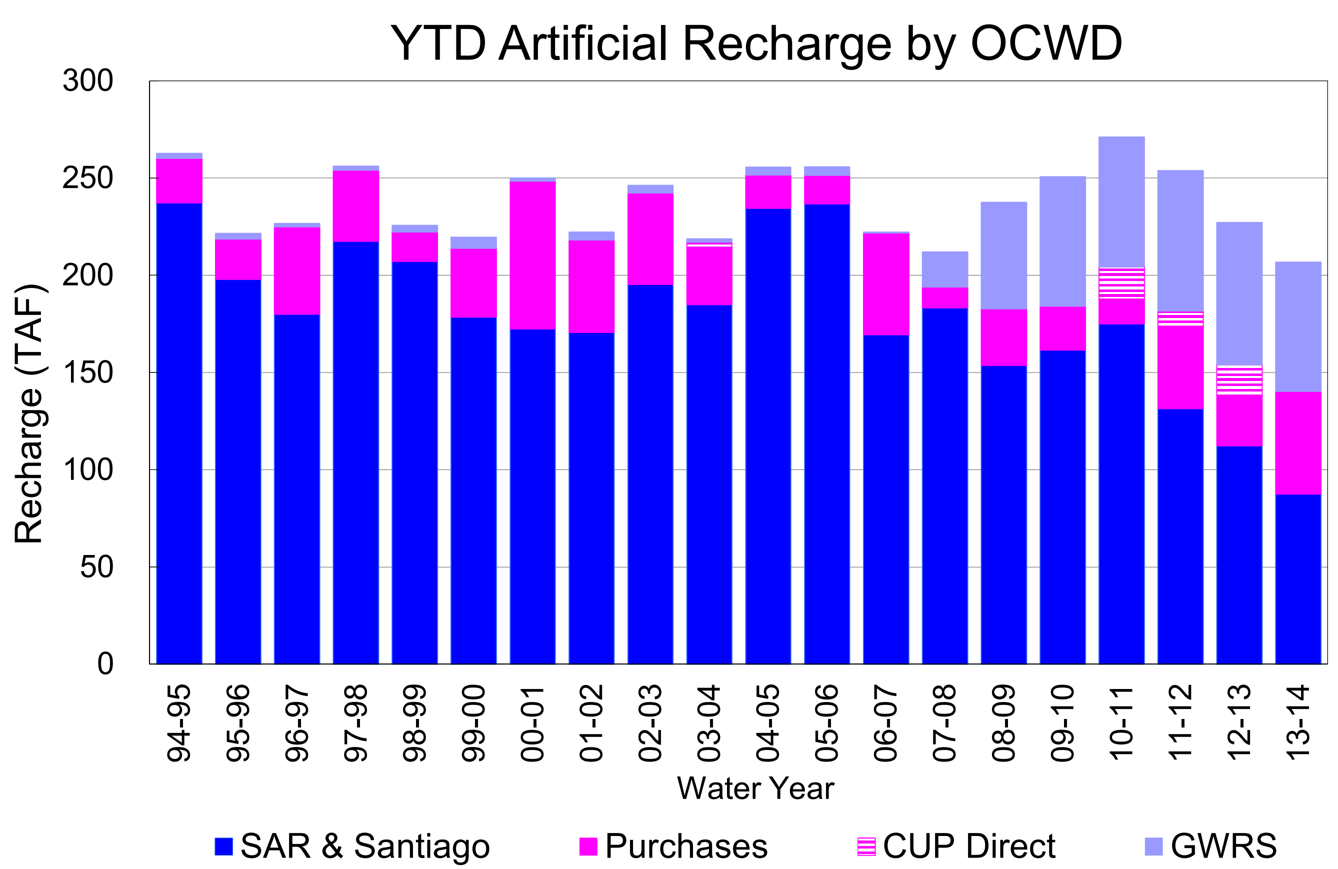
WATER AGENCY	Ground-water	In Lieu	MWD CUP In Lieu	Reclaimed Water	Total Import	Total Demand	2013-14 YTD Demand	2012-13 YTD Demand	JUNE 2014 BPP	2013-14 YTD BPP	2012-13 YTD BPP
Anaheim	4,158	0	0	0	1,963	6,120	68,064	66,593	67.9%	76.6%	68.3%
Buena Park	1,043	0	0	0	456	1,498	15,275	15,189	69.6%	78.1%	65.4%
East Orange County	100	0	0	0	0	100	1,070	1,036	100.0%	77.3%	58.4%
Fountain Valley	972	0	0	180	0	1,153	11,800	11,319	100.0%	74.3%	68.0%
Fullerton	2,171	0	0	0	703	2,874	30,058	28,697	75.5%	70.8%	67.9%
Garden Grove	2,266	0	0	0	448	2,714	26,233	25,819	83.5%	80.1%	73.3%
Golden State	1,652	0	0	0	1,057	2,710	27,313	27,448	61.0%	69.8%	67.8%
West OC System	1,492	0	0	0	118	1,610	16,286	16,397	92.7%	97.3%	92.9%
East OC System	400	0	0	0	700	1,100	11,027	11,050	36.4%	34.5%	30.5%
Huntington Beach	1,563	0	0	0	1,411	2,973	31,137	29,907	52.6%	59.7%	68.0%
Irvine Ranch	4,750	0	0	1,094	63	5,907	67,882	61,183	98.7%	98.8%	97.7%
DRWF Clear	2,668	0	0	0	-	2,668	27,811	27,765	0.0%	na	na
DRWF Color	692	0	0	0	-	692	8,707	8,858	0.0%	na	na
La Palma	206	0	0	0	0	206	2,210	2,190	100.0%	74.2%	77.0%
Mesa Water (MW)	1,460	0	0	147	354	1,962	20,037	20,814	80.5%	89.2%	85.4%
MW Clear	926	0	0	0	-	926	11,153	11,474	0.0%	na	na
MW Color	534	0	0	0	-	534	5,622	5,357	0.0%	na	na
Newport Beach	1,359	0	0	69	242	1,669	17,558	16,297	84.9%	64.6%	70.8%
Orange	2,103	0	0	0	898	3,001	32,616	31,385	70.1%	70.9%	67.3%
OCWD (GAP)	61	0	0	1	0	61	443	1,097	100.0%	100.0%	100.0%
Santa Ana	2,698	0	0	48	985	3,731	40,221	39,443	73.3%	70.1%	68.2%
Seal Beach	97	0	0	0	295	393	3,901	3,697	24.8%	59.6%	69.3%
Serrano	269	0	0	0	53	323	3,381	3,194	83.5%	68.1%	60.8%
Tustin	*746*	0	0	0	600	*1,346*	12,594	12,254	55.4%	63.6%	74.9%
Westminster	920	0	0	0	251	1,172	12,623	12,451	78.6%	65.8%	68.0%
Yorba Linda	1,234	0	0	0	462	1,697	16,956	16,102	72.8%	69.0%	68.0%
SUBTOTAL:	29,829	0	0	1,539	10,241	41,608	441,372	426,114	80.8%	76.0%	73.6%
Other Producers (Est 4% of Subtotal)	930	na	na	0	10	941	10,495	10,161			
TOTAL:	**30,759**	**0**	**0**	**1,539**	**10,251**	**42,549**	**451,867**	**436,275**	**80.8%**	**76.0%**	**73.6%**
OCWD (Talbert Barrier)	0	na	na	606	0	606	31,906	27,209			
OCSD (GAP)	na	na	na	72	na	72	1,509	3,478			

Estimated


Annual Groundwater Production
400
350
300
250
200
150
100
50
0
Production (TAF)
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2011-12
2012-13
2013-14


YTD Total Demand in OCWD
600
500
400
300
200
100
0
Total Demand (TAF)
94-95
95-96
96-97
97-98
98-99
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
09-10
10-11
11-12
12-13
13-14
Water Year
Groundwater
MWD+OCWD In Lieu
CUP Withdrawals
Import
Recycled Water


Annual Forebay Recharge
Recharge (TAF)
250
200
150
100
50
0
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
2011-12
2012-13
2013-14


YTD Artificial Recharge by OCWD
Recharge (TAF)
300
250
200
150
100
50
0
94-95
95-96
96-97
97-98
98-99
99-00
00-01
01-02
02-03
03-04
04-05
05-06
06-07
07-08
08-09
09-10
10-11
11-12
12-13
13-14
Water Year
SAR & Santiago
Purchases
CUP Direct
GWRS

RECHARGE AREAS REPORT
June 2014

	Percolation (AF)	Remarks
RIVER SYSTEM	947	About 1/3 of river used (all flow diverted for fishin)
DESILTING SYSTEM	60	
OFF-RIVER SYSTEM	788	Includes Off River, Olive (passive) and 5 Coves
WARNER SYSTEM	1,790	Includes Foster and Conrock basins
OLIVE BASIN	0	See off river
ANAHEIM LAKE	218	OC-28a water
MINI-ANA LAKE	3	OC-28a water
MILLER BASIN	1,221	GWR inflow and OC-28a
KRAEMER BASIN	1,179	OC-28a water
MIRA LOMA	471	GWR inflow
LA JOLLA BASIN	1,318	
PLACENTIA BASIN	0	
RAYMOND BASIN	634	
FIVE COVES BASIN	na	See off river
BURRIS BASIN	468	
RIVER VIEW BASIN	0	
SANTIAGO BASINS	925	
SANTIAGO CREEK	4	
TOTALS	**10,026**	
5-YR AVERAGE	**17,409**	

FLOWS TO RECHARGE AREAS (AF)		
Imperial Headgates (estimated)		3,760
GWRS		610
OC-28 (MWD)		0
OC-28a (MWD)		3,890
CB-11		0
CB-18		0
Est'd local Forebay inflow below Imperial		0
Est'd local Santiago inflow (estimated)		0
Irvine lake releases (OC-13 MWD)		0
Villa Park Dam releases (estimated)		0
Precip at Warner Basin (inches)	0	
Precip direct to open water surfaces		0
TOTAL INFLOW		8,260

LOSSES FROM RECHARGE AREAS (AF)		
Est'd SAR flow past Chapman Ave.		0
Est'd Santiago Cr. flow to SAR		0
Est'd flows past Raymond Basin		0
Calc'd evap (inches) Estimated	6.3	
Est'd evaporative losses		263
TOTAL LOSSES		**263**

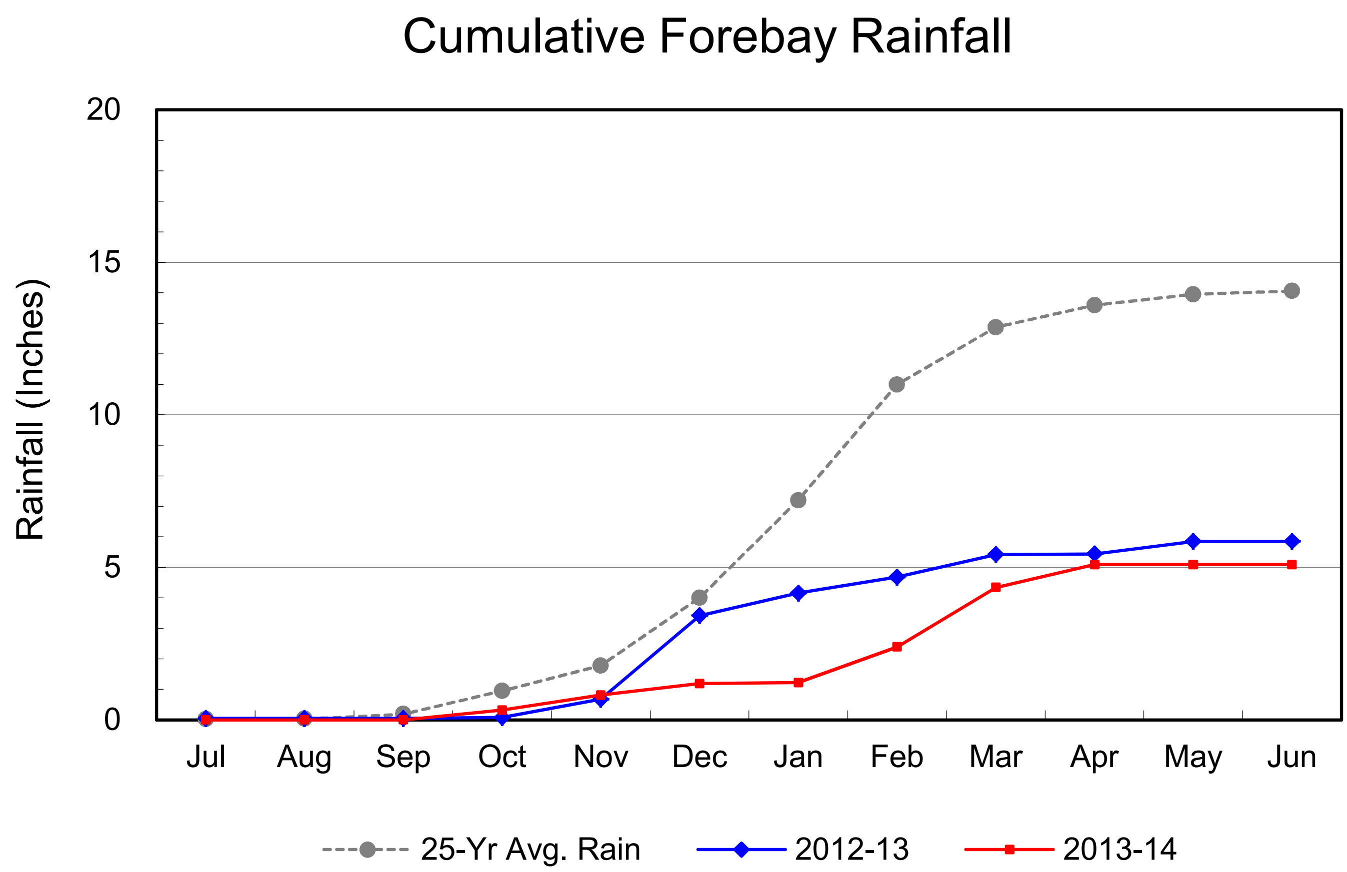
STORAGE CHANGES (AF)			
Facility	*Begin*	*End*	*Net*
Deep basins	6,521	5,431	-1,091
Santiago Pits	5,658	4,720	-938
River			0
Off-river			0
Irvine Lake			
TOTAL	12,179	10,151	-2,028

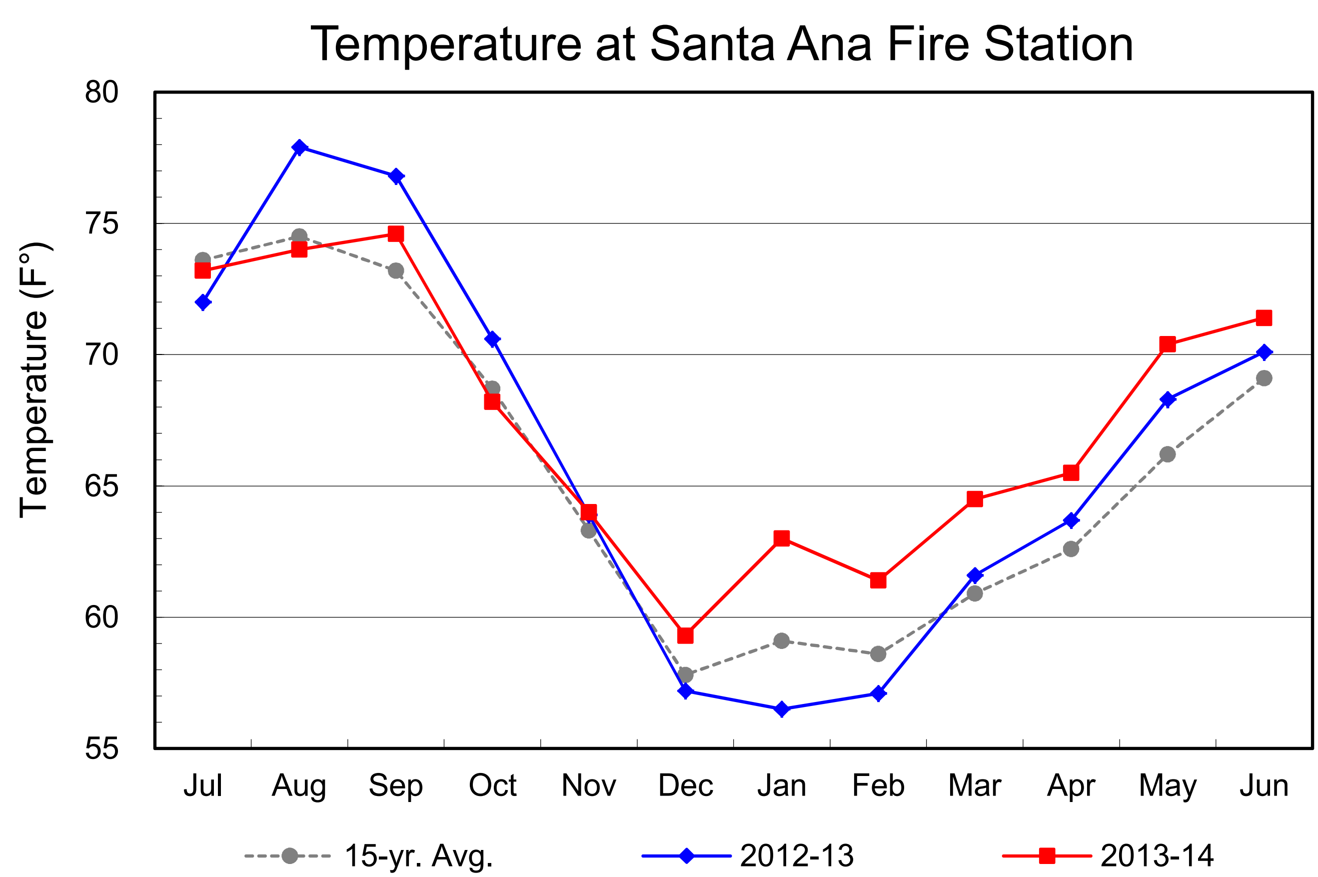
SUMMARY (AF)	
TOTAL INFLOW	8,260
TOTAL LOSSES	263
STORAGE CHANGE	-2,028
CALC'D PERCOLATION	10,026

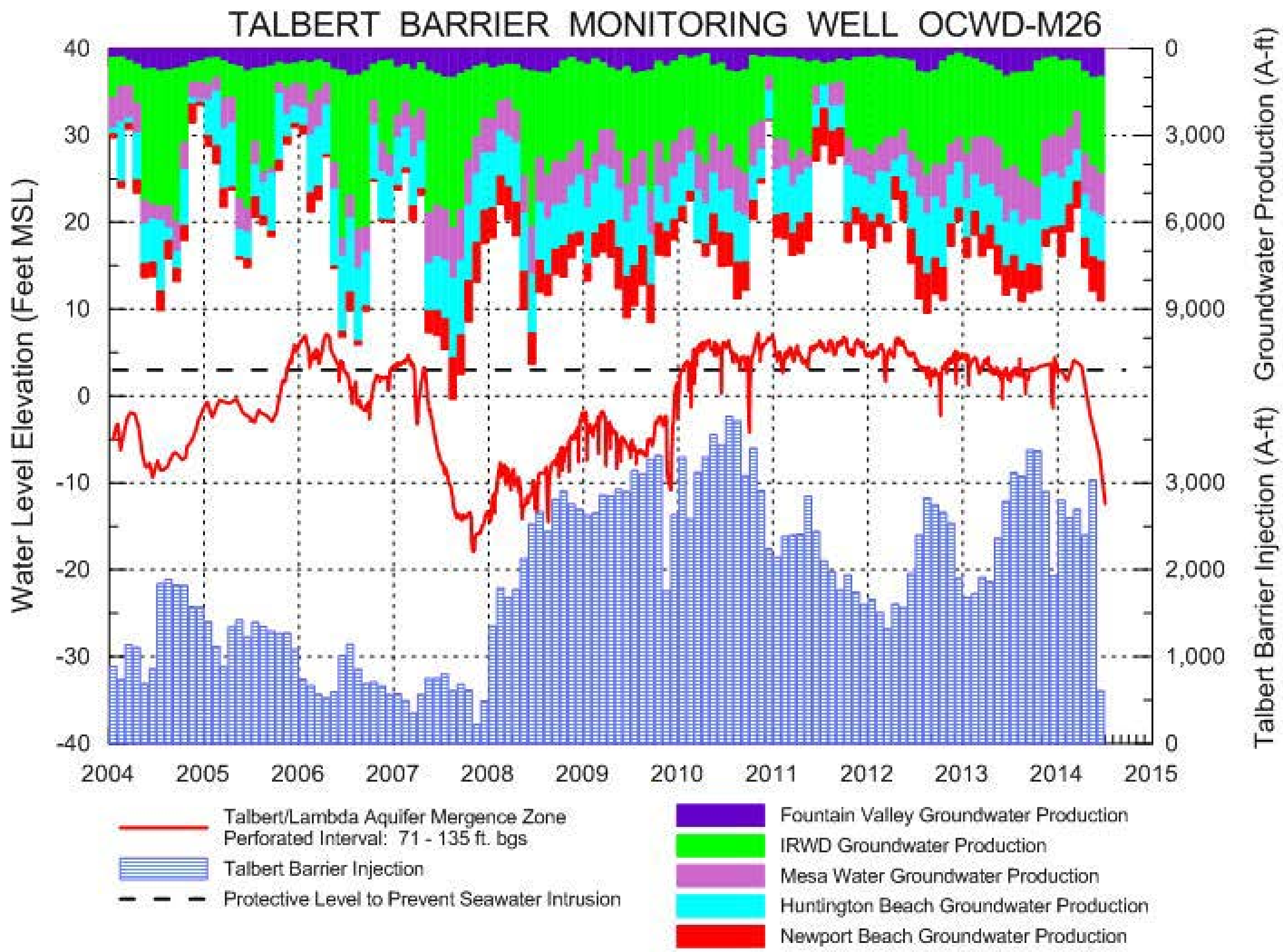
DEEP BASINS MONTHLY STATUS
June 2014

(values in acre-feet)

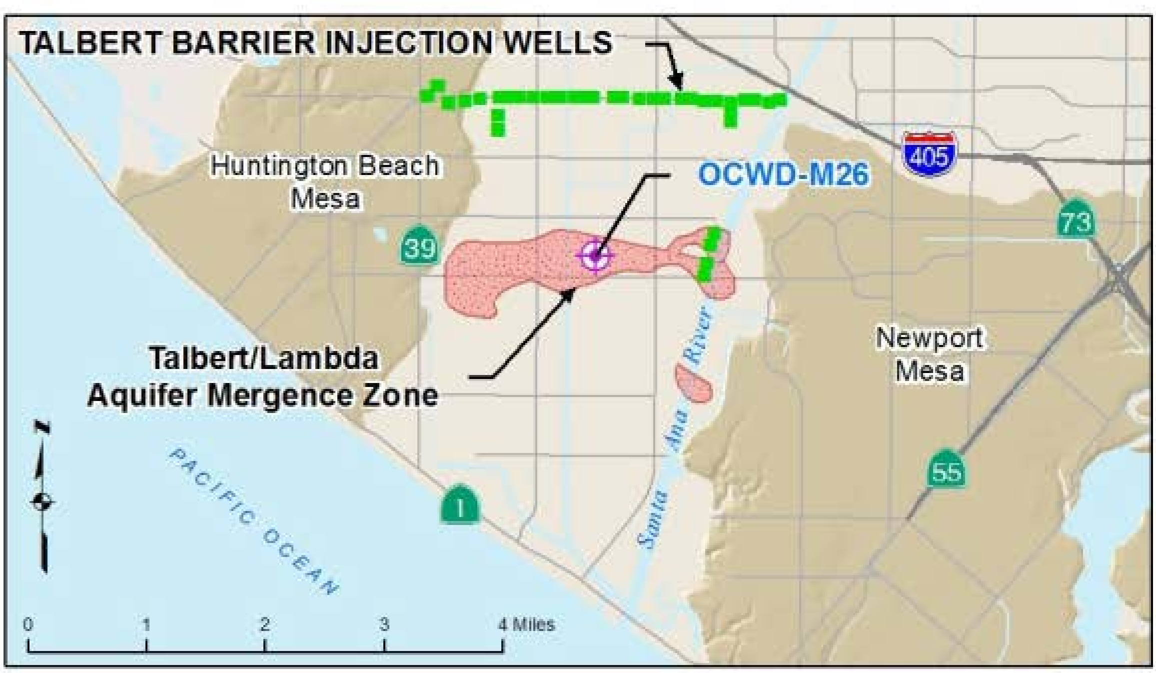
Facility	*Storage Start*	*Storage End*	*Maximum Storage*	*Total Perc*	*Max Perc*	*Avg Perc*	*Avg W.S. Elev*
Desilting Ponds	230	136	230	30	na	na	na
Fos-Huckleberry	522	530	630	0	na	na	na
Conrock Basin	559	568	660	0	na	na	na
Warner Basins	2,404	2,538	2,810	1,790	na	na	na
Olive Pit	0	0	183	0	na	na	na
Anaheim Lake	546	47	2,300	218	54	7	174
Mini-Anaheim Lk	0	4	21	3	na	na	na
Miller Basin	39	76	340	1,221	68	41	206
Kraemer Basin	510	426	1,050	1,179	80	39	194
Mira Loma	33	0	62	471	74	13	213
La Jolla Basin	0	8	36	1,318	53	44	201
Placentia Basin	120	0	350	na	na	na	na
Raymond Basin	100	140	370	634	na	na	na
Five Coves Basins	148	88	350	na	na	na	na
Burris Pit	1,310	870	2,670	468	19	16	156
River View Basin	0	0	12	0	na	na	na
Santiago (Bond)	4,032	3,466	8,690	925	41	31	228
Santiago (Blu Dia)	1,625	1,254	5,240	0	0	0	228
Totals	12,179	10,151	26,004	8,257			
Prado Dam	3	0	25,000				


Cumulative Forebay Rainfall
20
15
10
5
0
Rainfall (Inches)
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
25-Yr Avg. Rain
2012-13
2013-14


Temperature at Santa Ana Fire Station
80
75
70
65
60
55
Temperature (F°)
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
15-yr. Avg.
2012-13
2013-14



TALBERT BARRIER MONITORING WELL OCWD-M26
Water Level Elevation (Feet MSL)
Groundwater Production (A-ft)
Talbert Barrier Injection (A-ft)
40
30
20
10
0
-10
-20
-30
-40
0
3,000
6,000
9,000
3,000
2,000
1,000
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Talbert/Lambda Aquifer Mergence Zone
Perforated Interval: 71 - 135 ft. bgs
Talbert Barrier Injection
Protective Level to Prevent Seawater Intrusion
Fountain Valley Groundwater Production
IRWD Groundwater Production
Mesa Water Groundwater Production
Huntington Beach Groundwater Production
Newport Beach Groundwater Production



TALBERT BARRIER INJECTION WELLS
Huntington Beach
Mesa
OCWD-M26
405
73
39
Talbert/Lambda
Aquifer Mergence Zone
Newport
Mesa
Santa Ana River
PACIFIC OCEAN
55
1
N
0
1
2
3
4 Miles