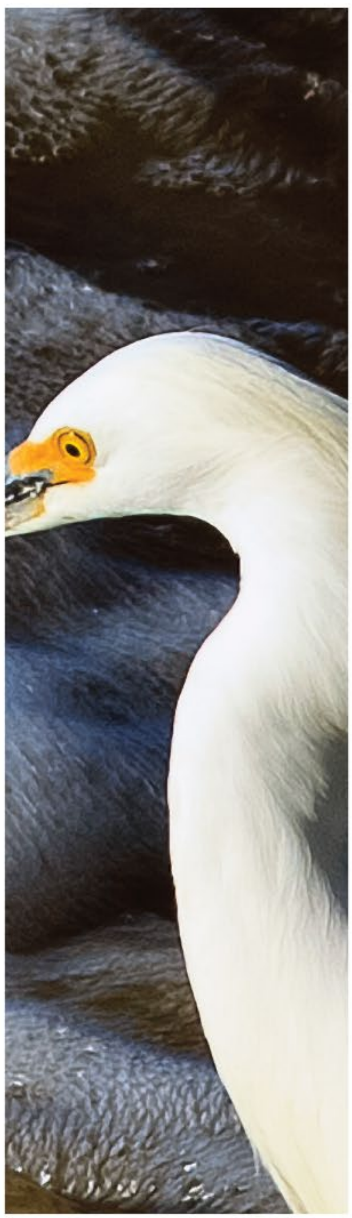
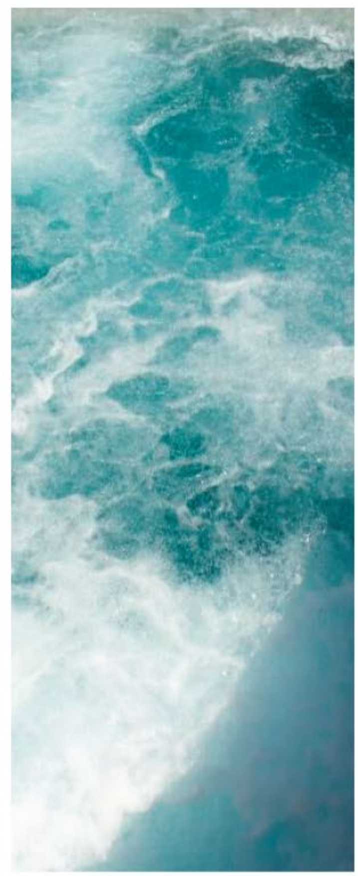
ORANGE COUNTY WATER DISTRICT

OCWD Resilience Plan

Adaptive Strategies for Securing Abundant and Reliable Water Supplies

February 2025



Page Intentionally Left Blank

Tables

Figures

Appendices

EXECUTIVE SUMMARY

OCWD's mission is to provide a reliable, high quality water supply in a cost-effective and environmentally responsible manner

The Orange County Water District (OCWD or District) was created in 1933 by the California legislature to manage the Orange County Groundwater Basin (Basin).

The District replenishes and manages the basin to enhance water reliability and quality and to prevent seawater intrusion. Groundwater produced from the basin is the primary water supply for approximately 2.5 million residents living within District boundaries.

Over the past 90 years, OCWD has been able to triple the sustainable amount of groundwater that can be pumped from the basin by implementing projects that maximize the amount of water recharged into the basin, developing new recharge sources, and increasing the effectiveness of District facilities. Groundwater supplies are managed by balancing recharge and pumping to maintain water levels and groundwater storage within an established safe operating range.

The **OCWD Resilience Plan: Adaptive Strategies for Securing Abundant and Reliable Water Supplies** is an adaptive management plan that builds resilience by anticipating future conditions and creating a readiness to respond to changing conditions by offering various short-term and long-term response strategies.

"Resilience is the ability to anticipate, recover, and adapt from disruptions and challenges to ensure sustainable, abundant, and reliable high quality water supplies."

Although the planning horizon encompasses 5 to 25 years, the Resilience Plan is a living document that will be modified based on evolving needs and conditions. This plan was created at the District's discretion to provide stakeholders with an assessment of anticipated future water demands and available supplies and present potential projects the District could consider to protect or increase those supplies.

Key District Assets and Challenges

The District manages a number of key assets, including the Groundwater Basin, Santa Ana River, the Groundwater Replenishment System (GWRS), and Natural Resources behind Prado Dam. There are a number of known threats and challenges to these assets, with just a few shown on Figure ES-1. This Resilience Plan is organized and centered on addressing threats and challenges to these key assets.

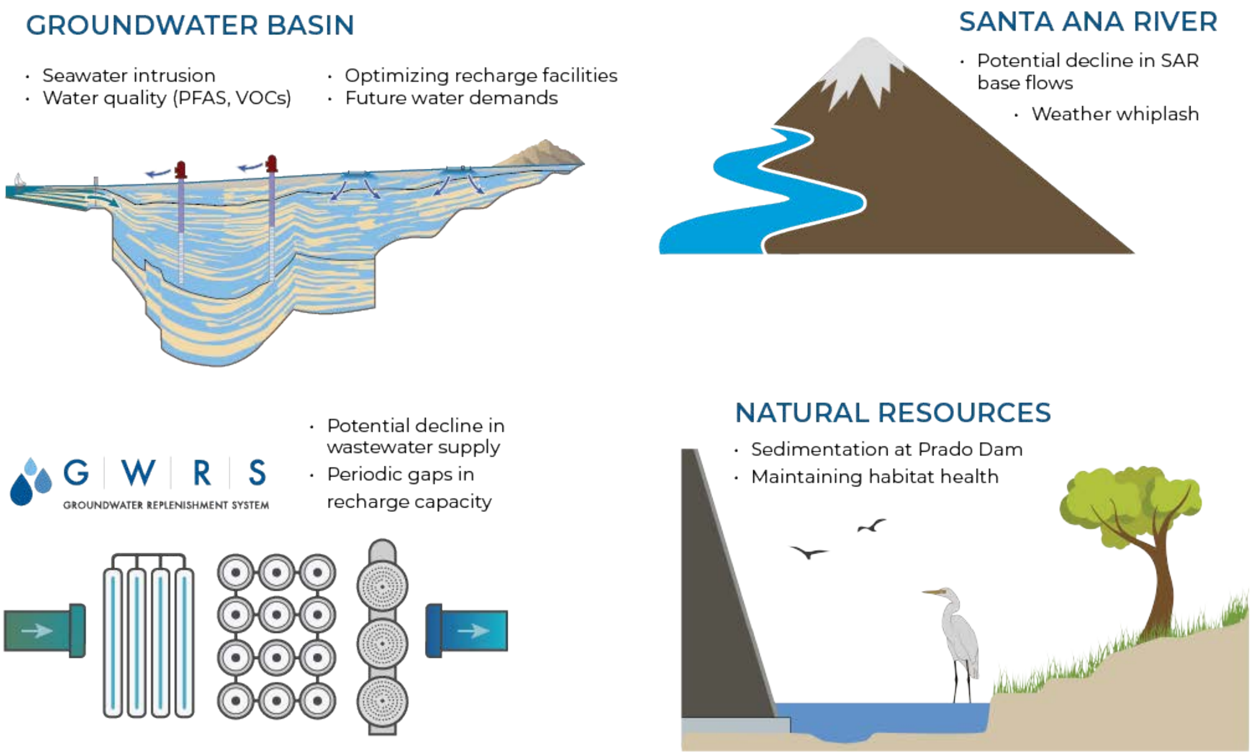


Figure ES-1: Key District Assets and Threats/Challenges

Proposed List of Priority Projects

To identify key strategies in the Resilience Plan to address the threats and challenges to District assets, a list of 53 projects, concepts, and studies, were reviewed at multiple workshops to identify 16 priority projects that will be the focus of District efforts over the next five years. Table ES-1 lists the 16 priority projects. Figure ES-2 shows where these projects are located. The priority projects are described in detail in Appendix A with supplemental projects described in Appendix B. Note that the priority project numbers are not indicative of project importance and are only for identification purposes. If selected for further development, projects would be evaluated and moved forward following the established District process that includes multiple Board approvals.

Table ES-1: List of Priority Projects

PROJECT	DESCRIPTION
BASIN MANAGEMENT	
1. PFAS Treatment Project	Construct treatment systems on production wells affected by PFAS.
2. Sunset Gap Barrier Project	Construct seawater barrier for Sunset Gap.
3. Groundwater Basin Operating Range Expansion Study	Study potential of expanding the operating range of the groundwater basin.
4. South Basin Groundwater Protection Project	Pursue appropriate actions to contain and remediate contaminated groundwater in the South Basin area.
5. Talbert Barrier Injection Well Replacement and Optimization	Replace selected aging Talbert Barrier injection wells and locate replacement wells in more optimal locations.
WATER SUPPLY	
6. GWRS Supply Augmentation	Examine opportunities to bolster GWRS supplies, including diverting urban runoff to OC San.
7. Brackish Water Desalination	Participate with Mesa Water, Huntington Beach and Newport Beach in Local Groundwater Supply Improvement Project to examine using purified brackish groundwater for additional water supplies.
8. Increasing Stormwater Capture	Increase stormwater capture using Forecast Informed Reservoir Operations (FIRO) at Prado Dam. Municipal stormwater for water supply projects that include direct and indirect diversions.
9. Prado Basin Sediment Management Regional Strategic Plan	Develop a regional, watershed-wide approach that involves multiple stakeholders, including Orange County Public Works, beach cities and others that would benefit from increased sediment for beach replenishment, protecting coastal resources, and other needs.
RECHARGE FACILITIES	
10. GWRS Recharge Optimization Study	Study existing capacity to recharge GWRS water and suite of potential projects to increase recharge capabilities and operational flexibility.
11. Desilting Santa Ana River Flows	Evaluate potential of removing suspended sediment from Santa Ana River water that is supplied to deep basins prone to clogging and thereby increase OCWD's recharge capacity, especially for stormwater.
12. Anaheim Lake Recharge Basin Rehabilitation	Rehabilitate OCWD's oldest recharge basin by removing clogged material and regrading the basin to increase storage, recharge capacity and make future cleanings more efficient.
13. Recharge in Lower Santiago Creek	Construct facilities to convey water to lower Santiago Creek downstream of Hart Park.
OPERATIONAL IMPROVEMENTS	
14. Warner System Optimization	Improve conveyance capacity to the Warner Basin Recharge System and reoperate the system for increased stormwater capture.
15. Recharge System Conveyance Optimization	Evaluate conveyance capacity of recharge system, including potential constraints at Lakeview Ave. and Warner-Anaheim Pipeline.
16. Zero-Emissions Vehicle Charging Infrastructure	Construct infrastructure at OCWD field operations in Anaheim and Prado to supply zero-emissions vehicles that will need to be purchased in the near future.

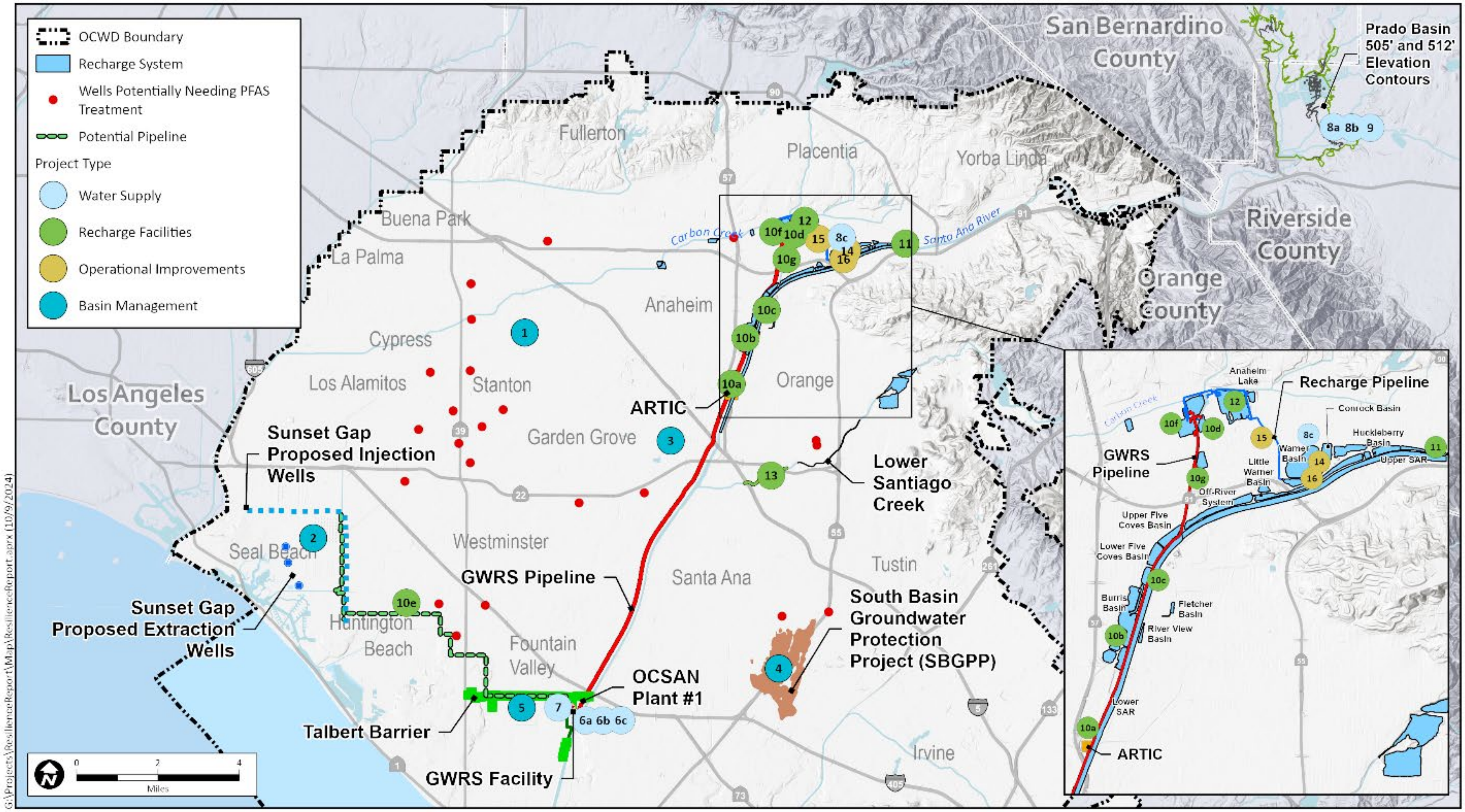


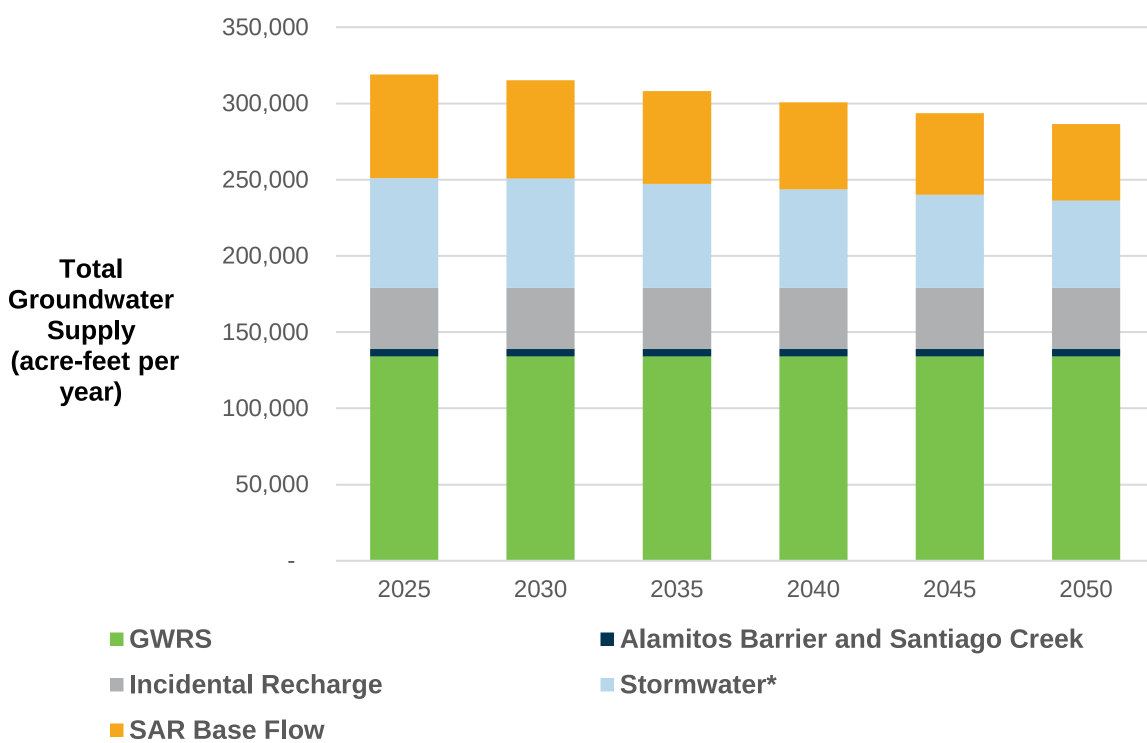
Figure ES-2: Location of Priority Projects

Future Supplies and Demands

OCWD has a diverse water supply portfolio that includes the following sources:

- Santa Ana River base flows
- Stormwater
- Incidental recharge (i.e., unmeasured recharge)
- Groundwater Replenishment System (GWRS)
- Alamitos Gap Seawater Barrier
- Imported water (purchased when needed)

Santa Ana River base flows and storm flows are projected to decline in the future as agencies in the upper Santa Ana River watershed utilize these flows to meet their demands. A further decline in stormwater capture is projected at Prado Dam due to sediment accumulation within the water conservation pool, which is a volume of storage space behind the dam that is used to temporarily impound stormwater for release to OCWD's recharge facilities. Figure ES-3 shows the projected sources of water to the groundwater basin from 2025 to 2050. Note that the years shown are meant to represent the average conditions over five-year periods.



*Assumes sedimentation is taking place in Prado Dam Water Conservation Pool.

Figure ES-3: Projected Groundwater Supplies, 2025-2050

Demand projections for OCWD are estimated to be relatively flat as shown in Figure ES-4 with future water demands expected to increase by approximately 19,000 acre-feet by 2050. This corresponds to an approximately 4 percent increase over the 25-year period, or slightly less than a 0.18 percent annual increase.

Note that 2022-24 water demands are lower than projected demands largely due to wetter than average hydrologic conditions.

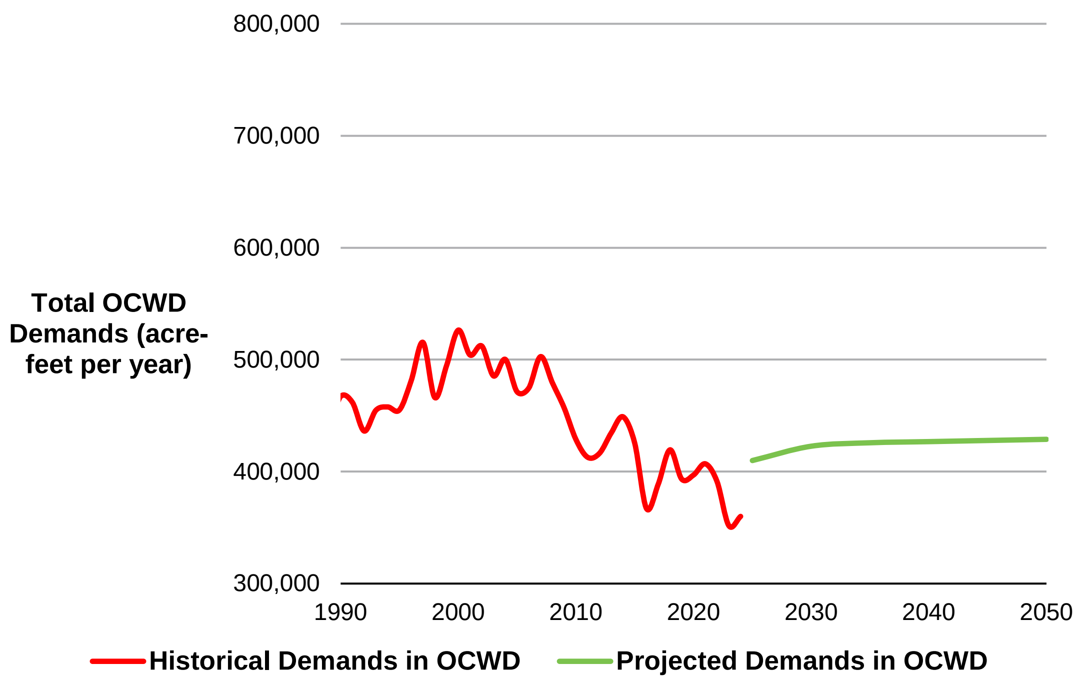
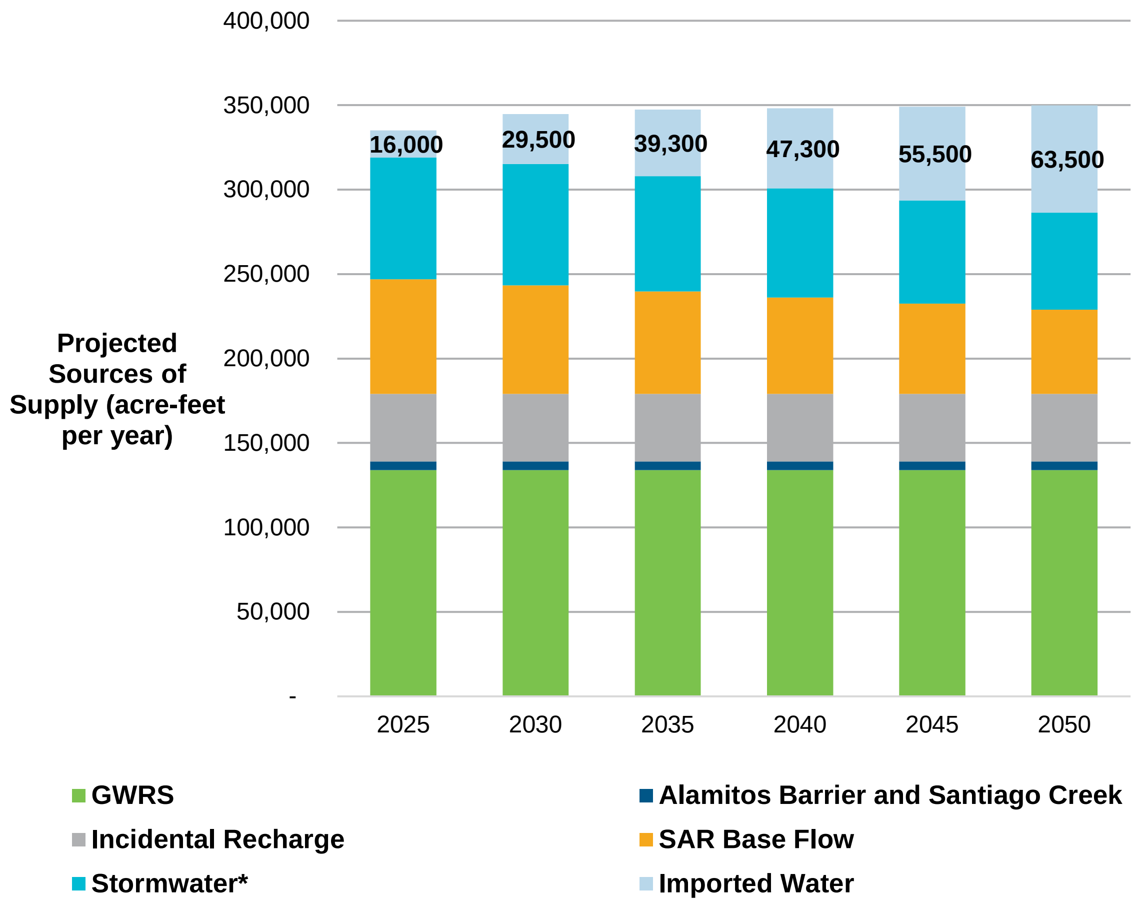


Figure ES-4: Historical Demands and Projected Water Demands within OCWD

Projected Groundwater Basin Pumping

Based on the projected modest increase in future water demands, OCWD is anticipating being able to support a Basin Production Percentage (BPP) of 85 percent. The BPP is a percentage of each Producer's water supply that comes from groundwater pumped from the basin and is uniform for all the Groundwater Producers in the basin.

As seen in Figure ES-5, over the 25-year planning period OCWD will need to purchase increasing amounts of imported water to offset increases in water demands and the reductions in Santa Ana River base flow and storm flow arriving at Prado Dam and continued loss of storage due to sedimentation in Prado Basin. Based on average hydrology, imported water purchases for groundwater replenishment will need to ramp up to 63,500 acre-feet per year over the next 25 years. In the near term, however, with reduced groundwater pumping from wells affected by per- and polyfluorinated alkyl substances (PFAS) and relatively full basin conditions, it is not expected that imported water will need to be purchased for recharge for several years.



*Assumes sedimentation is taking place in Prado Dam Water Conservation Pool.

Figure ES-5: Projected Groundwater Supplies and Amount of Imported Water for Groundwater Replenishment Needed to Sustain 85% BPP

Maintaining a high BPP provides tremendous cost savings to the Groundwater Producers in that it avoids the need to purchase treated, imported water, which costs approximately two times more than groundwater. The cost of groundwater is the combination of the Replenishment Assessment (RA) charged by OCWD and Groundwater Producer pumping costs. Key assumptions regarding future groundwater costs include:

- The RA is projected to increase an average of 6 percent annually
- Pumping costs include estimated additional PFAS costs that will be incurred by the Producers in the future

Figure ES-6 shows projected RA and groundwater pumping costs for the next decade. Imported water costs are projected to increase from 3 to 11 percent annually based on data from the Metropolitan Water District of Southern California. On average, the cost of groundwater, including pumping is 45 percent less than imported water. This difference represents the savings provided by sustainable groundwater pumping from the basin, which has grown over time due to the wide array of projects implemented by OCWD. Figure ES-6 shows how the projected cost of groundwater compares to imported water over the next 10 years.

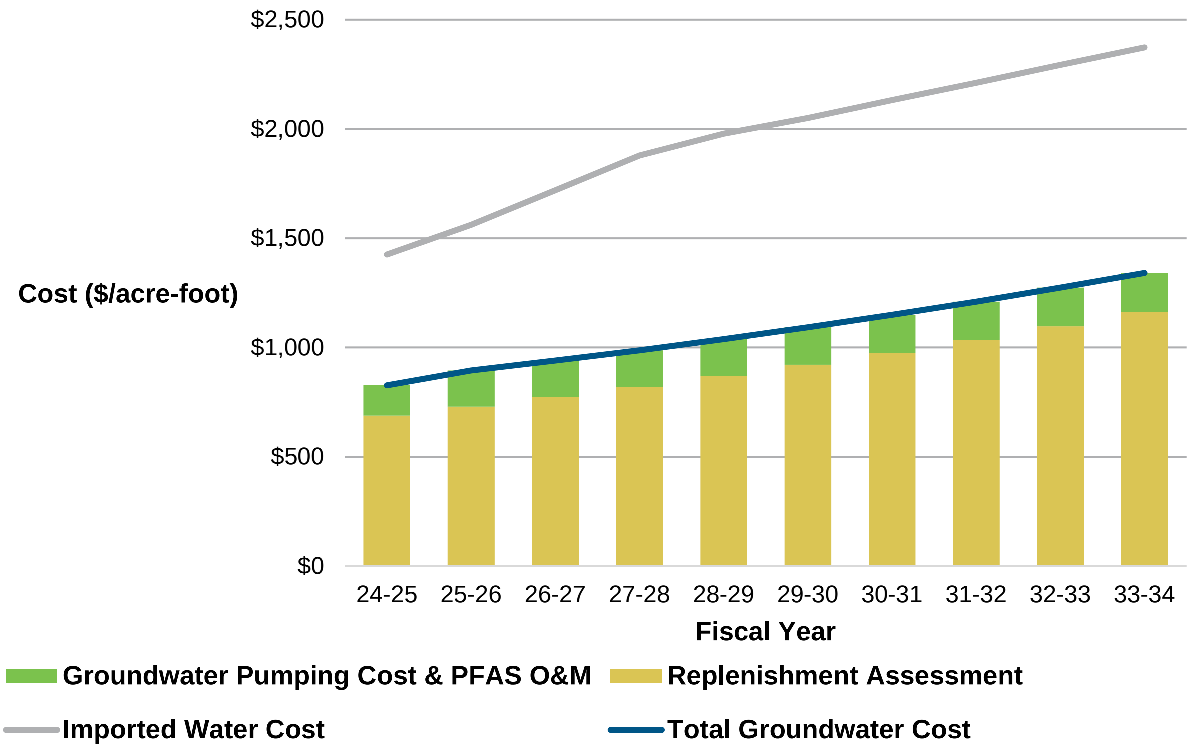


Figure ES-6: Projected Costs of Groundwater, Pumping and Treated Imported Water

Maintaining this cost differential is important as it shows the value of OCWD management of groundwater resources. Many projects presented in this Resilience Plan are designed to sustain and potentially increase groundwater pumping from the basin. A key metric in decision-making regarding projects that provide increased supply is how the cost of projected project yields compares to the cost of imported water.

"A key metric in decision making is how the cost of water from a project compares to the cost of imported water."

Due to a long history of investments in the groundwater basin, OCWD has developed a reliable, resilient supply of groundwater. This Resilience Plan outlines multiple projects and adaptive strategies to continue supporting sustainable groundwater pumping from the basin, including an 85 percent BPP or higher and meeting the District's mission of providing a reliable, high-quality water supply in a cost-effective and environmentally responsible manner. The Resilience Plan is a living document that will be responsive to new challenges and threats. As such, project priorities can shift, and new projects added as needed. Any significant changes will be communicated to the OCWD Board and Groundwater Producers, and the plan itself is intended to be updated every five years.

INTRODUCTION

The Orange County Water District (OCWD or District) was established in 1933 by the California legislature to manage the Orange County Groundwater Basin (Basin). The basin is the primary water supply source for the approximately 2.5 million people who live within the District's boundary, which covers the north-central part of Orange County as shown in Figure 1.

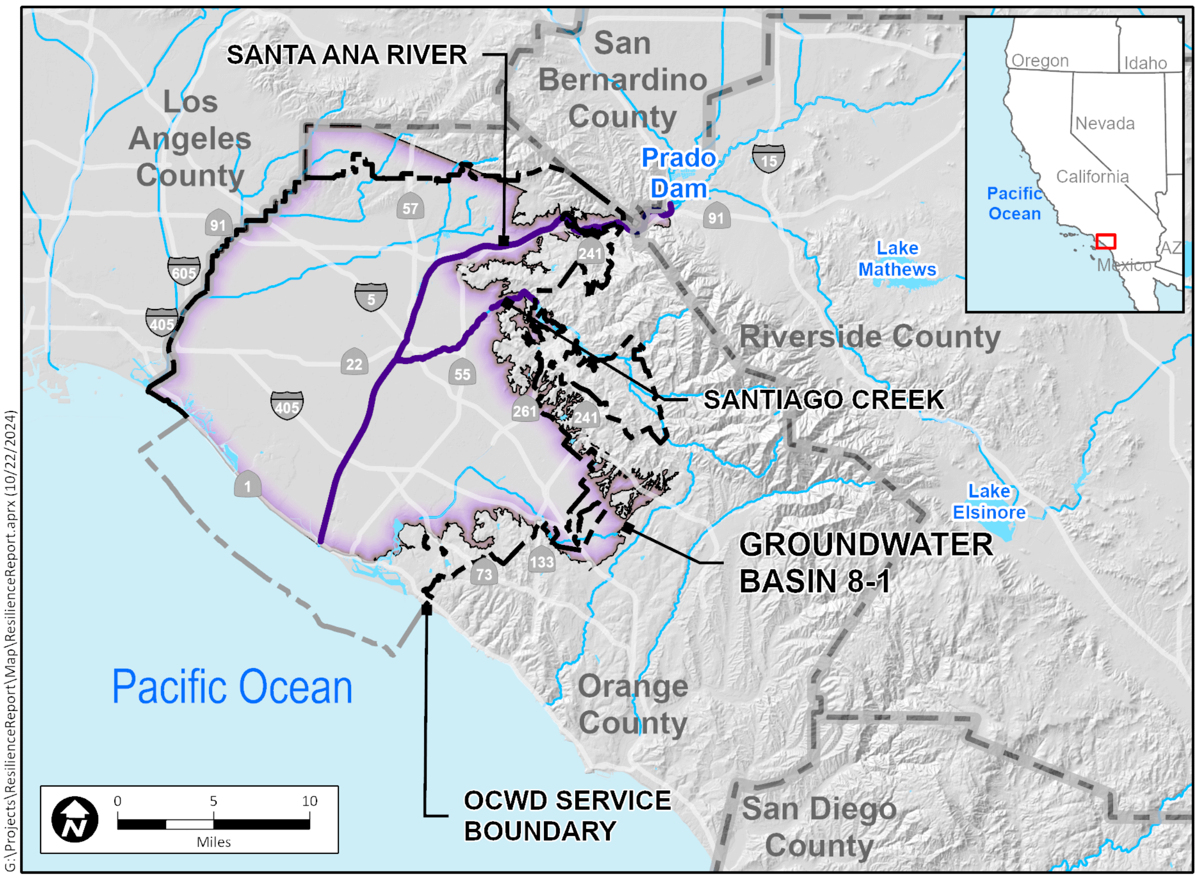


Figure 1: Location of Coastal Plain of Orange County Groundwater Basin (Basin 8-1) and OCWD Boundaries

The driving forces behind the creation of OCWD were the significant challenges facing the basin, including reduced flows from the Santa Ana River, basin overdraft, and seawater intrusion. Over the past 91 years, the District has implemented numerous measures to address these and many other issues and achieve sustainable groundwater conditions. Figure 2 presents a timeline showing selected key District accomplishments.

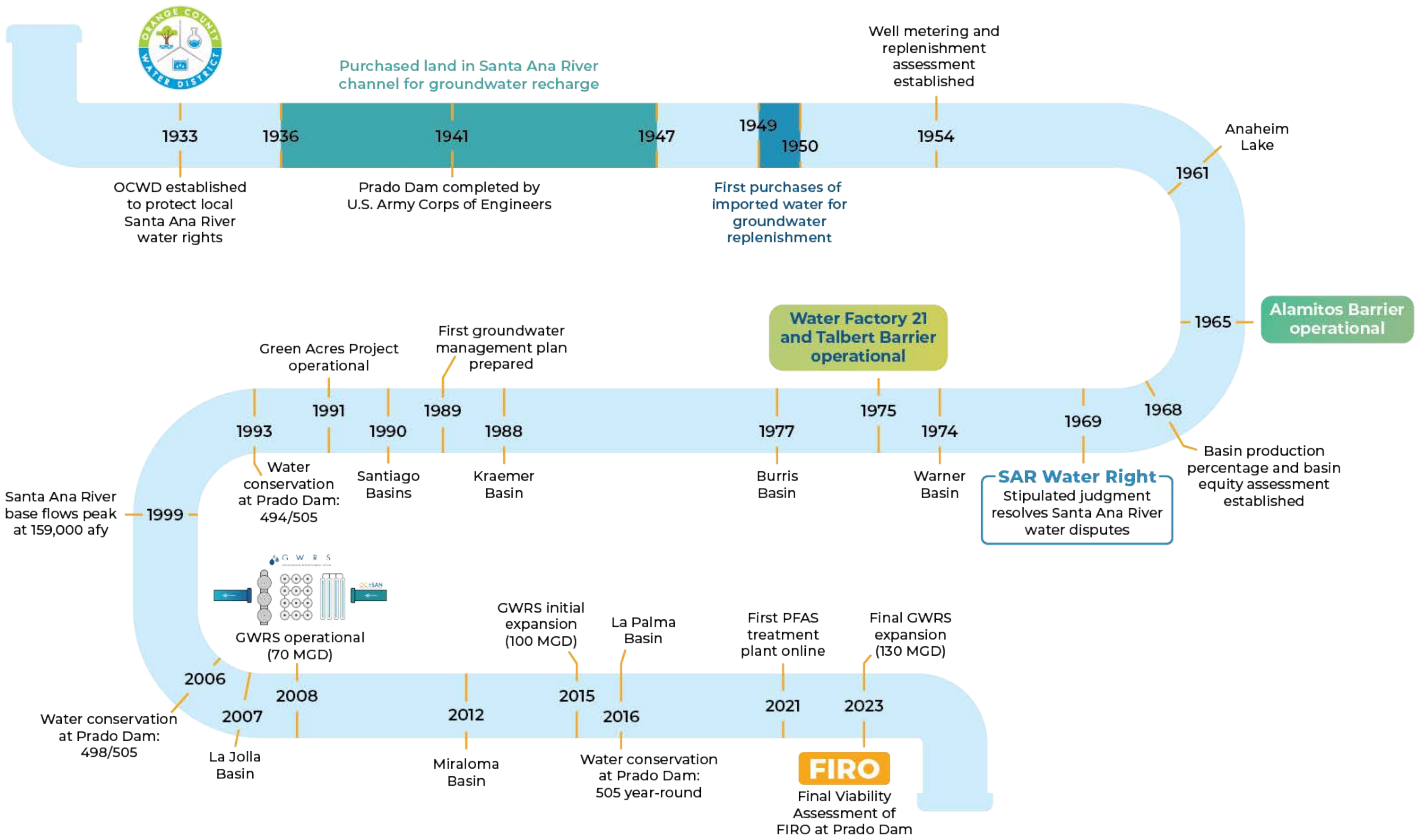
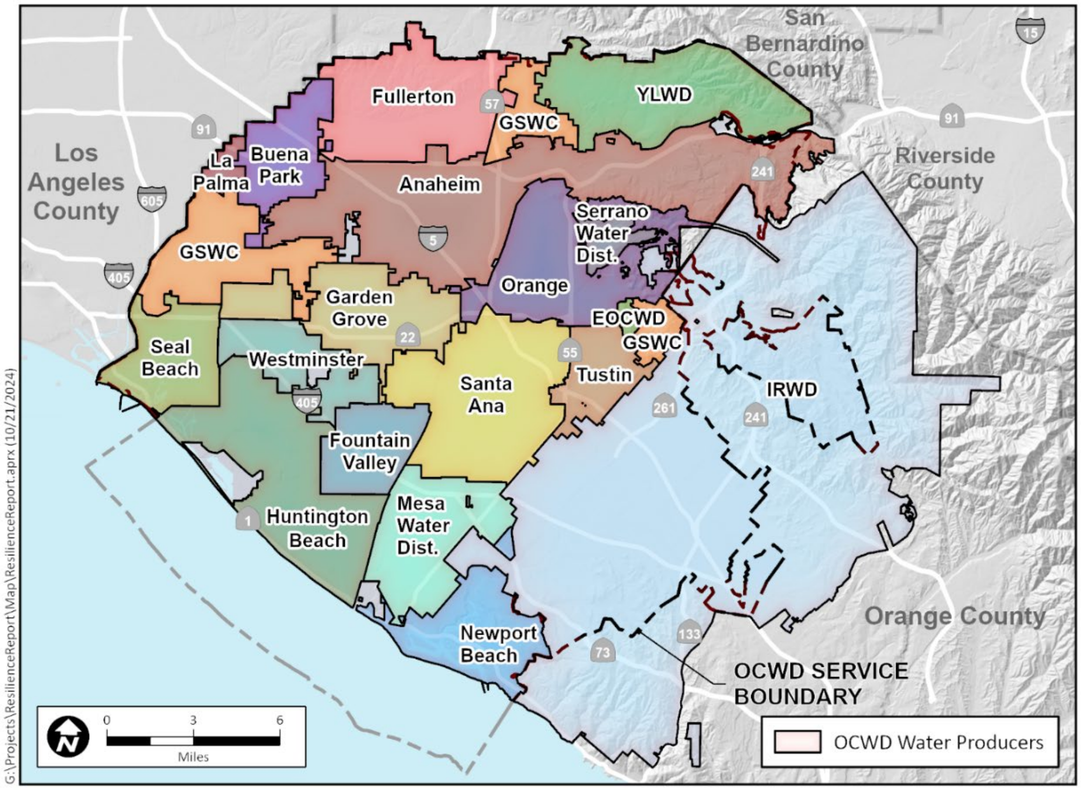


Figure 2: Selected Key Accomplishments in OCWD's History

As a result of the District's work, the basin can sustainably produce three times more groundwater than it could without active management. The beneficiaries of this are the residents in OCWD's service area, most of which are supplied with groundwater from one of 19 major water retailers which include cities, water agencies, and others. These retailers are called Groundwater Producers (Figure 3).



GSWC – Golden State Water Company; EOCWD- East Orange County Water District;
YLWD- Yorba Linda Water District; IRWD- Irvine Ranch Water District

Figure 3: Orange County Water District Groundwater Producers

To ensure the District can continue to achieve its mission and secure the future of its water resources, it is critical to not only sustain current conditions but also to build resilience by adopting adaptive strategies that address both known and unforeseen challenges.

OCWD's mission is to provide a reliable, high quality water supply in a cost-effective and environmentally responsible manner

The **OCWD Resilience Plan: Adaptive Strategies for Securing Abundant and Reliable Water Supplies** is an adaptive management plan that builds resilience by anticipating future conditions and creating a readiness to respond to changing conditions by offering various potential short-term and long-term response strategies.

"Resilience is the ability to anticipate, recover, and adapt from disruptions and challenges to ensure sustainable, abundant, and reliable high quality water supplies."

The Resilience Plan is a discretionary planning document that builds on the District's historical planning efforts, such as the Groundwater Management Plan initiated in 1989, and the Long-Term Facilities Plan (LTFP) developed in response to annexations that added groundwater demands on the basin. The LTFP was first published in 2009 and last updated in 2014. With the passage of the Sustainable Groundwater Management Act (SGMA) in 2014, the Groundwater Management Plan has been replaced with what is called an Alternative to a Groundwater Sustainability Plan (GSP). The Alternative shows the California Department of Water Resources (DWR) that the Basin is being managed sustainably based on criteria established in SGMA. DWR requires this plan to be updated and submitted every five years.

The Resilience Plan marks a shift from a facilities-based planning approach to a project-based planning tool. This new approach identifies not only facilities but also feasibility plans, studies, and new water sources, thus providing a more comprehensive and flexible framework for future planning. The new plan reimagines and broadens the scope of these earlier efforts, integrating adaptive strategies to maintain sustainable basin conditions as defined by SGMA as well as enhance the resilience of key District assets.

The planning horizon extends from 5 to 25 years and is adaptable to the evolving needs and conditions of the District. This planning horizon aligns with demand forecasts required in Urban Water Management Plans (UWMP) which water retailers must submit to the state every five years. The District uses the UWMP demand forecasts along with its supply projections to estimate the percentage of groundwater the Groundwater Producers can use to meet overall demands. Finally, the 25-year planning horizon helps pinpoint future grant funding opportunities while facilitating early identification of environmental permitting and other requirements.

Key District Assets and Challenges

The Resilience Plan is organized and centered on addressing threats and challenges to four key District assets shown in Figure 4 and summarized in Table 1.

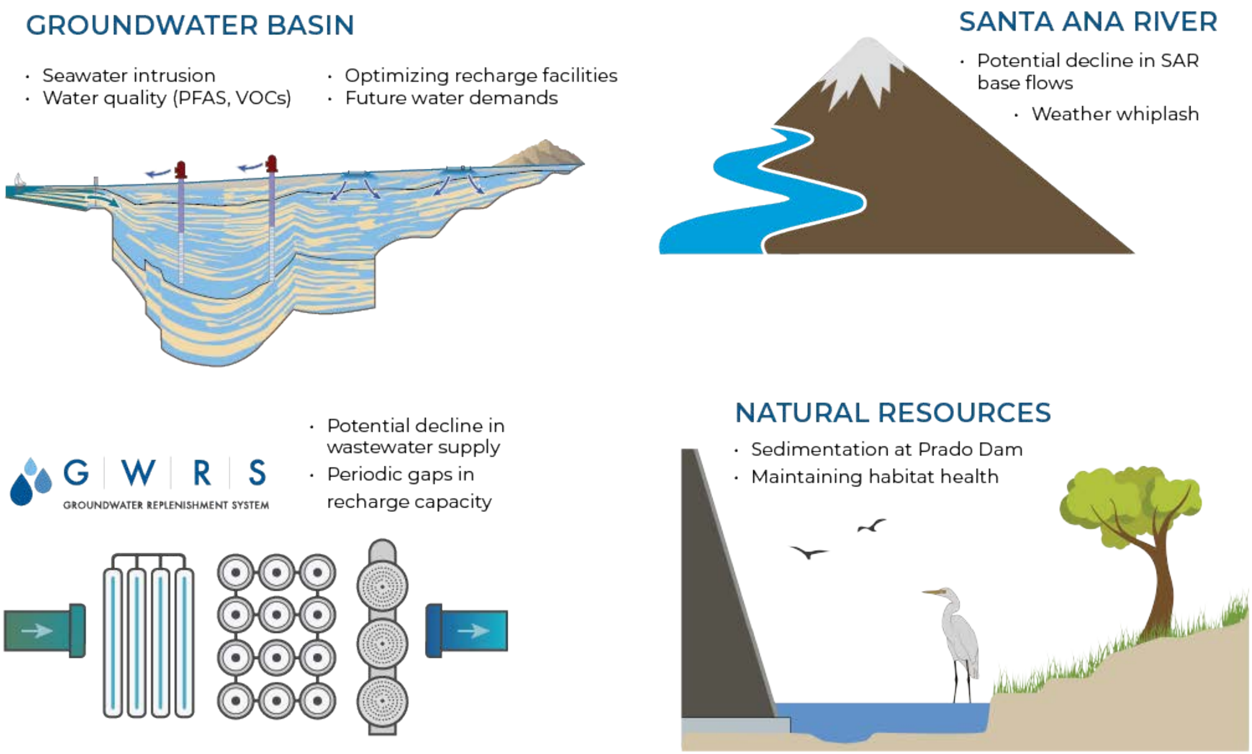


Figure 4: Key District Assets and Threats/Challenges

Table 1: Key Assets (1), Asset Components, and Threats/Challenges

Asset	Asset Components	Threats/Challenges
Groundwater Basin	• Groundwater supply • Groundwater quality • Recharge facilities • Seawater barriers	• PFAS • Seawater intrusion • Recharge system optimization • Groundwater demands
Santa Ana River	• Base flow • Storm flow	• Weather whiplash, extreme rain events • Clogging caused by stormwater recharge • Potential decline in base flows
Groundwater Replenishment System	• OC San wastewater • GWRS supply • GWRS recharge facilities	• Potential reduced wastewater supply • Recharge capacity for GWRS supplies
Natural Resources	• Treatment wetlands • Prado Basin habitat • Mitigation areas • Conservation pool	• Effect of increased water conservation on habitat health • Reduced capacity of water conservation pool due to sedimentation • Changing water quality in Santa Ana River flows

(1) Note that this table only presents selected key District assets and asset components and is not meant to be comprehensive.

Resilience Plan Process

The process of building the Resilience Plan is shown in Figure 5 and starts with ideas. The main forums for generating ideas are the Recharge Enhancement Working Group (REWG) and the Strategic Planning Group. The REWG is a long-standing internal, multi-departmental working group, that often includes outside technical experts, that is focused on ways to increase the capacity and effectiveness of the District's groundwater recharge system. The Strategic Planning Group is also an internal, multi-departmental working group that is focused on all District functions not related to groundwater water recharge. Ideas can also come from the Groundwater Producers, the Board of Directors, and others.

The next consideration is data on future demands and supplies as well as imported water costs to provide important context for the ideas generated. These data can move a project from concept to study, development, and implementation.

Finally, regulatory requirements are mandatory responses that must be addressed. Examples include complying with SGMA, and water quality standards established by the Environmental Protection Agency (EPA) or another regulatory agency.

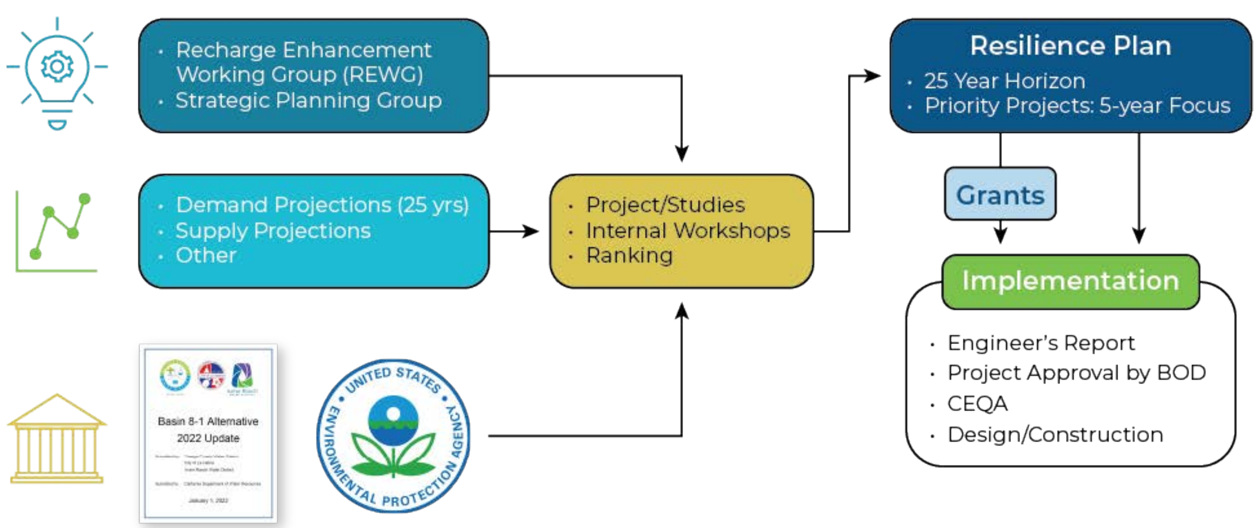


Figure 5: Resilience Plan Development and Implementation Process

The ideas generated can range from concepts, programs, research ideas, strategic plans, and studies, to infrastructure projects. For this Resilience Plan, District staff started with a list of 53 projects, concepts, and studies, that were reviewed at multiple workshops. Through this process, staff and management identified 16 priority projects that will be the focus of District efforts over the next five years. The goal is not to complete each project in the next five years but to advance them as appropriate. Some of the projects listed, such as the PFAS Treatment Project, are already being planned or implemented while others are purely conceptual. Regardless of priority, District staff will regularly evaluate and advance projects and studies to ensure readiness for grant funding opportunities.

Note that the priority project numbers are not indicative of project importance and are only for identification purposes. If selected for implementation, projects would be advanced through the established District process (see Figure 5) that would require Board approvals and could include preparation of an Engineer's Report, environmental permitting, design, and construction.

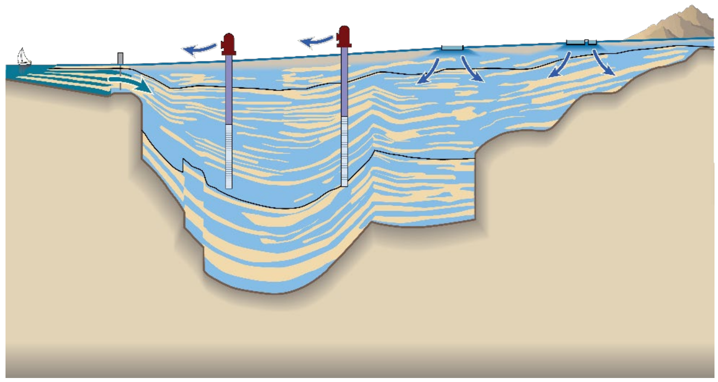
The Resilience Plan is meant to be adaptive and nimble. As such, the priority projects listed in this plan are not necessarily fixed for the next five years. This means projects can be added or removed from the priority project list as needed. Projects that are not priority projects are described as supplemental projects. Supplemental projects represent a repository of ideas and concepts that may be advanced as needed or as grant funding opportunities arise.

Plan Organization

The Resilience Plan is organized by describing the four key District assets, threats, and challenges to each asset and then a list of priority projects that address the threats and challenges. Other priority resilience plan projects that don't fit within the four key District assets are also presented. Finally, the projected supplies and demands for groundwater are presented along with projected groundwater costs.

Detailed descriptions of each priority project are presented in Appendix A along with location maps. Appendix B presents descriptions of supplemental projects.

GROUNDWATER BASIN



The Orange County Groundwater Basin (Basin) covers an area of approximately 350 square miles in north-central Orange County (Figure 1). The California Department of Water Resources (DWR) has designated this as Basin 8-1, Coastal Plain of Orange County Groundwater Basin. The basin is bordered by hills and mountains to the north and northeast and by the Pacific Ocean to the southwest. The northwest boundary is the Orange County-Los Angeles County line, where groundwater flow is unrestricted into the Central Basin of Los Angeles County.

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; however, in some areas, such as in the 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).

The shallower fresh-water sedimentary deposits form a complex layered system of interconnected sand and gravel deposits that are separated by clay and silt deposits. The sand and gravel deposits form aquifers, which are defined as permeable material from which groundwater can be extracted using a well. The clay and silt deposits form aquitards, which are of lower permeability and transmit water at a slow rate. The clay and silt deposits are thinner and not as extensive towards the inland part of the basin, particularly where the Santa Ana River enters the basin in Anaheim and Yorba Linda. As a result, larger quantities of surface and groundwater can more easily flow into the deeper aquifers (DWR, 1967). OCWD strategically constructed its surface water

Note: This section presents a high-level overview of the Groundwater Basin. For more information, please see the reports listed below, which are posted on OCWD's website.

- Groundwater Management Plan Update (2015)
- Basin 8-1 Alternative Final Report (2017)
- Basin 8-1 Alternative, 2022 Update (2022)

groundwater replenishment system in this area to recharge the deeper aquifers that are used for water supply as shown in Figure 6. Figure 6 presents a geologic cross-section through the basin along the Santa Ana River.

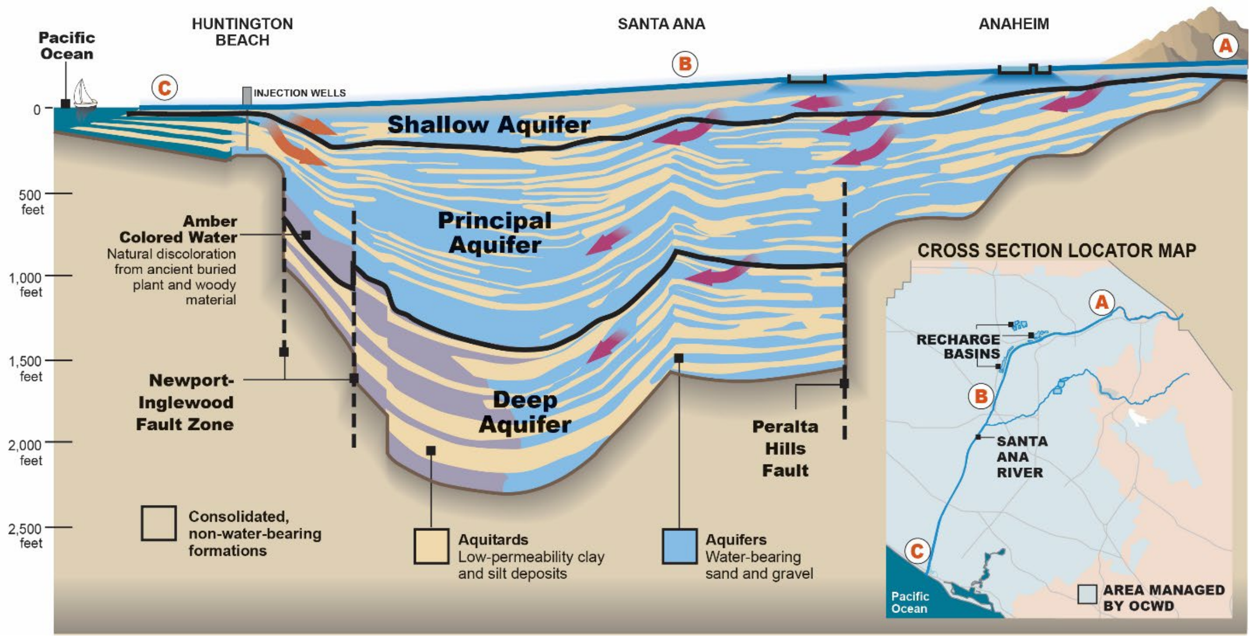


Figure 6: Geologic Cross-Section, Orange County Groundwater Basin

Due to complex layering in the basin, groundwater levels measured in OCWD's extensive monitoring well network define three major aquifer systems, which are called the Shallow, Principal, and Deep Aquifers. Over 90 percent of groundwater production comes from the Principal Aquifer and even though these aquifer systems are frequently treated separately, they are hydraulically connected, in that groundwater can flow between them albeit via leakage through the intervening aquitards or discontinuities in the aquitards.

The three aquifer systems contain an estimated 66 million acre- feet of water, which is more than double the volume of Lake Mead. Despite this large volume, OCWD manages basin storage within a defined operating range with a lower limit of 500,000 acre-feet below full, or 0.8 percent of total storage. However, on a short-term basis, the basin can be operated at an even lower storage level in an emergency. The optimal storage target is 150,000 to 200,000 acre-feet below full conditions. Figure 7 shows how basin storage levels have varied over time in relation to the optimal storage target.

The 500,000 acre-feet lower limit is in place to protect the basin and prevent increased pumping costs, reduced well yields, potential problems with groundwater production wells going dry, potential seawater intrusion, and land subsidence. Some of the impacts of operating the basin at a lower level are shown in Figure 8.

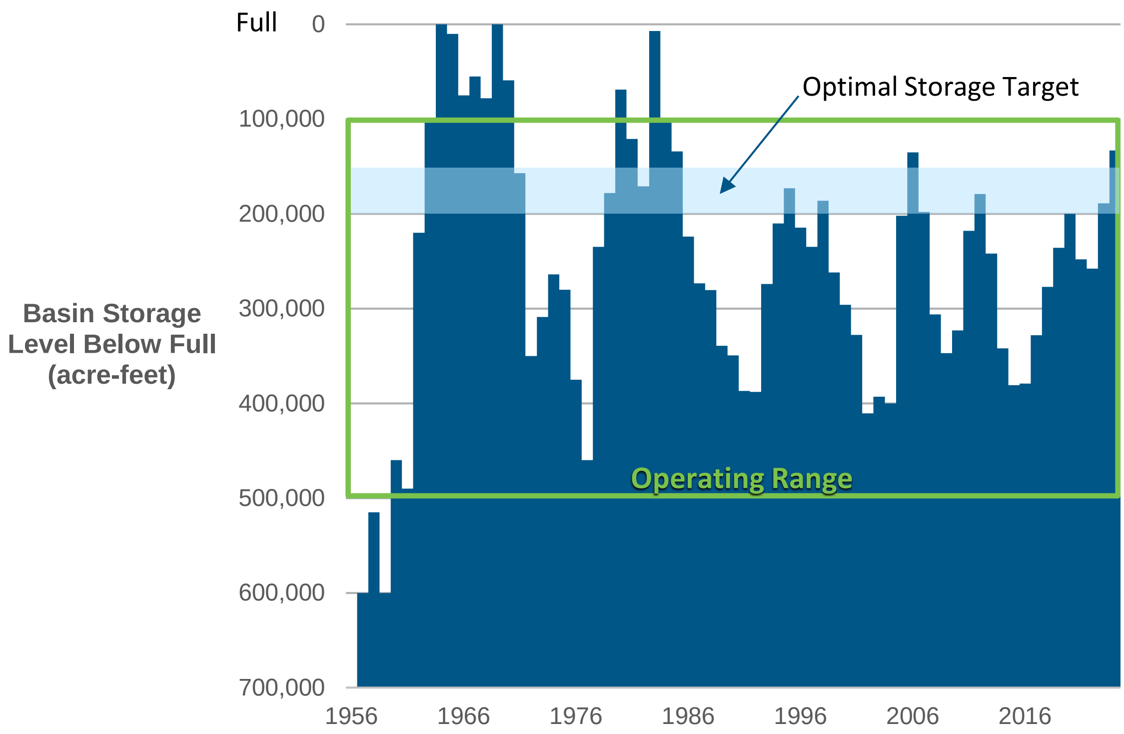


Figure 7: Basin Storage Levels and Operating Range

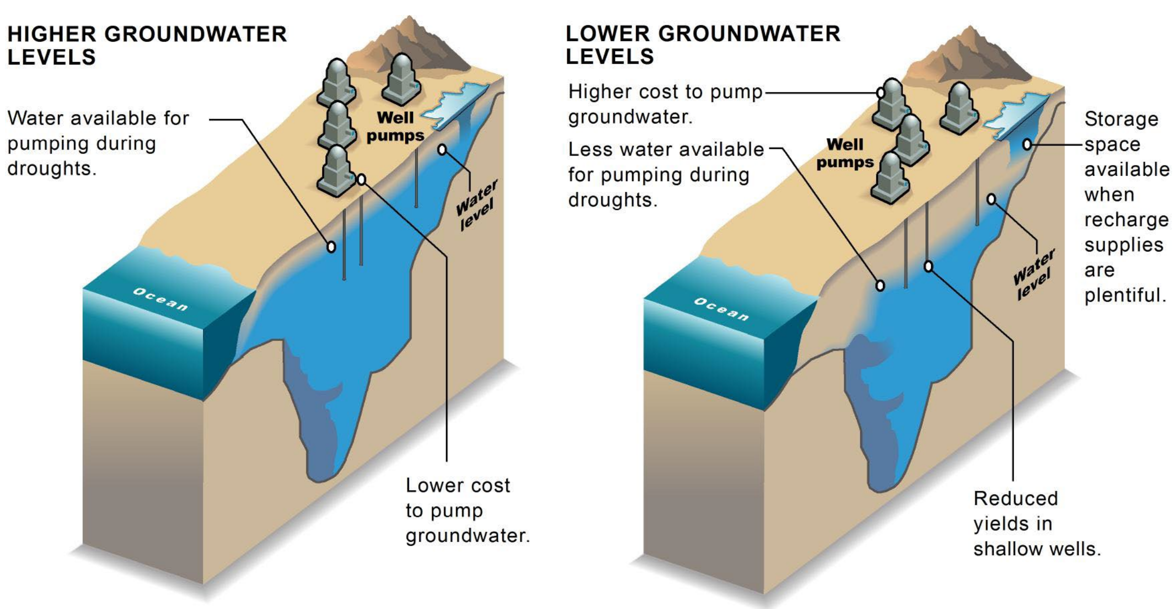


Figure 8: Illustration of Impacts of Lowering the Amount of Groundwater in Storage

Along the coast, there are four relatively flat elevated areas, known as mesas, that were formed by ground surface uplift along the Newport Inglewood Fault Zone. At the same time, the ancient Santa Ana River carved notches through the uplifted areas as it meandered across the coastal plain and left behind sand- and gravel-filled deposits beneath the lowland areas between the mesas, known as gaps (Poland et al., 1956).

These gaps in the Newport-Inglewood Fault provide pathways for seawater to intrude into the groundwater basin as shown in Figure 9. Seawater intrusion was noted in the Talbert Gap as far back as the 1920s. In response to seawater intrusion, the Alamitos Gap (1965) and Talbert Gap (1975) Seawater Intrusion Barriers were constructed. Data collected thus far indicate that seawater intrusion is not a threat in the Bolsa Gap; however, planning is underway for constructing a seawater barrier in the Sunset Gap.

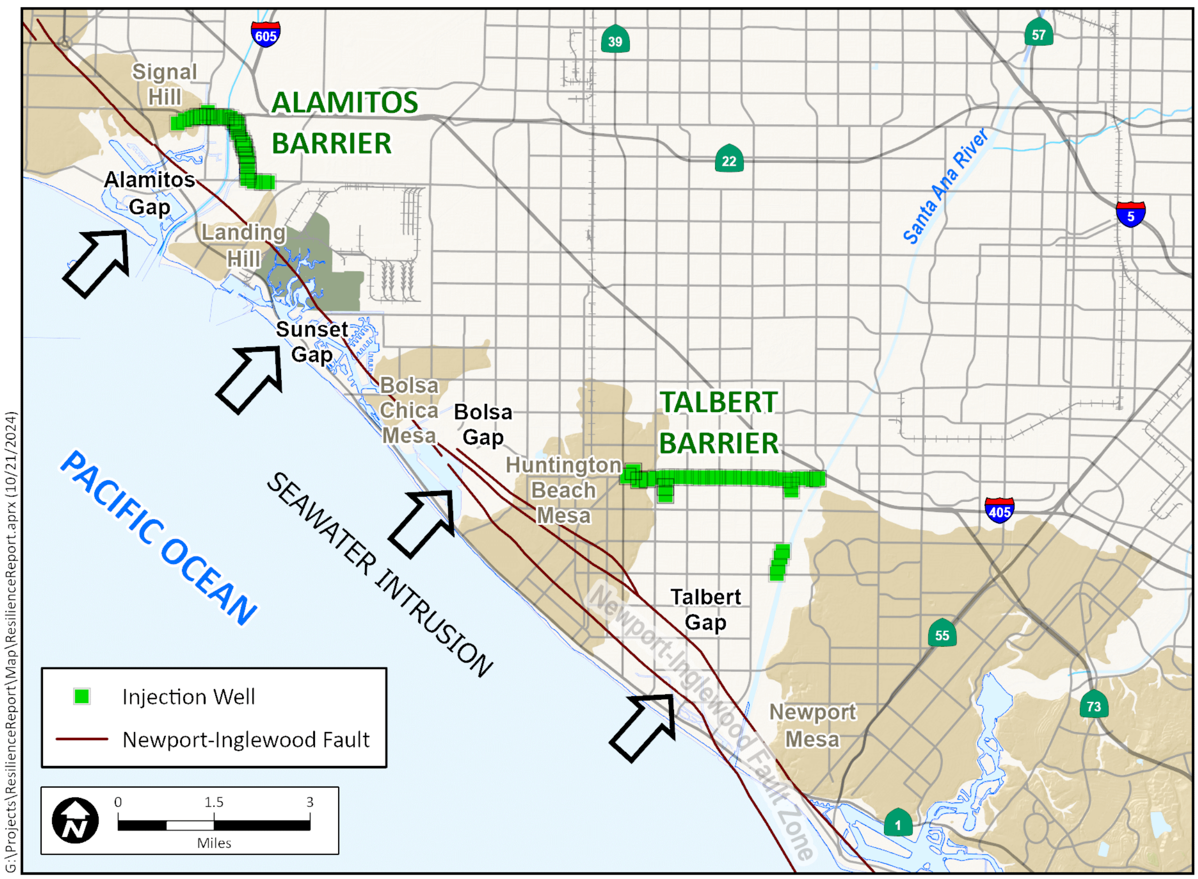


Figure 9: Coastal Gaps and Mesas

Managed Aquifer Recharge System

Developing an extensive managed aquifer recharge (MAR) system has been central to allowing OCWD to sustainably manage the basin and support increased groundwater pumping. OCWD began its MAR operations in the 1930s soon after it was formed. OCWD, in cooperation with the Orange County Flood Control District (OCFCD) began experimenting with methods to increase the percolation capacity of the Santa Ana River channel. Due to the success of this program, the District purchased 6 miles of the channel to maximize the recharge of Santa Ana River water into the basin. As opportunities arose to recharge additional water, such as imported water, increasing Santa Ana River base and storm flows, and more recently, recycled water, OCWD expanded its recharge system. Today, OCWD operates a network of over two dozen recharge facilities covering 1,500 acres that are in the cities of Anaheim and Orange where geologic conditions are favorable for recharge (see Figure 10).

Although the surface water system provides the bulk of recharge to the basin, recharge from the Alamitos and Talbert Gap seawater barriers and the Mid-Basin injection wells (Figure 10) are also important. The Mid-Basin injection wells were constructed in the center of the basin to provide additional recharge in an area of heavy pumping where groundwater levels tend to be low.

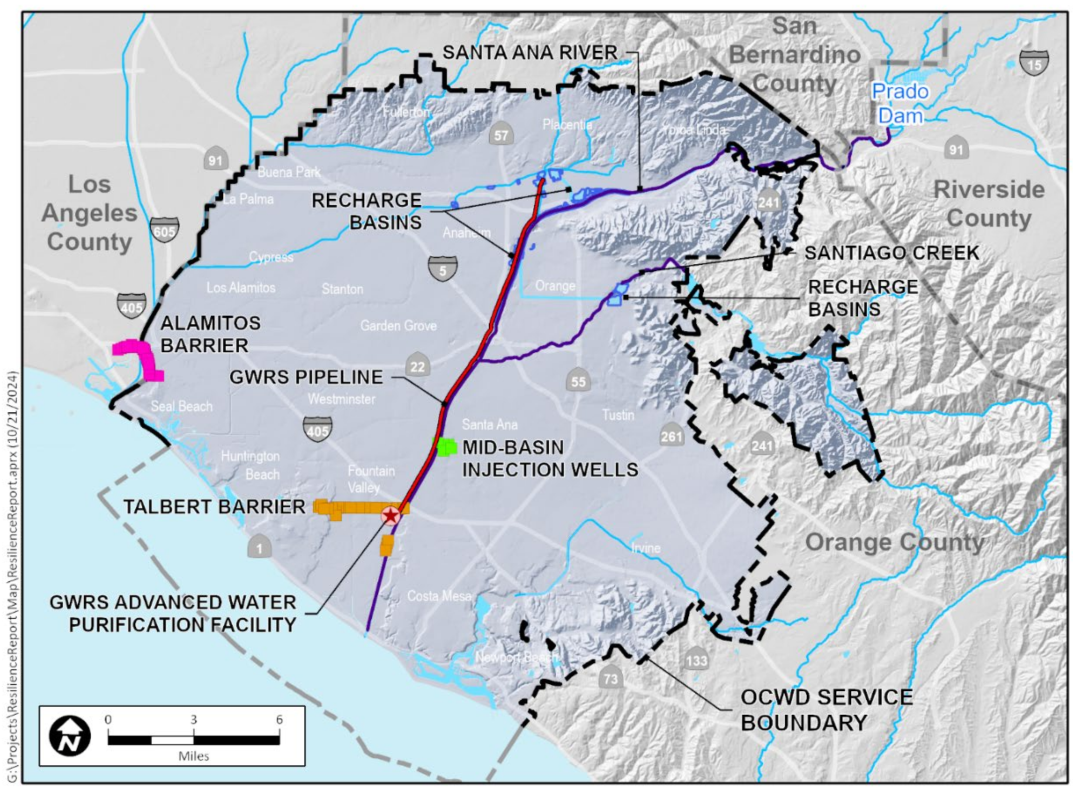


Figure 10: Groundwater Replenishment Facilities

Water Sources

OCWD has developed a diverse water portfolio that includes Santa Ana River base flow, stormwater, recycled water, and when needed, imported water to replenish the groundwater basin. Another important source of water is natural, unmeasured recharge from rainfall and subsurface groundwater inflow from the mountains surrounding the basin. Table 2 describes the various sources of water used to recharge the basin and where they are recharged.

Table 2: Sources of Recharge Water

Supply Sources and Descriptions			Recharge Location
Santa Ana River	Base Flow	Perennial flows from upper watershed in Santa Ana River; predominately treated wastewater discharge	Santa Ana River, Santiago Creek, and recharge basins
	Storm Flow	Precipitation from upper watershed flowing in Santa Ana River through Prado Dam	Santa Ana River, Santiago Creek, and recharge basins
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, Santiago Basins
Incidental Recharge	Precipitation and subsurface inflow	Precipitation and runoff from Orange County foothills, subsurface inflow from basin boundaries	Basin-wide
Recycled Water	Groundwater Replenishment System	Advanced treated wastewater produced in Fountain Valley	Talbert Gap Barrier and Mid-Basin injection wells; various recharge basins
	Water Replenishment District of Southern CA	Water purified at the Leo J. Vander Lans Treatment Facility in Long Beach	Alamitos Barrier
Imported Water	Untreated	State Water Project and Colorado River Aqueduct	Various recharge basins and the Santa Ana River
	Treated	State Water Project and Colorado River Aqueduct treated at MWD Diemer Water Treatment Plant	Alamitos Barrier

From the late 1940s to the early 1970s, OCWD purchased large volumes of imported water to refill a depleted groundwater basin. In 1969, the basin was essentially full due to cumulative effect of imported water recharge and very wet conditions in 1969. Figure 11 shows which sources and volumes of water have been used to replenish the groundwater basin since the late 1940s using OCWD's surface water recharge system. In the mid-1970s to early 2000s, Santa Ana River base flow greatly increased, peaking in 1999 at approximately 158,000 acre-feet. This rise in base flow, which is primarily comprised of wastewater discharged to the Santa Ana River, was due to rapid growth and urbanization in the upper Santa Ana River watershed. Since 2005, Santa Ana River base flow has declined by over half and is projected to continue to decline due to increased conservation and recycling by upstream water agencies. OCWD's ability to divert, capture, and recharge stormwater has increased since the early 1990s due to investments in infrastructure and by working with the United States Army Corps of Engineers (USACE) to increase the volume of stormwater that can be temporarily retained behind Prado Dam. More recently, with the completion of OCWD's Groundwater Replenishment System (GWRS), recycled water now plays a critical role in recharging the groundwater basin.

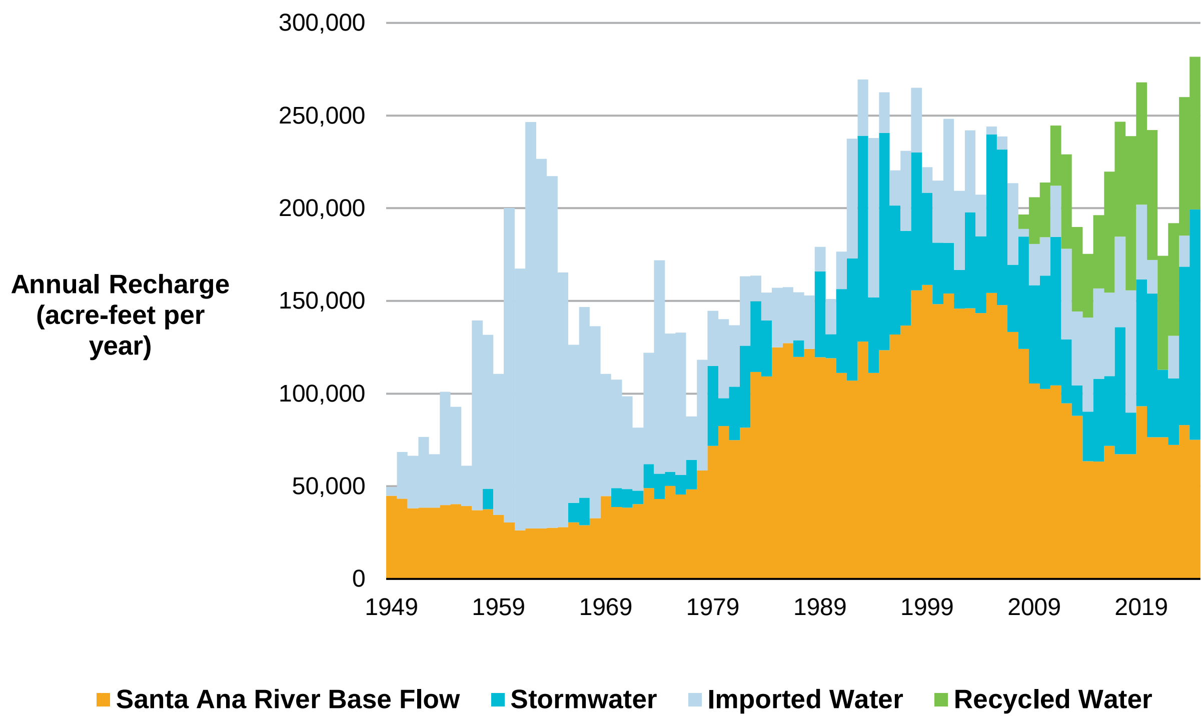


Figure 11: Sources Used to Replenish the Groundwater Basin Using OCWD's Surface Water Recharge System

The availability of water sources to the basin has changed over time and will continue to do so. Imported water that was once abundant and inexpensive is now expensive and under pressure due to environmental restrictions on the State Water Project (SWP) and reduced supplies on the Colorado River. Santa Ana River base flow was an important source of supply for many years but has declined and is projected to decline further in the future. Storm flows are expected to become more intense but occur less frequently.

Groundwater Production

Groundwater is withdrawn from the basin by numerous large and small production wells. There are approximately 220 large system production wells, which account for an estimated 97 percent of total pumping. These wells are used by cities, water districts, and a private water company to deliver large volumes to their service area. The remaining groundwater pumping comes from smaller wells typically used by small systems, such as mutual water companies, agricultural companies, golf courses, cemeteries (irrigation wells), and private-well owners. When OCWD was founded, most groundwater use was for agriculture, but presently, pumping for agricultural use accounts for less than one percent of total pumping. To keep track of pumping, OCWD requires that large wells be metered, and pumping reported at regular intervals. Figure 12 shows where the large and small system production wells are located. Figure 13 shows how groundwater pumping has more than doubled since the early 1960s.

Water Budget

OCWD carefully measures inflows and outflows from the basin. All recharge from District facilities is measured. Outflow via groundwater production wells is measured and reported to OCWD. The only recharge that is not directly measured is 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. This unmeasured recharge is called "incidental recharge." Incidental recharge also includes losses from subsurface flows leaving the basin across the county line into Los Angeles and at the Alamitos and Talbert Gaps. OCWD tabulates inflow and outflow data to produce a monthly estimate of the change in groundwater storage which allows for virtually real-time decision-making with respect to managing the basin.

On an annual basis, OCWD calculates the change in storage in each of the three basin aquifer layers. This method involves creating groundwater elevation contour maps for the three aquifer layers (Shallow, Principal, and Deep Aquifers) at the end of June each year. The elevation contours are compared to the prior year to calculate the change in water level for each aquifer layer. Changes in water level are multiplied by aquifer storage properties from OCWD's calibrated groundwater flow model to determine the change in storage. The changes in storage for the three aquifers are totaled to provide an annual storage change for the basin. The total storage change is used to calculate incidental recharge since all the other water budget components (i.e., managed recharge and pumping) are measured. Historical basin storage conditions are shown in Figure 7.

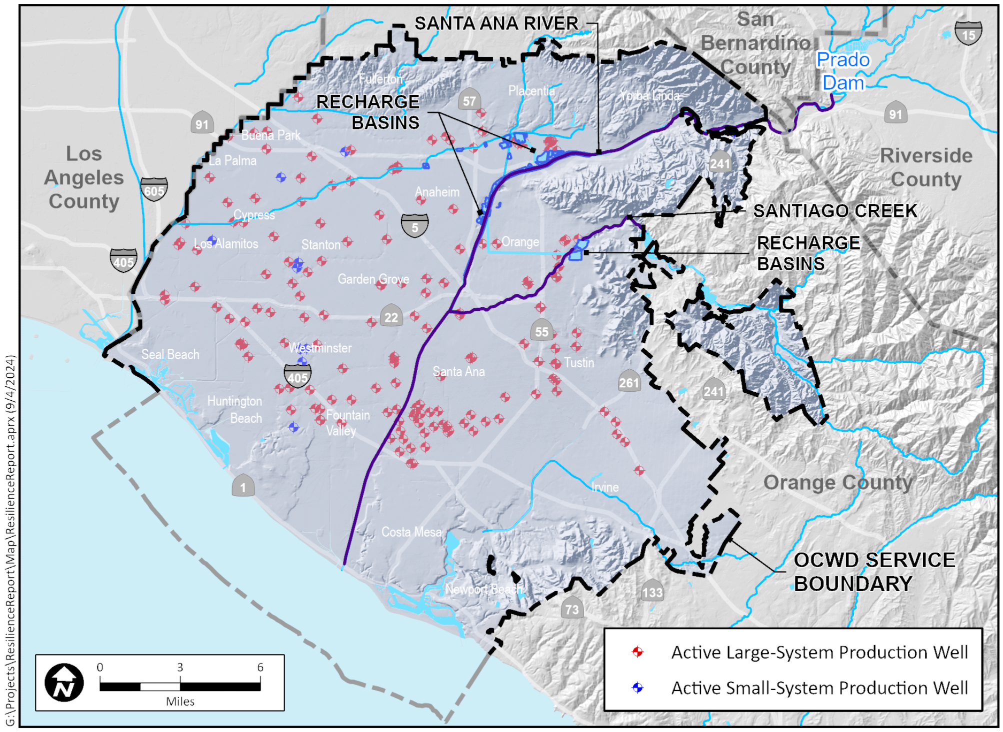


Figure 12: Location of Large and Small System Groundwater Production Wells

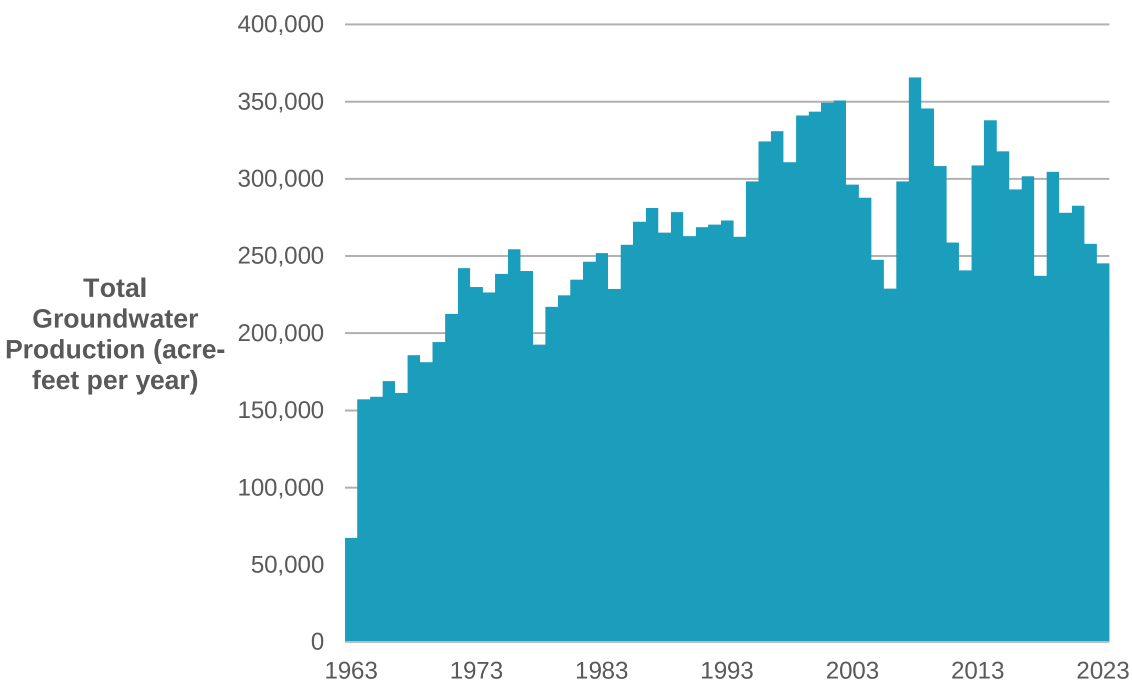


Figure 13: Historical Groundwater Production

Management of Groundwater Production and Basin Storage

The primary mechanisms used by OCWD to manage pumping are the Basin Production Percentage (BPP) and the Basin Equity Assessment (BEA). The BPP is a percentage of each Producer's total water supply that can come from the groundwater basin without incurring additional fees. The BPP is uniform for all Groundwater Producers and is set annually by the OCWD Board. Groundwater production at or below the BPP is assessed the Replenishment Assessment (RA). Any production above the BPP is charged the RA plus the BEA. The BEA is set by the Board and is presently calculated so that the cost of groundwater production above the BPP is equivalent to the cost of purchasing imported potable supplies. This approach serves to disincentivize production above the BPP.

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

A simplified formula to estimate the BPP is shown in Figure 14. To estimate the BPP for a given year, the supplies to the basin are estimated. Subtracted from the supplies are special water quality improvement projects and any volume that is to remain in storage at the end of the year to refill the basin, if necessary. This is divided by the total water demands minus reclaimed water use.

$$\frac{\text{Supplies to Basin} - \text{Water Quality Improvement Pumping} - \text{Planned Basin Refill}}{\text{Total Water Demands} - \text{Reclaimed Water}} = \text{BPP}$$

Figure 14: Basin Production Percentage (BPP) Formula

In 2013, the OCWD Board of Directors adopted a policy of maintaining a BPP of at least 75 percent (OCWD, 2013). Since then, with additional supplies from the GWRS, OCWD has been able to increase the BPP to 85 percent and will continue to look for opportunities to increase it in the future.

The BPP can be adjusted based on basin storage conditions. Table 3 shows how basin storage guides management actions in setting the BPP.

Table 3: Management Actions based on Available Basin Storage Space

Available Basin Storage Space (Level below Full)	**Basin Management Action to Consider**
Less than 100,000 acre-feet	Raise BPP
100,000 to 300,000 acre-feet	Maintain and/or Raise BPP
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 and lower BPP

Maintaining healthy quantities of groundwater in storage provides drought resilience. Drought conditions can occur in the local Santa Ana River watershed but can also occur in areas where imported water comes from, including northern California and the Colorado River watershed. During a drought, flexibility to maintain or even increase pumping from the basin becomes increasingly important. To ensure 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
- Possessing adaptive strategies to recover basin storage following drought, including having sufficient financial reserves to purchase imported water for groundwater replenishment

Adaptive strategies to respond to drought conditions and manage groundwater storage, including refilling the basin are described in Table 4.

Table 4: Groundwater Storage and Drought Recovery Strategies

Strategy	Discussion
Decrease Total Water Demands	• Increase water conservation efforts and water-use efficiency measures
Decrease BPP	• Allows water levels to recover • Increases costs to Groundwater Producers • No additional recharge facilities required • Dependent on availability of other sources of water such as imported water
Increase Recharge	• Depends on availability of recharge water • Could deliver more imported water to Groundwater Producers instead of groundwater (e.g., In-lieu recharge) • Water transfers and exchanges • Construct additional recharge capacity
Combination of Above	• A combination of approaches provides flexibility and range of options for refilling the basin

Groundwater Quality

OCWD's water quality monitoring and protection programs are a vital component of assuring sustainable basin management by:

- Monitoring coastal water quality and controlling seawater intrusion
- Monitoring and remediating 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
- Assuring that the groundwater basin is managed in full compliance with all relevant laws and regulations

In support of sustainable and effective basin management, OCWD collects water elevation and water quality data from over 1,300 wells, including Groundwater Producer wells, over 500 District monitoring wells, and other monitoring wells shown in Figure 15. Comprehensive groundwater, surface water, and recycled water quality monitoring programs are conducted to comply with permits and drinking water regulations, to conduct research programs, and to provide important data used to inform groundwater basin management.

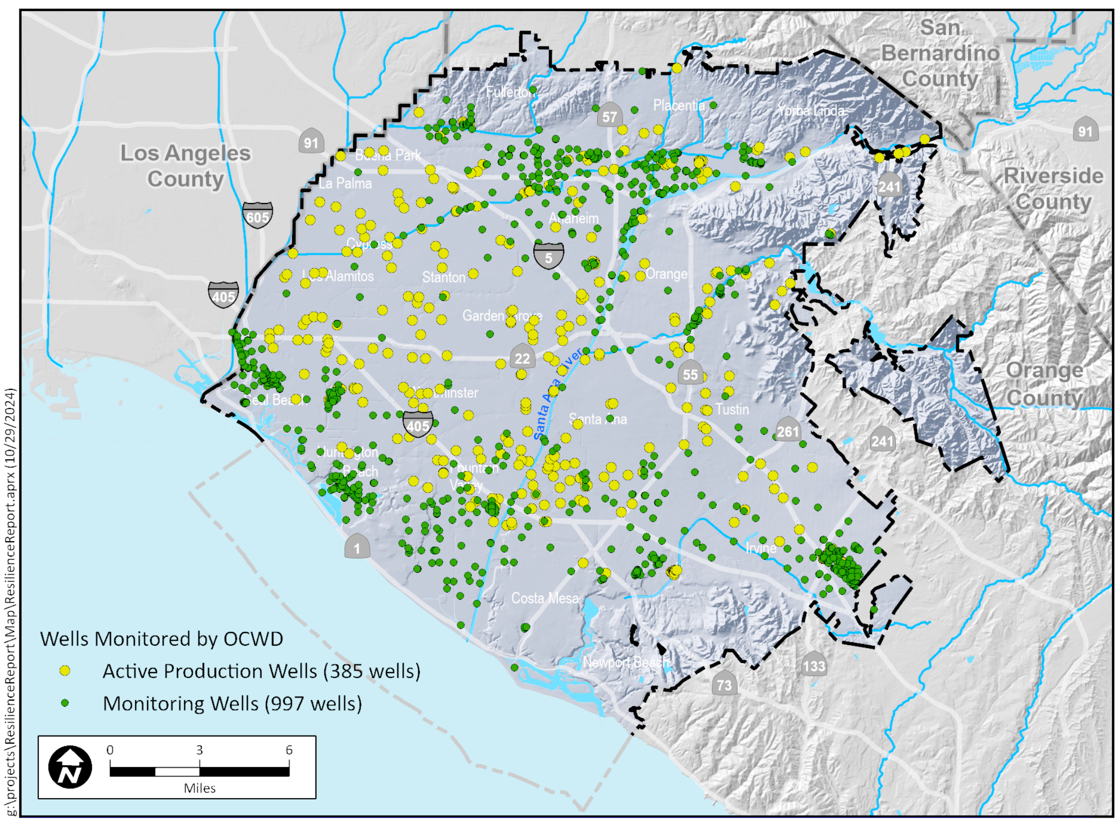


Figure 15: Wells Monitored by OCWD

There are several major groundwater contamination sites within the District at which a primary drinking water standard is exceeded. In some areas, the contamination has migrated beyond the sources forming plumes that have degraded the quality of the underlying groundwater. These plumes, shown in Figure 16, are in the process of being remediated. Other localized contamination sources and smaller plumes exist within District boundaries but are not represented on Figure 16, nor is the occurrence of per- and polyfluorinated alkyl substances (PFAS).

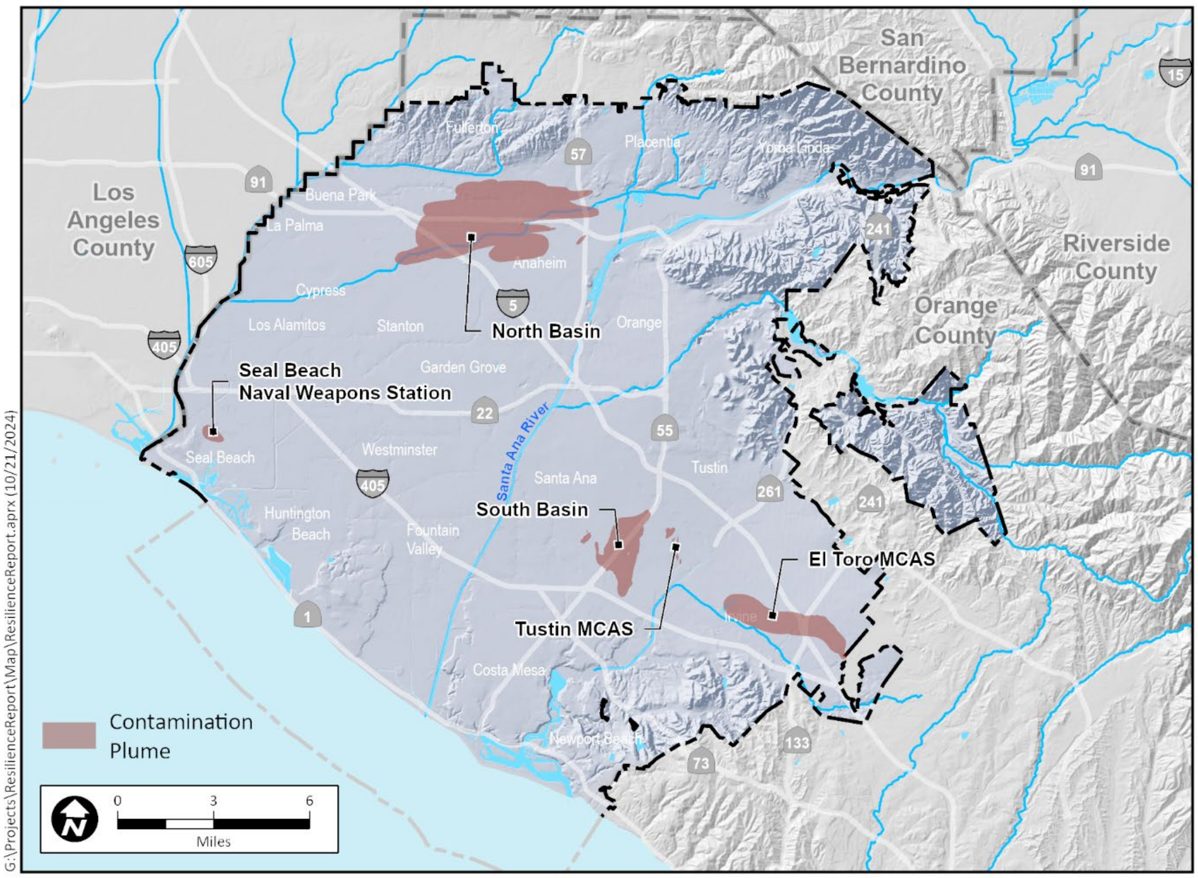


Figure 16: Groundwater Contamination Plume Locations

Sustainable Groundwater Management Act (SGMA)

In 2014, Governor Brown signed legislation establishing the Sustainable Groundwater Management Act (SGMA). SGMA required all high and medium-priority basins, as ranked by the DWR, to submit a Groundwater Sustainability Plan (GSP) by 2020 or 2022, depending on the basin conditions. The GSP must demonstrate how the basin would achieve sustainable conditions in 20 years. If a groundwater basin was already being managed sustainably, an alternative plan could be submitted.

In June 2014, DWR published a report on basin prioritization and designated the Coastal Plain of Orange County Groundwater Basin (Basin 8-1) as a medium-priority basin, primarily due to its heavy reliance on groundwater for water supply. OCWD submitted a plan called the "Basin 8-1 Alternative" to DWR in January 2017. OCWD collaborated with Irvine Ranch Water District (IRWD) and the City of La Habra in preparing the plan to cover the entirety of Basin 8-1 as required by SGMA. OCWD's service area covers approximately 90 percent of Basin 8-1 with IRWD and La Habra covering the remaining 10 percent. The plan is called an Alternative because the basin had been managed sustainably over a decade prior to SGMA's passage. It was only one of two plans in the state to obtain approval based on 10 years of prior sustainable management. The first Basin 8-1 Alternative was submitted to DWR in January 2017 and approved by DWR in July 2019. The first five-year periodic update was submitted in 2022 and approved in 2024. SGMA is an outcome-based law in that sustainability is defined as the lack of undesirable results for six criteria, which are shown in Figure 17.

Figure 17: SGMA Sustainability Criteria

OCWD's approach to managing the groundwater basin within a defined storage range (see Figure 7) allows it to address the following sustainability criteria:

- Lowering of Groundwater Levels
- Reduction of Storage
- Land Subsidence

Seawater intrusion has historically been addressed by the Talbert and Alamitos Barriers. More recent intrusion has been noted in the Sunset Gap and the feasibility of constructing a new barrier is currently being studied. The Surface Water Depletion criterion, also called Surface Water-Groundwater Interactions criterion does not apply to Basin 8-1. The Degraded Quality criterion is addressed by OCWD's groundwater quality monitoring and cleanup programs.

Even though Basin 8-1, including OCWD's service area, currently complies with SGMA, OCWD, IRWD and La Habra must continue to show DWR that it meets sustainable management criteria through its annual reports and periodic updates to the Basin 8-1 Alternative, which are due every 5 years.

Threats/Challenges and Priority Projects

Even though the groundwater basin is being managed sustainably, there are known threats and challenges that the District needs to prepare for, including:

- Impacts to groundwater quality, including seawater intrusion
- Potential for prolonged droughts
- Aging managed aquifer recharge facilities

Priority projects to address these threats and challenges are listed in Table 5. More specifically, priority projects to address impacts to groundwater quality are listed in Table 5 as:

- **Project 1: PFAS Treatment Project**
- **Project 2: Sunset Gap Barrier Project**
- **Project 4: South Basin Groundwater Protection Project**.

A priority project to examine strategies to address potential long-term drought is **Project 3: Groundwater Basin Operating Range Expansion Study.**

Priority projects to enhance aging managed aquifer recharge infrastructure include:

- **Project 5: Talbert Barrier Injection Well Replacement and Optimization**
- **Project 12: Anaheim Lake Recharge Basin Rehabilitation**
- **Project 15: Recharge Conveyance Optimization**.

A priority project to examine a potential source of additional supply is **Project 7: Brackish Water Desalination Study**.

Detailed descriptions of each priority project are provided in Appendix A. Appendix B presents descriptions of supplemental projects.

Table 5: Priority Projects to Address Threats/Challenges to Groundwater Basin

PROJECT	DESCRIPTION
BASIN MANAGEMENT	
1. PFAS Treatment Project	Construct treatment systems on production wells affected by PFAS.
2. Sunset Gap Barrier Project	Construct seawater barrier for Sunset Gap.
3. Groundwater Basin Operating Range Expansion Study	Study potential of expanding the operating range of the groundwater basin.
4. South Basin Groundwater Protection Project (SBGPP)	Pursue remedial investigation and other appropriate actions to contain and remediate contaminated groundwater in the South Basin area.
5. Talbert Barrier Injection Well Replacement and Optimization	Replace selected aging Talbert Barrier injection wells and locate replacement wells in more optimal locations.
WATER SUPPLY	
7. Brackish Water Desalination Study	Participate with Mesa Water, Huntington Beach and Newport Beach in Local Groundwater Supply Improvement Project to examine using purified brackish groundwater for additional water supplies.
RECHARGE FACILITIES	
12. Anaheim Lake Recharge Basin Rehabilitation	Rehabilitate OCWD's oldest recharge basin by removing clogged material and regrading the basin to increase storage, recharge capacity and make future cleanings more efficient.
OPERATIONAL IMPROVEMENTS	
15. Recharge Conveyance Optimization	Evaluate conveyance capacity of recharge system, including potential constraints at Lakeview Ave. and Warner-Anaheim Pipeline.

SANTA ANA RIVER

The Santa Ana River begins in the San Bernardino Mountains, flows through Prado Dam, and eventually to the Pacific Ocean. The river is the longest coastal stream in southern California stretching 96 miles through San Bernardino, Riverside, and Orange Counties, draining approximately 2,670 square miles of a densely populated area. Figure 18 shows the Santa Ana River watershed.

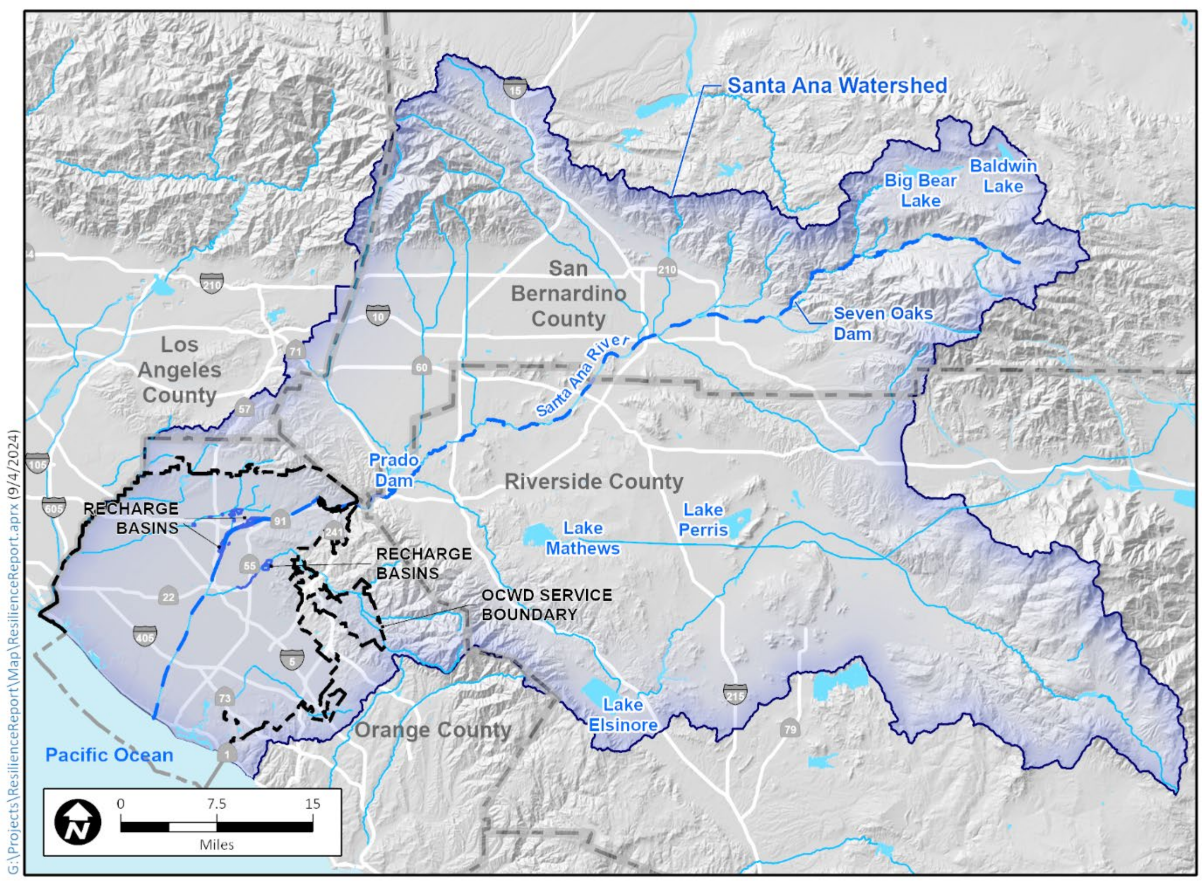


Figure 18: Santa Ana River Watershed

During the dry season, flows in the river are largely made up of wastewater discharge and in some sections rising groundwater. Some sections of the river regularly run dry. Flows in the river that are not immediately due to precipitation are called base flows. However, following rain events, the flow of the river can quickly increase with rain-fed runoff called storm flow. A number of large floods have occurred in the watershed including the 1927 event that caused significant damage leading to the formation of the Orange County Flood Control District (OCFCD) and the eventual construction of Prado Dam by the U.S. Army Corps of Engineers (USACE) in 1941 for flood risk management and other purposes.

The Santa Ana River has long been a key source of water in the watershed and to the groundwater basin. Due to reduced flows to Orange County as a result of diversions upstream, the first in a series of lawsuits was filed in the 1930s against parties in the upper watershed. These suits culminated in the lawsuit OCWD v. City of Chino, et al., Case No. 117628 which was settled in 1969 and requires a minimum annual base flow of 42,000 acre-feet per year at Prado Dam. Annual base flows have exceeded this requirement for many years, resulting in a credit that allows flows to be reduced to 34,000 acre-feet per year. Due to development in the upper watershed, base flows increased from the 1970s to the early 2000s reaching 154,000 acre-feet in 2005. Since this time, base flows have declined due to increased recycling of wastewater and water conservation. Base flows appear to have leveled off in recent years; however, upstream agencies have proposed projects to further increase wastewater recycling and reduce discharges to the river. Figure 19 shows the annual base flow and storm flow arriving at Prado Dam over the last 100 years from 1924 to 2023.

OCWD’s surface water recharge facilities (Figure 10) are more than adequate to capture and recharge all Santa Ana River base flows. In addition to base flows, stormwater represent a significant source of water used to recharge the groundwater basin. Over the last 20 years, OCWD has captured and recharged an average of 50,000 acre-feet per year of stormwater with a maximum of 124,000 acre-feet from July 2023 to June 2024.

Capturing and recharging stormwater presents significant challenges due to its high variability and high suspended solids load which clogs recharge basins. High storm flow variability is attributed to California’s wide swings in annual rainfall compared to the rest of the United States (Dettinger et al., 2011). Recent research has shown that much rainfall in California comes from atmospheric rivers (ARs), which are narrow bands of moisture in the atmosphere that can carry as much water as 15 Mississippi Rivers. Figure 20 illustrates how ARs form in the ocean and provide rain to the land surface. ARs are important and often make the difference between wet years and droughts. It is projected that even though average rainfall is not expected to change, the way it comes is anticipated to change with increased duration and intensity of dry periods interspersed with more intense wet periods (Swain et al., 2018). This is sometimes referred to as “weather whiplash.”

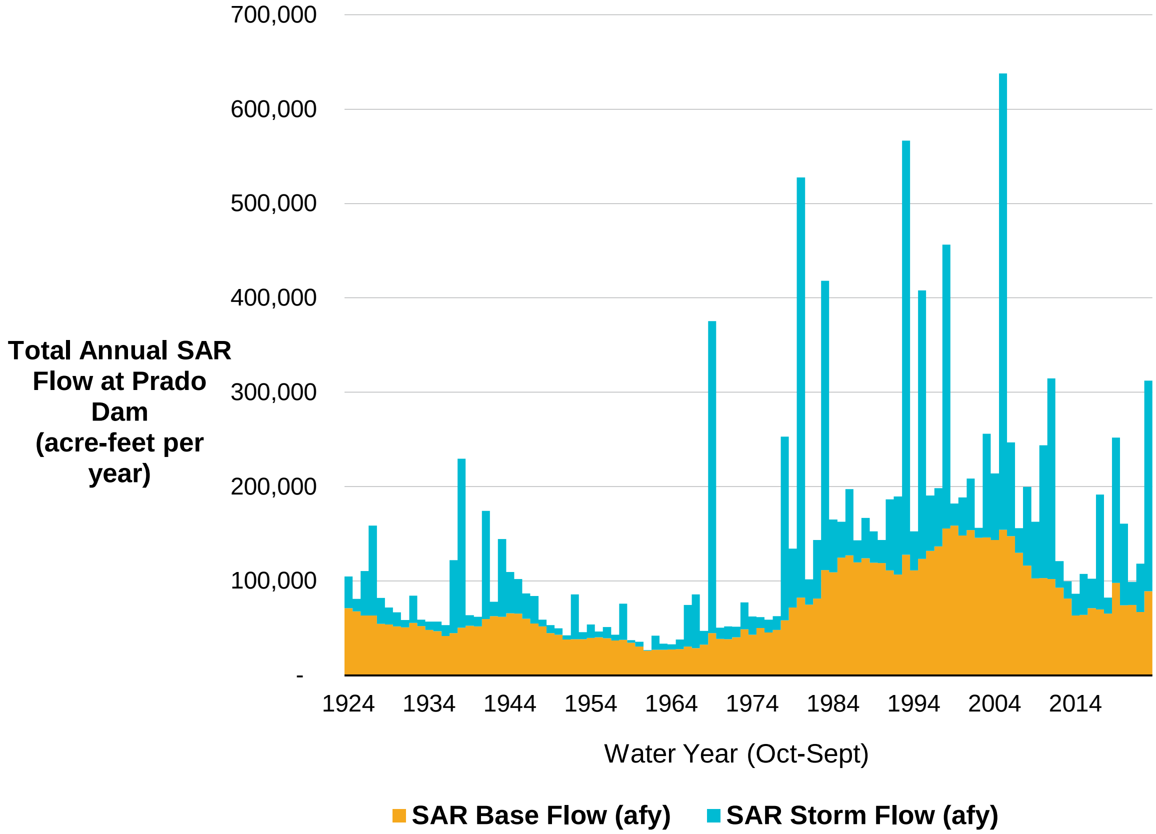


Figure 19: Santa Ana River Base Flow and Storm Flow at Prado Dam, 1924-2023

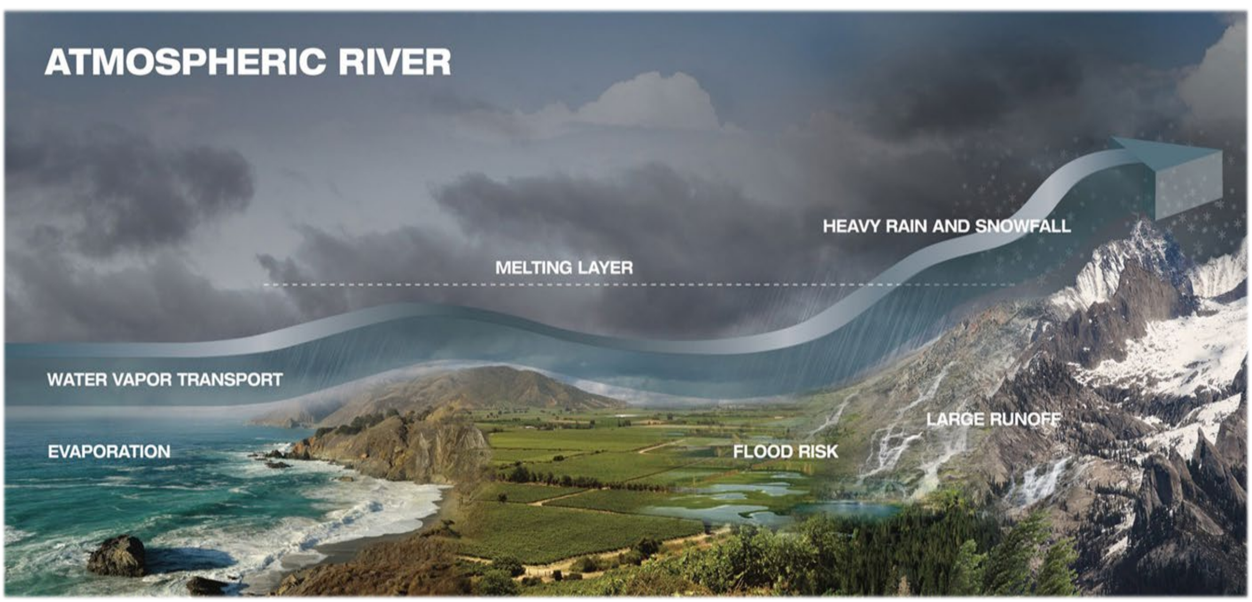


Figure 20: Atmospheric River

To capture stormwater, OCWD relies heavily on Prado Dam. OCWD and the USACE have been collaborating since the 1960s to temporarily impound storm flows behind the dam for release at a rate that can be captured by OCWD for groundwater recharge. To not affect the dam's primary flood risk management purpose, the amount of water that is temporarily held is small in relation to the total flood control capacity of the dam. Stormwater can be impounded in what is called the water conservation pool or buffer pool. Currently, stormwater is allowed to be held up to elevation 505 ft, which equates to 20,000 acre-feet of storage as shown in Figure 21.

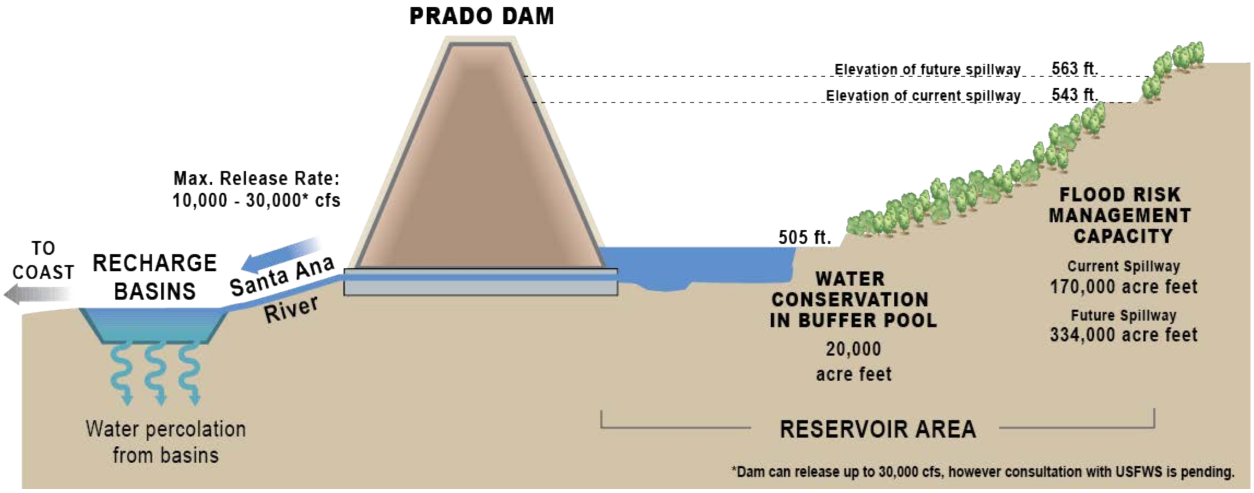


Figure 21: Prado Dam and Water Conservation Pool

As part of the USACE's Santa Ana River Mainstem (SARM) Project, Prado Dam was raised 20 feet and the outlet works were replaced in 2008 so that the dam can release 30,000 cfs, which is three times greater than the original design. The SARM also included modifying the downstream Santa Ana River channel to accommodate the higher release capabilities. A new spillway, targeted for completion in 2032, will essentially double the flood control storage capacity to approximately 334,000 acre-feet (see Figure 21).

The combination of SARM improvements to the dam and recent improvements in the ability to accurately forecast the size and intensity of ARs has led to a new approach to operating Prado Dam using what is called Forecast Informed Reservoir Operations (FIRO). FIRO is a flexible water management strategy that uses data from watershed monitoring and modern weather and hydrologic forecasting to help water managers selectively retain or release water from reservoirs in a manner that reflects current and forecasted conditions. FIRO uses advances in science and technology to optimize the beneficial use of limited resources and adapt to changing conditions, while simultaneously improving flood risk management.

To explore the potential for increased stormwater capture using FIRO, OCWD embarked on a multi-phase study in collaboration with the Center for Western Weather and Water Extremes (CW3E) at the Scripps Institution of Oceanography in 2017. This study marked the second FIRO pilot study in the country, following the initial one conducted at Lake Mendocino on the Russian River. The study of FIRO at Prado Dam was guided by a diverse steering committee that included OCWD, CW3E, USACE, U.S. Fish and Wildlife Service, California Nevada River Forecast Center, DWR, Sonoma Water, and Orange County Public Works.

The FIRO study was completed in 2023 with the publication of the Final Viability Assessment (Ralph, et al., 2023). The study found that it is viable to use FIRO at Prado Dam and recommended a FIRO water conservation pool ranging from elevation 510 ft to 512 ft be considered, which could yield an average of 4,000 to 6,000 acre-feet per year of additional stormwater recharge, respectively.

To formalize the use of FIRO at Prado Dam, the USACE's Prado Dam Water Control Manual (WCM) needs to be modified. The WCM is the governing document that describes the rules the USACE follows in operating Prado Dam. It is targeted to complete the WCM update in 2029. In the interim, a temporary increase in the water conservation pool to elevation 508 ft will be implemented to test FIRO and provide a bridge to the WCM update. The temporary increase to elevation 508 ft is estimated to provide an average of 2,000 acre-feet per year of additional stormwater recharge.

Another challenge to recharging stormwater is clogging caused by the accumulation of suspended sediment in OCWD's recharge basins. Suspended sediment loads are much higher in stormwater compared to base flow and this suspended sediment settles out in recharge basins and forms a thin clogging layer that greatly reduces the percolation rate. Figure 22 shows what the clogging layer looks like in a basin when it has dried.

OCWD has been studying ways to minimize the impact of clogging. These studies have included looking at cleaning the basins while full of water using an experimental, custom-designed Basin Cleaning Vehicle (BCV). The BCV concept is similar to a remotely operated pool cleaner. After much testing, it was found to be inefficient and not cost-effective. OCWD has also studied removing the suspended sediment, also called desilting, before the water is placed in a recharge basin. Many treatment methods were examined and one, using the natural filtration properties of Santa Ana River channel sediments, called Riverbed Filtration, was found to be effective.

Figure 22: Clogging Layer in a Recharge Basin

The Riverbed Filtration System (RFS) employs a series of collection pipes buried 3 to 4 feet below the river channel that collects the filtered water and conveys it in a pipe to a recharge basin. The RFS has been tested on a large scale and was able to double the recharge capacity of the receiving basin. Based on these results, the potential of scaling up the RFS to treat water received by other recharge basins will be evaluated, with the goal of increasing stormwater capture in a cost-effective manner.

Threats/Challenges and Priority Projects

Known threats and challenges related to the Santa Ana River include:

- Increasing volatility in storm flow events (weather whiplash)
- Clogging of recharge facilities from suspended sediment in stormwater

Priority projects to address these threats and challenges are listed in Table 6. More specifically, priority projects to address increasing storm flow volatility are listed in Table 6 as **Project 8: Increasing Stormwater Recharge**. Project 8a is focused on increasing stormwater capture at Prado Dam using FIRO and Project 8c is focused on capture and recharge of stormwater below Prado Dam. **Project 13: Recharge in Lower Santiago Creek** will also assist in recharging Santa Ana River storm flows as water pumped from the river will be the main source of water to this reach of the creek.

A priority project to minimize clogging of OCWD's recharge basins and increase stormwater recharge is listed in Table 6 as **Project 11: Desilting Santa Ana River Flows**. This project involves the potential expansion of the RFS into the main Santa Ana River channel to increase stormwater capture and reduce clogging of the receiving basins.

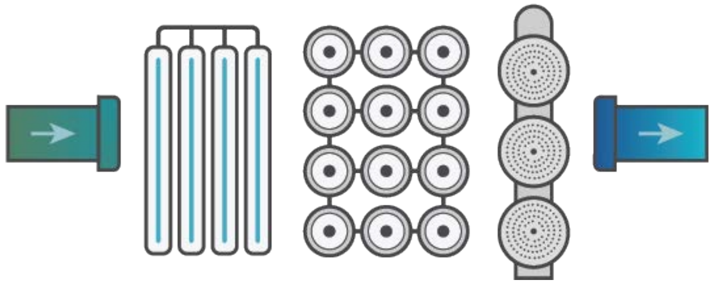
Detailed descriptions of each priority project are provided in Appendix A. Appendix B presents descriptions of supplemental projects.

Table 6: Priority Projects to Address Threats/Challenges to Santa Ana River

PROJECT	DESCRIPTION
WATER SUPPLY	
8. Increasing Stormwater Recharge	Adaptive strategies to increase stormwater capture and recharge.
8a. Incorporate FIRO into Prado Dam Water Control Manual	Formalize using forecast information in operating water conservation pool at Prado Dam.
8c. Local Stormwater Capture	Capture and recharge of local storm flows downstream of Prado Dam and Municipal stormwater for water supply projects that include direct and indirect diversions.
RECHARGE FACILITIES	
11. Desilting Santa Ana River Flows	Evaluate potential of removing suspended sediment from Santa Ana River water that is supplied to deep basins prone to clogging and thereby increase OCWD's recharge capacity, especially for stormwater.
13. Recharge in Lower Santiago Creek	Construct facilities to convey water to lower Santiago Creek downstream of Hart Park.

GROUNDWATER REPLENISHMENT SYSTEM

G | W | R | S
GROUNDWATER REPLENISHMENT SYSTEM



In 1963, a U.S. Supreme Court decision (Arizona v. California) limited the amount of Colorado River water that California was guaranteed and provided more water to Arizona. This decision signaled a need for California water agencies using water from the Colorado River to begin looking for alternative sources of water. OCWD began looking at wastewater as an alternative source of water, knowing it could take 20 to 30 years to perfect the process (OCWD, 2003). This gave rise to the construction of what became known as Water Factory 21 (WF21) in 1975. This groundbreaking water treatment plant was designed to purify wastewater to supply the new Talbert Gap Seawater Intrusion Barrier. WF21 was the first plant in the world to use reverse osmosis (RO) to purify wastewater to drinking water standards. In addition to treated wastewater, groundwater and imported water were used to supply the barrier. The barrier not only protects the basin from seawater intrusion but also replenishes the basin. Groundwater modeling estimates that 95 percent or more of the water injected into the barrier flows into the basin and becomes part of the groundwater supply.

The early 1990s were marked by drought, and groundwater levels in the basin were low. Concerned that the existing amount of water injected into the seawater barrier was inadequate, OCWD staff recommended doubling the injection volume to ensure that the barrier could still protect the basin. Plans to build a larger replacement for WF21 coincided with Orange County Sanitation District's (OC San) need to build a second ocean outfall to dispose of increased wastewater flows. Expanding OCWD's ability to treat and recharge more recycled would not only increase water supplies to the basin but would reduce the need for OC San to construct an expensive second ocean outfall.

By avoiding the need to build the outfall and investing in the reuse of its wastewater, OC San was willing to contribute half the construction cost of a new wastewater treatment plant and expand the seawater barrier. The two agencies decided that such a project could be developed and proposed an advanced treatment plant with an ultimate capacity of 130 million gallons per day (mgd) along with a 14-mile pipeline. This pipeline would convey treated water from Fountain Valley, where the treatment facility is located, to recharge basins in Anaheim. The project also included 15 new injection wells to expand the seawater barrier.

This collaboration resulted in the construction of the Groundwater Replenishment System (GWRS). The GWRS is the world's largest advanced water purification system for indirect potable reuse. It takes all the reclaimable treated wastewater that otherwise would be discharged to the Pacific Ocean and purifies it using a three-step advanced treatment process. Applying microfiltration (MF), reverse osmosis (RO), and ultraviolet light with hydrogen peroxide (UV), this innovative process produces high-quality water that exceeds all state and federal drinking water standards (Figure 23). After post-treatment stabilization, the purified water is recharged to the basin and later extracted by the Groundwater Producers for potable uses.

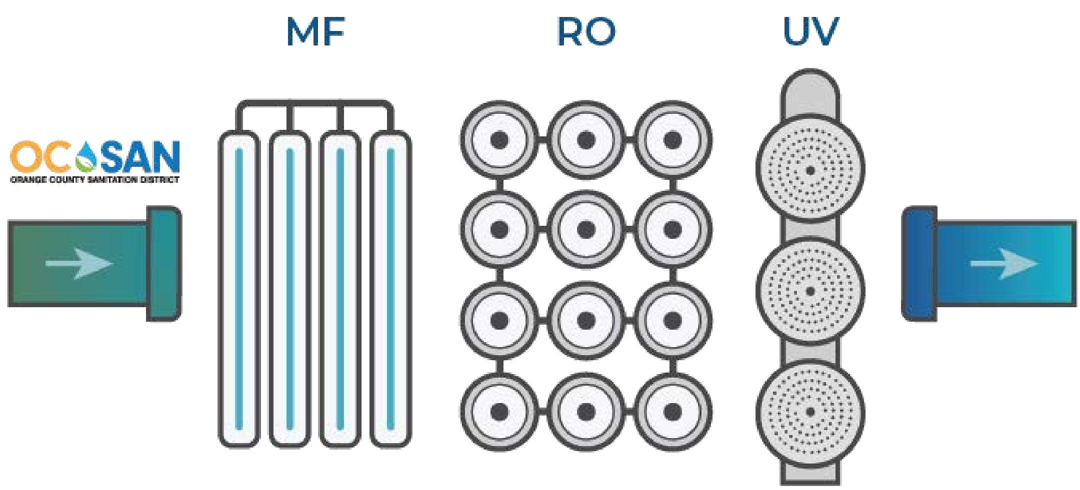


Figure 23: GWRS Treatment Process

The idea that it would take 20 to 30 years to perfect the process to treat wastewater to potable quality on a large scale, proved to be the case. WF21 went online in 1975 and its successor, GWRS, went online 33 years later in 2008. The GWRS now provides the basin with a high-quality source of drought-proof supply and greatly reduces reliance on imported supplies. In fact, imported water supplies now cost more than GWRS water, resulting in tremendous ongoing cost savings to the Groundwater Producers and their customers.

The GWRS was constructed in three phases:

Phase 1: 70 mgd treatment plant, injection wells, 14-mile pipeline to Anaheim spreading facilities. This phase went online in 2008.

Phase 2: Initial Expansion. This expanded the treatment capacity to 100 mgd and consumed all of the wastewater supplies of OC San's Plant 1 which is adjacent to OCWD in Fountain Valley. This phase went online in 2015.

Phase 3: Final Expansion. This expanded the treatment capacity to 130 mgd. The additional wastewater needed for the Final Expansion comes from OC San's Plant No. 2 located in Huntington Beach. This phase went online in 2023.

GWRS Source Water Supplies

For GWRS to produce 130 mgd of purified water, an average of 170 mgd of wastewater from OC San is required. Because the purification process, particularly reverse osmosis, removes salt and other contaminants, approximately 15 percent of the influent flow is returned to OC San as a brackish water called concentrate. This concentrate commingles with non-reclaimable treated secondary effluent from OC San's Plant 2 facility and then is further diluted via turbulent mixing at the outfall into the ocean.

Over the years, due to water conservation and more efficient use of water by residents of Orange County, the volume of wastewater received by OC San has declined as shown in Figure 24. Although the volume of OC San inflow is currently sufficient to supply GWRS, projects have been identified to augment OC San inflows should they decline in the future.

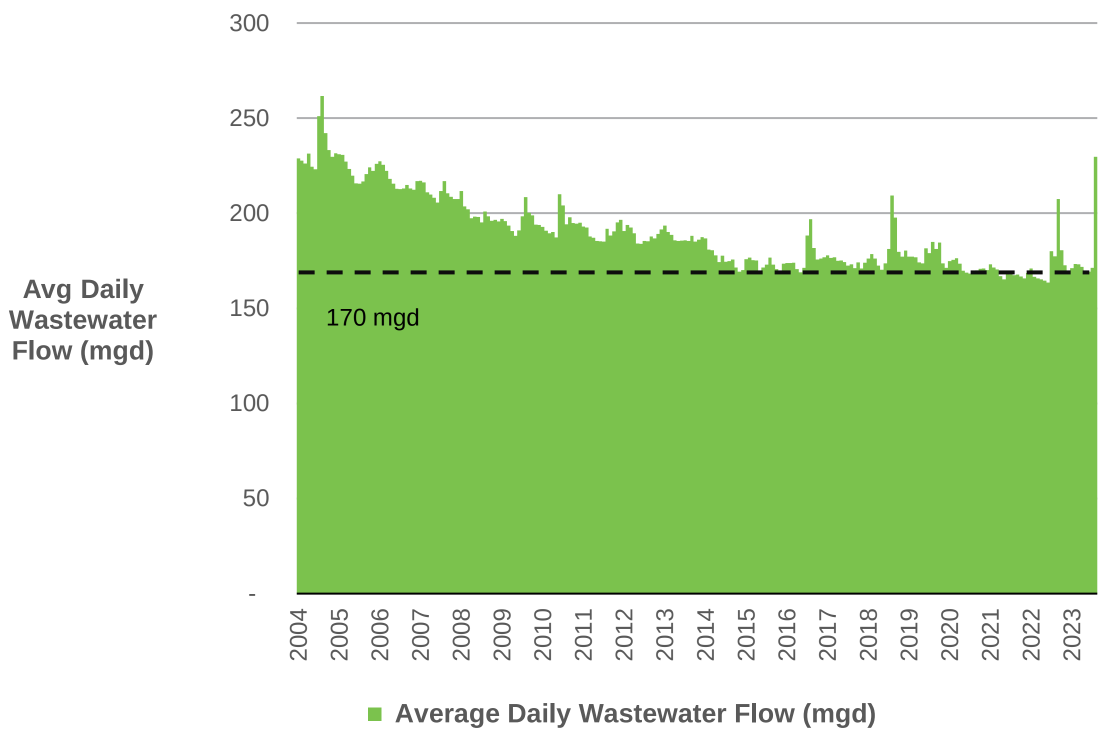


Figure 24: Average Daily Wastewater Inflow to OC San (Plants 1 and 2)

GWRS Facilities

Figure 25 shows the location of GWRS facilities including where GWRS water is recharged. GWRS supplies are recharged at three facilities:

- Talbert Gap Seawater Intrusion Barrier
- Mid-Basin Injection Wells
- Four Permitted Surface Water Recharge Basins

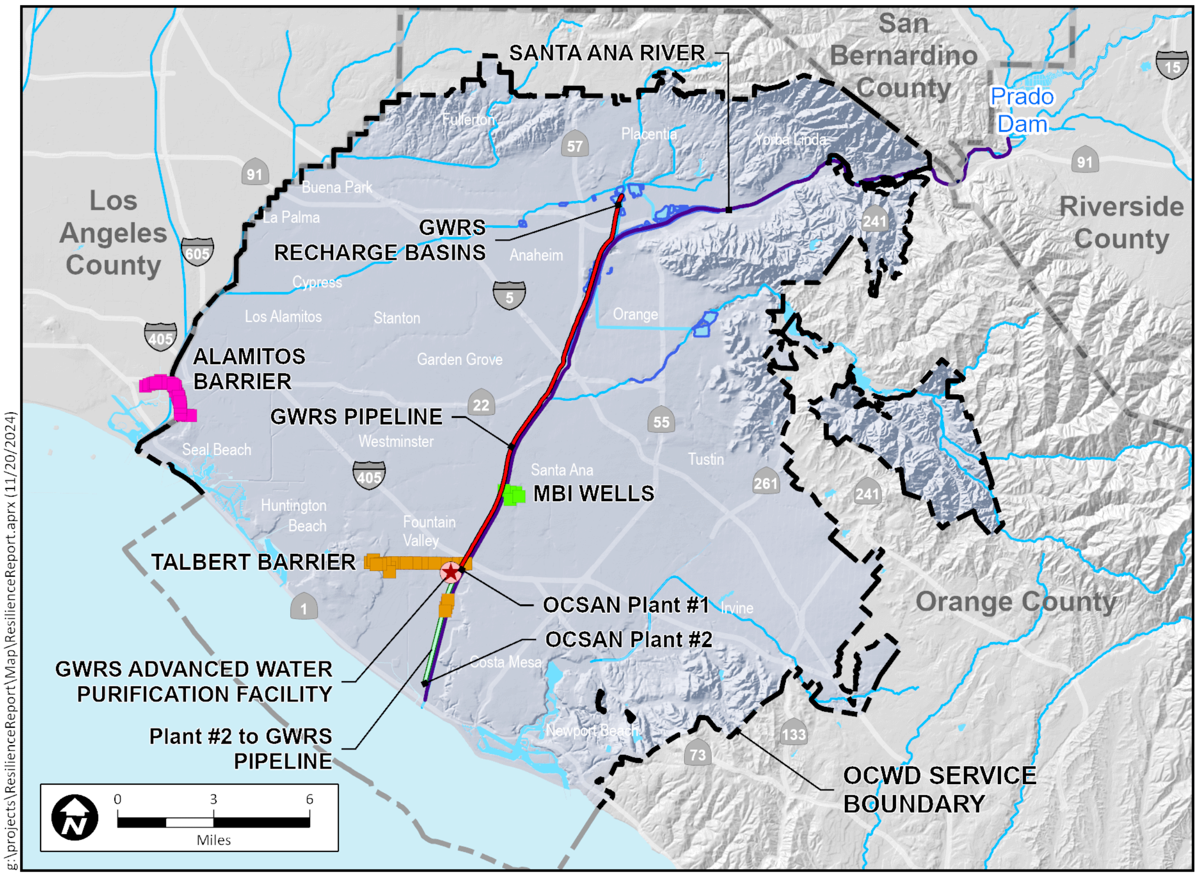


Figure 25: GWRS Facilities

The Talbert Gap Seawater Intrusion Barrier consists of a series of 36 injection well sites that are supplied with GWRS water. Barrier injection rates vary depending on the time of year with rates being highest in the summer months when pumping from nearby wells is heaviest and lowest in the winter when pumping is low. Injection rates typically range from 16 to 30 mgd.

Several miles up the Santa Ana River, in the City of Santa Ana, GWRS water is injected into five injection wells. These wells, called the Mid-Basin Injection (MBI) wells, are strategically located where groundwater levels tend to be low. Filling this area of low water levels reduces pumping costs, decreases the threat of seawater intrusion, and frees up capacity in the surface water recharge system for other sources of water, such as stormwater. The MBI wells recharge the Principal Aquifer at depths ranging from 530 to 1,190 feet below the ground surface. The combined injection rate for the MBI wells ranges from 6 to 8 mgd.

The bulk of GWRS water is recharged in four surface water recharge basins. These basins include Kraemer, Miller, Miraloma, and La Palma Basins. Kraemer and Miller Basins can recharge GWRS water as well as imported water and Santa Ana River water. Miraloma and La Palma Basins are OCWD's newest basins and are dedicated to the recharge of GWRS water. Dedicating these basins to pure GWRS water allows them to operate for long periods at high percolation rates without clogging. Figure 26 is a picture of La Palma Basin in operation. Note the clarity and color of GWRS water in the basin.

Figure 26: La Palma Recharge Basin With GWRS Water

Threats/Challenges and Priority Projects

Known challenges related to the GWRS include:

- Potential reduced wastewater supply
- Recharge capacity for GWRS supplies

Priority projects to address these challenges are listed in Table 7. More specifically, priority projects to address potential future declines in wastewater supplies to the GWRS are listed in Table 7 as **Project 6: GWRS Supply Augmentation**. Two of these projects (6a and 6b) are focused on increasing the volume of wastewater available to the GWRS. The third project (6c) looks at the potential of increasing GWRS output by producing more purified water and less concentrate for every unit of water treated (also called recovery efficiency).

An operational challenge to recharging the full amount of GWRS water is periodic gaps in recharge capacity. Because the capacity of the Talbert Gap Seawater Barrier and Mid-Basin Injection wells varies during the year, typically lower in the winter months and higher in the summer months, the flow of GWRS water to the surface water spreading basins also varies. This can create a conflict in wet years when there is an ample supply of stormwater to recharge. Because Kraemer and Miller Basins can also recharge Sana Ana River stormwater, there can be brief periods when the recharge basins are full, and the operators have to decide whether GWRS water or stormwater takes priority. Ideally, there would be sufficient capacity to always recharge GWRS supplies given that these supplies are available year-round.

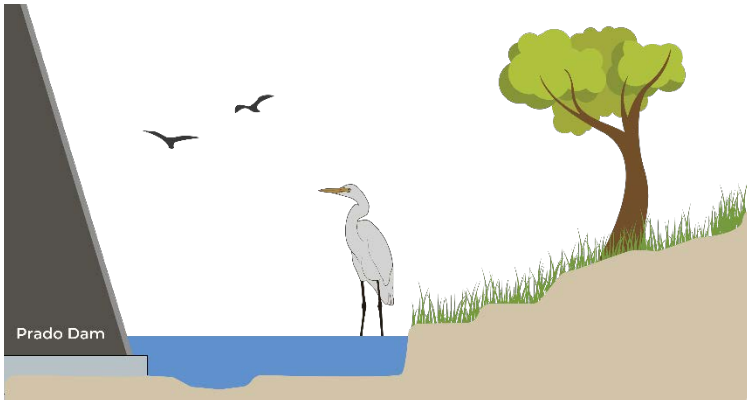
Priority projects to address potential gaps in GWRS water recharge capacity are listed in Table 7 as **Project 10: GWRS Recharge Optimization Study.** Since all of the projects listed achieve the same goal, they will be considered together with the most cost-effective project or projects considered for implementation.

Detailed descriptions of each priority project are provided in Appendix A. Appendix B presents descriptions of supplemental projects.

Table 7: Priority Projects to Address Challenges to GWRS

PROJECT	DESCRIPTION
WATER SUPPLY	
6. GWRS Supply Augmentation	Adaptive strategies to bolster GWRS supplies if needed.
6a. *Diversions from SARI to OC San Plant #1*	Diversion of sewage out of SARI line in Anaheim for new source of wastewater supply to GWRS
6b. *Urban Runoff Diversion to OC San*	Divert dry weather urban runoff to OC San to supply GWRS.
6c. *Demonstration Scale Test of Flow Reversal RO to Enhance GWRS Recovery via Retrofit of One RO Unit*	Increase GWRS output by reducing brine production.
RECHARGE FACILITIES	
10. GWRS Recharge Optimization Study	Study existing capacity to recharge GWRS water and suite of potential projects to increase recharge capabilities and operational flexibility.
10a *Injection Wells at ARTIC and Ball Road Basin*	Provide additional injection capacity for recharge of GWRS product water
10b *GWRS Burris Basin Turnout*	Turnout of GWRS water to Burris Basin.
10c *Recharge of GWRS Water Using Horizontal Collector Well*	Construct horizontal collector well to recharge GWRS water.
10d *Permitting Locations for Additional GWRS Recharge*	Regulatory permitting to place GWRS water in Carbon Creek Facilities, Anaheim Lake, SAR, 5 Coves to Burris & Santiago, Riverview & Fletcher.
10e *Supplying Sunset Gap with GWRS water*	Examine the feasibility of supplying the future Sunset Gap Seawater Barrier with GWRS water.
10f *Subsurface Recharge of GWRS water*	Examine the feasibility of constructing shallow subsurface systems to recharge GWRS water.
10g *Purchase Land for New GWRS Recharge Basins*	New basins to increase GWRS recharge capacity.

NATURAL RESOURCES



When Prado Dam was completed in 1941, it not only reduced flood risks downstream, it also expanded the existing riparian forest into the largest in coastal Southern California. This forest supports an abundance and diversity of wildlife including many federal and state listed endangered and sensitive species. A key species of concern for OCWD's stormwater capture program is the endangered least Bell's vireo, a small songbird that migrates to the area in the spring to nest.

For many years, two private water companies, Anaheim Union Water Company and Santa Ana Valley Irrigation Company, owned land behind Prado Dam for water conservation and farming. OCWD purchased this land in the late 1960s and now owns approximately 2,100 acres behind Prado Dam. This area includes 465 acres of treatment wetlands constructed by OCWD, which are comprised of 50 shallow interconnected ponds.

OCWD began actively managing habitat and natural resources in the Prado Basin in the 1980s, shortly after the District began working with the USACE to increase the storage of stormwater behind Prado Dam. The availability of water in the Prado Basin supports wetland habitat but inundation for long periods could negatively impact habitat value. In addition to providing a habitat for sensitive species, the wetlands are operated to improve the quality of Santa Ana River water that is eventually used to recharge the groundwater basin. Figure 27 shows the location of OCWD land behind Prado Dam, the constructed wetlands, and habitat that OCWD has created over the past forty years as mitigation for water conservation, treatment wetlands, and other projects.

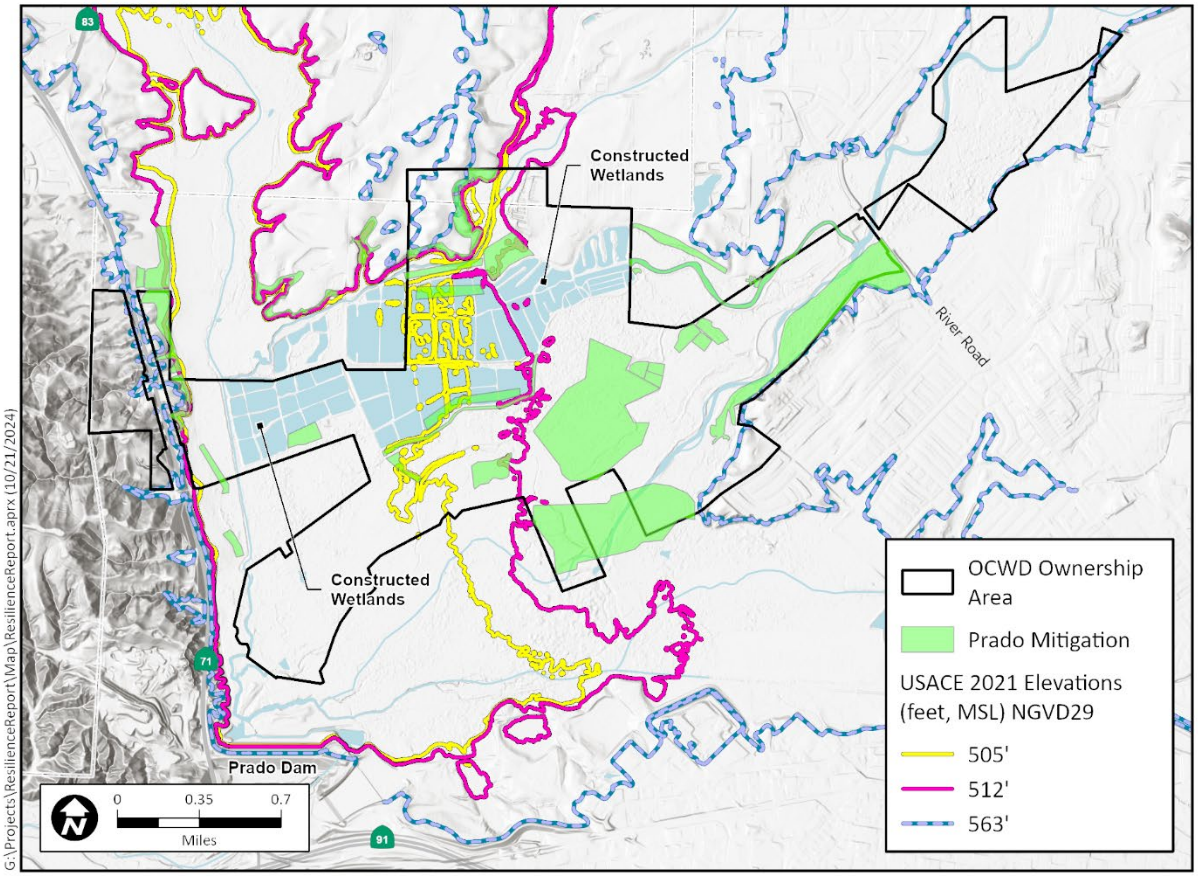


Figure 27: OCWD Resources Behind Prado Dam

Least Bell's Vireo

In 1986, there were only 19 least Bell's vireo territories in the Prado Basin and extirpation was imminent. Since then, OCWD has created more than 950 acres of habitat for the endangered least Bell's vireo and other species in the Prado Basin. Vireo populations have increased, with 714 observed territories in the Prado Basin in 2023. Figure 28 shows the distribution of vireo territories in 1986 and 2023.

Despite the tremendous recovery of the least Bell's vireo, there is concern that water conservation at higher levels could negatively impact the vireo habitat, particularly the mule fat plant (*Baccharis salicifolia*) that the vireo preferentially uses for nesting. Historically, the key metric used to assess potential impacts to habitat is the number of days of inundation caused by water conservation; however, scientific research is lacking on habitat response to various durations of inundation. In addition, there are many other co-morbidity factors affecting riparian vegetation and these are poorly understood.

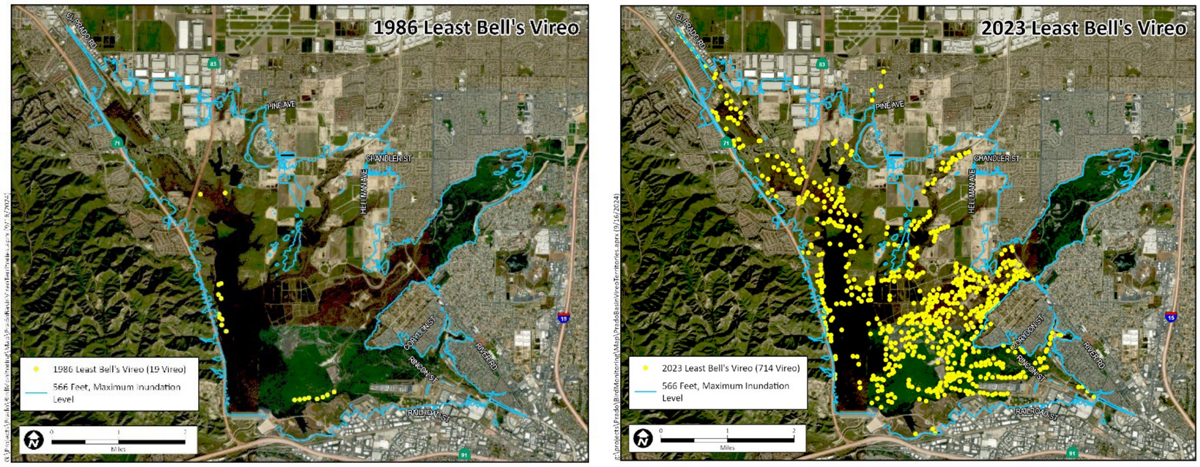


Figure 28: Least Bell's Vireo Territories, 1986 and 2023

To address this data gap, OCWD is taking a two-pronged approach: (1) Conducting experiments to measure the response of mule fat to various durations of inundation and (2) Looking at other factors that can affect habitat health, some of which are listed in Table 8. Recent advances in machine learning and increased computing power opens the door to examining the complex interrelationships between these factors to identify which ones are most impactful. The goal is to develop a model that can be used to better understand critical factors affecting habitat health and proactively manage habitat to ensure continued viability for least Bell's vireo and other sensitive species while also maximizing stormwater capture in the Prado Dam water conservation pool.

Table 8: Potential Habitat Stressors in Prado Basin

Potential Habitat Stressors
Santa Ana River base flow
Storm flow rate and flow path
Inundation depth and duration
Inundation time of year
Rainfall
Temperature
Wind
Groundwater levels
Surface and groundwater quality
Pests, Arundo, Fire

Sedimentation

The large riparian forest that has developed behind Prado Dam sits atop sediment that has accumulated behind the dam since it was constructed. Like other dams, Prado Dam is an effective trap for sediment, trapping more than 95 percent of all sediment behind the dam (Warrick and Rubin, 2007). As a result, sediment accumulation behind Prado Dam is continually reducing the storage of the water conservation pool. From the time the dam was constructed in 1941 to 2021, a total of 53,000 acre-feet of sediment has accumulated behind the dam. This is enough sediment to fill over 60 Empire State Buildings.

The rate of sedimentation in the lower elevations where water is temporarily held, based on the change from 1969 to 2015, is estimated to be approximately 480 acre-feet per year, or enough sediment to fill an Empire State Building every 2 years. The volume of the potential future water conservation pool at elevation 512 ft is approximately 35,000 acre-feet. With sedimentation, it is estimated that in 50 years, more than half of the water conservation storage below elevation 512 ft will be filled in as shown in Figure 29.

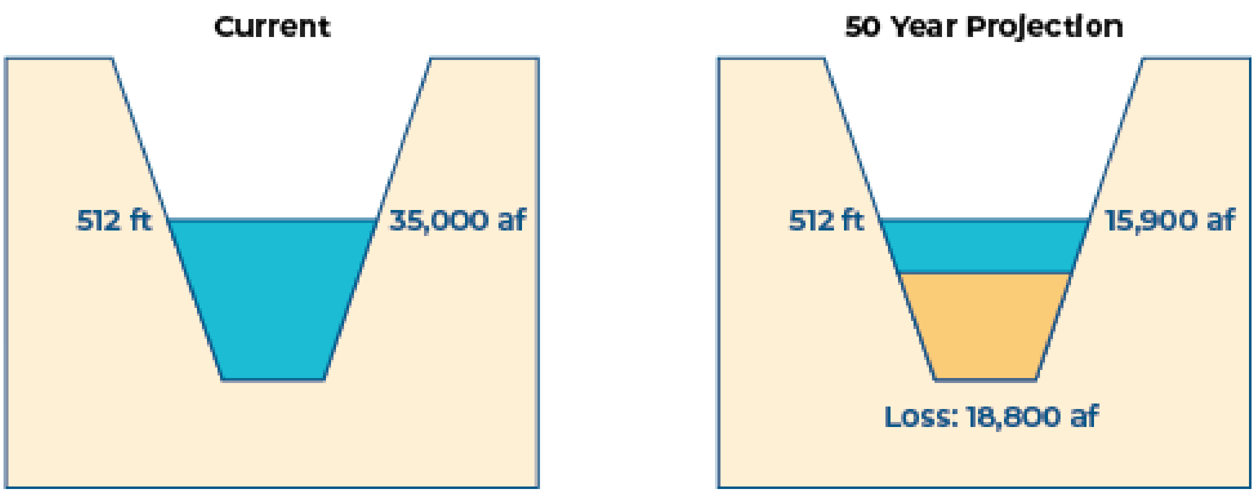


Figure 29: Projected Loss of Water Conservation Pool Storage over 50 years

The District removed approximately 80,000 cubic yards (or 50 acre-feet) of sediment as part of the Prado Basin Sediment Management Demonstration Project in 2020. This project showed that traditional suction dredging is not feasible in Prado Basin due to the amount of buried vegetation and trash encountered. However, excavation with heavy equipment is a technically and environmentally feasible alternative. One of the key barriers to removing sediment is the cost of transporting the sediment and the intermittent demand for construction or other uses. Nevertheless, removing sediment is important to reduce the impact of storage losses in the water conservation pool. The sediment is also a resource to the region, especially to stakeholders such as the coastal communities that are dealing with threats to near-shore infrastructure and the loss of beach sand.

Threats/Challenges and Priority Projects

Known threats and challenges related to natural resources include:

- Effect of increased water conservation on habitat health
- Reduced capacity of water conservation pool due to sedimentation

Priority projects to address these threats and challenges are listed in Table 9. More specifically, a priority project to identify the potential impacts of increased water conservation on habitat health is listed in Table 9 as **Project 8b: Prado Dam Habitat Assessment Tool Development.** The Prado Dam Habitat Assessment tool involves the development of a multi-parameter digital twin environmental model to identify the specific effects of water conservation on least Bell's vireo habitat and carrying capacity in Prado Basin. In parallel, OCWD will be conducting rigorous field inspections along pre-agreed transects to document habitat changes over time. These field inspections will be used to validate the model output.

A priority project to address sedimentation behind Prado Dam is listed in Table 9 as **Project 9: Prado Basin Sediment Management Regional Strategic Plan.** The goal of developing this strategic plan is to connect the stakeholders in the region that need sediment, such as beach cities, construction firms, transportation agencies, etc. with those agencies, such as OCWD, that have surplus supplies of sediment. This strategic plan will also assist OCWD in complying with regulatory obligations to remove sediment that is estimated to be caused by water conservation at Prado Dam.

Detailed descriptions of each priority project are provided in Appendix A. Appendix B presents descriptions of supplemental projects.

Table 9: Priority Projects to Address Threats/Challenges to Natural Resources

PROJECT	DESCRIPTION
WATER SUPPLY	
8. Increasing Stormwater Capture	Adaptive strategies to increase stormwater capture and recharge.
8b. *Prado Dam Habitat Assessment Tool Development*	Develop tools to assess impact of increasing stormwater capture at Prado Dam on habitat health.
9. Prado Basin Sediment Management Regional Strategic Plan	Develop a regional, watershed-wide approach that involves multiple stakeholders, including Orange County Public Works, beach cities and others that would benefit from increased sediment for beach replenishment, protecting coastal resources, and other needs.

OTHER RESILIENCE PLAN PROJECTS

Although most of the priority projects identified apply to the four key asset categories just described: Groundwater Basin, Santa Ana River, GWRS, and Natural Resources, there will occasionally be those that don't fit within these asset categories. In this Resilience Plan, the regulatory requirement to meet future electrical vehicle mandates fits the "Other" category.

A priority project to address State air emission regulations issued by the California Air Resources Board (CARB) is listed in Table 10 as **Project 16: Zero-Emissions Vehicle Charging Infrastructure.** CARB regulations require the District's medium and heavy-duty on-road vehicles to transition from internal combustion engines to zero-emission vehicles. Commercially available zero-emission vehicles include battery-operated (electric), plug-in electric hybrids, and hydrogen power sources. The most commercially available source is electric. The transition to electric vehicles will require the construction of infrastructure to charge the vehicles.

Detailed descriptions of each priority project are provided in Appendix A. Appendix B presents descriptions of supplemental projects.

Table 10: Other Resilience Plan Priority Projects

PROJECT	DESCRIPTION
OPERATIONAL IMPROVEMENTS	
16. Zero-Emissions Vehicle Charging Infrastructure	Construct infrastructure at OCWD field operations in Anaheim and Prado to supply zero emissions vehicles that will need to be purchased in the near future.

PROJECTED SUPPLIES AND DEMANDS

"Resilience is the ability to anticipate, recover, and adapt from disruptions and challenges to ensure sustainable, abundant, and reliable high quality water supplies."

To ensure sustainable, abundant, and reliable high-quality water supplies, it's essential to have accurate information on water supplies and demands, as well as how these may evolve in the future. In this section, the projected water supplies and demands in the OCWD service area are presented.

Water Supplies

OCWD has a diverse water supply portfolio. The largest and most reliable source of water is from the GWRS. A smaller, but consistent source of recharge is the Alamitos Gap Seawater Barrier. Other sources can change over time due to various factors and include:

- Santa Ana River base flow
- Storm flow (Santa Ana River and Santiago Creek)
- Incidental recharge
- Imported water

The estimated future contribution of these sources to the groundwater basin is described in Table 11.

Projected future Santa Ana River base flows and storm flows are based on the Upper Santa Ana River Habitat Conservation Plan (SARHCP). The SARHCP is a collaborative conservation plan designed to enable water resource agencies to continue to provide a secure source of water for the residents and to conserve and maintain natural river habitat (ICF, 2020). The SARHCP includes, but is not limited to, planned stormwater diversion and capture projects and wastewater recycling projects. To account for impacts resulting from these potential projects, an integrated surface water-groundwater model was developed for the upstream area of Prado Dam. The model, called the Integrated Upper Santa Ana River Model (ISARM) was developed by Geoscience Support Services Inc. and uses historical rainfall from 1966-1990 and planned projects in the SARHCP that would reduce the amount of Santa Ana River flows reaching Prado Dam due to stormwater diversion and water recycling projects (Geoscience, 2020).

As part of the development of the SARHCP, two ISARM bookend scenarios were run, including "No Projects" and "All Projects" scenarios.

Table 11: Description of Projected Recharge Water Supplies

Supply Sources			Projected Future Supply
Santa Ana River	Base Flow	Assumes planned projects in upper watershed are constructed that will reduce wastewater discharges to the Santa Ana River.	68,000 to 50,000 acre-feet per year
	Storm Flow	Assumes Water Conservation Pool increases to 508 ft in 2025 and then to 512 ft in 2030.	72,300 to 57,400 acre-feet per year
Santiago Creek	Storm Flow	Highly dependent on local rainfall in Santa Ana Mountains.	2,000 afy based on net capture from FY02-03 to FY23-24
Incidental Recharge	Precipitation and subsurface inflow	15-year average	40,000 acre-feet per year
Recycled Water	GWRS	Delivered to Talbert Barrier, MBI wells and surface recharge basins.	134,000 acre-feet per year
	Water Replenishment District of Southern CA	Alamitos Barrier	3,000 acre-feet per year
Imported Water	Untreated	Delivered to recharge basins.	Purchased as needed.
	Treated	Alamitos Barrier	1,000 acre-feet per year

The No Projects scenario represents current conditions while the All Projects scenario assumes all planned projects are ultimately constructed. It is unlikely that the All Projects condition will occur within the next 25 years given that some of the projects identified may not be cost effective. Nevertheless, it is conservative to plan for low Santa Ana River flows by 2050.

Figure 30 shows the estimated average annual inflow to Prado Dam for the No Projects and All Projects scenarios. This figure shows SARHCP projects have the potential by 2050 to reduce storm flows arriving at Prado Dam by 28,000 acre-feet per year and reduce base flow by 18,000 acre-feet per year.

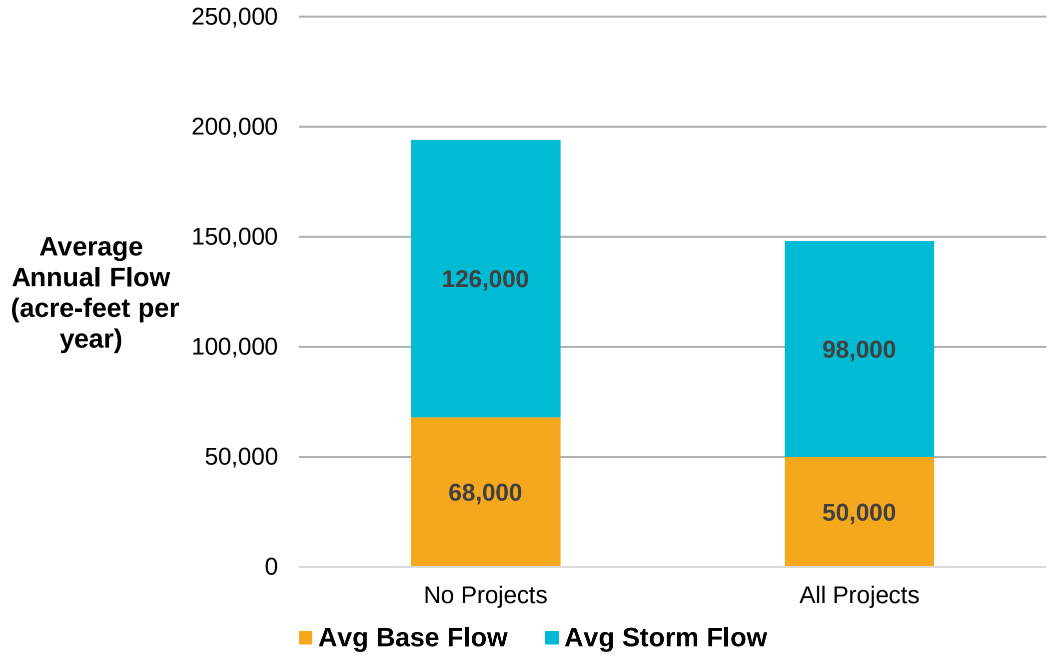


Figure 30: Average Annual Santa Ana River Inflow to Prado Dam for No Projects and All Projects Scenarios

OCWD is able to capture and recharge essentially all base flows that arrive at Prado Dam, but storm flow capture is more challenging given the episodic nature of these flows. OCWD, in collaboration with the USACE, is currently able to temporarily impound stormwater up to elevation 505 ft (20,000 acre-feet) behind Prado Dam. However, the dam's primary purpose is flood risk management, and during high storm flow periods Prado Dam's discharge rates can exceed OCWD's diversion capacity, and those flows are lost to the Pacific Ocean.

Work is underway to increase the water conservation pool from the current elevation of 505 ft to elevation 508 ft (26,500 acre-feet) for a five-year period to test Forecast Informed Reservoir Operations (FIRO). The goal is to ultimately increase the water conservation pool to elevation 512 ft (35,000 acre-feet) by 2030.

To evaluate projected stormwater capture given future SARHCP projects, increases in the water conservation pool elevation to 508 ft and then to 512 ft, and sedimentation, the ISARM output for the No Projects and All Projects scenarios was processed with OCWD's Recharge Facilities Model (RFM). Future conditions assume that continued sedimentation of the Prado Basin will reduce the storage available at elevation 512 ft from 35,000 to 23,000 acre-feet over the next 25 years. Although on an annual basis, the reduction of storage due to sedimentation is small, over time, if left unaddressed the cumulative loss of storage space grows in significance as the storage space declines.

OCWD's RFM, developed with CH2M Hill (now Jacobs), can replicate the operations Prado Dam and OCWD's surface water recharge system. The model contains information on all the recharge facilities, their recharge rates, storage capacities, rates of flow to and out of the facilities, cleaning schedules, and most importantly, the rate of percolation decline of each facility due to clogging. The ability of the model to simulate the percolation decay of each facility is the key to the success of the model. Once constructed, the model was able to successfully replicate historical operations over six years spanning June 2002 to June 2008 (OCWD, 2009). The model has been in use since 2009 and continues to be upgraded.

The estimated amount of stormwater captured and recharged with the water conservation pool at 508 ft and then increasing to 512 ft in 2030 is shown in Figure 31. What is noticeable is that stormwater recharge declines over time due to planned stormwater capture projects upstream of Prado Dam. Also shown is the impact of sediment accumulation, which is projected to decrease stormwater recharge up to 2,400 acre-feet per year by 2050.

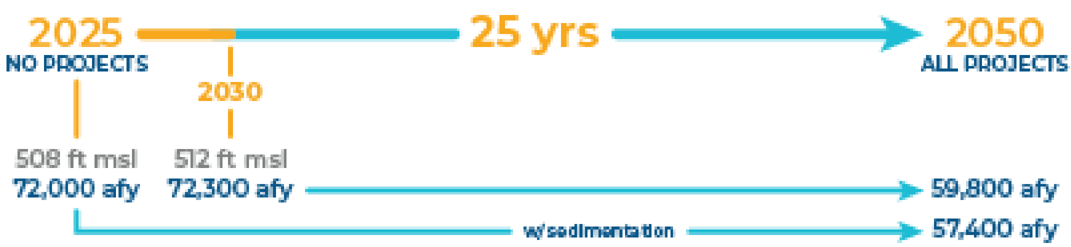


Figure 31: Estimated Recharged Stormwater Over the Next 25 Years

Incidental recharge, also called unmeasured recharge, typically rises and falls with hydrologic conditions with wet years providing more recharge and dry years less. Based on available estimates from 1987 to 2024, the long-term incidental recharge has averaged 53,000 acre-feet per year; however, for more recent years from 2010 to 2024, estimated incidental recharge has averaged 40,000 acre-feet per year. It is unclear what is causing this decline. Factors affecting this could include reduced outdoor irrigation, increased hardening of the land surface with development, changes in precipitation patterns, increasing temperatures, and more accurate estimates of incidental recharge. More research is needed to better understand what is affecting incidental recharge in the basin. The total projected sources of groundwater supply to the basin are shown in Figure 32 and summarized in Table 12. Note that the years shown are meant to represent the average conditions over five-year periods.

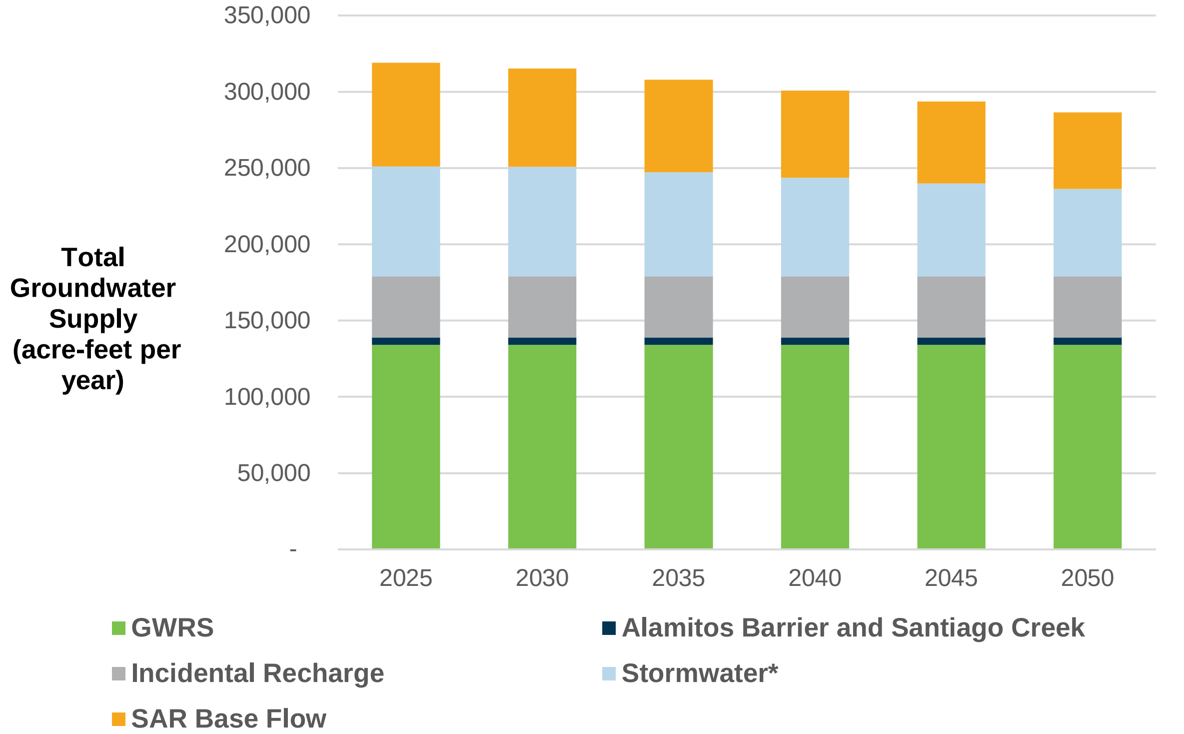


Figure 32: Projected Groundwater Supplies, 2025-2050

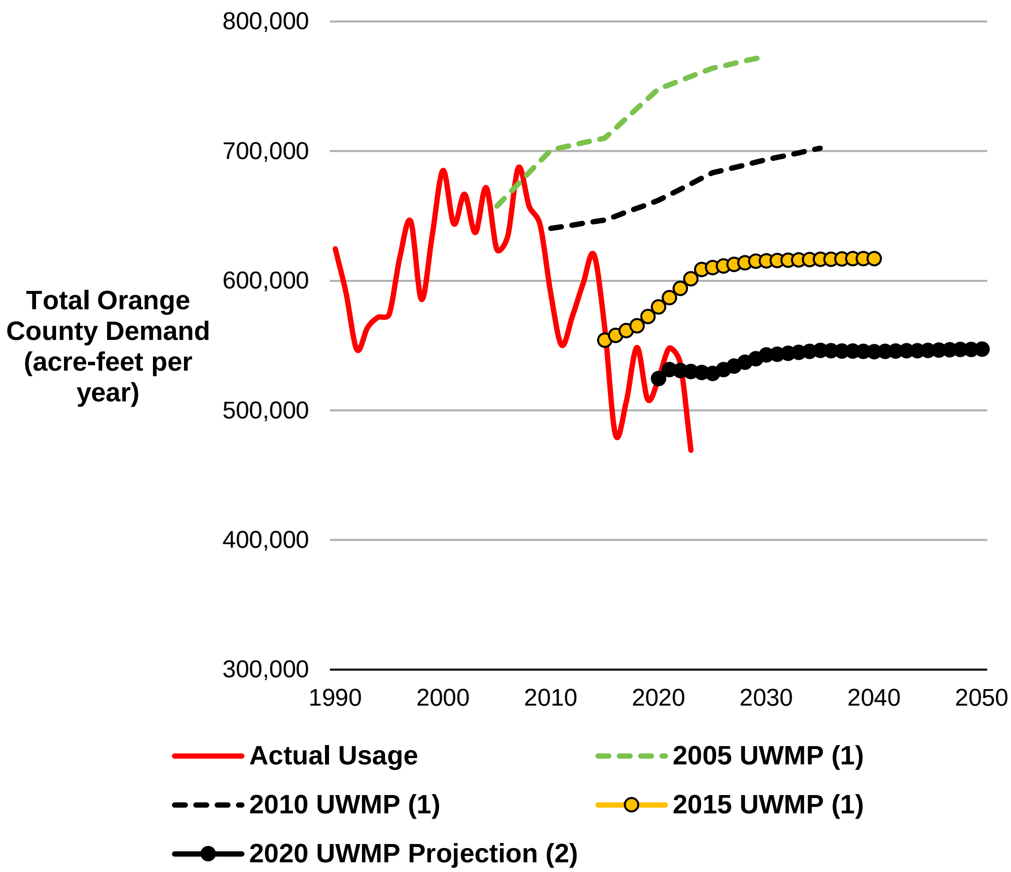
Table 12: Projected Groundwater Supplies (Acre-Feet per Year)

Year*	SAR Base Flow	Stormwater w. Sedimentation	Incidental	GWRS	Alamitos Barrier and Santiago Creek**	Total
2025	68,000	72,000	40,000	134,000	5,000	319,000
2030	64,400	71,800	40,000	134,000	5,000	315,200
2035	60,800	68,200	40,000	134,000	5,000	308,000
2040	57,200	66,000	40,000	134,000	5,000	300,800
2045	53,600	62,900	40,000	134,000	5,000	293,600
2050	50,000	57,400	40,000	134,000	5,000	286,400

*Represent average conditions over a 5-year period.
**Alamitos Barrier contributes 3,000 afy and Santiago Creek contributes 2,000 afy.

Water Demands

OCWD partners with the Municipal Water District of Orange County (MWDOC) to develop water demand projections for a 25-year planning horizon, aligning with the forecast period required in Urban Water Management Plans (UWMP) that water retailers must submit to the State every five years. Numerous factors can influence future water demands, including population growth, economic conditions, water use efficiency programs, and hydrologic conditions. Annual variations in hydrologic conditions alone can cause fluctuations ranging from 5 to 10 percent. Consequently, estimating future demands is challenging and involves some uncertainty. This is illustrated by how prior demand projections have diverged from actual usage. Figure 33 shows how actual demands in all of Orange County compare to projections made in 2005, 2010, 2015, and 2020.



(1) Using Agency Data
(2) Mid Scenario – assumes 0.5% annual growth in commercial/institutional/industrial (CII) use.

Figure 33: Historical Water Demand Projections vs Actual Water Usage for Orange County

The most recent demand projection to 2050 was developed for the 2020 UWMP (CDM Smith, 2021). Projected demands within OCWD's boundaries mirror Orange County's demands and are estimated to be relatively flat as shown in Figure 34. The potential increased demands from the Regional Housing Needs Assessment (RHNA) mandates are not a factor in the 2020 UWMP projections as only one Groundwater Producer provided this information. Table 13 presents projected water demands within the OCWD service area in 5-year increments starting in 2025. Future water demands are expected to increase by approximately 19,000 acre-feet by 2050. This corresponds to an approximately 4 percent increase over 25 years or slightly less than a 0.18 percent annual increase. Note that recent water demands are lower than future projected demands largely due to wetter than average hydrologic conditions.

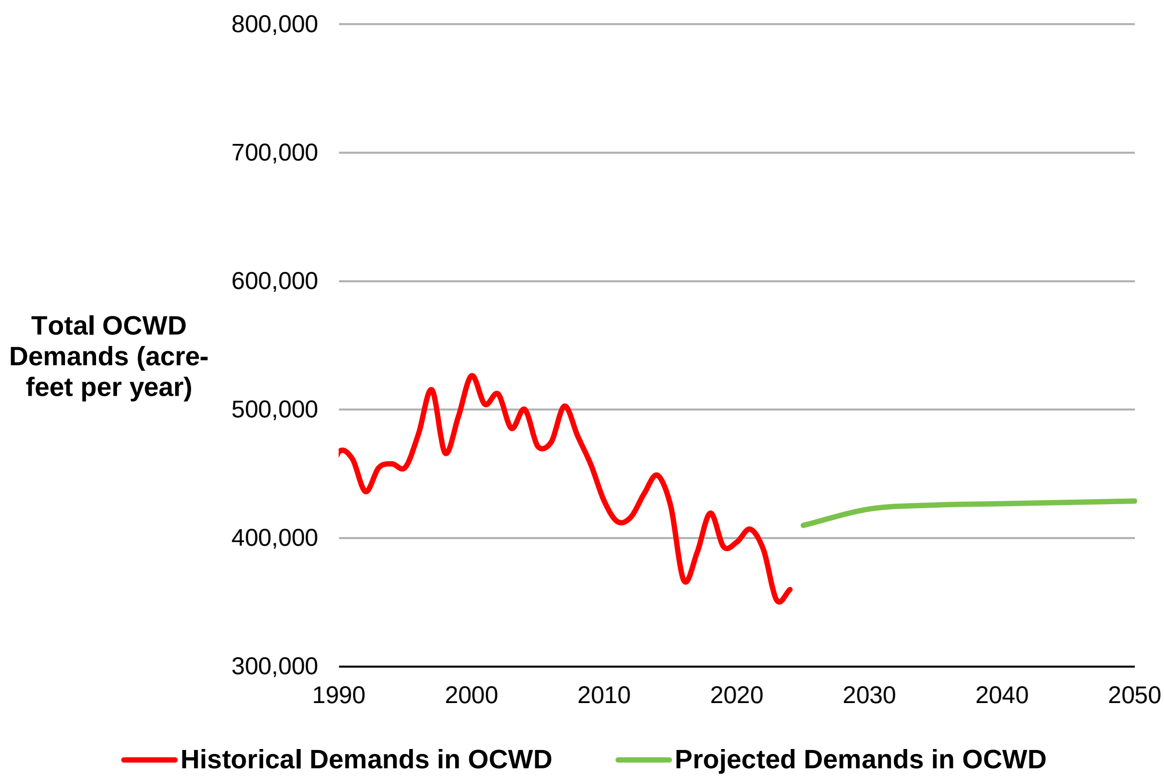


Figure 34: Historical Demands and Projected Water Demands within OCWD

Table 13: Projected Water Demands within OCWD Boundaries (Acre-Feet per Year)

Year*	Groundwater Producer Potable Demand **	Small System Groundwater Production***	Recycled Water*	Total OCWD Demand
2025	376,500	5,700	24,000	406,200
2030	388,000	5,800	25,000	418,800
2035	391,000	5,900	25,000	421,900
2040	392,000	5,900	25,000	422,900
2045	393,000	5,900	25,000	423,900
2050	394,000	5,900	25,000	424,900

*Represent average conditions over a 5-year period.
**Agency estimates in 2020 UWMP (CDM Smith, 2021)
***Estimated based on 1.5% of Groundwater Producer potable demand.

Although not included in the current projections, long-term changes in weather patterns are estimated to increase average water demands in the range of 2 to 6 percent (CDM Smith, 2021).

MWDOC is starting work to update the demand projections for the upcoming 2025 UWMP cycle. Some important factors that may affect future demands include regulatory efforts such as the Conservation as a California Way of Life regulation (SB

606 & AB 1668) to establish water use objectives for all urban water suppliers. This includes a gallons per day per person (GPCD) standard for indoor residential water use (codified by Senate Bill 1157) and outdoor landscape standards for residential and commercial landscapes. The indoor standard would decline to 42 GPCD starting in 2030 and the outdoor standards would decline to 0.55 and 0.45 (ET Adjustment Factors) for residential and commercial landscapes respectively beginning in 2040. The establishment of Water Use Objectives by the state will put significant pressure on retail water providers to reduce water demands. Additionally, new water-efficient appliances and technology continue to be developed and adopted which will assist in reducing indoor water use, further decreasing water demands. Finally, there is the potential that RHNA mandates could increase demands in the future.

OCWD staff will review the results of MWDOC's 2025 demand projections and revise the Resilience Plan if the new projections are significantly different from the 2020 projections.

Projected Groundwater Basin Pumping

Based on the projected modest increase in future water demands, OCWD anticipates being able to support a BPP of 85 percent. OCWD is aiming to further increase the BPP, but a BPP of 85 percent was chosen for this planning effort partially because a BPP higher than 85 percent would be difficult for some Groundwater Producers to achieve. However, there are efforts underway to support the Groundwater Producers in increasing their groundwater production capacity.

As seen in Figure 35, over the 25-year planning period OCWD will need to purchase increasing amounts of imported water to offset increases in water demands and the reductions in Santa Ana River base flow and storm flows, and continued loss of storage due to sedimentation in Prado Basin. Based on average hydrology, imported water purchases for groundwater replenishment will need to ramp up to approximately 63,500 acre-feet per year over the next 25 years. In the near term, however, with reduced groundwater pumping from wells affected by PFAS and relatively full basin conditions, it is not expected that imported water will need to be purchased for recharge for several years.

Maintaining a high BPP provides tremendous cost savings to the Groundwater Producers in that it reduces the need to purchase treated imported water, which costs approximately two times more than groundwater. The cost of groundwater is the combination of the Replenishment Assessment (RA) charged by OCWD and Groundwater Producer pumping costs. Key assumptions regarding future groundwater costs include:

- The RA is projected to increase an average of 6 percent annually

- Pumping costs include estimated additional PFAS costs that will be incurred by the Groundwater Producers in the future

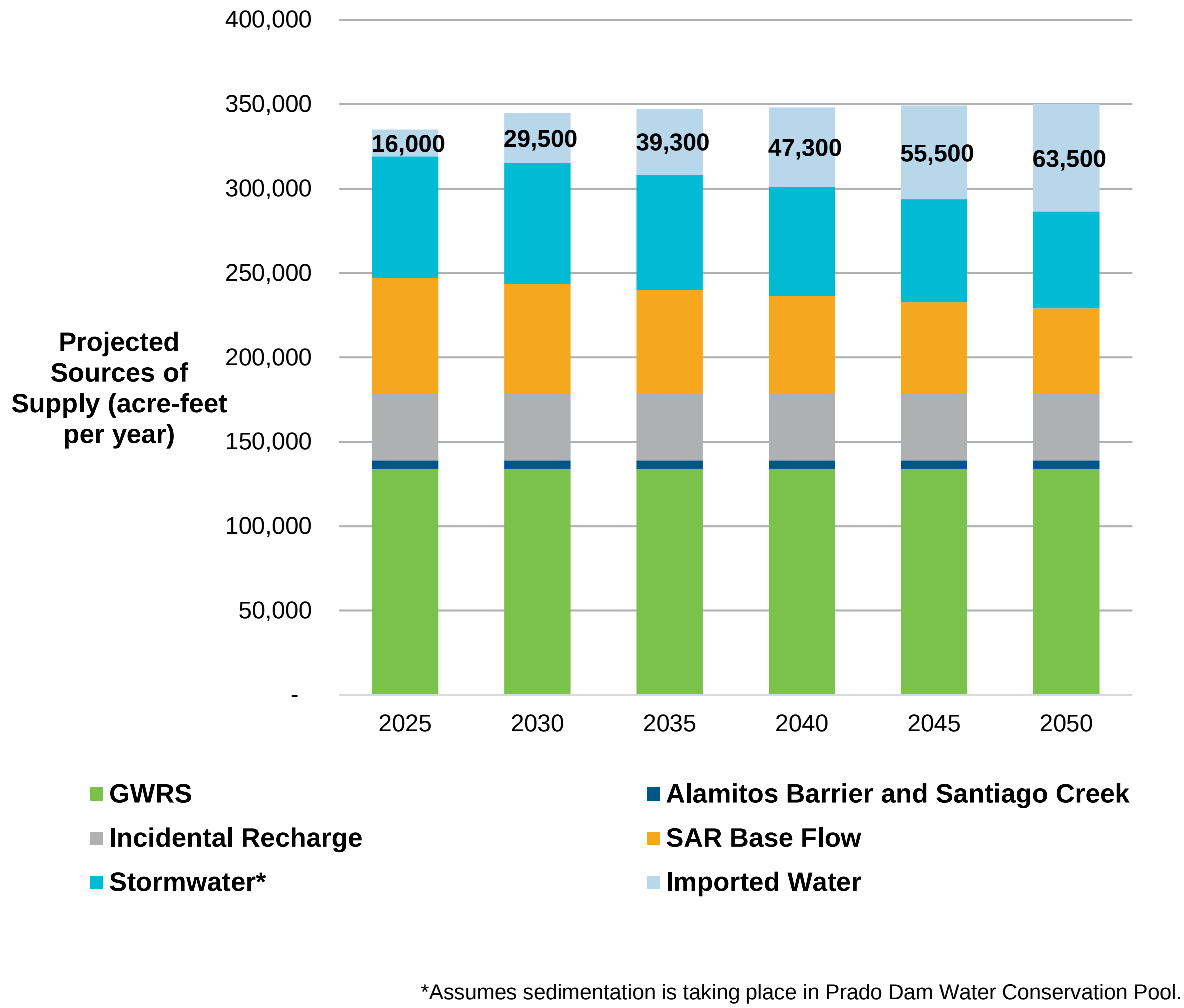


Figure 35: Projected Groundwater Water Supplies and Amount of Imported Water for Groundwater Replenishment Needed to Sustain 85% BPP

Imported water costs are projected to increase from 3 to 11 percent annually based on data from the Metropolitan Water District of Southern California. On average, the cost of groundwater including pumping is 45 percent less than imported water. This difference represents the savings provided by sustainable groundwater pumping from the basin, which has grown over time due to the wide array of projects implemented by OCWD. Figure 36 shows how the cost of groundwater compares to imported water over the next 10 years.

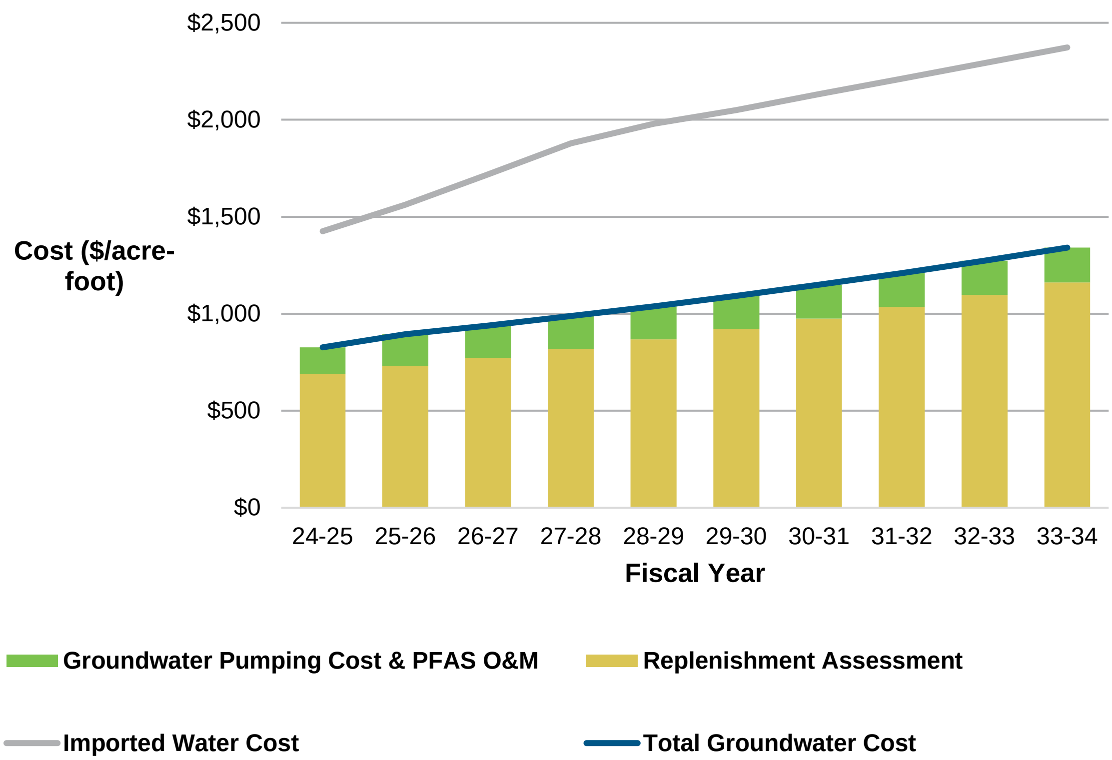


Figure 36: Projected Costs of Groundwater, Pumping and Treated Imported Water

Maintaining this cost differential is important as it shows the value of OCWD management of groundwater resources. Many projects presented in this Resilience Plan are designed to sustain and potentially increase groundwater pumping from the basin. A key metric in decision-making regarding projects that provide increased supply is how the cost of projected project yields compares to the cost of imported water.

"A key metric in decision making is how the cost of water from a project compares to the cost of imported water."

Due to a long history of investments in the groundwater basin, OCWD has developed a reliable, resilient supply of groundwater. This Resilience Plan outlines multiple projects and adaptive strategies to continue supporting sustainable groundwater pumping from the basin, including an 85 percent BPP or higher and meeting the District's mission of providing a reliable, high-quality water supply in a cost-effective and environmentally responsible manner. This Resilience Plan is a living document that will be responsive to new challenges and threats. As such, project priorities can shift, and new projects added as needed. Any significant changes will be communicated to the OCWD Board and Groundwater Producers, and the plan itself will be updated every five years.

REFERENCES

California Department of Water Resources, 1967. Progress Report on the Ground Water Geology of the Coastal Plain of Orange County.

CDM Smith, 2021. Orange County Water Demand Forecast for MWDOC and OCWD - Memorandum, March 2021.

Dettinger, M.D, F.M. Ralph, T. Das, PJ. Neiman, and D.R. Cayan, 2011. Atmospheric Rivers, Floods and the Water Resources of California. Water 2011, 3, pp. 445-478. https://doi.org/10.3390/w3020445.

Geoscience, 2020. Upper Santa Ana River Integrated Model – Summary Report. Prepared for San Bernardino Valley Municipal Water District by Geoscience Support Services, Inc, dated September 2020.

Herndon, Roy L., and Bonsangue, John, 2006. Hydrogeology of the Orange County Groundwater Basin – An Updated Overview, Published in Geology of the Orange County Region, Southern California, Annual Field Trip Guide No. 33, pp. 157-179, South Coast Geological Society, Inc.

ICF, 2021. Upper Santa Ana River Habitat Conservation Plan. Public Review Draft. May 2021. Prepared for San Bernardino Valley Municipal Water District. Document is available at USAR CAMMP (uppersarhcp.com).

Poland, J. F. et al., 1956. Ground Water Geology of the Coastal Zone Long Beach-Santa Ana Area, California, USGS Water Supply Paper 1109.

OCWD, 2003. A History of Orange County Water District.

OCWD, 2009. Technical Memorandum, Orange County Water District Recharge Facilities Model – Development and Calibration of the Orange County Water District Recharge Facilities Model. Prepared for OCWD by CH2M HILL, October 2009.

OCWD, 2013. Board of Directors Resolution No. 13-1-6, Stating the District's Goal to Develop the Necessary Supplies and Facilities to Achieve and Maintain a 75% Basin Production Percentage.

Ralph, F. M., Hutchinson, A., Anderson, M., Fairbank, T., Forbis, J., Haynes, A., Sweeten, J., Talbot, C., Tyler, J., White, R., 2023. Prado Dam Forecast Informed Reservoir Operations Final Viability Assessment. UC San Diego. Retrieved from https://escholarship.org/uc/item/8rx4n0vp

Swain, D.L., Langenbrunner, B., Neelin, J.D., and A. Hall, 2018. Increasing precipitation volatility in twenty-first-century California. Nature Clim Change 8, 427–433. https://doi.org/10.1038/s41558-018-0140-y

Warrick, J. A., and D. M. Rubin, 2007. Suspended-sediment rating curve response to urbanization and wildfire, Santa Ana River, California, J. Geophys. Res., 112, F02018, doi:10.1029/2006JF000662.

APPENDIX A

PRIORITY PROJECT DESCRIPTIONS

Sections

Tables

Figures

INTRODUCTION

OCWD staff have prepared descriptions for each priority project. Table 1 lists the 16 priority projects. For ease of reference, the projects/concepts have been categorized as follows:

- Basin Management
- Water Supply
- Recharge Facilities
- Operational Improvements

Location maps are also provided showing, for each category, where the projects are located.

For each project, the following information is presented:

- Project description
- Pros/Cons
- Estimated costs and benefits
- Project status

Table 1: Priority Project List

PROJECT	DESCRIPTION
BASIN MANAGEMENT	
1. PFAS Treatment Project	Construct treatment systems on production wells affected by PFAS.
2. Sunset Gap Barrier Project	Construct seawater barrier for Sunset Gap
3. Groundwater Basin Operating Range Expansion Study	Study potential of expanding the operating range of the groundwater basin.
4. South Basin Groundwater Protection Project	Pursue remedial investigation and other appropriate actions to contain and remediate contaminated groundwater in the South Basin area
5. Talbert Barrier Injection Well Replacement and Optimization	Replace selected aging Talbert Barrier injection wells and locate replacement wells in more optimal locations.
WATER SUPPLY	
6. GWRS Supply Augmentation	Examine opportunities to bolster GWRS supplies, including diverting urban runoff to OC San.
7. Brackish Water Desalination	Participate with Mesa Water, Huntington Beach and Newport Beach in Local Groundwater Supply Improvement Project to examine using purified brackish groundwater for additional water supplies.
8. Increasing Stormwater Capture	Increase stormwater capture using Forecast Informed Reservoir Operations (FIRO) at Prado Dam. Municipal stormwater for water supply projects that include direct and indirect diversions.
9. Prado Basin Sediment Management Regional Strategic Plan	Develop a regional, watershed-wide approach that involves multiple stakeholders, including Orange County Public Works, beach cities and others that would benefit from increased sediment for beach replenishment, protecting coastal resources, and other needs.
RECHARGE FACILITIES	
10. GWRS Recharge Optimization Study	Study existing capacity to recharge GWRS water and suite of potential projects to increase recharge capabilities and operational flexibility.
11. Desilting Santa Ana River Flows	Evaluate potential of removing suspended sediment from Santa Ana River water that is supplied to deep basins prone to clogging and thereby increase OCWD's recharge capacity, especially for stormwater.
12. Anaheim Lake Recharge Basin Rehabilitation	Rehabilitate OCWD's oldest recharge basin by removing clogged material and regrading the basin to increase storage, recharge capacity and make future cleanings more efficient.
13. Recharge in Lower Santiago Creek	Construct facilities to convey water to lower Santiago Creek downstream of Hart Park.
OPERATIONAL IMPROVEMENTS	
14. Warner System Optimization	Improve conveyance capacity to the Warner Basin Recharge System and reoperate the system for increased stormwater capture.
15. Recharge System Conveyance Optimization	Evaluate conveyance capacity of recharge system, including potential constraints at Lakeview Ave. and Warner-Anaheim Pipeline.
16. Zero-Emissions Vehicle Charging Infrastructure	Construct infrastructure at OCWD field operations in Anaheim and Prado to supply zero-emissions vehicles that will need to be purchased in the near future.

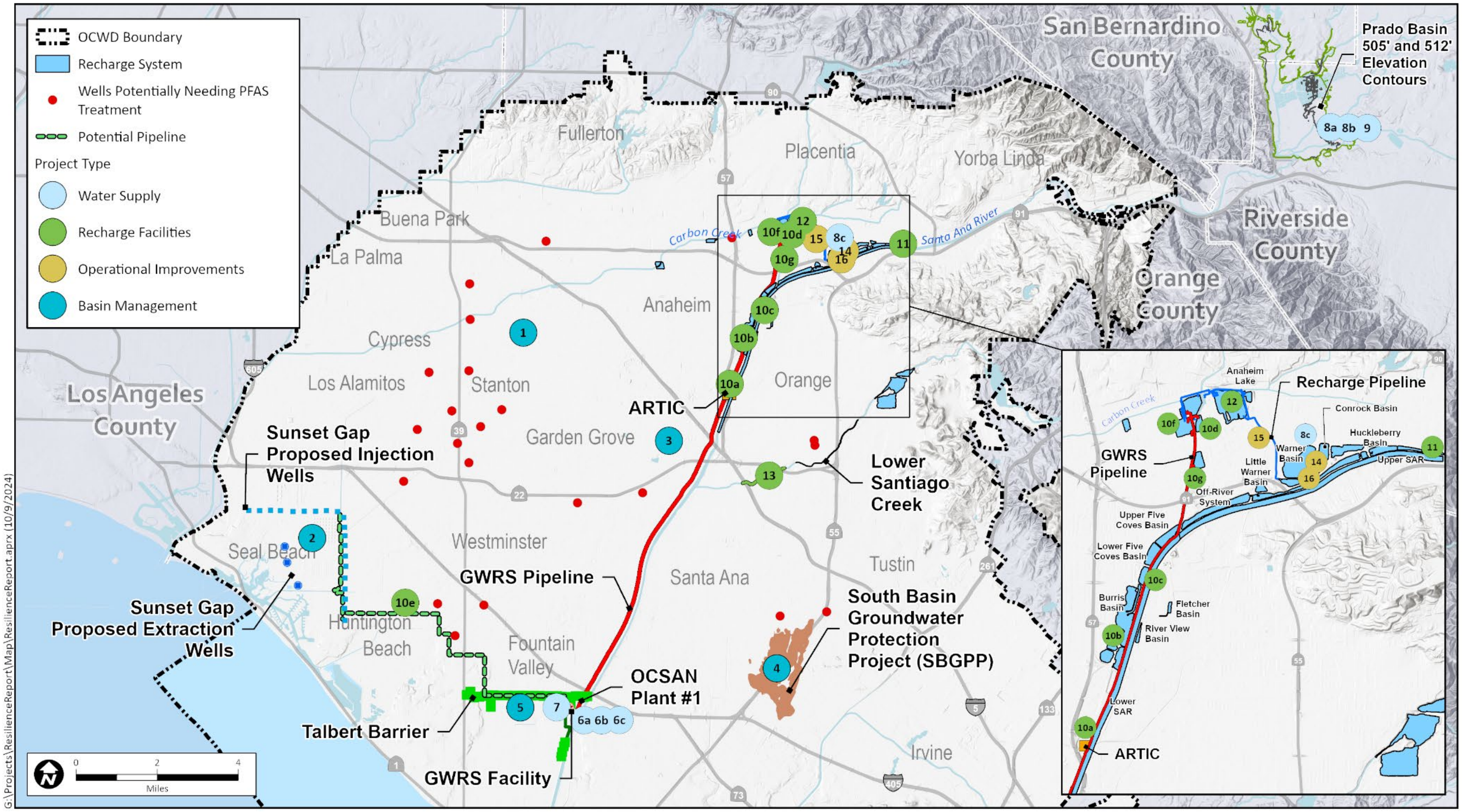


Figure 1: Location of Priority Projects

BASIN MANAGEMENT

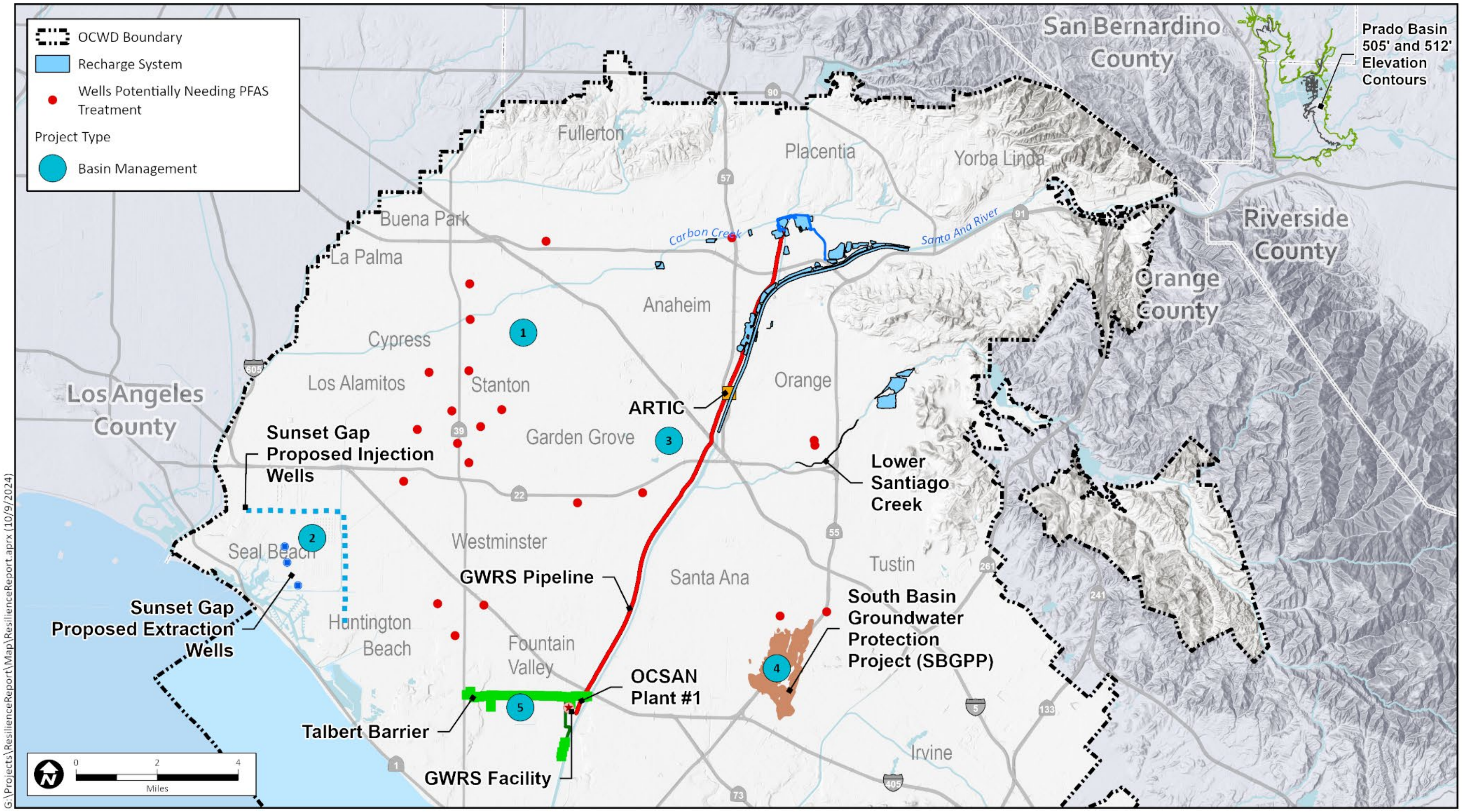


Figure 2: Location of Priority Basin Management Projects

1. Per- and Polyfluoroalkyl Substances (PFAS) Treatment Projects

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are chemicals that were commonly used to make carpets, clothing, fabrics for furniture, paper packaging for food, and other materials that are resistant to water, grease, or stains. PFAS have been detected in the Orange County Groundwater Basin, entering via both local release sites and the Santa Ana River (SAR) whose flows infiltrate into the Basin.

In 2009, the United States Environmental Protection Agency (EPA) established a provisional health advisory of 400 parts per trillion (ppt) for PFOA and 200 ppt for PFOS to assess the potential risk for short-term exposure through drinking water. The EPA later released a non-regulatory health advisory level of 70 ppt for PFOA and PFOS (combined) in 2016.

In March 2019, the State Water Resources Control Board Division of Drinking Water (DDW) issued mandatory PFAS testing orders to 12 public water systems (Groundwater Producers) in the District's service area. Dozens of wells in the District's service area had water quality testing results exceeding the DDW Notification Levels. Affected Producers were required to provide governing body notifications for exceedances of the Notification Level. Later in 2019, DDW lowered the Notification Level to 5.1 ppt for PFOA and to 6.5 ppt for PFOS. In February 2020, DDW lowered the Response Levels to 10 ppt for PFOA and 40 ppt for PFOS.

The EPA established maximum contaminant levels (MCL) for PFOA and PFOS at 4 ppt in April 2024 as well as for PFNA, PFHxS, and GenX at 10 ppt, with a five-year compliance period for public water systems. It's anticipated that the State will adopt and otherwise enforce the federal MCL without any substantive changes.

Activities

In preparation for the impacts of PFAS on groundwater supplies, the District adopted a PFAS policy in November 2019. Among other items, the policy states that OCWD will fund the lowest reasonable and efficient treatment system design and construction costs to remove PFAS compounds for Groundwater Producers. Additionally, the policy states that OCWD will provide a 50 percent subsidy for operation and maintenance expenses up to $75 per acre-foot which will increase with inflation.

In 2019, the District hired Carollo to conduct a PFAS Planning Study to evaluate options for the treatment of groundwater wells that are potentially impacted by PFAS, and to develop preferred alternatives. The five alternatives evaluated in the Planning Study were shutting down the potentially impacted well and replacing the source with imported water, blending well water with imported water, blending well water with other groundwater, packing part of the well to avoid zones with PFAS, and engineered treatment. It was determined that engineered treatment was the preferred alternative and identified the smaller site footprint of ion exchange treatment as potential advantage at most impacted Producer well sites.

In December 2019, OCWD launched the nation's largest treatment assessment and pilot testing project to develop and implement effective treatment technologies with the goal of getting local groundwater supplies back online as soon as possible. The first phase of the project identified several cost-effective adsorbents that could be implemented in the full-scale treatment systems. Subsequent phases of the piloting effort have tested additional newer adsorbents emerging in the market.

In early 2020, the District entered into agreements to pre-purchase treatment vessels that can be used for either Granular Activated Carbon (GAC) or Ion Exchange (IX). The vessels are long lead-time items, so purchasing them prior to finalizing design and issuance of construction contracts allows the PFAS treatment systems to start operating much sooner.

Since 2020, OCWD has been designing and constructing PFAS treatment systems on affected wells. As of Spring 2024, 40 wells are operational, 22 are in design or construction and another 40 wells will need treatment or other measures as a result of the newly established MCLs. Figure 3 shows the locations of the affected wells. When EPA established the PFAS MCLs in April 2024, they provided a 5-year compliance period and OCWD is working on treatment plant design and construction for the additional 40 wells within the 5-year time frame.

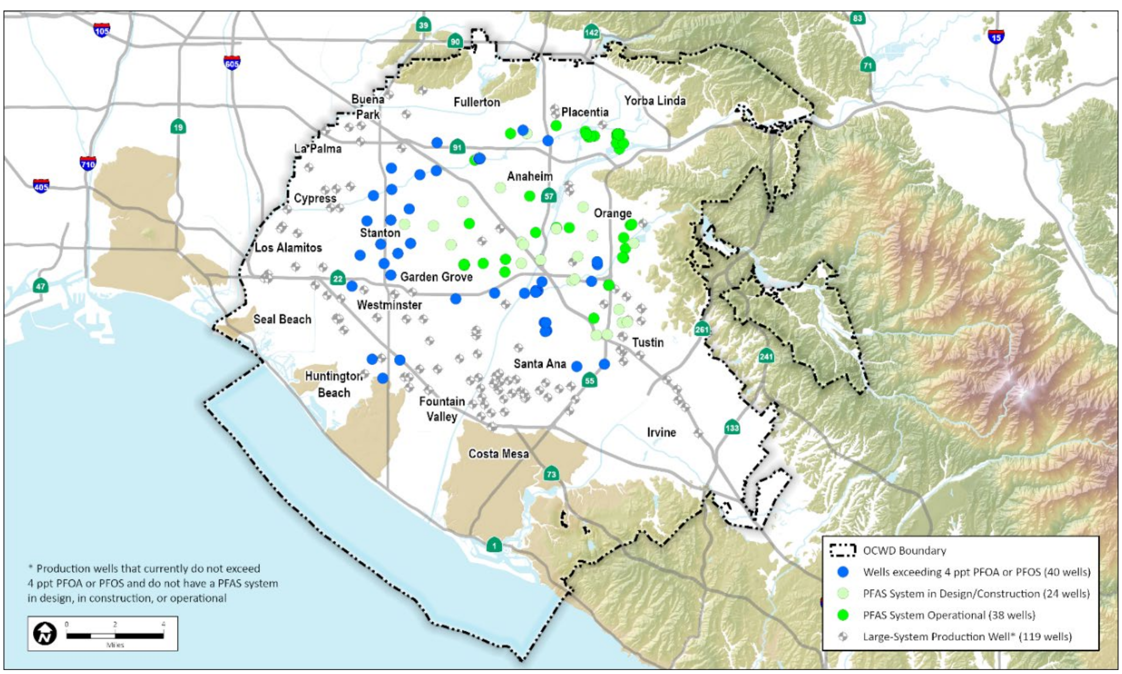


Figure 3: Location of Production Wells Affected by PFAS

Pros

- Removes PFAS-contaminated groundwater from the basin
- Restores groundwater pumping

Cons

- Expensive
- Potential supply chain issues that could delay construction

Estimated Costs

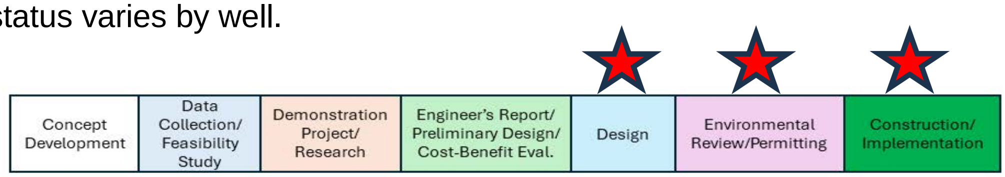
The estimated cost is $300M for the first 62 wells and $250M for the next 40 wells.

Estimated Benefits

Removes PFAS from the groundwater and restores groundwater pumping.

Project Status

Project status varies by well.



2. Sunset Gap Barrier Project

After the discovery of brackish water at former Huntington Beach well No. 12 (which ultimately led to its destruction), OCWD began investigating the source pathways and extent of seawater intrusion in the Sunset Gap. Since 2012, OCWD has constructed a network of multi-depth monitoring wells to depths up to 1,000 feet in Sunset Gap to better define the source areas, pathways, and overall inland extent of seawater intrusion to develop potential remedies. This investigation has confirmed substantial ongoing intrusion beneath the Naval Weapons Station Seal Beach (NWSSB). Current (2022) chloride concentration contours indicating the farthest inland extent of seawater intrusion in the Beta aquifer (approximately 250-300 feet below ground surface) are shown in Figure 4. Elevated chloride concentrations also exist in the overlying Alpha aquifer, underlying Lambda aquifer, and the deeper Omicron-Upper Rho aquifer, but all with a lesser areal extent than in the Beta aquifer.

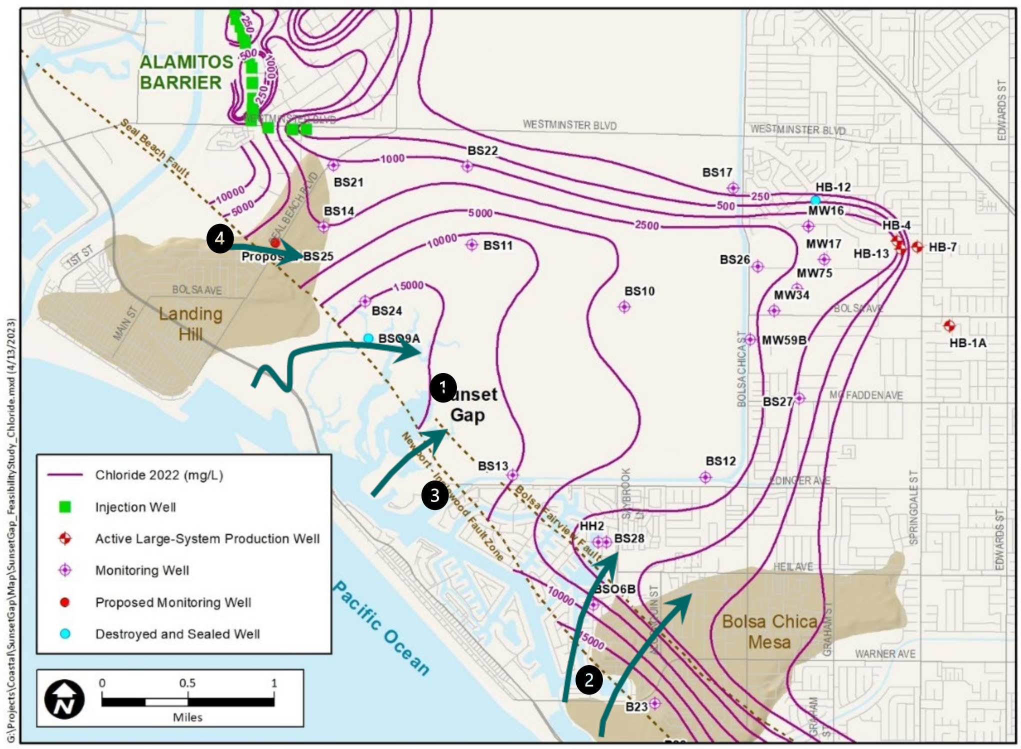


Figure 4: **2022 Beta-Lambda Aquifer Chloride Concentration Contours (mg/L)**

Four potential seawater intrusion source areas appear likely, including:

1. Lateral leakage across the Newport-Inglewood Fault Zone (aka, Seal Beach Fault) in the Landing Hill and Sunset Gap areas primarily within the Alpha and Beta aquifers.

2. Intrusion from the Huntington Harbor area from leakage across the Newport-Inglewood and Bolsa-Fairview faults and/or from dredged marina canals which may have breached the shallow aquitard overlying the Alpha aquifer.
3. Downward infiltration from the tidal inlets within the Seal Beach National Wildlife Refuge inland of the Newport-Inglewood Fault Zone.
4. Intrusion from Alamitos Gap south of the Alamitos Barrier.

The nearest active production wells inland and downgradient of the elevated chloride plume are Huntington Beach wells HB-7, HB-13, and HB-1A. Farther to the north are two Westminster wells and a Seal Beach well.

<u>Groundwater Modeling</u>

Due to evidence of ongoing seawater intrusion in the Sunset Gap, OCWD extended the Alamitos Barrier groundwater flow and solute transport model to include the Sunset Gap area to support the District's understanding of, and management decisions related to, seawater intrusion in the Sunset Gap area.

Five predictive modeling scenarios were simulated to achieve the above objectives. The most effective and efficient scenario was Scenario 3 (Table 3), which includes 34 injection wells at 20 sites with an L-shaped alignment along Westminster Avenue and Bolsa Chica Road (Figure 5). The combined average injection rate was 13 million gallons per day (mgd). Scenario 3 also included three extraction wells seaward of the injection alignment on the NWSSB with a combined average extraction rate of 3 mgd. The 34 injection wells primarily target the Beta and Lambda aquifers and to a lesser extent the Alpha and Omicron-Upper Rho aquifers. The three extraction wells target the Beta and Lambda aquifers. The analysis is summarized in a technical memorandum (Intera 2021)[1].

Table 2: Summary of Injection and Extraction Predictive Scenario 3

Predictive Scenarios	Rate # Wells	Injection			Extraction
		Alpha	Beta/Lambda	Omicron/ Upper Rho	
Scenario 3 Extraction in Beta-Lambda	mgd	1.0	10.0	2.0	3.0
	Wells	6	20	8	3
	Wells	6	16	8	-

[1] Intera, 2021. *Technical Memorandum – Extension of the Alamitos Barrier Model to Assess Sunset Gap Seawater Intrusion.* Dated December 20, 2021

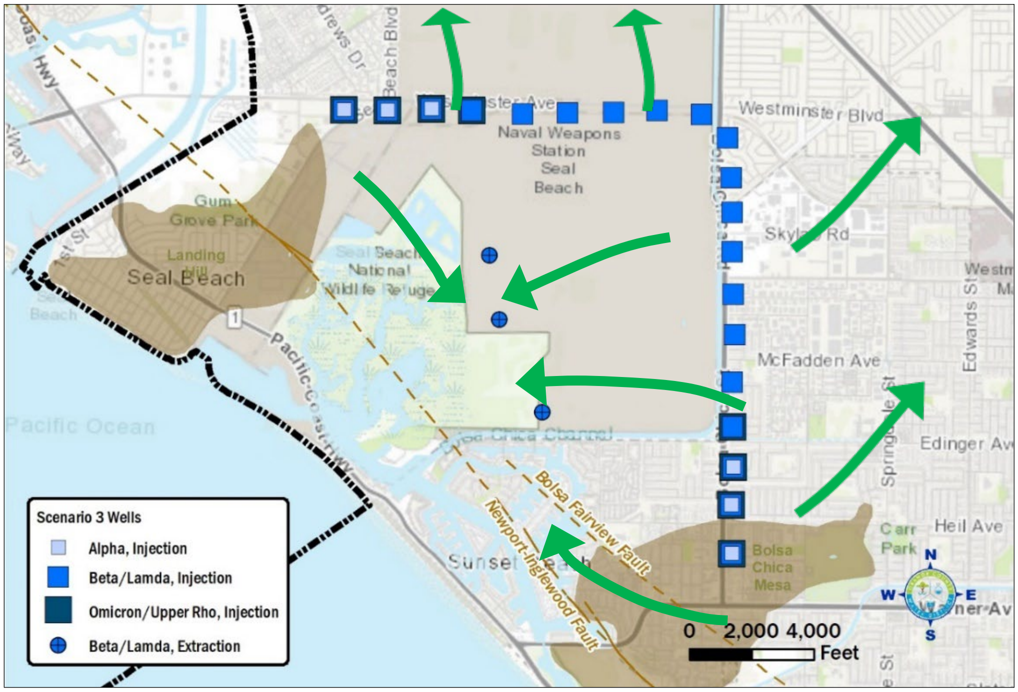


Figure 5: Scenario 3 Proposed Injection and Extraction Wells

The District recently updated the groundwater flow and solute transport model through June 2020 and refined the calibration to achieve an improved match with observed historical conditions. Once calibrated, the model was used as a predictive tool to simulate two “no-barrier” scenarios 60 years into the future to inform how seawater intrusion may progress inland and eventually impact municipal wells in the absence of a seawater intrusion barrier. The model update included incorporating new hydrogeologic data from several new groundwater monitoring wells in the Sunset Gap.

The preferred Scenario 3 injection/extraction alternative described above will be simulated using the updated model, which may result in changes to the number of wells, targeted aquifers, spacing, and flow rates described in Table 2. Additionally, the model will be used to analyze variable injection and extraction rates to account for seasonal and long-term variability in groundwater elevations in the Sunset Gap area. Such seasonal adjustments in injection are part of the standard operation of the Talbert and Alamitos barriers, where summer/fall injection rates may be twice that of winter/spring rates. The injection rate estimates derived from the modeling will be provided to the Consultant for incorporation in the feasibility study. Lastly, the model will also be used to analyze a few extraction-only barrier alternatives, including using existing municipal water supply wells as the extraction barrier (assuming eventual well-head treatment) and augmenting with additional extraction wells as deemed necessary based on model results.

Feasibility Study

In October 2023, the District initiated a Feasibility Study (FS) to evaluate potential injection water supplies, extraction well siting and discharge, and barrier alignment, and to develop a test well implementation plan. Identifying the most feasible source of water supply for the injection barrier is a critical first step. Source water supply options being evaluated include GWRS, imported water, recycled water from LA County, brackish water, and Deep Aquifer water. Identifying suitable extraction well sites and determining the most feasible discharge option is another critical component of the FS. Extraction wells will likely be located on the NWSSB and discharge of the produced water will need to be determined, with discharge options including surface waters, sewer, and treatment and reuse for barrier supply. Finally, the injection well alignment will be evaluated. Alignment options include within the public right-of-way along Westminster Blvd. and Bolsa Chica St., private property, or NWSSB property. Once the selection of a water supply source, extraction well siting and discharge, and injection well barrier alignment has been made, a preliminary design of the barrier system, construction, and O&M costs will be prepared for Board review. Should the Board desire to move forward with the project, a test well implementation plan will be prepared that will identify the number, location, and methods to construct and test injection and extraction wells that will inform the final design.

Pending the results of the modeling described above, the FS may be expanded to include cost and implementation options for no-barrier and/or extraction-only barrier alternatives. The FS is still in its early stages of development and detailed implementation costs are not yet available. Estimated costs are shown below.

Pros
- See Estimated Benefits

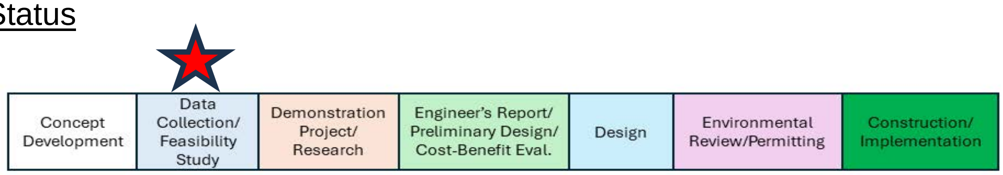
Cons
- May impact existing contaminant remediation systems that would need to be mitigated

Estimated Costs
- $180M

Estimated Benefits
- Prevent further inland migration of seawater into the Principal aquifer in the Sunset Gap area
- Prevent eventual salinity impacts to SB, HB, and WM wells and beyond
- Maintain compliance with SGMA, as prevention of seawater intrusion is a key “undesirable” impact to be avoided

- If selected, groundwater produced from the Deep aquifer to supply the new barrier would take advantage of an underutilized groundwater resource

<u>Project Status</u>



3. Groundwater Basin Operating Range Expansion Study

The Basin operating range refers to the upper and lower levels of groundwater storage in the Basin that can be reached without negative or adverse impacts. The current operating range is between 0 and 500,000 acre-feet (af) of accumulated overdraft (AOD) as shown on Figure 6. Each year the District determines the optimum level of AOD within that range and raises or lowers the Basin Production Percentage (BPP) to manage the desired level of pumping, among other potential actions such as purchasing more or less imported replenishment water. Only a small fraction of the water in the Basin can be safely removed, primarily because of the threat of seawater intrusion. Expanding the Basin's operating range would involve investigating options to overcome factors that limit the amount of water that can be safely withdrawn from the Basin, which may include expanding seawater barriers, deepening wells to accommodate lower water levels, and establishing a more formal process to monitor ground surface changes to detect potential land subsidence.

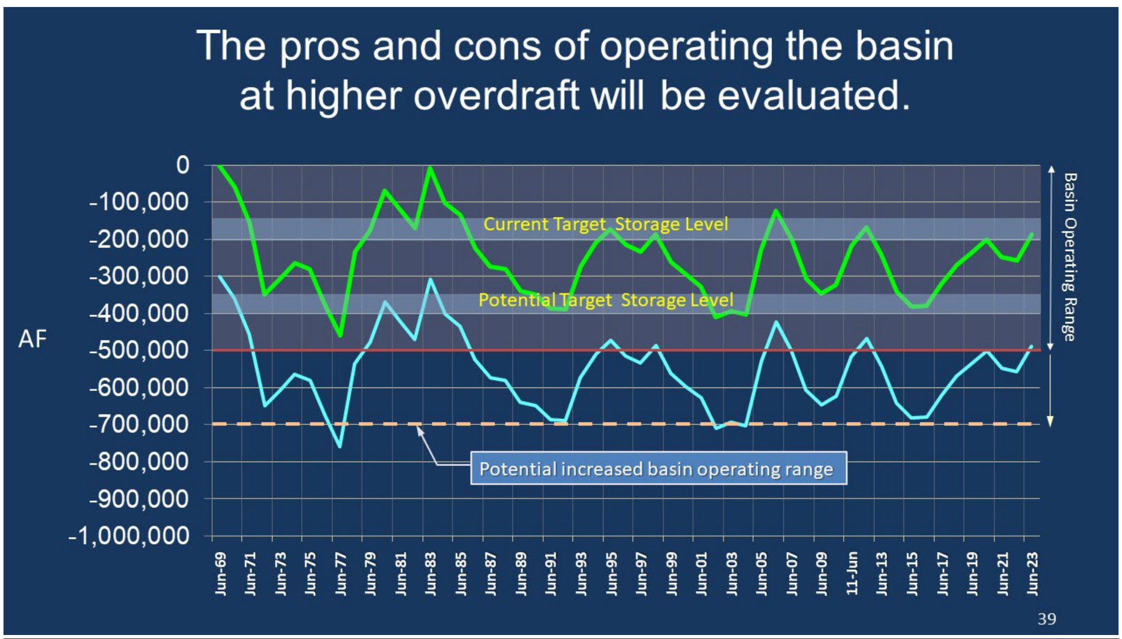


Figure 6: Current and Potential Expanded Storage Target Range

The following tasks are recommended to evaluate a larger operating range:

1. Estimate the AOD under a 10-year drought scenario (reasonable best and worst cases).
2. Use existing groundwater models to evaluate seawater barrier impacts by operating the basin at AOD volumes derived from Task 1.
3. Use models to estimate groundwater level drawdown and effects on production well capacities at AOD volumes derived from Task 1.

4. Develop a land subsidence monitoring program that could be used to detect ground surface changes associated with increased AOD and threshold changes that could trigger basin management actions to cease further overdrafts.
5. Either as part of a larger basin operating range or the current operating range, evaluate the pros and cons of a potential new target AOD, e.g., 300,000 af.

<u>Pros</u>

- Increase drought resilience
- Reduce groundwater underflow to LA County
- Reduce purchases of imported replenishment water

<u>Cons</u>

- Increased risk of seawater intrusion without strengthening seawater barriers
- Potential need to deepen or replace some production wells due to lower pumping levels
- Increased potential upwelling of colored water

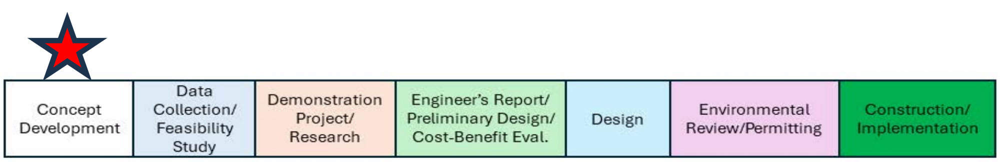
<u>Estimated Costs</u>

No estimated costs have been developed.

<u>Estimated Benefits</u>

Every 100,000 af of reduced storage in Orange County relative to Los Angeles County is estimated to decrease underflow by 7,000 af/year with a value of ~$9,000,000/year.

<u>Project Status</u>



4. South Basin Groundwater Protection Project

Groundwater contamination in the South Basin area has been caused by releases into the subsurface of chlorinated solvents, perchlorate, Chromium-6, and other hazardous materials that were used at industrial sites in the southern part of the Basin. The District has investigated the extent and magnitude of the contamination and initiated litigation to recover costs expended to remediate the contamination. The District has obtained remediation commitments for some sites through settlements and is working to complement the efforts of state regulatory agencies that are overseeing investigation and remediation activities by responsible owners and operators. The South Basin area groundwater contamination is in the Shallow Aquifer and has been detected in Irvine Ranch Water District well IRWD-3. Without abatement measures, the contamination will continue to spread laterally and vertically. The District's objective is to coordinate with regulatory agencies and willing responsible parties to implement remedial actions to prevent further contaminant migration. In 2023, the District completed a remedial investigation and feasibility study (RI/FS) in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan (National Contingency Plan) to evaluate interim remedial action alternatives to protect the vital groundwater resources in the South Basin area. The District is currently conducting a CEQA evaluation (program EIR) of the tentatively preferred remedy and is developing an Interim Remedial Action Plan. The OCWD Board preferred remedy is groundwater extraction wells with local treatment and further treatment and recycling at the GWRS facility (per OCWD Board Resolution 23-2-23).

Pros

- Containment and reduction of toxicity of groundwater contaminants in the Shallow Aquifer System
- Reduced threat to Principal Aquifer and groundwater production wells
- Treated water will be recycled and recharged into the Basin
- Follows the District's Groundwater Quality Protection Policy

Cons

- Will require long-term operation, monitoring, and maintenance (30+ years)
- Access to private property may be required to construct and operate remediation facilities

Estimated Costs

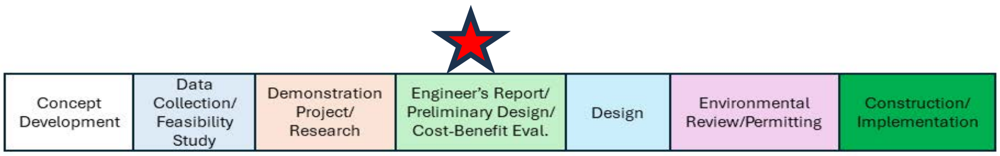
$45.7M project lifetime (30 years)

- $15M design and capital
- $31M O&M

Estimated Benefits

Remediation of Shallow Aquifer System groundwater and reduced threat to Principal Aquifer drinking water supply.

Project Status



5. Talbert Barrier Injection Well Replacement and Optimization Study

A study is recommended to develop a long-term plan for replacing Talbert Barrier Ellis Ave. “legacy” injection wells (constructed in the 1970s) that have exceeded their useful life and diminished the barrier’s overall injection capacity and system redundancy. This study would also analyze the need to install injection wells in areas where seawater intrusion has not effectively been mitigated since the GWRS expansion of the barrier in 2008, such as the west side of Talbert Gap north of Yorktown Avenue (Figure 7). Lastly, this study would analyze the potential to augment the barrier with deeper injection wells to increase the capacity for Basin replenishment.

The Talbert Barrier Groundwater Flow and Transport Model (Talbert Model) would be used as a predictive tool to determine barrier requirements for intrusion control and new well configurations based on future projected conditions. The Talbert Model is currently being revised by Hydrogeology staff to improve its accuracy and reliability for predictive analyses. Planned improvements include:

- Extending calibration from June 2017 to June 2023
- Revising geologic cross-sections and model layering based on new monitoring well data collected in recent years
- Extending Talbert aquifer boundary offshore per mapped seafloor outcrop
- Implementing freshwater equivalent heads for improved calibration at intruded wells

Based on the predictive groundwater modeling analysis, any proposed new injection wells either along Ellis Ave. or elsewhere would then need to be included in Engineering’s existing Talbert Barrier Hydraulic Model to determine associated improvements to barrier pipelines and appurtenances.

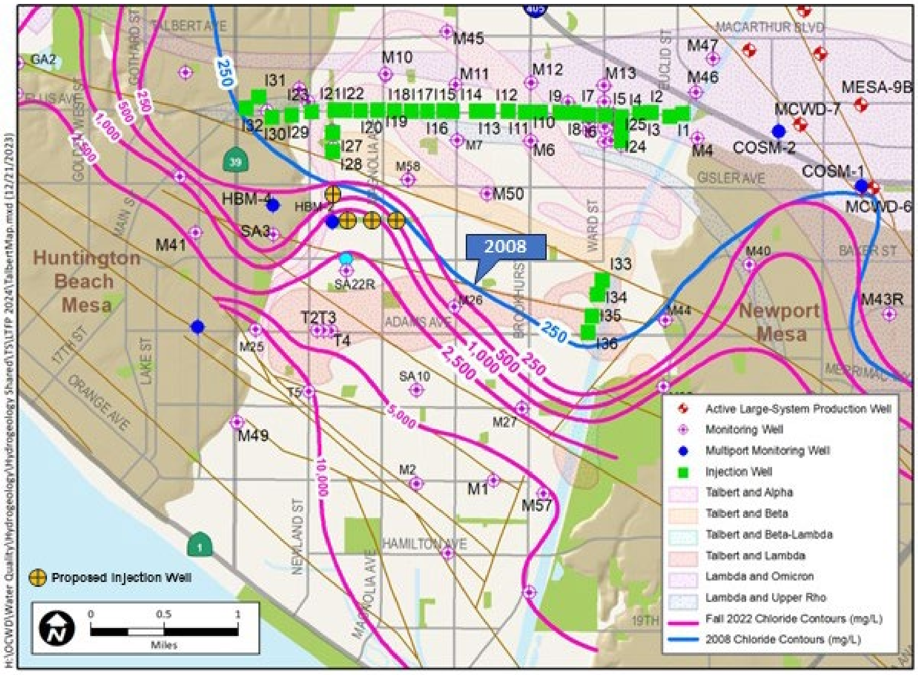


Figure 7: 2022 Chloride Contours in the Talbert Barrier Area and Proposed Injection Wells

The primary objective of this study is to determine the appropriate number, location, and flow rates of injection wells to replace poor-performing legacy wells and to address stubborn areas of intrusion under a range of basin-accumulated overdraft conditions.

Replacement of existing legacy wells would not necessarily need to be one-for-one. For example, a preliminary concept for replacing injection wells I2 and I3 would be one new injection site anticipated to have higher injection capacity into the same aquifers as I2 and I3 and an additional deeper well into the Main aquifer (not susceptible to intrusion) for Basin replenishment like the modern barrier injection wells I26 through I32. The Main aquifer injection would increase the overall capacity of the barrier and is less susceptible to shallow groundwater issues during high Basin conditions. A potential location for the I2/I3 replacement well site could be in the parking lot of the new OC San office building on Ellis Ave.

Since GWRS expansion of the barrier in 2008, seawater intrusion has generally been controlled in the Talbert Gap. On the east side of the Talbert Gap, seawater intrusion has been pushed back toward the coast, seaward of the critical mergence zone between the Talbert and Lambda aquifers near Adams Ave. (Figure 5); however, on the west side of the Talbert Gap, the intrusion front extends inland to Garfield Ave., with chloride concentrations in the Lambda aquifer at monitoring well HBM-2 showing a gradual increase over the last several years.

Additional injection wells on the west side of the Talbert Gap could help to push this stubborn lobe of intrusion farther seaward past Adams Ave. Figure 7 shows a potential concept with four proposed injection wells along the Edison easement near HBM-2.

Using the Talbert Model, the location and timing of phasing in new injection wells for either legacy replacements or barrier improvements would be refined to optimally achieve groundwater elevations protective of seawater intrusion year-round under a range of accumulated overdraft conditions, especially during multi-year droughts. The future conditions would assume increased coastal pumping at the higher BPP of 85% with GWRS Final Expansion online.

Another key objective of this study is to develop project alternatives for additional injection wells (locations, number, and flow rates) for the purpose of increasing barrier capacity to recharge GWRS water in the Main aquifer.

GWRS Final Expansion increased purified recycled water production capacity to 130 mgd. The GWRS Pipeline to the Forebay currently has a maximum capacity of 85 mgd and the five existing Mid-Basin Injection (MBI) wells have a capacity of 8 mgd, for a combined total of 93 mgd. Therefore, the Talbert Barrier along with any other future recycled water recharge projects would need to recharge at least 37 mgd to fully utilize the 130 mgd of GWRS supply.

Over the last 10 years, Talbert Barrier's annual average injection has ranged from a high of 32 mgd in CY 2015 during a period of high accumulated overdraft to a low of 20 mgd in CY 2022 during low accumulated overdraft conditions. As such, the existing Talbert Barrier does not have sufficient injection capacity under a wide range of Basin conditions to fully utilize GWRS Final Expansion supplies without additional GWRS recharge projects. Therefore, this study will evaluate increasing GWRS recharge capacity at/near the Talbert Barrier by constructing injection wells in the upper Principal aquifer zones susceptible to intrusion (Beta, Lambda, and Omicron-Upper Rho aquifers) as well as in the lower Principal aquifer zones not susceptible to intrusion (Lower Rho and Main aquifers) for Basin replenishment. The need to increase Talbert Barrier injection capacity would be lessened if the proposed Sunset Gap barrier were to be built using GWRS water for injection supply.

Legacy injection well replacements and additional well sites for barrier optimization and Basin replenishment may require new or upsized pipelines which would be evaluated using the existing Talbert Barrier hydraulic model. A regulatory consideration is the potential need to modify the District’s GWRS recycled water recharge permit, depending on the locations of new injection wells and whether they would affect the current permitted boundary area.

A potential project that was previously considered (2014 and 2019 Long-Term Facilities Plan) would be to construct three new injection wells for Basin replenishment north of the barrier adjacent to the three OCWD Deep well sites D3, D4, and D5 (Figure 8). Previous analyses found that it would not be technically feasible to convert these three existing Deep wells to injection wells primarily based on their age and deep screened intervals penetrating the colored water aquifer. As an alternative, Figure 6 shows three potential injection well sites adjacent to or relatively close to D3, D4, and D5 and the existing pipeline, which could potentially be sleeved and used to supply the proposed injection wells with GWRS water; however, the pipeline may need more extensive modifications to sustain a maximum injection pressure of 70 psi.

Pros

- Optimize the barrier's capacity and effectiveness in preventing seawater intrusion and recharging GWRS water by selectively replacing obsolete injection wells
- Push back seawater intrusion south of Garfield Ave. on the west side of the Talbert Gap
- Increase capacity to recharge GWRS water
- Increase barrier reliability in high overdraft conditions by increasing injection capacity
- Reduce the potential for upwelling of colored water

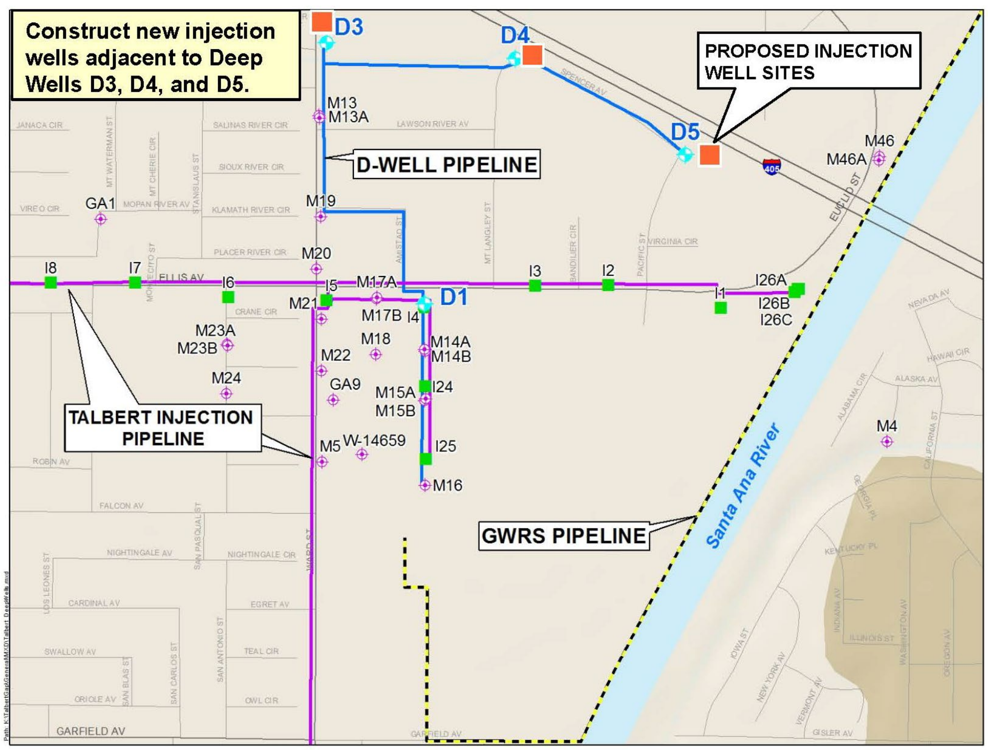


Figure 8: Potential Injection Well Sites Adjacent to Existing OCWD Deep Wells

Cons

- Potential need to revise GWRS permit boundary area

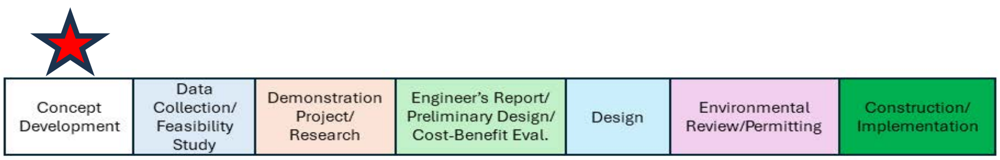
Estimated Costs

Estimated costs are to be determined based on modeling and other analyses.

Estimated Benefits

- Better control of seawater intrusion
- Increased GWRS injection

Project Status



WATER SUPPLY

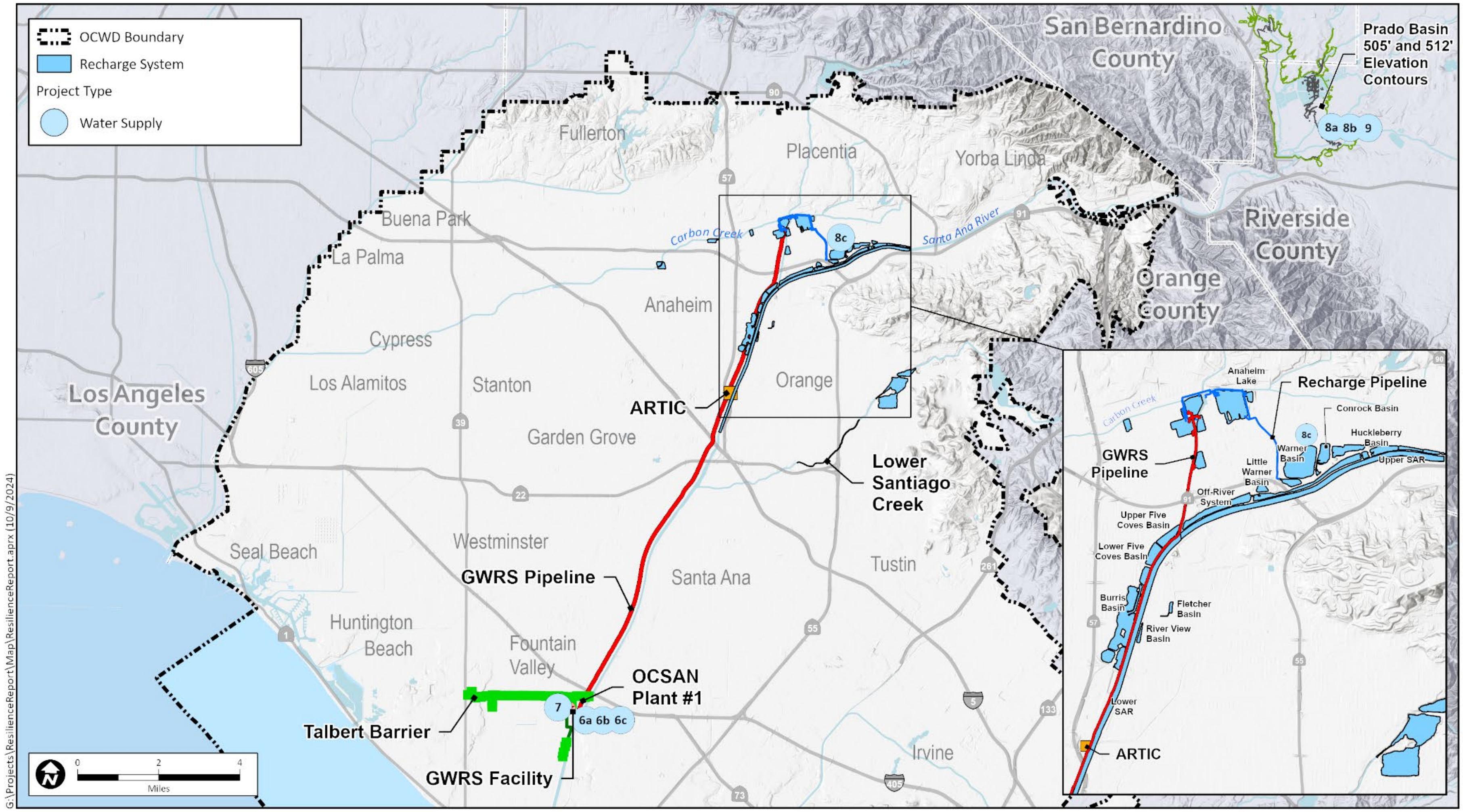


Figure 9: Location of Priority Water Supply Projects

6. GWRS Supply Augmentation

The Groundwater Replenishment System (GWRS) Final Expansion was completed in 2023. GWRS can now produce up to 130 million gallons per day (mgd) of highly treated water. The feed effluent from OC San to produce this volume of water must average 170 mgd. Although the volume of OC San inflow is currently sufficient to supply GWRS, as shown in Figure 10, efforts are underway to look at potential sources to augment OC San inflow in the event that inflows decline in the future. The District is also looking to increase GWRS production by enhancing GWRS recovery rates. Three projects that are being studied are described below.

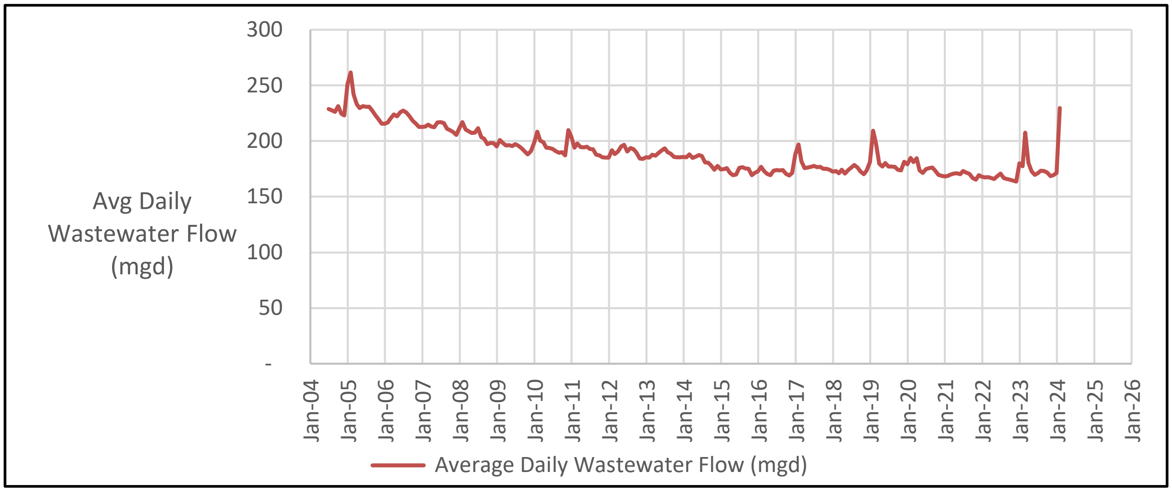


Figure 10: Average Daily Wastewater Inflow to OC San (Plants 1 and 2)

a. Urban Runoff Diversion to OC San

Urban runoff (dry-weather flow) conveyed in flood control channels could be a potential source of additional water to OC San and for GWRS. Municipalities are under regulatory pressure through the MS4 permit to reduce urban runoff for the purpose of improving surface water quality and reducing pollutant loads to the ocean. OC San has an approved ordinance of accepting 10 mgd of urban runoff through the sewer lines without charging a treatment fee. Although approximately 20 diversion projects have been constructed, less than 3 mgd is currently being diverted to OC San.

OC San is actively leading a comprehensive, multi-agency Uban Runoff Optimization Study, which includes participation by OCWD and OC Public Works. This study is looking to evaluate opportunities to maximize the utilization of the urban runoff diversion program. When complete, this study will present viable locations for the construction of new dry weather diversions and identify existing diversions that could be modified to maximize flow. If constructed, these diversions represent a new source of water to OC San, which could be particularly important if sewer flows decline due to increased conservation and/or new regulatory limits on water usage.

Pros

- If diversion projects are built, additional urban flows would be diverted to OC San and be available to GWRS
- Represents a new water source
- Regulatory driver is MS4 and TMDL compliance, meaning that other public agencies (MS4 permittees) would likely fund most of the project costs
- Multi-agency/benefit projects are good candidates for grant funds
- Diverting dry weather urban runoff benefits surface and ocean water quality
- Potential opportunities for reoperation for wet weather flow diversion in the future

Cons

- Dry weather flows are anticipated to decrease over time to meet Conservation as a Way of Life and MS4 regulations
- Potential environmental conflicts resulting from removing water from native habitat
- OCWD is not the project lead
- Evolving water quality concerns to ensure OC San can meet their NPDES discharge requirements

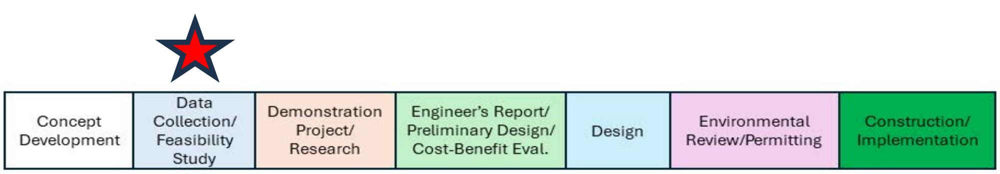
Estimated Costs

No estimated costs have been developed.

Estimated Benefits

Unknown – anticipate between 1,000 – 5,000 acre-feet per year (afy) of new flows to GWRS if all new projects are built and existing facilities optimized, could be higher if diversions are reoperated for wet weather flows.

Project Status



b. Diversions from SARI to OC San Plant #1

This project will divert raw domestic wastewater flows out of the Santa Ana Regional Interceptor (SARI) trunkline that is currently routed to OC San Plant No. 2 and conveyed through primary and secondary treatment before being sent to OC San's ocean outfall. The SARI trunkline flows are not allowed to be recycled through GWRS due to the industrial/brine flows it contains and therefore any raw domestic wastewater that can be diverted out of the SARI trunkline will add to the influent into OC San's reclaimable sewer flows and therefore contribute to the overall GWRS production.

A study was completed that looked at diverting all the raw domestic out of the SARI trunkline. The study concluded that to divert all the flows – several new sewer lift stations would have to be constructed within the County. OC San and OCWD agreed that no new sewer lift stations would be constructed, and the “gravity” diversion projects would be pursued when needed. There are 4 potential projects that with the construction of new manholes and new sewer lines (no lift stations) could divert up to an additional 7.5 mgd of domestic wastewater out of the SARI line and divert those flows to the reclaimable sewer trunks to be recycled by GWRS. Currently, the recovery efficiency of GWRS is 85 percent, which would result in an additional 7,100 afy of GWRS product water if the entire 7.5 mgd were diverted. The costs for these projects range from $120,000 - $15.3 million and can be considered should influent flows to OC San decline below what is required to produce 130 mgd at the GWRS facility.

Pros

- Provides additional flows that could be recycled by GWRS

Cons

- Additional infrastructure needed

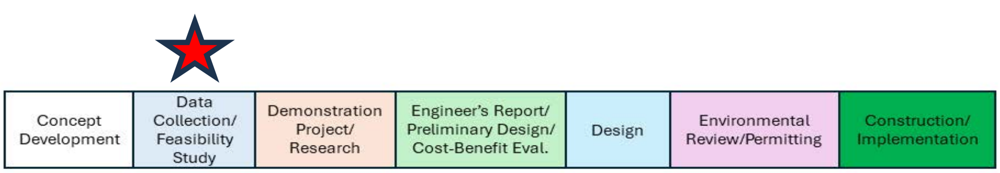
Estimated Costs

Estimated costs range from $120,000 to $15.3M.

Estimated Benefits

Up to 7.5 mgd of additional wastewater flow to be recycled by GWRS. At 85% recovery efficiency, this could result in up to 7,100 afy of additional supplies.

Project Status



c. Demonstration-Scale Test of Flow Reversal RO to Enhance GWRS Recovery via Retrofit of One RO Unit

The current recovery of the GWRS system is 85%, leaving 15% of the RO concentrate (ROC) that is discharged via OC San’s ocean outfall. It is possible to increase this recovery rate using technologies available today, some of which have been piloted by the District’s R&D Department. Increasing recovery would allow producing more water for recharge or injection using the same OC San effluent supply volume; or under the scenario of a decreased supply (e.g., reduced available OC San effluent such as from water conservation), it would allow OCWD to maintain production.

Available technologies could increase recovery from the current 85% to up to 90-92%, or even up to 93-95% with further optimization. This translates to an additional several million gallons per day (mgd) depending on the achievable recovery assumption as indicated in Figure 11.

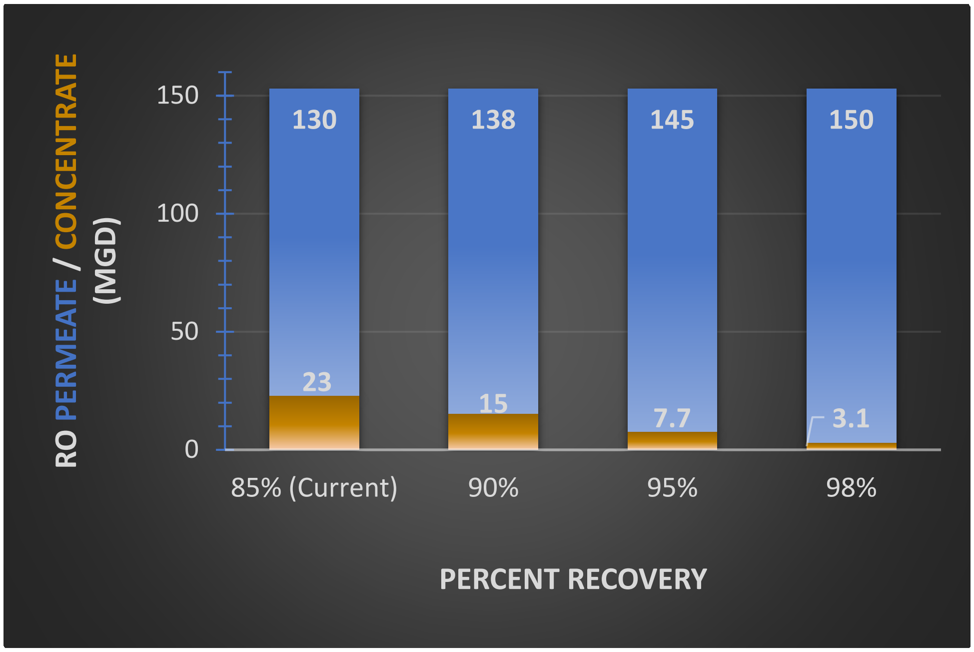


Figure 11: Projected GWRS RO permeate and concentrate flow volumes with enhanced RO system recovery

Figure notes: The total volume per day (y-axis) is fixed at 153 mgd representing the current influent to the GWRS RO system. The RO influent flow separates into permeate or concentrates according to the RO recovery (efficiency) (x-axis). A likely best-case scenario may be ~95%, corresponding to ~15 mgd of new water produced over the current 130 mgd. A more realistic scenario may be ~90%, corresponding to ~8 mgd of new water.

This project summary describes alternatives and provides cost estimates for different technology scenarios and capacities. However, for the five-year period relevant to this planning document, a demonstration-scale test of flow reversal RO (FR-RO) is proposed which would entail retrofitting a single RO unit in the GWRS plant to enable the FR-RO technology. This would allow a multi-year evaluation before potentially proceeding with a plant-wide retrofit. For both a single-unit retrofit or a plant-wide retrofit, a formal engineering cost estimate is first required.

GWRS RO recovery may be enhanced using two alternative approaches or a combination of both: plant retrofit or a separate RO plant to treat RO concentrate. The first approach, a retrofit, would modify the existing (primary) RO plant to increase its recovery. OCWD R&D has piloted FR-RO, which if implemented would add a system of valves and interstage boosting to the existing RO unit(s). The retrofit would enable feed flow reversal along the direction of the pressure vessel and block rotation wherein 1st stage "block" switches to 3rd stage and vice versa every few hours. The primary RO plant operating at higher recovery would generate a smaller volume of more concentrated RO concentrate.

The second approach does not involve modifications to the primary RO plant. Instead, a separate, secondary RO plant would be constructed to receive and treat the primary RO plant's concentrate. A membrane-based technology would extract water as new permeate (and generate a more concentrated ROC). R&D has piloted three such technologies directly treating ROC to extract more water. Forward osmosis RO achieved a slightly lower recovery than the others and is less mature. FR-RO was not successful when operated in this mode. Closed-circuit RO (CC-RO) pilot was generally successful and reached a recovery equivalent to approximately 88-91% overall recovery (calculated from the addition of any extracted purified water from the ROC added to the primary RO system permeate and accounting for CC-RO efficiency related to side conduit).

The target capacity of the final design could be scaled to the level of production considered desirable or economical. For example, a plant-wide retrofit of all current 27 RO units to FR-RO at ~90% recovery would correspond to an increase in plant production from 130 to 138 mgd; or some number less than 27 of these RO units could be retrofitted to FR-RO depending on the target production increase. Similarly, a separate, secondary RO plant treating ROC need not be constructed to treat all the available 23 mgd ROC as influent but could instead be designed at a capacity to produce a specific production rate such as an additional 1-10 mgd.

Theoretically, a combination of the two approaches (primary RO retrofit or ROC recovery plant) could be pursued simultaneously. For example, a modular, risk-averse approach could retrofit only one primary RO unit for FR-RO as a full-scale test; and a single CC-RO unit could be constructed to treat ROC (at the time of the CC-RO evaluation, the smallest CC-RO unit available was 1 mgd). These could be built out over time by adding more units (or retrofits) depending on the outcomes.

Costs for enhanced GWRS RO recovery could range from $65 million to $121 million to increase the overall production by almost 10 mgd if the maximum capacity increase is pursued (assuming ~90% recovery, recognizing that further optimization may be possible).

Pros

- Increasing RO system recovery would produce more purified water for recharge and injection
- Increasing recovery also reduces the volume of ROC discharged to the ocean which may have benefits to reducing strain on the outfall and addressing possible future increased regulation of ROC
- Having both a primary and secondary RO plant (the latter treating ROC for water extraction) could lead to creative and beneficial operational modes such as backing off on the recovery rate for the primary RO plant (e.g., target 75%) leading to less primary membrane fouling and associated cost while pushing the secondary plant harder (more scaling but fewer membranes to be maintained and replaced)

Cons

- Enhancing recovery leads to scaling and fouling of RO membranes, requiring them to be cleaned more frequently and perhaps replaced more frequently, thereby increasing O&M costs and operator labor
- High cost. It is commonly recognized that extracting “the last drop” of water (increasing recovery) is costly i.e., diminishing returns as the cost per acre-foot of water goes up for the new water associated with each percent increase in recovery

Estimated Costs

$3M for a demonstration-scale test of FR-RO via retrofit of a single GWRS RO unit. For reference, larger-scale implementation costs could range from $65M to $121M depending on the choice of technology and design capacity.

Based on:
Capital cost for a FR-RO retrofit: 1 RO unit producing an additional 0.28 mgd (~$3M), or all 27 RO units to produce ~7.5 mgd (~$73M)

(These estimates correspond to approximately $640/af total unit cost with capital and O&M and assume 90% recovery)

Capital cost for a secondary RO plant treating RO concentrate using CC-RO:

10 mgd CC-RO system producing ~4.6 mgd of permeate: $65M
20 mgd CC-RO system producing ~9.2 mgd of permeate: $121M

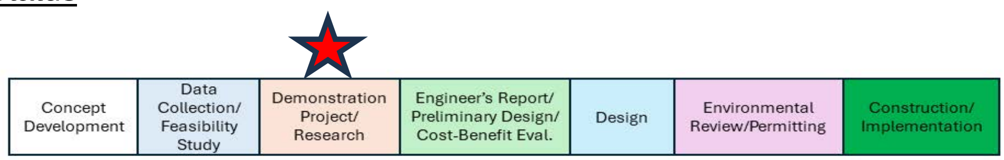
These estimates correspond to approximately $1,200/af (total unit cost with capital and O&M) and assume 88-91% recovery which depends on design capacity as related to efficiency associated with CC-RO side conduit.

Background information for these estimates is provided in the R&D Department published reports and based on pilot performance.

Estimated Benefits

Demonstration-scale test of FR-RO would allow a multi-year evaluation before potentially proceeding with a plant-wide retrofit. A plant-wide retrofit (or a secondary RO plant using alternative technology) would produce an estimated 8-10 mgd additional purified water for GWRS recharge and injection, assuming the current 85% recovery is increased to 90%.

Project Status



7. Brackish Water Desalination Study

Several agencies, including OCWD, Mesa Water, the City of Huntington Beach, and the City of Newport Beach, have embarked on a Local Groundwater Supply Improvement Project (Local SIP) to examine the potential of extracting, treating, and delivering brackish groundwater as a new local source of supply. The areas of brackish groundwater being studied include areas seaward of the Talbert Barrier and Newport Mesa as shown in the Study Area boundary on Figure 12. Funding for the Local SIP includes grant funding from the U.S. Bureau of Reclamation.

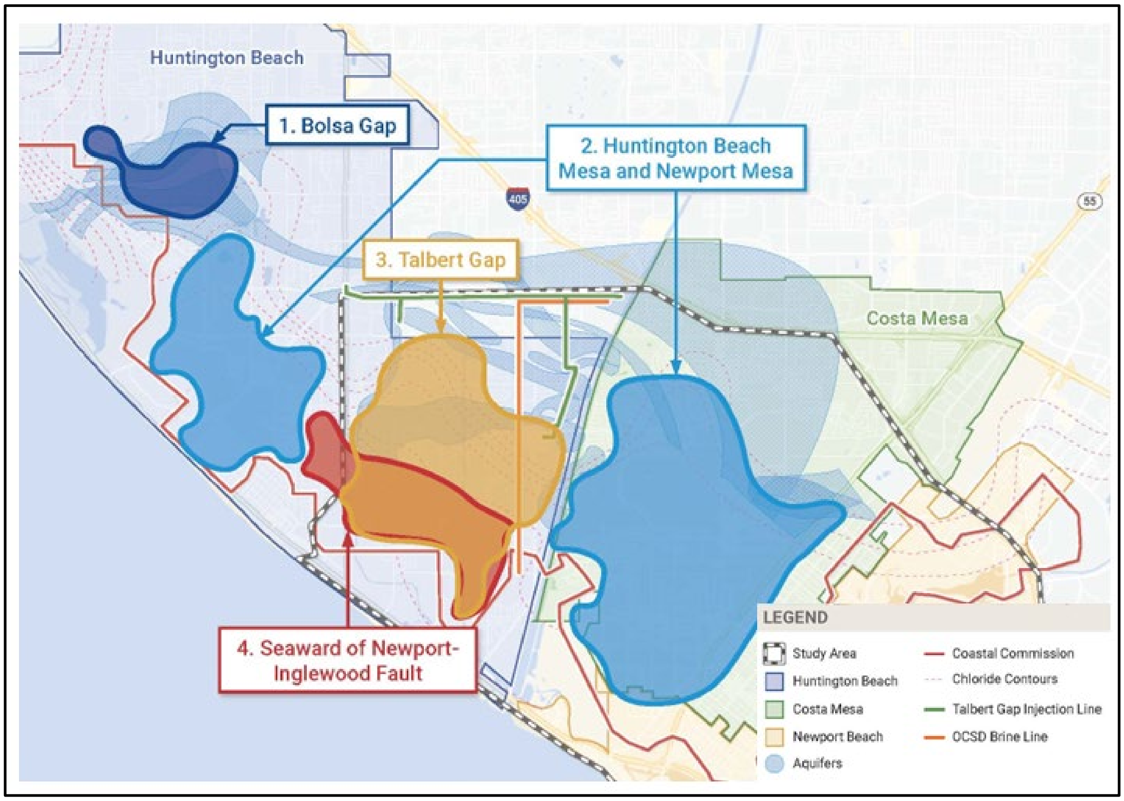


Figure 12: Areas of Potential Brackish Water Supply

The scope of the Local SIP includes developing a feasibility study that evaluates potential locations for groundwater wells seaward of the Talbert Barrier and estimates their impacts on the Talbert Barrier and seawater intrusion, raw water quality, impacts to treatment facility design (5 to 8 mgd), and waste management.

Pros

- Creates a new source of local supply

Cons

- High-cost source of water

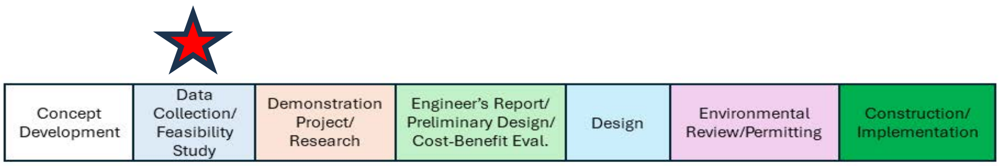
Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.

Project Status



8. Increasing Stormwater Capture

Storm flows from the Santa Ana River and Santiago Creek represents a significant source of recharge to the Basin. Over the last 20 years, OCWD has captured and recharged an average of 55,000 afy of stormwater with a maximum of 117,000 af in 1995. Much of this recharge is made possible by the capture of stormwater in the Prado Dam Conservation Pool but there are also opportunities to increase stormwater capture downstream of Prado Dam.

a. Incorporate FIRO Into Prado Water Control Manual

OCWD continues to work closely with the U.S. Army Corps of Engineers (USACE) to manage and increase the amount of water that can be temporarily impounded in the Conservation Pool. Currently, the Conservation Pool can rise to an elevation of 505 feet mean sea level (ft msl) (approx. 20,000 af of storage).

Advances in weather and storm flow runoff forecasting hold promise to allow USACE to capture more stormwater at Prado Dam. Future increases in the volume of stormwater that USACE can capture at Prado Dam need to be implemented in such a manner that the dam’s primary flood risk management purpose is unaffected. For this to happen, more refined weather and runoff forecasting tools need to be provided to USACE for their operation of Prado Dam.

Forecast Informed Reservoir Operations (FIRO) represents the next generation of operating water reservoirs using the best available technology. Moreover, given the importance of atmospheric river (AR) storms on water supplies in California, FIRO represents a methodology to take advantage of our increasing understanding of AR storms which are infrequent but provide a large percentage of total precipitation.

To examine the potential of FIRO to increase stormwater capture, OCWD embarked on a multi-phase study of applying FIRO at Prado Dam in partnership with the Center of Western Weather and Water Extremes (CW3E), at the Scripps Institution of Oceanography, in 2017. This work culminated in the completion of the Final Viability Assessment (FVA) in November 2023. A key finding of the FVA is that FIRO is a viable tool to increase stormwater capture without compromising flood risk management and that an additional 4,000 to 6,000 afy of stormwater could be captured and recharged by raising the Conservation Pool to elevation 510 to 512 ft msl.

FIRO Implementation Roadmap

With the publication of the FVA, the roadmap to implementing FIRO involves completing two key activities, including:

1. Water Control Manual Update No. 2

2. Habitat Assessment Tool Development

The ultimate objective is to incorporate FIRO into the USACE's Prado Dam Water Control Manual (WCM), which describes the rules the USACE follows in operating Prado Dam. The USACE is currently working to complete WCM Update No. 1 which addresses the future spillway and increased discharge capacity of the dam from 10,000 cfs to 30,000 cfs. This is expected to be completed by early 2027 as shown in Figure 13.

Water Control Manual Update No. 2 is solely to incorporate FIRO into the WCM. This update cannot be implemented until WCM Update No. 1 is completed in 2027; however, work will proceed in parallel for Update No. 2 so it can be implemented as soon as possible. Efforts are already underway with the USACE, Sonoma Water, DWR, and Yuba Water Agency to develop flexible language describing the application of FIRO in the WCM's of Lake Mendocino, Lake Oroville, and New Bullards Bar Reservoir. These efforts will assist in developing the language for WCM Update No. 2.

The USACE received partial funding of $540,000 in its FY24 budget for WCM Update No. 2. As a project partner, OCWD will assist with the work required, including the environmental review and documentation. The current target time frame for completing WCM Update No. 2 is early 2029 (Figure 13).

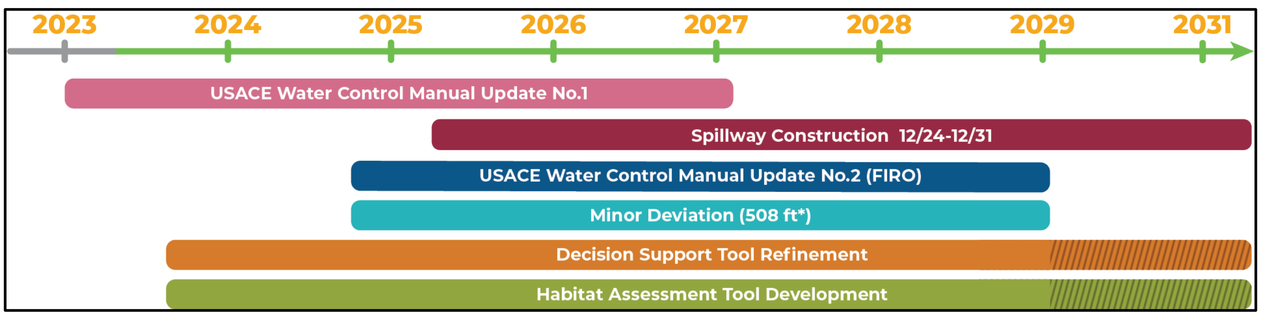


Figure 13: FIRO Implementation Roadmap and Schedule

FIRO (Minor) Deviation and Decision Support Tool Refinement

To support the incorporation of FIRO into WCM Update No. 2, OCWD and the USACE are working to process a deviation to the WCM to temporarily increase the elevation of the Conservation Pool to 508 feet msl for a five-year period. This is a minor deviation (also called a FIRO Deviation) and there are multiple reasons for seeking this deviation. The first is to test FIRO at an intermediate Conservation Pool elevation, continue developing decision support tools and forecast tools specific to Prado Dam operations, and develop assessment tools to better understand how FIRO may affect the habitat behind Prado Dam. The second reason is to act as a bridge until WCM Update No. 2 is implemented. A five-year period was selected to provide sufficient time for wet years to occur to test FIRO and to ensure this additional storage was available for stormwater capture in case there were delays in implementing WCM Update No. 2. Based on FVA modeling, the FIRO deviation (508 feet) will provide an average of 2,000 afy of additional recharge to the Basin.

Multiple Decision Support Tools (DST's) specific to Prado Dam were developed by CW3E and the USACE during the development of the FVA. These tools have already proven useful and are being used by USACE Los Angeles District Reservoir Regulation staff. USACE, CW3E, and OCWD staff regularly meet to discuss these tools and will continue to refine them over time to increase their value. This is expected to be an ongoing process as forecast tools improve, and new technologies come to the fore. In the long term, FIRO tools will need to be incorporated into the USACE's existing toolset, including the Corps Water Management System (CWMS). In the short term, improvements envisioned include a FIRO Dashboard and a dedicated website that include selected links and tools that are useful to USACE reservoir operators.

Pros

- The Final Viability Assessment (FVA, FIRO_Prado_FVA.pdf (ocwd.com)) showed that FIRO is viable at Prado Dam
- Additional water supply is estimated to average 4,000 to 6,000 afy depending on the final Conservation Pool elevation (510 feet or 512 feet)
- Can benefit habitat by providing additional water

Cons

- Unknown potential impact to the environment

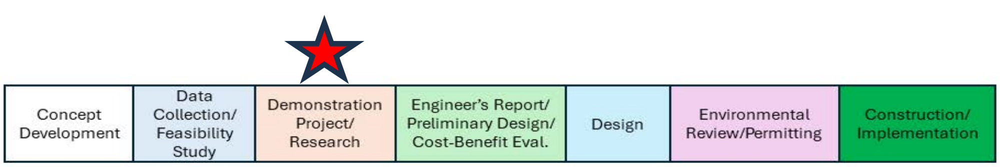
Estimated Costs

Estimated cost to implement FIRO at Prado Dam, including Water Control Manual Update No. 2, is approximately $2,800,000. This includes $1,000,000 in federal funding through the USACE for Water Control Manual Update No. 2.

Estimated Benefits

FIRO is estimated to provide an average of 4,000 to 6,000 afy of water captured and recharged depending on the final target elevation (510 feet or 512 feet). This is worth $4M to $6M per year based on imported water costs of $1,000/af.

Project Status



b. Prado Dam Habitat Assessment Tool Development

One of the biggest remaining challenges to implementing FIRO at Prado Dam is understanding the various factors affecting habitat health behind Prado Dam. Increased inundation caused by water conservation activities can affect habitat depending on the time of year, duration of inundation, and frequency. As shown on Figure 14, there are multiple factors, including habitat, that must be considered when implementing FIRO at Prado Dam.

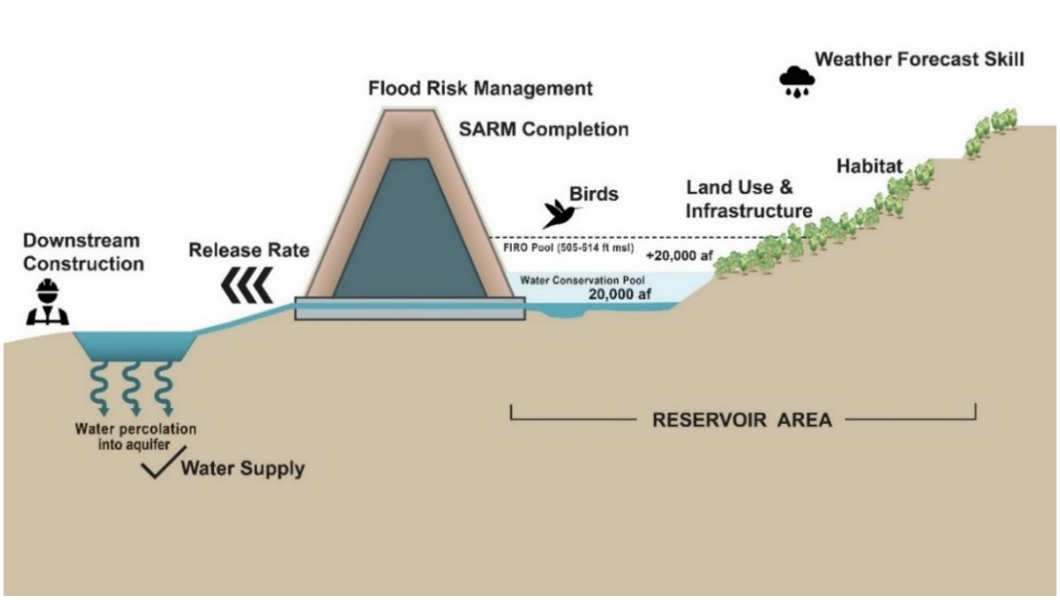


Figure 14: Issues that Need to be Considered in Potential FIRO Conservation Pool

The Final Viability Assessment and U.S. Fish and Wildlife Service (USFWS) recommend expanded monitoring of habitat above elevation 505 feet msl to determine if the additional water will have impacts on riparian habitat. OCWD has established habitat values that will be monitored for the Prado Basin forest and its inhabitants. Specific recommendations for expanded habitat monitoring are as follows:

- Expand the existing monitoring program above elevation 505 feet msl identify potential environmental impacts, and as needed, implement adaptive management program to offset impacts.
- Preemptively and adaptively manage adequate riparian habitat to offset potential temporary or long-term impacts associated with FIRO.
- Explore and study opportunities for habitat value creation made possible by FIRO. For example, continue experimenting with habitat islands and flood irrigation pathways above elevation 505 feet msl to expand the area benefiting from temporary flood irrigation, which could offset potential environmental impacts in the lower elevations associated with FIRO.

- Develop new methods to study riparian habitat responses to prolonged dry and wet conditions.
- Create operational procedures based on observed field conditions to maximize viable vireo habitat and success.

These recommendations are timely in that over the past several years, OCWD Natural Resources staff have worked with the USFWS to employ a "Stacked Cube Method" to assess habitat suitability, particularly for the endangered least Bell's vireo. Both OCWD and the USFWS have concluded that this methodology is not useful. In the Biological Opinion for the FIRO Deviation, the USFWS is requiring OCWD to develop a new approach and tools to better understand the critical factors affecting habitat health and least Bell's vireo population and distribution. One approach being explored is to develop a multi-parameter model to better understand the interconnectivity of habitat health and vireo populations to other factors, such as inundation, inundation duration, groundwater levels, Santa Ana River base flow, temperature, fire, and others.

One key data collection method to support the multi-parameter habitat model is Light Detection and Ranging (LiDAR) collected by aircraft. LIDAR has the potential to measure habitat structure and density to determine if it is suitably for vireo nesting. If successfully developed a LiDAR-based Vireo Habitat suitability model would provide a complete picture of habitat structure and quickly identify areas that need further evaluation or study. Additionally, it would allow for the riparian habitat to be monitored overtime and could quantify OCWD mitigation obligations and status. Quantifying habitat changes is critical for resources agencies to permit advancements in stormwater capture.

<u>Pros</u>

- Develop better understanding of factors affecting habitat health
- May show that increased water conservation is a net positive for the environment
- Will provide tool to more accurately assess mitigation that may be needed
- May ultimately reduce the field data collection needs
- Model approach is likely transferrable to other parts of the SAR watershed as well as other watersheds

<u>Cons</u>

- May take time to develop due to data gaps
- Additional time-series data may be needed to train the model and improve predictive capabilities

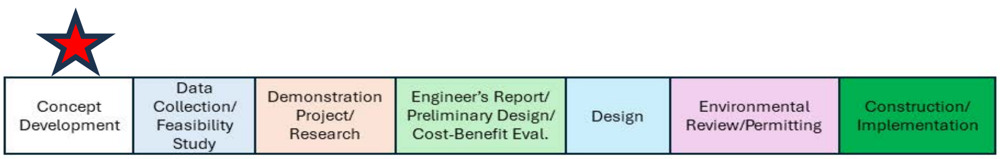
<u>Estimated Costs</u>

Working with CW3E, it is estimated that development of a multi-parameter model will take 3 years and cost approximately $500,000. Other consultants will be employed to create a model in parallel with CW3E to validate the approach and demonstrate to USFWS that such a model is viable.

Estimated Benefits

Additional tools to understand the effects of water conservation on the habitat behind Prado Dam. This could result in reduced mitigation requirements and ultimately, reduced field time to monitor habitat conditions.

Project Status



c. Local Stormwater Capture

During storm events, OCWD coordinates with the USACE to reduce the outflow from Prado Dam to allow for increased capture of local storm flows to the Santa Ana River below Prado Dam. While this is effective, there may be additional opportunities to capture stormwater, including storm drains near OCWD's recharge facilities as well as municipal stormwater in other facilities not owned by OCWD. This study would examine the potential of increasing local stormwater capture directly to OCWD's recharge facilities and distributed recharge of municipal stormwater.

Pros

- Capture of local stormwater that otherwise is lost to the ocean

Cons

- Conveyance to OCWD recharge facilities

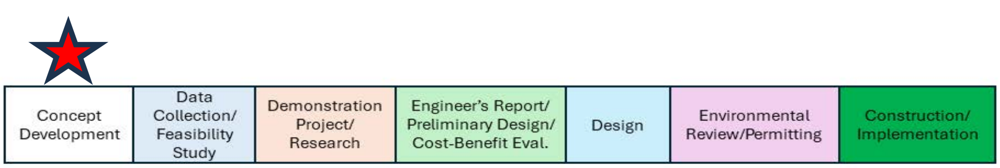
Estimated Costs

Estimated costs have not been developed.

Estimated Benefits

Estimated benefits have not been developed.

Project Status



9. Prado Basin Sediment Management Regional Strategic Plan

Prado Dam is an effective trap for sediment, trapping more than 95% of all sediment behind the dam. As a result, sediment accumulation behind Prado Dam is reducing the storage of the Conservation Pool.

OCWD is responsible for removing some sediment from the dam over the next 10 years. This requirement was imposed by the USFWS to mitigate the estimated additional sedimentation caused by Conservation Pool activities. However, this removal will not keep up with the volume projected to enter the basin over time. To make progress and minimize future impacts to the Conservation Pool, a Prado Basin Sediment Regional Strategic Plan needs to be developed to build a coalition of stakeholders and interested parties, such as the USACE, Orange County, and beach cities that are dealing with the loss of sand and threats to near-shore infrastructure.

Multiple tools will be used to measure and monitor sediment accumulation at Prado Dam, including Aerial Light Detection and Ranging (LiDAR) collected by aircraft. LIDAR has the potential to be critical tool to monitor understand sedimentation transport throughout the watershed. OCWD has piloted LiDAR in Prado Basin to identify locations where sedimentation and erosion are occurring. On a watershed scale, LiDAR could be used to study and monitor sediment transport. This information could be used to design projects to reduce sediment deposition in Prado Basin and maintain the size of the water conservation pool behind Prado Dam.

Pros

- Reduce the impact of sedimentation on water conservation pool storage
- Increase resiliency of near-shore infrastructure
- Increase participation of parties willing to pay for sediment

Cons

- Will take time
- Funding

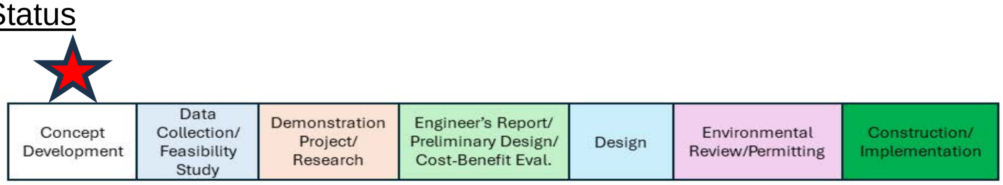
Estimated Costs

Estimated costs have not been developed.

Estimated Benefits

Benefit of reducing loss of water conservation storage is having to import less water to meet demands.

Project Status



RECHARGE FACILITIES

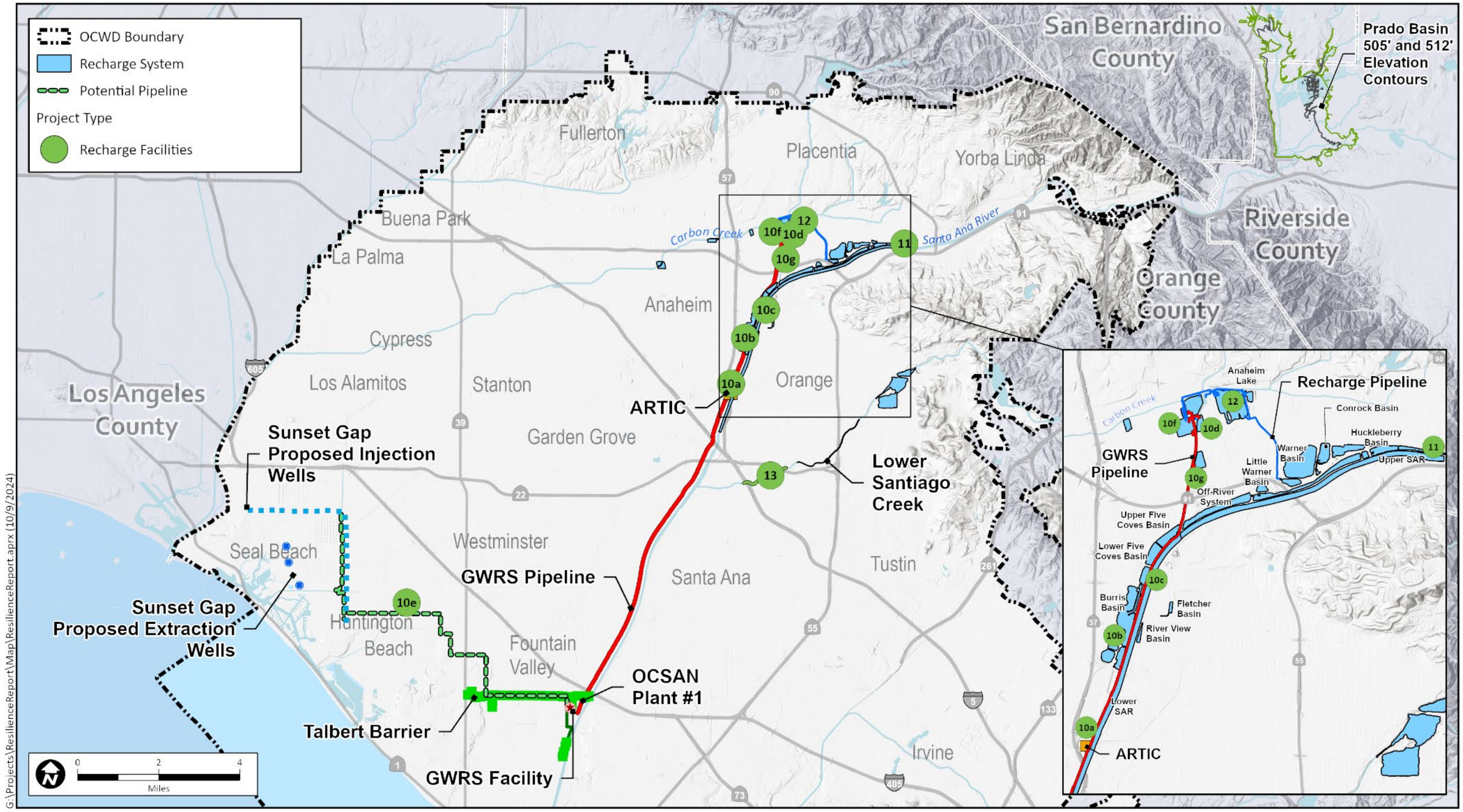


Figure 15: Location of Priority Recharge Facility Projects

10. GWRS Recharge Optimization

GWRS water is recharged to the Basin via the Talbert Seawater Intrusion Barrier, Mid-Basin Injection wells and four surface recharge basins, Miraloma, La Palma, Miller, and Kraemer Basins. With the GWRS Final Expansion, up to 130 mgd of water is available for recharge. Generally, these facilities are capable of accepting and recharging GWRS flows; however, there are periods of time, particularly in the winter months when groundwater pumping is reduced and stormwater is available for recharge, that it is not possible to maximize the recharge of GWRS supplies.

Reduced groundwater pumping affects injection rates at the Talbert Barrier. During peak summer months when groundwater pumping is highest, injection rates can be as high as 24 mgd. However, during winter months, injection rates can be as low as 11 mgd. Stormwater can also impair the recharge of GWRS water. Miraloma and La Palma Basins are dedicated to the recharge of GWRS water, however, some GWRS flows need to be diverted to Kraemer and Miller Basins, which also can recharge stormwater.

To ensure the maximum use of GWRS flows, there are seven project concepts that will be explored as described below. Since they all achieve the same objective, they will be considered together to identify the most cost-effective project to move forward to the next stage of planning and implementation.

a. Injection Wells at ARTIC and Ball Road Basin

The use of injection wells to recharge GWRS water frees up storage/recharge capacity in the surface water recharge system. In turn, the freed capacity can be used for storage/recharge of imported water, Santa Ana River base flow, storm flows, and/or operational flexibility. The District has several existing options for additional injection wells for recharge, including at the Anaheim Regional Transportation Intermodal Center (ARTIC) and at Ball Road Basin.

The District entered a 30-year lease in January 2013 for land to house an injection well at ARTIC; which terminates in January 2043. The site is immediately adjacent to the existing GWRS pipeline and is approximately 1 mile south of the District’s Burris Basin. The proposed injection well is estimated to cost $3 to $4 million and recharge 0.8 to 1.2 mgd. Two monitoring wells downgradient will likely be required. Including these monitoring wells, the estimated project cost is $5-6 million.

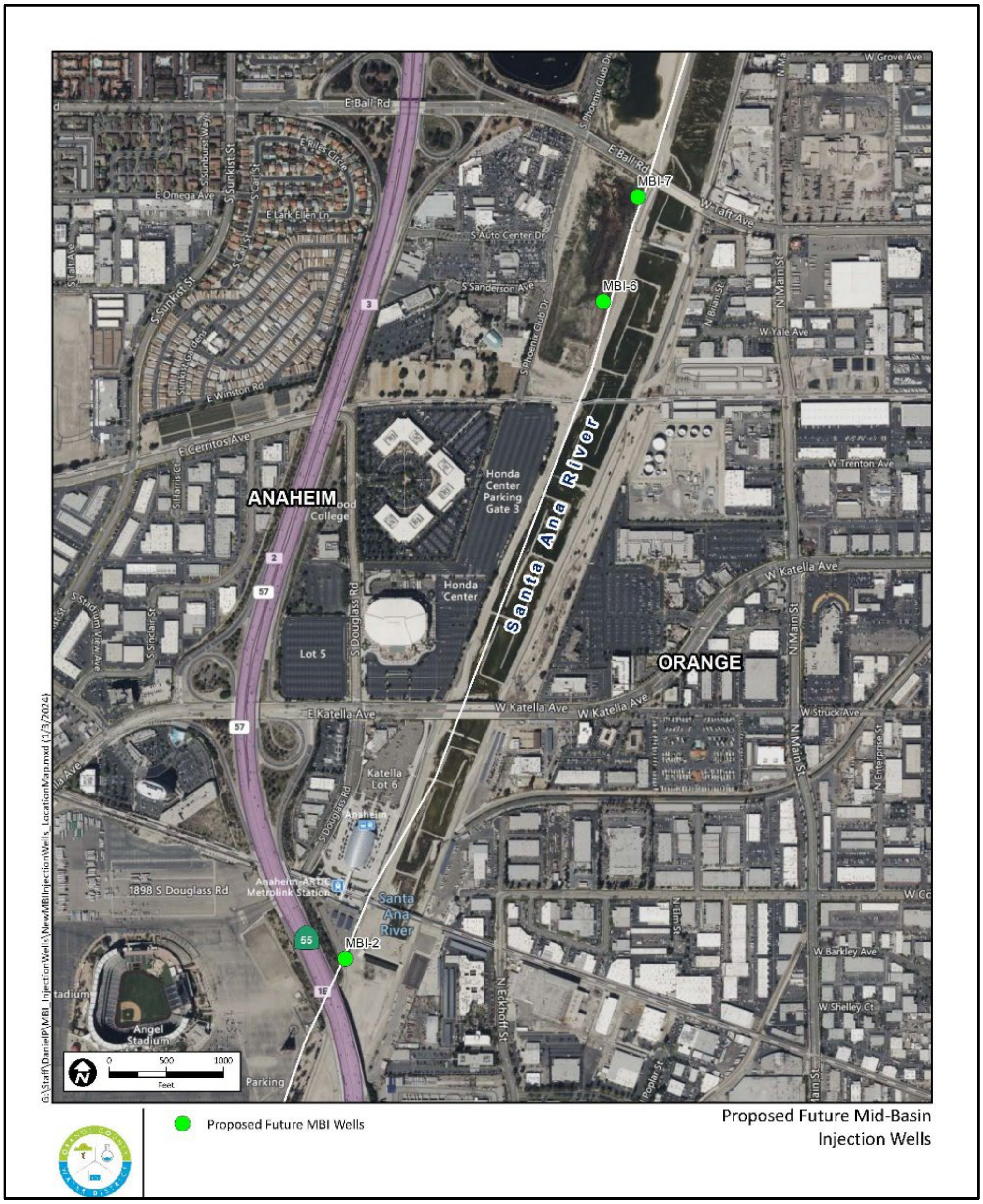


Figure 16: Potential Mid-Basin Injection Well Sites at ARTIC (MBI-2) and Ball Road Basin (MBI-6 and 7)

Permanent easements for land to house two injection wells and one monitoring well at the District's former Ball Road Basin were granted in 2019. The injection well sites are immediately adjacent to the existing GWRS pipeline and are approximately 250 feet and 1,050 feet south of the District's Burris Basin. Construction of the two injection wells, monitoring well with the existing easement, and second monitoring well is estimated to cost $8-10 million and recharge 2-4.5 mgd. Figure 16 shows where the three well sites are located.

Pros

- Additional capacity to recharge GWRS water
- Would take water off GWRS pipeline before Burris Basin where the diameter and flow capacity decreases
- Additional recharge into the Principal aquifer

Cons

- Additional maintenance

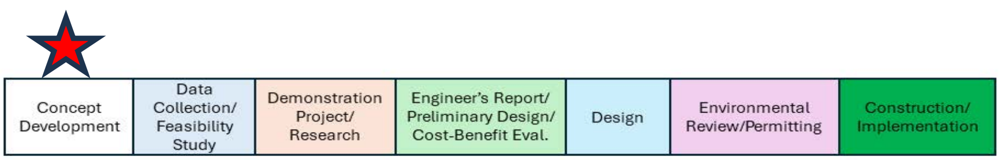
Estimated Costs

Estimated costs for all three wells, including required monitoring wells is $13M to $16M.

Estimated Benefits

Estimated additional recharge ranges from 2.8 to 5.7mgd or 3,000 to 6,400 afy.

Project Status



b. GWRS Burris Basin Turnout

This project would allow GWRS water to be discharged to Burris Basin and pumped to Santiago Basins, providing increased operational flexibility and increased recharge capacity when other locations, such the Talbert Barrier, are operating at low capacities. An overall plan for the distribution of GWRS water would be needed to determine if this additional capacity is needed.

There is also the potential that this turnout could be modified to serve the City of Anaheim's OC Riverwalk Project, which would require the delivery of GWRS water to a section of the Santa Ana River channel near Anaheim Stadium.

Pros

- Increased flexibility in recharging GWRS water
- Would allow for maintenance of GWRS receiving facilities
- Could supply water to Santiago Creek, including area through the City of Santa Ana

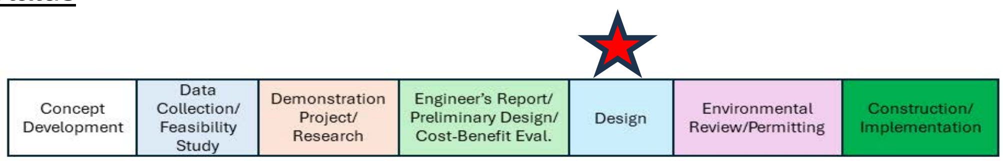
Cons

- Dechlorination of water before discharge to Burris Basin

Estimated Costs
The design of the turnout is currently at 90% completion. The estimated cost to construct the turnout is $9M. O&M costs would include dechlorination.

Estimated Benefits
No estimated benefits have been developed.

Project Status



c. Recharge of GWRS Water Using Horizontal Collector Well

A horizontal collector well is a radial well that is commonly used to extract water from an aquifer near a surface water source, such as a river or lake. These wells can have large capacities, achieving extraction rates of up to 40 mgd. The first collector well was constructed in London in 1933. This type of well is used extensively in Europe. In the United States, cities using these types of wells include Lincoln, NE, Louisville, KY, and Kansas City, MO. The Sonoma County Water Agency in northern California uses six horizontal collector wells to extract water from below the Russian River for water supply.

The wells are constructed by installing a large caisson (large diameter vertical pipe), typically constructed of reinforced concrete, and then jacking screened conduits (also referred to as laterals or lateral well screens) horizontally outwards up to 200 feet. The radial arrangement of screens forms a large infiltration gallery with a single central withdrawal point. As a point of comparison, a typical recharge well in the Orange County groundwater basin could have 200 feet of screen. A horizontal collector well could have six 200-foot laterals, resulting in 1,200 feet of screen. Figure 17 shows a typical horizontal collector well configuration.

This type of well could be used to recharge GWRS water. With the completion of the Final Expansion, additional locations to recharge GWRS water will be useful to free up capacity in basins used to capture stormwater and to provide operational flexibility. Thus far, staff have identified a potential location near Lincoln Basin where hydrogeologic conditions appear favorable. A geophysical survey was conducted in the Santa Ana River channel and in Lincoln and Five Coves Basins that confirmed that geologic conditions in the potential well location will allow the water recharged to enter the Principal aquifer, which is the aquifer in which most groundwater production takes place.

Groundwater modeling suggests that 10 to 20 mgd of recharge could be achieved while limiting the rise of groundwater to within 30 feet of the ground surface to not interfere with ongoing surface recharge from the Santa Ana River and adjacent facilities. The estimated cost for the well and other facilities are shown in the table below.

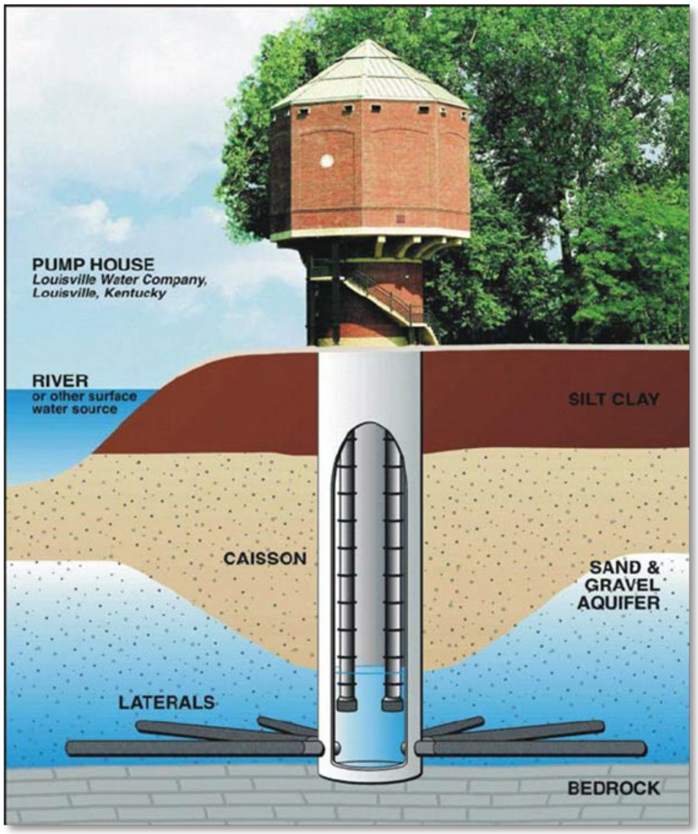


Figure 17: Typical Horizontal Collector Well

<u>Pros</u>

- A potentially more cost-effective way to recharge GWRS water compared to traditional injection wells
- Could free up capacity in Kraemer and Miller Basins for stormwater recharge
- Can be constructed on OCWD property (near Lincoln Basin)
- Would primarily recharge Principal aquifer if constructed near Lincoln Basin

<u>Cons</u>

- Groundwater levels must be less than 150 feet when the system is constructed
- Well design typically used for pumping and not recharge
- Could require booster pump at Burris Basin

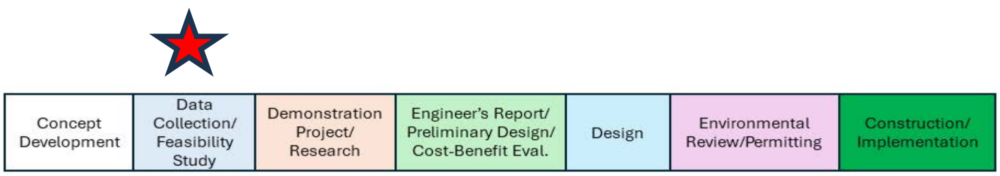
<u>Estimated Costs</u>

Item	Estimated Cost
Horizontal Collector Well	$4.5-5M
Monitoring Wells (2)	$2.4M
Backwash Pump	$250,000
Piping, Controls, etc.	$500,000
Total	$7.7-8.2M

<u>Estimated Benefits</u>

The well could be located on OCWD property and could free up capacity in Kraemer and Miller Basins for stormwater recharge. Potentially more cost-effective than traditional injection wells.

<u>Project Status</u>



d. <u>Permitting Additional Locations for GWRS Recharge</u>

Permitting additional recharge locations may provide increased recharge capacity, particularly during high basin conditions such as those experienced during the winters of 2022-23 and 2023-24. Additional recharge locations could also provide operational flexibility such as the ability to easily drain permitted basins to another location for maintenance or to prepare for storm flows. To achieve recharge rates that match GWRS production, the recharge basins must be partially or filled which can diminish the storage available for stormwater capture. When a basin is storing GWRS water, there are limitations about where that water can be sent when it comes time for a basin cleaning or to maximize percolation. A key concept to maximizing annual recharge is to percolate water first and store it second. Having additional locations available for GWRS percolation will increase the overall surface recharge performance.

Recharge of GWRS water requires a permit from the Santa Ana Regional Water Quality Control Board (Regional Board). In writing the permit, the Regional Board receives conditional project approval and recommended water recycling requirements from the State Water Resources Control Board Division of Drinking Water (DDW). Therefore, it is necessary to coordinate with both DDW and the Regional Board to permit additional recharge locations. Lead time to permit new locations is estimated at one to three years, depending on the recharge location. Consultant support may be required.

Elements that may impact the complexity of permitting additional locations include: 1) whether some permitting steps have already been completed; 2) whether additional supporting groundwater modeling is needed; and 3) whether the proposed recharge location is considered a Water of the United States (WOTUS).

OCWD staff have completed required groundwater modeling and associated identification of project boundary areas and project monitoring wells for some potential recharge locations, namely: *Santiago Basins, Santiago Creek to Hart Part, lower Santiago Creek to the confluence with the Santa Ana River, Santa Ana River from Carbon Diversion to Orangewood Avenue, and Burris Basin*. These locations are identified as “Proposed GWRS Recharge Facilities” in Figure 18. DDW has issued their conditional approval for recharge in these locations. To continue to full permitting of these areas, OCWD would need to submit a Report of Waste Discharge (ROWD) and permit application to the Regional Board. Additional consultation with DDW may be needed if proposed project conditions have changed since DDW issued their conditional approval in 2022 (e.g., if recharge in the Santa Ana River is proposed below Orangewood or if proposed recharge volumes are greater than modeled).

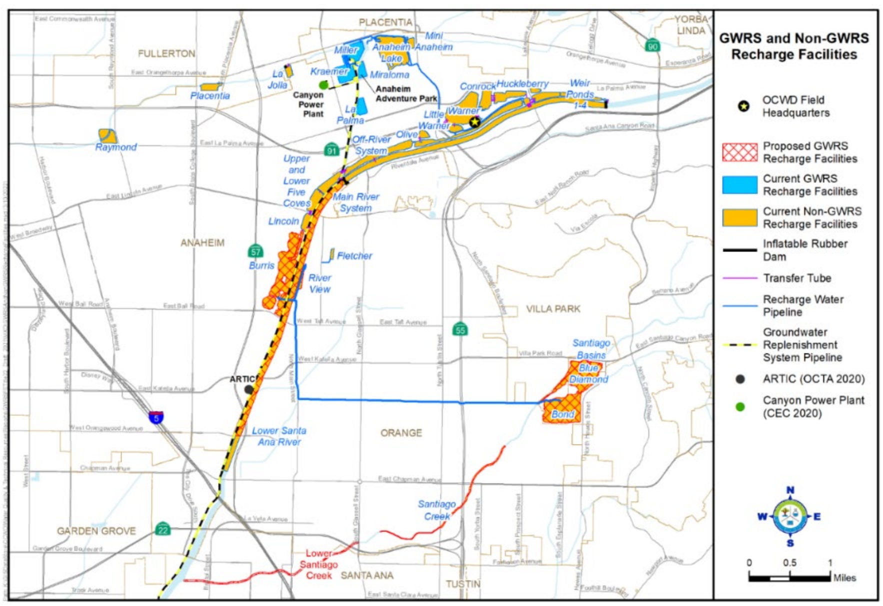


Figure 18: Current GWRS Surface Recharge Facilities and Proposed Surface Recharge Facilities with Completed Groundwater Modeling

For proposed recharge locations outside of the above list, a modification or updated to the GWRS Title 22 Engineering Report may be needed. Additional groundwater modeling to identify the direction and velocity of recharged water, project boundary areas, and project monitoring wells may also be needed. These project submittals would need to be reviewed and approved by DDW. A ROWD and permit application could then be submitted to the Regional Board.

If a recharge location is considered a WOTUS, a National Pollutant Discharge Elimination System (NPDES) permit would be needed, as compared to current recharge GWRS locations which only require a Waste Discharge Requirements (WDR) permit. The *Santa Ana River*, *Santiago Basins*, and *Santiago Creek* are WOTUS and would require an NPDES permit as discharges tributary to these waterbodies. The Regional Board has indicated that *Anaheim Lake* may also be a WOTUS. For permitting of GWRS recharge to Anaheim Lake, the USACE may need to be consulted for a determination of federal jurisdiction to confirm the correct permitting vehicle. GWRS recharge to a WOTUS would need to meet surface water quality objectives in the Santa Ana Basin Plan including a chlorine limit of 0.1 mg/L and pH limit of 6.5 to 8.5. These limits are more stringent than the limits in the current GWRS permit and may require dechlorination and pH adjustment to meet. California Toxics Rule (CTR) standards and statewide aquatic toxicity standards for inland surface waters would also be applicable and are not currently required for recharge of GWRS water. NPDES permits carry an annual permit fee which escalates annually but, as of FY 23-24, is set at $3,576 plus 6,323 multiplied by the permitted flow, in mgd. Therefore, to minimize permit fees it may be beneficial to limit any permitted flows to WOTUS to the minimum flow that meets operational needs.

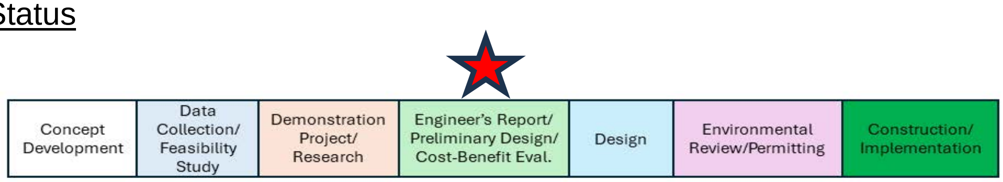
<u>Pros</u>
- Increased recharge capacity
- Increased operational flexibility

<u>Cons</u>
- Time to evaluate potential buffer zone
- May require additional monitoring wells
- May require replacement of production wells within the buffer zone
- May require chemical dechlorination or pH adjustment of GWRS water
- Potential for higher annual permit fees

<u>Estimated Costs</u>
No estimated costs have been developed.

<u>Estimated Benefits</u>
No estimated benefits have been developed.

<u>Project Status</u>



e. Supplying GWRS Water to Sunset Gap Barrier

GWRS water is one source of supply being evaluated for the proposed Sunset Gap Barrier. The barrier is estimated to require an annual average of 13 mgd of injection supply. However, seasonal variability would likely increase in the summer and decrease in the winter as basin water levels change. The pipeline would be separate, but roughly parallel to the Talbert Barrier pipeline until its western end, then continue northwesterly to Bolsa Chica Street in Seal Beach. At the anticipated flow, the GWRS pump station would be upgraded with an additional pump to supply the approximately 8-mile pipeline and barrier.

Pros

- Known water source controlled and supplied by OCWD
- No additional cost for the water
- Offsets need for/avoids cost of other potential projects to increase GWRS recharge capacity during winter/spring [winter/spring barrier injection supply demands will be estimated by modeling in the next few months]
- Relatively streamlined DDW permitting due to existing GWRS permit

Cons

- Expensive, but comparable to other source supplies
- 8-mile-long pipeline required
- GWRS recharge water will likely increase the outflow of groundwater from OC to LA (amount to be estimated by modeling in next few months)

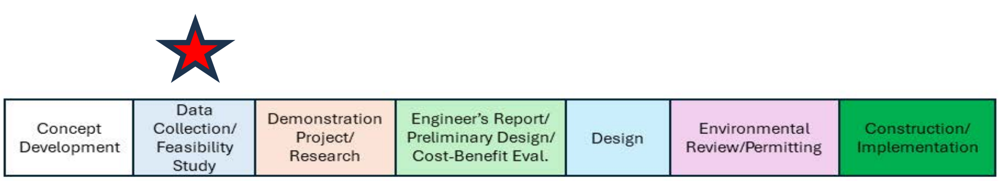
Estimated Costs

Preliminary pipeline-only construction cost is approximately $200M.

Estimated Benefits

Protects groundwater supply by controlling seawater intrusion into Huntington Beach, Seal Beach, Westminster, and beyond. Maintains OCWD's full compliance with the requirements of SGMA.

Project Status



f. Subsurface Recharge of GWRS Water

For this project, GWRS water would be recharged in shallow subsurface recharge galleries. These galleries could, for example, consist of a series of shallow, perforated pipes installed in various locations in the Forebay near the GWRS pipeline. Sites with favorable geology would have to be located and property may need to be purchased. Constraints to this approach include identifying methods to mitigate clogging and the need to comply with travel time restrictions for recharge of GWRS water.

Staff are looking into conducting small-scale testing of this method at La Palma Basin to assess the potential yield, costs, and performance of several types of subsurface recharge methods.

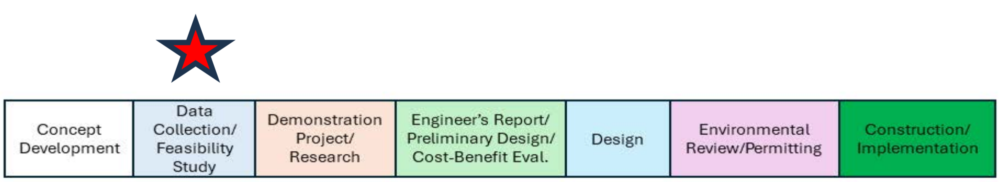
Pros
- Relatively inexpensive
- Can use property owned by others

Cons
- Systems will eventually clog and need to be redeveloped or abandoned
- Redevelopment methods and costs are unknown
- Unknown operational lifespan before becoming clogged
- Potentially expensive pipelines may be required

Estimated Costs
No estimated costs have been developed and will depend on site location and proximity to supply pipelines.

Estimated Benefits
No estimated benefits have been developed.

Project Status



g. Purchase Land for New Basins

OCWD's last two purchases of land for Miraloma and La Palma Basins were to provide recharge for GWRS water. Even with these two basins, there are times when Kraemer and Miller Basins are needed for GWRS water, thus competing with stormwater. The purchase of additional land for new recharge basins will need to be carefully evaluated to determine how much and in which locations new facilities are needed based on the availability of source water, proximity to conveyance, and hydrogeologic conditions. This is a conceptual project as no locations for new basins have been identified at this time.

Although adding additional injection wells is a viable option to increase GWRS recharge capacity, it is more cost-effective to purchase land for constructing surface recharge basins. A case in point is the unit cost per acre-feet of recharge for constructing La Palma Basin compared to four Mid-Basin Injection Wells as shown on Table 4. This shows that the unit cost per acre-feet of surface recharge is an order of magnitude less than injection well recharge. The costs presented in Table 4 are for capital costs only and do not include operations and maintenance costs.

It must be noted that although injection wells are more costly, they are often the only method of recharge that is viable to address a specific issue, such as seawater intrusion (Talbert Barrier) or addressing areas of low water levels (Mid-Basin Injection Wells). Another advantage is that wells require less space and can be incorporated into existing developments without encumbering or interfering with their uses.

Table 3: Comparison of Capital Costs per af of Recharge for La Palma Basin and Mid-Basin Injection Wells in Centennial Park

La Palma Basin (Surface Recharge)	
Land Purchase	$28,399,475
Other Costs	$8,185,976
Total Costs	$36,585,451
Total Recharge (af)	354,612
Time in Service (yrs.)	7
Avg Recharge (afy)	49,481
Cost/Avg afy Recharge	$739
Cost/af Total Recharge	$103

MBI Centennial Park* (Injection Recharge)	
Well Costs (4 wells)	$27,708,834
Mon. Well Cost (SAR-13)	$1,181,163
Total Costs	$28,889,997
Total Recharge (af)	25,759
Time in Service (yrs.)	4
Avg Recharge (afy)	6,720
Cost/Avg afy Recharge	$4,299
Cost/af Total Recharge	$1,122

*Does not include MBI-1

Pros

- Increased recharge capacity
- Maximize GWRS output
- Increased operational flexibility

Cons

- High cost of land
- Limited areas where hydrogeologic conditions are favorable and not impacted by the existing recharge system
- Potential challenges to constructing conveyance to new facilities
- Could be contrary to city desires

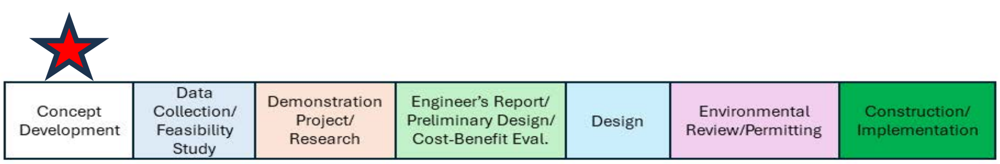
Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed. The Recharge Facilities Model could be used to estimate benefits once a potential facility is identified.

Project Status



11. Desilting Santa Ana River Flows

Suspended sediments in Santa Ana River water, especially during the storm season, contribute to clogging of the District's recharge facilities. High recharge rates obtained using GWRS and imported water show that the capacity of the recharge basins can be increased significantly if suspended sediment concentrations are reduced in the recharge water. The main goal of this project is to reduce suspended sediment concentrations in recharge water before it reaches the recharge facilities, thus increasing the District's overall recharge capacity, particularly for stormwater.

A large demonstration-scale Riverbed Filtration System (RFS) was constructed in the District's Off-River Channel that is comprised of a system of shallow horizontal perforated pipes that receive infiltrated water which is then conveyed via pipeline to nearby Olive Basin (Figure 19). The RFS operates by gravity and after several years of testing has shown to be able to double the recharge capacity of Olive Basin. Staff are now examining the potential of expanding this concept to the

Santa Ana River channel between Imperial Highway and Weir Canyon Road as well as constructing a system that could be pumped when water is needed during peak flow events. Such a system could produce enough water to supply Anaheim Lake and other deep basins with filtered water. Another benefit is the ability to capture water from the Santa Ana River during times when the inflatable rubber dams must be deflated for flood control purposes. Because the RFS is buried below the river channel, it would be able to continuously divert water regardless of the flow rate in the Santa Ana River channel. In addition to increasing the District's recharge capacity, it will reduce operations and maintenance costs because fewer basin cleanings will be required.

Figure 19: Construction of the Pilot Riverbed Filtration System

A variation of this approach is to construct subsurface collection and recharge systems (SCARS) that collect shallow, sediment-free water below the surface, and convey it to other locations such as parking lots, for recharge.

Pros

- Maximizing the recharge capacity of existing recharge basins
- Reducing flows lost to the ocean due to clogging and during high flows when the inflatable dams need to be deflated
- Can mix filtered water in basins receiving GWRS water without causing increased clogging
- Cost savings due to reduced need to clean the recharge basins

Cons

- Obtaining permits to construct the system in the SAR channel
- Mitigation for any environmental impact during construction
- Increases operational system complexity
- Would need to upsize Warner Transmission Pipeline to maximize the benefits

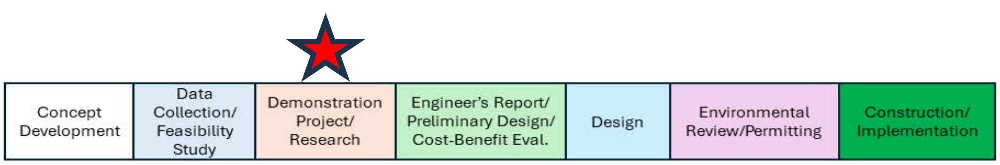
Estimated Costs

No estimated costs have been developed. A preliminary engineering design report is needed to develop a reliable estimated cost.

Estimated Benefits

Preliminary modeling suggests that 7,000 to 9,500 afy of increased recharge could be obtained. This is water that would otherwise be lost to the ocean. The annual value of this water is $7M to $9.5M.

Project Status



12. Anaheim Lake Recharge Basin Rehabilitation

Anaheim Lake is the District's oldest off-channel recharge basin, purchased in 1958 for the recharge of imported water. The basin was expanded by purchasing parcels to the west in the 1960s and 1970s. With the completion of the Warner Transmission Pipeline connecting Warner Basin with Anaheim Lake in the mid-1970s, Anaheim Lake began receiving and recharging Santa Ana River water. Santa Ana River water contains suspended sediment, especially in the winter when the District is diverting and recharging stormwater.

The suspended sediment in Santa Ana River water causes clogging of all basins that receive this water. To maintain recharge rates, basins are periodically drained, allowed to dry, and then mechanically cleaned using heavy equipment. The cleaning process on the flat basin bottom is effective at removing the clogging sediment; however, it is difficult to clean basin sidewalls. The process of cleaning the basin sidewalls doesn't remove much of the clogging layer but breaks it up. As a result, over time, this mixture of clean and clogged material accumulates on the basin sidewalls and degrades the recharge capacity of the sidewalls.

Because Anaheim Lake was expanded to the west by purchasing additional parcels, there are several peninsulas and an island that occupy space in the basin as shown in Figure 20. Removing these peninsulas and the island would increase basin storage by 300-600 af and create a large, uniform basin bottom that could be cleaned more efficiently. The native sand in the peninsulas would be re-purposed within the basin to regrade portions of the bottom and sidewalls.

Figure 20: Anaheim Lake

Finally, there is a fine-grained sedimentary layer that is located approximately 40 feet below the basin bottom. Monitoring well data shows that this fine-grained layer impedes the downward flow of water, causing mounding and forcing water in the basin to migrate laterally through the basin sidewalls. Nearby Kraemer Basin does not have a fine-grained layer underlying the basin. This could be one reason why it is able to recharge as much water as Anaheim Lake despite being half the size. Staff is exploring the possibility of over excavating a portion of the basin to remove the fine-grained layer and open a “window” of high permeability and thus increase the overall recharge capacity of the basin.

In summary, the Anaheim Lake Rehabilitation Project has three components:

1. Remove clogged sidewall material and regrade sidewalls;
2. Remove peninsulas and island to increase basin storage and create large, uniform bottom area; and,
3. Remove portion of fine-grained layer underlying the basin.

Pros

- Increased recharge capacity
- Increased basin storage
- Reduced cleaning time
- Could do with internal OCWD staff over a period of time

Cons

- Cost of disposing of poor-quality sediment removed from the basins
- Could take a long time using internal OCWD staff

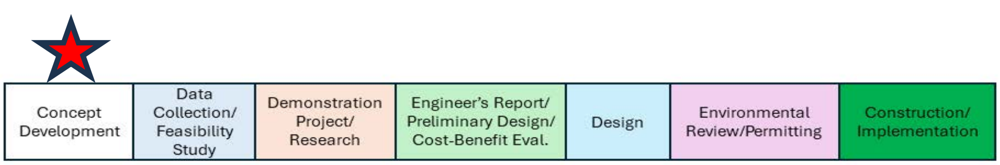
Estimated Costs

No estimated costs have been developed.

Estimated Benefits

Benefits are increased percolation rates, increased storage, and reduced cleaning time.

Project Status



13. Recharge in Lower Santiago Creek

OCWD has been using the upper portion of Santiago Creek for recharge for many years; however, the presence of the Hart Park parking lot has prevented the reach downstream of the park from being used. Testing has been conducted in the reach below Hart Park and it shows that up to 10 cfs of additional recharge could be attained in this reach. A feasibility study was conducted to look at supplying water to the lower reach by constructing facilities to bypass Hart Park or by using an existing storm drain that would be supplied with water from the Santiago Pipeline (Figure 21).

Pros

- Utilizes an unused portion of the creek bed for recharge
- Creates up to 10 cfs of additional recharge capacity
- Bypasses Hart Park
- Increases capacity to recharge stormwater and drain Santiago Basins between storms
- Creates flowing stream in an area frequented by the public and is supported by the City of Santa Ana

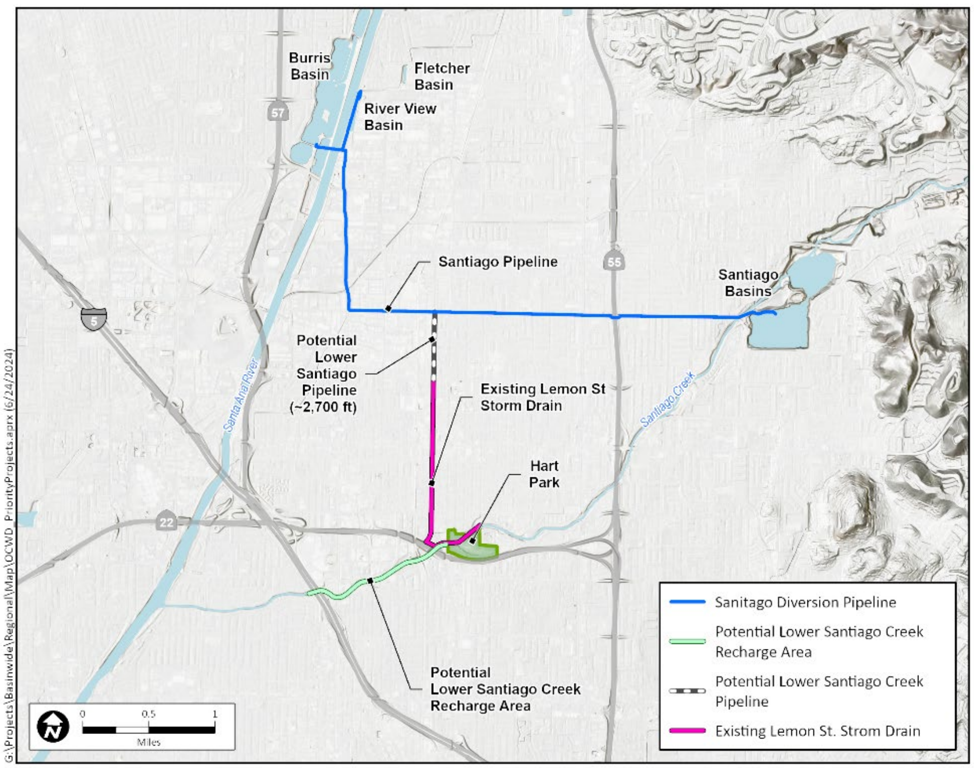


Figure 21: Santiago Creek and Pipeline

Cons

- Routing water past Lawn Bowling Center parking lot
- Creates expectation of water in the channel by the public
- Potential for midge fly issues
- Will have to get permission to periodically maintain this stretch of the creek

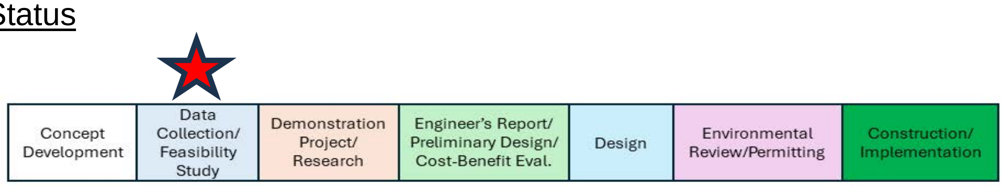
Estimated Costs

Based on the 2015 Feasibility Study, the cost to install a pipeline from Santiago Pipeline to the storm drain and constructing a drain through the Lawn Bowling Center parking lot is approximately $500,000.

Estimated Benefits

Increased recharge capacity of 10 cfs. Modeling shows an average of 200 to 300 afy of additional recharge. Peak wet year recharge is approximately 900 af.

Project Status



OPERATIONAL IMPROVEMENTS

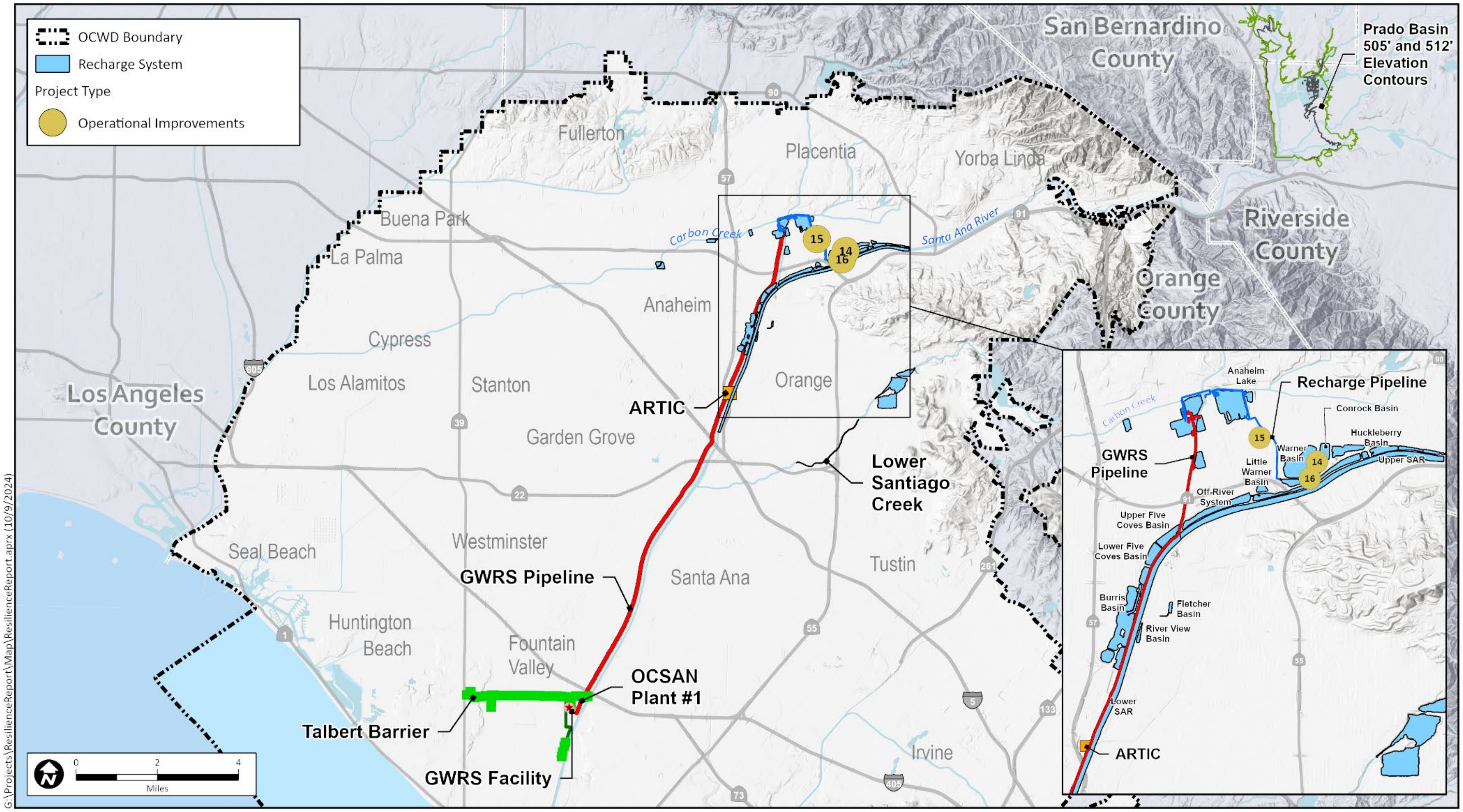


Figure 22: Location of Priority Operational Improvement Projects

14. Warner System Optimization

The Warner System includes the following recharge basins: Huckleberry Basin, Conrock Basin, Warner Basin, and Little Warner Basin as shown in Figure 23.

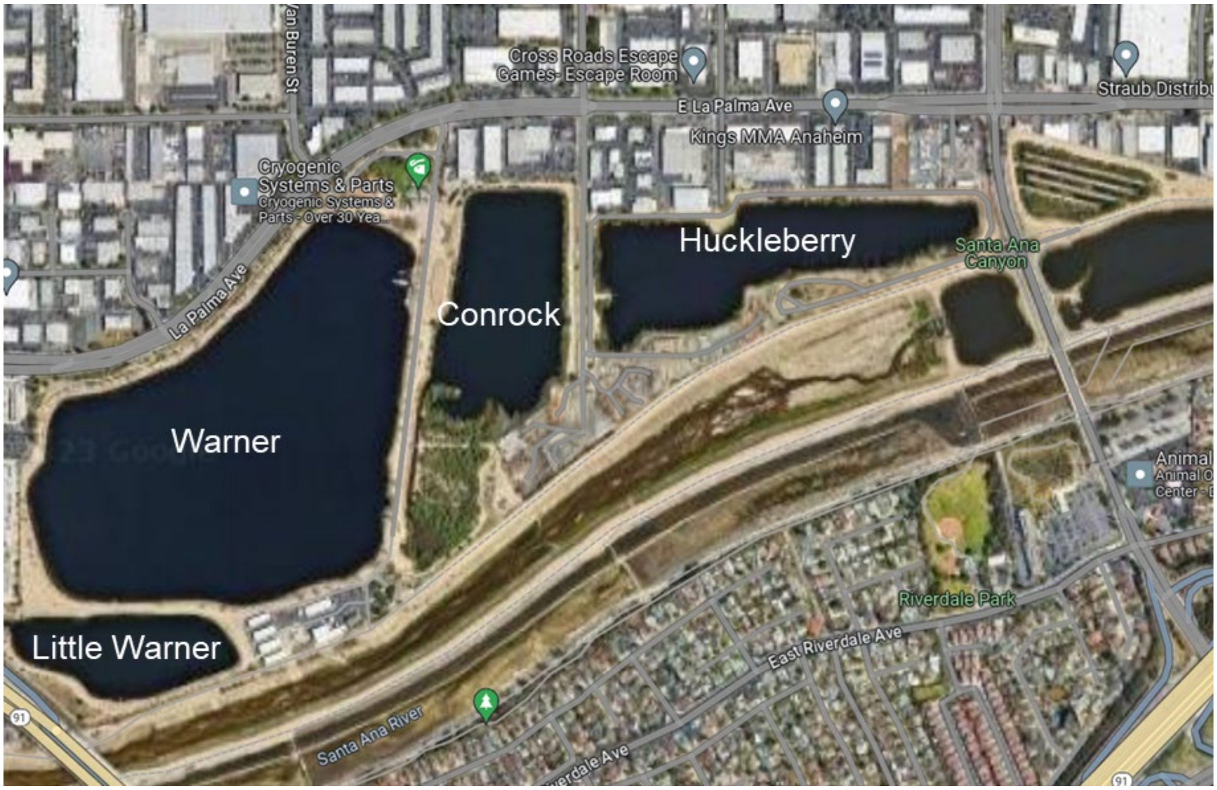


Figure 23: Warner Basin System

Santa Ana River (SAR) water is diverted at the Imperial Rubber Dam and transferred through the Weir Pond System which desilts the water. Once SAR water reaches Weir Pond 4, it is conveyed to the Warner System where it flows in sequence through Huckleberry Basin, Conrock Basin, Warner Basin, and then to Little Warner Basin. Once reaching Little Warner Basin, water is then conveyed to Anaheim Lake and other basins downstream of Anaheim Lake.

Warner Basin is a large basin with a storage capacity of 2,600 af. The entire Warner System has a storage capacity of 4,300 af, which represents 16 percent of the District's recharge system storage capacity (26,400 af). The Warner Basin System is ideally situated to capture stormwater from the Santa Ana River. Currently, these basins have to fill to the top before they begin to transfer water to the next basin. This can slow down the rate of filling and draining the basins. To optimize the use of Warner System storage, District staff have designed the installation of large diameter transfer tubes to be installed at the base of Huckleberry and Conrock Basins.

It is estimated that full utilization of Warner System storage for stormwater capture would yield up to 4,000 afy of stormwater that would otherwise be lost to the ocean. This is solely based on having the storage available for stormwater capture. Cleaning Warner Basin regularly will further increase the volume of stormwater captured and recharged. Constructing these facilities would require these basins to be offline for several months. Regular cleaning of Warner Basin would require the basins to be offline for several months every summer to fall.

Pros

- Increase pre-storm season available storage by 4,000 acre-feet
- Increase recharge capacity of existing basin by cleaning annually

Cons

- Reduces time Warner Basin is available for other recreational uses

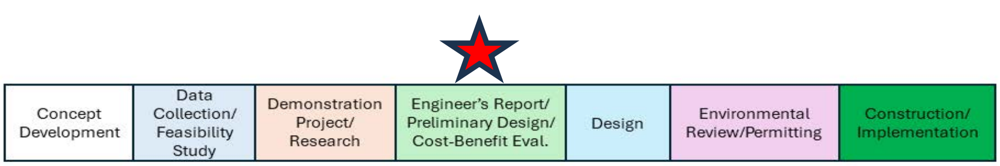
Estimated Costs

Estimated cost is approximately $6,000,000. The project design is 30% design complete.

Estimated Benefits

Benefits are increased stormwater capture and recharge. It is estimated that an additional 4,000 afy of stormwater capture will occur in an average year. This benefit would be greater during wet years.

Project Status



15. Recharge System Conveyance Optimization Study

There are locations in the recharge system that limit the amount of water that can be conveyed, particularly downstream of Imperial Rubber Dam. At times this can limit the capture of local storm flow (below Prado Dam) and can increase the amount of time it takes to drain water captured in the Prado Dam Conservation Pool. The conveyance bottlenecks constrain filling the recharge facilities downstream of Imperial Rubber Dam. Locations that are currently limiting flowrates include:

1. Warner to Anaheim Pipeline;
2. Lakeview Transfer Tube; and,
3. Off-River at Olive Basin.

The 66-inch diameter Reinforced Concrete Pipe (RCP) Warner-Anaheim Lake Pipeline conveys Santa Ana River flows from Little Warner Basin to Anaheim Lake for infiltration in the Deep Basin System (Figure 24). Because it operates via gravity, the flow capacity is dependent upon the water level elevations in both Little Warner Basin and Anaheim Lake with a maximum capacity of 170 cfs. When Anaheim Lake and downstream basins are clean and have available storage, they can receive more than 170 cfs, which means the Warner-Anaheim Lake pipeline is a constraint to capturing water, especially stormwater.

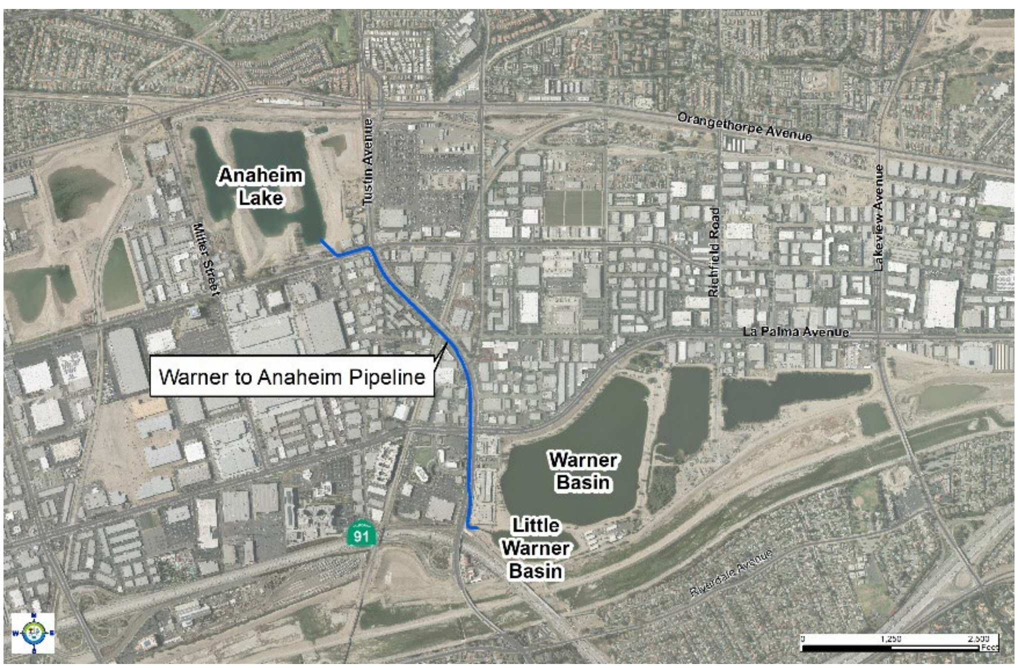


Figure 24: Location of Warner-Anaheim Lake Pipeline

Operational improvements that increase the volume of water conveyed to Anaheim Lake would increase the recharge system capacity. Options include (1) constructing a second gravity-fed pipeline from Little Warner Basin to Anaheim Lake that would effectively double the conveyance capacity, (2) building a pump station, and (3) increasing the existing pipeline's capacity with pipe replacement, pipe bursting, pipe lining, and/or adjusting the available head at the Little Warner inlet.

There is a 7 x 7 box culvert at Lakeview Avenue that allows for the transfer of water from Weir Pond 3 to Weir Pond 4. The culvert was structurally reinforced in 2011 which reduced the flow area. The recommended maximum flow rate that can be conveyed by this culvert is currently 350 cfs while downstream facilities can convey up to 500 cfs. To optimize downstream conveyance, it is proposed that a second, parallel box culvert be installed or the bank surrounding the culvert be hardened to prevent erosion which would increase conveyance capacity above 500 cfs.

In the Off-River Channel at Olive Basin there is a railroad trestle where flows in the Off-River become constricted, which results in high velocities and the potential for erosion. The current typical flow that can be safely conveyed at this location is 200 cfs. To increase conveyance at this location, it is proposed to modify the Off-River Channel to remove the restriction and allow water to flow over a wider area. The goal would be to increase the maximum conveyance at this location to 300 cfs.

<u>Pros</u>

- Maximizes the flow of water downstream of Imperial Rubber Dam
- Increased capture of stormwater
- Faster draining of the Prado Dam Conservation Pool

<u>Cons</u>

- Could be challenging to expand Warner-Anaheim Pipeline in major thoroughfare (Tustin Ave)

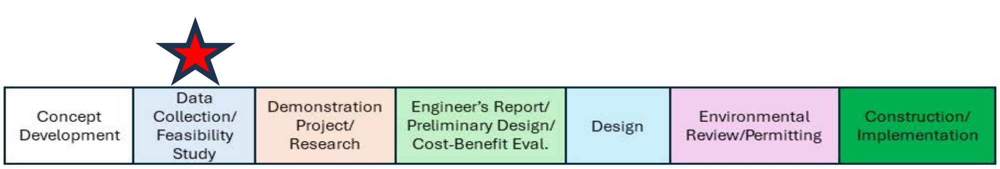
<u>Estimated Costs</u>

No estimated costs have been developed.

<u>Estimated Benefits</u>

Preliminary recharge modeling suggests that increasing the capacity of the Warner-Anaheim Pipeline could increase recharge in Anaheim Lake and other basins by up to 2,000 afy.

<u>Project Status</u>



16. Zero-Emission Vehicle Charging Infrastructure

State air emission regulations issued by the California Air Resources Board (CARB) require the District's medium and heavy-duty on-road vehicles to transition from internal combustion engines to zero-emission vehicles. Commercially available zero-emission vehicles include battery operated (electric), plug-in electric hybrids, and hydrogen power sources. The most commercially available source is electric. The transition to electric vehicles will require the construction of infrastructure to charge the vehicles. The District currently has 39 vehicles subject to the regulation, which are located at all three campuses: Fountain Valley, Field Headquarters, and Prado. Fountain Valley and Prado are serviced by Southern California Edison while Field Headquarters is serviced by the City of Anaheim. Projects to construct the charging infrastructure are required at all three locations, as well as the gradual purchase of electric vehicles.

Figure 25: Example Large Truck Charging Station

Pros

- Compliance with regulatory mandates
- Reduction in fuel expenses
- Early adoption allows the use of utility provided funding for infrastructure.

Cons

- Time and cost to construct the projects

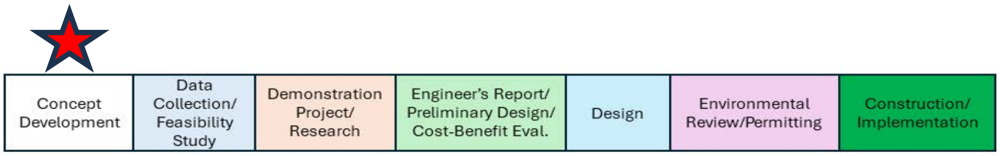
Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.

Project Status



APPENDIX B

SUPPLEMENTAL PROJECT DESCRIPTIONS

Section

Tables

Figures

This section presents the descriptions of supplemental projects. Work on supplemental projects will take place if the need arises or if potential grant opportunities develop. Project numbers have been assigned for those projects that have written descriptions. Note that the level of detail in the project descriptions varies. Projects without descriptions are conceptual.

Table 1: Supplemental Projects List

Proj No.	Asset	Project Name
BASIN MANAGEMENT		
17	Groundwater Basin	West Orange County Enhanced Pumping
18	Groundwater Basin	South Orange County Storage
19	Natural Resources	OCWD Prado Basin and Wetlands Strategic Plan
	Groundwater Basin	Facilitate Investments by Producers to Increase Pumping Capacity
	Natural Resources	Arundo Removal Strategic Plan
WATER SUPPLY		
20	Santa Ana River	Capture of Carbon Canyon Diversion Flood Flows
21	Santa Ana River	Recovery of Evapotranspiration (ET) Loss in Prado Basin
22	Santa Ana River	New Basin Storage Above Prado Dam Water Conservation Pool
23	Santa Ana River	Off-Stream Stormwater Storage (Aliso Canyon Dam)
24	Groundwater Basin	Regional Stormwater Infiltration Facilities
25	Santa Ana River	Capturing Stormwater Runoff in Chantilly and Other Storm Drains
26	Groundwater Basin	Field-Scale Demonstration Test of In-Situ Removal of PFAS During Groundwater Recharge
27	Santa Ana River	Applying FIRO Tools at Corona Airport
	Santa Ana River	Purchase Upper Watershed Wastewater
	Groundwater Basin	FIRO at Villa Park Dam, Irvine Lake, Carbon Canyon Dam
RECHARGE FACILITIES		
28	Groundwater Basin	Enhanced Recharge in Santa Ana River between Five Coves & Lincoln Ave.
29	Groundwater Basin	Increased Lower SAR Recharge (below Ball Road)
30	Groundwater Basin	New River View Basin & New Lincoln Nursery Basin
31	Groundwater Basin	Turnout to SAR at Fletcher Channel-Riverview Basin Pipeline
32	Groundwater Basin	Expand Recharge Basin Footprints
33,34,35	Groundwater Basin	Increased Use of Carbon Creek System Recharge Facilities
OPERATIONAL IMPROVEMENTS		
36		New Lab/Office Building for Natural Resources and R&D Field Research
37	Groundwater Basin	Santiago Pipeline Connection to SAR
38	Groundwater Basin	GAP Treatment Plant & Other Modifications
39	Groundwater Basin	Mobile Sand Wash Plant
		Energy Supply Resilience

BASIN MANAGEMENT

17. West Orange County Enhanced Pumping

Projects have been identified to decrease aquifer outflow from Orange County by increasing production in western Orange County. Potential projects include 1) Coastal Agencies funding well construction and connection costs for wells in northwest Orange County and utilizing the West OC Water Board Pipelines to deliver this water to the Coastal Agencies; 2) Increasing the BPP of producers in the vicinity of the county line, such as Fullerton and Anaheim, thereby shifting pumping closer to the county line; 3) OCWD constructing four production wells near the county line and building a discharge pipeline to the West OC Water Board Pipeline. The objective of this project is to decrease groundwater losses of approximately 5,000 afy from the aquifer in Orange County. Project 3 would require negotiated use of the West OC Water Board Pipeline for water deliveries to West OC Water Board member agencies.

Concept 3 includes installing 4 new production wells called the West Orange County Enhanced Pumping (WOCEP) wells in western Orange County on properties located near the Katella Avenue corridor. As shown in Figure 1, three different alternative locations (Alternatives 1-3) varying in distance from 0.1 miles to 3.5 miles east of the OC/LAC line have been studied to install four new production wells. Pumping 10,000 acre-feet per year (afy) from the wells in each of the alternatives could reduce the outflow from OC to LAC by 6,100 afy to 3,300 afy, respectively.

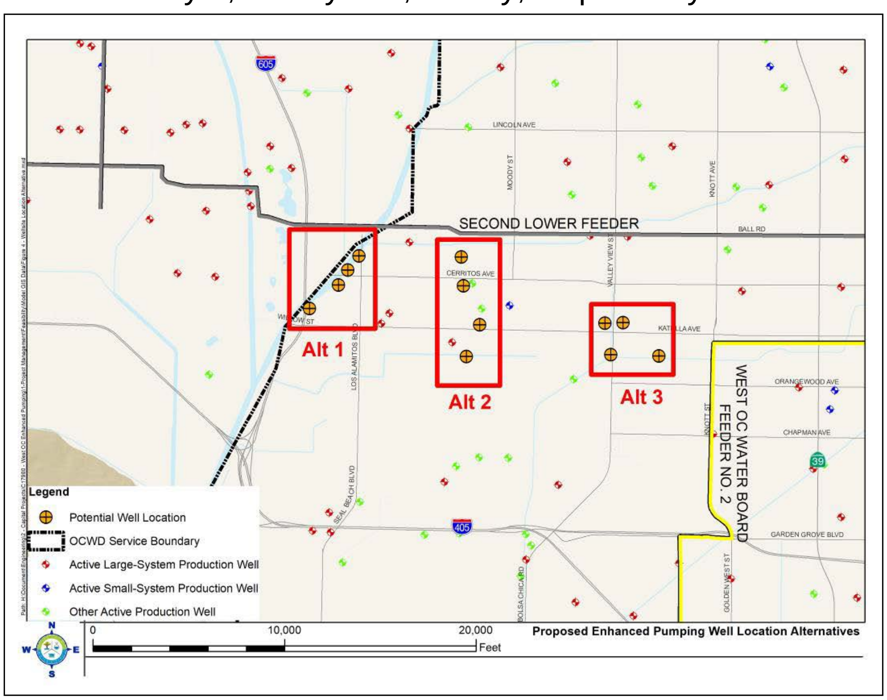


Figure 1: Alternative Locations of WOCEP Production Wells

Regardless of the final location, the proposed project assumes a total annual production of 10,000 af. Water from the WOCEP wells could be delivered to the Golden State Water Company (GSWC) and the member agencies of the West Orange County Water Board (WOCWB) including the cities of Huntington Beach, Seal Beach, Garden Grove, and Westminster. Water could be conveyed to the GSWC and the WOCWB feeder OC-35 through a new pipeline built as part of the project. Water conveyed to the OC-35 feeder could then be distributed to the WOCWB member agencies through existing turnouts in OC-35. Alternatively, a new pipeline (Alternative 4) could convey water from the project directly to Huntington Beach

Pros

- Reduce outflow to LA County
- Could increase resiliency of recipients by pumping from a different part of the basin

Cons

- Expensive
- Institutional arrangements to utilize WOCWB pipeline

Estimated Costs

The estimate cost could be up to $34M.

Estimated Benefits

Reduced outflow to LA County ranging from 3,300 to 6,100 afy.

18. South Orange County Storage

South Orange County water agencies are primarily dependent upon imported water supplies. Allowing these agencies to store a relatively small amount of water in the groundwater basin (in the area of 20,000 acre-feet) would greatly increase their overall water reliability during drought and/or emergency events. This small amount of storage would have very little impact on OCWD operations and would allow the District to generate additional revenues to offset future expected increases to the Replenishment Assessment. In January 2019 OCWD and the Moulton Niguel Water District (MNWD) entered into an agreement to formally study establishing a small pilot storage program that would be around 5,000 acre-feet. Consultants have been hired to: (1) develop conveyance options to transport the water from OCWD to MNWD; and (2) review and document existing water storage programs. An existing agreement with OCWD and SOC agencies allows for up to 50 cfs of water to be sent to SOC via the IRWD water system for up to 30 days for emergency events.

Pros

- Provides emergency supplies to areas dependent on imported water
- Could generate additional revenue and offset RA increases

Cons

- To be determined

Estimated Costs

No estimate costs have been developed.

Estimated Benefits

Emergency supplies to areas dependent on imported water and potential for additional revenue.

19. OCWD Prado Basin and Wetlands Strategic Plan

The OCWD Prado Treatment Wetlands consist of a series of 50 shallow ponds on 465 acres of land. The main driver for the wetlands when they were constructed was the removal of nitrates in Santa Ana River water. However, nitrate concentrations have since declined as well as the volume of Santa Ana River base flow. A strategic plan is needed to evaluate the purpose of the wetlands and the appropriate size and type of wetlands needed to meet current and future objectives.

Pros

- Increased efficiency to meet current and future needs
- Potential for reduced maintenance costs
- Potential for reduced evapotranspiration losses
- Potential conversion of wetlands to other needed habitat types
- Diversion of water to support native habitat in other parts of the Prado forest

Cons

- Could impact recreational uses of wetlands (e.g., hunting)

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.

WATER SUPPLY

20. Capture of Carbon Canyon Diversion Flood Flows

The Orange County Flood Control District operates Carbon Creek and Atwood Channel as part of their flood management facilities in northeast Orange County. Carbon Creek drains a portion of the Puente and Chino Hills and Atwood Channel drains portions of Yorba Linda and east Anaheim. To improve flood control capacity, Carbon Canyon Diversion Channel was constructed in the early 1960s to drain the flows from both the creek and channel that would otherwise drain into Coyote Creek to the Santa Ana River (Figure 2).

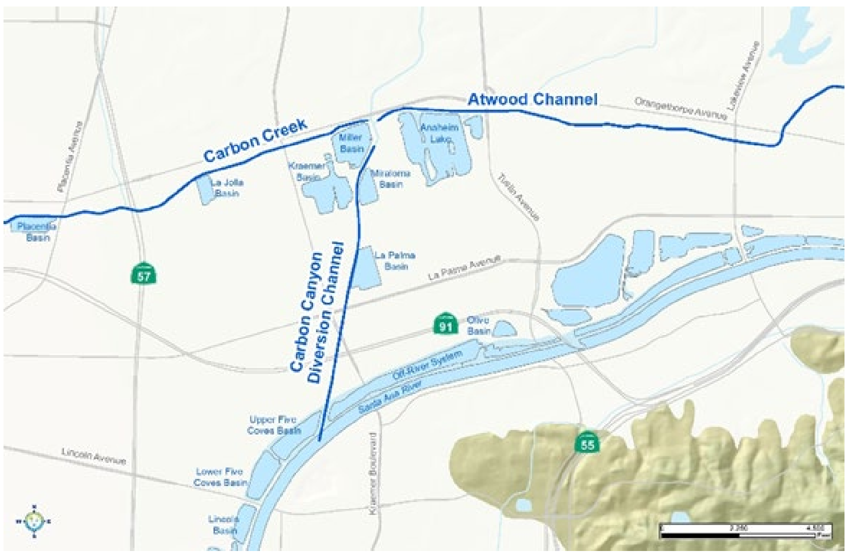


Figure 2: Carbon Canyon Diversion

At Miller Basin, the combined flows in the creek and channel are conveyed through the Carbon Canyon Diversion to the Santa Ana River just downstream of OCWD's Five Coves Inflatable Dam. During periods of high flows, much of this storm flow is lost to the ocean. This project involves constructing in-channel diversion structures to divert flows from the Carbon Canyon Diversion channel into Five Coves Basins by gravity before they reach the Santa Ana River. This would allow for increased capture of local (non-Santa Ana River) stormwater and reduce flows lost to the ocean. The primary constraint to this project is designing a structure that would not interfere with the existing flood control capacity of Carbon Canyon Diversion during high flow events. This could be a challenge given the potential for debris to clog intake structures.

Pros

- Potential capture of water that would otherwise be lost to the ocean

- Located within the existing recharge system
- Would typically divert water when Prado Dam outflows are reduced to allow OCWD to capture local inflows

Cons
- Cannot impede flows in Carbon Canyon Diversion channel
- Potentially high suspended sediment load
- Unknown water quality
- Limited data on available water in Carbon Canyon Diversion channel

Estimated Costs
No estimated costs have been developed.

Estimated Benefits
No estimated benefits have been developed. Would need to obtain more data on water flow in Carbon Canyon Diversion.

21. Recovery of Evapotranspiration (ET) Loss in Prado Basin

This project would focus on recovering water lost by evapotranspiration in the Prado Basin. This would involve taking credit for water savings achieved by removing Arundo Donax and other non-native plants. The 1969 Judgment references prior claims to up to 5,000 afy that is separate from the base flow obligation

Pros
- Preserving a senior water right for up to 5,000 afy
- This water would be in addition to the required base flow per the 1969 Judgement
- Improves habitat quality and reduces fire risk

Cons
- Would need to carefully quantify Arundo and other non-native plants removed and maintain removal

Estimated Costs
No estimated costs have been developed.

Estimated Benefits
The benefit is preserving a senior water right that would be in addition to the required minimum base flow per the 1969 Judgement.

22. New Basin Storage above Prado Dam Water Conservation Pool

OCWD would construct storage facilities behind Prado Dam above an elevation of 505 feet or a future maximum water conservation pool elevation (e.g., 510 or 512 feet) that could be operated independently of dam operations. Water would be released into the Prado Basin at rates that would not interfere with USACE operations or in conflict with existing agreements between OCWD and USACE regarding releasing flows from Prado Dam. The ability to store large volumes of water in newly constructed surface storage basins could be limited due to shallow groundwater. Another potential benefit is the diversion of sediment that would otherwise migrate downstream to areas where it would be more difficult to remove. This project is conceptual; there are no specific sites that have been studied or identified.

Pros

- Creates water storage independent of USACE operations
- Could create sediment trap where it could be more easily removed

Cons

- Shallow groundwater conditions could limit where basin could be constructed
- Permitting and construction could be difficult
- Would create a new area of operations behind Prado Dam

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.

23. Off-Stream Stormwater Storage (Aliso Canyon Dam)

Stormwater capture behind Prado Dam is an important source of high-quality, low-cost water for groundwater recharge. The USACE collaborates with OCWD to release water behind the dam at rates that can be diverted into the District's recharge facilities. USACE's primary mission is flood protection, which means that water must occasionally be released to provide adequate protection from flooding. These flood control releases are often at rates that exceed OCWD's capacity to divert water, resulting in water lost to the ocean. In addition, continued sedimentation behind Prado Dam will continue to degrade stormwater capture capabilities at Prado Dam.

This proposed project would construct a reservoir in Aliso Canyon located in Chino Hills State Park, creating between 10,000 to 50,000 af of storage (see Figure 3). In concept, Santa Ana River water would be pumped from either the river or from behind Prado Dam to the reservoir when water is available. Water from the reservoir would flow back to the Santa Ana River and be recharged later when recharge capacity becomes available and when the Prado water conservation pool is empty. The project would require construction of the reservoir on state park land, pipelines, and a pump station. The potential benefits of this project would be increased stormwater capture and a reduction in the impact of sedimentation at Prado Dam on stormwater capture. Preliminary modeling has been conducted but additional analysis will be needed. Permits may be needed from the USACE, CA Fish and Wildlife Service, and the State Lands Commission to construct facilities on state land. No analysis of constructability or costs has been conducted.

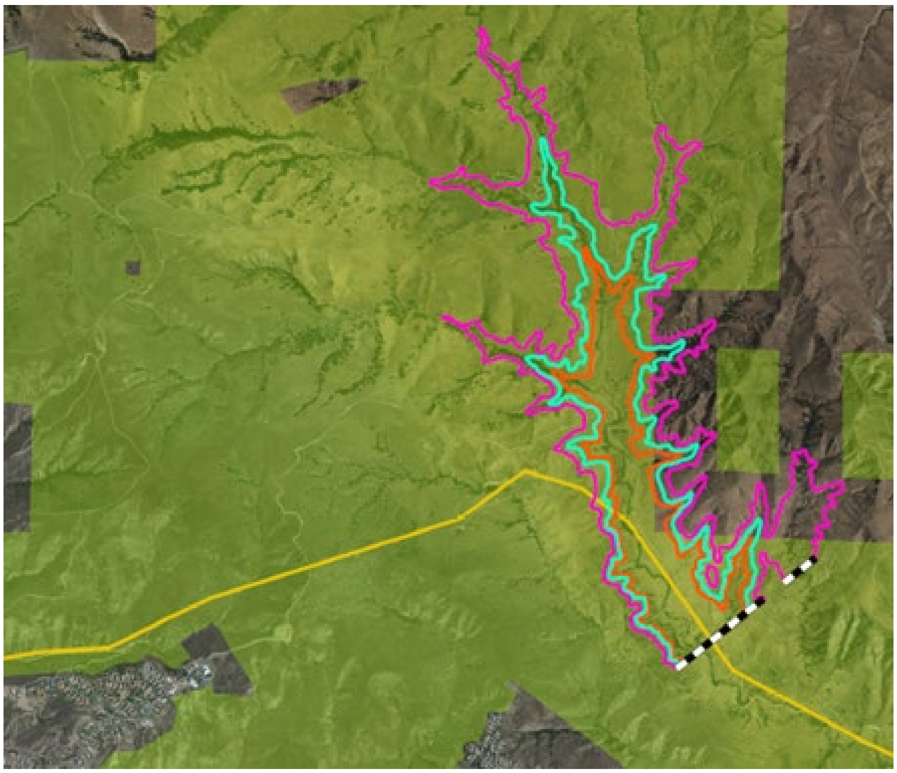


Figure 3: Potential Aliso Canyon Dam Location

<u>Pros</u>

- A source of storage that would be relatively immune from sedimentation
- A source of storage that would not have to be released for flood risk management
- Could improve flood risk management of Prado/Seven Oaks system

Cons

- Located on state lands
- Would require significant conveyance capacity from Prado to dam site

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

Modeling using the Recharge Facilities Model estimated the benefits of additional storage as follows:

200 CFS Fill Rate

Reservoir Size (af)	Estimated Additional Recharge* (afy)
10,000	4,400-5,700
20,000	5,300-6,900
50,000	5,300-7,850

500 CFS Fill Rate

Reservoir Size (af)	Estimated Additional Recharge* (afy)
10,000	6,700-9,000
20,000	8,800-12,300
50,000	11,500-16,500

*First number is for minimum base flow condition (36,000 afy) and second number is for medium base flow condition (52,000 afy). Maximum Prado Dam conservation pool assumed to be 505 feet year-round.

24. Regional Stormwater Infiltration Facilities

Municipal stormwater permits require new development and significant redevelopment projects to capture and infiltrate stormwater on-site when feasible. OCWD is concerned that on-site systems will not be properly maintained in the long term and that the use of regional recharge basins may be more cost-effective and beneficial. Although the use of regional facilities is allowable, permit conditions make such use difficult. This project would involve working with County of Orange Watershed staff and Regional Water Board staff to craft a program to construct regional stormwater capture projects. One option would be for developers to pay an in-lieu fee for OCWD to manage the stormwater at District facilities and/or construct facilities to convey storm flows to District facilities. Stormwater that would otherwise drain to the ocean (such as via Carbon Canyon Diversion) would be captured and recharged. New facilities could potentially be used to recharge other sources of water during the summer months.

Pros

- Additional source of supply to the basin
- Regional system would ensure long-term performance

Cons

- Area tributary to existing recharge system is relatively small
- Finding suitable areas for recharge
- Conveyance costs

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.

25. Capturing Stormwater Runoff in Chantilly and Other Storm Drains

The Chantilly Storm Drain discharges into Ball Road Basin, which then drains into the Santa Ana River (Figure 4). The Chantilly Storm Drain watershed covers 1,120 acres in central Anaheim and can produce high flows. As currently configured, almost all the flows produced by this storm drain are lost to the ocean. This project would entail constructing a pipeline to intercept water in the storm drain and divert it into Burris Basin at an estimated cost of $500,000. Modeling suggests the Chantilly Storm Drain could produce an average of 645 afy of stormwater supply. Immediately to the west is a large storm drain system that parallels State College Blvd. Water in this storm drain system, which drains 638 acres, could also be potentially intercepted and diverted via a pump station to Burris Basin for recharge at an estimated cost of $1,200,000. Modeling suggests there is an estimated average of 400 afy of supply from this storm drain.

Another benefit of diverting storm flow from the State College system is that the lower portion of the system needs upgrading due to insufficient flood conveyance capacity. The City of Anaheim has plans to invest in addressing the shortfall in flood conveyance capacity. As a result, the State College system presents a potential partnership between OCWD and the City of Anaheim to construct this project for mutual benefits. The constraints for this project are obtaining access for pipelines and other project needs.

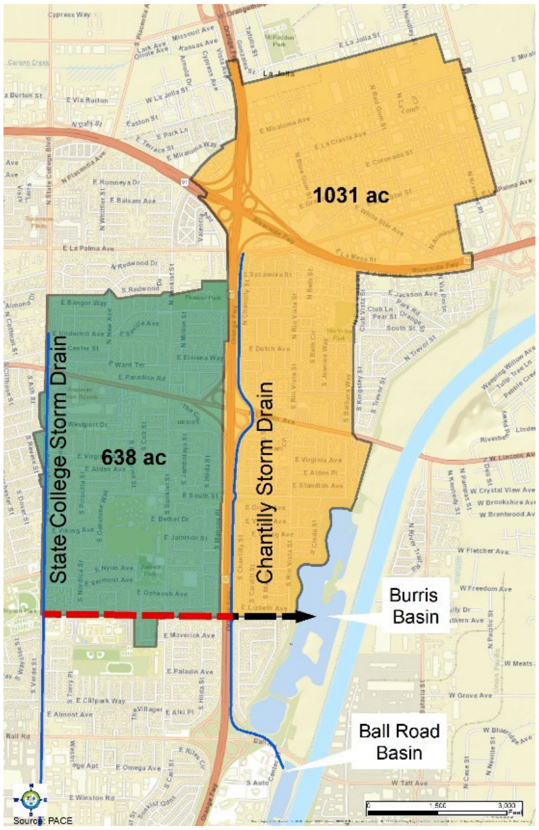


Figure 4: Chantilly and State College Storm Drains

Pros

- Up to 1,000 afy or more of new water supply that is now largely lost to the ocean
- Potential partnerships with City of Anaheim and other agencies (e.g., Caltrans) to assist with funding

Cons

- Pipeline access
- Overflow needed for Burris Basin
- Poor water quality, including PFAS at concentrations above the MCL

Estimated Costs

Pipeline to Burris Basin from Chantilly storm drain: $500,000. Pipeline and pump station from State College Storm Drain to Burris Basin: $1,200,000.

Estimated Benefits

An estimated 645 afy from Chantilly storm drain. An estimated 400 afy from State College storm drain. Assuming imported water costs approximately $1,000/af, the annual value of this water is $1,045,000/year.

26. Field-Scale Demonstration Test of In-Situ Removal of PFAS During Groundwater Recharge

Per- and polyfluoroalkyl substances (PFAS) are present in Santa Ana River (SAR) surface waters utilized by the District for groundwater recharge. The District and Producers are constructing regional treatment plants to remove PFAS from groundwater where it is pumped for drinking water supply. Managed aquifer recharge (MAR) sites, i.e. District recharge basins, could be engineered to remove PFAS in-situ during infiltration to prevent impacts to groundwater via deployment of engineered media in the shallow subsurface – pending outcomes of research underway at the District to pilot this technology.

The innate stability of PFAS has pushed the drinking water practice toward sorption technologies. Engineering MAR to remove PFAS could provide long-term, sustainable, in-situ treatment of large volumes of PFAS contaminated waters. The proposed configuration (see below schematic) is applicable to a traditional percolation pond. Buried (~1 m) deployments of PFAS-specific adsorptive media could be installed in select basins. Based on the low concentrations of PFAS present in SAR and the low hydraulic loading rate of a percolation pond (water flow rate percolated per square foot area), contact time between the water and the installed layer of media is inherently maximized and the estimated expected media life would be on the order of many decades (for strongly sorbing PFAS such as PFOA and PFOS).

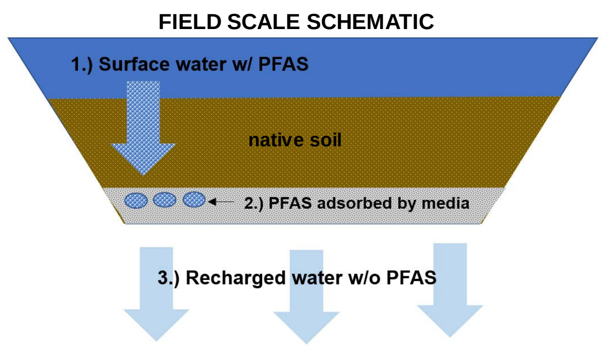


Figure 5: Schematic of Field-Scale In-Situ PFAS Removal

After that timeframe, the PFAS-sorbing media would be exhausted and would no longer remove PFAS; it could be left in place or excavated for removal (and potentially replaced to continue treatment). It is proposed that native soils would be integrated into the design as a layer above the sorptive media to provide functions such as filtering suspended solids and biomass while reducing total organic carbon (TOC), as well as serving as a sacrificial layer to be periodically scraped at the surface of the bottom of pond per normal District maintenance activities for basins.

The R&D Department is evaluating the technology concept using pilot-scale testing. Hence the below cost estimate is based on a number of assumptions. The total cost of installing an alternative absorptive media (assuming CETCO's FLUOROSORB-200) under a layer of native soil for in-situ PFAS treatment within a 2.5-acre recharge site is estimated at $12.9M. The wetted area of Olive and La Jolla basins was averaged to attain this 2.5-acre value, as they are basins where this media could be deployed. Both basins recharge SAR water at approximately 4,000 acre-feet per year. The cost estimate includes purchasing the media, freight transportation, geotextile to encase the media, if necessary, soil excavation, backfilling, labor related to installation, and (after media life) eventual excavation and removal of the treatment media if desired. This design is predicted to remove PFOA to non-detect or near non-detect levels for at least 40 years from the overlying water percolated to the subsurface and sequester it in the buried media. The scale of approximately 2.5 acres represents the upper end (highest cost) of a potential field-scale demonstration test of this technology, i.e. implementation of an entire, relatively small basin. However, a smaller scale test e.g., a 0.5-acre test, could be pursued in part of a basin and would reduce costs.

Pros

- Removes PFAS from infiltrating water in SAR recharge ponds to prevent PFAS impacts to local groundwater
- Addresses PFAS in recharge settings in the short-term, recognizing that upstream wastewater discharges that introduce PFAS to SAR may continue for decades
- Gravity-driven treatment system requiring no energy or maintenance other than the maintenance of recharge ponds already conducted

Cons

- The District has hundreds of acres of recharge ponds that infiltrate SAR water hence it is unlikely that this technology could be broadly implemented at all District MAR facilities. It would require prioritization of select locations
- Cost may be significant even for relatively small basins
- There is inherent risk since to our knowledge this technology has not been used for such an application. Pilot-scale testing and modeling may predict success over a very long media life, but ultimately there is no way to confirm through testing that a multi-decadal media life would be attained
- After the media is exhausted, it is unclear whether the spent media could be simply left in place versus requiring excavation

Estimated Costs
$12.9M per 2.5-acre recharge site if a relatively large scale-up test is implemented. Costs would be less for a smaller scale test such as for 0.5-acre representing a partial basin.

Estimated Benefits
Preventing PFAS occurrence in groundwater related to infiltration of PFAS impacted water sources.

27. Applying FIRO Tools at Corona Airport

The Corona Municipal Airport was constructed on approximately 100 acres of U.S. Army Corps of Engineers (USACOE) land that is leased to the City of Corona. The airport is home to 300-350 general aviation aircraft and is strictly a recreational airport with no commercial flights.

The elevation of the airport is from 514 to 521 feet mean sea level (ft msl). Although the airport lies within the flood control space behind Prado Dam, the USACE takes steps to avoid flooding the airport if possible. This could be a constraint to holding water at higher elevations contemplated with Forecast Informed Reservoir Operations (FIRO) at Prado Dam. In the Final Viability Assessment (FVA) completed in November 2023, the target elevation for the water conservation pool is 510 to 512 ft msl. Holding water higher than the current maximum water conservation elevation of 505 ft msl will increase the risk of airport flooding. This project aims to study ways to mitigate the risks of airport flooding and thus reduce the risks of losing water to the ocean.

Pros
- Allow for higher storage levels in the water conservation pool
- Reduces the risks of high releases that may be lost to the ocean

Cons
- Time and cost to construct the projects

Estimated Costs
No estimated costs have been developed.

Estimated Benefits
No estimated benefits have been developed.

RECHARGE FACILITIES

28. Enhanced Recharge in Santa River between Five Coves and Lincoln Ave

An approximate 6.5-acre area in the Santa Ana River channel between the Five Coves Inflatable Dam and Lincoln Avenue is underlain by distinctive reddish-brown fine-grained sediment that has a very low percolation rate (Figure 6). The project would entail removing this sediment and replacing it with sand. Given the percolation rate of the other portions of the river, this 6.5-acre area is projected to have a percolation rate of 3 cfs or 6 acre-feet per day. Additional recharge in the Santa Ana River will increase stormwater capture and increase the ability to recharge imported water. The project would include disposing of removed sediment, securing a supply of sand, obtaining several permits, and evaluating current and potential recharge rates.

Figure 6: Red Colored Fine-Grained Sediment in SAR Channel at Lincoln Ave.

Pros

- Increased recharge rate
- OCWD owned property
- Could manage with OCWD staff
- Could use existing stockpile of good quality sand to replace fine-grained materials

Cons

- Obtaining permits to conduct work

Estimated Costs

No estimated costs have been developed.

Estimated Benefits
Estimated additional recharge is 3 cfs or 6 af/day.

29. Increased Lower Santa Ana River Recharge

The 3-mile reach of the Santa Ana River below Five Coves Inflatable Dam has an approximate recharge capacity of 50 cubic feet per second (100 acre-feet per day). However, maximizing recharge in this portion of the river is constrained because District operators are unable to control the flow once the water flows past the inflatable dam. Under current conditions, operators conservatively manage releases into the river to prevent flows being lost to the ocean. This results in an underutilization of the lowermost reaches of the river channel. Concepts to increase unitization of this reach include installing cameras to allow for remote observations of water flow in the river channel to more accurately assess optimal release rates and installing an inflatable rubber dam in the lowermost reach of the river channel to more efficiently manage recharge operations.

Pros
- Maximize recharge of existing facility

Cons
- Could be impacted by proposed Riverwalk Project by City of Anaheim

Estimated Costs
No estimated costs have been developed.

Estimated Benefits
Benefit is increased recharge in the lower reach of the Santa Ana River channel.

30. New River View Basin & New Lincoln Nursery Basin

This project would construct additional surface recharge basins north of the existing River View Basin. The land is currently being used by the Sandbagger Company and Harvest Landscape Enterprises. A portion of the Sandbagger site contains an abandoned landfill. The site is approximately 2.8 acres with a potential recharge area of 1.8 acres and an expected capacity of 1.3 cfs based on 3 cfs at 4.2 acres of existing River View). The extent and characteristics of the abandoned landfill need to be evaluated before proceeding with this concept. Supply and de-watering infrastructure would be required. The site occupied by Harvest Landscape Enterprises is a long, thin strip of land north of the Sandbagger lot. Research into past land use at this site may be required. This site is approximately 4.16 acres with a potential recharge area of 1.16 acres and an expected percolation rate of 0.83 cfs assuming similar performance as River View Basin. This property is directly adjacent to existing homes that have a history of encroachment. Supply and de-watering infrastructure would be required.

Pros

- Use existing OCWD property
- Increase stormwater capture

Cons

- Unknown extent and quality of landfill material
- Small sites
- Conveyance infrastructure required to cross Fletcher Channel
- Could have midge issues near residential area
- Increases operational complexity
- Loss of lessee revenue ($14,000/month)

Estimated Costs

Bason	Estimated Cost	Estimated Percolation Rate
New River View Basin	$ 1.6 million	1.3 cfs
New Lincoln Nursery Basin	$1.9 million (smaller excavation, but longer supply pipe required)	0.83 cfs

Estimated Benefits

Would increase the ability to capture and percolate stormwater. The recharge facilities model could be used to further evaluate these potential basins.

31. Turnout to SAR at Fletcher Channel - River View Basin Pipeline

Extending the existing 24-inch River View Pipeline would allow for the discharge of approximately 25 cfs into Fletcher Channel and ultimately the lower reach of the Santa Ana River. The expected benefits include the recharge of an additional 25 cfs of storm water into the lower Santa Ana River (up to 5,000 afy in a wet year). Construction and design are estimated to be $500,000. OCWD would need a permit from the Orange County Flood Control Division to discharge 25 cfs into Fletcher Channel.

Pros

- Increased stormwater capture
- Increased use of the lower reach of the SAR channel.
- Faster draining of Santiago Basins

Cons

- Increased operational flexibility
- Potential constraints due to future GWRS water mixed with SAR flows in Burris Basin

Estimated Costs

Estimated cost is $500,000 (2019 costs).

Estimated Benefits

Up to 5,000 afy in a wet year.

32. Expand Recharge Basin Footprints

Explore potential removals of material at existing basins to increase their footprint, and storage volumes and potentially increase percolation capacities. In evaluating potential basin expansions, a host of factors need to be considered, including existing infrastructure, land ownership, required setbacks, operational needs, etc. Potential locations include La Palma and Miraloma stockpile areas, the Kraemer Basin ramp, the Burris center levee side and south end, and Blue Diamond Basin east side and center peninsula.

Pros

- Optimize existing land ownership
- Potential for relocating clean material to other recharge facilities

Cons

- Expensive to remove material
- Overall impact on storage is minimal

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.

Increased Use of Carbon Creek System Facilities

There are five flood control basins owned and operated by Orange County Department of Public Works that are located on Carbon Creek, including Miller Basin, Placentia Basin, Raymond Basin, Crescent Basin and Gilbert Basin (see Figure 7). The Flood Control Act adopted by the state legislature in 1927, included the following language:

> *"The purpose of this act is to provide for the control of flood and storm water within said district ---, and to conserve such waters for the beneficial and useful purposes by spreading, storing, retaining and causing to percolate into the soil within said district…"*

The Orange County Flood Control District (OCFCD) designed the Carbon Creek system to accomplish these functions. OCFCD's Carbon Creek System Manual describes the flood and water conservation functions of these basins. Miller Basin has been used intensively by OCWD for many years; however, use of the downstream basins could be increased by investing in infrastructure and increased maintenance.

Figure 7: Potential Recharge Sites along Carbon Creek (projects 33-35)

33. Placentia Basin Improvements

This project would construct capital improvements to the Placentia Basin to increase the amount of water recharged in the basin. Placentia Basin is a flood-retarding basin owned and operated by the Orange County Flood Control Division. The District uses the basin to recharge imported water, when available, and Santa Ana River water during the non-storm season. Improvements would include modification of inlets and installation of pumps, flow measuring devices, water level sensors, and equipment to remotely control water levels and flows. Since the basin was originally constructed for flood control purposes, use for recharge is constrained by several factors. Current operations require the construction of temporary sandbag dikes just downstream of the drain in the channel. The grated drain inlet into the basin quickly becomes clogged with debris and algae. During the summer months, the grating occasionally requires daily cleaning. In addition to frequent maintenance, the current grating configuration limits the flow into the basin to an average of seven cubic feet per second (cfs), which is less than the estimated 15 cfs capacity of the basin.

The addition of a submersible pump capable of emptying the basin in a short amount of time to maintain the use of the basin for flood control may enable the District to use the basin during the storm season.

Pros

- Provides increased recharge capacity and operational flexibility
- Use of an existing facility not owned by OCWD
- Can use to recharge imported water when available

Cons

- Located in North Basin groundwater cleanup area
- Would require infrastructure improvements

Estimated Costs

Estimated costs have not been developed.

Estimated Benefits

Modeling conducted for the 2014 LTFP showed a potential annual recharge benefit ranging from 75 to 260 afy depending on SAR base flow conditions.

34. Raymond Basin Improvements

This project would construct capital improvements to Raymond Basin to increase the amount of water recharged in the basin. Raymond Basin is a flood-retarding basin owned and operated by the Orange County Flood Control Division. The District uses the basin to recharge imported water, when available, and Santa Ana River water during the non-storm season.

The inlet into Raymond Basin is comprised of two sluice gates and inlet pipes located on the vertical wall of each side of the concrete-lined Carbon Creek Channel. To divert water, District staff installed flashboards just downstream of the inlet pipe to be used as a dam in the channel. The installation of these flashboards is time-consuming and requires the use of a crane. Like Placentia Basin, it is estimated that the range of flows currently sent to Raymond Basin is approximately half of the recharge capacity of 15cfs. Improvements would include modification of inlets and installation of pumps, flow measuring devices, water level sensors, and equipment to remotely control water levels and flows. The addition of a submersible pump that can empty the basin in a short amount of time to maintain the use of the basin for flood control may enable the District to use the basin during the storm season.

Pros
- Provides increased recharge capacity and operational flexibility
- Use of an existing facility not owned by OCWD
- Can use to recharge imported water when available

Cons
- Would require infrastructure improvements
- Distant from Field Headquarters

Estimated Costs
Estimated costs have not been developed.

Estimated Benefits
Modeling conducted for the 2014 LTFP showed a potential annual recharge benefit ranging from 40 to 350 afy depending on SAR base flow conditions.

35. Crescent and Gilbert Basins

OCWD uses three flood control basins for recharge on Carbon Creek, including Miller, Placentia and Raymond Basins. Crescent and Gilbert Basins are flood control basins located downstream of Raymond Basin. Crescent Basin covers 8 acres and Gilbert Basin covers 46 acres, 36 acres of which is used as a golf course. The golf course portion cannot be used for water conservation in the summer months. OCWD will investigate the potential of partnering with the County of Orange in using these basins for recharge.

Pros
- Provides increased recharge capacity and operational flexibility
- Use of an existing facility not owned by OCWD

Cons
- Requires additional investigation to assess recharge potential
- Would need to coordinate with the Golf Course for Gilbert Basin

Public access at Gilbert Basin presents potential safety issues

Estimated Costs
Estimated costs have not been developed.

Estimated Benefits
Estimated benefits depend on potential recharge capacities.

36. Santiago Basins Rehabilitation Project

Santiago Basins are three former gravel and sand mines called Smith Pit, Blue Diamond Pit and Bond Pit that were purchased in 1983-85. The combined storage capacity is over 13,000 acre-feet, which is approximately half of the total storage capacity OCWD surface water recharge system.

Improvements would include modification of inlets and installation of pumps, flow measuring devices, water level sensors, and equipment to remotely control water levels and flows. The addition of a submersible pump that can empty the basin in a short amount of time to maintain the use of the basin for flood control may enable the District to use the basin during the storm season.

Pros
- Provides increased recharge capacity and operational flexibility
- Use of an existing facility not owned by OCWD
- Can use to recharge imported water when available

Cons
- Would require infrastructure improvements
- Distant from Field Headquarters

Estimated Costs
Estimated costs have not been developed.

Estimated Benefits
Modeling conducted for the 2014 LTFP showed a potential annual recharge benefit ranging from 40 to 350 afy depending on SAR base flow conditions.

OPERATIONAL IMPROVEMENTS

37. Lab/Office Space for Natural Resources, R&D Field Research Departments and visiting staff/professionals

This project would seek to provide a temporary structure at OCWD Field Headquarters (FHQ) to be used as office and laboratory space for Natural Resources Department and R&D Department staff and other visiting staff as needed. This would be an improvement and replacement of the current facilities at FHQ used by these staff (Figure 8) which are currently not in good shape.

The project would seek to provide temporary space to be used as office and laboratory space. The current modular outbuildings at FHQ consist of the “Library” building used by Natural Resources staff and two R&D laboratory trailers. The current buildings have been subject to age degradation, infestations of termites, ants and more recently rodents. The library is an older modular building with a history of termite damage, poor climate control, and lacks office privacy for senior staff (shared area with three workstations and conference table). The R&D trailers were originally intended to be temporary and are now 30+ years old; the main trailer houses two offices for scientists, a shared office for two interns and one limited term postdoctoral research associate as needed and has approximately three rooms of laboratory space for instrumentation and benchtop work (e.g., wet chemistry and soils analysis). The second R&D trailer has additional laboratory space. Despite efforts to address the various issues, the R&D trailers also suffer from age deterioration, near constant ants (year-round), and are currently experiencing a significant mice problem including droppings on staff desks every day.

Nearby, the main OCWD FHQ building features staff offices, one conference room, and a shared kitchen that is also used by R&D and Natural Resources staff. When available, one office in the main FHQ building is periodically borrowed by visitors from other departments (e.g., GM, HR, Risk and Safety, Water Production, Property Management, and R&D).

A new temporary modulated building for shared use by Natural Resources and R&D staff would seek to provide a more stable structure and additional space to be used as office and laboratory space, which could also provide extra office space for FHQ staff as well as workstations for visiting departments. The updated space would need to include restrooms, a small kitchen, and a shared conference room which could act as a secondary conference room for the FHQ campus. The plan could include an enlarged parking area and accommodate storage sheds/garage to house utility vehicles.

Potential constraints to the size of the facility are existing city of Anaheim power lines.

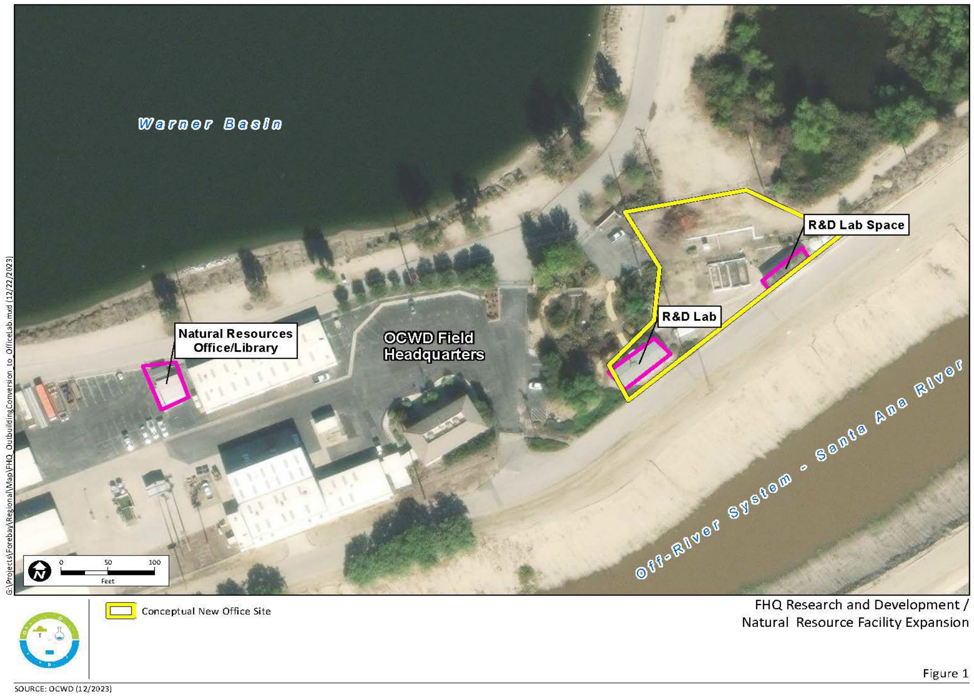


Figure 8: Location of Existing Natural Resources and R&D Lab/Office Facilities

Pros

- Replace aging modular buildings (pink outlines in figure) with permanent structure that are needed for staff and provide energy-efficient cost savings
- Improve research capabilities, more space, safety in age, and integrity of the structures
- Provides increased space for R&D, Natural Resources and Recharge Operations
- Power supply located nearby (left over from Sediment Removal Study)
- Could reuse other newer modular buildings from other locations rather than purchase new

Cons

- Overhead powerlines
- Nearby MWD pipeline

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

Provides safer, more efficient workspace for R&D, Natural Resources and Operations.

38. Green Acres Project (GAP) Treatment Plant and Other Modifications

The operation and maintenance of the Green Acres Project (GAP) continues to involve a high degree of staff time and O&M expenses to maintain the effective production of recycled water. The average historical (2015-23) production of the GAP water treatment plant (WTP) is 4,300 afy (3.6 mgd). Instantaneous demand for GAP water can exceed 14 mgd. This project would replace the current multi-media filtration system with a microfiltration (MF) treatment system assuming there is excess MF capacity that can be used to generate GAP supply water. To provide total MF treatment capacity for GAP average flows, a 7 mgd facility would need to be provided or a cap would need to be placed on the total amount of GAP water sold. This capacity could be included in the GWRS final expansion or split with the existing media treatment.

Microfiltration has been found to cost less per af than the current media treatment and is expected to provide better quality effluent.

Conversion to MF treatment will also simplify operations because the number of treatment technologies and independent process monitoring would be reduced. The existing media treatment plant can be demolished (estimated to cost about $2 million) or left standing. Part of the media building houses the distribution pumps and would need to remain.

There are operational efficiencies that may be gained through distribution pump operation and reservoir control logic, although this should be evaluated to make sure that GAP efficiency does not decrease the efficiency of GWRS. The economics of GAP can also be improved by adding additional end-user demand. Many sites along the existing pipeline alignment can be encouraged to use GAP, although adding new users to the system would increase the need for staff time. The District may wish to incentivize new users with discounted financing or capital cost assistance.

GAP distribution consists of 37 miles of high-pressure pipeline (typically 100-125 psi) primarily located in public rights-of-way. It may be beneficial to add some real-time monitoring of the distribution to detect leaks and performance problems before they become catastrophic.

Alternative disinfection compliance is an option. The existing compliance method is the state-wide standard measured as concentration time (CT). Preliminary studies have indicated there is a possibility to transition to a lower CT value which would reduce chlorine chemical consumption.

Pros

- Potential to reduce operational costs
- Potential to reduce the number of treatment system types being operated by staff
- Improvements to GAP product water quality

Cons

- Capital investment cost
- Possibility for some GAP customers to have objection to water quality change

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.

39. Mobile Sand Wash Plant

Restoration of recharge rates in the District's percolation basins is a continual process. After the basins become clogged, the basins are drained, dried and then cleaned using heavy equipment. The heavy equipment removes the clogging layer and some clean material from the basin bottoms. This mixed material is then stockpiled onsite. Heavy equipment also attempts to clean the basin sidewalls, but this process is not efficient and results in a continuous buildup of mixed material on the sidewalls. The District has taken steps to increase the efficiency of its cleaning efforts, greatly reducing the amount of material removed during each cleaning cycle. Nevertheless, over time, the basin bottoms become deeper and the mixed material on the sidewalls begin to constrain recharge rates and provide a source of clogging material that is resuspended in the basin when it is refilled with water. This process reduces overall recharge performance and is unsustainable over the long term. One way to restore basin bottom and sidewall conditions is to wash the mixed material removed from the basins using a sand wash facility. Washed sand would then be stockpiled and returned to the basins when they are cleaned. A mobile sand wash plant would allow District staff to continuously keep up with the mixed material removed from the basins and keep them operating at higher capacities. Having this capacity in-house would produce sand that meets District specifications and would allow for greater flexibility in the timing and location of sand-washing operations.

Pros

- Optimize recharge basin performance
- Creates a sustainable basin maintenance program
- Sand washing could be done at various locations and when District operations allow

Cons

- May require additional staff
- Would need to maintain equipment

Estimated Costs

No estimated costs have been developed.

Estimated Benefits

No estimated benefits have been developed.