G | W | R | S

GROUNDWATER REPLENISHMENT SYSTEM

QUENCHING A THIRST

Orange County is a semi-arid region that receives on average 14-inches (355 millimeters) of rain a year. This sun-drenched land is home to over 3 million people. North and central Orange County overlies a large groundwater basin managed by the Orange County Water District (OCWD). The Orange County Groundwater Basin provides approximately 75% of the potable water supply for 2.4 million people. Although the basin is vast, the average annual withdraws must be balanced by recharge from a variety of sources. The primary sources of supply for the basin include flows from the Santa Ana River, rainfall from local wintertime storms, reused water, and excess imported water from distant sources: the Sacramento - San Joaquin River Delta and the Colorado River. Dry weather conditions, water conservation and recycling upstream of Orange County and environmental restrictions on imported supplies have made it more challenging to fill the Orange County Groundwater Basin.

The Groundwater Replenishment System (GWRS), a joint project of the OCWD and the Orange County Sanitation District (OCSD), provides enough new water for nearly 850,000 residents and has become an essential element of local water supply.

MAJOR WATER CONVEYANCE FACILITIES IN CALIFORNIA

LEGEND
- FEDERAL AQUEDUCT
- STATE AQUEDUCT
- LOCAL AQUEDUCT

Two-thirds of California's population lives in Southern California where less than one-third of the State's precipitation falls. While other Southern California counties rely mostly on imported water supplies to meet their water needs, Orange County does not. A large percentage of its water supply is derived from a large groundwater basin. The Orange County Groundwater Basin underlies north and central Orange County. Extending from the Pacific Ocean to Yorba Linda, it holds over 40 million acre-feet (AF) (49 billion cubic meters) of water, the annual yield of the basin is nearly 300,000 AF (370 million cubic meters) of water, with an operational capacity of roughly 500,000 AF (617 million cubic meters).

Since its establishment in 1933, OCWD has been monitoring groundwater levels in the basin. In the 1940s, its role shifted. Natural recharge could no longer offset groundwater extraction. As a result, OCWD launched a groundwater replenishment program. Monitoring efforts were soon accompanied by active management of groundwater levels in order to protect the basin.

Historically, the main source of water for basin replenishment had been the Santa Ana River. Flowing west from the San Bernardino Mountains, the river winds through San Bernardino and Riverside counties before reaching Orange County. At upstream locations water conservation and recycling occur. Between these activities and periodic drier weather patterns, river flows fluctuate from year to year.

To compensate for these fluctuations in replenishment water, OCWD began importing water from other sources, first the Colorado River and later, the Sacramento-San Joaquin River Delta. Approximately 30 percent of the water supplied to north and central Orange County is derived from these sources. Still, relying on these distant watersheds to quench our thirst and recharge groundwater poses several challenges. Importing water from distant sources is energy-intensive and expensive. Further, the Delta is an environmentally sensitive area that is home to water-dependent threatened and endangered species.

Water rights to the Colorado River are shared among seven states and Mexico, each facing population growth and reduced precipitation. At a time when our thirst is increasing, the river's flow is decreasing.

The GWRS has become an essential component in the provision of reliable water for Orange County.

GROUNDWATER REPLENISHMENT SYSTEM

The GWRS is the world's largest advanced water purification system for potable reuse. OCSD treats wastewater and produces water clean enough to undergo purification at the GWRS, instead of discharging it into the Pacific Ocean. This water is then purified at the GWRS using a three-step advanced process. Consisting of microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide, this purification process produces high-quality water that meets and exceeds state and federal drinking water standards. This purified water is injected into a seawater barrier and pumped to recharge basins where it naturally percolates into the Orange County Groundwater Basin and supplements Orange County's drinking water supplies.

Operational since January 2008, the GWRS originally produced 70 million gallons a day (MGD) (265,000- cubic meters) of highly purified water. In 2015, the project was expanded to produce 100 MGD (378,000 cubic meters). Ultimate capacity for the GWRS is projected at 130 MGD (492,000 cubic meters) after infrastructure is built to increase wastewater flows from OCSD to the GWRS.

IN THE SPIRIT OF COLLABORATION

The GWRS is the result of a collaborative effort between OCWD and OCSD. Both sought solutions to issues they faced. In the mid 1990s, OCWD needed to expand Water Factory 21 (WF 21) and address continued problems with seawater intrusion. At the same time, OCSD faced the challenge of having to build a second ocean outfall. The GWRS resolved these issues.

Both districts shared the cost of constructing the first phase of the GWRS ($481 million US dollars). OCWD funded the initial expansion which cost $142 millon. OCSD supplied OCWD with stringently controlled, secondary treated wastewater at no charge. It also invested money and resources to build the Steve Anderson Lift Station to maximize wastewater flows to the GWRS. OCWD in turn agreed to manage and fund the GWRS operations. Through this collaboration, the GWRS emerged as one of the most celebrated civil engineering and water reuse projects in the world.

Three components comprise the GWRS:

The Advanced Water Purification Facility at OCWD Headquarters in Fountain Valley

After receiving clean water that was once wastewater from OCSD, this facility further purifies the water through microfiltration, reverse osmosis and ultraviolet light with hydrogen peroxide.

Seawater Intrusion Barrier in Huntington Beach and Fountain Valley

Approximately 30 MGD (113,000 cubic meters) of the final product water is conveyed by the barrier pump station to injection wells along the Seawater Intrusion Barrier.

Kraemer, Miller and Miraloma Basins in Anaheim

The remaining 70 MGD (265,000 cubic meters) final product water is conveyed by the product water pump station to the Kraemer, Miller and Miraloma Recharge Basins.


Kraemer, Miller
& Miraloma Basins
Fullerton
Santa Ana River
Buena Park
Anaheim
Cypress
GWRS
Pipelines
Orange
Santiago Creek
Garden
Grove
Fountain
Valley
Santa Ana
Huntington
Beach
Irvine
ORANGE COUNTY WATER DISTRICT
SINCE 1933
Ocean
Outfall
C
OCEAN
Orange County
Groundwater Basin
Advanced Water
Purification Facility
Seawater Intrusion
Barrier
OCSD Treatment
Facilities

Before treated wastewater is fed into the GWRS, it must undergo extensive pre-purification. The stringent source control and treatment of the wastewater is operated and managed by OCSD. Pre-GWRS purification includes preliminary, primary and secondary treatment.

Preliminary Treatment

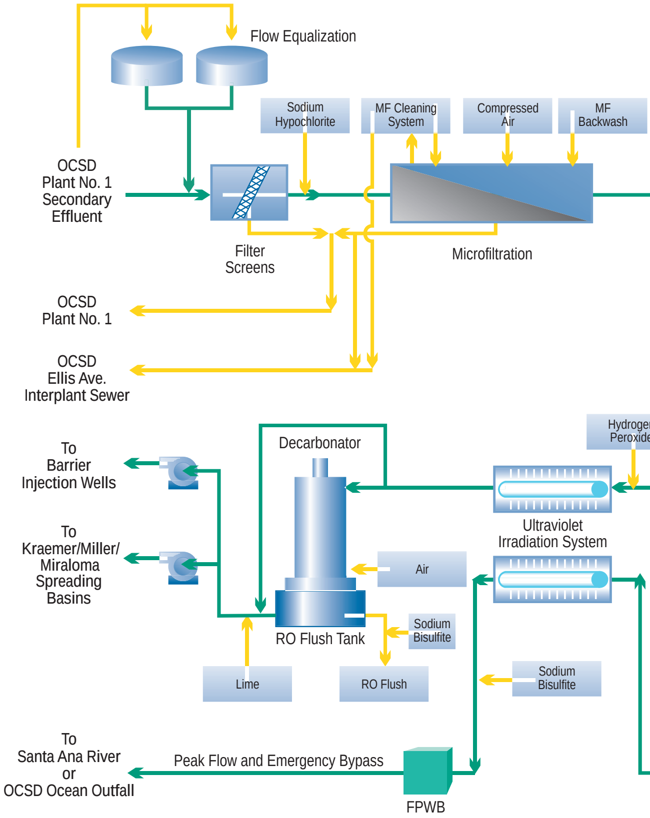
Preliminary treatment, or screening, is the first step in cleaning wastewater. Before the raw sewage is introduced into OCSD's plants, large contaminants such as rocks, rags, toys, and golf balls must be removed. Such items could plug pumps and damage the equipment. Bar screens accomplish this task, removing the material and depositing it into dumpsters for disposal at a landfill. Following the bar screens, the water travels to the grit chambers to remove any grit and sand-like material before the wastewater is routed to primary treatment.

Primary Treatment

In primary treatment, the incoming flow is slowed in large tanks called settling basins or clarifiers, which allow the dirt, gravel and other heavier organic solids to settle or sink to the bottom. Grease, oil and other floatables are also removed here. Rotating arms simultaneously remove the settled solids from the bottom and the separated floatables from the top. The solids are then pumped into large heated holding silos, called digesters.

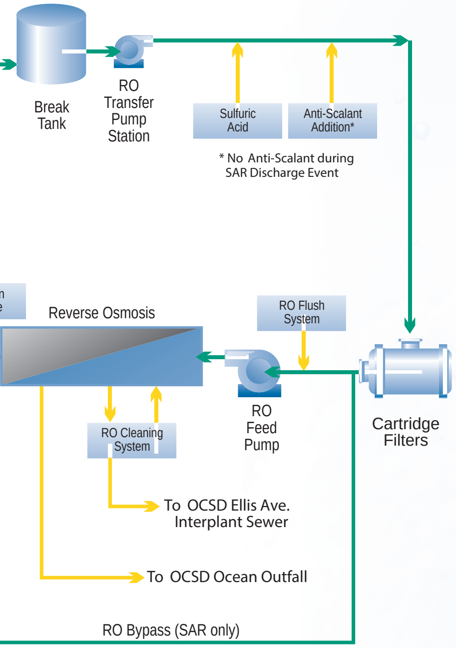
Secondary Treatment

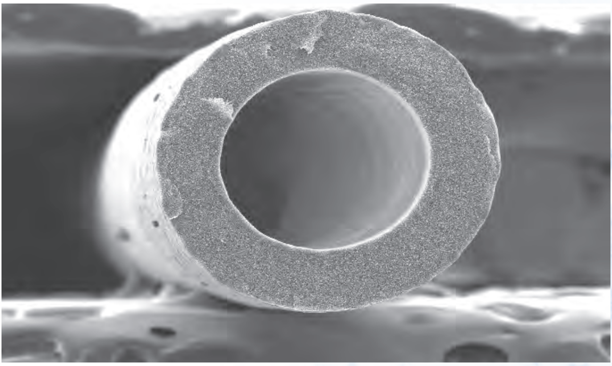
Secondary treatment removes the dissolved organic matter that was not removed during primary treatment. The treatment technologies include activated sludge process, trickling filters, clarifiers, and other forms of treatment which use biological activity to break down organic matter. This process uses microbes that consume organic matter as food and convert it to carbon dioxide, water and energy for their own growth and reproduction. After consuming the organic material, the microorganisms are introduced into settling tanks where they settle out. After settling out in these clarifiers, one of two routes is taken. Some will be reintroduced to consume more of the organic materials, while others are sent to be thickened, digested, dewatered, and ultimately trucked to a composting facility or farmland in Arizona to be used as a soil amendment. The cleaned water, called secondary effluent, is then either sent into the ocean through an outfall pipeline or sent to the OCWD to be purified at the GWRS.



Following treatment at OCSD, secondary effluent passes through the microfiltration (MF) process at the GWRS operated by OCWD. The MF process uses bundles of hollow polypropylene fibers to remove particulate contaminants from water. Under a vacuum, water is drawn through the fibers' minute pores, each approximately 0.2 microns in diameter, and suspended solids, protozoa, bacteria, and some viruses are strained out.

Microfiltration works most efficiently when turbidity in the feed water is between 3 to 5 Nephelometric Turbidity Units (NTU) and when feed pressure stays within the 3 to 12 pounds per square inch (PSI) range. To prevent higher pressure from building up, each MF cell undergoes a backwash every 22 minutes and a full chemical cleaning every 21 days. These operating procedures reduce energy costs (by reducing pressure) as well as improve process recovery (allowing more

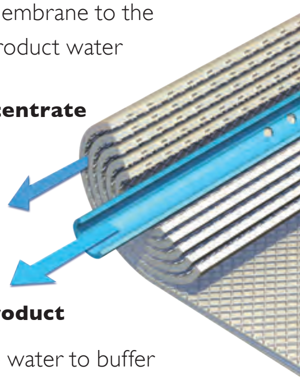




Microphotograph of a single microfiltration fiber

feed water to be pulled through the MF membranes). Ongoing research continues to yield advances in membrane technology that further reduce energy needs and unit costs of production.

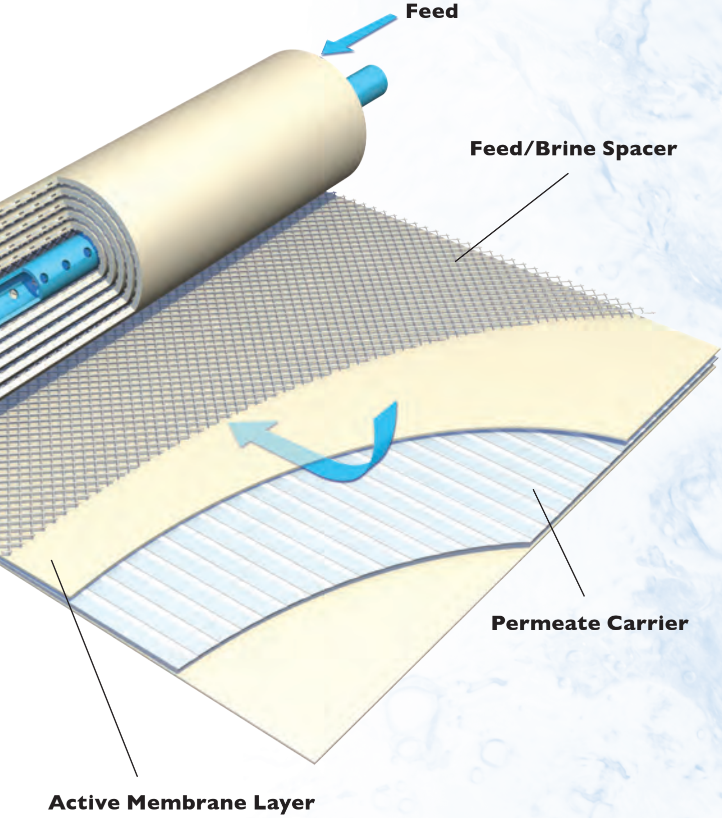
The MF product water advances to the next step in the purification process, reverse osmosis (RO). This system uses envelopes of semi-permeable polyamide membranes rolled into bundles and encased in long pressure vessels. Pressurized microfiltered water enters at one end of each vessel and passes through the membrane to the inside of the envelope where purified product water is collected, exiting through the product water pipes. Left behind in the brine concentrate are unwanted components such as dissolved salts, organic chemicals, viruses, and pharmaceuticals. The product water emerges so pure that minerals have to be added back into the water to buffer and stabilize it prior to entering distribution pipes.



Close monitoring of two key features ensures efficient operation of the reverse osmosis process. The first is electrical conductivity (EC) which acts as a surrogate for measuring salts or total dissolved solids (TDS). The second is total organic carbon (TOC) used to monitor the removal of organics. Product water TOC is also closely monitored by the Regional Water Quality Control Board (RWQCB) and the State Water Resources Control Board Division of Drinking Water. Monitoring of influent and product water for both electrical

conductivity and total organic carbon ensures both the efficient operation of the membranes and adherence to water quality requirements.

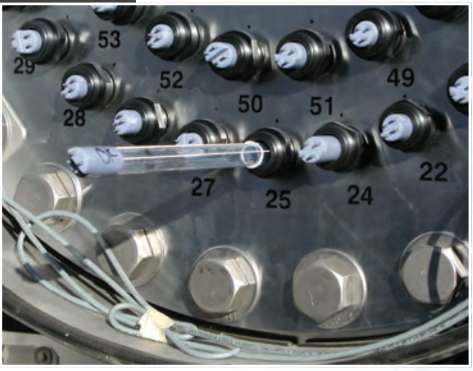
The use of RO to purify wastewater was pioneered at OCWD where it was first used at WF 21, which operated from 1976 to 2004. OCSD provided WF 21 with the source wastewater. Data derived from decades of research demonstrate the reliability and effectiveness of this advanced purification process which has now become the standard for best available purification.



ULTRAVIOLET LIGHT WITH HYDROGEN PEROXIDE, FOLLOWED BY LIME TREATMENT

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

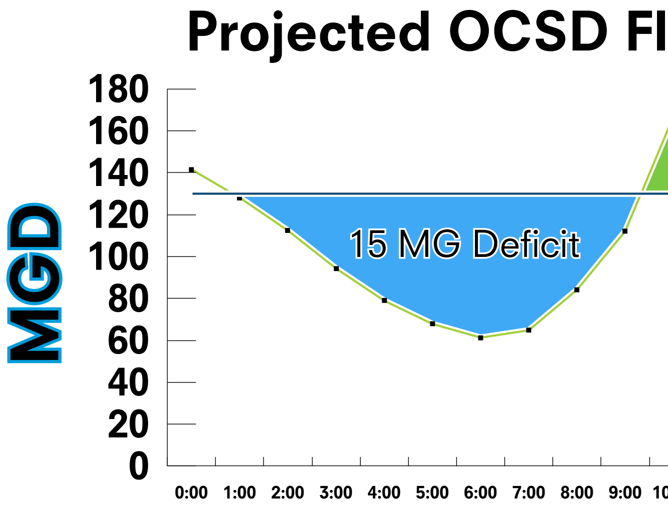
At the end of the process, the pH of the finished product water is checked to make sure that it remains between pH 6 and 9. The reason this is done is to assure that the stabilized water is neither corrosive to pipes nor scale forming. The post PH analysis is required due to the addition of acid just prior to introduction into the RO stage. Sulfuric acid improves RO performance, but results in the buildup of excess carbon dioxide which drives down pH. The RO process itself also significantly reduces alkalinity through mineral ion removal. To stabilize the product water and increase pH, excess carbon dioxide is removed by air stripping.



After purification, calcium hydroxide (hydrated lime in powder form) is blended with water in a slurry mixing box. Cationic polymers are added to improve settling of any undissolved particles. This blend is added to the final GWRS product water to stabilize and buffer it, maintaining the targeted pH range in the distribution system.

The production capacity of phase one of the GWRS was 70 MGD (265,000 cubic meters), which required an influent flow of 93 MGD (344,000 cubic meters). Flows in excess of 100 MGD (378,000 cubic meters) were available from OCSD during a portion of each day, but were discharged to an ocean outfall via OCSD's Plant No. 2. Due to normal diurnal variations, raw wastewater flows arriving at Plant No. 1 fluctuate between 60 MGD (227,000 cubic meters) and 150 MGD (568,000 cubic meters) throughout the day, resulting in periods of shortfall at night and periods of surplus during the day. The production from the GWRS was ramped up and down to align with the flow available from Plant No. 1. As a result, the GWRS was unable to consistently achieve its full design production capability.

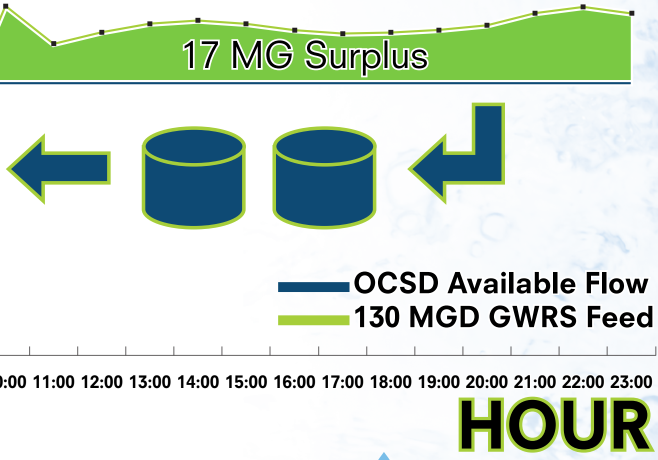
Knowing the GWRS can operate at various flows, the initial expansion of the GWRS included greater capacity to accommodate the higher flows of wastewater available during the day. The initial expansion included the addition of two flow tanks to equalize secondary effluent flow, which helps increase daily GWRS production to 100 MGD (378,000 cubic meters) by storing wastewater during the day and feeding the plant at night during low flow periods. A storage volume of 15 MGD (57,000 cubic meters) is required to equalize flows through the day to provide a constant 130 MGD (492,000 cubic meters) to the GWRS.



Flow equalization involved the construction of two 7.5 million gallon (28,000 cubic meters) capacity, above ground steel storage tanks. The tanks contain enough storage volume to ensure that the initial expansion provides an additional 30 MGD (114,000 cubic meters) of production from the GWRS. Each tank is 216 feet (66 meters) in diameter and 35 feet (11 meters) tall. The tanks include solar powered mixers and a pump station consisting of five 75 horsepower (56 kilowatts) vertical turbine pumps. The pumps are used to fill the equalization tanks with excess secondary effluent. The contents are then discharged from the tanks by gravity to the GWRS screening facility. A common pipeline is used for both filling and draining of the equalization tanks.

Flow equalization allows the GWRS to operate at a steady-state flow, simplify operation, increase water production, and reduce the unit cost of the water produced.

ow and GWRS Feed

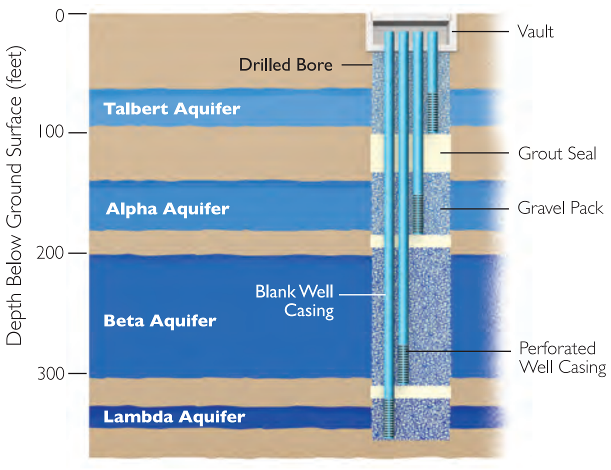


The Huntington Beach coast is home to a shallow aquifer and a geological feature known as the Talbert Gap. Here alluvial deposits of sand and gravel cross a fault barrier and create conditions conducive to seawater intrusion. When water is pumped from inland wells, seawater can migrate inland through the Talbert Gap to deeper aquifers, eventually reaching drinking water wells.

Knowledge of the vulnerability of the basin to seawater intrusion goes back over half a century. In 1965, OCWD began a pilot project to determine how to halt the flow of ocean water into the aquifers. Based on experience with other seawater barriers in Southern California, it was determined that water could be injected under pressure along the Talbert Gap through a line of injection wells. This would create a hydraulic barrier to push the intruding seawater back toward the ocean.

Because of the critical importance of maintaining a protection barrier, a 100 percent dependable supply of water was sought. OCSD provided a reliable source of wastewater for treatment at WF 21. After years of pilot testing, WF 21 was built to provide a safe and dependable supply of injection water. Decades of monitoring data have shown both the effectiveness and safety of using advanced purification processes to produce ultra-pure water for injection into the Talbert Barrier.

Cross section of an injection well

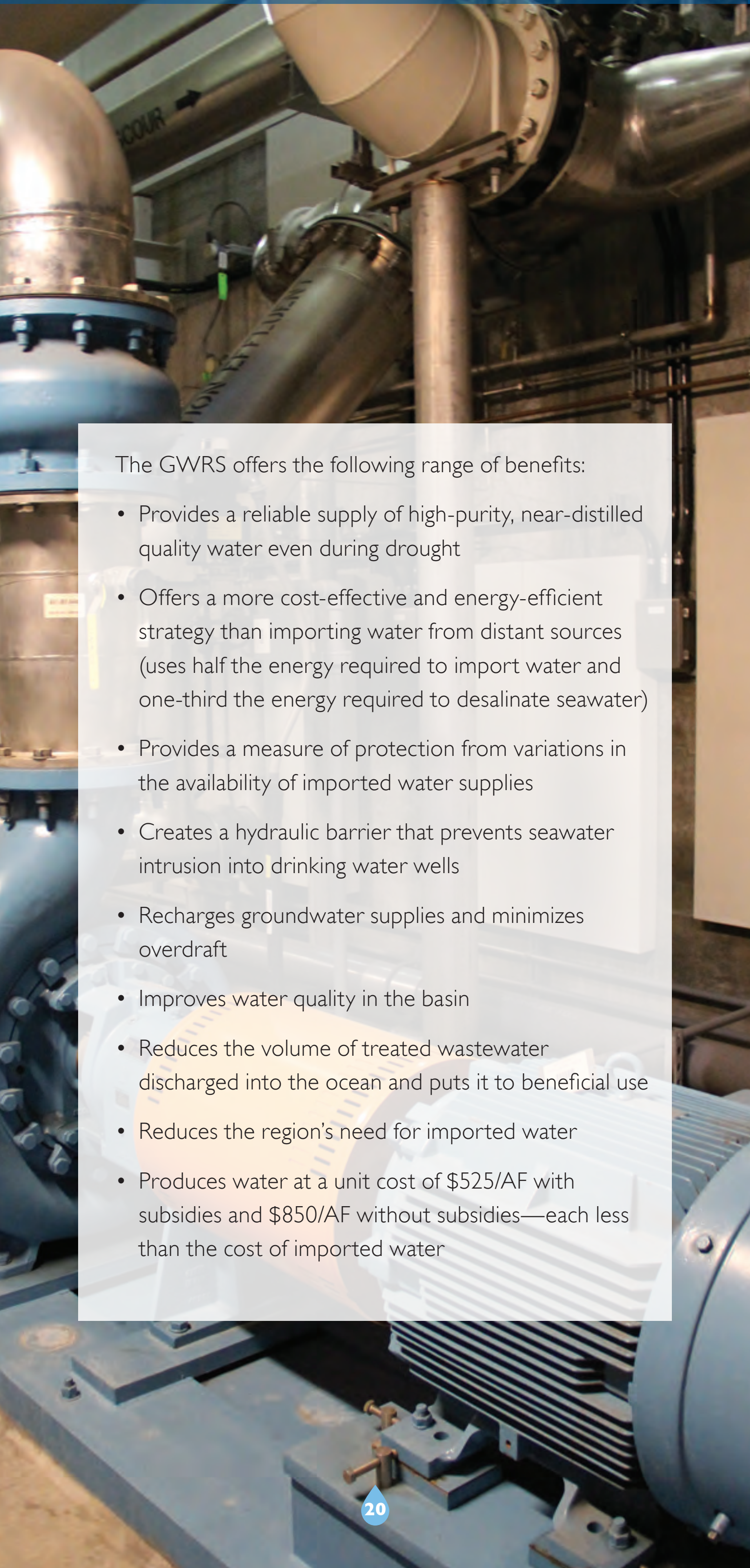


INLAND SPREADING AND PERCOLATION BASINS

One of the principal methods for recharging groundwater involves supplying source water to OCWD's spreading basins in Anaheim and Orange. Water sources for recharge include GWRS water, imported water from the State Water Project and Colorado River, and both base flow and captured storm water in the Santa Ana River. Three of these basins, Kraemer, Miller and Miraloma, are used primarily for recharging GWRS water. Kraemer Basin consists of 31 acres (12 hectares) and has an average recharge volume of 35,000 acre-feet per year (AFY) (11 billion gallons per year; 43 million cubic meters per year). Miller Basin is 25 acres (10 hectares) with an average annual recharge volume of 19,000 AFY (6 billion gallons per year; 23.4 million cubic meters per year). One of OCWD's newest basins, Miraloma Basin, is 13.2 acres (5 hectares) and percolates at an exceptional rate, recharging an average of 29,000 AFY of water into the groundwater basin annually (9.45 billion gallons per year; 36 million cubic meters per year). Percolation rates with cleaner sources of water, such as GWRS and imported water, are approximately double the rates achieved with Santa Ana River water. This is because Santa Ana River water contains suspended solids, typically comprised of inorganic silts and clays that clog the basin surface.

GWRS water is conveyed to these basins through a 13-mile (20 kilometers) long pipeline that runs through the cities of Fountain Valley, Santa Ana, Orange, and Anaheim. Five feet (1.5 meters) in diameter at its end point, this pipeline is capable of delivering over 80 million gallons (302,000 cubic meters) of purified water to the basins each day. Turnouts in the pipeline could accommodate direct injection in the future.

PROJECT COSTS AND BENEFITS



The GWRS offers the following range of benefits:

- Provides a reliable supply of high-purity, near-distilled quality water even during drought
- Offers a more cost-effective and energy-efficient strategy than importing water from distant sources (uses half the energy required to import water and one-third the energy required to desalinate seawater)
- Provides a measure of protection from variations in the availability of imported water supplies
- Creates a hydraulic barrier that prevents seawater intrusion into drinking water wells
- Recharges groundwater supplies and minimizes overdraft
- Improves water quality in the basin
- Reduces the volume of treated wastewater discharged into the ocean and puts it to beneficial use
- Reduces the region's need for imported water
- Produces water at a unit cost of \$525/AF with subsidies and \$850/AF without subsidies—each less than the cost of imported water

ENSURING WATER QUALITY

Ensuring water quality for the GWRS begins at the Orange County Sanitation District (OCSD), which has an award-winning source control program that has helped decrease the amount of toxic pollutants entering the sewer.

OCWD maintains a vast network of monitoring wells within the groundwater basin, with concentrated monitoring along the seawater barrier and near the spreading basins. A number of GWRS-related monitoring wells have been added in the vicinity of the Kraemer, Miller and Miraloma basins to determine water levels and collect comprehensive water quality data. In addition to ensuring the protection of water quality, these wells can also be used to determine travel time from spreading basins to production wells.

Because of the long history of using advanced purified water at the coastal barrier, OCWD is able to use 100 percent GWRS water for injection into the barrier without blending with imported water or other sources as required for other barrier projects in Southern California. At the spreading basins, blending is required and the blend of GWRS water to other water is 75 percent, with the balance of diluent water coming from Santa Ana River stormflows and occasional purchases of imported water.

The Regional Water Quality Control Board permit requires adherence to rigorous product water quality specifications, extensive groundwater monitoring, buffer zones near recharge operations, reporting requirements, and a detailed treatment plant operation, maintenance and monitoring program.

WATER QUALITY (2014)

Parameter Name	Units	QI	MFF
Electrical Conductivity	umhos/cm	1,524	1,574[2]
Total Dissolved Solids	mg/L	954	na
Suspended Solids	mg/L	5	4.4
Turbidity	NTU	2	2.50[2]
Ultraviolet percent transmittance @254nm	%	na	na
pH	UNITS	7.4	7.2[2]
Total Hardness (as CaCO3)	mg/L	311	na
Calcium	mg/L	82.5	na
Magnesium	mg/L	25.4	na
Sodium	mg/L	207	na
Potassium	mg/L	17.8	na
Bromide	mg/L	na	na
Chloride	mg/L	255	na
Sulfate	mg/L	199	na
Hydrogen Peroxide	mg/L	na	na
Bicarbonate (as CaCO3)	mg/L	na	na
Nitrate Nitrogen	mg/L	9.90	na
Nitrite Nitrogen	mg/L	0.583	na
Ammonia Nitrogen	mg/L	2.1	na
Organic Nitrogen	mg/L	0.4	na
Total Nitrogen	mg/L	12.8	na
Phosphate Phosphorus (orthophosphate)	mg/L	0.46	na
Iron	ug/L	332	na
Manganese	ug/L	31.7	na
Aluminum	ug/L	10.2	na
Arsenic	ug/L	<1	na
Barium	ug/L	28	na
Boron	mg/L	0.38	na
Cadmium	ug/L	<1	na
Chromium	ug/L	1.2	na
Copper	ug/L	4.3	na
Cyanide	ug/L	<5	na
Fluoride	mg/L	0.91	na
Lead	ug/L	<1	na
Mercury	ug/L	0.2	na
Nickel	ug/L	7.6	na
Perchlorate	ug/L	na	na
Selenium	ug/L	1.0	na
Silica	mg/L	20.2	na
Silver	ug/L	<1	na
Zinc	ug/L	21.8	na
N-nitrosodimethylamine	ng/L	29.1	na
1,4-Dioxane	ug/L	1.0	na
Total Trihalomethanes	ug/L	na	na
Dibromoacetic Acid	ug/L	na	na
Dichloroacetic Acid	ug/L	na	na
Monobromoacetic Acid	ug/L	na	na
Monochloroacetic Acid	ug/L	na	na
Trichloroacetic Acid	ug/L	na	na
Apparent Color (unfiltered)	UNITS	na	na
Total Organic Carbon (unfiltered)	mg/L	8.69	9.26
Surfactants (MBAS)	mg/L	0.17	na
Total Coliform[4]	MPN/100 mL	251,000	3,400
Total Coliform[5]	MPN/100 mL	228,000	16,877
Fecal Coliform[4] (Mult. Tube Fermentation)	MPN/100 mL	70,800	601

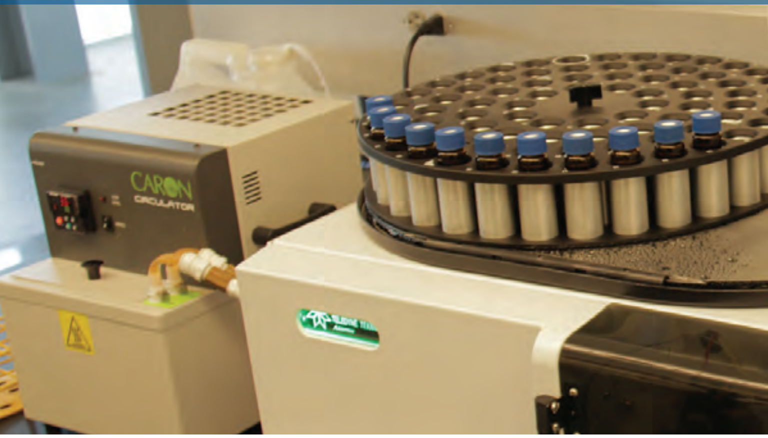
BGT note: ROP Aluminum = 5.16 ug/L in 2011. It was <1 ug/L in 2010.
We deleted the Al grab sample WQ result on 11/15 because it was extremely high (50.2 ug/L).
Without the 50.2 ug/L the average was 1.06 ug/L.
20110325-Revised permit limit for Boron from NL to N/A.
20110422-Confirmed high ROF lead value of 31.9 ug/L on 8/16/10. This makes the average higher than last year.
Reason is unknown. (Lead in 2009 was <1 ug/L.)
20110520-added perchlorate
20110422-Confirmed high ROF zinc value ug/L on 8/16/10. This makes the average higher than last year.
Reason is unknown. (Average 2010 zinc is 2x 2009 zinc level.)
20110325-Revised permit limits for NDMA and 1,4-dioxane from NL to N/A
20110325 - Added "MBAS"

MFE	ROF	ROP	UVP	FPW	Permit Limit
1,664	1,587[2]	55[2]	65	95[1]	900
na	968	33	33	54	500[3]
<0.1	na	na	na	na	N/A
0.09[2]	0.13[2]	0.07[2]	na	0.05[2]	≤0.2 / ≤0.5
68.3	na	98.3[2]	na	na	>90
7.4	6.9[2]	5.6[2]	5.9	8.2[2]	6 - 9
na	304	0.2	<1	23.11	240[3]
na	81.1	<0.5	0.03	9.0	N/A
na	24.6	<0.5	<0.1	<0.5	N/A
na	205	10.2	6.72	9.6	45
na	18.1	0.8	0.8	0.7	N/A
na	na	na	na	0.01	N/A
na	247	7.6	7.9	7.5	55
na	217	0.1	0.1	0.2	100
na	na	na	2.4	2.2	N/A
na	158	8.7	7.5	27.3	N/A
na	9.63	1.57	1.67	1.49	3[3]
na	0.518	<0.002	0.016	0.059	1[3]
na	1.8	0.3	na	0.3	N/A
na	0.1	0.02	na	0.02	N/A
na	12.1	na	na	1.8	5
na	na	na	na	<0.01	N/A
na	119	<1	<1	1	300
na	34.1	<1	<1	<1	50
na	5.6	1.3	1.4	1.4	200[3]
na	0.3	<1	<1	<1	10
na	26.2	<1	<1	<1	1,000
na	0.40	0.29	0.27	0.26	N/A
na	<1	<1	<1	<1	5
na	1.1	<1	<1	<1	50
na	8.9	<1	0.8	<1	1,000[3]
na	1.0	<5	na	<5	150
na	na	na	na	<0.1	2
na	3.6	<1	<1	<1	15
na	0.2	<0.1	<0.1	<0.1	2
na	9.1	<1	<1	<1	100
na	na	na	na	<2.5	6
na	1.1	<1	<1	<1	50
na	21.6	0.5	1.4	1.4	N/A
na	<1	<1	<1	<1	100
na	40.8	1.2	1.4	<1	5,000
na	38.3	23.5	0.2	1.8	N/A
na	<1	<1	<1	<1	N/A
8.9	na	na	na	1.4	80
na	na	na	na	<1	60,total HAA5
na	na	na	na	<1	60,total HAA5
na	na	na	na	<1	60,total HAA5
na	na	na	na	<1	60,total HAA5
na	na	na	na	<1	60,total HAA5
na	30.2	<3	na	<3	15
6.97	7.66	0.17	na	0.16	0.5[3]
na	0.17	<0.02	na	<0.02	0.5
<2	na	<2	<2	<2	2.2
<1	na	<1	<1	<1	2.2
<2	na	<2	<2	<2	N/A

QI Secondary Effluent (AWPF Influent)
MFF Microfiltration Feed
MFE Microfiltration Effluent
na Not analyzed
ROP Reverse Osmosis Product
UVP Ultraviolet UV/AOP Product
FPW Finished Product Water
N/A Not applicable

[1]For purposes of calculating annual averages, 10% of the Reportable Detection Limit was used for all non-detect values.
[2]On-line average
[3]See Appendix A for more information
[4]Multiple Tube Fermentation Method (Averages shown for January 1 through September 21, 2014, after which use of this method ceased.)
[5]Colilert Method (Averages shown for January 1 through December 31, 2014. The Colilert Method will be used going forward.)

OVERVIEW OF RESEARCH



OCWD has a long history of supporting research on both the technical and water quality aspects of water purification. Searching for a reliable source of injection water in the 1970s, it sponsored innovative pilot projects to study advanced methods for treating wastewater. OCWD realized that research was integral to its goal of becoming a leader in water recycling. A "testing facility" was built where new technologies could be installed and evaluated on a pilot basis. This test facility prompted the need for additional water analyses, leading to expansion of the water quality laboratory. Full-time research scientists soon thereafter joined the staff at OCWD to tackle challenges associated with emerging water treatment technologies.

Early on, one of the major problems that had prevented use of reverse osmosis for treating wastewater was biofouling of the membranes. Biofouling greatly increased operating costs, requiring continual cleaning and higher operating pressures. Working in close association with the academic community, OCWD scientists developed an intensive research program that ultimately generated cost-effective solutions. This research also gave OCWD a worldwide reputation for supporting a culture of innovation that exists to this day. This professionalism, combined with increasingly sophisticated water analyses, provided the confidence needed by the health and regulatory community and the general public to allow OCWD to continually push the frontiers of water reuse.

GWRS is the ultimate expression of OCWD and OCSD's long-term goal of developing a dependable water supply from a resource that formerly was wasted to the ocean. Research remains an integral part of water resource development at OCWD, and the testing facility continues to evaluate new membranes and processes. OCWD's state-certified Advanced Water Quality Assurance Laboratory has gained a reputation as one of the premier water quality laboratories in the world.

The GWRS has its roots in WF 21, OCWD's original flagship treatment plant. Established in 1976, WF 21 was an innovative plant built to produce high quality supplemental water supplies for Orange County. Its facilities included a 15 MGD (56,000 m3/day) advanced water purification plant that provided lime clarification, ammonia stripping, recarbonation, multimedia filtration, granular activated carbon (GAC) adsorption, and chlorination of secondary effluent received from OCSD at no additional cost. By 1977, it also included a 5 MGD reverse osmosis demineralization plant to reduce total dissolved solids. WF 21 was the first plant in the world to use RO to purify wastewater to drinking water standards. The GAC-treated water and RO-treated water were blended with deep well water and injected into a series of injection wells to create a hydraulic barrier and prevent seawater intrusion, as well as augment groundwater supplies. In response to new water quality issues in 2000, WF 21 subsequently used only RO treated water combined with deep well water for injection into the barrier.

The original WF 21 ceased operations in 2004. At that time, Interim Water Factory 21 (IWF 21) began operations for two years while the GWRS was being built by OCWD and OCSD. In addition to continuing the seawater intrusion prevention effort, IWF 21 served as a training facility, enabling staff to become familiar with the treatment processes they would operate at the GWRS facility. IWF 21 modified the existing WF 21 facilities and introduced new treatment processes that included microfiltration and low pressure-high intensity ultraviolet light with hydrogen peroxide to create an advanced oxidation process. The new processes, together with the existing RO system—now retrofitted with thin film composite polyamide membranes—resulted in increased energy efficiency and more effective removal of contaminants. The addition of hydrogen peroxide upstream of the UV light enhanced the oxidation process and enabled the destruction of UV-resistant contaminants. IWF 21 also retained the original chlorination system to prevent biofouling of injection wells. Interim Water Factory 21 ceased operations in 2006. Until the GWRS facility was completed in 2008, OCWD used potable water from imported sources and the City of Fountain Valley for injection into the Talbert Barrier.

THE INDEPENDENT ADVISORY PANEL

In addition to reports generated by OCWD's research department and water quality laboratory and the Annual GWRS Report prepared by a diplomate of the American Academy of Environmental Engineers and scientists, reports produced by an Independent Advisory Panel (IAP) document on-going scientific peer review. The IAP analyzes data in OCWD's Annual GWRS Report of plant operations as well as water quality data collected throughout the groundwater basin. The IAP is appointed and administered by the prestigious National Water Research Institute to provide credible, objective review of all aspects of the GWRS by scientific and engineering experts from around the world. Although the IAP reports are scientific and technical in nature, and written mainly for the health and regulatory community, they are available for review by any interested party. In addition to formal written reports, the IAP also offers suggestions for enhanced monitoring of water quality and for improving the efficiency of current GWRS technologies and for evaluation of future projects associated with the GWRS.

The internationally renowned GWRS is the largest advanced water purification facility of its kind in the world. It has garnered more than 40 awards. Below are some award highlights:

Courtesy of SIWA

- Stockholm Industry Water Award, the highest international honor given to a water project (2008)
- American Society of Civil Engineers Outstanding Civil Engineering Achievement Award, the highest national honor bestowed upon engineering projects (2009)

- California Association of Sanitary Agencies Outstanding Capital Project of the year (2015)
- U.S. Water Prize (2014)
- Lee Kuan Yew Water Prize bestowed on OCWD for its pioneering work in groundwater management, including advanced water reuse (2014)

- American Water Works Association and American Membrane Technology Association "Membrane Facility of the Year" Award (2012)
- International Ultraviolet Association UV Engineering Project of the Year Award (2009)
- United States Environmental Protection Agency Clean Water State Revolving Fund PISCES Award (2009)
- Säid Khoury Award for Engineering Construction Excellence, bestowed upon four engineers associated with the GWRS (2009)
- Toshiba Green Innovation Award (2008)
- Orange County Coastkeeper Coastal Preservation Award (2008)
- WateReuse Association Water Recycling Agency of the Year Award (2008)
- Global Water Intelligence Award of Distinction, Water Project of the Year (2008)
- Groundwater Resources Association of California Kevin J. Neese Award (2008)
- Silver Anvil Award, Public Relations Society of America for Excellence in Community Relations Government Award (2006)

The Orange County Water District (OCWD) takes the limited water supply found in nature and supplements it to provide water for 19 cities and water agencies serving 2.4 million residents in north and central Orange County. Since 1933, when the California Legislature formed it, OCWD has been entrusted to guard the region's groundwater basin. It manages and replenishes the basin, ensures water reliability and quality, pervents seawater intrusion, and protects Orange County's rights to Santa Ana River water.

The Orange County Sanitation District (OCSD) is a public agency that provides wastewater collection, treatment and recycling for residents in central and northwest Orange County. OCSD is a special district that is governed by a 25 member board of directors comprised of 20 cities, four special districts, and one representative from the Orange County Board of Supervisors. OCSD has two operating facilities that treat wastewater from residential, commercial and industrial sources. The wastewater from these communities travel through 587 miles of regional sewers to one of the two treatment plants in Fountain Valley or Huntington Beach where it is treated and sent for water recycling or released into the Pacific Ocean.

ORANGE COUNTY WATER DISTRICT
BOARD OF DIRECTORS

ORANGE COUNTY SANITATION DISTRICT
BOARD OF DIRECTORS

GWRS

GROUNDWATER REPLENISHMENT SYSTEM

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