ABOUT THE COVER:
Water Factory 21, a world-renowned wastewater reclamation plant, attracts more than 1,000 government leaders, university students, engineers, and hydrogeologists from 30 nations every year.

SINCE 1933 · ORANGE COUNTY WATER DISTRICT · A TRADITION OF INNOVATION

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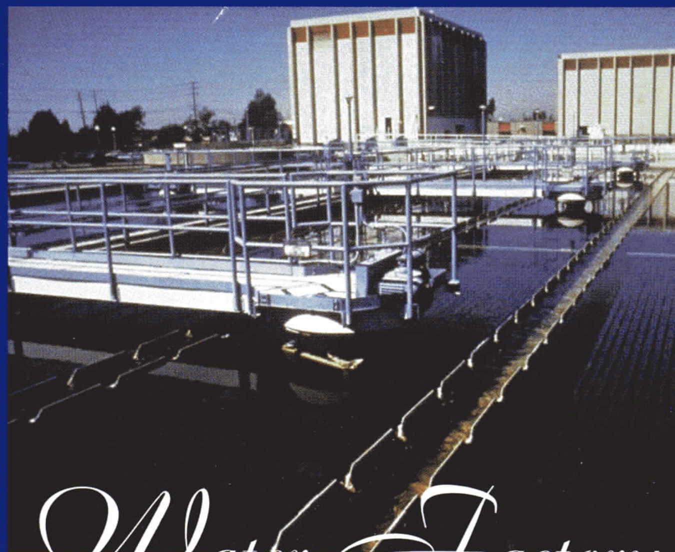


Water Factory 21

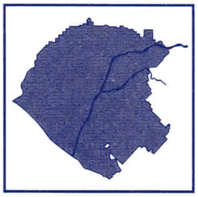
ORANGE COUNTY WATER DISTRICT

Orange County, California, receives an average of only 13 to 15 inches of rainfall annually, yet sustains a population of approximately 2.5 million people. The Orange County Water District (OCWD) manages the massive groundwater basin that underlies the northwest half of the county, supplying about 75 percent of the District's total water demand. The remaining 25 percent is obtained through the Colorado River Aqueduct and the State Water Project via the Metropolitan Water District of Southern California.

Orange County's groundwater basin was used by early settlers to supplement flows from the Santa Ana River. As the area developed into a thriving agricultural center, the increased demand upon the subsurface water by the county's many wells resulted in a gradual lowering of the water table. In response, the Orange County Water District was formed by an act of the California Legislature in 1933 to protect and manage the groundwater basin.

In addition to effecting aggressive groundwater recharge and recovery programs to optimize local water resources, District officials have for decades advocated treating and recycling municipal wastewater as a reliable supplemental supply. As long ago as the mid-1960s, OCWD began a pilot-scale reclamation project that developed into the now-famous Water Factory 21. Located in Fountain Valley, California, the plant is well-known internationally, attracting more than 1,000 visitors annually from 30 countries.

TALBERT BARRIER PROJECT and WATER FACTORY 21



By 1956, years of heavy pumping to sustain the region's agricultural economy had lowered the water table below sea level and saltwater from the Pacific Ocean had encroached as far as five miles inland. The area of intrusion is primarily across a four-mile front between the cities of Newport Beach and Huntington Beach known as the Talbert Gap. The mouth of an alluvial fan formed millions of years ago by the Santa Ana River, the Talbert Gap has since been buried along the coast by several hundred feet of clay.

Massive seawater intrusion has been prevented by the District's recharge program. However, the threat of saltwater encroachment along the coast is still present. To prevent further intrusion and to provide basin management flexibility, the District operates a hydraulic barrier system. A series of 23 multi-point injection wells four miles inland delivers fresh water into the underground aquifers to form a water mound, blocking further passage of seawater.

The first blended reclaimed water from Water Factory 21 was injected into the coastal barrier in October 1976. Several alternative sources of water were thoroughly evaluated for the seawater barrier injection program, including deep well water, imported water, reclaimed wastewater, and desalted seawater. The source of injection water finally adopted for Water Factory 21 is a blended combination

of deep well water and recycled secondary effluent supplied by the County Sanitation Districts of Orange County (CSDOC).

The recycled product water from Water Factory 21 meets drinking water standards through treatment using advanced processes. Recycled water was chosen for many reasons. Cost was a definite consideration, but even more important were the environmental advantages:

- Reduction of 15,000 acre-feet of wastewater discharged to the ocean annually.
- Reduction of dependency on State Water Project and Colorado River supplies.
- Constant availability of reclaimed water supply; seawater intrusion barriers are last priority when imported supplies are diminished by drought or emergency interruption of importation systems.

Water Factory 21 product water is a blend of five million gallons per day (MGD) reverse osmosis-treated water, nine MGD carbon adsorption-treated water, and 8.6 MGD deep well water. This blend, with a total dissolved solids (TDS) content of 500 milligrams per liter (mg/L) or lower, meets all California Department of Health Services primary and secondary drinking water standards.

Product water also complies with the injection requirements of the California Regional Water Quality Control Board, Santa Ana Region. The use of recycled water, at a cost comparable to that of less dependable imported supplies, has rendered the project virtually drought proof.

Water Factory 21 reclaims approximately 15 MGD, and, with the deep well water used for blending, produces 22.6 MGD. The blended injection water not only protects the basin from saltwater intrusion, but also replenishes aquifers from which 50 percent of the county's water is drawn.

The plant's treatment train includes chemical clarification, recarbonation, multi-media filtration, granular activated carbon, reverse osmosis, chlorination and blending. All processes are discussed fully on the next pages.

CHEMICAL CLARIFICATION

Chemical clarification reduces turbidity, organics, trace metals, and phosphate, and elevates pH for disinfection and virus removal. The system includes separate rapid mixing, flocculation, and settling basins. Lime, at a dose of 375 to 500 mg/L, is added in slurry form into the rapid-mix basin as a primary coagulant and disinfectant (raising the pH to 11.3), and an anionic polymer, at a dose of 0.1 mg/L, is added as a settling aid in the third-stage flocculation basin.

Water flows from the bottom of the third flocculation basin into a settling basin where it flows horizontally into the notched weirs of collection troughs. Approximate detention time in the clarification basin is 117 minutes: one minute for each of the two rapid-mix basins, 30 minutes in the flocculation basins and 85 minutes in the settling basins.

Originally, air stripping (for removal of ammonia) followed chemical clarification in the treatment train. It is no longer needed, however, because CSDOC now treats to a higher level of secondary treatment utilizing activated sludge.

OCWD is currently studying the possibility of using microfiltration (MF) as a replacement for chemical clarification. Benefits of MF may include reduction of space used for pre-treatment, less labor-intensive maintenance, and the possibility of producing even higher-quality water.

The purpose of the recarbonation basin is to neutralize the pH of the highly-alkaline water produced during chemical clarification. Off gases, containing carbon dioxide gas, are recovered from the lime recalcining furnace stack. They are added in a single stage to lower pH between 6.5 and 7.0. The recarbonation basins also serve as chlorine contact basins. Generally, five to 10 mg/L of chlorine is added for partial disinfection and algae control. Detention time in the recarbonation basin is about 70 minutes.

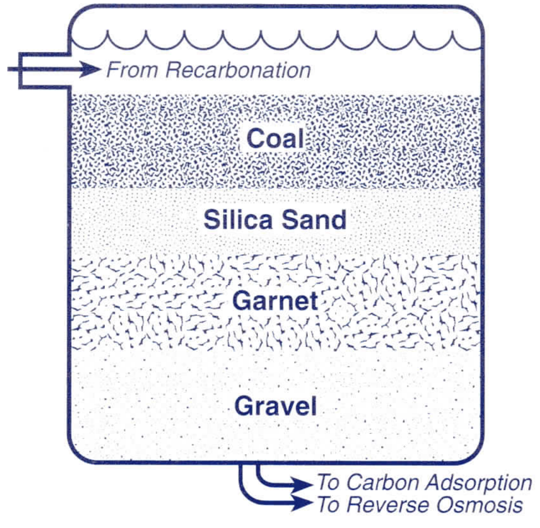
LIME RECALCINATION and SOLIDS HANDLING

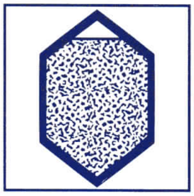
Solids that have settled to the bottom of the settling basins - about 30 tons per day - are transported to the sludge thickening basin, then sent to one of two centrifuges in the lime building for further dewatering and sludge separation. Sludge removed in the centrifuge is fed into a 1700° F. furnace for recovery and reuse. Nearly 75 percent of this material is recoverable.

The lime building contains a six-hearth lime recalcining furnace, lime storage bins, centrifuges for dewatering of thickened sludge from the sludge thickener, lime feeders and slakers, carbon dioxide compressors, and a control room. The lime recalcination furnace can recover up to 24 tons of lime per day. Furnace stack gases are cooled and compressed to recover carbon dioxide to be used in the recarbonation process. Dry lime is made into a wet slurry and added to the rapid mix basins.

Water from the recarbonation basin passes through four open, gravity-flow filtration beds which operate in parallel. Filtration reduces turbidity. Each filter has a design capacity of 3.75 MGD at a rate of five gallons per minute per square foot of surface area. The filters provide coarse to fine filtration in the direction of flow. The filter media are anthracite coal, silica sand, and fine and coarse garnet. Combined, they are 30 inches deep and are supported by a bed of gravel and a tile block underdrain system. A typical filter run generally exceeds 100 hours. The filters are backwashed at the rate of 15 gpm/ft^2 from the filter effluent sump.

Following filtration, the flow is split into two parts, with roughly two thirds of the water going to granular activated carbon adsorption and one third bound for treatment using reverse osmosis.

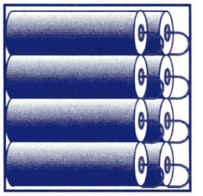




The daily flow rate from multi-media filtration is nine million gallons. Each carbon contactor has a capacity of .9 MGD. The carbon adsorption system consists of a total of 17 contactors, each containing 43 tons of granular activated carbon, operating at a hydraulic loading rate of 5.8 gpm/ft^2. Contact time is 30 minutes.

The carbon contactors operate in parallel and are designed to operate either upflow or downflow (they are currently operated in the upflow mode). The purpose of the GAC is to adsorb various dissolved organic compounds from the treated water. Typically, the carbon removes up to 70 percent of total organic carbon. As the system is operated, the adsorptive capacity of the carbon is eventually exhausted and must be regenerated at regular intervals.

A furnace is located in the carbon building to reactivate spent carbon. The furnace has a regeneration capacity of 12,000 pounds per day. Approximately 93 percent of the carbon is recovered during each regeneration cycle. When regeneration takes place, the spent carbon is taken from the bottom of the columns in slurry form and sent via two-inch hoses to the carbon regeneration tanks. In the upflow mode the bottom half of the carbon is that which becomes exhausted. Operating the contactors in upflow mode allows the regeneration of the bottom half of the contactor's carbon, which is also the portion that is easier to remove.



Water Factory 21 product water must have a total dissolved solids (TDS) content of 500 mg/L or lower. Demineralization of a third of the plant's process water is achieved in the reverse osmosis (RO) process. In addition to removal of TDS, RO is very effective in reducing other minerals, ammonia, and total organic carbon (TOC).

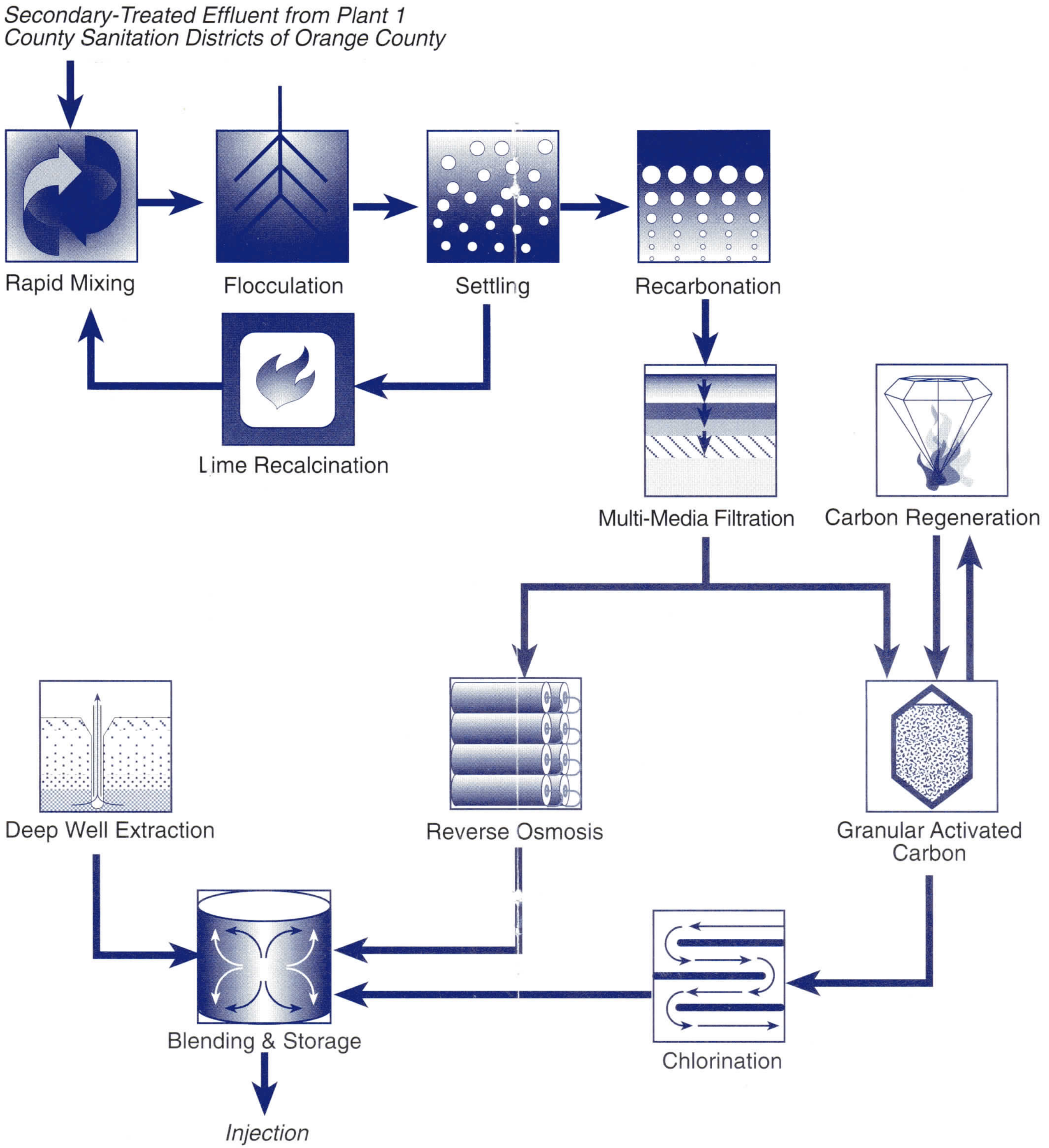
Six million gallons per day enters RO treatment after leaving the multi-media filter beds. Before the water enters the RO membranes, it receives additional pretreatment consisting of antiscalant addition; sulfuric acid addition to lower the pH to 5.5; and cartridge filtration.

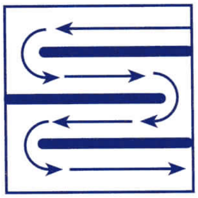
Operation of the RO unit requires pressures of 200-325 pounds per square inch (psi) produced by two high-pressure pumps. The RO unit is designed as two parallel 2.5 MGD systems. The basic element consists of six spiral-wound cellulose acetate membranes placed end-to-end inside an eight-inch diameter fiberglass-reinforced vessel 23 feet long. There are six banks of membranes, each containing 42 vessels, arranged in a three-stage "inverted triangle" pattern (24 vessels, 12 vessels, 6 vessels) to provide 85 percent recovery.

Product water which has passed through the membranes has had 90 percent of TDS removed. The concentrated brine (15 percent of the total input) is returned to the County Sanitation Districts for disposal via their ocean outfall.

Membranes are cleaned *in situ*, using product water with a detergent additive.

WATER FACTORY 21 TREATMENT PROCESS





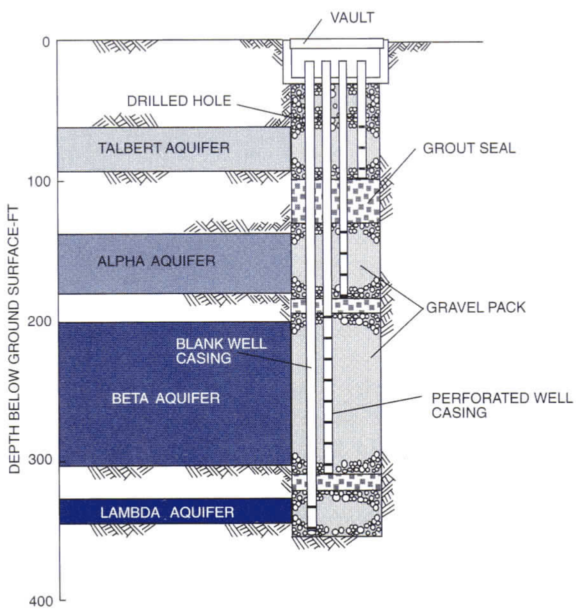
The chlorination basin, 90 feet by 53 feet, is baffled to provide a serpentine flow path for the water. Effluent from the carbon columns flows to the chlorine contact basin for chlorination to oxidize residual ammonia, and to destroy remaining bacteria and virus. Chlorine is added through a diffuser in the pipeline, just upstream of the entrance to the contact basin. Effluent from the chlorination basin flows by gravity to the blending and storage reservoir where it mixes with RO product water and deep well water.

Currently, injection water for the Talbert Barrier is a blend of 62 percent reclaimed wastewater and 38 percent groundwater pumped from a deep aquifer zone that is not subject to seawater intrusion. OCWD has applied for and received a permit to modify the treatment process to allow for injection of 100 percent reclaimed water, eliminating the use of deep well water for blending.

The treatment plant's efficiency in reducing COD, TOC, nitrogen, and turbidity is demonstrated by the water quality data. A higher proportion of RO product water will reduce TOC below levels found in most drinking water supplies. And the high quality water from deep wells which is currently used for blending will be treated to remove color; it holds great promise as a potable water source.

The purpose of Water Factory 21 is to produce a water supply for the Talbert Barrier to prevent seawater intrusion. Final plant effluent, meeting all California Department of Health Services primary and secondary drinking water standards, is pumped into the groundwater basin via a series of 23 multi-point injection wells with a total of 81 individual injection points. Injection wells are placed approximately every 600 feet along Ellis Avenue from the Santa Ana River to the bluffs at Beach Boulevard. This injected water forms a freshwater mound between the ocean and the groundwater basin, providing a hydraulic barrier to seawater intrusion and permitting the groundwater basin to be safely drawn below sea level.

Once underground, some of the injected water flows toward the ocean, forming the seawater barrier. The majority of the water, however, flows into the groundwater basin to augment Orange County's domestic groundwater supply.



CAPITAL AND CONSTRUCTION COSTS

	Total	Federal	State	OCWD
Investigations and Improvements	$2,275,000	$ 130,000	$ 0	$ 2,145,000
Wastewater Reclamation	13,400,000	6,850,000	3,116,000	3,434,000
Injection Barrier Facilities	1,430,000	350,000	160,000	920,000
Deep Wells	732,000	0	0	732,000
Reverse Osmosis	3,000,000	0	0	3,000,000
TOTAL	**$20,837,000**	**$7,330,000**	**$3,276,000**	**$10,231,000**

Capital and construction costs above are actual figures from the mid-1970s.

OPERATING COSTS AT MAXIMUM CAPACITY

Process	Amount Produced, in Million Gallons per Day (MGD)	Cost per 1,000 Gallons	Cost per Acre-Foot
Advanced Water Treatment (AWT): Lime Clarification, Recarbonation, Multi-media Filtration, and Chlorination	15.0	$1.01	$322
Granular Activated Carbon (GAC) treatment and Carbon Regeneration, not including AWT	9.0	$0.18	$58
Reverse Osmosis, not including AWT	5.0	$0.96	$312
Advanced Water Treatment (blended GAC and RO product waters) **Subtotal**	14.0	$1.44	$470
Blending water extracted from deep wells	8.6	$0.12	$38
Blended product water used for injection (62% reclaimed water and 38% deep well water) TOTAL	**22.6**	**$0.93**	**$306**

Operating costs above include energy requirement and labor.

Constituent	Units	OCWD Influent From CSDOC	RO Product Water	Deep Well Blend Water	WF-21 Blended Product Water	California DHS Standards*
Inorganics						
Total Nitrogen	mg/L	18.3	2.6	0.6	3.0	10.0
Boron	mg/L	0.57	0.31	0.18	0.23	1.0
Chloride	mg/L	237.6	18.4	11	43.8	250
Electrical Conductivity	µmho	1,721	182	365	419	1600
Fluoride	mg/L	1.0	0.21	0.72	0.46	1.4 - 2.4
pH	mg/L	7.4	6.7	8.7	7.6	6.5 - 8.5
Sulfate	mg/L	217.5	13.8	11.8	34	250
Cyanide	µg/L	14.7	8.1	-	15.4	200
TDS	mg/L	935.9	60.2	231	235.3	500
Physical Characteristics						
Color	color units	27	4.0	59	21	15
Turbidity	NTU	2.25	0.05	-	0.8	5.0
Coliform	CFU/100mL	1,536,981	<1.0	-	<1.0	<1.0
Heavy Metals						
Arsenic	µg/L	1.2	<5.0	<5.0	<5.0	50
Barium	µg/L	51.2	1.2	3.9	6.3	1000
Cadmium	µg/L	3.0	<1.0	<1.0	1.2	5.0
Chromium	µg/L	1.6	<1.0	<1.0	0.2	50
Cobalt	µg/L	<1.0	<1.0	-	<1.0	200
Copper	µg/L	13.6	4.8	13.2	7.3	1000
Iron	µg/L	165.7	8.6	37.4	23	300
Lead	µg/L	1.2	0.2	<1.0	0.5	<1.0
Manganese	µg/L	43.9	2.0	2.6	6.7	50
Mercury	µg/L	<0.5	<0.5	0.2	0.1	2.0
Selenium	µg/L	4.8	<5.0	<5.0	<5.0	50
Silver	µg/L	0.6	1.0	1.0	0.3	100
Organics						
COD	mg/L	39	3.0	-	8.0	None
TOC	mg/L	10.2	0.72	2.59	2.09	None
THMs	µg/L	-	-	-	9.7	100

* *Department of Health Services (DHS) Drinking Water Standards*

NOTES

TOURS OF WATER FACTORY 21

Offered to adults on weekdays by appointment only, tours take from one to one and one-half hours and include background information and viewing of the treatment train. Tours are canceled in the event of inclement weather.

If you would like to arrange a tour, please call at least two weeks in advance. Requests for specific dates are subject to staff availability, and all guests to Water Factory 21 must be accompanied. Flat shoes are suggested. When calling, please be prepared to provide the following information:

- Date and Time
- Number of Tour Guests
- Contact Name and Affiliation
- Address and Phone and Fax Numbers

To arrange for a speaker on water recycling, groundwater management, or other related programs, contact OCWD's Public Affairs Department at (714) 378-3200.