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Water Rights, Water Quality & Water Solutions in the West

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GROUNDWATER REPLENISHMENT & WATER REUSE

ORANGE COUNTY CALIFORNIAS'S WATER PURIFICATION AND REUSE PROJECT

by Michael R. Markus, P.E., General Manager
Orange County Water District (Fountain Valley, CA)

Introduction

As is true throughout Southern California and elsewhere in the West, securing future water supplies adequate to serve the projected population growth in Orange County, California, remains an ongoing challenge. Central and northern Orange County water demands are expected to increase nearly 20 percent by 2020.

Adding to the challenge, Orange County's allotment from some previous sources of water is expected to decrease. For decades, water purchased from outside of southern California, such as from the Colorado River and California's State Water Project, provided an ample supplement to Orange County drinking water supplies. The expected further reduction in these imported water supplies, combined with recurring droughts and the dramatic population growth projected for the area, clearly indicate that demand for water will overwhelm supply unless new water supplies are secured.

In Orange County, a substantial "new" supply has arisen from water already at hand.

Orange County Water District's (OCWD's) Groundwater Replenishment System (GWR System), brought on-line in January of 2008, is the largest water purification and reuse project of its kind in the world. The GWR System reclaims and purifies a portion of the highly treated wastewater that is otherwise discharged to the ocean. Averaged throughout the year, the GWR System is already producing 265,000 cubic meters (70 million gallons) per day of purified water. Construction is scheduled to begin in the next year on an expansion that will increase facility production to between 85-90 million gallons per day. A third expansion, allowing for the full site capacity of 130 million gallons per day, may begin within the next five years.

Planned since 1994, construction of the GWR System began in 2003 and consists of three major components.

GWR System components include:

- The Advanced Water Purification Facility (AWPF)
- A 13-mile pipeline connecting the AWPF to OCWD's groundwater recharge basins
- The expansion of the existing seawater intrusion barrier with additional injection and monitoring wells

This new system increases OCWD's water independence by providing a locally controlled, drought-proof supply of safe, high quality water. At full capacity, the GWR System will generate approximately 72,000 acre-feet per year of water — enough pure water to meet the needs of 500,000 people. GWR System purified water has water quality similar to distilled water and exceeds all state and federal drinking water standards.

Groundwater Replenish

Groundwater Basin

Imported Supply

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In addition to enhancing OCWD's water supply, the GWR System provides water that is injected into a seawater contamination barrier to protect Orange County's groundwater basin from seawater intrusion from the Pacific Ocean.

The following article describes the GWR System program, construction and start-up, and operational performance.

Project Partners

Development and implementation of the GWR System was made possible through the joint partnership between two very unique agencies: OCWD and the Orange County Sanitation District (OC-Sanitation).

OCWD

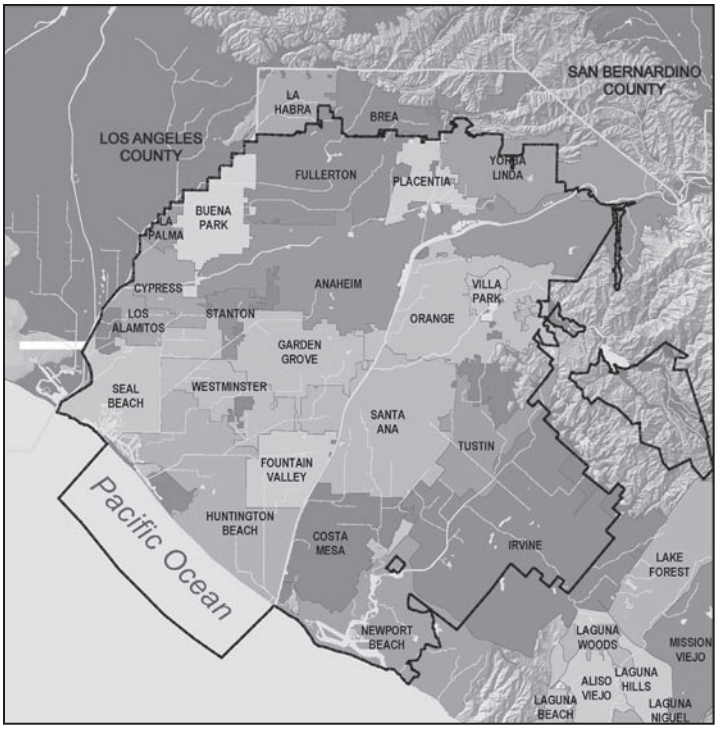
OCWD was formed in 1933 by the California Legislature as a California Special District to manage and protect the large groundwater basin that underlies north and central Orange County in southern California. The groundwater basin supplies more than half of the water needs for 2.3 million residents in the cities of Anaheim, Buena Park, Cypress, Costa Mesa, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, Irvine, La Palma, Los Alamitos, Newport Beach, Orange, Placentia, Santa Ana, Seal Beach, Stanton, Tustin, Villa Park, Westminster and Yorba Linda. OCWD supplies water to these retail water agencies and cities who then directly deliver water to approximately two million Orange County residents and businesses. OCWD is a special district, separate from the County of Orange or any city government. [See map of OCWD service area].

The groundwater basin provides approximately 2/3 of the water needs within the OCWD service area and more than half the water needs of Orange County. The balance of Orange County's supply is provided through imported water supplies from the State Water Project of California (from the Sacramento/San Joaquin Delta) or the Colorado River. In the past, OCWD has imported an average of 65,000 acre-feet per year, of mostly Colorado River water, to recharge the groundwater basin. Due to recent cutbacks from the Metropolitan Water District of Southern California (Metropolitan District), this water has not been available to OCWD for the last two years.

OCWD has an international reputation of industry leadership and creativity that has contributed to solving many of the world's water challenges by providing an example of the utilization of innovative technologies. Each year engineers, scientists, elected officials and water experts from around the globe visit OCWD to learn about their cutting-edge work. OCWD's showcased innovations include advances in: water reuse; groundwater recharge; groundwater monitoring; modeling and management; water quality management; and public education.

OC-Sanitation

OC-Sanitation is a regional wastewater collection and treatment agency serving 2.5 million residents and businesses in north and central Orange County. OC-Sanitation collects, treats, and safely disposes of approximately 910,000 cubic meters of wastewater per day through two treatment plants, 17 pumping stations and 1,050 kilometers of sewer pipelines. OC-Sanitation is governed by a board of directors, comprised of 21 city council members, three directors of special districts, and one county supervisor.



In addition to managing the county's wastewater, OC-Sanitation has an award-winning ocean monitoring program that monitors and evaluates water quality, sediment quality, and sea life from Seal Beach to Corona Del Mar as part of its longstanding commitment to environmental stewardship. OC-Sanitation also has an active biosolids program that generates an average of 575,000 kilograms per day of biosolids. Ninety-eight percent of the biosolids are beneficially reused through land applications or composting.

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Groundwater Replenish

Capital Cost

"New" Water Supply

Cost Comparisons

Given Orange County's proximity to the ocean and impacts that are felt on the coast, OC-Sanitation and OCWD take pride in being environmentally responsible. In addition, the support of the environmental community has proven crucial in moving forward on a number of issues.

Project and Operating Costs

The GWR System's total capital cost was $480,900,000. This figure includes design, construction, public education, and every cost associated with bringing the project online, plus one year of operating costs ($30 million). Approximately $90 million in Federal and State grants were used to help pay the capital costs — thus, after grants/subsidies were factored-in, the cost was around $390 million. OC-Sanitation and OCWD split this remaining cost.

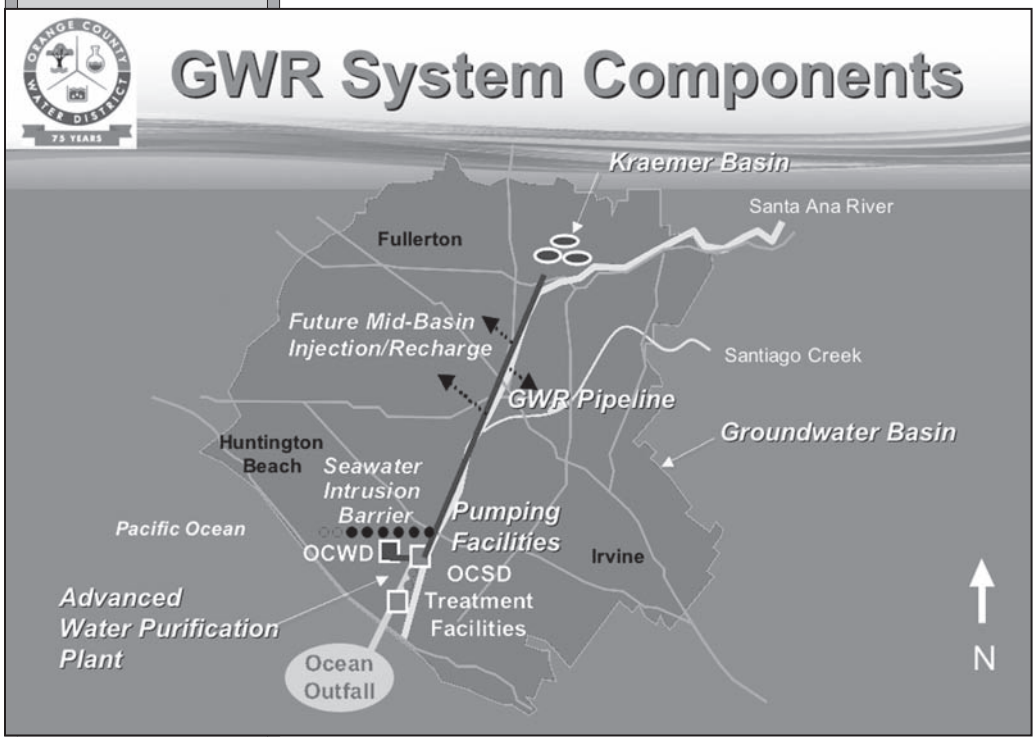
In 2007, OCWD began receiving an annual subsidy of $3.7 million for 23 years from the Local Resources Program of the Metropolitan District, which will defray part of the yearly $30 million in operating costs of the GWR System. The subsidy was granted because the project creates enough new water for more than 500,000 residents. The project lifts a significant burden from limited and costly imported water supplies. In fact, the cost of GWR System water is currently equivalent to imported water. In just a few weeks, the cost of imported water will be higher than GWR System water (when factoring-in subsidies). It is anticipated that in two years, imported water costs will be higher than GWR System water even without the subsidies.

Once grants and subsidies are included, the cost to recharge or inject GWR System water is approximately $550 per acre-foot. With imported water costs currently at approximately $650/acre-foot and climbing, and desalinated water costs ranging anywhere from $800 to $2,000 per acre-foot to produce, the $480 million price tag of the GWR System is very palatable. It is also noteworthy that the GWR System produces water using half the energy that would otherwise be required to pump a similar amount of water to southern California from northern California — saving enough energy to power 21,000 homes each year. The California Energy Commission provided a $700,000 grant for the GWR System because of these energy savings.

Injection Wells

Seawater Contamination Barrier

The seawater barrier is an underground pressure ridge of water formed by injection wells along the northern coast of Orange County that protects the groundwater basin from seawater contamination. Because the basin is naturally connected to the ocean, this dam of pressurized pure water prevents saltwater from contaminating the fresh water aquifers underlying the central coastal zone of Orange County. The Orange County Groundwater Basin consists of multiple aquifers that extend over 2,000 feet deep and form a complex series of interconnected sand and gravel deposits. The areas where the shallow aquifers are adjacent to the ocean are known as "gaps" and are susceptible to seawater intrusion. [See GWR System Components figure this page]



The original seawater intrusion barrier, Water Factory 21 (WF-21), was a wastewater reclamation plant which provided water for a seawater intrusion barrier beginning in 1976. The plant reclaimed approximately 19,000 cubic meters per day of clarified secondary wastewater effluent using lime clarification pretreatment, reverse osmosis, and recently, **u**ltra**v**iolet treatment (UV). WF-21's purified water was injected into the groundwater basin. The original system of injection and monitoring wells that was part of Water Factory 21 was expanded as part of the GWR System project in order to provide added protection from saltwater intrusion.

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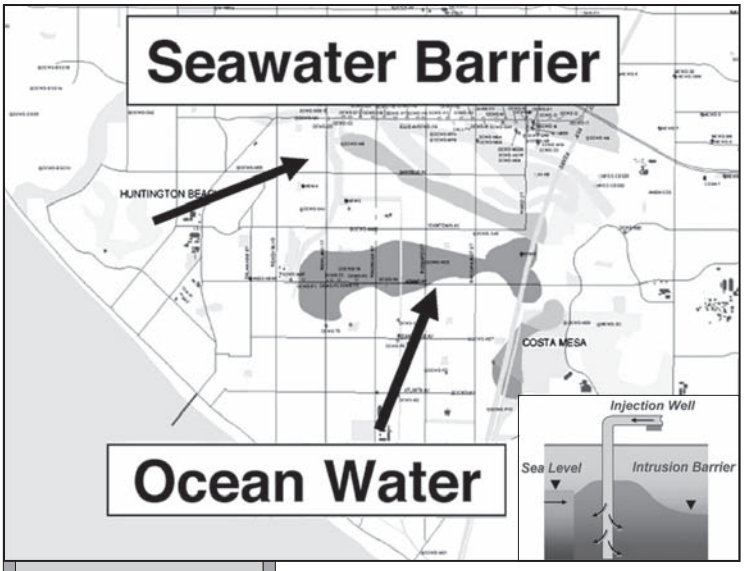

The GWR System replaced WF-21 by using more advanced treatment processes, expanding the existing seawater intrusion barrier, and using the remaining water produced to recharge the groundwater basin. WF-21 had been retrofitted with the inclusion of UV with hydrogen peroxide to remove constituents of concern, including n-**n**itroso**dim**ethyl**a**mine (NDMA) and 1,4-Dioxane.

The GWR System purifies highly treated sewer water using a state-of-the-art, three-step process. This same technology is used to purify baby food, fruit juices, medicine and bottled water. Once purified by the three-step process — micro-filtration, reverse osmosis, and ultraviolet light with hydrogen peroxide disinfection — roughly half of the water from the GWR System is injected into Orange County's expanded seawater intrusion barrier (known as the Talbert Gap Barrier). Eight new injection wells were added to the existing 28 injection wells to increase barrier-water production from 15 to 35 million gallons per day to protect groundwater from intrusion.

Groundwater Replenish

Santa Ana River

Imported Water

Recharge Basins

Demand

Quality Improvement

Water Treatment

Groundwater Replenishment

Most of the water that OCWD recharges into the ground comes from the Santa Ana River. The river provides a constant source of water throughout the year, generated by upstream river flows, with a baseflow of 150,000 acre-feet/year (247 million cubic meters per year). Various agencies discharge more than 150 million gallons per day of their tertiary treated wastewater into the river and the baseflow of the river is dominated by these effluent discharges (*Santa Ana River Water Quality and Health Study*, 1994-2004).

In the past, OCWD also relied on purchasing imported "replenishment water" from the Metropolitan District. When the Metropolitan District had excess water, OCWD purchased it for groundwater replenishment. This replenishment allowed OCWD to pull more water out of the groundwater basin. With recent cutbacks from the State Water Project, as well as drought along the Colorado River, these replenishment waters are not available.

About half of the water produced by the GWR System is piped to recharge lakes in Anaheim, California. These recharge lakes are used as percolation basins to provide groundwater replenishment. In the percolation basins the water takes the natural path, not unlike rainwater, as it filters through sand and gravel to the deep aquifers of the groundwater basin. There, the water blends with existing groundwater before it is used as a source of drinking water for northern and central Orange County residents. There is approximately a six-month travel time before reuse, verified by a groundwater tracer study of travel time from the percolation basins to the nearest well (distance of 5300 feet). Permit R8-2004-0002, March 2004, page 9).

Currently, the demand for groundwater for water supply is approximately 431 million cubic meters per year (350,000 acre-feet per year). As noted above, the GWR System decreases Orange County's reliance on imported water from northern California and the Colorado River. The project will help prevent predicted water shortages in the future. The first phase plans to produce approximately 72,000 acre-feet of water per year and the project can be expanded in future years.

The GWR System also helps reduce mineral build up in Orange County's groundwater by providing a new source of ultra-pure water to blend with other sources, including imported water. This water quality improvement takes place when the purified water from the GWR System, low in minerals, mixes with existing groundwater, lowering the average mineral content of Orange County's water. Lowering the amount of minerals in the water (reducing water hardness) decreases maintenance costs for Orange County's residents and businesses by extending the life of water heaters, boilers, cooling towers and plumbing fixtures.

Advanced Water Treatment Facility

The heart of the GWR System is the Advanced Water Purification Facility. The three major purification processes include: 1) Micro-Filtration; 2) Reverse Osmosis; and 3) Advanced Oxidation Processes — which include ultraviolet light and hydrogen peroxide. A sophisticated distributed control system guides accurate and efficient process management — facilitating local computations, simplifying code maintenance, and enabling rapid adjustments. The easily-expandable system enables the thousands of input and output connections required for this instrument-intensive plant.

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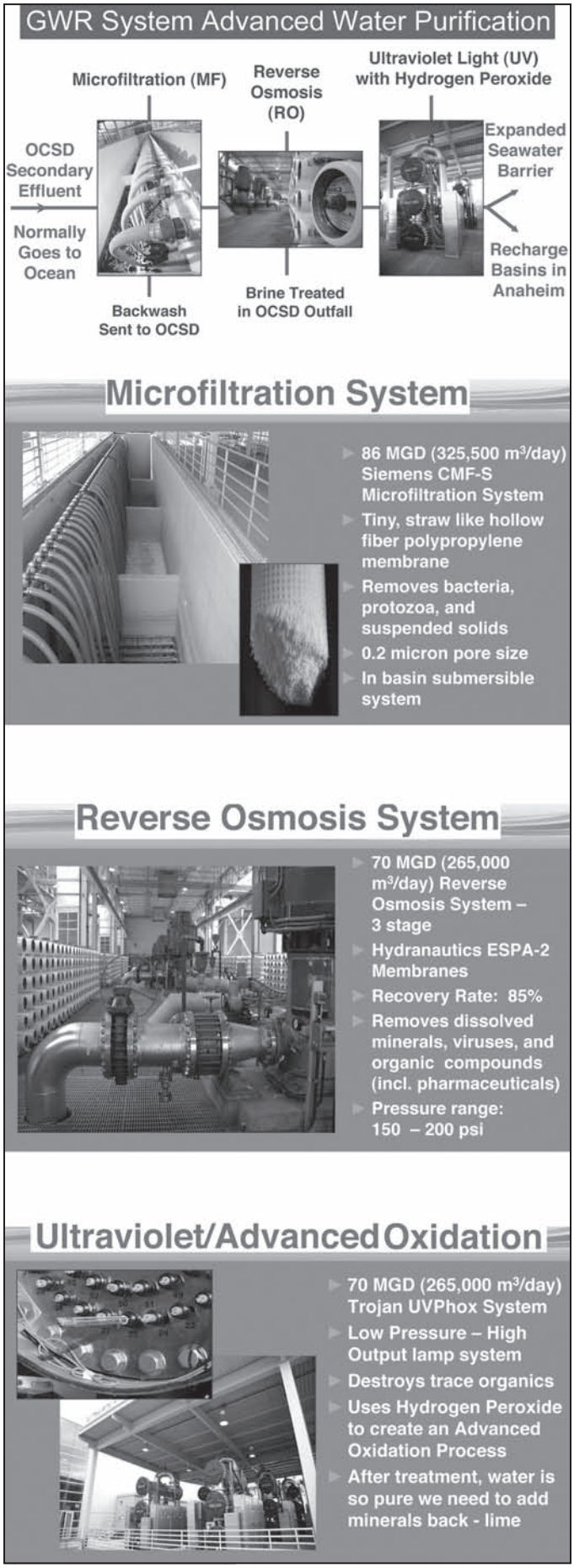

Following filter screening, clarified secondary effluent from OC-Sanitation (which is otherwise disposed to the ocean) receives micro-filtration membrane treatment. Micro-Filtration (MF) is a low-pressure membrane process that removes suspended matter from water. OCWD is using a Siemens CMF-S submerged MF membrane system. Each one of these micro-filters consists of polypropylene fibers. MF specifically is used to separate suspended and colloidal solids including bacteria and protozoa from the OC-Sanitation secondary effluent. Sodium hypochlorite is added to the MF feedwater to minimize MF membrane fouling. Initially, the original WF-21 conventional facilities were evaluated for the GWR System RO pretreatment, but due to space limitations and increased costs for WF-21 retrofitting, MF was chosen to replace the conventional treatment processes of WF-21. Acceptable MF filtrate is fed into the Reverse Osmosis system while MF reject streams are returned to OC-Sanitation's Plant No. 1 for treatment. MF has demonstrated exceptional effectiveness as a pretreatment for Reverse Osmosis. Based on a design recovery of approximately 90%, 86 **m**illion **g**allons per **d**ay (mgd) of filtrate will be produced by MF. Excess filtrate may be used to supplement tertiary non-potable reuse.

The feedwater passes through polypropylene wound cartridge filters prior to Reverse Osmosis (RO) treatment. The RO process rejects most dissolved contaminants and minerals in the water. Particularly, RO treatment reduces dissolved organics, pesticides, total dissolved solids, pharmaceuticals, silica, and viruses from MF filtrate. Generally, constituents with a molecular weight above 100 will be removed by RO. Sulfuric acid is added to the RO feedwater for pH reduction and carbonate scaling control. A threshold inhibitor or antiscalant will be also added to minimize membrane fouling. OCWD is using Hydranautics ESPA-2 membranes (polyamide membrane). These membranes operate at a fairly low pressure of about 150 pounds per square inch. The **t**otal **d**issolved **s**olids (TDS) coming into the plant are fairly low — about 1,000 parts per million — which enables OCWD to operate at a lower pressure. In addition to a permeate stream which receives further treatment, RO produces concentrate or brine which is discharged into the ocean via the existing OC-Sanitation ocean outfall. Based on a design recovery of approximately 85%, the production rate of RO is 265,000 cubic meters per day. The plant may be upsized in the future to produce approximately 490,000 cubic meters per day of product.

The product water resulting from RO treatment is so low in mineral content that it has a corrosive nature. This problem is mitigated with the addition of lime. If this did not take place, the concrete transmission pipe would corrode in the presence of the unstabilized water.

Following RO treatment, the permeate undergoes the final major step of the process — the Advanced Oxidation Processes which utilize **u**ltraviolet light (UV) treatment in conjunction with hydrogen peroxide. UV treatment involves the use of ultraviolet light to penetrate cell walls of microorganisms, preventing replication and inducing cell death. UV thus provides additional bacterial and viral inactivation and, combined with RO treatment, increases removal efficiency. With the addition of hydrogen peroxide, UV and the hydroxyl radicals can oxidize organic compounds for ultimate removal from water. UV and peroxide treatment will be used for NDMA and other low molecular weight organic removal. UV product water undergoes additional chemical treatment prior to groundwater injection and recharge.

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Groundwater Replenish

Quality Testing

Water Quality

During the start-up of the Advanced Water Purification Facility (AWPF), monitoring water quality was an important component of the permit issued by the Santa Ana Regional Water Quality Control Board (original Permit #R8-2004-0002, March 2004) in conjunction with the Department of Public Health. During the acceptance testing of the AWPF, specific water quality tests were required to be run for the MF treatment as well as for the entire AWPF. Specific criteria had to be met in order for the acceptance test to be valid. These criteria could be monitored directly using on-line instrumentation or indirectly by taking grab water quality samples. The major water quality testing requirements for the MF, RO and UV systems are shown in Table 1.

Table 1. Water Testing Requirements

Microfiltration Criteria	**Requirement**
Pressure Decay Test Result (psi/min), per membrane unit	< 0.1 psi/min at start-up; 0.2-0.5 psi/min in operation for problem confirmation
Silt Density Index, per membrane unit	<1 for start-up <2 for problem confirmation and pinning
Turbidity (NTU), per membrane unit	< 0.05 NTU at start-up <0.15 for problem confirmation
Reverse Osmosis Acceptance Criteria	**Requirement**
Permeate Conductivity	< 50 umho
Individual Vessel Permeate Conductivity	< 125percent of average
Permeate Total Organic Carbon	< 0.5 mg/L
Permeate Total Nitrogen	< 3 mg/L
Ultraviolet Acceptance Criteria	Requirement
Log Reduction of seeded effluent Bacteriophage MS-2	4-log reduction
NDMA Reduction	1.2-log reduction

Quality Parameters

Table 2 summarizes all of the required water quality tests and their frequency per day (d) or week (w). Many of the water quality test requirements are one sample per day for the first five days, then once per week to the end of the Acceptance Tests (1d/1w).

The water quality requirements for the project come from two sources. Ultimately, the "maximum contaminant levels" and "action levels" are defined by the operating permit from the Regional Water Quality Control Board as proposed by the California Department of Public Health. Since the permit includes various texts and tables detailing the project water quality requirements, it is difficult to summarize the required water quality parameters in an abbreviated format. In general, the water must meet many of the primary and secondary drinking water standards. Other requirements include **t**otal **o**rganic **c**arbon (TOC), nitrogen products, turbidity, pH, coliform, and UV transmittance. Some of the criteria are defined as quarterly averages, others are annual averages, 12-month running averages, 20-week running average (total nitrogen), and various other time periods. (Chalmers, et.al. 2008)

Table 2. Water Quality Testing Requirements

Parameter	**Frequency of Samples (day/week)**				
	Influent (SE)	**MF Effluent**	**RO Permeate**	**Decarb. Product Water**	**Finished Product Water**
Turbidity	2d	2d	2d	2d	2d
PH	2d	2d	2d	2d	2d
Chlorine Residual	2d	2d	2d	2d	2d
Conductivity	2d	2d	2d	2d	2d
Temperature	2d	2d	2d	2d	2d
Title 22 Drinking Water	1d/1w	1d/1w	1d/1w	1d/1w	1d/1w
Title 22 Secondary Drinking	1d/1w	1d/1w	1d/1w	1d/1w	1d/1w
NDMA			1d/1w	1d/1w	1d/1w
1,4 Dioxane			1d/1w	1d/1w	1d/1w
Fecal Coliform				1d/1w	1d/1w
Total Coliform				1d/1w	1d/1w
TOC			1d	1d/1w	1d/1w
Total Nitrogen			1d/1w		
RO Unit permeate			2d		
RO Vessel permeate conductivity			1d		

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Groundwater Replenish

Performance Measures

Sample water quality parameters measured during the first five months of operation at the AWPF are shown in Table 3. Water quality is available for the MF feed (stream Q1), the RO **p**ermeate (ROP), and the Finished Product Water after lime addition. The AWPF water quality was acceptable and the purification processes worked as designed.

The primary measure of the plant's performance is based on water quality parameters that include TOC, Total Nitrogen, TDS, and NDMA. These parameters give an indication of the overall plant performance, especially in regards to the reverse osmosis and advanced oxidation processes. Many of the water quality requirements are beyond those for primary and secondary drinking water standards. Table 3 shows the RO and AOP processes are functioning properly, especially in regards to TOC (less than 0.5 mg/L) and NDMA (less than 10 ppt). Based on this information, the plant construction was accepted by the Santa Ana Regional Water Quality Control Board.

Table 3. Water Quality Results

	MF Feed (Q1) (mg/L)			ROP (mg/L)			FPW (mg/L)		
Constituent	Min.	Avg.	Max	Min	Avg.	Max	Min.	Avg.	Max.
Total Suspended Solids	2.3	5.8	22.0						
Total Dissolved Solids	834	925	974	4.0	16.6	25.5	14.0	33.5	52.0
Total Organic Carbon	2.7	14.0	15.2	.005	.179	.480	.060	.198	.360
Turbidity (NTU)	1.6	2.6	6.7						
PH	7.6	7.8	8.0	5.9	6.7	7.5	6.9	8.2	9.3
Total Alkalinity	298	312	335	14.0	16.5	21.4	25.4	31.4	37.0
Total Hardness	262	293	313	<.10	<.10	<.10	16.0	21.6	27.2
Total Nitrogen	20.9	29.8	33.0				.90	1.7	2.5
Ammonia	19.6	27.6	30.8	1.0	1.4	1.8	1.0	1.4	1.8
NDMA (ug/L)	19.6	27.6	30.8	11	11	11	.20	1.6	14.0
1,4-Dioxane (ug/L)	.10	1.8	3.3				<.10	<.10	<.10

Operational Experience of Treatment Facility

Effluent Flow Limit

The first Finished Product Water (FPW) was injected into the Talbert Barrier (seawater barrier) from the GWR System on January 10, 2008 and the first water was sent to the Kraemer/Miller Basin on January 17, 2008 for percolation into the groundwater aquifer. Since that time, OCWD has been working to optimize the system. Currently, plant production is limited by the effluent flow available from the Orange County Sanitation District due to diurnal flow fluctuations. The new Ellis Avenue Pump Station, scheduled for completion in April 2009, will allow for the operation of the plant at a continuous production rate of approximately 265,000 cubic meters per day. Currently, plant production has been limited to approximately 75,000 cubic meters per day between the hours of 2am to 9am and between 208,000 cubic meters per day between the hours of 9am to 2am.

Increasing Production

Efforts to increase production out of the plant include the following:

- Conducting a micro-filtration pilot study on the trickling filter effluent in an effort to resolve concerns a GWR System Independent Advisory Panel had about operating the AWPF with an 80%/20% blend of activated sludge and trickling filter effluent
- Incorporating trickling filter effluent resulted in approximately 19,000 cubic meters more water available during the day (further description is provided below)
- Improvements were made to the lime dosing system at the end of the treatment process. Initially, a concern was raised that constituents in the lime were contributing to accelerating fouling of the injection wells (see additional details below).
- Optimization of the micro-filtration recovery by limiting the number of MF cells available during the night time low flow period. The cells are designed to operate over a range of flow rates based on plant demand. However, when a large number or cells are run at lower flow rates the recovery is reduced. By decreasing the number of available cells the flow rate per cell is increased which also increases the process recovery. A higher process recovery allows for greater production. This can increase overall production by 5–10%.
- Optimizing plant process control strategies to allow taking the maximum flow from OC-Sanitation throughout the diurnal flow swings. This effort has involved some very complex programming to prevent the plant from inadvertently shutting down.

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Groundwater Replenish

Effluent Concerns

Trickling Filter Effluent

Plant No. 1 at OC-Sanitation, the source of secondary treated wastewater effluent for the GWR System, has two sources of secondary effluent: enhanced trickling filter and activated sludge. As noted above, the GWR System was designed to receive about 80-percent activated sludge treated secondary effluent and 20-percent trickling filter treated secondary effluent. Just prior to the AWPF start-up, the GWR System Independent Advisory Panel, appointed by the National Water Research Institute, raised a concern about the AWPF's ability to treat trickling filter effluent. The Advisory Panel's primary concern was that snails or snail shells conveyed to the AWPF MF system could damage the MF membrane fibers. The trickling filter effluent would also have higher suspended solids and dissolved organic content as compared with activated sludge treated water. Due to these concerns, the California Department of Public Health would not allow the treatment of any trickling filter effluent. Since the early operation of the AWPF needs the trickling filter effluent to maintain operation at the design capacity, it was imperative that this issue be resolved quickly.

Pilot MF Study

A pilot scale MF study was implemented to determine whether the trickling filter had a negative effect on the MF process. The pilot tests began in March 2008 using a four module CMF-S pilot unit fed with 100-percent trickling filter treated effluent. Since the AWPF will never treat 100% trickling filter effluent, this was believed to represent a very conservative operating scenario. The pilot tests continued for four months, showing no signs of membrane integrity issues. Even though the trickling filter effluent quality was thought to be inferior to the activated sludge, the pilot MF unit produced surprisingly good operational results. The system was able to operate with a full 21 days between clean-in-place chemical cleanings, identical to the projected cleaning interval for the full AWPF operating on a 80/20 blend of influent water. Based on the positive results of the pilot tests, the Advisory Panel was convinced that a 20-percent trickling filter content was acceptable and would have no significant impact on the AWPF operation. In June 2008, OCWD successfully began treating influent with 20-percent trickling filter content, allowing an AWPF production increase of approximately 5-mgd per day. (Chalmers, et al. 2008)

Fouling Issue

Lime Stabilization Operation

After three months of AWPF operation to the new barrier wells, it was noticed that the pressure required to inject the recycled water into the ground had increased, suggesting fouling of the injection wells. To determine the source of the fouling, the project team focused on methods to further reduce the fouling potential of the GWR final product water (FWP), including: jar tests; improving the performance of the lime saturator; investigating the lime system operation at other similar facilities; and engaging the experience of the lime saturator manufacturer.

JAR TESTING: Jar tests were conducted to determine if an adjustment of the FPW water quality would reduce the fouling potential.

THE FOLLOWING CHEMICAL ADDITION APPROACHES WERE INVESTIGATED:

- Adding more sulfuric acid ahead of the RO system, thereby lowering the pH of the **d**ecarbonated **p**ermeate **w**ater (DPW) before the lime solution is fed to increase the CO2 level in the DPW
- Lowering the pH of the FPW by adding sulfuric acid, hydrochloric acid, or CO2 after the point where the lime solution is added.

The jar testing results were inconclusive. Lowering the pH of the FPW by adding acid or CO2 did appear to dissolve suspended calcium carbonate; however, it produced water that did not meet the OCWD corrosion control goals. Additional lime was required which back calcium carbonate and nullified the benefits of the acid or CO2 addition.

Improving the Performance of the Saturator

Improving the performance of the lime saturator was critical to reducing solids carryover into the FPW. It was shown that incrementally better results could be obtained using decarbonated RO permeate water to make the lime solution in the saturator. Higher lime concentrations (i.e. greater than 0.1-percent) lowered the turbidity in the saturator effluent (also known as limewater). A little testing showed that feeding polymer to the saturator resulted in a lower turbidity in the saturator effluent as compared to not feeding polymer. Unfortunately, the incremental improvements in the saturator performance did not significantly reduce the fouling potential of the FPW. The hydrated lime itself was determined not to be an issue. (Chalmers, et al. 2008)

Public Education and Outreach

Many projects similar to the GWR system were stopped by public and political opposition. In this case, public outreach and education began more than 10 years prior to start-up. OCWD researched public concerns and was involved in more than 1,200 presentations, 700 tours, and many news stories. This outreach resulted in there being no active opposition to the project and widespread support.

LESSONS LEARNED FROM PUBLIC OUTREACH:

- People do not know about water supply needs
- Messages must address health and safety
- Orange County citizens wanted reliability, local control, and high quality water
- Women, mothers, minorities and elderly are key audiences
- Face-to-face presentations are best
- Avoid jargon
- Testimonials from outsiders are important — especially medical/public health
- "Reverse osmosis" elicits positive response
- Word "purified" better than reclaimed, reused, etc.
- Independent scientific review is important

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Groundwater Replenish

Visionary Partnership

Benefits

Conclusions

The GWR System was more than a decade in development. The elected leaders of Orange County Water District and the Orange County Sanitation District were visionary in their pursuit of the GWR System and their understanding of water reuse and its potential as a new water resource. The partnership between the two agencies to develop the GWR System is groundbreaking and has already significantly assisted in the advancement of water reuse throughout the world. For example, the Singapore Public Utilities Board and communities in Australia have implemented similar programs.

The GWR System is approaching completion of one year of successful operations. While there have been minor challenges along the way, water quality has consistently been excellent, meeting and exceeding all regulatory requirements. The next few months of operation will be dedicated to increasing production from the plant by treating more OC-Sanitation secondary effluent made available by the construction of the Ellis Avenue Pump Station. The challenge going forward will be finding additional sources of water to recycle as OCWD foresees expanding this project in the future.

GWR System Benefits

The Groundwater Replenishment System:

- Helps meet the long-range plan developed by the Metropolitan Water District of Southern California to maintain and improve the reliability of Southern California's water supply
- Helps protect against future droughts
- Produces high quality water to replenish the groundwater basin
- Helps protect the environment by reusing a precious resource
- Uses approximately one-half the amount of energy that is required to transport water from Northern California to Southern California
- Helps maintain Orange County's active lifestyle in our dry, desert-like region
- Eliminates the need to build another ocean outfall pipe for wastewater
- Provides "water diversity" in an arid region, similar to the concept of "financial diversity"
- Augments an existing seawater contamination barrier

For Additional Information: Eleanor Torres, OCWD, 714/ 378-3268 or email: etorres@ocwd.com OCWD website: www.ocwd.com; Permit is available at: www.swrcb.ca.gov/rwqcb8/ >> Public Records >> Adopted Orders for 2004

References

Chalmers, R.B., Patel, M, Dunivin, W. Cutler, D., *Orange County's Groundwater Replenishment System is Now Producing Water*, presented at: WEFTEC 2008 Annual Conference, Chicago, Illinois, October 19-22, 2008.

Michael R. Markus, P.E., became the General Manager of the Orange County Water District in September 2007. With more than 27 years of experience, Mike is well known for his expertise in construction management, planning and water resource management. Mr. Markus joined OCWD in 1988 as construction manager. In 2004, Markus was elevated to assistant general manager overseeing water production and groundwater recharge operations, in addition to serving as program manager for the Groundwater Replenishment (GWR) System. His portfolio at OCWD is impressive and includes overseeing construction of many of the water facilities OCWD depends upon today to refill and manage the groundwater basin. Since joining OCWD, Markus has overseen the capital projects program that includes construction of more than 70 projects, including the Green Acres Project, a water recycling effort that provides reclaimed water for landscape irrigation at golf courses, schools and parks. Other projects include installation of two rubber dams across the Santa Ana River, pump stations at all of OCWD's major recharge basins and the construction of wetlands behind Prado Dam. Prior to OCWD, Markus spent two years with John Carollo Engineers and eight years with Peter Kiewit Sons' Co. He earned his bachelor's degree in civil engineering from California State Polytechnic University, Pomona, and his master's in civil engineering from the University of Southern California. He is a registered Civil Engineer in the state of California.

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Stream Access

STREAM ACCESS DECISION

WHEN IS A STREAM A STREAM, WATER NATURAL, AND PROPERTY PRIVATE?

by Jack R. Tuholske, Vermont Law School

Access Blocked

On November 17, 2008, the Montana Supreme Court (Court) decided the controversy over stream access to Mitchell Slough, a side channel of the Bitterroot River in western Montana. *Bitterroot River Protective Assoc. et al. v. Bitterroot Conservation District et al.*, 2008 MT 377 (*Mitchell Slough*). Long a favorite fishing venue for locals, adjacent landowners began blocking public use of the spring-fed slough in the 1990s, claiming the slough was a private irrigation ditch. Landowners included several wealthy out-of-staters, such as rock star Huey Lewis and broker Charles Schwab, which helped fuel the controversy. The landowners were also supported by four stockgrower and resource organizations, who filed an amicus brief.

Natural Water Body

The Bitterroot River Protective Association, a coalition of local fisherman and public use advocates, sued to have the water body declared open to public access. The Court held that Mitchell Slough is a natural water body and thus open to public recreational use, despite its history of significant human manipulation and despite the fact that much of its water consisted of irrigation "return flows." [Editor's Note: Return flow is water that returns to a natural stream or river following irrigation. Return flow is, therefore, water that was diverted from a stream, is not consumed by the crop and instead finds its way back to a natural water body.]

This article discusses only the portion of the decision that pertains to public stream access. Another significant portion of the case held that Mitchell Slough is a natural stream subject to the Montana Streambed Protection Act. The determination that Mitchell Slough is a natural stream subject to both public access and the Streambed Protection Act turned on many of the same facts and legal principles.

Stream Access in Montana

State Ownership of Water

The Court's holding was based a 1984 landmark ruling, *Montana Coalition for Stream Access v. Curran*, 210 Mont. 38, 682 P.2d 163 (1984). Curran blocked the Dearborn River with a barbed wire fence in an effort to stop floaters from using the river. Curran owned both sides of the river, and claimed the stream was not navigable and thus private property. To resolve the dispute, the Court in *Curran* looked to Article IX, Section 3(3), of the Montana Constitution, which provides: "All surface, underground, flood, and atmospheric waters within the boundaries of the state are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law." The Court noted that this Constitutional provision — not part of Montana's 1889 Constitution — "expressly addressed the state's ownership of all waters." *Mitchell Slough* at ¶51.

Public Trust Doctrine

In determining whether a private party could bar public recreation on a stream, the Court in *Curran* held (210 Mont. 52-3):

> The Constitution and the public trust doctrine do not permit a private party to interfere with the public's right to recreational use of the surface of the State's waters…In sum, we hold that under the public trust doctrine and the 1972 Montana Constitution, any surface waters that are capable of recreational use may be so used by the public…

Navigability

The Court conducted a traditional public trust analysis for navigability. The Dearborn River was used to float logs and thus was subject to the public trust (see *Id.* at 43-45 discussing *The Daniel Ball*, 77 U.S. (10 Wall.) 557 (1870), *Illinois Central Railroad v. Illinois*, 146 U.S. 387 (1892), and other traditional navigability cases and their relationship to the public trust doctrine). The Court, however, ultimately extended the public trust to all waters that were capable of public use, without regard to the underlying title to the bed and banks. Montana's view of the public trust is thus broader than states that rely on traditional notions of navigability and exclude non-navigable streams from the trust (see Tuholske, *Groundwater and the Public Trust Doctrine: A Fresh Application of an Age-old Principle,* 9 Ver. J. Envtl. L. 189 (No. 2) (2008) for a view of the public trust doctrine and groundwater issues).

Stream Access Law

The Montana Legislature responded to the *Curran* decision by passing the Stream Access Law (SAL), which provides for citizen access to all waters between the normal high-water marks of a river. The original SAL permitted camping and hunting, which the Court later found too intrusive for private property rights in *Galt v. State,* 225 Mont. 142, 732 P.2d 912 (1987). The current version of the law still provides for absolute public access to all "natural" water bodies without regard to the ownership of the land underlying the water (Mont. Code Ann. § 23-2-301 (2)). Waters "diverted away from" natural streams for beneficial use are not open to public recreational use (Mont. Code Ann. 23-2-302 (2) (c)). The diversion must be into a "man-made conveyance system." Mont. Code Ann. § 23-2-301 (6) (a).

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Stream Access

Physical Background

Ditch Assertion

District Court Finding

Human Alteration

Conveyance Systems

Return Flows

Mitchell Slough History and Physical Characteristics

The Court set out the basic factual background as follows:

> The Mitchell Slough is located in Ravalli County, Montana, east of the Bitterroot River between Hamilton and Stevensville. Tucker Headgate directs water from the East Fork of the Bitterroot River into the Mitchell. The water travels through and across private property in a north/northeasterly direction, covering a linear distance of approximately ten miles before rejoining the Bitterroot River. The Mitchell Slough itself meanders along a pathway approximately 16 miles in length. The Mitchell splits into its own east and west channels, which both flow northerly in a parallel fashion and empty into the Bitterroot River. Ditch companies and private water users have historically used water from the Mitchell Slough for irrigation, stockwater, and fish and wildlife purposes, and have routinely taken actions upstream of Tucker Headgate to ensure an even supply of water into the East Fork of the Bitterroot River, thereby also ensuring the consistent flow of water for diversion by the Tucker Headgate into the Mitchell. This activity has been ongoing for decades, for most of a century. Approximately 4,300 acres are irrigated from the Mitchell's flow every season. *Mitchell Slough* at ¶12.

It was estimated that over 40,000 acre-feet of water is diverted from the Bitterroot River into Mitchell Slough for irrigation purposes. *Id.* at ¶44.

The landowners involved in the case claimed Mitchell Slough was a ditch — as opposed to a natural water body — because it began with a headgate, carried a substantial amount of irrigation water, and has been channeled, bermed and manipulated in numerous places. The landowners also claimed that the source of Mitchell Slough's water was either diverted at the headgate or consisted of irrigation return flows. Over 123,000 acre-feet of irrigation water is diverted *upstream* of Mitchell Slough into ditches which irrigate thousands of acres. Along with irrigating crops, that water percolates into the alluvial aquifer, mixes with groundwater, and is captured by Mitchell Slough and nearby springs. *Id. at* ¶15, 16, 33, 68.

The State District Court found that Mitchell Slough may have been a natural water body in the past, but that years of human manipulation, and the fact that the water in Mitchell Slough was largely composed of return irrigation flows meant that it was no longer a natural water body (*Id.* at ¶ 74, 76). A major piece of evidence used by both parties was the 1872 Government Land Office Survey Map (GLO Map). The GLO Map labeled the Right Fork of the St. Mary's Fork of the Bitterroot River in a location in close proximity to the current Mitchell Slough. Plaintiffs found the remarkable similarity of the GLO Map and the current location of Mitchell Slough on the United States Geologic Survey map to be powerful evidence that Mitchell Slough is a natural water body. The Defendants (landowners) commissioned a professional surveyor to survey Mitchell Slough and use a digitized comparison of his survey and the GLO Map. Defendants argued that the fact that Mitchell Slough was not in the same location as the Right Fork proved that it was a human-dug ditch. The Court noted that Mitchell Slough was in places still co-extensive with the GLO Map, indicative of a natural channel. *Id.* at 74.

The State District Court, in reaching its decision, discounted the fact that Mitchell Slough had been used by the public for recreation for over 70 years, contained a vibrant native fishery interconnected with the Bitterroot River, and was shown as a natural water body on numerous historic maps, decrees and water right records. *Id.* at ¶ 15, 74 81.

The fact that Mitchell Slough had been significantly altered by humans was not determinative to whether it is a natural water body. Indeed, Defendants' own expert opined that nearly every river in Montana has undergone extensive manipulation. *Id.* at ¶14, 15, 72. The Court rejected Defendants' theory that a stream can be manipulated into a man-made conveyance system. The Court also noted that no evidence had been introduced showing that humans actually dug Mitchell Slough other than a short section connecting the current headgate to the historic channel. *Id.* at ¶78. The Court pointed out that Montana water law recognizes that rivers can be used as irrigation conveyance systems, but that does not render the rivers themselves man-made conveyance systems (Mont. Code Ann. § 85-2-411).

The fact that Mitchell Slough carries a substantial volume of irrigation return flows did not render the water unavailable for public use. In Montana, once return flows leave the place of beneficial use and resurface in a natural channel, that water is available for beneficial use. *Popham v. Holloron,* 84 Mont. 442, 275 P. 1099 (1929). These "freed waters," once collected in a natural channel, are no longer under the control of irrigators. *Hidden Hollow Ranch v. Fields*, 2004 MT 153, 320 Mont. 505, 92 P.2d 1185. Return flows intermingle with "natural" water, are subject to appropriation, and thus are also subject to public recreational use. The Court found that Mitchell Slough is no different than every other river system in Montana, where irrigation has altered surface and subsurface flows. *Mitchell Slough* at ¶43, 76-77.

The Court also noted that the year-round, native trout fishery contributed to its conclusion that Mitchell Slough is a natural water body. "Although we agree that the presence of fish alone does not make a water

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Stream Access

Private Property

Access Limited

Court's Rationale

body natural, it is one fact to be considered in the determination, both of a stream's recreational capability and its naturalness...The fish are a public resource." *Id.* at ¶ 81. The presence of a natural fish population was an important factor, and one for which the evidence in this case was undisputed.

Landowners' Private Property Rights

In recognizing Mitchell Slough as a natural water body subject to the SAL, the Court also respected landowners' private property rights. These rights are also accorded constitutional status, just as the public's rights in waters of the state. The SAL does not create any right of access or easements across private property. *Id.* at ¶ 84. As the Court recognized in the *Curran* and *Galt* decisions defining the parameters of stream access, the public's right in water must be balanced against long-standing notions of the right of peaceful enjoyment of private property.

In its concluding paragraph, the Court forcefully reiterated this point (*Id.*):

> The Mitchell flows through private property. What we have previously emphasized we once again repeat: "nothing herein contained in this opinion shall be construed as granting the public the right to enter upon or cross over private property to reach the State-owned waters hereby held available for recreational purposes." *Curran*, 210 Mont. at 55, 682 P.2d at 172. The Landowners are entitled to every expectation of the peaceful enjoyment of their property and the exclusive use thereof, excepting only the public's right to recreate as provided by the SAL on the water and on the banks of the Mitchell "up to the ordinary high-water mark." Section 23-2-301(12), MCA.

Conclusion

The litigation over Mitchell Slough is important for several reasons. First, the Montana Supreme Court reaffirmed its commitment to the Stream Access Law, while respecting the competing property rights of adjacent landowners. The Court restated its belief in the constitutional and public trust underpinnings of stream access. The Court found that humans cannot manipulate a natural channel into a ditch and in so doing exclude the public from recreational use of the water. This holding is significant. As the Court noted, nearly every stream in Montana, or for that matter, nearly every stream in the United States has undergone extensive human manipulation. Many streams serve as parts of irrigation conveyance systems. Those facts alone do not convert a river into an irrigation ditch. The Court recognized that for over 150 years, Montanans have altered surface and groundwater hydrology to the point where no river system is purely natural. Yet the Prior Appropriation system has always recognized that return flows and vagrant groundwater, surfacing again in a natural channel, are available for new beneficial uses. These "freed" waters are no longer under private control. In western river valleys where irrigation has been a way of life for generations, the entire surface and subsurface hydrology is no longer "natural." But that does not mean the water in those systems is no longer public water.

The holding in Mitchell Slough may have wide applicability in Montana, and perhaps in other parts of the West. Large rivers like the Yellowstone, Missouri and Clark's Fork have literally hundreds of interconnected side channels, spring creeks and remnant sloughs. The fact that those water bodies have been extensively manipulated does not mean they, or the water they carry, become private property. The waters in these channels will always be open to the public. In Montana, once natural means always natural.

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Website: full case is available at:
www.plol.org/Pages/Secure/Document.aspx?d=HZ6qRgOvNDasOTJpDJjkpQ%3d%3d&l

Jack Tuholske has been a solo private practitioner in Montana for 23 years, with an emphasis in a wide variety of natural resource and environmental law areas in state and federal court. In addition, he is an adjunct faculty member at the University of Montana School of Law and has been a Visiting Professor at Vermont Law School for the past 7 years. He was lead counsel for the Plaintiffs in the *Mitchell Slough* case.

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California Supply

Groundwater Rule

Delta Bottleneck

Ecosystem Protection

Water Storage

Curtailed Water Imports

Colorado River Supply

CALIFORNIA WATER SUPPLY

CHALLENGES & SOLUTIONS

by Dr. Cat Shrier, Watercat Consulting (Washington, DC)

The Groundwater Resources Association of California explored the role of groundwater in meeting water supply challenges during its 17th Annual Meeting and Conference, held in Costa Mesa, California, September 25-26, 2008.

Overview of California Water Supply Challenges and Proposed Solutions

The conference opened with an overview of the challenges associated with water supplies in California and throughout the nation, and how groundwater withdrawals, protection, management, and storage play a role in meeting those challenges. As noted by conference chair Ted Johnson, Chief Hydrogeologist for the Water Replenishment District of Southern California, the State is "on the cusp of transition" in its approach to water resource.

Representing the California Department of Water Resources (CDWR), Statewide Drought Coordinator Wendy Martin, kicked off the general session with an overview of the current crisis facing the State's water supplies, and how the State is responding to manage change in uncertain times. Ms. Martin is leading CDWR's efforts to address the drought that was declared by Governor Schwarzenegger in his June 4th Executive Order. She noted that the drought has been exacerbated by changing weather patterns, increased regulatory constraints, and huge demands. The San Francisco Bay Delta was identified as a particularly critical component in the State's water supplies. Martin compared California's water system to an "hourglass" — with the Delta being the neck through which water from the northern parts of the State are delivered to the population-heavy southern parts of the State. The water infrastructure in the Delta region has become extremely vulnerable to loading, with considerable risks to the system related to floods, subsidence, and earthquakes. She reported that new science has found a 64% chance of catastrophic failure of the State Water Project infrastructure at the Delta due to an earthquake or storm in next 50 years, to the point where no water could be transported through this region. Because of the critical nature of the Delta to the State's water supplies as well as to support habitat for the Delta Smelt and many other species, the State has worked towards the development of a Delta Vision and Bay-Delta Conservation Plan that is designed to protect the ecosystem within the context of a water conveyance system. Martin stressed the importance of linking ecosystems with water supply, stressing that "we can't manage one without other."

Other important tools identified to address the State's water crisis were water storage and the Drought Water Bank. Water storage increases flexibility in the face of increased risk from climate change, flood protection needs, and changing water demands. Storage can also provide emergency water supplies needed due to disasters such as floods, earthquakes, and droughts. The State has dedicated significant funds to the increased development of groundwater storage projects, recognizing these projects as important "tools in the toolbox." The Drought Water Bank was also developed to provide greater institutional flexibility, enabling CDWR to buy water from the north and sell it to southern California water users. Martin ended by stressing that, in any effort to address water crises in the State, it is essential to "distinguish...what's realistic and what's implementable."

Jeff Kightlinger, General Manager of the Metropolitan Water District of Southern California (MWD), provided an overview of Southern California's water issues. He noted that MWD supplies about half of the water demands in Southern California with imported water, while 40% of the region's demand is met by local groundwater. The majority of the water for the groundwater basins comes from local runoff, 10% from recycled water and about 15% is replenished with imported supplies. MWD and other water suppliers in Southern California rely heavily on "imported water supplies" which come from Northern California (delivered through the "State Water Project") and from the Colorado River. Both sources of imported water have recently been curtailed dramatically due to species and infrastructure issues in the Delta (for water from Northern California) and drought in the Colorado River Basin, which has just had eight of the driest years on record.

Kightlinger noted that starting in 2003, after three years of drought, access to "surplus" water supplies in the Colorado River was cut off by the US Department of Interior. Since California's allocation of Colorado River water is divided under the Prior Appropriation Doctrine, with 80% going to senior agricultural water rights (such as Imperial Valley and Coachella Irrigation Districts), MWD's junior rights became unavailable. As a result, MWD lost half of its available imported water "overnight." To meet the demands of its contracts with the groundwater replenishment districts, MWD used water from the State Water Project and from its storage facilities. This year, due to Delta issues, the State Water Project was

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California Supply

Reservoir Supply

only able to deliver 35% of the two **m**illion **a**cre-**f**eet (MAF) contracted by MWD. Consequently, MWD has only received 700 **t**housand **a**cre-**f**eet (KAF) from the State Water Project, plus 800 KAF from the Colorado River, for a total of 1.5 MAF in supplies — compared with a demand of 2.2-to-2.5 MAF. As a result, MWD has had to curtail its deliveries to the "interim agricultural" water program, which provides water for citrus and avocado farms, as well as groundwater replenishment, and has also reduced storage.

MWD's current storage policies require that its surface reservoirs in the region hold six months of water demands in case there is an earthquake or other disaster that would cut off the ability to transport imported supplies. If current circumstances continue, MWD will hit that six-month storage level within one-to-two years. Historically, MWD has been able to increase its storage (or "fill") in seven out of 10 years, while drawing down its water storage (or "pull") in the remaining three years each decade. Due to the changes in the situation with the Delta hydrology and Colorado River conditions, that ratio of "filling" and "pulling" years has been reversed.

Storage Increase

In response to these conditions, MWD has been investing heavily in projects to increase its ability to store Colorado River supplies.

MWD efforts to increase storage capacity include:

- Working with Imperial Valley Irrigation District and others to: fill storage reservoirs with conserved water; line canals; and pay farmers to fallow fields in order to rebuild storage in the Colorado River Aqueduct system.
- Increasing funding of the Orange County Water District (OCWD) facilities for "Phase 2" of its recycled water activities
- Providing funding to support the development of five seawater desalination plants (Carlsbad plant being the first) after a 10-year permitting process. If all five plants are built, they can provide 2-3% of southern California's water demands.
- Initiating discussions with Arizona about the use of Arizona aquifers to store water for California supplies.

Arizona Storage

Arizona has been spending considerable funds to develop groundwater storage facilities to meet its anticipated future shortages. MWD is arranging to provide funds so that a portion of that underground storage can be developed to meet current California shortages, with arrangements for California and Arizona to share underground storage to meet future shortages. Kightlinger said these discussions are currently occurring at the staff level to determine what "makes sense." Ultimately, the boards of the California and Arizona water entities will determine whether this approach is implementable.

Aquifer Management

One critical component in the availability of groundwater supplies to meet these challenges is the ability to monitor and manage aquifers. Bill Alley, the US Geological Survey (USGS) Chief of the Office of Ground Water, provided an overview of USGS' strategy for monitoring and assessment of groundwater supplies. USGS has been adding new, more sensitive, measurement tools. Increased sensitivity supports a better understanding of how different groundwater systems respond to changes in pumping. Artificial recharge and storage in aquifers is recognized as a dominant part of the groundwater budget in California and many other parts of the country. USGS is developing a strategy for national assessment of groundwater availability, including studies of regional aquifer systems prioritized on water use. USGS is working closely with several organizations, such as the National Ground Water Association and American Society for Civil Engineers, through the federal Advisory Committee on Water Information and the Subcommittee on Ground Water on the development of a national groundwater monitoring program. While such a program is considered critical to program success, Alley noted that currently "there is no money to maintain monitoring networks."

Several breakout sessions were held at the conference to address issues highlighted during the keynote addresses, including a session on groundwater storage (chaired by Tom McCarthy, Wildermuth Environmental); a session on Delta Issues (chaired by Chris Petersen, Montgomery Watson Harza); and a half-day double session on California's water recycling regulations, technologies, and projects that use groundwater storage.

Groundwater Storage Issues and Recent Studies

ASR Water Quality Issues

The Groundwater Storage session featured national experts and provided an overview of MWD's recent Groundwater Assessment. David Pyne (ASR Systems, LLC), a leading expert on aquifer storage, explored some of the most important water quality issues associated with groundwater recharge and storage through wells (**a**quifer **s**torage **r**ecovery or "ASR"), and some of the tools and approaches that can be applied by agencies and water providers to ensure that these issues are being addressed. Water quality issues he identified include problems associated with: arsenic mobilization; **t**ri**h**alo**m**ethanes (THMs) attenuation during storage; and nutrients.

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California Supply

Arsenic Issues

Arsenic mobilization issues have become particularly critical in Florida, where the presence of arsenic at aquifer storage sites was discovered during 2001 after many ASR facilities had been in operation for years, some for as long as two decades. Arsenic mobilization in Florida is linked to an interaction between the low oxidation-**r**eduction **r**eaction (R2 or "redox") native water in the aquifer and the high redox stored water. More recent studies of recovered water quality from these ASR wells suggest that there is a low correlation (R2 < 25%) between redox potential and arsenic, although a higher correlation (R2 > 70%) has been found between arsenic and chloride and other conservative constituents at many sites. Peak arsenic concentrations tend to decline with increasing number of operating cycles, and elevated arsenic concentrations were found to extend no more that 200-350 feet from the ASR well, even though the stored water extended much further. Increasing the target storage volume, including forming and maintaining a "buffer zone" between the stored water and native water in the aquifer, was found to be a simple and cost-effective means of ensuring that elevated arsenic concentrations do not occur in the recovered waters. Pretreatment through "de-gassing" has also been investigated to prevent arsenic mobilization, although this option would be cost-prohibitive for most water providers. Pyne discussed the recent development of the ASR Arsenic Surrogate model, which is a valuable tool for understanding the mechanics of arsenic mobilization, and has potential applications for understanding mobilization of other constituents during aquifer storage.

"Buffer Zone"

Disinfection Byproducts

Pyne suggested that the concerns regarding **d**isinfection **by**p**r**oducts (DBPs) become an issue only if a very low standard is used. If primary drinking water standards are applied to the recharge water, levels of haloacetic acids become nondetectable in days and THMs typically become nondetectable in weeks in confined and semiconfined aquifers with low redox conditions. For storage aquifers containing oxygen, significant THM attenuation may not occur except by dilution. In Central Valley, California, and the State of Washington, more conservative standards are being applied by regulatory agencies for individual THM constituents, particularly chloroform. Pretreatment to meet chloroform standards would likely require reverse osmosis treatment of the drinking water used for aquifer recharge, with the associated need for concentrate disposal. This would likely make underground storage of drinking water not cost-effective in these areas of the country. The chloroform standard is based upon outdated science regarding the dose-response between chloroform and cancer. Reevaluation of the chloroform standard for these regulatory agencies based on current science would likely resolve this issue.

Groundwater Storage

Kathy Kunysz has been with MWD since 1987 and is currently the Program Manager for groundwater storage issues. She recently led a study to determine opportunities to increase groundwater storage in southern California through assessment of available storage space. The study found that 3.2 MAF of basin capacity could be available for aquifer storage if institutional and other issues could be resolved. Kunysz suggested that the "easy" sites have already been developed and identified several challenges to aquifer storage.

Storage Challenges

Aquifer storage challenges include:

- Funding for water quality treatment prior to injection
- Funding for capital infrastructure for injection, recovery, and conveyance
- Mismatch of storage locations with overlying demand (ability to recover water from storage areas and convey to demand areas)
- Legal and institutional disagreements among water users overlying groundwater basins that can be used for storage
- Regulatory issues regarding aquifer storage in different aquifers with different water quality and geochemical concerns
- Availability of surplus water to store

Reclaimed Water

Kunysz pointed out that the need for surplus water for groundwater storage projects has driven the interest in the use of reclaimed water as a source.

Managed Underground Systems

Dr. Will Logan, Study Director for the National Academy of Science's (NAS) recently released study on *Managed Underground Storage of Recoverable Water*, provided an overview of its conclusions. He noted that there has been adequate experience in the US with managed underground storage projects from which to draw some general conclusion about the degree to which systems are successful in meeting their stated goals and the challenges that some of them face. Though failures have occurred, and there is potential for contamination of groundwater under certain conditions, most managed underground storage systems have successfully achieved their stated purposes. The study committee reported that given the complexity of the nation's water management challenges, **m**anaged **u**nderground **s**ystems (MUS) should be seriously considered in our nation's arsenal of water management approaches. The study committee identified several areas where further understanding of MUS is needed.

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California Supply

Legal Aspects

MUS needs include:

- Development of aquifer suitability indices for storage, including considerations such as geochemistry, distance from pipelines, land use, and location of well users to incorporate MUS in plans to determine where systems can work best
- Economic analysis on aspects of underground storage, including a focus on third party impacts and benefits
- Analysis of the legal and regulatory aspects of aquifer storage projects, such as: definition of water property rights for water before, during, and after storage; improvement of consistency among federal and state programs in the application of the US Environmental Protection Agency's (EPA's) **u**nderground **i**njection **c**ontrol (UIC) program for well recharge systems; and regulation of basin recharge systems
- Development of science-based criteria to help determine adequate subsurface residence time or distance, and the need to be flexible to consider risk and weigh overall benefits of MUS while protecting human health and the environment
- Analysis of approaches to monitoring (a major cost driver for MUS projects) including control of analytical costs through the use of surrogates and indicators

2008 MUS Activities

Dr. Logan recognized your author (a member of the study committee), who noted several follow-up activities that occurred in 2008 to explore MUS issues and recommendations identified in the NAS study. 2008 MUS activities include:

- A one-day webcast forum in March 2008 on aquifer storage policy, planning, and permitting issues, organized by the National Research Council, Ground Water Protection Council (GWPC), National Ground Water Association, and Groundwater Resources Association of California (available on-line at www.aquifer-storage.com)
- The organization of an exploratory committee of water providers, consultants, and water agency personnel for a national network on aquifer storage projects and permitting agencies
- The organization of a half-day session on the application of UIC regulations to aquifer storage by GWPC at their 2008 conference, and interest by state agencies, through GWPC in collaboration with EPA, in the development of guidance on UIC permitting for aquifer storage projects under various conditions
- Exploration of a national Aquifer Storage Institute at a university, potentially in affiliation with a member organization of the National Institutes of Water Resources

Conjunctive Management

Delta Issues

The Sacramento-San Joaquin Delta has been described as a global environmental treasure which is often overlooked and frequently mistreated. A session was held on Delta issues due to the role of this unique estuary as a vital water source — essential to preserving California's status as one of the world's leading economies. This session included presentations on innovative technologies and management constructs employed to preserve water supply and protect the fragile Delta ecosystem, focusing on the role that groundwater and conjunctive water management plays in the management of the Delta.

Salinity Intrusion

Robert Niblack from CDWR led the session with an *"Overview of the Sacramento Valley Water Management Program and Related Conjunctive Use Projects."* Mr. Niblack provided an overview of water fluxes into and out of the Delta, identified the water uses both upstream and downstream, and explained the causes of salinity intrusion into the Delta and the impacts to the water supply and the environment. Under the Sacramento Valley Water Management Agreement, upstream water users are required to implement water projects that contribute water to meet Delta water quality standards. Up to 174,400 **a**cre-**f**eet (AF) of groundwater may be pumped to replace surface water diversions in some years for local uses and Delta water quality.

Groundwater Model

Claudia Faunt from USGS presented *"Role of Delta in Central Valley Groundwater System-Results from Central Valley Groundwater Model."* The study updates the USGS Central Valley Regional Aquifer System and Analysis model that was originally calibrated to 1961-1977 conditions. The updated model, the Central Valley Hydrologic Model, was calibrated to 1961-2003 observed conditions and incorporates a dynamically integrated water supply-and-demand accounting to simulate groundwater and surface water flow across the entire Central Valley aquifer system, including the Delta.

Wetlands

Kim Taylor closed the session by describing *"Subsidence Reversal Through Wetland Restoration and Carbon Sequestration in the Delta."* Ms. Taylor explained that long-standing farming practices in the Delta expose fragile peat soils to wind, rain and cultivation, emit carbon dioxide (CO_2), and cause land subsidence. To capture or contain the carbon, farmers could instead "grow" wetlands. By doing so, they would begin to rebuild the Delta's unique peat soils, take CO_2 out of the atmosphere, ease pressure on the

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Delta's aging levees and infuse the region with new economic potential. This concept is being proven out through a demonstration project involving USGS and CDWR conducted on Twitchell Island in the western portion of the Delta.

Groundwater Storage in Adjudicated Basins

Groundwater Replenishment

The Groundwater Resources Association's Southern California chapter hosted a dinner presentation on the legal and institutional framework being developed for groundwater storage in the Central and West Coast Sub-basins in the Coastal Plain of Los Angeles. Referred to as "Central Basin" and "West Coast Basin," both basins are "adjudicated" — i.e. their water/groundwater use and replenishment are determined on the basis of court decisions. Both basins have allocated groundwater rights in excess of their safe yield, resulting in the necessity for groundwater replenishment. Each basin receives water for groundwater replenishment from contracts with MWD. Every year, the Water Replenishment District of Southern California (WRD) determines the amount of supplemental recharge required on the basis of the prior year's groundwater production and estimated annual change in storage, based on a measurement of groundwater levels collected throughout the basin.

Adjudication Limitations

Russ McGlothlin of Brownstein Hyatt Farber Schreck presented on behalf of the Central Basin Water Management District, and Bill Kruse of Lagerlof, Senecal, Gosney & Kruse presented on behalf of the West Basin Water Management District. In 2000, the two basins began exploring options to use their aquifers for storage, as opposed to simply replenishment to offset withdrawals. Storage was not addressed in the adjudications for the basins, and there had already been a court determination that a groundwater pumping water right does not have an "attendant right" for groundwater storage. California allows "non-native" water to be stored underground and recaptured, and does not permit overlying landowners to capture that water or object to the storage if there is no impact (e.g. flooded basements).

Storage Rules

Central and West Basins began to work together to develop an institutional framework through which the storage capacity of the two basins could be divided. In May 2005, the WRD, which delivers water to the two basins, adopted Interim Rules for Conjunctive Use Storage and In-Lieu Exchange and Recovery in the Central and West Coast Basins to govern storage in the basins outside and above the adjudicated water rights that would utilize up to 450,000 AF of unused space in the two basins (120,000 AF in West Coast Basin and 330,000 AF in Central Basin). However, the basins themselves needed to determine their approach to administration of water storage — addressing issues such as carryover from one year to the next, individual and community storage needs, assurance that groundwater replenishment needs were met, and the use of the basins for storage of water from outside users to provide a regional benefit.

Legal Certainty Needs

Kruse emphasized the need for legal certainty associated with groundwater storage and provided an overview of the discussions held for development of a framework. Monthly mediated discussions involving more than 60 stakeholders held between 2003 and 2005 (the "Rauch" mediation) broke down when "people dug in." Another facilitated stakeholder mediation process was initiated by in 2006 by CDWR under the leadership of Director Les Snow. This "Waldo" mediation produced a draft framework that addressed WRD's involvement in approval of storage projects; the rights of individual pumpers; communications between Central and West Basins; reservation of 20% of the stored water for current producers; and the ability to "leave behind" water in storage. This framework development process illustrates the complexity of the institutional issues associated with groundwater management, where sources of water supplies and aquifers often cross multiple jurisdictions. Subsequent to this meeting, however, the talks between Central and West basins broke down and a lawsuit was recently fought over payment of benefits for staff hired to manage joint administration of groundwater replenishment and storage.

Water Follies and America's Water Crisis

Pumping Impacts

The conference featured a keynote luncheon with noted author Dr. Robert Glennon, who wrote *Water Follies* (2002). Glennon teaches at the University of Arizona and lives in Tucson on the Santa Cruz "River," which is a dry river bed where the water disappeared due to groundwater withdrawals. Glennon cited several examples from his book of situations where environmental consequences have occurred due to groundwater pumping. Glennon provided one case study, near Tampa Bay, Florida, where a lake had been dried up due to groundwater pumping. The utility responsible for the lake property agreed to refill the lake, and did so by lining the lake and filling it with water from wells from the same aquifer that caused the lake to dry up in the first place. Another example of groundwater use to fill surface water features was the "San Antonio River Walk." Glennon noted that San Antonio is the largest city entirely dependent upon groundwater. Glennon said that the "River Walk" has no real river, but a canal was built and filled with groundwater to provide a tourist attraction.

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Valuable Resource

Glennon also provided some history of McDonald's "Supersize" french fries and their relationship to water use. The average American eats 35 pounds of french fries a year. In the 1980s, McDonald's started creating "supersize" portions which required fries long enough to fit in the larger carton. These larger fries require a high water content, and must be "perfectly white and blemish free." McDonald's began buying only "industrial potatoes" from farms irrigated from the Straight River (which is a meandering stream) in Minnesota.

Glennon concluded by stating that "It's imperative that we treat water as valuable." He noted that, in the eastern US, a groundwater permit is not even required if there is less than 100,000 gallons per day of pumping. He noted that a solution to the US issues to groundwater management problems are "urgent but possible" if we accept that water is "both a public resource and private property." To address these problems, Glennon recommended a combined approach that includes a "command-and-control model of government rules and regulations" in combination with "market forces of transferable rights and price incentives."

Suggestions

Glennon's specific recommendations included:

- Restricted pumping versus unlimited access
- Required conservation
- Using metering with appropriate pricing (increasing block rates) to encourage conservation
- Facilitating the transfer of water from low value to higher value uses
- Recognizing the economic value of water

Dr. Glennon ended his presentation by noting that there is a "human right" to water. However, Glennon stated that humans reasonably require only 6-15 gallons of water per person per day, which is one percent of the average amount of water used by Americans. He ended with the question, "What are we doing with other 99 percent?"

Groundwater Recharge and Water Reuse

Water Reuse Components

The conference featured a half-day two-part session on the role of groundwater recharge in California's approach to water reuse. California is currently drafting regulations for groundwater recharge water reuse. This effort has produced a detailed engineering report which describes important components of the water reuse process under California regulations. These components include: residence time; pretreatment source control; water quality monitoring; monitoring wells; multiple reliable treatment processes ("barriers") for contaminants; blending with diluent water; and a public hearing.

The State agency perspective on the new reuse regulations were presented by Brian Bernados with the California Department of Public Health (CDPH), and Gordon Innes, with the State Water Resources Control Board (SWRCB). These two agencies signed a memorandum of agreement in 1996 to prevent duplication of efforts and clearly define agency roles on groundwater recharge and reuse.

2015 Goal

Mr. Innes reported recycled water use is currently small — less than one percent of total water supply — but that the State's Recycled Water Task Force and the State Water Board's Strategic Plan Update establish a goal to recycle 1250 million acre feet per year by 2015. Groundwater Recharge Reuse Projects (GRRPs) are viewed as a good way to increase recycled water use, and can often be developed without the need for extensive "purple pipe" separate conveyance systems for recycled water. Mr. Innes provided a brief history of the current efforts to develop new state regulations. During the 2006 hearings for the Alamitos Barrier Project Order, the Water Replenishment District of Southern California (WRD) objected to the use of effluent limits for chemicals that have no established drinking water standards. The State Water Board agreed with the argument of WRD that standards for recycled water should not be more stringent than those for drinking water. After making in its decision, the State Water Board directed its staff to develop a policy for recycled water.

Recycling Policy

The policy that was proposed was poorly received throughout the water community, with environmental interests stating that the draft policy did not protect water quality and the water interests stating that the draft policy did not encourage recycling. These disparate groups came together to request an opportunity to develop an alternative policy. The State Water Board granted this request and a group of stakeholders submitted a new proposed policy. The new proposed policy includes: sections on mandates to promote and encourage the use of recycled water; roles of the State Water Board and regional water quality control boards, CDPH and the California Department of Water Resources; criteria for landscape irrigation projects (including an expedited permitting process); requirements for developing salt and nutrient management plans; GRRPs; anti-degradation; emerging constituents of concern; and incentives for recycled water use (including **t**otal **m**aximum **d**aily **l**oad (TMDL) credits). The revised proposed policy was released for public comment in November 2008, and the public comment period was closed December 22, 2008.

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Reuse Criteria

Mr. Bernados described CDPH's criteria for GRRPs.

GRRP considerations include:

Source Control: As with all recycled water projects, the first step is source control — that is, understanding what goes into the wastewater and control to ensure that contaminants are minimized.

End Uses and Treatment Requirements: Next, the end uses are considered, with the amount of treatment required determined by the end use. Less treatment is required for uses such as crops that do not include contact between recycled water and edible portions of the crops, pasture irrigation, restricted use golf courses, landscape impoundments, and restricted recreational impoundments. Tertiary treatment, i.e., secondary treatment followed by chemical coagulation (if needed), filtration and disinfection is required for nonpotable recycled water applications where direct or indirect contact with the recycled water is likely (such as nonrestricted recreational impoundments and the irrigation of parks and playgrounds).

Recharge Method: California permits indirect potable reuse that incorporates groundwater recharge, which can be accomplished through either surface spreading or injection. Surface spreading produces credits for soil aquifer treatment.

Blending Requirements: Recycled water is blended with "diluent" water from other sources such as raw surface water, groundwater, or stormwater. The amount of blending required is based on achieving a Total Organic Compounds (TOC) level not exceeding 0.5 mg/L of wastewater origin in the blended water. OCWD is working towards the development of California's first project using 100% recycled water.

Monitoring Requirements: Extensive monitoring is required for regulated and unregulated constituents.

Retention Time and Monitoring Wells: The retention time in the aquifer must be calculated to ensure that recycled water will not reach the nearest potable extraction well for at least six months, which provides an additional barrier for virus die off and allows time for corrective action to be taken if groundwater monitoring indicates that the water does not meet all appropriate water quality standards. At least two monitoring wells are required, including one monitoring well that is required at a point in the aquifer where recharge water has been retained for one-three months, but will take at least three months before reaching the nearest domestic water supply well.

Residence Time and Tracer Method: The recycled water must be retained underground for at least six months before it can be withdrawn for potable uses, and no degradation of the aquifer is allowed. However, until a GRRP has demonstrated compliance with a six-month added tracer test, a proponent should plan to site the GRRP by using an estimated retention time of nine, 12, or 24 months, depending on the precision of the method used. If a simple Darcy formula is used to calculate retention time, a safety factor of 4 is incorporated, so that 24 months of retention is required. More precise and accurate methods, such as three-dimensional models, intrinsic tracers, or the addition of a tracer, are required to ensure the six-month retention time is met as measured via the added tracer demonstration test.

Recycling Projects

Other speakers dealt with recycled water projects involving groundwater recharge throughout California:

Jeff Soller (Soller Environmental) on a four-year WateReuse Foundation funded project in the Montebello Forebay and Chino Basin to use existing tools to evaluate and explain the relative human health risks related to use of reclaimed water, develop safe exposure concentrations for constituents of emerging concern, and predict the future contaminants of concern five to twenty years in the future

Leslie Dumas (RMC) presented on a study to select a site for aquifer storage with reclaimed water at the Armstrong Ranch (donated land adjacent to the wastewater treatment plant, in Monterey Bay)

Andy Campbell (Inland Empire Utility Agency) on the use of Soil-Aquifer Treatment to remove total organic carbon and total nitrogen in pilot tests in the Chino Basin

Shivaji Deshmukh (OCWD) on the new GW Replenishment System in Orange County

Integrated Management

Emerging Issues in Groundwater

The final session of the conference featured speakers on "emerging issues" in groundwater, including climate change, carbon sequestration, and emerging contaminants. Bob Wilkinson from the University of California at Santa Barbara recognized the high level of energy intensity associated with water supply systems, and noted the need for institutional procedures for water management in light of climate change. He emphasized the need for "integrated, whole-system approaches to water and energy management" that included conjunctive use of surface and groundwater resources.

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Carbon Migration

Sally Benson from Stanford University discussed the potential impacts of carbon sequestration on groundwater. Although the international *Intergovernmental Panel on Climate Change Special Report on Carbon Capture and Storage* (2005) reported that 99% of carbon was likely to be "retained in appropriately selected and managed geological reservoirs," there remain potential pathways for release of carbon to aquifers. Specific migration pathways cited by Dr. Benson included: well leakage through injection wells as well as abandoned wells in the same aquifer; undetected faults from poor site characterization; and faults in the seal used on injection wells for carbon sequestration or damage to the well seal from excessive pressure buildup. Impacts to groundwater from carbon sequestration could include: migration of carbon into shallow aquifers; displacement and migration of saline brines into shallow aquifers; and migration of hydrocarbon and gases co-injected into shallow aquifers. Risk management measures include careful site selection and monitoring, to prevent and minimize these impacts to groundwater.

Emerging Contaminants

David Sedlak from the University of California at Berkeley discussed emerging contaminants in groundwater. Emerging contaminants include contaminants for which regulatory standards have not yet been set, or where there may not be sufficient studies to determine the impacts of the presence of these contaminants on human health and the environment. Emerging contaminants associated with industrial contamination of groundwater include: **m**ethyl **t**ert-**b**utyl **e**ther (MTBE); 1,4–dioxane; n-**n**itroso**d**i**m**ethyl**a**mine (NDMA); and perchlorate. All are similar in terms of their mobility, degradability, toxicity, and/or treatability. The latest issues related to emerging contaminants involve a "new genre" of constituents, particularly those related to recharge of groundwater by treated municipal wastewater. These contaminants include: perfluorinated organics; NDMA precursors; as well as emerging disinfection byproducts such as: haloacetonitriles; haloketones; and halomethanes; Dr. Sedlak cited the need for funding for better assessment of the water sources used for groundwater recharge with reclaimed water.

Awards Presentation

Groundwater Resources Association Awards and Legislative Session Wrap-up

The conference Awards Luncheon included a summary of groundwater legislation. The Groundwater Resources Association of California (GRA) annually gives the Kevin J. Neese Award to recognize a significant accomplishment by a person or entity within the last year that fosters the understanding, development, protection or management of groundwater. This year, OCWD was recognized for its Groundwater Replenishment System (see Markus, this TWR). GRA also recognized Stanford Groundwater Engineering Professor Perry McCarty with its Lifetime Achievement Award. Special Recognition was awarded to Senator Michael Machado for his commitment to California's water policy and funding during his ongoing service in the State legislature. Senator Machado co-authored several important pieces of legislation including Proposition 13 (the Safe Drinking Water, Clean Water, Watershed Protection, and Flood Protection Bond Act) and assisted in the passage of Proposition 50 (the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002).

Legislation

GRA is an organization "dedicated to resource management that protects and improves groundwater through education and technical leadership" and plays an active role in the development and promotion of policies and legislation. GRA's Legislative Advocate Chris Frahm reported on GRA's 2008 legislative activities, which included "lots of legislative education, especially for groundwater." Several bills were proposed in 2008 related to Integrated Regional Water Management Plans, recycled water, water conservation, and groundwater.

Water Board

Water bond discussions had been a central focus of discussion in California, including a proposal developed jointly by Governor Schwarzenegger and US Senator Diane Feinstein as a "bipartisan compromise water bond." The Schwarzenegger/Feinstein proposal, however, failed to gain enough support from either party. Senator Machado also introduced a bill that was intended to provide a means of bringing together stakeholders to get something on the ballot, not necessarily a comprehensive "fix" to all of California's water needs. Frahm reported that the nation's and California's financial crisis has had a major impact on the availability of funds to address water issues, stating "if the financial meltdown doesn't stop everything, this will be a very interesting year in water." The next GRA "Legislative Day" was also announced, to be held in Sacramento on April 15, 2009.

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GRA WEBSITE: www.grac.org — information on additional sessions at the conference may be found in the Winter 2008 issue of the GRA's quarterly publication, *Hydrovisions* (see GRA's website)

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Water Reuse

WATER REUSE & SUPPLY SUSTAINABILITY

WateReuse association and international water association

by Dr. Cat Shrier, Watercat Consulting (Washington, DC)

Reclaimed Water

Recognizing the critical role that reclaimed water will play in meeting increasing demands for potable water supplies, the WateReuse Association, in partnership with the International Water Association, held a three-day specialty conference in Long Beach, California, on the topic of Potable Reuse for Water Supply Sustainability, November 16-18, 2008. The conference featured speakers from several locations around the United States, as well as Singapore, Australia, Belgium, and the United Kingdom (UK), where advances in technology and water recycling techniques have been used to incorporate reclaimed water as a local water resource to be used for drinking water purposes.

Salient themes at the conference included:

- Potable reuse is an essential tool needed to meet water challenges
- That multiple barriers are an important means of ensuring adequate treatment, although increasing technological advances in treatment and monitoring may enable the removal of "natural buffers" to allow a shift from "indirect" to "direct" potable reuse
- That enhancing public and policymaker understanding and acceptance is a critical issue that must be addressed

Global Increases in Potable Reuse

Increasing Demands

During the opening session, Paul Reiter, Executive Director of the International Water Association, presented on the global nature of water reuse. He noted that the locations of the world's largest cities have shifted to include not only such cities as New York and London, but also burgeoning cities throughout southern Asia and northern Africa. With increasing demands in areas with no new water sources (as in many portions of India) and where climate change impacts are likely to be significant (as in sub-Saharan Africa), there is an increasing likelihood that reuse will become a major component of water supplies for these cities. These changes will bring large institutional challenges, especially as water shifts from being "centralized" to being more "nodal" and involving more stakeholders. As Reiter noted, "Saying 'reuse is a great thing' is not enough. We need to embrace some of the institutional challenges."

Aquifer Recharge

Those institutional challenges on the international stage were discussed further in a panel led by water reuse expert Jim Crook. Emmanuel Van Houtte (Intermunicipal Water Company of the Veurne Region) of Belgium, presented on European applications, which typically involve surface recharge through sand dunes to aquifers, with a residence time at least 30 days, as well as multiple specific treatment requirements and technologies. Ultra-filtration, to remove suspended particles and bacteria, has been successfully used in Europe as a pre-treatment for reverse osmosis, which is needed to remove targeted organic contaminants (e.g. pesticides, pharmaceuticals, endocrine disrupting compounds in addition to any remaining bacteria and viruses).

"Yuck" Factor

In the UK, as reported by Sian Hills (Thames Water), aquifer recharge has been used to combat the "yuck factor" associated with potable reuse. Although often thought of as a rainy city, London can be described as a "cloudy desert" as it averages only 613 mm/year rainfall — less than Dallas, Texas. "Unplanned" potable reuse happens regularly where water intakes are located downstream of wastewater discharges. The UK's first "planned" indirect potable reuse has been Essex and Suffolk's Langford scheme, which serves the eastern suburbs of London. This system has been operating since 2003, and still combats negative press, such as a recent London Times article. Thames Water hopes to meet the challenges of public perception and project promotion with an aggressive public and stakeholder participation program, which involves two-way communication, rather than just "consultation" for the public to provide feedback to the utility.

Direct Potable Reuse and the Use of Multiple Barriers

Direct Potable Use

Professor Ian Law (University of Queensland in Brisbane, Australia) provided some lessons from Southern Africa, Singapore, and Australia. Operational since 1968, the Windhoek facility in Namibia is considered the only "direct potable reuse" facility in the world. Professor Law suggested that direct potable reuse should receive greater attention. It can be a viable approach provided there is adequate quality, reliability, monitoring, and regulatory oversight. He stressed the need to view municipal wastewater as a valuable resource and not a waste. He stressed the importance of incorporating a "multiple barrier approach" including catchment management and efficient wastewater treatment plants to ensure adequate

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Water Reuse

control of the source water for reuse. Advanced water treatment plants (with multiple internal barriers), ongoing monitoring of multiple parameters, and environmental buffers can be combined to produce a reliable program.

Multiple "Barriers"

R. Rhodes Trussell (Chair of the new National Research Council Committee on Water Reuse— see Brief, this TWR) also spoke on the need for multiple "barriers" in water reuse projects. Water reuse incorporates a series of water treatment processes (or "barriers"), each of which operate independently to remove targeted contaminants, and work together to reduce the risk of failure. Historically, by disposing of treated wastewater into a stream or aquifer, we have relied on the natural environment as the ultimate barrier of protection for downstream water users. Multiple barriers provide redundancy to ensure treatment goals are met and improve the reliability of water treatment for reuse. Determining what redundancy and reliability is required involves an understanding of the probability distribution of failure of the overall "process train" and requires collection of adequate amounts of data. Once the process train is understood, rational and risk-based regulatory approaches can be developed.

Public Perception and Regulatory Issues

"Green" Technology

Wade Miller (Executive Director of the WateReuse Association & Foundation) noted that ultimately all water is "reused" — and there is substantial "unplanned" reuse on every major river system. He encouraged a change in the way in which water is viewed. The level of water "purity" should be matched with its intended use and the past history of the water is of little importance. Water reuse is a "green" technology that emulates Mother Nature. Increasing technological advances and acceptance for indirect potable reuse has resulted in new projects around the US and globally. In 1995, 95% of all US water reuse was performed in only four states, but there are now at least nine additional states with projects in operation or under development. Currently, twenty-eight states have regulations addressing water reuse, so project development is anticipated in other states as well. Potable reuse may gain further acceptance as the National Aeronautics and Space Administration (NASA) continues to promote the development of its new Space Station facility, which will recycle 93 percent of the water used in the station. Water reuse can also save energy and associated costs, particularly compared with alternatives such as desalination. Public acceptance remains a key concern, as there is little understanding of the difference between planned and unplanned reuse among the public, the media, and politicians.

Public Acceptance

Public Perception issues associated with potable reuse were addressed several times during the conference. CH2M Hill's Linda Macpherson, spoke on the ways the water industry can be its "own worst enemy" in addressing public attitudes about water reuse. She emphasized that it is critical for the water industry to talk about recycling of "water" as opposed to "recycled effluent" or "wastewater" or "sewage." She noted that the most negative associations and stigma associated with recycled water come from warning signs posted by the water industry. Wastewater presented as water from toilets increases the "yuck factor." Ron Wildermuth from the West Basin Municipal Water District emphasized the need to engage the public early and to incorporate water reuse into overall water management activities along with desalination and conservation.

Inclusive Process

Marci Steirer related the experiences of the City of San Diego Water Department. In 1999, plans for the use of indirect potable reuse as part of the City's Water Repurification Project's were shelved following "11th hour negative publicity and community protest" as well as environmental justice objections raised during the 1998 local political campaigns. Now, the City is revisiting the possibility of incorporating water reuse into their water plan in a process that involves a 67-member "Assembly on Water Reuse" which represents a range of community group representatives. The City's effort also includes: an independent advisory panel to review the technological aspects; a speakers' bureau; and surveys, stakeholder interviews, and other public education tools. Through this more broadly inclusive process, the City has gained more widespread support and cooperation from broad-based coalitions, such as "Suits and Surfers."

Shift to "Direct" Use

Brent Haddad (Center for Integrated Water Research at the University of California, Santa Cruz) addressed the particular challenges associated with the shift from indirect to direct potable reuse. "Indirect" reuse is typically distinguished from "direct" reuse by the presence of a "natural process" — such as storage in a surface water body or aquifer. However, the benefits of that "natural process" can now be supplied by increasingly reliable technologies which can be integrated into the treatment, conveyance, and storage of recycled water. Unfortunately, a wide range of different agencies and institutions are currently involved in the management and regulation of wastewater treatment and discharge, stored water, and water treatment for potable water supplies. Thus management remains "fragmented."

Approaches to more integrated management and regulation were addressed by Jim Crook, who reviewed guidelines and regulations developed in California, Florida, the UK, Australia, and the World Health Organization. The authority and responsibility of regulatory agencies differs depending upon

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Water Reuse

Regulatory Criteria

Reclaim to Recharge

Key Messages

Board Member Education

Shift from Indirect Use

whether potable water reuse is recognized as "planned" or is considered unplanned. Dr. Crook noted that pressures on agencies have increased with the heightened public awareness of waterborne pathogens as well as endocrine disrupting compounds and pharmaceuticals. The latter can be particularly challenging, since adequate studies may not be available to form the basis for regulatory criteria. Regulatory criteria consider both the target levels of specific contaminants and the treatment approach, which can reduce the need for routine monitoring. Agencies need the expertise and flexibility to determine adequate regulation for reuse projects.

Orange County Water District

EDUCATING PUBLIC & BOARD MEMBERS ABOUT POTABLE REUSE

Prior to the start of the conference, the Orange County Water District (OCWD) hosted a tour, preceded by a presentation by OCWD General Manager Mike Markus (see Markus, this TWR). Mr. Markus presented an overview of the OCWD tertiary water treatment process for the water received from OCWD's neighboring Orange County Sanitation District facility, including microfiltration, reverse osmosis, and ultraviolet/hydrogen peroxide advanced oxidation treatment. In addition, he stressed the importance of public relations and public education for the success of this project. Extensive public education resulted in no active opposition. Spending $4 million on their outreach program, OCWD met face-to-face with as many groups as possible, from Kiwanis to City Councils, and obtained letters of support from all 21 cities in their service area.

Mike Wehner (OCWD Assistant General Manager), later spoke at a session entitled "Pathways to Success" — which featured presentations regarding facilities that treat reclaimed water to obtain potable water quality and then use that water to recharge aquifers. This session also included: Ed Archuleta (El Paso Water Utilities); Marshall Brown (City of Scottsdale); Rich Nagel (West Basin Municipal Water District; and Tom Love (Inland Empire Utilities Agency).

Wehner discussed the necessity for ensuring the public first understands the need for additional water supplies before getting into a discussion of "purified" water. Messages to key audiences should address: health and safety; water reliability with local control; and high quality water. This effort should also provide testimonials from outsiders — particularly from the medical and public health communities. OCWD has found the public can accept potable reuse in cases where: the need is clear; outreach is effective and ongoing; politicians and community leaders make a commitment; water quality is higher than that provided by alternatives; regulations have ongoing oversight; and there is independent scientific review.

The conference also featured a third OCWD speaker who represents an important segment of the public that needs to be included in the outreach process — i.e. pubic utility board members. OCWD Director Philip Anthony is the Chair of the district's Groundwater Replenishment System (GWR System) steering committee. In his address, he emphasized the importance of water utility staff educating board members to ensure that they can play an effective role in sorting out the institutional issues associated with reuse projects. In the case of OCWD's GWR System, close coordination and "Joint Cooperative Agreements" were required between the boards of the Orange County Sanitation District and OCWD. Arranging for such agreements often occurs over many years and board membership may change extensively during this period. Outreach and education for new board members was critical to ensure that the GWR System could move successfully towards full operation.

Potable Reuse

BEST RESORT OR LAST RESORT?

The conference ended with a lively discussion of whether potable reuse is a method of "best resort" or of "last resort" and whether technology or society have reached the point where the use of indirect potable reuse can be shifted to direct potable reuse (where the environmental or "natural" buffer is removed). With respect to potable reuse, the term "last resort" comes from a National Research Council (NRC) report on potable reuse published in 1998. The general conclusion of the NRC study supported planned, indirect potable reuse as "a viable application of reclaimed water" provided there is "careful, thorough, project-specific assessment that includes contaminant monitoring, health and safety testing, and system reliability evaluation." The report also stated that potable reuse should be adopted only in cases where "all other alternatives for nonpotable reuse, conservation, and demand management have been evaluated and rejected as technically or economically infeasible." In light of significant advances in treatment technology, analytical monitoring, and water quality evaluations at existing potable reuse projects since publication of the 1998 report, there is increased confidence that indirect potable reuse does not present undue public health risks. A heightened awareness of the need for water in the face of increasing demands and climate change has resulted in the planning and/or implementation of several indirect potable reuse projects in the US and elsewhere in the last decade.

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Water Reuse

Time Requirement

Quality Issues

Reuse Integration

Bob Hultquist, recently retired from the California Department of Public Health (CDPH), supported a cautious approach to potable reuse, citing the need for water providers to seek "the most protected source for drinking water." He also recommended that communities "avoid the temptation to use potable reuse to dispose of wastewater."

As recommended in the recent draft regulations from CDPH on Groundwater Recharge and Reuse Projects ("GRRPs" — see pages 18-19, preceding article), California has required the inclusion of an environmental buffer, e.g. aquifer storage for at least six months, before potable reuse can occur. The rationale for this is to ensure viral die-off, to provide dilution, and to provide time to identify and respond to problems. Regulators have asked whether monitoring technology for contaminants is as advanced as treatment technology, and whether water quality test results can reliably be obtained faster so that treated water can be used more quickly while still providing assurances that treatment has been successful.

Conclusion

The conference ended with discussion regarding the viability of direct potable reuse. Several speakers pointed out that if the current technology was trusted, we would not require the environmental buffer. The quality of reclaimed water after advanced treatment has been completed is extremely high.

Experts and practitioners such as Wade Miller, Ian Law, and Mike Wehner have questioned the merits of taking highly treated water and placing that water into aquifers or surface storage. New water quality issues may be introduced, thus creating a need for further treatment after water has been recovered from storage. Given the technological advances that have been put into practice at facilities such as those at OCWD and in Singapore, questions were raised about what steps are needed for advanced technology to be trusted so that environmental buffers can be removed.

Generally, there was support for the critical role that potable water reuse will play in meeting water supply challenges and the need to view water as a resource that can be treated and reused, not wasted. Participants committed to bringing a better understanding to the public, regulators, and policymakers of the need, source water control, treatment methods, and monitoring and testing methods that are used for potable water reuse, so that there can continue to be greater integration of reuse into water supply planning and management, nationally and internationally.

For Additional Information: Cat Shrier, 202/ 344-7894 or email: cat@watercatconsulting.com

Cat Shrier, Ph.D., P.G., has a broad background in public policy, hydrogeology, water planning and systems engineering. She has served as a Senior Water Resources Planner and Engineer with environmental consulting firms in Calgary, Denver, Raleigh, and Richmond. Cat also headed her own independent consulting practice to provide support on water resources regulatory interactions and public involvement on water resources management issues. Since 1984, Cat has worked with and for federal and state legislative offices and regulatory agencies in Washington, DC; New Jersey; Virginia; North Carolina; Colorado; and the Province of Alberta. Her work has involved conjunctive use of groundwater and surface water resources; environmental impact assessments; water and wastewater reuse; multicriteria decision analysis incorporating spatial analysis and knowledge bases; water and watershed planning programs; and water policy. Dr. Shrier served on the National Academy of Sciences Study Committee on Managed Underground Storage of Recoverable Water (e.g. Aquifer Storage Recovery, recharge basins), which published its report in January 2008.

Stormwater

Guidelines & Standards

NEW STORMWATER REGULATIONS

EPA PROPOSES RULE FOR NEW EFFLUENT LIMITATIONS - GUIDELINES FOR CONSTRUCTION AND DEVELOPMENT

by Jason Ziemer, Z Environmental Services (Seattle)

Overview

On November 28, 2008, the US Environmental Protection Agency (EPA) issued a proposed regulation which would strengthen the existing National Pollutant Discharge Elimination System (NPDES) permit program that currently regulates stormwater discharges from construction and development sites (see Water Brief, TWR #58). The proposed technology-based Effluent Limitations Guidelines and New Source Performance Standards (NSPSs) would impact all construction sites one acre or larger which are covered under a construction NPDES permit. The requirement for individual construction sites will depend on a variety of factors including site size, precipitation and soil type and will range from implementation of construction Best Management Practices to the use of Active Treatment Systems. EPA estimates that the proposed rule would cost $1.9 billion dollars per year to implement and reduce stormwater pollutants by 27 billion pounds annually. The cost estimate did not include costs for Alaska, Hawaii and the US Territories (see 73 Fed. Reg. 72569).

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Stormwater

While the new regulations will have impacts nationwide, the timing and extent of those impacts will depend upon whether a particular state has been granted NPDES program authority and NPDES permit renewal schedules.

Background

Impairment Widespread

Since the US Congress passed the Clean Water Act (CWA) in October of 1972, substantial improvements in the nation's water quality have been achieved through implementation of the industrial, municipal and construction NPDES stormwater permit programs. Although significant progress has occurred, major water quality issues associated with construction stormwater runoff remain. According to EPA's draft Effluent Limitations Guidelines, "45% of assessed river and stream miles, 47% of assessed lake acres and 32% of assessed square miles of estuaries show impairments from a wide range of pollutant sources." EPA has identified sediment-laden stormwater runoff from construction sites as one of major remaining water quality problems throughout the United States.

Sediment Impacts

Sediment is a primary pollutant of concern because it can have tremendous detrimental impacts to downstream aquatic resources, such as fish. Sediment can smother spawned fish eggs, reduce visibility (which decreases feeding capability), and may raise water temperature due to the absorption of ultraviolet radiation. In addition, other pollutants such as metals, nutrients and petroleum products may adhere to suspended sediment carried to receiving waters in construction stormwater runoff. Like sediment, these pollutants can cause an array of physical, chemical and biological impacts on aquatic systems. According to EPA's proposed Guidelines, turbidity and suspended solids impair 695,133 miles of streams and 376,832 acres of lakes and reservoirs nationwide.

Litigation

In 2002, EPA addressed these concerns by issuing a proposed rule to regulate discharges from the construction and development industry. In 2004, EPA withdrew this earlier proposal stating that existing standards within the NPDES permit were sufficient and additional requirements would be too costly to implement. This decision was challenged in District court by the National Resource Defense Council (NRDC). The Ninth Circuit affirmed the District court's decision which required EPA to promulgate Effluent Limitations Guidelines and New Source Performance Standards for the construction and development industry. *NRDC v. EPA*, 2008 WL 4253944 (9th Cir. 2008)

Regulatory Implications

Numeric Limits

EPA's draft Guidelines have the potential to affect all municipal and construction NPDES permit holders. The proposed rule is technology-based and would establish a numeric effluent limit for turbidity in discharges from construction sites (see: www.epa.gov/fedrgstr/EPA-WATER/2008/November/Day-28/w27848.pdf).

Additional Treatment

The draft rule states: "EPA envisions these turbidity limits as requiring an additional layer of management practices and/or treatment above what most state and local programs are currently requiring." 73 Fed. Reg. 72564. This provision would require Federal and State permitting authorities to implement new standards and controls into construction NPDES permits that they issue. Although the proposed rule is targeted towards the construction and development industry, NPDES Phase I and II regulated municipalities will also be affected because they are required to develop comprehensive stormwater programs which must include provisions to address construction stormwater discharges.

Options Considered

When developing the proposed Guidelines, EPA considered three options:

Option 1 would require all construction and development sites to implement Best Management Practices (BMPs) to prevent, reduce and eliminate stormwater pollutants. In addition, sites greater than 10 acres would be required to install temporary sediment basins designed to treat the runoff from a two-year, 24-hour storm event. The sediment basins may require up to 3,600 cubic feet of storage per acre of disturbed land. Implementation of Option 1 is anticipated to cost the construction and development industry $132 million/year (2008 $).

Active Treatment Systems

Option 2 would require the provisions in Option 1 and would also establish a numeric effluent limit of 13 **n**ephelometric **t**urbidity **u**nits (NTU) for most sites that have a soil clay content of more than 10% and are at least 30 acres in size (areas of the country with "high rainfall energy and with soils with significant clay content." 73 Fed. Reg. 72569). Option 2 would also require NPDES permit holders to monitor construction stormwater runoff for turbidity. EPA also notes that compliance with the numeric effluent limit of 13 NTU for large construction sites (30 acres or larger) will typically require implementation of Active Treatment Systems (ATS). ATS utilize water treatment chemicals, such as chitosan, to clarify turbid construction stormwater prior to discharge. Implementation of Option 2 is estimated to cost the construction and development industry $1.9 billon/year (2008 $) and reduce stormwater pollutants by 27 billion pounds annually.

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Stormwater

Chosen Option

Option 3 would include the requirements of Options 1 and 2 and lower the threshold for sites required to meet the 13 NTU numeric effluent limit to 10 acres or larger. Option 3 is estimated to cost the construction and development industry $3.8 billion/year and reduce stormwater pollutants by 50 billion pounds annually.

EPA is proposing to implement Option 2 on the basis of ATS as the Best Available Technology (BAT).

Construction & Development Industry Implications

Final December 2009

When EPA effluent limitations are finalized in December 2009, municipal and construction NPDES permit holders will be required to implement additional measures to achieve compliance. These measures will vary depending on site conditions and range from aggressive implementation of traditional BMPs to the use of ATS.

Numeric Turbidity Limit

The proposed effluent limits for turbidity include BMPs, sediment basin requirements, and for larger sites a turbidity limit of 13 NTU. The technology discussed to achieve the turbidity limit is ATS, which consist of polymer-assisted stormwater clarification followed by filtration. Although ATS have been utilized on construction sites for over a decade to reduce turbidity in stormwater runoff and minimize offsite water quality impacts from construction activities, most contractors, developers and municipalities have limited knowledge of the use and proper application of this technology.

ATS Referenced

EPA's draft rule references ATS that utilize water treatment polymers such as chitosan (a material made from recycled crab shells) to coagulate suspended sediment which is then settled in a pond or removed through filtration methods. The most common ATS is **c**hitosan-**e**nhanced **s**and **f**iltration (CESF), which is an engineered flow-through process. CESF has been implemented on hundreds of construction sites, treated billions of gallons of turbid stormwater, and is consistently capable of reducing turbidity to levels less than 5 NTU. Smaller projects often recognize cost benefits from batch ATS that use conventional water treatment polymers such as aluminum chloride. Selecting the appropriate and most cost effective ATS approach to achieve compliance with new effluent limitations will require careful consideration of onsite factors such as project duration, rainfall quantity, hydraulic modeling data, and other environmental permits. Key cost control factors include: upfront planning; effective use of conventional BMPs; and appropriate application of ATS.

CESF

Cost Control

Active Treatment Systems

ATS Evaluation

EPA based their technical and economic analysis of BAT on the performance of ATS — specifically CESF technology. Although other ATS technologies such as electro-coagulation, batch treatment, and other methods are utilized for construction stormwater clarification, CESF is the leading technology utilized in the construction and development industry to achieve stormwater discharge limits of less than 10 NTUs. EPA has evaluated more than 6,000 data points and cost information from many projects which have utilized ATS and has determined that "Option 2 is technologically available, economically achievable and has acceptable non-water quality environmental impacts." This means that construction projects over 30 acres in size will need to consider ATS and in most cases will have to implement these systems to achieve the proposed 13 NTU numeric effluent limit.

CESF System

CESF utilizes a bio-polymer made from recycled crab shells to coagulate the fine particles suspended in the water. The particles and associated pollutants, such as phophorus, are then removed from stormwater by pressurized sand filters. The CESF system occupies a small footprint adjacent to the site's retention pond and is capable of producing a continuous output of 500 gallons-per-minute (i.e. nearly three-quarters of a million gallons-per-day) with discharge turbidity of less than five NTU. Multiple CESF systems are also utilized together to achieve greater treatment capacity. For instance, 12 CESF systems were utilized to achieve 6,000 gallons-per-minute during the construction of SeaTac International Airport's new runway. The discharge from ATS is similar in clarity to that which is found in pristine salmon-bearing streams.

CESF Components

Although the treatment system looks complex, the CESF system requires just six key components. CESF SYSTEM COMPONENTS INCLUDE:

- Stormwater Retention Basin
- CESF System Pump
- Interconnecting Pipes and Hoses
- Chitosan Delivery System
- Water Quality Monitoring System
- Industrial Sand Filtration Unit

Treatment Process

CESF treatment begins when turbid stormwater is pumped from a retention basin to the systems automated water quality monitoring system which continuously measures and records flow, pH and turbidity. Next, a small dose (typically 0.5 to 1.0 parts-per-million) of liquid chitosan is added and mixed with the stormwater flow. The coagulation and agglomeration of fine sediments and associated pollutants happens within seconds as the water travels to the sand filtration unit. The sand filter removes the sediment (turbidity) from the stormwater as it passes through a thick layer of filtration-grade sand. The treated stormwater travels back to the automated monitoring system where flow, pH, and turbidity is measured and recorded prior to surface water discharge. The CESF monitoring system includes a safety feature that sends treated water back to the retention basin if it does not meet predetermined discharge standards.

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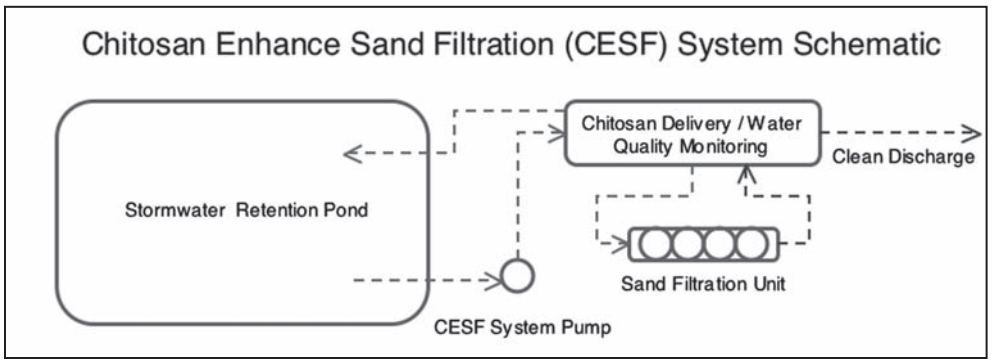
Stormwater



Economic Feasibility

In developing the numeric effluent limitations, EPA determined that ATS systems such as these are consistently capable of achieving compliance with effluent limitations and are economically feasible. Implementation of CESF and other ATS requires proper planning, trained personnel to operate the system and routine water quality monitoring.

Shift to Numeric Limits

Conclusion

EPA's proposed Effluent Limitations Guidelines were published in the Federal Register in November, 2008 and will be finalized no later than December 1, 2009. The proposed Guidelines include a fundamental shift from a non-numeric or narrative approach to regulating construction stormwater to a water quality based numeric effluent limit. If implemented as they are currently proposed, these Guidelines would have some impact on all municipal and construction NPDES permit holders. The requirements will depend on project size and may include improved use of BMPs, installation of engineered sediment basins, routine stormwater discharge monitoring and the implementation of ATS.

Once the draft Guidelines are finalized, they will be incorporated into new NPDES construction permits. These permits are issued by EPA regional offices or NPDES authorized states and tribal agencies. The primary pathway for implementation of the new Guidelines will be through state-wide NPDES **c**onstruction **g**eneral **p**ermits (CGPs). EPA retains NPDES/CGP authority in five states (Alaska, Idaho, Massachusetts, New Hampshire, and New Mexico) as well as the District of Columbia, most US Territories, and most Indian lands. These areas are thus likely to be the first effected.

NPDES-authorized states may choose to adopt the new Guidelines immediately into their CGP or wait until the permit renewal date. The implications of the Guidelines will therefore differ from state-to-state depending on the existing regulations with the specific state's CGP. For instance, states such as Washington, Oregon and California already have relatively stringent construction stormwater requirements. This means that small (<10 acre) and medium (>10 and <30 acres) sized construction and development sites may not see a tremendous difference in requirements. Projects greater than 30 acres in these areas, however, would likely see significant impacts associated with meeting the 13 NTU numeric effluent limit. Other states such as Alaska and Idaho, which fall under EPA NPDES authority, typically have less stringent requirements and will likely see more significant impacts for all sizes of sites.

Comment Period Open

EPA is accepting public comments on the proposed Guidelines through February 26, 2009. Comments can be submitted online by referencing Docket ID No. EPA-HQ-OW-2008-0465 at www.regulations.gov

EPA CONTACTS:

For technical information: Jesse W. Pritts, EPA, 202/ 566–1038 or email: pritts.jesse@epa.gov

For economic information: Todd Doley, EPA, 202/ 566–1160 or email: doley.todd@epa.gov

FOR ADDITIONAL INFORMATION, CONTACT: JASON ZIEMER, Z Environmental Services, 253/ 670-4054 or email: jziemer@comcast.net; Federal Register notice at 73 Fed. Reg. 72562 (11/28/08)

Jason Ziemer is an environmental scientist whose work has focused on municipal, construction and industrial stormwater management. Mr. Ziemer holds two US patents on chitosan-based stormwater treatment technologies and served a critical role in the development of chitosan enhanced sand filtration. Mr. Ziemer enjoys instructing erosion control/stormwater management courses and is currently serving on the Board of Directors for the Northwest Environmental Business Council.

Managing Stormwater in Washington 2009

Tuesday, March 3, 2009 — Tacoma, Washington — Hotel Murano, 1320 Broadway Plaza

This one-day Northwest Environmental Business Council conference will address current issues in construction and industrial stormwater management. This second annual event will address dramatic regulatory changes at both the federal and state levels.

Contact: Sue Moir NEBC, 503-227-6361 or email sue@nebc.org — **NEBC WEBSITE:** www.nebc.org

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WATER BRIEFS

WATER REUSE TO MEET FUTURE WATER SUPPLY NEEDS: NAS STUDY BEGINS US

by Dr. Cat Shrier, Watercat Consulting (Washington, DC)

In December 2008, the Water Science and Technology Board of the National Academy of Sciences held the first meeting of a new committee to undertake a phased study of the potential for water reclamation and reuse of municipal wastewater to expand and enhance the nation's available water supply. The study is sponsored by the US Environmental Protection Agency (EPA), with additional funding provided by several organizations and water providers including the National Water Research Institute; Los Angeles County Sanitation Districts; Inland Empire Utilities Agency; Los Angeles Dept. of Water and Power; Orange County Water District; Orange County Sanitation District; West Basin Municipal Water District, Irvine Ranch Water District; Metropolitan Water District of Southern California; and the National Science Foundation.

The initial meeting of the committee was held in Orange County, which is one of the leading areas of the US in terms of water reuse for water supplies. At the committee's first meeting the members toured the reuse facilities of the West Basin and Orange County Water Districts. Briefings were provided on "Wastewater as a Resource" by EPA; on "Southern California's Water Picture" by the Metropolitan Water District of Southern California, and on water reuse challenges in the US. This meeting was held as part of the planning phase (Phase I), through which the committee will agree on a work plan to support execution of the Phase II study on water reclamation and reuse. This is expected to result in a consensus report in 2010. The committee will consider a wide range of uses, including drinking water, non-potable urban uses, irrigation, industrial process water, groundwater recharge, and water for environmental purposes.

The committee's report will address the following issues and questions:

- Contributing to the nation's water supplies: What are the potential benefits of expanded water reuse and reclamation? How much municipal wastewater effluent is produced in the United States, what is its' quality, and where is it currently discharged? What is the suitability — in terms of water quality and quantity — of processed wastewaters for various purposes, including drinking water, non-potable urban uses, irrigation, industrial processes, groundwater recharge, and environmental restoration?
- Assessing the state of technology: What is the current state-of-the-technology in wastewater treatment and production of reclaimed water? How do available treatment technologies compare in terms of treatment performance (e.g., nutrient control, contaminant control, pathogen removal), cost, energy use, and environmental impacts? What are the technology challenges and limitations? What are the infrastructure requirements of water reuse for various purposes?
- Assessing risks: What are the human health risks of using reclaimed water for various purposes, including indirect potable reuse? What are the risks of using reclaimed water for environmental purposes? How effective are monitoring, control systems, and the existing regulatory framework in assuring safety and reliability of wastewater reclamation practices?
- Costs: How do the life cycle costs (including environmental costs, such as energy use and greenhouse gas emissions) and benefits of water reclamation and reuse generally compare with other supply alternatives, such as seawater desalination and non-technical options such as water conservation or market transfers of water?
- Barriers to implementation: What important implementation issues must be addressed to significantly improve the applicability of water reuse to help meet the nation's water needs (e.g., public acceptance, regulatory, financial, institutional, water rights)? What are means to overcome these challenges? Based on a consideration of case studies, what are the key social and technical factors associated with successful water reuse projects and favorable public attitudes toward water reuse? Conversely, what are the key factors that have led to the rejection of some water reuse projects?
- Research needs: What research is needed to make water reclamation and reuse an attractive and cost-effective water supply alternative compared with other options? What are appropriate roles for governmental and non-governmental entities?

The committee is being chaired by Dr. R. Rhodes Trussell, founder of Trussell Technologies, Inc. and a worldwide authority in the development of advanced processes for treating water or wastewater to achieve the highest drinking water quality standards. The other committee members represent a range of experience related to research and application of water reuse technology and related issues.

Committee members are:

- Mr. Ed Archuleta, Manager, El Paso Water Utilities Public Service Board
- Dr. James Crook, Water Reuse Consultant, Monterey Regional Water Pollution Control Agency
- Dr. Jorg E. Drewes, Associate Professor in Environmental Science and Engineering, Colorado School of Mines
- Ms. Denise D. Fort, Professor, The University of New Mexico School of Law
- Dr. Charles N. Haas, Professor of Environmental Engineering, Drexel University
- Dr. Brent Haddad, Founder and Director of the Center for Integrated Water Resources and Professor of Environmental Studies, University of California, Santa Cruz
- Dr. Duane Huggett, Assistant Professor of Biology, University of North Texas
- Dr. Sunny Jiang, Associate Professor of Civil and Environmental Engineering, University of California, Irvine
- Dr. David L. Sedlak, Associate Professor of Civil and Environmental Engineering, University of California, Berkeley
- Dr. Shane Snyder, Research and Development Project Manager, Southern Nevada Water Authority
- Dr. Margaret H. Whittaker, Chief Toxicologist, ToxServices
- Dr. Dale Whittington, Professor of Environmental Sciences & Engineering, City & Regional Planning, and Public Policy, University of North Carolina at Chapel Hill

The second committee meeting, and first meeting of "Phase II" of this study, has tentatively been scheduled for March 30-31, 2009 and will likely be held in Florida (location TBD).

For Info: Stephanie Johnson, 202/ 334-3385 or email: sjohnson@nas.edu); additional information on the study at: www8.nationalacademies.org/cp/projectview.aspx?key=48995

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WATER BRIEFS

AQUATIC PESTICIDES: SIXTH CIRCUIT STRIKES EPA AQUATIC PESTICIDE RULE WEST/US

by J. Mark Morford, Stoel Rives (Portland, OR)

On January7, 2009, the US Sixth Circuit Court struck down the US Environmental Protection Agency's (EPA's) aquatic pesticide rule in *Nat'l Cotton Council of Am. v. EPA*, No. 06-4630 *et seq.*, 2009 WL 30292 (6th Cir Jan. 7, 2009).

In November 2006, EPA promulgated a new rule concluding that pesticides applied in accordance with the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) are exempt from federal Clean Water Act permitting requirements. *See* 71 Fed Reg 68,483 (Nov. 27, 2006). This rule was in direct response to federal court decisions finding that NPDES permits were required for certain application of aquatic herbicides, *e.g., Headwaters, Inc. v. Talent Irrigation Dist.*, 243 F3d 526 (9th Cir 2001), and for aerial application of pesticides where residue drifts or washes into surface water, *League of Wilderness Defenders v. Forsgren*, 309 F3d 1181 (9th Cir 2002). In its rule, EPA reasoned that application of aquatic pesticides is not the discharge of a pollutant from a point source, because the pesticide is not a waste at the time it is applied to the water. EPA conceded that residuals from pesticide application are a waste but concluded that such residuals are not discharged from a point source, but are the product of the breakdown of diffuse pesticide after it is in the water. The Sixth Circuit rejected most of EPA's logic.

In particular, the Court concluded that biological pesticides are pollutants from the moment they enter the water. The Court appears to agree with EPA's interpretation that chemical pesticides are not a pollutant until they become a waste, which the Court interpreted as the point at which the pesticide has performed its intended purpose. The Court, however, rejected EPA's point source argument and held that such pesticide residuals are discharged by a point source at the moment of the pesticide application. The Court did not reach the arguments involving the intersection of FIFRA and the Clean Water Act.

In vacating EPA's rule and providing detailed interpretation of the Clean Water Act, the Court catapulted aquatic pesticides back to the post-*Talent* period — albeit with a broader and clearer opinion. The case is clear that NPDES permits will be required for most applications of aquatic pesticides. The one exception is the possibility of an aquatic pesticide that leaves no residual or excess in the water after completing its intended purpose. The implications of this decision are fairly clear with respect to aquatic pesticides. The case, however, also has implications for aerial or terrestrial application of pesticides that drift or wash into surface waters. The Court cites with approval the *Forsgren* opinion that aerial application is a point source. Given the Court's conclusion that the point of application is a point source for excess and residual pesticide, the opinion appears to speak to aerial and terrestrial applications as well as direct aquatic applications. The Court's opinion potentially has broad geographic reach because the case consolidated petitions challenging the rule that were filed in most of the circuit courts, including the Ninth Circuit.

In response to the *Talent* and *Forsgren* cases, the Oregon, Washington and California agencies began issuing permits, either individual or general permits, variously for aquatic pesticides and aerial applications. We expect the agencies in these states to continue or resurrect those permitting programs.

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Mark Morford is a partner with Stoel Rives, LLP where he advises industrial, energy, forest products and agricultural facilities on the full range of environmental issues and opportunities

GW WATER AVAILABILITY CO

NO INJURY RULE / SMALL WELL OWNERS

The Colorado Supreme Court (Court) issued a decision that denied new ground water rights for a subdivision development to protect existing domestic ground water rights. *Buffalo Park Development Company v. Mountain Mutual Reservoir Company*, No. 06SA373, 195 P.3d 674 (Nov. 24, 2008). The Court's decision, in an opinion written by Justice Gregory Hobbs, was based on the finding that Buffalo Park Development Company (Buffalo Park) "did not meet its burden of proof" to prove the existence of "available unappropriated water for the ground water rights" it sought for three subdivisions, or, in the alternative, to prove that it proposed "a non-injurious augmentation plan sufficient to protect the vested ground water rights of small domestic well owners who divert from the aquifers between the proposed three subdivisions and the surface waters of Bear Creek and Turkey Creek." Slip Op. at 5.

The Court's decision is important due to its value as a precedent on several issues that confront water users throughout the West, including "water availability" determinations, augmentation plans, the rights of small domestic groundwater users (often "exempt wells"), "injury" to existing groundwater users, and the use of expert testimony. TWR plans additional coverage regarding this case in the next issue.

For info: Case available at: www.courts.state.co.us

PERCHLORATE REGS NM

DRINKING WATER PROTECTION URGED

New Mexico Environment Department Secretary Ron Curry urged the US Environmental Protection Agency (EPA) to provide greater protections for state drinking water by regulating perchlorate — a component of rocket fuel. The contaminant has been discovered in numerous drinking water systems and groundwater aquifers across New Mexico and can have detrimental health effects on humans, particularly pregnant women, newborns and children. Most perchlorate contamination in drinking water across the country stems from improper disposal by rocket test sites, military bases and chemical plants. No national safety standard exists for perchlorate levels in drinking water.

Secretary Curry sent a letter to EPA Administrator Stephen L. Johnson on November 26 detailing the state's concerns after the federal agency decided it would not set a drinking water safety standard for the chemical (*Preliminary Determination on Perchlorate*: 73 Fed. Reg. 60262 (Oct. 10, 2008). "We must protect our state's limited drinking water supply from this harmful contaminant," said Curry. He also expressed concerns in the letter that the scientific model that the federal agency used to support its decision has not been fully peer reviewed and vetted by outside scientists. "We are concerned that EPA is rushing to a decision on perchlorate — without sufficient consideration — in the closing days of the current administration.

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WATER BRIEFS

EPA's decision is driven by politics and reducing cleanup requirements for the military rather than protection of public health based on science."

In Curry's letter, he also stated, "The Environment Department has gathered additional data demonstrating widespread perchlorate contamination in groundwater at several military installations and nuclear weapons facilities throughout the State. In many cases, this contamination threatens present and future drinking water supplies."

For info: Marissa Stone, NMED, 505/ 827-0314; letter and press release available at NMED's website: www.nmenv.state.nm.us/OOTS/press_releases.html

WATER RIGHTS GUIDE WA

LANDOWNER'S GUIDE RELEASED

The Washington Rivers Conservancy recently released its Landowner's Guide to Washington Water Rights. A copy can be downloaded from the website listed below.

For info: WRC website: www.warivers.org

FARM EFFICIENCY CA

WATER MANAGEMENT PRACTICES SURVEY

The Agricultural Water Management Council of California recently released a 64-page report entitled "*Efficient Water Management - Irrigation District Achievements.*" The report is a summary of activities performed by agricultural water suppliers in California in their efforts to implement efficient water management practices. Water supply members of the Council were asked to participate in a survey that would provide insight regarding actions taken during the past ten years pursuant to the Council's Efficient Water Management Practices. The survey represents more than 3.27 million irrigated acres, more than 35% of the state's irrigated acreage. The survey of farm water districts found that improved measurement systems are used on more than 87% of the irrigated acreage from surveyed districts, resulting in very efficient management and delivery of farm water.

For info: AWMC website: www.agwatercouncil.org/

ESA SCIENCE V. POLICY US

INSPECTOR GENERAL DETAILS FLAWS

In a scathing 141-page report entitled "*The Endangered Species Act and the Conflict Between Science and Policy*" (Dec. 10, 2008), Inspector General Earl Devaney of the Department of the Interior set out serious flaws in the decision-making process related to endangered species. Referring specifically to Deputy Asst. Secretary of Fish and Wildlife and Parks Julie MacDonald, Devaney's cover letter of December 15 stated that "Overall... MacDonald's zeal to advance her agenda caused considerable harm to the integrity of the ESA program and to the morale and reputation of the FW, as well as potential harm to endangered species. Her heavy-handedness has cast doubt on nearly every ESA decision issued during her tenure; of the 20 decisions we reviewed, her influence potentially jeopardized 13 ESA decisions...In the end, the cloud of MacDonald's overreaching, and the actions of those who enabled and assisted her, have caused the unnecessary expenditure of hundreds of thousands of dollars to re-issue decisions and litigation costs to defend decisions that, in at least two instances, the courts found to be arbitrary and capricious."

The report also notes that many US Fish & Wildlife Service employees "believe their daily work continues to be hampered by the lack of clear and established policies for implementation of the ESA. In instances where policies do exist, they appeared to change from listing decision to listing decision... MacDonald was clearly able to use these policy voids to impose her will on the ESA process." Report at 2.

At the end of the report, it is noted that "MacDonald refused to be interviewed regarding this investigation despite multiple attempts to arrange an interview. In a June 30, 2008 letter to Inspector General Devaney, MacDonald stated, 'Given the breathtaking arrogance with which you have conducted previous so-called investigations of me, I have no interest in any further discussions with your office.' " Report at 139. MacDonald resigned from her position on May 1, 2007, shortly after the issuance of the report from an earlier investigation of MacDonald by the Inspector General.

For info: Full Report available at: www.doioig.gov/

NONPOINT SOURCES CA

SWRCB WEB REFERENCE GUIDE

The NPS Encyclopedia is a free on line reference guide designed to facilitate a basic understanding of nonpoint source (NPS) pollution control and to provide quick access to essential information from a variety of sources by providing direct hyperlinks to resources available on the Internet. References pertaining to hyperlinks can be accessed by selecting (clicking) on the blue underlined font. The purpose of this on line resource guide is to support the implementation and development of NPS total maximum daily loads (TMDLs) and watershed (action) plans with a goal of protecting high quality waters and restoring impaired waters.

For info: Molly Munz, 916/ 341-5485 or email: MMunz@waterboards.ca.gov

BLACK ROCK DAM EIS WA

DAM ECONOMICALLY UNJUSTIFIABLE

On December 19, the federal Environmental Impact Statement (EIS) on the Black Rock Dam proposal was released by the Bureau of Reclamation (Reclamation). According to the *Yakima River Basin Water Storage Feasibility Study Final Planning Report/EIS*, none of the alternatives evaluated for the Storage Study proved economically justifiable based on the costs and benefits measured. The cost of the Black Rock Dam proposal was estimated to range from $4.95 to $7.73 billion, with a probable cost of $5.69 billion, plus annual operating and maintenance of $60.2 million. The dam, proposed in the Yakima Basin in Washington, would inundate 3,850 acres and store 1.3 million acre-feet of water in order to meet the water needs of the area.

The public review and comment period ends on February 3. Comments may be submitted electronically or by regular mail.

For info: EIS available on Reclamation's website: www.usbr.gov/pn/programs/storage_study

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CALENDAR

January 21-22 ID
Idaho Water Users Ass'n 71st Annual Convention, Boise. DoubleTree Hotel. For info: IWUA website: www.iwua.org

January 22-23 NM
Transboundary Water Crises: Learning from Our Neighbors in the Rio Grande (Bravo) and Jordan River Watersheds, Las Cruces. Corbett Ctr., NMSU. Sponsored by NM Water Resources Research Institute & International Relations Institute. For info: NMWRRI website: http://wrri.nmsu.edu/

January 22-23 AZ
Adaptation to Climate Change in the Desert SW: Impacts & Opportunities, Tucson. Westward Look Resort. Sponsored by Institute for the Study of Planet Earth, James E. Rogers College of Law, & Economics, Law & Environment Program. For info: Conference email: adaptationconference@law.arizona.edu or website: www.law.arizona.edu/adaptationconference/

January 26-28 TX
2009 UIC Conference, San Antonio. Sheraton Gunter. Sponsored by the Ground Water Protection Council. For info: GWPC website: www.gwpc.org

January 27-28 WA
Endangered Species Act 16th Annual Conference, Seattle. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

January 27-31 TX
Golden Alga International Symposium & Texas Chptr of American Fisheries Society Annual Meeting, Fort Worth. Radisson Fossil Creek Hotel. For info: Gerald Kurten, TPWD, email: gerald.kurten@tpwd.state.tx.us or Conference website: www.tpwd.state.tx.us/

January 28 CA
Annual Water Law Update Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension website: http://extension.ucdavis.edu/

January 28-29 OR
Oregon Sustainable Building Expo & Conference, Portland. For info: Expo website: http://oregon.sustainableexpos.com/Home.aspx

January 28-29 CO
Colorado Water Congress 51st Annual Conference, Denver. Hyatt Regency Denver Tech Center. For info: CWC, 303/ 837-0812, email: cwc@cowatercongress.org or website: www.cowatercongress.org/

January 28-30 UT
Low Cost Remediation Strategies for Contaminated Soil & Groundwater Course, Salt Lake City. Sponsored by National Ground Water Assn. For info: NGWA, 800/ 551-7379, email: customerservice@ngwa.org, or website: www.ngwa.org

January 29 CA
FERC Hearing on Klamath Dams, Yreka. Best Western Inn, 129 East Minor Street, 1pm & 7pm. For info: John Murdre, FERC, 202/ 502-8902 or email: johnmurdre@ferc.com

January 29 CA
State of the Santa Ana River Watershed Conference: Overcoming Boundaries, Ontario. Ontario Convention Center. For info: Conference website: www.santaanawatershed.com/

January 29 OR
Water for People & the Environment: Conflict, Compromise & New Directions Conversation, Eugene. Bowerman Center for Environmental Law, 5pm. For info: ENR , 541/ 346-1395, email: enr@uoregon.edu or website: www.law.uoregon.edu/org/enr

January 29-30 KS
Kansas Natural Resources Conference: Renewable Energy - Renewable Resources, Wichita. Hilton Airport. For info: Conference email: KNRC@kaws.org or website: www.kansasnrc.net/index.html

January 30 MT
Water Law Update Seminar, Bozeman. Gran Tree Inn. CLE Institute - MT State BAR. For info: BAR website: www.montanabar.org/

February 2-3 UT
Monitored Natural Attenuation for Remediation of Contaminated Sites Course, Salt Lake City. Sponsored by National Ground Water Assn. For info: NGWA, 800/ 551-7379, email: customerservice@ngwa.org, or website: www.ngwa.org

February 3-4 TX
Carbon & Climate Change Conference, Austin. AT&T Conference Center. Presented by the U of Texas at Austin School of Law. For info: Conference website: www.utcle.org/conferences/CH09

February 3-4 CA
2009 California Irrigation Institute Conference & Meeting, Sacramento. Embassy Suites, Riverfront Promenade. For info: CII website: www.caii.org/register.htm or email: bsouza@agwatercouncil.org

February 3-5 WA
Stream Restoration Design Symposium, Stevenson. Skamania Lodge. For info: Rob Sampson, 208/ 378-5727, email: Rob.sampson@id.usda.gov or website: http://rrnw.org

February 3-6 GA
2009 Winter Conference: National Association of Clean Water Agencies, Atlanta. Westin Buckhead. For info: NACWA website: www.nacwa.org

February 4 WA
Marine Shoreline Development Seminar, Seattle. For info: Law Seminars Int'l, 800/ 854-8009, email: registrar@lawseminars.com, or website: www.lawseminars.com

February 4-5 UT
Advanced Data Analysis Techniques for Evaluating & Quantifying Natural Attenuation Course, Salt Lake City. Sponsored by National Ground Water Assn. For info: NGWA, 800/ 551-7379, email: customerservice@ngwa.org, or website: www.ngwa.org

February 5-6 Canada
"Bringing the Future into Focus:" The State of the Salmon's Second Annual International Conference, Vancouver, B.C.. Speakers from around the Pacific Rim will share knowledge and explore possible solutions to the crises that plague some salmon populations. For info: Conference website: www.stateofthesalmon.org/

February 5-6 FL
Water & Energy Sustainability Seminar, Deerfield Beach. For info: CLE International, 800/ 873-7130 or website: www.cle.com

February 8-11 WA
Puget Sound Georgia Basin Ecosystem Conference, Seattle. Washington State Convention & Trade Center. Hosted by Puget Sound Partnership & Environment Canada. For info: Debra Bryant, Conferences UW, 206/ 616-1902, email: dbryant@EXTN.wshington.edu or website: www.psgbconference.org

February 9 CA
Water Resource Issues in California: Creating Certainty in an Uncertain World, Ontario. Ontario Convention Center. Sponsored by Ass'n of Ground Water Agencies & American Ground Water Trust. For info: AGWT website: www.agwt.org

February 9 OR
Water Quality Seminar, Portland. For info: Holly Duncan, Environmental Law Education Center, 503/ 282-5220, email: hduncan@elecenter.com or website: www.elecenter.com

February 10-11 CA
Advanced Asset Management Workshop, San Diego. Sponsored by National Water Resources Institute. For info: Conference website: www.regonline.com/assetmanagement

February 11 CA
Environmental Review of California Water Projects: Legal Requirements, Approaches & Techniques Course, Sacramento. Sutter Square Galleria, 2901 K Street. For info: www.deq.state.or.us/wq/SB737

February 11 WA
Energy & Water in the West: Priorities for a Healthy Washington, Seattle. Sponsored by Sustainable Path. For info: SP website: http://sustainablepath.org/

February 12 OR
Sustainability Using the Natural Step Framework Meeting, Portland. DoubleTree Hotel - Lloyd's Center. For info: NSN website: www.ortns.org

February 12 WA
Carbon Credits Seminar, Seattle. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 12 WA
Washington Climate Change Impacts Assessment Conference, Seattle. Washington State Convention Center. For info: Conference website: http://cses.washington.edu/cig/outreach/waccia/

February 13 WA
Green Building Conference, Seattle. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

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February 17-18 England
3rd Annual Climate Change Summit, London. Regents Park Marriott. Sponsored by the Ethics Corporation. For info: Conference website: www.ethicalcorp.com/climate/10

February 18 WA
The Water Center Annual Review of Research, Seattle. University of Washington. For info: Conference website: http://water.washington.edu/

February 18 OR
Columbia River Basin Toxics Reduction Working Group Meeting, Portland. Columbia River Inter-Tribal Fish Commission, 729 NE Oregon. For info: EPA website: http://yosemite.epa.gov/R10/ECOCOMM.NSF/columbia/trwg

February 18-19 CO
Design & Construction of Wells Course, Denver. Sponsored by National Ground Water Assn. For info: NGWA, 800/ 551-7379, email: customerservice@ngwa.org, or website: www.ngwa.org

February 18-19 NV
2009 Tamarisk & Russian Olive Research Conference, Reno. Grand Sierra Resort. For info: Tamarisk Coalition website: www.tamarisk.colostate.edu

February 18-20 CA
ABA Water Law Conference - 27th Annual, San Diego. Hotel del Coronado. American Bar Association Conference; Sponsored in part by The Water Report. For info: ABA website: www.abanet.org/

February 19 CA
Low Impact Design Approach to Stormwater Management Course, Davis. Da Vinci Bldg., 1632 Da Vinci Ct.. For info: UC Davis Extension website: http://extension.ucdavis.edu

February 19-20 GA
2009 Georgia Wetlands & Water Law Update Conference, Atlanta. For info: The Seminar Group, 800/ 574-4852, email: info@theseminargroup.net, or website: www.theseminargroup.net

February 19-20 Ontario
18th Annual International Conference on Stormwater & Urban Water Systems Modeling, Toronto. For info: Bill James, CHI, 1-519/ 756-0197, email: info@computationalhydraulics.com or website: www.computationalhydraulics.com

February 19-20 CO
"AG to Urban Transfers of Water: Can Ditch Companies Come Out Ahead?", Pueblo. Sponsored by The Ditch & Reservoir Company Alliance (7th Annual Convention). For info: DARCA, 970/ 412-1960, email: john.mckenzie@darca.org or website: www.darca.org

February 23-24 FL
5th Conference on Hydrogeology, Ecology, Monitoring, and Management of GW in Karst Terrains, Safety Harbor. Sponsored by National Ground Water Assn. For info: NGWA, 800/ 551-7379, email: customerservice@ngwa.org, or website: www.ngwa.org

February 23-24 CA
Introduction to Groundwater & Watershed Hydrology: Monitoring, Assessment & Protection Short Course, Orange. Doubletree Anaheim. Sponsored by Groundwater Resources Ass'n of California and U of Cal. Cooperative Extension. For info: GRA website: www.grac.org

February 23-26 South Africa
Implementing Environmental Water Allocations Conference, Port Elizabeth. For info: Conference website: http://ewa.innercirclestudios.co.za/

February 24-26 DC
2009 Assn of California Water Agencies Washington D.C. Conference, Washington. Washington Court Hotel. For info: ACWA, 916/ 441-4545 or website: www.acwa.com

February 24-27 WA
Pacific Salmonid Recovery Conference 2009, Seattle. For info: NW Environmental Training Center website: www.nwetc.org

February 25 FL
Karst Aquifer Characterization & Restoration Course, Safety Harbor. Sponsored by National Ground Water Assn. For info: NGWA, 800/ 551-7379, email: customerservice@ngwa.org, or website: www.ngwa.org

February 25 CA
Clean Water Act Section 404: Nationwide & Other Specialized Permits, Sacramento. Sutter Square Galleria, 2901 K Street. For info: UC Davis Extension website: http://extension.ucdavis.edu

February 25-26 CA
Groundwater Monitoring Conference: Design, Analysis, Communication & Integration with Decision Making, Orange. Doubletree Hotel. Sponsored by Groundwater Resources Ass'n of California. For info: GRA website: www.grac.org/

February 26 FL
Ground Water Management Issues in Florida Forum, Tampa. Sponsored by National Ground Water Assn. For info: NGWA, 800/ 551-7379, email: customerservice@ngwa.org, or website: www.ngwa.org

February 26-27 NV
Nevada Water Law Conference, Reno. For info: CLE International, 800/ 873-7130 or website: www.cle.com

February 26-27 NM
14th International Water Conservation & Xeriscape Conference, Albuquerque. Marriott Pyramid Hotel. For info: Xeriscape Council website: www.xeriscapenm.com

February 26-March 1 OR
Public Interest Environmental Law Conference, Eugene. University of Oregon, Knight Law Center. For info: Conference website: www.pielc.org

March 4-5 VA
Water Quality Committee DC Meeting - Western States Water Council, Alexandria. Crowne Plaza Old Town Alexandria. For info: Cheryl Redding, WSWC, 801/ 561-5300, email: credding@wswc.state.ut.us or website: www.westgov.org/wswc/meetings.html

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Water Rights, Water Quality & Water Solutions in the West
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