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Toilet to Tap: Once Again

Indirect potable reuse is assuming a life of its own in the American West. Are we heading in the right direction?

Photo: Southern California Water Replenishment District

By Penelope B. Grenoble

Toilet to Tap—with all that's gone on in the West in the last half-dozen years, from drought to reallocation of Colorado River water, and restrictions coming out of California's Sacramento Delta, the once-maligned, supply-side strategy seems to be an idea whose time has finally come.

Supposedly attributed to a clever copy editor at the *Los Angeles Daily News*, "Toilet to Tap" brought down a 33,000-acre-foot groundwater recharge project slated for Los Angeles' San Fernando Valley, as well as projects in San Diego and Dublin, CA. But the continuing issue for water professionals is that the negative and potentially divisive phase suggests that developing new sources of potable reuse is a simple and capacious undertaking.

In traditional water systems, raw water is diverted from its source in a lake, stream, or aquifer; treated; and distributed, with little more to do. Wastewater is subsequently collected, treated, and discharged to a receiving body. The fact that, in many places in the US, this results in unplanned potable reuse (as the Southern Nevada Water Authority puts it, "borrowing water") does not in any way diminish the well-developed planned reuse projects emerging in this country.

Planned potable reuse in the US is largely indirect, wherein treated effluent is subject to multiple contaminant-removing barriers, from extensive chemical and physical treatment to dilution and natural cleansing in soil or a body of water. In a 1998 report, the Water Science and Technology Board of the National Research Council's Commission on Geosciences, Environment, and Resources concluded that, while analytical and toxicological testing, as well as epidemiological studies, have identified no significant health risks in communities using reclaimed water, indirect potable reuse projects should exceed the requirements for conventional water treatment and should employ strong chemical disinfection processes in addition to physical treatment systems. Also, barriers for microbiological contaminants should be more robust than in conventional water treatment.

So, what does it look like out there? Is jumping on the reverse osmosis (RO) bandwagon the way to go? Or is nature perhaps a resource we've bypassed in our regulatory zeal? Is it more effective to pull out all the stops before the effluent goes into the ground or treat it as it's drawn out?

Southern California is served by a complicated mix of city and county utilities, which are in turn regulated by a Byzantine web of agencies, so it might be surprising to learn that Los Angeles has been practicing potable reuse since the 1960s. While Orange County has made a splash with its huge 70-million-gallon-per-day Groundwater Replenishment Project, the Water Replenishment District of Southern California (WRD) has been quietly recharging groundwater with tertiary-treated wastewater, in part with effluent supplied by West Basin Municipal Water District. The WRD's original rationale was similar to Orange County's emphasis in its groundbreaking public outreach campaign—protection of natural groundwater by maintaining the barrier that keeps saltwater from contaminating the region's aquifers. And if some of this water also makes it into raw supplies used for drinking water, well, so be it.

Over the years, WRD has used a mix of treated effluent, stormwater running off the San Gabriel Mountains, and potable water supplied by the Metropolitan Water District of Southern California to recharge the Central and West Basin aquifers, two of the most heavily used groundwater basins in California, serving four million Los Angeles County residents.

Recurrent drought convinced various powers-that-be that neither nature nor the Metropolitan Water District was reliable enough to keep the aquifers and the sea barriers supplied, and, in 1995, West Basin christened its own advanced water treatment plant. Today, it produces what it describes as five distinctive grades of "designer" recycled water: *tertiary, nitrified tertiary* (with the ammonia removed for use in industrial cooling towers), *softened RO* (secondary treated wastewater pretreated by either lime clarification or ultrafiltration, then followed by RO and disinfection—the water that's now used for groundwater recharge), *pure RO* (secondary treated wastewater that had undergone microfiltration, RO, and disinfection for low-pressure boiler feed water), and *ultrapure RO* (microfiltration, RO, disinfection, and second-pass RO for high-pressure boiler feed).

Both West Basin and WRD have committed to increasing use of recycled water as a means of diversifying their water supply portfolios. To this, West Basin has added more efficient water conservation and ocean desal. The target shared by both agencies, to increase the amount of recycled water used in Los Angeles' seawater barriers from 75% to 100%, is also a goal in Orange County.

At least one industry observer suggests that West Basin's effluent treatment chain, which mimics what Orange County established at its original Waterworks 21 and is currently using in its Groundwater Recharge Project, has set a standard that has caused state regulators to be preoccupied with RO. An extensive groundwater basin underlies northern Orange County, although, as in Los Angeles County, the aquifers are subject to seawater intrusion. And, although the Groundwater Replenishment project was largely sold to the public as a way to shore up the saltwater barrier and manage wastewater effluent, the project's spreading grounds are only six month's travel time from the groundwater supplies that local utilities depend on for drinking water.

These factors considered, the Orange County Advanced Purification Facility first subjects secondarily treated effluent to microfiltration, which—as Ron Wildermuth, former public information point person for Orange County and now West Basin, suggests—can be thought of as the last step in tertiary treatment, or the first step in RO. Out come suspended particles, protozoa, bacteria, and some viruses freeing up the RO to concentrate on smaller microscopic salts and organic constituents. Ultraviolet (UV) and hydrogen peroxide then eliminate any remaining organic compounds. According to Shivaji Deshmukh, program manager of the Orange County's Groundwater

Replenishment System, the advantage of disinfecting with UV instead of chlorine is that it avoids creating any additional trihalomethanes.

The highly purified effluent is either injected into wells at the saltwater barrier or sent to the Santa Ana spreading grounds where it is blended with other water sources. The California Department of Health Services considers a stay underground to be an additional barrier to viruses, and blending as a means to control unregulated chemicals. Extensive monitoring at multitudinous critical stages is slated to cost the district an estimated $1 million annually.

Orange County's Groundwater Recharge Project is now the largest of its type in the world, but Scottsdale, AZ, has a similar history of using effluent to recharge its groundwater. Lacking ample surface supplies, for years Scottsdale used its groundwater as an exclusive source of supply. As late as 1996 with a population of just under 200,000, the city was using some 23 billion gallons per day. At that rate, with the population expected to jump to 285,000 by 2012, the city would need twice that supply.

This unsustainable level of groundwater pumping came to a halt with Arizona's 1980 Groundwater Management Act, which established safe yield as the goal statewide. Through a combination of strategies that included using effluent for aquifer recharge, the city hit its safe yield milestone in 2006, when as much water was recharged into the aquifer as was pumped out from its wells. In addition to effluent, which is treated to drinking water standards before it's injected, the Scottsdale Water Campus also injects surface water from the Central Arizona Project into shallow dry wells, as well as treated drinking water directly in the aquifer.

Scottsdale's effluent treatment chain includes: 400-micrometer strainers, followed by ammonia to eliminate free chlorine, which is followed by microfiltration and an antiscalant. Next comes pH adjustment using sulfuric acid, then 20 micrometer cartridge filters, a thin film composite polyamide RO in a three-stage configuration of 24:10:5 with a recovery rate of 85%, degasifier towers for reduction of carbon dioxide, and, finally, lime feed for RO permeate stabilization. The injected water percolates through several hundred feet of soil, where it commingles with local groundwater and is pulled out by down-gradient production wells.

Emergency wells are designed to recharge tertiary effluent diverted from the water treatment plant when necessary, to prevent hydraulic overloading during Scottsdale's short wet season. These are monitored and controlled collectively and discharged into a three-fourth-inch gravel pack roughly 20 feet below the ground surface. While Central Arizona Project water is used for recharge primarily during the summer months when irrigation demand is high, reclaimed water is used for recharge primarily during the winter months. To achieve the goal of 450 milligrams per liter total dissolved solids (TDS) per liter prior to recharge, some reclaimed water receives RO treatment year-round to blend with water from the Central Arizona project, which has a TDS of about 700 milligrams per liter.

Photo: Tom Stewart

Highly purified RO is one step in the process to turn wastewater into a purified product.

To do all of this, the Arizona Department of Environmental Quality requires a wastewater reuse permit and an Aquifer Protection Permit. The Arizona Department of Water Resources requires an underground storage facility permit. All aquifers in Arizona are currently classified for drinking water protected use, and the state has adopted national primary drinking water maximum contaminant levels as its aquifer water quality standards. The initial construction costs for the first two phases of the Scottsdale Water Campus for tertiary and advanced water treatment facilities totaled $75 million (compared to the multi-millions required today), and Scottsdale estimates its cost to produce potable quality water via this method is less than $1.30 per 1,000 gallons.

"Although Scottsdale has been reclaiming water since 1984, it wasn't until 1998 that we started reusing it," says Water and Wastewater Treatment Director Art Nuñez. "Until then, we just poured usable water down the drain and paid to dispose of it."

Aside from its groundwater recharge program, Scottsdale also markets its reclaimed water for irrigation to the city's numerous golf courses.

Close to the border in El Paso, TX, the El Paso Water Utilities once had similar ideas about ensuring potable supply sustainability. Circumstances changed, however, such as the utility finding it more cost effective to sell effluent than put it in the ground.

"In 1979, we undertook an assessment that suggested we would be in serious trouble by the year 2030, with respect to our groundwater pumping," says Water Resources Manager Bill Hutchison. "Actions were taken including expanding our surface water use, implementing a pretty stringent conservation program, and increasing our reclaimed water use. All of this has helped make the Heco Bolson essentially sustainable."

In addition, the utility constructed the essentials for a groundwater recharge project, including a water reclamation facility, injection wells, and monitoring systems. "Then the golf course opened and the power plant started sniffing around, and we built lines to supply them both with recycled water, which meant less and less water was going in the ground," says Hutchison. "But it also decreased potable water use. In addition, the injection wells were presenting their own set of problems with clogging, collapsing, and having to be re-drilled. At one time, we were putting as much as 20,000 acre-feet a year in the ground. Now it's down to about 1,500 acre-feet a year."

To hedge its bets, however, El Paso also instituted studies which determined that spreading basins were a better alternative to wells, so that the water that goes into the ground these days goes through spreading basins.

And, while El Paso is feeling comfortable with less is more, the 700 resident community of Cloudcroft is among a number of New Mexico communities committing to technological innovation. Cloudcroft relies on snow melt to recharge the small pockets of groundwater that provide the town's drinking water supply, and, with less precipitation than normal over recent years, the community literally found itself running out—to the point that the National Guard had to bring in truckloads to sooth the dry throats of summer tourists. Stuck in a considerable bind, the residents of the small community were saved by the Governor, who, concerned about drought conditions throughout the state, established a water innovation fund to finance the development of additional water supplies and help conserve what supplies were available.

Thus, Cloudcroft was able to secure the $3.5 million it needed to build the system that its designer, Eddie Livingston, of Livingston and Associates in Alamogordo, NM, likes to point out is the first of its kind in the country. ITT/Advanced Water Treatment supplied the equipment for the wastewater treatment/reuse project.

As Livingston describes it, the elaborately redundant system will reclaim 100% of the town's wastewater to drinking water quality, blend this with existing well and spring water, and then retreat everything before the water is introduced into the town's drinking water supply. On average, 100,000 gallons will be added to the Cloudcroft system annually. This elaborate treatment chain was necessary, in part because the town has no opportunities for groundwater storage, is not on top of a mountain, and has no natural surface resources.

Cloudcroft's water treatment begins with a membrane bioreactor wastewater treatment plant, which replaces the town's existing trickling filter plant. The effluent is filtered through microfiltration membranes, disinfected with chloramines, and pumped to a storage tank, from which it gravity feeds three miles to the town's potable water facilities. Here it receives its first run through RO.

"Because the facility is downhill, we have enough pressure that we don't need a pump on the RO system, which is very energy efficient," says Livingston. "We end up with about 175 psi pressure."

Again, local conditions help define the treatment process. "The spring water is moderately hard, and it gets higher in dissolved solids by the time it goes through the wastewater plant, so we're using the same RO membranes Orange County used in Water Factory 21," he adds.

For redundancy and public health concerns, the system also mimics Orange County's use of advanced oxidation, using hydrogen peroxide and UV light.

The highly purified RO permeate is then stored in a million-gallon, lined and covered reservoir. From there, it's blended approximately half with spring water and the other half with well water at another reservoir, and the blended water is subjected to ultrafiltration to remove not only particulates and large pathogens like giardia and cryptosporidium, but also bacteria and viruses. The blended water is then disinfected again with UV.

“We use UV after ultrafiltration for a couple of reasons,” says Livingston. “Number one, it’s a very good disinfection method, but also the state required us to have at least 5.5 LOG [inactivation versus contact time plotted on a Logarithmic (LOG) scale] removal of cryptosporidium. The regulators gave us 4.5 LOG for the ultrafiltration membranes and two LOG for the UV. After the UV disinfection, we polish everything off with activated carbon to remove emerging contaminants, then disinfect one last time with chlorine.”

Too much of a good thing? It depends. Given the restrictions of Cloudcroft’s geology and the relatively small amount of water that will be processed, the town will not be facing the same challenges with RO brine disposal that inland facilities treating large amounts of water are exposed to, and will, in fact, use the brine to keep the dust down on its roads and to make snow at the local ski area.

Anything extra will be injected into one of the dry wells the consultants dug when they were looking for additional sources of water. And as Livingston points out, not only will residents now have a reliable source of water, the quality of that water will improve, meaning their hot water heaters will last longer than three years.

An entirely different set of circumstances prevailed outside metropolitan Dallas that convinced the North Texas Municipal Water District (NTMWD) to take a more natural approach to indirect potable reuse. Taking advantage of treated effluent that flows down the East Fork of The Trinity River from facilities the district either owns or manages, it will use constructed wetlands to treat the river water, which will then be blended with raw water to help sustain the region’s potable supply.

As a state agency, NTMWD provides water, wastewater, and solid waste services to 61 municipalities on the north and east side of Dallas, one of the fastest growing areas of the nation. Surface water storage is provided by four manmade lakes, which are fed by an annual rainfall of 40 inches a year, but which recede considerably under drought conditions. An additional consideration is that NTMWD’s service area is currently growing at the rate of 4–5% annually, and it expects to serve 700,000 additional residents by 2020.

According to Assistant General Manager Mike Rickman, the district had developed all easily developable local resources. “There are no additional reservoirs that can be constructed in or adjacent to our area," he says. "We were having to go further out, at considerably more expense, so we started looking at what options we had locally."

Photo: Southern California Water Replenishment District

Both West Basin and WRD have committed to increasing use of recycled water as a means of diversifying their water supply portfolios.

The utility took its cue from neighboring Tarrant Regional Water District, which will construct a similar project to serve the Fort Worth area. NTMWD will draw water out of the river, run it through a 2,000-acre constructed wetlands to reduce phosphorous and nitrogen, and reintroduce it to 22,000-acre Lake Lavon, one of its four reservoirs, where it will remain for over a year before it's drawn out and treated as raw water for potable use. The lake serves as a blending basin for fresh water from the three other lakes, so the river water will also be diluted.

The project required a deal with the state that NTMWD would only capture 70% of the flow its upstream facilities contribute to the river, leaving 30% for the environment and downstream uses. Estimates are that the $300-million project, which was financed by selling bonds, will produce 102,000 acre-feet of water in the next 10 years.

"We're making very efficient use of the land to produce water," says Rickman. "Using current technology, we can't put any more reuse water into Lake Lavon, because it will have reached its assimilative capacity once this project is fully operational. But that doesn't mean we can't take additional reuse water that has gone through wetlands to another supply source and do the same thing. What we're doing with this project is allowing nature to help us."

A similar river source water project is underway in Aurora, CO. When completed, the $750-million Prairie Waters Project is expected to move as much as 50 million gallons of water a day, boosting the community's water supply by approximately 3.3 billion gallons per year and effectively doubling the value of its $300-million water rights. The project will draw water from the South Platte River, use it, treat it, and then discharge it back into the river. The water then flows downstream, where it is recaptured in wells the city has constructed, filtered through the riverbank, and pumped back to Aurora for additional treatment. Travel time is seven to 10 days, and this riverbank natural filtration method—which is in regular use in Europe—will remove most of the nitrates, phosphorous, and other organic compounds.

From there, the recovered water will be pumped to an artificial aquifer, where it will remain for approximately 30 days to provide enhanced biological and organic treatment. Next comes a water purification facility where the water is softened and treated with advanced ultraviolet oxidation, then flocculation, sedimentation, and filtration. After this, it will be subjected to an activated-carbon gravity filter and, finally, disinfected with chloramines before it enters the regular distribution system.

The two river projects warm the heart of Peter Fox, who is a Professor of Civil and Environmental Engineering at Arizona State University and a long-time advocate of using natural systems to treat reclaimed wastewater, in particular soil aquifer treatment (SAT).

“In my viewpoint, soil aquifer treatment has the potential of using biological processes to remove the majority of the organics that are present in a lot of different waters,” says Fox. “Given sufficient time—a year or so in the subsurface—you can expect that the amount of organic carbon might be reduced to one milligram per liter or less, which is similar to a lot of natural groundwater. So if you’re thinking of RO, maybe you should also look at soil aquifer treatment.

“In the Aurora project,” he continues, “after soil aquifer treatment, they’re going to treat that water with activated carbon and advanced oxidation to destroy or remove residual compounds. That way they don’t have to use reverse osmosis to remove everything, because the matrix is so much cleaner that the oxidation technologies should be much more effective. To my mind, this is a much more sustainable type of operation.”

Fox further gives his opinion: “My thought is we should be looking a lot closer for other types of indirect potable reuse, instead of doing all of this reverse osmosis,” he says. “The Montebello Forebay in Los Angeles County has been doing basically soil aquifer treatment since 1962, and they’ve done epidemiological studies to show there’s been no health effects. Scottsdale

has seriously considered getting rid of their system—which they modeled after Water Factory 21—
because they're having such problems with salt disposal. They're saying maybe they should look to just doing groundwater recharge and treat the water when they recover it. With Hydrosystems Inc., in Phoenix [AZ], they've pioneered Beta zone injection wells, which can be used where you don't have enough land for SAT."

"I think we need to think 'big picture,'" says Hoover Ing, of the WRD. "RO is a very energy-intensive process, and you've got the salts. The studies I've seen have shown that soil does a tremendously effective job of removing a lot of contaminants. A few more pharmaceuticals tend to go through the soil than persist with RO, but a lot of these are removed with organic carbon. And, the water begins to look like what it was before it became wastewater.

"In Los Angeles, we are trying to get the regulators to allow us to use 100% recycled water in our seawater barriers," Ing goes on to say. "Right now, this is kind of uncharted territory. One concern is the RO water may leach out chemicals in the ground—that it's so pure it hasn't been quite stabilized. Which means, all things considered, percolation may not be as rudimentary as we've been thinking. Have enough barriers, have enough blending, and have enough travel time—these are at the heart of any kind of requirements. Monitor it carefully, and, if something isn't going right, shut it off."

From Los Angeles comes news that the city has revised its 1990 "Toilet to Tap" project. Ing remembers that, at the time it was first conceived and then abandoned, $60 million in combined federal, state, and local funds had gone into constructing a 10-mile, 60-inch pipeline to take disinfected tertiary effluent from the Donald C. Tillman Wastewater Treatment Plant in the eastern San Fernando Valley, to spreading grounds at the far northern end of the San Fernando Valley Aquifer. Today, under Mayor Antonio Villaraigosa, indirect potable reuse has been given a new lease on life, although, at 15,000 acre-feet per year, the project will be approximately half the size of what was originally planned.

According to Jim McDaniel, Assistant General Manager at the Los Angeles Department of Water and Power (LADWP), a significant determining factor has been restoration of the Los Angeles River, in that effluent from the Tillman plant is needed to keep the river running in the summer. The city's recently completed comprehensive water supply plan emphasizes increased water conservation and expanded use of recycled water to generate an additional 100,000 acre-feet of new water a year, with 35,000 acre-feet of the recycled total coming from purple pipe uses and the remainder from the groundwater replenishment project.

The city is currently in the process of developing a Recycled Water Master Plan, which it hopes to have completed by 2011, and then the effluent flowing by 2019. Although the treatment chain is yet to be developed, McDaniel says the project will include a $500-million upgrade of the Tillman plant.

In the meantime, LADWP is tackling the nemesis that brought down the 1990 East Valley Recycling Project. Taking a page from Orange County’s book, it is already in the process of developing its public outreach campaign.