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Droughts have accelerated a drive toward more sustainable water sources, including highly treated wastewater as a source for drinking water. Communities across the southwestern United States are using direct potable reuse to lessen their reliance on dwindling water supplies.

BY ANDREW SALVESON, EVA STEINLE-DARLING, AND GUY CARPENTER

WANTED: DROUGHT-RESISTANT WATER SOURCES

WITH RECORD-BREAKING droughts on the West Coast and in the southwestern United States, many states must respond to water shortages of unparalleled magnitude. The recent drought in the Southwest region began in 2008. By 2011, Texas was experiencing its worst single-year drought in history, devastating ranchers and other agricultural users with an estimated $7.62 billion in losses for that year alone, causing a record number of wildfires that destroyed more than 3,000 homes, and leaving many communities that rely on surface water within days of running out of water.

Now entering its third year, the West Coast drought has had similar results, with billions of dollars of losses in the nation's most productive agricultural region and devastating wildfires along much of the coast. In 2013, California experienced its driest year on record. As of January 2014, snowpack in the Sierra Nevada, which provides most of California's water supply, was at its lowest recorded level. The state's rainfall remains below 20 percent of normal.

Traditionally, US drinking water comes from two sources—two-thirds from surface water (rivers, lakes, and man-made reservoirs) and the remainder from groundwater. Across the Southwest, these resources have been stretched to their limits. Water systems are straining to keep up with the demands of growing communities, even in the absence of record-breaking drought.

PHOTOGRAPH: TRAVIS DOWELL, US GEOLOGICAL SURVEY

Ground-cracking drought has left the O.C. Fisher Reservoir in San Angelo State Park in West Texas almost entirely dry. Established in 1952 to provide flood control and a secondary drinking water source for San Angelo and surrounding communities, the reservoir has 0 acre-ft remaining and is officially at 0 percent capacity.

EFFECTIVE DROUGHT MANAGEMENT

The intuitive and correct initial reaction to a limited water supply is to find ways to eliminate waste through water efficiency and conservation. Water efficiency is achieved by adopting measures that require less water for existing uses. For example, a 10-minute shower uses less water with a water-efficient showerhead, and native vegetation uses less water than an emerald-green lawn.

Conservation, achieved through behavioral changes, can be implemented quickly during conditions of acute drought. For example, California Governor Jerry Brown recently asked Californians to reduce their water consumption by 20 percent by taking shorter showers, washing only full loads in dishwashers and washing machines, skipping the home car wash in favor of commercial establishments that recycle water, and filling kids' bathtubs only a few inches deep.

But for some communities, this incremental approach isn't enough. Water conservation and efficiency measures may reduce water needs temporarily, but acute drought and/or a fast-growing community requires a wholesale paradigm shift regarding water supply.

EXAMINING ALTERNATIVE WATER SUPPLIES

Water supply planning for communities under water stress must now include a variety of options. More conventional options include dam construction, water-rights purchases, additional well fields, and pipeline and pumping infrastructure to get water from point A to point B. However, none of these conventional methods constitute additional supply; they simply move existing supplies from one location to another, and some already have been fully used.

Water-supply horizons must be broader and include alternatives that, until recently, might have seemed too expensive, complicated, or unappealing. These include developing previously undesirable groundwater sources (brackish or contaminated), seawater desalination, or wastewater treatment plant effluent (much of which is released to surface water systems or the ocean). Compared with pulling water from a nearby lake, river, or well, these options may seem expensive and complex. However, when a well is 60 miles away and downhill from a community or the river is across a mountain range from the point of intended use, the complexity and cost of traditional options often surpass those of new alternatives.

THE PURPLE PIPE EVOLUTION

Beneficial water reuse isn't a recent development. Early US cities fertilized nearby farms with untreated sewage until synthetic fertilizers replaced its use. Agricultural use of wastewater treatment plant effluent still represents

CASE STUDIES

DIRECT POTABLE REUSE SUPPLEMENTS DWINDLING WATER SUPPLIES

Direct potable reuse (DPR) has been discussed for decades, but new water demands and technology advances are making it a reality. Here are a few examples of communities that have taken advantage of or will implement DPR as traditional water sources dry up.

Big Spring. The city of Big Spring, Texas, and several surrounding communities serving nearly a half million people get their water from the Colorado River Municipal Water District, which owns and operates three large reservoirs in West Texas. Because periodic droughts have reduced stored water volumes in area reservoirs to a minimum level, the district is actively developing additional water sources.

Projects include a recently completed well field to supply water during droughts and the Raw Water Production Facility (RWPF) at Big Spring, which began operating in May 2013. RWPF treats treated filtered effluent from the city's conventional wastewater treatment plant through microfiltration (MF), reverse osmosis (RO), and ultraviolet (UV)–hydrogen peroxide oxidation (advanced oxidation process, or AOP). The finished water is delivered directly into the district's raw-water pipeline system and sent to five conventional water treatment plants for further treatment and subsequent delivery to customers' homes. The district's motto for this project is "100 percent reuse, 100 percent of the time."

The Big Spring Raw Water Production Facility treats secondary wastewater and reintroduces it directly into the raw water supply for area water treatment plants.

The project is the only operating facility in which treated wastewater effluent isn't discharged into a natural water body before being reused as a water supply source, making it the only operating DPR scheme in the western hemisphere. Extensive testing and analysis of the system, funded by the Texas Water Development Board, is ongoing.

Wichita Falls. The city of Wichita Falls, Texas, is located in a corner of Texas that has yet to see recovery from ongoing drought. In response to its severe water shortage conditions, the city developed an emergency supply project

PHOTOGRAPHS: CAROLLO ENGINEERS

By the end of the decade, many more cities and towns will likely realize water supply reliability improvements through DPR.

a significant portion of the beneficially reused flow, with farms in Monterey County, Calif., as prime examples. In addition, many progressive utilities have developed networks of a dedicated infrastructure (purple pipe) to deliver treated, nonpotable reclaimed water to golf courses, cooling towers, car washes, and other commercial, industrial, and irrigation users. For example, the Carmel Area Wastewater District (Calif.) produces high-quality recycled water to irrigate the world-famous Pebble Beach golf courses.

In many places, reuse infrastructure has reached a saturation point. The large users (golf courses, other irrigation users, and cooling towers) already have been connected, and the cost of reaching additional users becomes too great to justify further purple pipe system expansion. This means that, although additional wastewater effluent is available, it's being discharged (lost) because there isn't sufficient demand for nonpotable water or it isn't possible to implement more nonpotable reuse.

THE DIRECT POTABLE REUSE REVOLUTION

For decades, large utilities in Arizona, California, Texas, Virginia, and elsewhere have practiced indirect potable reuse (IPR) in which reclaimed water is used to augment natural water bodies or groundwater serving as drinking water supplies. In addition, billions of gallons of treated effluent are discharged to water bodies by upstream communities and reused by downstream communities as a water supply source.

With IPR limited to locations with access to a suitable natural water body, the industry is moving toward more direct reuse of reclaimed water for potable purposes. The California Legislature mandated the California Department of Public Health to determine the feasibility of direct potable reuse (DPR) in California by 2016. Key to such determination is research demonstrating that potable reuse can be implemented safely and reliably.

The WateReuse Research Foundation's California DPR Initiative, sponsored by utilities and industry partners, has collected more than $6 million to support DPR research regarding public health goals, treatment technology, risk management, storage, water blending, monitoring, and public outreach. Many large California utilities are considering DPR as their next significant water supply. Utilities that don't already have active IPR projects are considering leapfrogging IPR in favor of DPR.

The forefront of DPR implementation in the United States is in Texas and New Mexico, where several projects are under way. The communities described in the case studies below are achieving DPR in different ways. By the end of the decade, many more cities and towns will likely realize water supply reliability improvements through DPR.

that repurposes existing water treatment infrastructure to create a DPR system. Treated wastewater effluent is sent via a temporary pipeline to the inlet of a former brackish surface water treatment plant, which treats the water with MF and RO. The water is then sent directly to an adjacent conventional surface water treatment plant where it's mixed 50/50 with raw surface water, treated, and then sent to the distribution system. Construction and a required full-scale verification that involves facility operation have been completed.The city is awaiting final approval from the Texas Commission on Environmental Quality.

Brownwood. The city of Brownwood, Texas, has approval to build an advanced treatment plant. Conventional wastewater treatment would be followed by ultrafiltration (UF), UV disinfection, RO, powdered activated carbon, a second UV disinfection, and chemical disinfection during storage and transmission before distribution.

Cloudcroft. Cloudcroft, N.M., is a mountain resort town with limited access to a groundwater supply. Because of a significant weekend population increase, the town needed additional water to supplement existing resources. The project consists of advanced wastewater treatment using a membrane bioreactor, RO, and AOP, much like the Big Spring production facility. Water is then blended with at least 50 percent groundwater, stored for 10 days, and then treated with UF, UV disinfection, granular activated carbon, and chlorine disinfection before being sent to customers' taps. The project is 80 percent constructed, working through the regulatory process, and will come online in 2015.


Wichita Falls uses a temporary pipeline to transfer treated wastewater effluent to a former brackish surface water treatment plant.


Cloudcroft will use advanced membrane and oxidation processes to purify water for public consumption.