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Potable reuse is a strategy more water professionals are exploring as threats to water supply and water quality compel water utilities to seek new, reliable, and sustainable sources. With no national regulatory framework, water reuse is nevertheless happening today and on track to be implemented even more widely. BY JOHN WHITLER

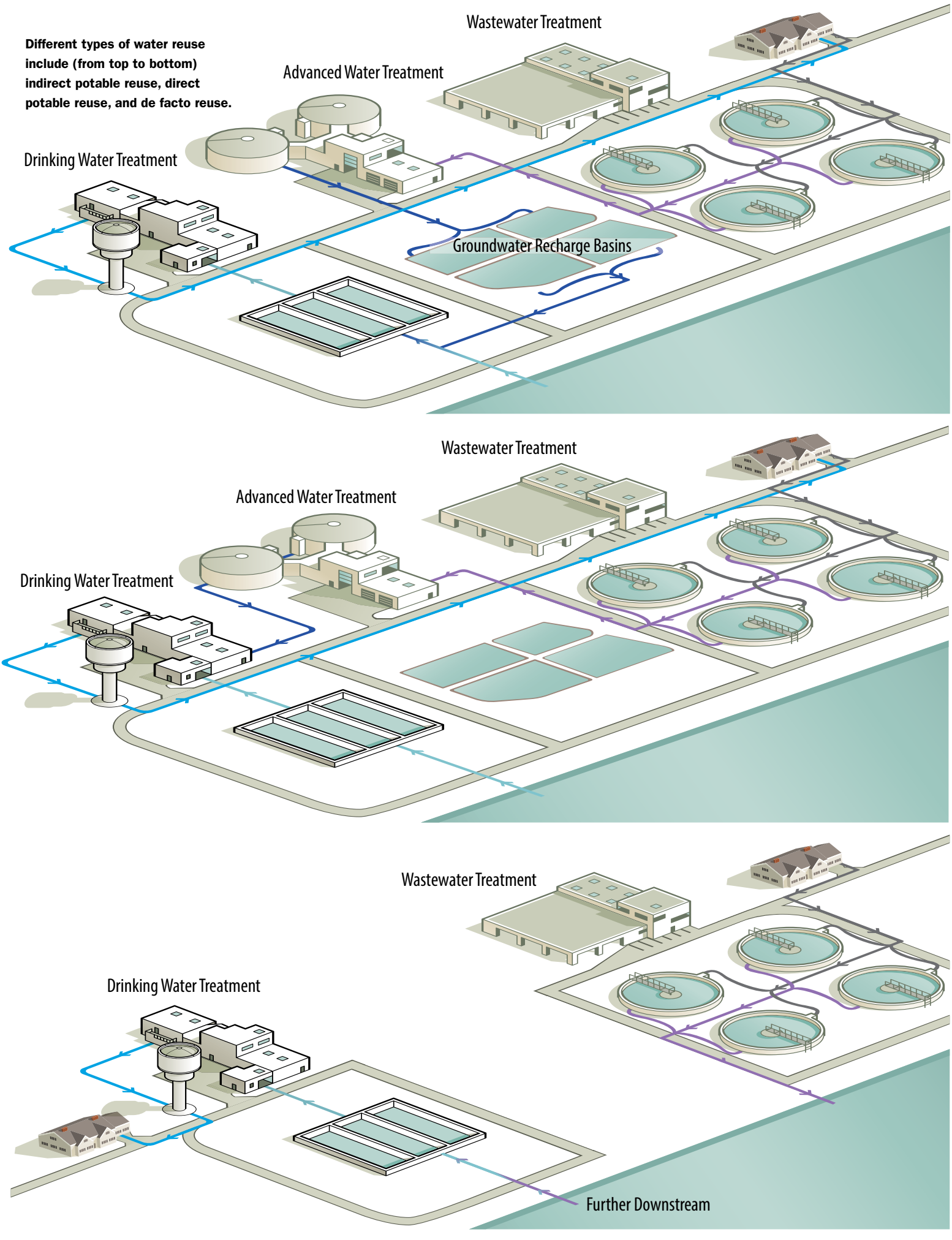
DIVERSIFY WATER SUPPLIES WITH POTABLE REUSE

WATER UTILITIES around the world are faced with increasing water supply pressures because of factors such as population growth, increased hydrologic and climate variability and uncertainty, decreasing availability of high-quality water sources, and increasing water demands from sectors such as energy and agriculture.

Although challenges to existing supplies have been managed successfully in many locations through demand management efforts, including water conservation, other challenges are leading to a tipping point where new supplies will need to be developed. Potable reuse is one component of a more integrated approach to water management that many utilities are interested in implementing.

Potable water supply sources are geographically and locally dependent. Whereas some utilities have the benefit of switching between sources when they have source quality or quantity issues, many utilities don't have a diversified portfolio of water supply options. This situation challenges utilities to look beyond traditional surface and groundwater sources to new water supply sources.

GRAPHICS: WATER RESEARCH FOUNDATION


Different types of water reuse include (from top to bottom) indirect potable reuse, direct potable reuse, and de facto reuse.
Wastewater Treatment
Advanced Water Treatment
Drinking Water Treatment
Groundwater Recharge Basins
Wastewater Treatment
Advanced Water Treatment
Drinking Water Treatment
Wastewater Treatment
Drinking Water Treatment
Further Downstream

TYPES OF WATER REUSE

Increasing interest is focused on several nontraditional water supply options to help water utilities diversify their water supplies. In addition to options such as desalination and aquifer storage and recovery (injecting water underground for future use), water reuse is becoming an increasingly popular option to explore.

Nonpotable Reuse. *Nonpotable reuse* refers to water that isn't treated or intended to be a part of the potable supply, so there's no human consumption. Nonpotable water may be treated to a specific quality depending on its purpose. For example, for agricultural or landscape irrigation, nutrients wouldn't be removed because of the benefits they provide—unless nutrient pollution is a problem in the area. Nonpotable reuse water may also be provided to industrial operations that don't require high-quality water, such as for cooling towers at a power plant. Although nonpotable reuse systems reduce demand on potable water supplies and require less treatment than potable reuse operations, such systems can be cost prohibitive to develop and maintain because of the need for a separate distribution system.

Indirect Potable Reuse. *Indirect potable reuse* means that, after extensive treatment, the water spends time in an environmental buffer such as impoundment in a surface reservoir or infiltration or injection underground. The water is then pumped back to the surface and may undergo additional treatment before entering the potable distribution system (see top figure, page 11).

Direct Potable Reuse. *Direct potable reuse* eliminates the environmental buffer, relying on more robust and redundant treatment. Although regulations for direct potable reuse don't currently exist at the national level, some states, including California, are working to develop direct potable reuse regulations. In the absence of federal and state regulations, different direct potable reuse systems are being explored, often driven by individual utility circumstances. The most aggressive approach would be for a utility to blend water from an advanced wastewater treatment facility with potable water in the distribution system. A more conservative approach would be to take highly treated wastewater and blend the water somewhere before or within a drinking water treatment system (see middle figure, page 11).

De Facto Reuse. Often overlooked in the conversation about reuse is the fact that water is already being used many times over in many places. *De facto (unplanned) reuse* occurs when a community downstream from another community withdraws its drinking water from the same surface water in which the upstream community discharges its treated waste-water (see bottom figure, page 11).

A comprehensive study hasn't been conducted to determine wastewater's contribution to downstream water treatment plants in the United States; however, one study was conducted in 2013 to review and update a 1980 study that focused on 25 cities. The updated study's results showed an increase in the amount of sewage discharged from the 25 cities and, in most cases, an increased wastewater contribution to downstream drinking water facilities. Although, in most cases, some distance

LEADING BY EXAMPLE

WATER UTILITIES WORLDWIDE BENEFIT FROM POTABLE REUSE

To provide more context and a better understanding of how water reuse has been implemented, a few examples provide an interesting perspective.

In the United States, the Montebello Forebay Spreading Grounds in Los Angeles is one of the oldest reuse projects in the United States. Since the late 1930s, the project has been recharging groundwater basins with stormwater runoff. Imported water was added in the 1950s and recycled water in the 1960s to supplement this natural source, because stormwater amounts are insufficient for the project's total replenishment needs. This operation began using recycled water in 1962 and has a capacity of 44 mgd. This project was started to prevent seawater intrusion into over-pumped drinking water aquifers. Through groundwater recharge, the project uses media filtration, chlorination, and soil aquifer treatment. These operations are intensely monitored to ensure that when the water is used for drinking water supply, it meets all applicable regulations.

Potable reuse projects aren't just limited to California or the Southwest. The Upper Occoquan Service Authority in Centreville, Va., was created in the early 1970s and oversees a surface water augmentation project. Prior to its creation, there were many small wastewater treatment plants along the reservoir, and there were nitrogen and phosphorus contamination problems. The new treatment facility wasn't conceived as a reuse facility, but rather as an effort to simply improve water quality in the reservoir. This simplified permitting and public perception issues. After discharging highly treated wastewater into the Occoquan Reservoir, Fairfax County Water uses that reservoir as part of its water supply.

Another example of potable reuse in the eastern part of the United States occurs in Gwinnett County, Ga. The surface water augmentation project returns highly treated wastewater back into Lake Lanier, which is also the county's water supply source. The challenge is how to account for the water that goes back into the lake and factor that into the county's net withdrawal. The use of Lake Lanier water for water supply is currently under evaluation by the US Army Corps of Engineers, which may affect its allocation.

Growing populations and limited water

Reuse isn't a one-size-fits-all approach, as it must be tailored to the specific location where it is being implemented.

exists between the discharge point and intake, creating an environmental buffer where some natural attenuation of contaminants can occur, in some parts of the United States at certain times of the year, these rivers and streams are dominated by an upstream community's effluent.

WATER SOURCES FOR REUSE

Utilities may look to many sources of water for reuse as part of their water supply portfolio. Wastewater effluent is one source that gets a lot of attention. Rather than discharging highly treated wastewater back into a stream, river, estuary, or ocean, one option is to close the loop and reuse this wastewater as part of the water supply.

Many communities struggle to manage stormwater, which left untreated or mismanaged can cause water quality problems where it is discharged. Some utilities may be able to capture and reuse stormwater as part of their water supply. Although potentially most effective on a smaller scale, reuse of graywater (water from laundry and non-kitchen sinks) from domestic or commercial buildings, or at a community scale, may offer utilities another supply option. Water Research Foundation (WRF) helped fund a 2014 National Research Council (NRC) study, *Beneficial Use of Graywater and Stormwater: An Assessment of Risks, Costs, and Benefits*. A report will be issued in 2015.

EXPANDING POTABLE REUSE

Several key issues must be addressed to successfully implement a water reuse project. The first and perhaps most important issue to consider is the regulatory context for the type of reuse the utility chooses to protect public health. Although the Clean Water Act and Safe Drinking Water Act serve as the foundation of how wastewater needs to be treated and the quality of drinking water provided, respectively, no federal regulations exist for reuse in the United States.

To implement reuse projects, utilities rely on state regulations. This patchwork system of regulations specific to each state has left differences in what types of reuse can be done in different states. In California, indirect potable reuse has been around for decades, and the state boasts one of the largest and most famous indirect potable reuse projects, the Orange County Water District Groundwater Replenishment System. California is also leading the charge for developing direct potable reuse regulations, as required by recent actions of the state's governor.

Extensive amounts of research are occurring in support of more widespread adoption of direct potable reuse. The 2012 NRC report, *Water Reuse: Potential for Expanding the Nation's Water Supply Through Reuse of Municipal Wastewater*, identifies 14 research needs to support the expansion of potable reuse. The issues identified in the report include treatment requirements, residuals and concentrate management, posttreatment issues such as blending with other supplies, monitoring requirements, source control, public acceptance, and issues with emerging contaminants.

In addition, WRF has a long history of research that supports potable reuse. Past WRF projects have focused on aquifer

resources in the eastern half of Colorado have led to a large potable reuse project in Aurora, Colo., called the Prairie Waters Project. Installed a few years ago, up to 50 mgd of water is reused through groundwater recharge using riverbank filtration along the South Platte River. The project could be expanded in the future, and the surplus water could serve additional Denver Metro communities through a partnership with Aurora Water. Water rights issues can present challenges to reuse in many Western states. In the case of the Prairie Waters Project, Aurora has the proper type of water right to allow water reuse.

One of the most recent potable reuse projects was just completed in Big Spring, Texas. About 2.5 mgd of reused water is used in the system, which blends highly treated wastewater with a raw surface water supply before going to a drinking water treatment plant. This example illustrates some of the terminology issues with potable reuse, as some people call this direct and others call it indirect. Some local news coverage of this project also highlighted some of the challenges with public perception concerning potable reuse. Surprisingly, many residents didn't drink the tap water previously being provided because of taste issues. Many residents hope the new project will make the water more palatable. Wichita Falls, Texas, also recently implemented a potable reuse project.

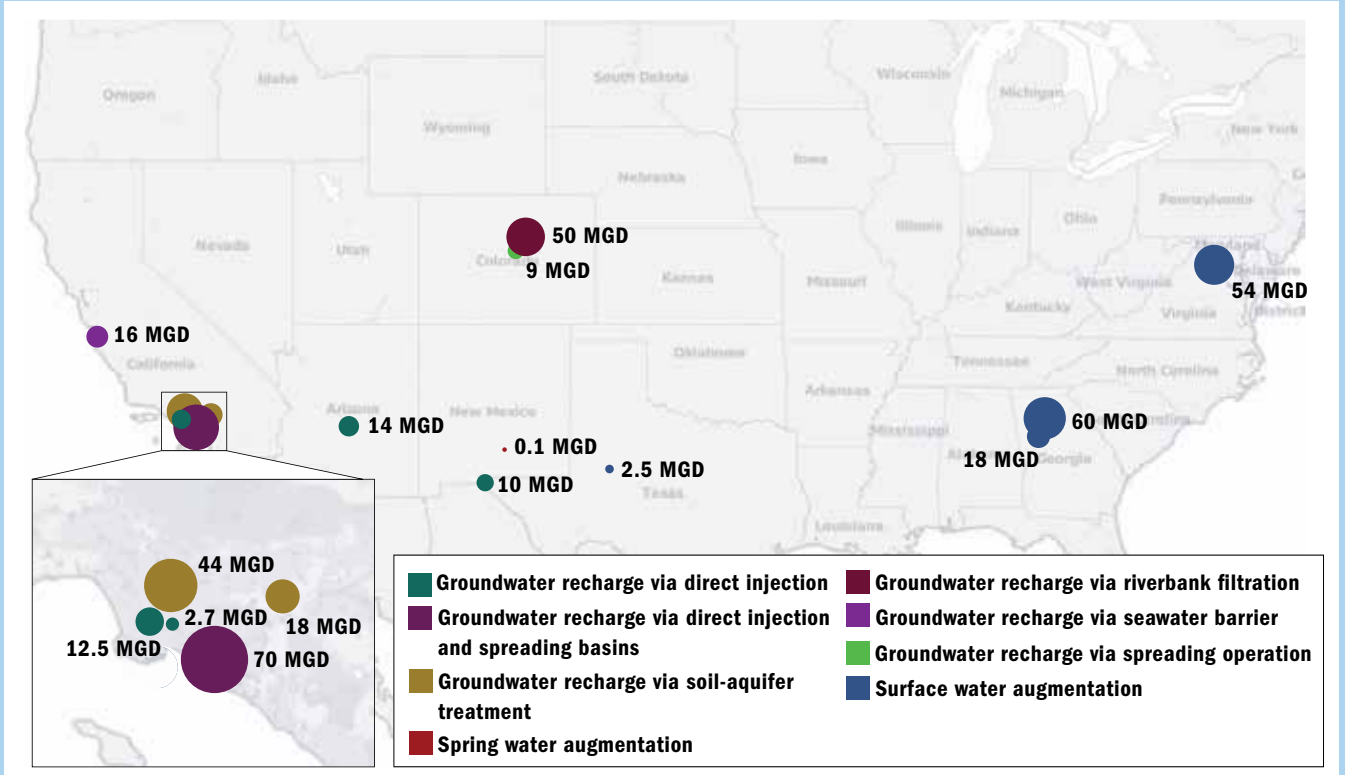
Although direct potable reuse in the United States has just started to gain in popularity, there are several international examples of direct potable reuse, including Namibia and Singapore. In Singapore, advanced treatment is used to distribute reuse water to nonpotable customers and to blend reuse water in reservoirs with rain water and imported water. Referred to as "NEWater," this project is necessary due to Singapore's small geographic area, high population density, and low rainfall amounts. Because most of the produced water from the NEWater facilities goes directly to industry, it composes less than 2 percent of the volume in the reservoirs used for potable supply.

The other well-known international example of potable reuse is in Windhoek, Namibia. Representing between 35–50 percent of the country's potable water supply, treated wastewater is blended with other potable sources. The reuse project has been in place since the 1960s, with changes occurring over time and upgrades in 2002 that represent its current configuration.

Total Water Solutions

Examples of Potable Reuse

Although approaches vary, depending on location, potable reuse is happening today in many parts of the United States.



storage and recovery, membranes, and brine or concentrate disposal.

In January 2014, the WRF board of trustees approved a new focus-area program called Integrated Water Management: Planning for Future Water Supplies. A planning workshop was held in 2014 to develop objectives and a research agenda for this new focus area. A knowledge portal will be established on the WRF website that organizes the foundation's water supply resources in one place. Some of the topics that will be included in this knowledge portal include potable reuse, desalination, and managed underground storage.

More recently, WRF has funded two direct potable reuse studies in collaboration with six funding partners: Alameda County Water Agency, Contra Costa Water District, East Bay Municipal Water District, Los Angeles Department of Water & Power, San Francisco Public Utilities Commission, and Zone 7 Water Agency. The projects were awarded in the spring of 2014, and results should be completed by the end of 2015. The projects are being coordinated with the California Direct Potable Reuse Initiative led by WateReuse California and the WateReuse Research Foundation.

NO ONE SIZE FITS ALL

As shown on the map above, potable reuse is happening today in different parts of the United States. The potable reuse approaches differ among locations, and in almost all cases some sort of environmental buffer exists. The distinction between types of reuse is closing, partially because the water industry is starting to recognize the actual incidence and widespread nature of de facto reuse in many surface water supplies. Solutions, including advanced treatment technologies and engineered buffers, may demonstrate capabilities to enable removing the environmental buffer, but public acceptance will remain a challenge in some locations.

Reuse isn't a one-size-fits-all approach, as it must be tailored to the specific location where it is being implemented. Fortunately, several organizations are leading reuse efforts, making it easier for water utilities to find information on this increasingly important topic.

Editor's Note: *For more information on water reuse, see* *How Water Works, pages 18 and 19.*