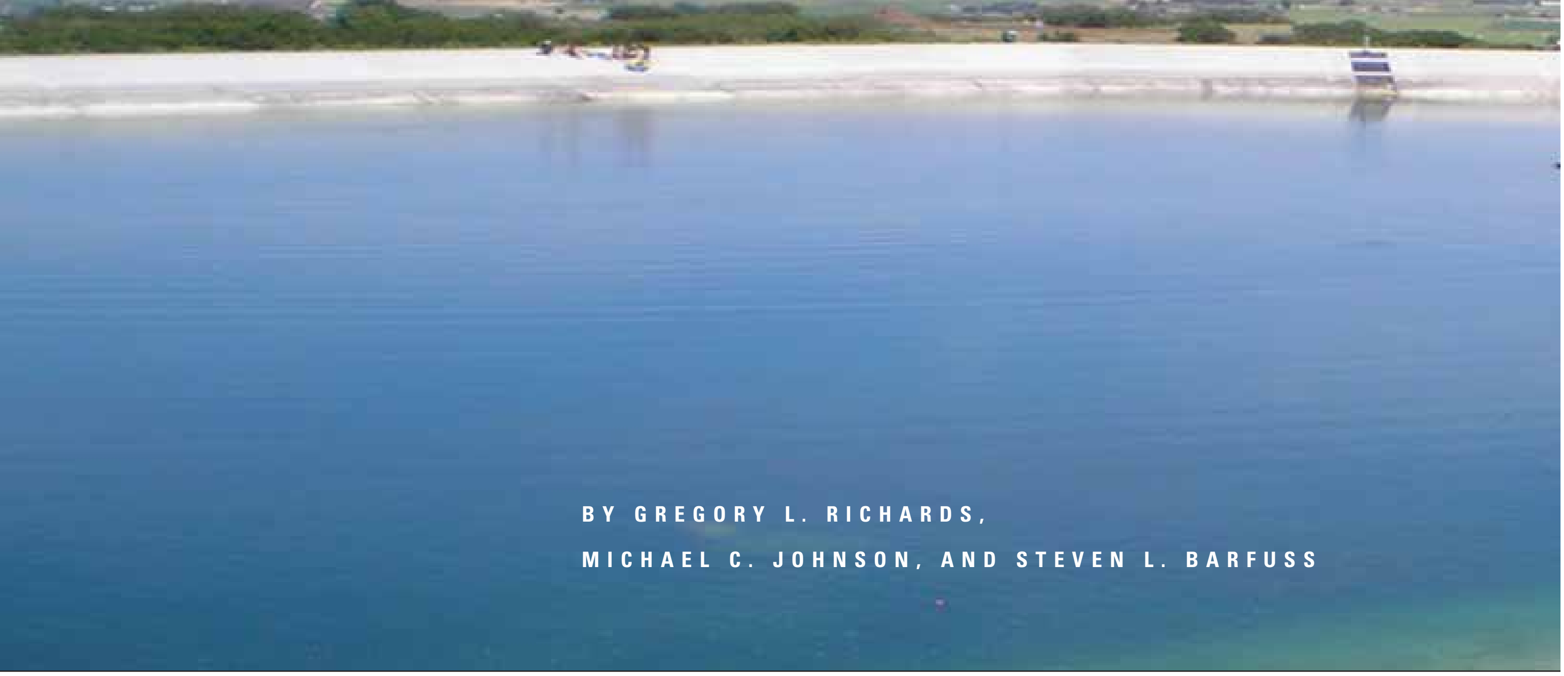


BY GREGORY L. RICHARDS,

MICHAEL C. JOHNSON, AND STEVEN L. BARFUSS

Besides providing storage for up to 22 million gallons of secondary water, Spanish Fork (Utah's) reservoir also serves as a public recreation area.

Metering secondary water in residential irrigation systems

SOME WATER SUPPLIERS, PARTICULARLY THOSE IN THE ARID WEST, ARE USING FILTRATION AND INNOVATIVE METER DESIGNS TO METER SECONDARY WATER IN ORDER TO CONSERVE PRECIOUS WATER RESOURCES.

Rapid population growth has prompted much discussion over water issues in the arid western United States. The country's five fastest-growing states (Nevada, Arizona, Colorado, Utah, and Idaho) also happen to be among the driest states in the nation (Utah DWRe, 2001; USDI, 2000). In order to sustain growth, sufficient water must be available. Water conservation is therefore a priority, and various techniques are being used to encourage conservation. For irrigation companies and other water providers, incentive pricing and increased efficiency of water distribution systems provide ways to conserve. Water-efficient appliances and toilets, soil moisture and evapotranspiration sensors for automatic sprinkler systems, and increased acceptance of xeric landscaping practices have contributed to reductions in residential water use.

Another common practice throughout the United States is the use of dual water systems. Dual systems, also known as secondary water systems, provide one connection for potable water and another connection for secondary, or nonpotable, irrigation water. Although these systems do not necessarily conserve water, they do significantly decrease the use of potable water.

Despite this benefit, the recent conservation push has drawn attention to a negative aspect of using nonpotable water for irrigation. This nontreated water typically contains debris including suspended and dissolved organic and inorganic matter. Conventional water meters used in secondary systems can become clogged, and suspended grit can wear away mechanical meter parts. Additionally, secondary systems that are drained during winter months are subject to a hardened buildup of minerals and other deposits. This buildup hinders the free movement of mechanical meter parts when the system is pressurized in the spring (Utah DWRe, 2004a).

Historically, unmetered secondary water systems used a fixed-rate fee system. Users generally paid a fee based on land acreage or connection size for their use of untreated water. In order to reach conservation goals and meet near-future water demands, user accountability must be increased. The state of Utah's awareness of this problem is evident in its municipal and industrial water conservation plan for the year 2003. In the plan, secondary water providers are advised to charge for secondary water based on individual use levels as soon as technology permits.

Either by their own efforts or with assistance from the Utah Division of Water Resources (Utah DWRe), a few secondary water providers have begun metering secondary water. Hindrances to metering secondary water as well as accounts of those who are currently metering their systems are summarized in this article.

DUAL SYSTEMS

A brief history. In 1995 67% (an amount equaling 143 gpcd) of all water used for residential purposes in Utah was used outdoors, amounting to nearly half of the total public supply of water (Figure 1). Unpublished statistics for 2005 from the Utah DWRe indicate similar results (Williams, 2007), and parallel trends occur in other desert states (SNWA, 2007; Mecham, 2003). In order to reduce the demand on limited potable water supplies, many communities have installed secondary water systems to provide irrigation water.

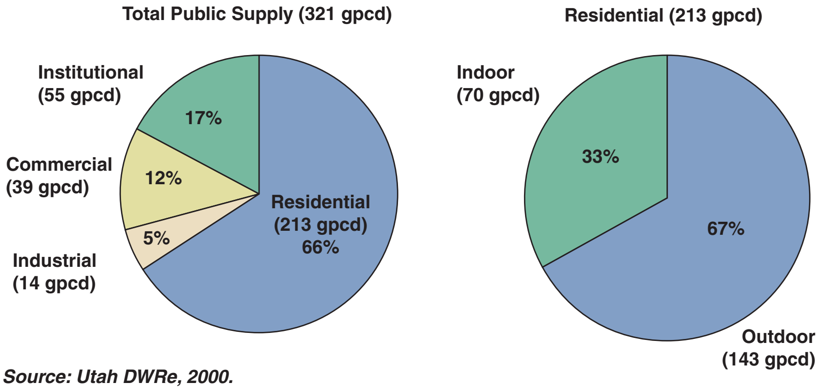
Secondary water systems are not a new idea. In fact, one of the first dual distribution systems was built in Rome as early as 40 AD. While certain aqueducts provided drinking water supplies, others conveyed water of an inferior quality to be used for bathing, irrigation, and decorative fountains (AWWA, 1983).

The idea of a secondary water system was first introduced in the United States in the early twentieth century, but it did not rise in popularity until recently. The first secondary distribution system in the United States was built in the 1920s in Grand Canyon Village, Arizona. Because rainfall and freshwater supplies were limited, rapidly growing demands spurred the development of a secondary system (Okun, 1997). In this system, nonpotable recycled wastewater was used for irrigation as well as toilet flushing. St. Petersburg, Fla., lays claim to development of the country's first major dual system in 1969. Because of saltwater intrusion into overdrawn aquifers and a limited supply of surface water, St. Petersburg implemented this system in order to meet the demands of its booming population. Recycled wastewater is also the secondary water source in this system (Okun, 1997). Similar systems in Florida are supplied by a mixture of recycled wastewater and untreated canal water (Godman & Kuyk, 1997).

Today, many dual systems exist in the arid western states. Although several of these systems use recycled wastewater as their primary source, a large portion use runoff and groundwater. In order to meet demands throughout an entire irrigation season, high spring runoff flows are collected and stored in open-air reservoirs. The Weber River Basin in Utah is home to one of the most complete secondary systems in the country. This system has doubled in size over the past 10 years (Table 1). In 2003, approximately 43% of municipal and industrial water demand and 68% of the total outdoor water demand in the basin was provided through secondary water systems (Utah DWRe, 2004b).

Experience has shown that dual systems effectively conserve potable water by providing nonpotable water for irrigation. However, they do require the construction of additional infrastructure, and this can be costly. Although secondary systems are less likely to be installed in existing developments, it is usually cost-effective to install them in areas of new develop-

FIGURE 1 Breakdown of 1995 publicly supplied water use including secondary water



Source: Utah DWRe, 2000.

gpcd—gallons per capita per day

TABLE 1 Estimated secondary system water use by Utah county

County	1992		2001		Increase in Water Use
	Number of Systems	Water Use *acre-ft*	Number of Systems	Water Use *acre-ft*	*%*
Davis	12	28,500	34	43,418	52
Morgan	7	200	16	240	20
Summit	15	1,800	30	1,637	–9
Weber	17	27,400	44	40,757	49
Basin Total	51	57,900	124	86,052	49

Adapted from Utah DWRe, 2004b.

ment. Secondary water systems may also be economical if their construction costs are less than the cost of expanding the potable water supply system to meet future indoor and outdoor demands (Utah DWRe, 2004a).

Dual systems and outdoor water use. Secondary water systems have successfully reduced potable water use; however, statistics show that overall water use drastically increases with the introduction of unmetered secondary systems. This increase in use occurs because of fixed-fee water pricing and a lack of user accountability. A recent five-year study performed by the Utah DWRe determined that unmetered secondary water users generally use 47% more water than necessary to sustain a healthy, green lawn. One documented user watered more than two and a half times the amount needed (Utah DWRe, 2004c). The Utah State Water Plan further validated this concern associated with secondary water systems. Its findings show that the five basins with the highest overall per capita use in Utah are also the five basins with the highest residential outdoor per capita use of nonpotable water (Figure 2). This indicates that consumers use more water outdoors in basins where inexpensive unmetered secondary water is available (Utah DWRe, 2001).

Metering. Researchers at Colorado State University performed a study in 2003 on the benefits and costs of pressurized dual water systems. Their study also explored the influence of metering secondary water. The researchers found that although residential indoor water demand has been found to be relatively inelastic (not susceptible to changes in use because of metering), outdoor use does change with the use of meters. Water use of residences with meters is usually lower than water use of residences that are charged a flat rate. The majority of this reduction is in outdoor water use. The study shows that over six years flat-rate users expended an average of about 39% more water than those who were metered (CSU, 2003).

Perhaps the simplest solution to excessive outdoor use and abuse is metering. The Utah Water Plan indicates that one way to deal with overuse is to meter the water and charge according to an incentive pricing rate structure (Utah DWRe, 2001). St. Petersburg reports that unmetered reclaimed water has been excessively wasted, and plans are under way to retrofit meters on all services (Okun, 1997).

SOLVING PROBLEMS WITH SECONDARY WATER METERING

Finding a suitable meter. Modern technology has provided ways to meter water that do not pose a problem to secondary systems. Two examples are the magnetic flowmeter and the ultrasonic flowmeter; neither meter has moving parts and both can readily pass debris. However, these meters can cost thousands of dollars, whereas standard residential meters generally cost less than $100. Accuracy, durability, and cost are important considerations for metering secondary water. Despite the inherent difficulties associated with secondary water metering, experimentation has not been inhibited. Existing and new meter technologies as well as filtration techniques have been used. Those experimenting in secondary water metering have exposed a variety of problems as well as possible solutions.

Secondary water quality. Perhaps the most obvious barrier to metering secondary water is the quality of the water. Secondary water, which generally comes from mountain runoff or groundwater wells, typically has smell, taste, or turbidity issues. Because it is not treated and is usually stored in open-air reservoirs, secondary water tends to carry a significant amount of debris. Many systems that receive water from rivers or storage reservoirs contain a large amount of organic material (Taylor, 2007). Moss, leaves, snails, insects, crawfish, and fish have been found inside meters. When debris clogs or blocks a meter, it generally causes pressure loss, flow reduction, and flow measurement problems.

Secondary systems supplied by surface water, along with those supplied by groundwater, can also contain suspended sands and silts. Not only can sand and silt clog meters, they can also wear out internal metering mechanisms, resulting in decreased accuracy and a shorter meter life (Utah DWRe, 2004a). Under these types of water quality conditions, either a meter must be immune to suspended solids, or adequate filtration must protect the meter.

To date, it has been difficult to find a meter that is unaffected by debris. Meters with no moving parts have an advantage in that they are resistant to plugging and degradation. Magnetic and ultrasonic flowmeters are debris-tolerant because debris readily passes through them and there are no wetted moving parts. Unfortunately, as stated previously, meters using these technologies are expensive and have significant power supply requirements. Fluidic-oscillation meters and single-jet turbine meters have also shown promise in handling debris (Stephens, 2007).

Although meters suitable for secondary water are still being developed, advanced filtration technologies provide a wide variety of options for treating secondary water. From simple screens that keep out large debris at the source to self-cleaning automated filter stations, the broad array of available filtration technologies can meet most secondary water treatment requirements. A major filter manufacturer[1] suggested a filtration degree of 80 µm in secondary water applications and also indicated that the final filtration degree would have to be based on the recommendations of the meter manufacturer or based on the smallest orifice size in the meter (Maher, 2007).

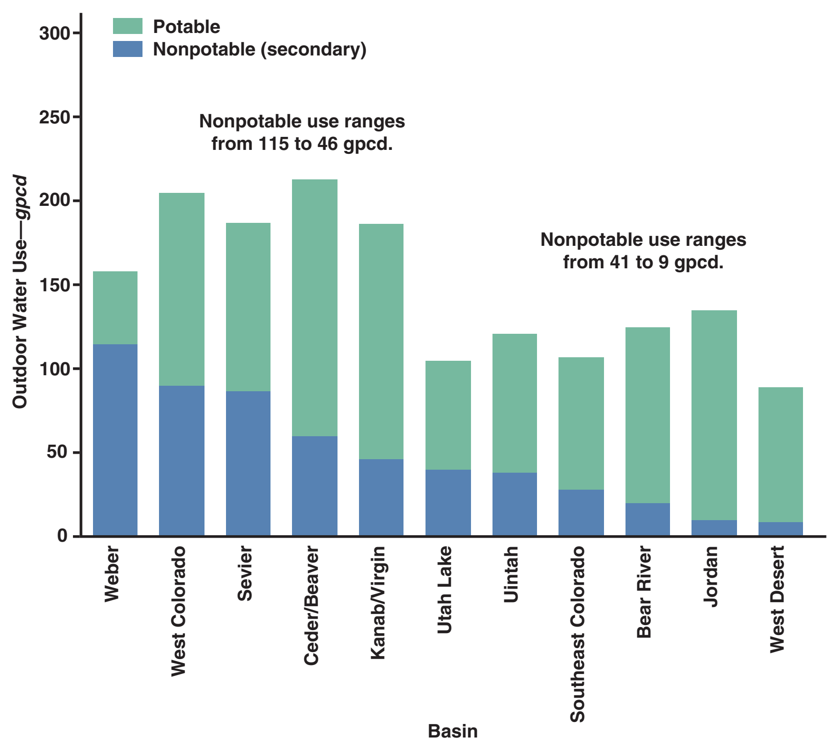
Harsh environment. Irrigation meters are generally installed in sprinkler boxes 1–2 ft below the ground surface, providing little protection against freezing. Even meters buried several feet below the ground surface can be subject to freezing in colder climates. Most systems are drained at the end of the irrigation season, but small amounts of water and moisture can remain in the meter. Freeze plates on the bottom of meters are a common safeguard against this problem.

Because the meters remain drained for several months each year, a layer of organic and inorganic buildup hardens on the meter interior, hindering the movement of mechanical parts when the system is repressurized. The nature of the buildup depends primarily on water quality.

Physical environment can impede water metering during warmer seasons as well. Poor drainage and overwatering commonly result in sprinkler boxes and meters becoming submerged. If the meter's registry system or electrical components are not watertight, the meter can fail.

Meter power requirements. In addition to their cost, magnetic and ultrasonic meters are prohibitive to most residential metering applications because of their power requirements. Ideally, a meter should be self-contained and have a battery life of 5–10 years. Batteries with a life of less than five years become labor-intensive, decreasing the cost-effectiveness of the meter.

FIGURE 2 Residential outdoor water use in Utah by basin



Adapted from Utah DWRe, 2000.

gpcd—gallons per capita per day

Several meters on the market that use battery power claim to have batteries that will last at least 10 years.

SECONDARY WATER PROVIDERS

Most communities with secondary water service as well as those planning construction of a secondary system have considered metering. The benefits of metering potable water are proven; however, the benefits of metering secondary water remain economically disputable. The cost of metering technology suitable for secondary water conditions has already been discussed. In secondary water markets, any cost increase interferes with inexpensive water pricing schemes. If nonpotable water does not cost less than potable water, there is no incentive to decrease potable use and therefore no point in operating a secondary water system. Economic feasibility seems to be the roadblock to metering for most secondary water providers.

Although most secondary water suppliers have made little or no effort to meter their water, a few suppliers have taken the initiative, often with government assistance.

The Weber Basin Water Conservancy District and a few communities along Utah's Wasatch Front have participated in an ongoing effort headed by the state to find a suitable secondary water meter. (The Wasatch Front is a colloquial geographic term for Utah's most populous region. It lies just east of the Wasatch Range, from which the region takes its name.) The city of Spanish Fork, Utah, is currently metering its entire secondary system with conventional potable water meters. In the Spanish Fork system, a centralized filtering station cleans the water sufficiently to make metering possible. The Grantsville Irrigation Company uses a similar approach, except that individual filters are installed at each connection. State of Utah metering experiments and the experiences of systems implementing secondary water metering have provided valuable information about how to meter secondary water.

State of Utah metering experiments. As the driving force in most metering experiments, Utah's Division of Water Resources has researched, donated, and monitored hundreds of test meters in various secondary water systems around the state. Chief among these test systems is the Weber Basin Water Conservancy District (WBWCD).

WBWCD, the state's largest secondary water provider, serves about 40,000 secondary residential connections and approximately 80,000 more through wholesale water deliveries. Secondary water comes from the Weber River drainage basin, four wells, runoff from nearby canyons, and a few springs. WBWCD has found that water quality depends on the location of the source as well as the time of year. Organic debris commonly found in WBWCD's system includes moss, algae, and snails. Its water also contains sand and sediment eroded from canyon sources during high spring runoff. Sand and sediment settle in the bottom of main water lines when velocities are low in the spring; as demand increases in the summer, high velocities carry the sand and sediment through the system (Hess et al, 2007).

Larger pieces of debris are kept out of WBWCD's secondary water system by a settling pond and a screen with ¼-in. openings. Although it is not mandated by the water district, many secondary water users install small filters in their systems. Customers sometimes complain that they are unable to run a single cycle on their sprinkler systems without their filters clogging completely (Hess et al, 2007).

WBWCD has participated in a state-sponsored study for several years to find a meter suitable for secondary water measurement. The district recognizes the benefits of water conservation; however, economic obstacles still discourage widespread secondary metering. Not only does the initial cost discourage metering, but a significant number of new employees would also be required to maintain the system. This would be economically difficult even for a large water district such as WBWCD. For most smaller irriga-

This experimental fluidic-oscillation–type meter in Utah's Weber Basin Conservancy District had a cracked and leaking base plate, which was likely the result of freezing. Despite the leak and submersion the meter was still registering flow.

tion companies, the implementation and maintenance costs associated with metering limit its use.

Currently, WBWCD's secondary system is easy to manage and operate without metering. However, WBWCD realizes that before it spends millions of dollars to import water from other hydrologic basins, it will need to use all the water within its own basin efficiently. In this case, secondary water metering would be obligatory. WBWCD realizes that secondary metering is an eventuality and it is therefore interested in possible solutions that will help the district prepare to implement complete secondary system metering (Hess et al, 2007).

As part of the state's research, several paddle-wheel–type water meters were installed in WBWCD's system in 2000. These 4-in. meters were installed to monitor small cul-de-sacs and dead-end areas. Because of difficulties with calibration and debris, most of the meters failed within the first season of use. This type of meter was abandoned, and its manufacturer has since discontinued the product. The Division of Water Resources then approved the purchase of several magnetic meters. These meters allowed for the completion of another portion of the study (determination of water usage compared with that needed to efficiently maintain the landscape), but the high cost and short battery life rendered these meters inadequate for any other use (Utah DWRe, 2004c).

Recently, the state of Utah provided 30 fluidic-oscillator meters[2] for testing on individual homes in WBWCD. This type of meter offers promise in terms of its design and its price ($100 per meter). The fluidic-oscillation– type meter contains no moving parts to foul or clog. As described in AWWA Standard C713 (AWWA, 2005), flowing water enters the meter through a converging entrance nozzle that forms a jet flow. Two diverging walls produce opposing forces on the jet flow because of the Coanda effect and cause the jet to oscillate. Each oscillation corresponds to a specific volume of water flowing through the meter and is electronically detected, integrated, and displayed in the register. Meters employing this technology were initially expensive, but recent advances in electronics have made fluidic-oscillator meters feasible for residential metering applications. The manufacturer's claims that the meter is unaffected by grit as well as positive results from endurance testing sparked the state's interest in the meter.

Despite large amounts of debris in its water, WBWCD has not had any complaints about the fluidic-oscillation–type meters clogging (Hess et al, 2007). Of the 30 meters installed, only 2 failed after an entire year of operation (Stephens, 2007). One meter had a dead register (because this type of meter has a digital register, the failure was probably the result of an electronic issue), and the other meter had a cracked base. This meter was still metering water despite the fact that it leaked. The failure was probably the result of freezing in the winter. Further investigations revealed that only a portion of the fluidic-oscillator meters has potted (protectively sealed) electronics (Searle, 2007). This extra protection may improve the performance of the digital register in underwater situations.

Two other significant water systems, the city of Draper and the Grantsville Irrigation Company, were included in the state's study of fluidic-oscillator meters. Draper's secondary water system is run by a private nonprofit company called WaterPro Inc. The system, installed in 1994, is supplied entirely by surface water sources (Gardner, 2007).

Unlike many secondary water providers, WaterPro is interested in metering all secondary water connections as soon as possible. Because the company's growing, mid-sized system is already running near capacity, conservation through metering would allow it to extend its service without much more expense. However, this universal metering goal is still economically out of reach for WaterPro. In order to reach this goal, the company is hoping that the state

A standard secondary connection like this one involves a simple configuration of a meter and valves.

will soon provide grants, rebates, or other incentives to allow the introduction of widespread metering. The drawback to secondary metering for Draper is the increased workload in areas such as billing, meter repair, and meter reading.

In light of its interest in secondary metering, WaterPro also has installed a few test meters provided by manufacturers. Waterpro has installed nearly 20 fluidic-oscillation–type meters from the state of Utah and three single-jet meters provided by two water meter manufacturers.[3] Although fluidic-oscillators do not have moving parts, single-jet meters have an impeller that is turned by a jet of water as it passes through the meter. The rotational speed of the rotor is proportional to the flow rate. To date, there have been no problems with the single-jet meters, although the limited size of the sample (three meters) gives little statistical credibility, and further research should be performed. Two of the fluidic-oscillator meters have failed because of electrical problems (Gardner, 2007).

Grantsville Irrigation Company was also given 25 fluidic-oscillator meters to be tested. Of the 25 meters provided, three have had battery or electrical failures in the past five years. There have also been problems with the meters freezing. Currently, 18 fluidic-oscillator meters remain in the system (Taylor, 2007).

Another problem associated with secondary water metering is that of public acceptance. According to Jeff Morgan, inspector for WBWCD, it was difficult to find 30 residences to participate in the fluidic-oscillator study. The public in general responded with reluctance and unease. In Draper, volunteers were requested through a monthly newsletter. When only 15 residents responded, the remainder of the meters were installed in new subdivisions where acceptance is generally easier to obtain (Gardner, 2007).

Although a definite solution has not been found, the Utah Division of Water Resources' efforts to find a meter suitable for secondary water applications have resulted in a better understanding of the problems related to secondary metering. Most meters either failed or were too expensive; however, the fluidic-oscillation–type meter has shown promise. Although apparently effective in debris-filled water, this type of meter is still in need of increased durability and protection of electrical components. Additionally, the effects of secondary water on the accuracy of the fluidic-oscillator meters have not yet been investigated. Considering these findings, the state of Utah continues its testing with fluidic-oscillator meters and its search for additional metering possibilities.

Centralized filtering in Spanish Fork, Utah. Spanish Fork decided to upgrade its secondary water system in early 2000. Rather than spend more than $25 million for improvements to its potable system to meet future demands, it chose to expand and update its secondary water system for $17 million. This system, which currently serves about 8,000 connections, has the capacity to serve more than 19,000 connections (Nielson, 2007).

To fulfill its secondary water demands, Spanish Fork uses two wells that do not meet drinking water standards, two wells with smell or taste issues, and two new wells that meet potable water standards. These wells are viewed as a temporary secondary water source. As soon as the Central Utah Project pipeline reaches Spanish Fork, the city will use water from Strawberry Reservoir as its primary secondary water source (Nielson, 2007).

Secondary water is pumped from the city's wells to a 22-mil gal reservoir at the mouth of Spanish Fork Canyon. The reservoir has been converted to a public recreation area that provides a beach, camping sites, and a pavilion; it is also stocked with fish. This public area is viewed as a benefit to the community while still serving its primary purpose as a secondary water storage structure. After the water leaves the reservoir,

A standard secondary connection such as this one consists of a valve, filter, drain, and meter contained in one or two valve boxes.

it is filtered by one of three 80-μm filters.[4] These filters have automatic self-cleaning features that reduce maintenance costs. Spanish Fork replaced the 80-μm filter screens with 130-μm filter screens at the end of the 2007 irrigation season because it experienced a few problems with the meters (Nielson, 2007). It is expected that this filtration level will sufficiently filter the water while decreasing power consumption and wear on the filter mechanisms.

Spanish Fork's system has been specifically designed to withstand harsh winters. For example, the lateral branches feeding each connection are sloped down toward the main line. By doing this, in theory, all meters and lateral branches are drained when the main is drained at the end of the season. The only problem with debris has been caused by backflow through discharge valves that have been left open for extended periods. An increased awareness of this maintenance issue has solved the problem.

Because the water is filtered to such a high level, Spanish Fork has been able to use standard residential water meters for secondary water purposes. It is currently using ¾-in. multijet meters.[5] During the course of one year, Spanish Fork replaces about six secondary meters—less than one tenth of a percent of the secondary meters. The most common defects occur in the registry of the meter, probably because the meters are not waterproof. Fortunately, these meters are under warranty and maintenance costs are minimal. One to two full-time employees maintain all of the meters (potable and secondary). With the present system, it takes three meter readers to read all connections once a month. Within the next two years, Spanish Fork expects to upgrade to an automatic meter reading system and has constructed a radio tower that will read both secondary and potable water meters as well as electrical power meters (Nielson, 2007).

Overall, the system has been a success. The secondary system currently serves 7,336 connections—almost 90% of all potable water connections (8,332 total potable water connections). Although water rates have been temporarily increased in order to pay off the project bond, they are expected to decrease dramatically within 10 years (Nielson, 2007). If all goes as planned, Spanish Fork will have succeeded in actually lowering water rates while almost doubling its potable water system's service capacity.

Several other secondary systems are looking into the possibility of centralized filtering (Bushman, 2007). Riverton City, Utah, is currently filtering all secondary water to 100 μm but has yet to find a meter manufacturer that will uphold a warranty on their meter (Dalton, 2007). (Not all metering companies will guarantee its meters in secondary water conditions, even if the water is filtered.)

Individual connection filtering—Grantsville Irrigation Company. Although centralized filtering has proven to be an effective approach for Spanish Fork, many smaller systems find that it is not economical. Grantsville Irrigation Company is one smaller system in which centralized filtering is not economically viable. Serving roughly 1,400 connections, many of which are large agricultural water connections, a centralized filtering unit is more expensive per customer compared with individual filter units at each connection (Taylor, 2007).

Water for Grantsville's pressurized irrigation system is supplied by runoff from six canyons west of the city. This runoff is collected and stored in a 3,400-acre-ft reservoir located five miles south of the town. Because only three employees maintain the entire system and perform all installations, the utility presently does not meter all connections. Of the 1,400 connections, Grantsville has installed about 540 meters, is converting old connections into metered connections, and is installing secondary water meters at all new residences. A standard connection in Grantsville consists of a valve, filter, two drains, and a meter. The entire connection is contained in one or two valve boxes (Taylor, 2007).

Grantsville has moved toward universal metering because of water waste. Lynn Taylor, water supervisor of Grantsville Irrigation, believes that people do not purposely waste water but that they are unaware of how much water they actually use. Over the past five years of metering, the company has found several water abusers. One shareholder who owns three shares of water used nearly eight shares in one season. The irrigation company considers such misuse a justification for metering, despite its added cost.

Grantsville knew that some type of filtration would be necessary in order for standard water meters to function; however, in analyzing the feasibility of a centralized filtering station, several problems were discovered. Grantsville must provide water to a wide variety of secondary water users. For example, farms and residential homes are interspersed, both on the same pressurized line. Because main line breaks occur frequently on farms where irrigation lines are exposed, dirt and other debris entering water lines can potentially damage meters.

In addition, a centralized filtering station is not economically justifiable for the Grantsville system. Grantsville is a relatively small system with 1,400 connections and a potential to expand by an additional 4,000 connections in the next 20 years. Given the estimated flow rates and considering only the initial costs of filtering, it was significantly more economical for Granstsville to buy individual filters at about $60 per connection than to pay more than $100 per connection for a centralized filtering station. In larger Spanish Fork where a centralized filter has been installed, the initial price for filtering per connection is about $40. It is evident that the number of connections served and the flow rate of each connection influence the type of filtering that will most effectively meet a particular system's needs.

For economic reasons, Grantsville chose to use individual filters for each connection. The company began using screen filters, which pass water through a perforated metal cylinder. It soon discovered that the filter's circular holes filled up much too quickly with debris and impeded the flow of water. In addition, these filters were only available in a model that must be glued into the line, making maintenance and replacement difficult. Grantsville then changed to 1- and 1½-in. compact filters. These filter to 250 µm and cost about $60 apiece. Initially, a disc element was used as a filtering media. This filter greatly improved the system's flow and seemed to do a better job than the screen filter. Over time, however, Grantsville still experienced problems with filter plugging. It continued using the same filters but changed the filtering media to a stainless-steel mesh. Although harder to clean than the disc filter, this medium has performed acceptably (Taylor, 2007).

Grantsville has many problems with debris such as snails, moss, and crawfish. One reason that the filter-clogging debris is such a problem is that the irrigation company cannot maintain the individual filters on every connection. The maintenance costs associated with the filters are one reason why Spanish Fork dismissed the idea of individual filtering. Grantsville gives the customer the responsibility of cleaning the filter; the smaller size of the irrigation company's system allows for greater control in seeing that this maintenance is performed. Some users clean their filters every week, whereas others report that it is only necessary every few months.

Invariably, a few customers refuse to maintain their filter. Half a dozen users have actually pulled the filter cartridge out in order to avoid filter maintenance. This allows the unfiltered water to go through their system, potentially ruining the water meter. Grantsville Irrigation's policy treats this as an act of vandalism, and water users who have done this are held responsible for the meter.

Grantsville has used a variety of water meters including some experimental fluidic-oscillator meters as well as some nutating-disc meters. Currently it is using vertical turbine meters,[6] which seem to be working well. The only problem experienced so far with these meters is freezing during the winter. The meters are designed to break out the bottom if they do freeze, and several freeze plates have been replaced. Some have also frozen out the top of the meter. During the harsh winter of 2006–07, Grantsville replaced more than 10 meters (Taylor, 2007).

Grantsville has alleviated freezing problems by installing automatic drains that are activated once the line pressure drops below a certain point. This has helped, but seeking further improvements, the company has started to install additional drains. Both sides of the meter are now protected by drains. The company reports that no problems have been experienced from debris buildup on the moving parts of any of the meters, although examination of a nutating-disc meter showed that debris buildup is present.

The economic success of Grantsville's metered irrigation system is still in question. In view of the conservation benefits and increased manageability, Taylor believes the system is a success. When maintenance and meter replacement costs are considered, the economic and overall success of the system can be evaluated over time.

CONCLUSIONS

With rapid growth and limited water supplies, many water systems throughout the United States, in particular those in western states, are aware of the need for water conservation. Supplying secondary water is an approach that reduces demand on potable water and allows for more connections. However, unmetered secondary water use has resulted in an increase in overall water use. Studies indicate that metering all water and charging based on use reduce overwatering and waste. The research efforts by the state of Utah's Division of Water Resources as well as the experiences of pioneering water providers such as Spanish Fork City and Grantsville Irrigation Company show that metering is not only possible but also economically feasible.

The state of Utah's experiences with Weber Basin Water Conservancy District, WaterPro, and Grantsville Irrigation Company have shown the possibilities that new water metering technologies will provide in the near future. Although magnetic meters and other such meters provide expensive functionality in a secondary water environment, the testing of the fluidic-oscillation–type meter gives hope for an inexpensive alternative. New technologies such as fluidic-oscillation suggest that the development of an economical meter for secondary water applications is not a possibility but an eventuality.

The systems of Spanish Fork and Grantsville demonstrated that filtration sufficiently cleans secondary water enough to meter its use. If secondary water quality can be improved through filtration, standard potable water meters can be used. Well-developed filtration technologies can meet the needs of a variety of secondary systems.

Although secondary metering is possible, economic feasibility can only be determined by considering many factors. The analysis of water demand, future population growth, water quality, and other factors will allow water providers to determine which approach to secondary water metering best suits their needs and will help them determine the cost-effectiveness of alternatives. Investigation into the economic viability for various secondary metering approaches will be discussed in a future article.

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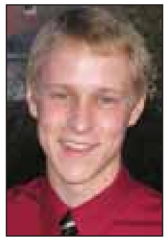
ABOUT THE AUTHORS



Gregory L. Richards is currently working on a master's degree in civil engineering with an emphasis in hydraulics at Utah State University, Logan, Utah. He works as a research assistant for the Utah Water Research Laboratory at Utah State University focusing on the accuracy and durability of residential water meters, especially those used in secondary water applications. Michael C. Johnson (to whom correspondence should be addressed) is a research assistant professor at the Utah Water Research Laboratory, Utah State University, 8200 Old Main Hill, Logan, UT 84322; e-mail, mikejnsn@engineering.usu.edu. Steven L. Barfuss is a research assistant professor at Utah Water Research Laboratory, Utah State University.

FOOTNOTES

[1]Amiad Filtration Systems, Oxnard, Calif.

[2]SmartMeter SM700, Severn Trent Services, Chesterfield, England

[3]Spectrum water meter, Metron-Farnier, Boulder, Colo.; Flostar water meter, Actaris US Liquid Measurement, Greenwood, S.C.

[4]Mega EBS filter, Amiad Filtration Systems, Oxnard, Calif.

[5]PMM® multijet meter, Sensus Metering Systems, Raleigh, N.C.

[6]Model MVR magnetic drive vertical turbine meter, Hersey Meters, Cleveland, N.C.

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