State of the Art Water Use Efficiency

An Online Continuing Education Course for Engineers

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Chapter 2

Water Use Efficiency: State-of-the-Art

Overview

Municipal water utilities in the United States and around the globe are increasingly aware of the narrowing gap between growing demands and finite supplies. This includes water utilities in the Southwest, which is both the fastest-growing and the driest region in the U.S.

With water so precious and scarce, one might expect all municipal water providers in this region to be world leaders in water conservation and efficiency. However, this is not yet the case.

To date, most western water providers have not come close to tapping the full potential of water conservation or to optimizing the efficiency of their existing facilities and delivery systems. Cities in other parts of the country, notably New York, Boston, and Seattle, made system-wide demand reductions of 20 percent or more in the 1990s. These coastal cities' efforts, focusing mainly on indoor use, obviated the need for new dams and wastewater treatment facilities. Factoring in potential reductions in outdoor use, western cities might achieve even greater savings. Creative supply-side alternatives can boost efficiency even further.

The engineers of the past century constructed a vast series of reservoirs and made way for tremendous population growth in the Southwest. As growth continues into the 21st Century, the engineers of today have a wide range of new and often cost-effective options to more effectively use our limited water resources. It is our collective challenge to take advantage of these new water efficiency technologies and practices to maximize our water use efficiency for both water supply systems and customers' demands.

This chapter describes the state-of-the-art technology, policies, and programs that are available to render our water use more efficient in this arid region. We present information on both the supply-side and demand-side of water use efficiency. By supply-side efficiency, we refer to ways that stretch existing, developed water supplies without constructing massive new dams, diversions, or pipelines. Demand-side efficiency refers to water conservation, but without loss of quality of life.

Both sides of the efficiency equation must be pursued not only to maximize the beneficial use of our scarce water resources but also to show that urban water suppliers and their customers have roles to play in water efficiency. In our view, the information in this chapter is every bit as important to westerners in the 21st Century as construction of Hoover and other dams was to westerners in the 20th Century.

"There once were men capable of inhabiting a river without disrupting the harmony of its life."

–Aldo Leopold

from "Song of the Gavilan" (1940)

Photo by Brian Holmes.

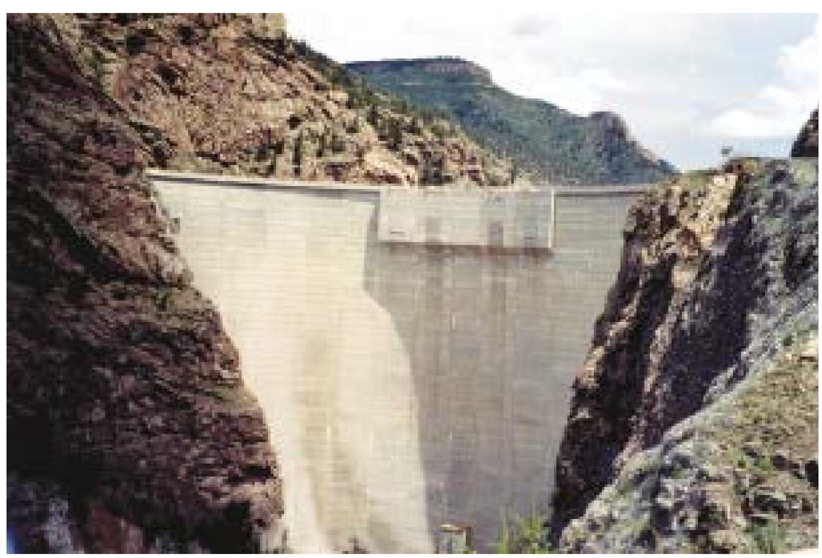

Photo by the Bureau of Reclamation.

Chapter 2

Supply-Side Water Efficiency Measures

Implemented on a broad scale, state-of-the-art supply-side measures can augment existing water system supplies and allow the downsizing or even avoidance of new, traditional supply development to meet future growth. This section describes many of these supply-side efficiency measures. In so doing, we do not endorse their use in every situation. Costs or environmental impacts may preclude their use under local conditions. However, these measures often provide significant benefits to urban water providers, suggesting they be reviewed by providers in their long-term planning and implemented where appropriate.

Water main maintenance.
Photo by the American Water Works Association.

A. Water Loss Management

Urban water suppliers lose copious quantities of water from their systems due to leaks and other causes. Water loss management in collection and delivery systems is integral to maximizing supply-side water use efficiency. Being attentive to delivery system leak detection and repair, accurate metering, and dam/reservoir maintenance and repair is necessary to achieve this goal.

1. Leak Detection and Repair

System leak detection and repair is a fundamental component of water loss management. This efficiency measure is a vital responsibility of the water supplier, and involves vigilant monitoring of collection and distribution systems (i.e., water storage and conveyance systems, water treatment facilities, municipal water main networks, etc.). We can save vast quantities of water by reducing or eliminating system leaks. Methods for water auditing, performance measurement, and leakage management are usually very cost-effective and self-sustaining, often a winning solution for all parties involved. Night flow assessment,[1] sonic leak detection, and strategic replacement of old deteriorating water mains are all excellent tools.

The value that a community places on water is likely to be inversely proportional to the amount of water loss that it tolerates. The 1995 United States Geological Survey data show a difference of nearly 6 billion gallons per day between source water withdrawals and water consumed in the United States.[2] This is nearly enough water to satisfy the total water demand of all use sectors for the entire State of Arizona (i.e., municipal use, agricultural use, industrial use, etc.).[3] As a direct result of system leaks, riparian and aquatic

1 "Night Flow" assessment refers to the monitoring of water flows during low-use periods (i.e., middle of the night) to search for possible pipe leakage (since actual consumer demands are typically low or negligible during these periods).
2 U.S. Geological Survey, "*Water Uses in the United States*" *1995 data,* water.usgs.gov/watuse/. Note: this figure includes firefighting and meter error as well as actual leakage.
3 *Id.* at 4. In 1995, the State of Arizona used a total of 6.8 billion gallons of surface water and groundwater per day for use in all sectors, including municipal, agricultural, and industrial.

ecosystems suffer unnecessarily, water suppliers lose millions of dollars annually, unnecessary water system infrastructure is built, and anywhere from 10 to 15 billion kilowatt hours of energy are wasted annually on water that never reaches the tap.[4] Other nations faced with similar challenges, particularly in the United Kingdom, have led the way in developing cost-effective methods to manage water loss.

Water loss consists of both real and apparent losses. In the water supply industry, these losses collectively are referred to as Unaccounted For Water (UFW).[5]

Real losses refer to the actual volume of water that physically leaks from the system. Although the real losses may eventually recharge an underlying aquifer, in most cases in our region, a "real loss" represents a direct and unnecessary water loss to nearby or distant surface water tributaries (sometimes in an entirely separate river basin). Leaks also correspond to financial losses to the utilities and taxpayers, both of whom pay to treat and transport water that never arrives.

Apparent losses (also called "paper/computational" losses) are miscalculations or metering errors. Apparent losses also represent services rendered without payment received. These losses may not be as destructive to water sources as real losses but may damage the efficiency of the overall water supply system in that they distort consumer water use data that is critical for developing future demand models and conservation plans, building water supply infrastructure, and designing equitable pricing mechanisms. The scope of apparent losses occasioned one water provider to say: "accountants peering in from outside of the water supply field might regard our industry as careless, complacent and not accountable for the water that it manages."[6]

The responsibilities of both suppliers and consumers of water are inextricably intertwined. When water districts experience real water losses at volumes comparable to what consumers are being asked to conserve, the ground is less fertile for promoting an ethic of conservation. To maintain a clear, consistent conservation message, water loss management efforts by water suppliers must meet or exceed the expectations of consumers to conserve water. As discussed in detail in Chapter 3, several surveyed water providers have reduced their Unaccounted for Water to less than 5 percent of total supply withdrawals.[7]

> "All of this points to one clear problem: we don't value water properly."
>
> —George Kunkel
>
> Philadelphia Water Department, Former Chair, AWWA Water Loss and Accountability Committee

2. Metering

Accurate accounting of water withdrawals, deliveries, and sales is critical to designing equitable rate structures, tracking UFW, and allowing consumers to monitor their conservation progress. The importance of an expanded metering system that is frequently calibrated has been clearly demonstrated by the City of Denver.

Water Metering Example

- **Denver, Colorado**

  The City of Denver's water utility, Denver Water, estimates that by 1999 it had saved 28,500 acre-feet from its conservation programs and natural replacement (of outdated, less efficient appliances and fixtures) since 1980, or about 10 percent of current demand.[8] About 44 percent of these savings were attributed to the universal metering program, and about 33 percent of the savings were attributed to the natural replacement of plumbing fixtures with more efficient fixtures.[9]

4 George Kunkel, *"Water Loss Recovery - Our Greatest Untapped Water Resource"*, Philadelphia Water Department from AWWA "Water Sources" Conference Proceedings, 2001, at 2.
5 In addition to real and apparent water losses, Unaccounted For Water (UFW) also includes unmetered beneficial uses such as water for fire-fighting and main flushing, usually using small volumes of water compared to other uses.
6 Kunkel, *supra.*
7 *See, e.g.*, Denver Water, *Comprehensive Annual Financial Report: 2001, 2002*, at C-53.
8 Maddaus Water Management, Inc. (prepared for Denver Water), *Qualitative Review of Water Conservation Program*, May 2001, at 1-8.
9 Of the remaining savings, about 10 percent was attributed to household/customer leak detection and audits, and 13 percent of savings was attributed to public education and related efforts.

Continuing as a leader in meter technology, Denver Water is currently in the midst of the largest Automatic Meter Reading (AMR) implementation in the western United States.[10] In addition to yielding a significant advancement in water use accounting, this system also provides more opportunity to inform customers about changes in their rates of use, and conservation progress or regress. With the AMR system complete, Denver Water expects that it will be able to reduce its fleet of 33 meter readers and 33 vehicles to a single meter reader with one vehicle. This transition will lead to savings on vehicles, maintenance, communication devices, worker's compensation insurance, and liability insurance, because meter readers will never have to set foot on the homeowner's property. Denver Water has decided to implement the system on a staggered schedule so that the project will begin to pay for itself as it goes. The AMR system is expected to cut at least $1.25 off of the fixed monthly charge per account and allow Denver Water to move from a bimonthly to a monthly billing system.[11]

3. Dam Repair and Reservoir Maintenance

Water storage capacity often can be gained by dam repairs and reservoir maintenance (*e.g.*, dredging). Silt deposits in reservoirs reduce storage capacity directly, and deteriorating dams result in storage reductions because the reservoirs cannot be filled safely to capacity. Although maintenance operations to address these conditions can be expensive initially, depending on the amount of water supply capacity gained, they can be cost-effective. Maintenance costs are often substantially lower than the monetary and environmental costs for most new water supply infrastructure projects.

Photo by the Bureau of Reclamation.

Reclaimed Storage Example

■ State of Colorado [12]

The Colorado Division of Water Resources (CDWR)—the agency that administers Colorado's Dam Safety Program—noted "the determination of safe water storage levels [via the Dam Safety Program] resulted in storage restrictions at 198 reservoirs that resulted in an estimated 132,115 acre-feet of reduced storage."[13] As of August, 2002, the CDWR increased this figure to 142,850 acre-feet of storage.[14] Although this lost storage is dispersed throughout the state on dams/reservoirs managed by many different water districts, the quantity suggests a large opportunity. For the sake of comparison and scale, 142,850 acre-feet (46,569 million gallons) of

10 Charlie Jordan, "*New AMR System Will Lower Costs, Improve Customer Service, and Increase Efficiency*", www.denverwater.org/waterwire, January 2002.

11 Note: The heart of an AMR system is the Encoder Receiver Transmitter (ERT), which is a device installed on the electronic register of existing meters that relays readings electronically to a handheld device carried by the meter reader. This information is then downloaded to the provider's database, and is always available for analysis of historical use, conservation savings, peak use, and any other pertinent details. AMR readings are only as accurate as the meters themselves. However, increasing the frequency of readings is also likely to increase the frequency of detecting errors.

12 Colorado Division of Water Resources, *2001 Annual Report*, Colorado Department of Natural Resources, 2002, at 2. Note: The mission of this Program is to "prevent loss of life and property damage, determine safe storage levels, and protect the state's water supplies from the failure of dams within the resources available."

13 *Id.* Note: A large portion of Colorado's lost storage capacity is in reservoirs that serve agricultural water uses, not urban uses.

14 *See* water.state.co.us/presentations/cwc_0902.pdf. Colorado Division of Water Resources website, Presentation: "Responsibilities and Roles in Water Matters," September, 2002.

water is 80 percent of Denver Water's 2001 annual retail sales volume (58,385 million gallons).[15]

A 2002 presentation by the CDWR indicates that 25,060 acre-feet of this lost storage in 45 reservoirs is recoverable at an approximate cost of $10 million, with the balance being recoverable at higher costs.[16] The savings potential for the first subset of capacity equals $399 per acre-foot of recovered storage, substantially lower than the costs of new storage proje

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For example, its future needs, the Southern Nevada Water Authority (SNWA) entered into a water banking agreement with the State of Arizona.[17] The agreement is administered by the AWBA. The AWBA banks Arizona's unused Colorado River water rights by pumping the excess water into groundwater aquifers to be sold to account holders in Arizona and other neighboring states at a later date (including the SNWA). Under the SNWA's agreement, the AWBA will store up to 1.2 million acre-feet of wat

credits for the SN

ces and demands,

ve the Denver metropolitan area. As water rights and return flows are traded, and interconnecting pipelines are installed,

15 The use of Denver Water in the example is not intended to imply that Denver Water is responsible for lost storage volume in Colorado.
16 *See* "Responsibilities and Roles in Water Matters," *supra*.
17 *See* Southern Nevada Water Authority website: www.snwa.com/html/wr_az_banking_agreement.html.
18 *Id.*
19 Western Resource Advocates correspondence with City of Mesa staff (6/03).