PENNSTATE

College of Agricultural Sciences • Agricultural Research and Cooperative Extension

Water Conservation for Communities

CONTENTS

Introduction

Although water is essential for life, most people take it for granted. Water is generally viewed as an inexpensive and unlimited resource, and people are satisfied as long as a seemingly endless supply of good-quality water is available.

However, water supplies in this country are not limitless. In many areas future water availability is uncertain, and escalating water development costs have become a serious obstacle to expanding water supplies. Global climate change threatens to create even greater variability in water resources in some areas as seasonal or periodic droughts occur more frequently. Even in areas of relative water abundance, increasingly stringent requirements on wastewater discharges and growing infrastructure needs place a premium on reducing the amounts of water used and wastewater produced by homes and businesses.

There is widening recognition of the importance of community-level water conservation programs in reducing demand on the nation's water resources and wastewater infrastructure. Proven strategies that can be used as part of a community water conservation program include the following:

- Public education programs
- Refit programs (installing water-saving devices in older buildings)
- Water-rate-structure revisions
- Distribution-system water loss reduction
- Water conservation regulations and ordinances

In this guide we discuss water conservation strategies, identify water conservation resources, and relate practical advice on beginning a conservation program based on research and experiences from across the country. The guide should be of interest and value to water utility personnel, planners, staff of environmental and community organizations, and individuals concerned with making our nation's water systems more efficient.

With increasing needs for water, comprehensive plans to conserve water are critical for preserving Pennsylvania's valuable surface and groundwater resources.

Why Conserve Water?

A mere one-half of one percent of all the water on earth is fresh water that is accessible to humans for water needs. Pennsylvania is fortunate to receive abundant precipitation, ranging from 32 to 48 inches per year. Roughly half of the state's residents rely on surface water supplied by the precipitation that flows to streams and into reservoirs. The remaining population relies on wells and springs that tap underground reservoirs of groundwater called "aquifers," also replenished by precipitation infiltrating deep into the ground.

Regardless of the source, the water available to humans is not only limited but in a continuous state of flux. In any given year, some areas may receive an overabundance of water, while others suffer from droughts. A growing and mobile human population also can stress traditionally adequate water supplies. Recent severe and recurring droughts in Pennsylvania resulted in increasing competition and disputes over water resources that ultimately led to the 2002 Water Resources Planning Act. The Act charged the Pennsylvania Department of Environmental Protection (DEP) to come up with a new State Water Plan to address current and future water use and demand.

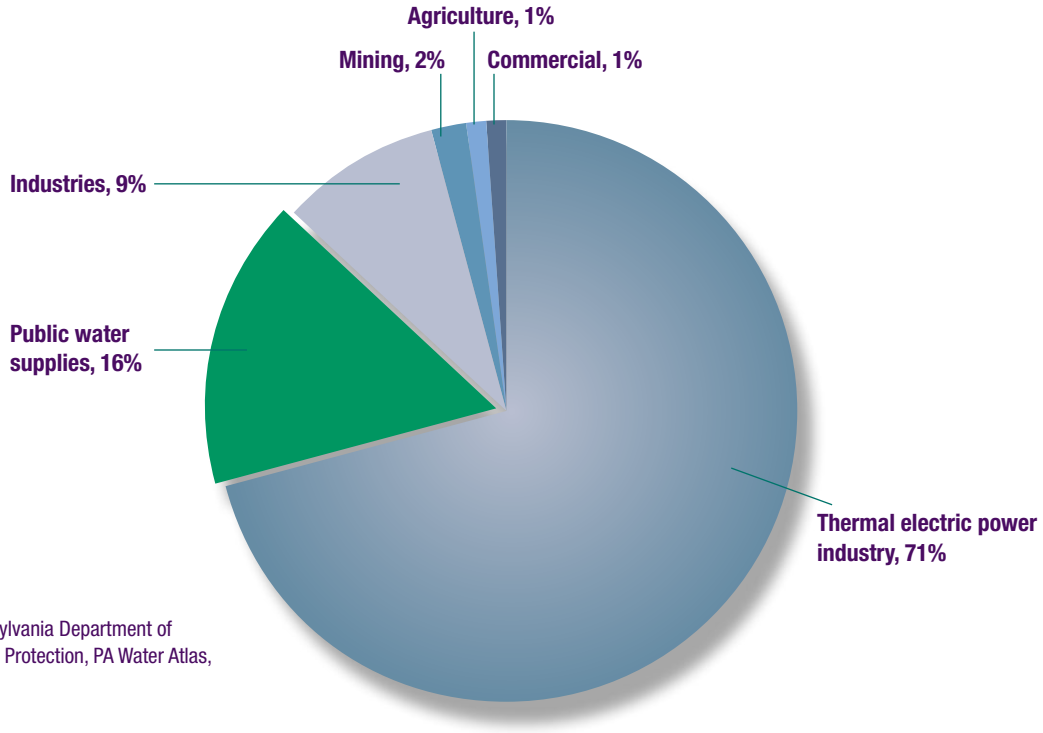
THE STATE WATER PLAN

Pennsylvanians withdraw about 9.7 billion gallons of water every day from a variety of surface- and groundwater sources. The various sectors using water in Pennsylvania are illustrated in the chart below.

Water-use patterns continuously evolve with population shifts, energy demands, farming practices, infrastructure management, consumer sophistication, national and international policies, and climate change. Each can influence how water resources are managed over the next several decades.

The current Pennsylvania State Water Plan replaces an outdated plan that was completed in 1983. The Water Resources Planning Act of 2002 established a statewide water resources committee and six regional committees to guide DEP in developing a new State Water Plan and updating it at five-year intervals. The updated plan seeks answers to the following questions: How much water do we have? How much water do we use? How much water do we need? Comprehensive water conservation programs for communities, industry, farmers, and households are an important component of the State Water Plan to ensure adequate water supplies for the foreseeable future.

Percentage of total water withdrawals for various water use sectors in Pennsylvania.



Source: Pennsylvania Department of Environmental Protection, PA Water Atlas, 2008.

ENERGY SAVINGS

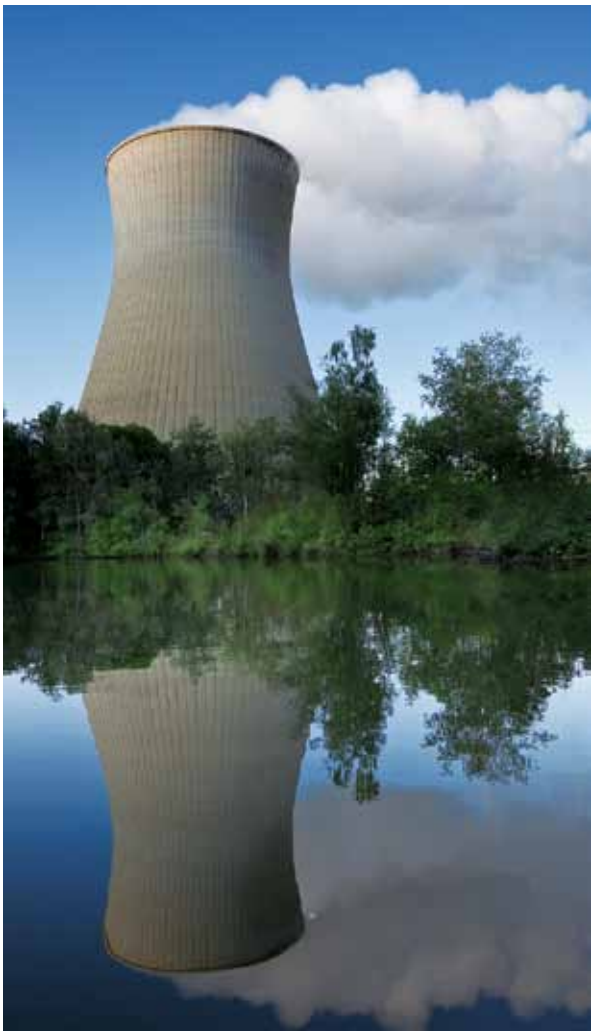
The fastest-growing cost in the nation's water budget is for the energy needed to pump water from one place to another. On an individual basis, an average homeowner pays more for energy to heat water than for all the water used in the home. Domestic water heating consumes three percent of the total national energy budget. Saving water saves energy, which, in turn, saves money on water and heating bills and reduces municipal energy costs.

Producing energy also requires significant amounts of water. The development of the natural gas industry in Pennsylvania, specifically the Marcellus shale, has many Pennsylvanians concerned about where the water will come from to harvest this gas resource. Other alternative and developing renewable energy sources also demand water usage during their production stages. It is clear that energy and water are closely associated, and conserving either resource can ultimately help conserve the other. For more information on the link between energy production and water resources, consult Sandia National Laboratories at www. sandia.gov/energy-water/.

REDUCED SEWAGE FLOW

Reducing per capita water use would concurrently reduce the amount of sewage generated and extend the "life" and capacity of many public sewage conveyance and treatment systems. This would lessen the need for construction of new sewage treatment plants or expansion of existing treatment facilities. Many communities have sewage facilities that are at or near their capacity. These overloaded sewage systems can result in bans on new sewer taps that can limit commercial and residential growth. A comprehensive approach to include replacing or updating faulty infrastructure, eliminating infiltration and inflow, as well as reducing water use could allow additional homes to be built in a given area without the need to add sewage conveyance or treatment plant capacities.

Homeowners with individual onsite septic systems would benefit from conserving water by reducing the hydraulic load or the amount of liquid waste entering their system. Overloaded systems are more likely to fail, posing problems for the homeowner and increasing the potential for polluting nearby groundwater or surface



Power plants represent the largest withdrawal of water in Pennsylvania.

Water conservation measures can reduce the need for expensive upgrades to water and wastewater infrastructure.

waters. Symptoms of a failed on-lot septic system include raw sewage pooling in the yard or backing up in the home. Preventing overload by using water conservation techniques would postpone or avert the need to make expensive repairs or replace the system.

REDUCED CAPITAL COSTS

Government and businesses are required to make capital investments to meet a community's need for water. Water systems include costly treatment plants and pumping stations, reservoirs, transmission lines, and a network of distribution pipes. Reductions in water use can delay or prevent costly expansions of these facilities. Reduced waste flows may also allow for the use of smaller, decentralized sewage systems in some cases. In addition, new water systems can be constructed smaller in capacity to meet the reduced water demand.

Urban sprawl leads to the need for more water infrastructure, increasing the potential for breakdowns that can result in water loss. Thoughtful approaches to future community development, coupled with the implementation of water conservation programs, could reduce or even prevent such environmental impacts, delaying the costs associated with creating "new" water systems.

Some communities are making a concerted effort to detain and infiltrate stormwater to enhance the recharge of local groundwater aquifers. Simple control measures such as installing rain gardens can go a long way toward reducing stormwater runoff and can lower the much greater expenses associated with constructing large stormwater management drainage basins and extensive drainage systems. Innovative practices to encourage stormwater infiltration increase the capacity to retain water resources at the most local level. DEP's new *Storm Water Management Best Management Practices Manual,* available on its Web site (www.dep.state.pa.us), lists a host of other innovative stormwater management practices that help conserve community water resources.

WATER DEMAND MANAGEMENT IN CRISIS AND NONCRISIS SITUATIONS

Regional and local droughts of some magnitude occur every few years somewhere in Pennsylvania. Managing the commonwealth's water resources during drought

KATHY HAMILTON, WESTMORELAND COUNTY CONSERVATION DISTRICT

Innovative water conservation measures like rain gardens can be used to augment groundwater supplies and reduce community stormwater infrastructure.

is the responsibility of the Pennsylvania Emergency Management Agency (PEMA), with direct support from the DEP. Drought emergencies are managed in conformance with PEMA's drought emergency regulations. There are three levels of drought declarations:

Drought watch—during a drought watch citizens are requested to volunteer to reduce water usage by 5 percent, and DEP increases its monitoring activities from monthly to weekly.

Drought warning—as droughts worsen from a drought watch to a warning, citizens are asked to volunteer to reduce their water usage by 10 to 15 percent.

Drought emergency—the final and most severe condition, in which nonessential water-use restrictions are imposed through PEMA's regulations. DEP also boosts its monitoring activities from weekly to daily.

Only the governor can proclaim a drought emergency, and the governor alone has the authority to ration resources, including water resources.

Water conservation programs should be an integral part of long-term resource planning during crisis or noncrisis situations. It is imprudent to wait for a regional drought or local water-quantity problems before planning for and actively managing our water resources. From this perspective, water conservation might be more appropriately termed "water demand management" in contrast to "water supply management."

Water is a finite resource. As such, community water resource management is imperative if we are to ensure that the myriad of challenges—water infrastructure and processing problems, new and emerging contaminant problems, and the demand for water by energy production technologies—can best be addressed for current and future needs. The challenges facing efforts to manage community water resources are great, making the need for community conservation programs more critical than ever.

Starting a Water Conservation Program

Water conservation programs most often come about as a result of a perceived need to save water and energy, reduce environmental impact, eliminate restrictions on new sewer hookups, lower capital costs, or cope with an emergency situation. With growing concern for the availability and cost of resources, communities strive to find better ways to use and conserve natural resources.

Water conservation needs to be part of any community water resource plan. Community leaders should develop a plan of action to ensure the success of their efforts. They might begin by defining the basic requirements of a water conservation program, including goals, budgets, plumbing codes, installation, and public relations as well as the appropriate audiences for each of these activities. Each element is essential for developing a water conservation program that is both practical and functional.

Community water conservation programs are critical for addressing recurring, serious droughts in Pennsylvania.

It is important to project how much water reasonably could be saved through a water conservation program and to establish a realistic and achievable goal for how much the community will save. Numerous U.S. cities and towns have reduced overall water consumption 10 to 25 percent by installing water-saving devices and implementing leak detection programs. Based on estimated savings, communities should set a goal that can be achieved by retrofitting either a total number of households or a given number of households per year over some given time frame.

A budget for implementing a water conservation program can vary widely. A number of factors need to be considered, including the availability of staff to coordinate the program or to install water-saving devices as well as educational needs and the extent to which existing agencies can assist with educational programs. Given the scope of the task and the need for careful attention, many communities elect to designate or hire a full-time water conservation program coordinator. Successful coordinators typically have a bachelor's degree and some experience and familiarity with water conservation. These credentials can aid them in effectively engaging with the range of sectors in the community that can institute a successful program and make it more likely that the costs associated with the position can be recovered.

Community administrators often overlook several economic benefits of conducting a water conservation program. Two such benefits are the savings that accrue because less water is treated and there is a reduced need to expand sewage conveyance and treatment systems. These economic factors are key considerations in deciding whether to begin a water conservation program. It is also a good idea to involve and partner with community wastewater utilities, which often have a critical stake in water conservation programs.

Another important consideration is how water-conserving fixtures will be installed. Options include having a community program that will supply and install water-saving devices in homes free of charge or cost-share the purchases and installation with homeowners. In some programs, devices are supplied to the homeowner free of charge, but the homeowner covers installation costs.

An essential component of a community water conservation program is the need to educate the public about water conservation devices and practices. A public education program can be launched to showcase water conservation's benefits, emphasizing the monetary savings in water, sewer, and energy bills as well as the positive influence on the environment. Workshops, feature stories in newspapers, direct mail brochures, water and sewer bill information inserts, involvement in civic organizations, and exhibits in schools, shopping areas, and other high-traffic areas are all ways to get water conservation messages into the hands of the public.

Target audiences should be established, with a focus on households using high levels of water. Often, young or growing families are a good initial audience because families with toddlers and teenagers could

Components of a Water Conservation Program

Public education programs—focused on the need and available methods for conservation.

Plumbing code/ordinances—to amend the building code or pass an ordinance that would require the use of water-saving equipment in new construction and to encourage outdoor water conservation.

Water-conserving rate structures—to create a pricing system that would discourage high-volume water use by pricing on marginal cost basis; and to collect revenues due to losses from reduced water consumption.

Refit programs—to establish incentives for the use of water-saving devices such as low-flow toilets and flow control aerators, including rebates on new appliances and fixtures.

Leak detection—start a leak detection and water meter maintenance program for the entire water distribution system.

benefit quickly and financially from water-saving devices installed in their homes.

Water conservation programs typically start with a pilot program designed to identify the best approaches within a given community before scaling up to more expensive, broader efforts. The most effective approaches demonstrate that the community leaders support the program and that there are benefits for those participating in a water conservation program. A pilot program could involve municipal officials installing the selected water-saving devices in their own homes. The personal experience gained from using these devices can then be enthusiastically shared with others in the community and would aid local leaders in understanding the concerns people may have about adopting new practices or installing conservation devices.

The following sections examine in more detail the most important aspects of a successful water conservation program.

Public Education Programs

Public education may prove the best way of bringing about substantial water savings. Long-term, ongoing programs can promote a conservation ethic, making people more receptive to the idea of reducing water use to conserve limited water resources and to save money. Water utilities are not in a position to police conservation programs effectively, so public engagement and involvement is essential.

Well-designed education programs can deepen the community's appreciation for the value of water and provide the opportunity to best utilize and protect it. Quantifying the value of such a program is difficult, but savings in consumer water and energy bills could be the best indicators of positive results.

Educational programs should stress the economic benefits for the homeowner and the environmental benefits for the community, as well as give the consumer instruction on the function and proper use of available conservation measures.

To begin a community education program, it is important to plan and consider (1) the type of program, (2) the program's duration, (3) the amount of funding available, and (4) the partnering organizations that can most effectively engage the public. Often, the limiting factors are time, money, and the availability of personnel. By coordinating efforts between existing state and federal initiatives, communities can make the most of both their funds and their human resources.

Public information and water conservation and management programs have cropped up in communities across the country. Two notable examples are:

- El Paso, Texas
  www.epwu.org/conservation/education.html
- San Diego, California
  www.sandiego.gov/water/conservation/consprogram.shtml

Stormwater management programs that focus on rerouting runoff to water-loving plants and landscapes are more often being incorporated into community water conservation education programs. Examples of efforts that have effectively used rain gardens and rain barrels for stormwater control are found in Kansas City, Missouri (www.rainkc.com/) and western Michigan (www.raingardens.org). More information

An essential component of a community water conservation program is public education.

on rain barrels and rain gardens for outdoor water conservation is provided later in this section.

SCHOOL PROGRAMS AND YOUTH EDUCATION CURRICULA

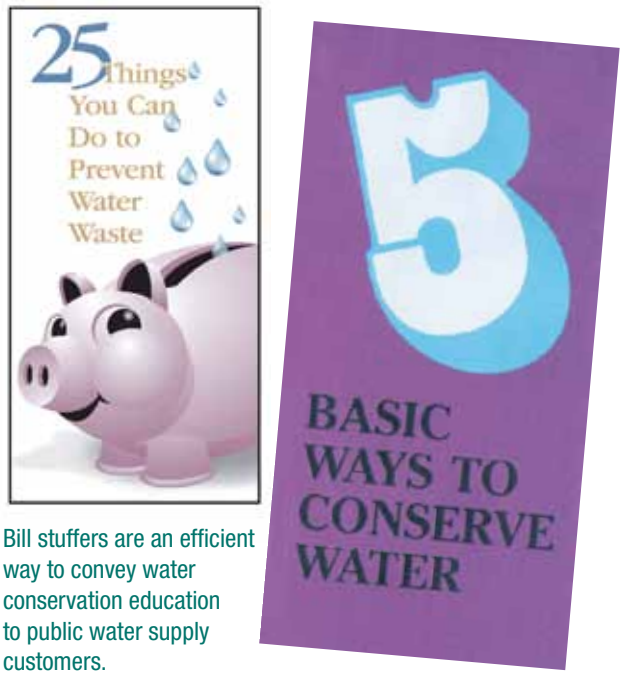
Water conservation education can start with Pennsylvania's children, positioning them for lifelong attitudes and behaviors that are water conscientious. Water conservation programs and curricula for the classroom or for youth organizations such as scout groups, church groups, afterschool programs, and 4-H are available through a variety of sources:

- Penn State Cooperative Extension 4-H Water Project Books, available for use by teachers, scouts, and 4-H clubs, were designed to support Pennsylvania's Academic Standards for Environment and Ecology. Workbook titles include *Water Conservation, Incredible Water,* and *Watersheds.* These resources can be obtained from your county Penn State Cooperative Extension office or at water.cas.psu.edu
- Project WET (Water Education for Teachers) is a nonprofit water education program and publisher of materials for educators and young people ages 5-18. The program promotes and facilitates awareness, appreciation, knowledge, and stewardship of water resources through the dissemination of classroom-ready teaching aids and the establishment of internationally sponsored Project WET programs. www.projectwet.org.
- Water Environment Federation provides resources to help educators and students at all levels to become involved in taking care of the water environment. www.wef.org/.
- Captain Hydro Water Conservation Workbooks are recommended for grades 8 and under. These comicbook-style pieces follow the adventures of the hero, Captain Hydro, as he fights for water conservation. In addition, The Official Captain Hydro Workbook contains worksheets, puzzles, and a glossary of water conservation terms. Workbooks are available for download on the East Bay Municipal Utility District Web site at www.ebmud.com.

Educational resources targeting youth are critical to the long-term success of any water conservation program.

WATER-UTILITY-ASSISTED PROGRAMS

Bill inserts are an efficient way for water companies to offer information directly to their customers on the topics of indoor and outdoor water conservation. Care should be taken to design and supply a bill insert that will attract attention, while avoiding the appearance of junk mail. The American Water Works Association (AWWA) has produced professionally written and illustrated bill stuffers; most are sized to fit in small, bill-sized envelopes. Available topics include: "25 Things You Can Do to Prevent Water Waste" (#70013), "5 Basic Ways to Conserve Water" (#70014), "Consumer's Guide to Water Conservation: The Inside Story" (#70113), "Consumer's Guide to Water Conservation: The Outside Story" (#70114), "55 Facts, Figures and Follies of Water Conservation" (#70077), and "Water Conservation at Home" (#70059). These publications are available online through the American Water Works Association at www.awwa.org. AWWA member organizations receive reduced rates for publications, including bill inserts.



Bill stuffers are an efficient way to convey water conservation education to public water supply customers.

(Reprinted by permission. Copyright © American Water Works Association. To obtain these documents, contact AWWA at 1-800-926-7337 or www.awwa.org/Bookstore.)

PROGRAMS FOR REDUCING OUTDOOR WATER DEMAND

Encouraging consumers to conserve water outdoors is just as important as encouraging them to conserve water for indoor use. Bill inserts from the American Water Works Association are one way to remind residents of the importance of reducing outdoor water demand. If bill inserts aren't cost effective, the bill itself can incorporate simple tips for consumers, such as watering plants in the early morning, mulching around plants to reduce water loss, cleaning sidewalks and driveways with brooms instead of hoses, and raising the lawn mower blade during the summer months.

Some communities have taken promoting outdoor water saving even further by offering rain barrel and rain garden programs. Both methods help conserve water and reduce stormwater runoff within residential and commercial areas, and they can easily be incorporated into a community water conservation plan.

Rain barrels, typically a container (usually some variation of a 50-gallon plastic drum) with a cover, collect water coming from the downspouts of buildings. The collected water may then be used to water plants and lawns, or for washing cars or other equipment, thus reducing demand on public water supplies. Local organizations such as conservation districts, watershed organizations, and Penn State Cooperative Extension often partner to conduct rain barrel workshops for individuals wishing to use these tools for water conservation.

Rain barrels may be purchased at lawn or outdoor equipment shops or can be constructed by reusing plastic drums that were not originally in contact with toxic materials. Used drums may be available at a low cost from local companies or businesses—particularly those dealing in food processing, recycling, or agricultural operations. Many companies also offer ready-made rain barrels for purchase in a variety of shapes, sizes, and prices to fit a homeowner's needs.

Rain gardens are made up of native perennial plantings positioned to intercept water as it empties from downspouts or runs off paved surfaces like parking lots or roadways. The objective is to lessen runoff and increase infiltration into the soil to reduce the potential for contaminated runoff to enter local water supplies, as well as to beautify the area. Garden plans, plant suggestions, and tips for establishing a local rain garden initiative are available at www.raingardens.org.

In Kansas City, the community has been challenged to install 10,000 rain gardens to conserve water and reduce runoff. A massive media and education campaign has been launched to inform the public and promote rain garden use. Visit www.rainkc.com/ for more information on this city's rain garden program.

MEDIA PROGRAMS

Public information programs that partner with local media (print, radio, and television) significantly broaden their audience and can more thoroughly disseminate information. The American Water Works Association has developed informational DVDs that are available for public information campaigns. The series includes *A Consumer's Guide to Water Conservation* and *Water Conservation and Efficient Use,* which can be ordered online at www.awwa.org.

COOPERATIVE EXTENSION PROGRAMS

Offices of Penn State Cooperative Extension have a variety of resources and materials available for public education programs. Cooperative Extension personnel also network with other extension professionals and

Rain barrels are a popular tool for teaching comprehensive water conservation while reducing outdoor water use.

associations throughout the United States to provide direct connections to a wide spectrum of specialized water resource knowledge. Penn State's Water Resources Web site (water.cas.psu.edu) is a valuable source of information and serves as a clearinghouse for Web-based water conservation information. Along with the youth publications discussed earlier, other water conservation topics available through county extension offices and online are:

20 Ways to Save Water in an Emergency

Estimating Water Use for the Farm and Home

Water Conservation—How Much Water and Money Could You Save?

Household Water Conservation

OTHER SOURCES OF EDUCATIONAL PROGRAM SUPPORT

A myriad of governmental and quasi-governmental organizations, as well as local water utilities, can administer or fund a community education program through grants and partnerships. Environmental groups, watershed associations, or local civic organizations can also be enlisted to help get the conservation message out to the community. Projects directed at homeowners are best organized at the local level, and municipal government may be effective in initiating school programs and distributing materials. Interactions with colleges or universities may be useful for developing and disseminating research-based informa-

Penn State's Water Resources Web site (water.cas.psu.edu) is a valuable source of information and serves as a clearinghouse for Web-based water conservation information.

tion that quantifies the effects of conservation techniques and their benefits for the consumer.

Plumbing Codes and Ordinances

Many ordinances and plumbing codes have been written to address water conservation. For example, the Building Officials and Code Administrators International (BOCA) includes many water conservation requirements that would apply to any municipality using these rules. During the 1970s and 1980s, additional local and state ordinances governing water conservation proliferated. Massachusetts became the first state to create a statewide water conservation law in 1989, prompting numerous states to follow suit. The United States Energy Policy Act of 1992 and subsequent federal legislation ultimately created national water conservation requirements, including:

1. Maximum water use standards for plumbing fixtures, as follows:
   - Toilets must use less than or equal to 1.6 gal/flush
   - Urinals must use less than or equal to 1.0 gal/flush
   - Faucets and showers must be less than or equal to 2.5 gal/min at 80 psi or 2.2 gal/min at 60 psi
2. Product making and labeling requirements and recommendations
3. State and local incentive programs to accelerate voluntary fixture replacement

More recently, many municipalities have passed water conservation ordinances focusing on retrofitting existing plumbing during real estate transactions or outdoor water conservation measures (irrigation methods, landscaping, timing of irrigation, etc.). Numerous examples of water conservation ordinances can be found online by typing "water conservation ordinance" into any Web search engine. Most examples originate from western U.S. cities such as Tucson, Los Angeles, and San Diego.

Many communities are also looking at LEED (Leadership in Environmentally Efficient Design) standards for energy and water efficiency in new and renovated structures. More information on water efficiency standards related to LEED design is available from the U.S. Green Building Council at usgbc.org.

Water-Conserving Rate Structures

Water utilities currently employ several forms of domestic use rate structures. Many variations and combinations of these basic types exist because of the metering practice in the area, classes of use, and conditions unique to the area including land use, growth, and social subsidy programs. In recent years, problems such as drought and resource depletion have occurred more frequently, increasing the number of utilities that have adopted conservation-oriented rate structures. These encourage water conservation by charging customers a higher price the more water they use. These structures are more appealing to communities or utilities that want or need to save water, but they have also created controversy. It is important to remember that metering is necessary for any pricing system other than a flat rate. Brief descriptions of both standard and water-conserving rate structures are provided in the following section.

Many communities have passed water conservation ordinances that include, among other things, irrigation methods and timing.

STANDARD RATE STRUCTURES—LACK INCENTIVES FOR CONSERVING WATER

Flat rate—Employed where meters are not used, this rate type is a constant charge per unit of time regardless of the amount of water used. The constant charge (or flat rate) usually depends on the class of use and/or the size of the service line. The charge can be collected monthly or bimonthly but usually is billed quarterly or semiannually and, in some cases, annually. The drawback of this type is that it actually encourages water wastage; consumers are left to reason that the more they use, the less they are actually paying on a unit cost basis.

Uniform rate—The uniform rate is normally applied so that, irrespective of user class or amount of water used or size of meter service, the same (uniform) rate is paid by all. Since this rate type also does not encourage conservation, some utilities are transitioning to one of the conservation rate structures described below.

Declining block rates—With declining block rates, each customer is charged a certain amount for an initial quantity or "block" of water. The rate for succeeding blocks decreases with each block as consumption levels increase. This rate structure discourages conservation. However, large water consumers such as industry or agriculture find it appealing. A community seeking new industries can potentially benefit from implementing this rate structure as it is viewed as industry friendly.

WATER-CONSERVING RATE STRUCTURES—INCLUDE INCENTIVES FOR REDUCING WATER USE

Increasing block rate—This type of structure operates very similarly to declining block rates except that the rate charged rises with increased usage. Such rate structures have been used in very few instances, but they are becoming more popular. This structure holds great potential for achieving considerable reduction in water use, especially in dry areas. The Washington Suburban Sanitary Commission has used such a rate effectively in its conservation program. Other communities, however, have petitioned against the increasing block rate. They argue that this type discriminates against large families because it does not take into consideration how many people live in each household. It may be appropriate to establish different usage block ranges based on customer class so that large-volume, conservation-conscious users are not unduly charged simply because of their size.

Standard water use rate structures often lack incentives for water conservation, resulting in wasteful water use by customers.

Peak load or seasonal rate—This rate type may be applied with existing metering equipment, but it requires more sophisticated bill calculation. It is designed to encourage water conservation during the time of year when utilities experience peak demand. The rate structure works by setting a rate based on winter-quarter water use for the average household, charging a premium on water use in excess of this base rate.

The aim of peak demand rates is to concentrate on the component of residential use that is most sensitive to price. Usually this component is outside lawn and garden irrigation since the peak time of year commonly coincides with the time when water usage outside the home is highest. Since most water consumption that exceeds the base allotment is for outside uses, the consumer has an economic incentive to avoid wasting irrigation water and to implement conservation practices.

Lifeline rate—A growing practice that discounts utility service for the small user is called the "lifeline" rate. It is done by identifying the average amount of water used in, for example, a two-person cottage or apartment unit and applying a reduced commodity rate for amounts within the first water-usage block. The state of California has required that the rate for the lifeline amount cannot be increased until rates for amounts above this level are raised 25 percent.

Joint water/wastewater rates—Some community water and wastewater utilities have worked together to create joint billing. This system provides simplified accounting for both the customer and the utilities, along with reduced staffing for utilities that can share billing personnel. Depending on the rate structures used under the joint billing, customers may also see a doubled incentive to conserve water. To be successful, both utilities need to share the billing costs, and both must have the capacity to handle identical rate structures. If utilities can work out a comprehensive agreement before implementation, joint billing can provide cost savings for the utilities along with more water conserved and lighter wastewater loads.

Refit Programs

Water-saving devices offer an inexpensive and lasting approach to conservation. They can be installed and used without major disruptions in water use habits, so for the typical consumer they offer a more acceptable approach to water conservation.

Plumbing fixtures and systems have long been designed to ensure a more-than-adequate flow of water to meet whatever demand. Historically, no thought was given to the design of fixtures and systems based more precisely on the needs of the water user. Consequently, pipe and fixture sizes and designs have encouraged water uses far in excess of those really necessary to do the job. Water conservation devices help to eliminate this waste by allowing only the necessary amounts of water to be used at the plumbing fixture. In many cases the user does not even notice their presence. The major advantages of water conservation devices are that they are:

- Relatively inexpensive
- Easily installed by the homeowner
- Effective in reducing water use, waste flows, and energy consumption
- Permanent

A simple and inexpensive refit program involves kits to repair leaks that are estimated to affect 25 percent of all toilets.

Water use data from the U.S. Geological Survey and the American Water Works Association show that each person in Pennsylvania uses nearly 70 gallons of water each day inside his or her home. The table at right shows the relative importance of various water appliances and fixtures in the home. Keep in mind that significant amounts of water used in clothes washers, showers (and baths), faucets, and dishwashers is heated at considerable energy costs. Water used inside the home also adds to wastewater treatment costs and infrastructure demand. For more information about household water and energy use, consult the EPA Energy Star (energystar.gov) and WaterSense (epa.gov/WaterSense) Web sites.

Outdoor water use varies considerably across the United States, averaging an additional 100 gallons of water use per person each day. Outdoor water use is used predominantly for landscape watering, car washing, and swimming pools—where most of the water evaporates during use. One detailed study found that outdoor water use in central Pennsylvania averaged only 17 gallons per person per day, which was only 6 percent of the overall household use of water. Pennsylvania's lower use of outdoor water reflects our humid climate which, in most years, provides adequate moisture for lawns and gardens.

To save water, it makes sense to concentrate on reducing the uses that require the most water; consequently, toilets and showers are prime targets for conservation. Fortunately, some inexpensive refit options are available to produce water savings. Many communities and water utilities have experience with various types of retrofit programs. *The Handbook of Water Use and Conservation* (Vickers 2001) categorizes these programs as:

1. Door to door canvass: retrofit kits delivered to homes with follow-up
2. Direct installation: by trained technician
3. Mass mailing: retrofit kits mailed directly to customers
4. Depot pickup: interested customers pick up kits based on publicity
5. Rebates: utilities provide incentive funds to promote voluntary retrofits

Average indoor domestic water use in the United States.

Plumbing fixture	Water use (gallons per person per day)	Percent of total indoor water use
Toilet	**18.5**	**27%**
Clothes washer	**15.0**	**22%**
Shower	**11.6**	**17%**
Faucets	**10.9**	**16%**
Leaks	**9.5**	**13%**
Other	**1.6**	**2%**
Bath	**1.2**	**2%**
Dishwasher	**1.0**	**1%**
Total	**69.3**	

Source: Mayer et al. 1999

6. Kit requests: publicity creates awareness about availability of kits, which customers can request.

Each of these methods has advantages and disadvantages related to cost, participation rates, administrative effort, and difficulty. As can be expected, higher participation rates require greater investments of both money and effort. Consult *The Handbook of Water Use and Conservation* cited at the end of this publication for details on community water retrofit programs.

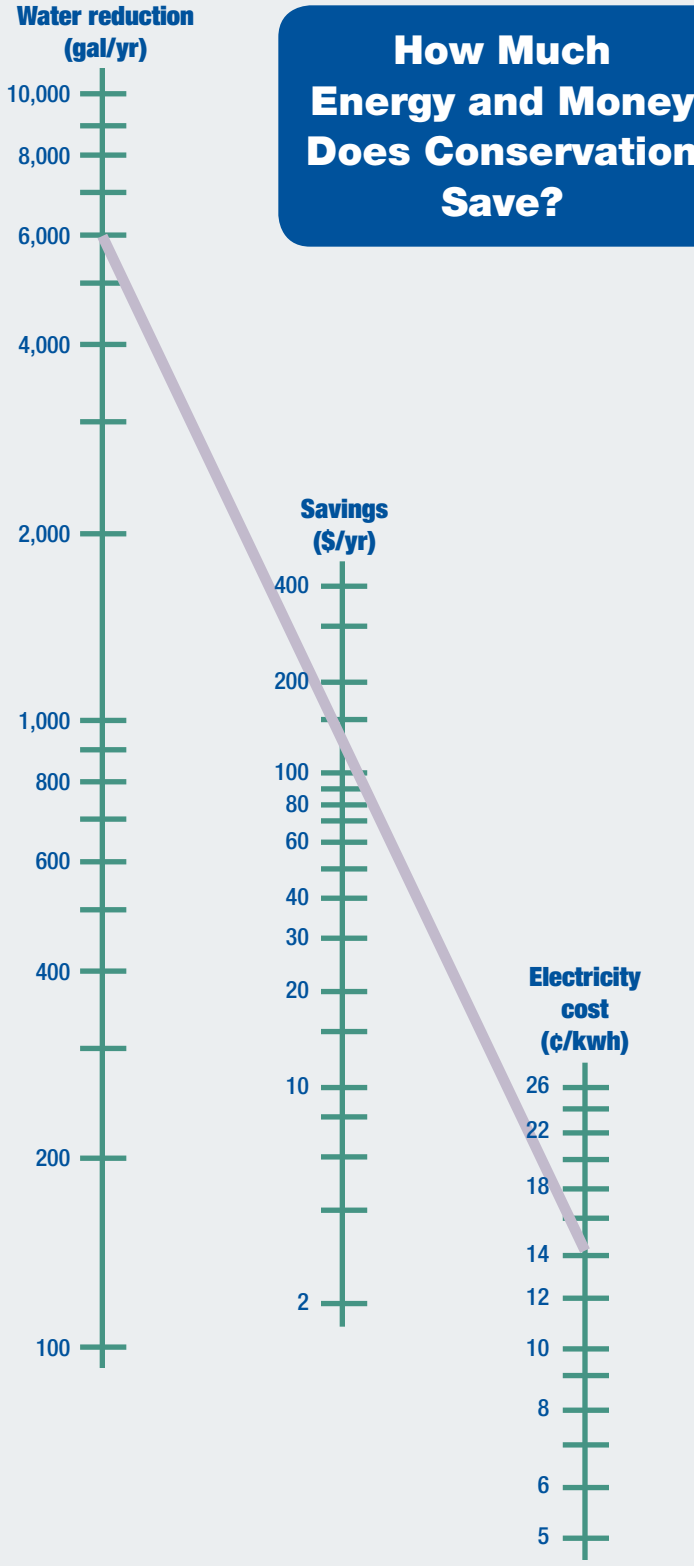
Cost savings to the individual homeowner will far exceed the cost of purchasing and installing water-saving devices. The devices recommended for toilets, showers, and faucets should pay for themselves in energy savings alone in four to six months. This does not include the additional savings in water and sewage flow reduction.

TOILETS

Toilet refit programs involve installing newer water-saving models, detecting and repairing leaks, and installing various devices on older toilets to reduce their water use.

The 1992 U.S. Energy Policy Act required the sale and installation of toilets using 1.6 gpf or less, effective in 1994. Replacement of older toilets with 1.6 gpf models will typically result in water savings of more than 4,000 gallons of water per person each year. Beyond the 1.6 gpf models, newer toilets now include dual flush models that allow users to select reduced

How Much Energy and Money Does Conservation Save?



The ultimate success of refit programs is largely determined by how much money consumers think they can save. The simple nomograph shown here illustrates how reduced use of hot water in a year (left) translates into annual dollar savings (center) based on current electricity costs (right). Simply draw a straight line from the annual "Water reduction" to the current "Electricity cost" to see the annual dollar savings from reduced heating of water following water conservation practices. The sample line shows that a 6,000-gallon water reduction at 14 cents per kilowatt hour (kwh) of electricity results in about $125 of annual energy savings. ■

water (less than 1 gpf) for liquid wastes or normal water use (1.6 gpf) for solid wastes. Some progressive communities and facilities are even installing composting or incinerating toilets, especially in outdoor recreation areas, which entirely avoid using water to transport human waste products. Similarly, waterless urinals are becoming more common in commercial and institutional settings.

An estimated 25 percent of all toilets installed in homes leak. These leaks may cause losses of a few gallons per day to more than 100 gallons per day, depending on the cause. Toilets with significant leaks may lose more water in this way than is used to flush them each day. While newer toilet models have a reduced incidence of leaking components, older models can leak from malfunctioning flapper valves, ballcocks, fill tubes, or flush levers. Leaking toilets can be diagnosed from obvious sounds or dye tests (a simple test where dye is placed in the toilet tank and observed to see if it appears in the toilet bowl). Dye tests are simple for the homeowner to perform and interpret. Materials needed for toilet repair are generally inexpensive (less than $15).

The critical component of a successful toilet repair program starts with creating awareness among water users. This is most often done with bill inserts or flyers discussing the causes, costs, repair options, and incentives related to toilet leak repairs. When done properly, toilet repair programs can exceed 50 percent water-user participation.

Toilet refit programs involve installing inexpensive devices to reduce water use in older toilets. They provide the advantage of reducing solid wastes in landfills by updating existing toilets rather than replacing them entirely. Most simply, this involves placing materials in the toilet tank to displace water and thus reduce water used with each flush. Toilet dams and flush adapters are other options that typically cost less than $20 per toilet.

More recently, retrofit kits to convert standard toilets into dual flush models have become available. Toilet refits can generally be installed by the homeowner with little effort; they are targeted at higher flush toilets (greater than 3 gpf) commonly installed in Pennsylvania prior to 1994. As a result, toilet refit programs are most efficient if focused on older service areas where toilets installed before 1994 are more likely to be located.

Retrofit programs focused on faucet aerators are simple and inexpensive for both water suppliers and customers.

SHOWERHEADS

Conventional showerheads typically deliver three to eight gallons of water per minute (gpm). Low-flow showerheads using 2.5 gpm or less have been required in new construction since the 1992 U.S. Energy Policy Act. Low-flow showerheads accomplish conservation by restricting the diameter of the hole through which water must pass. Showerheads with reduced flows as low as 2 gpm, at normal household water pressure, have been designed to give an acceptable shower while reducing water use. They can be sensitive to low water pressure and sudden changes in temperature; consequently, proper pressure and balanced water-mixing valves are necessary. Exiting water temperatures normally need to be slightly higher because the smaller droplets cool quickly. Slightly hotter water does not negate the substantial energy savings achieved by low-flow showerheads.

Each Pennsylvanian uses nearly 70 gallons of water each day inside the home.

Water-saving showerheads are preferable to the many types of inexpensive flow restrictors that can be purchased for insertion between the showerhead and the shower arm. The water-saving showerhead has been designed to give a pleasing shower with its built-in flow control, but a restrictor may or may not be compatible with an existing showerhead. Replacing conventional showerheads with low-volume 2 gpm models will reduce shower water usage by 30–60 percent, or approximately 650 gallons of water per year for each person in the home.

In addition to low-flow showerheads, retrofit programs can make use of shutoff buttons that allow the user to easily stop water flow when it is not needed in the shower. Because these devices rely on the bather to consciously turn the water off, they are less effective than showerheads that continuously deliver lower water flows.

FAUCETS

When the water flow from all faucets in the house is totaled, the sum constitutes a significant portion of household water use. Most older faucets deliver three to seven gallons of water per minute, while the 1992 Energy Policy Act requires faucets to be less than 2.5 gpm. For most faucet uses, maximum flow rates of 0.5 to 1.0 gpm are adequate. Flow rates this low will result in significant water and energy savings.

Retrofitting faucets to reduce water flow is generally easier than retrofitting showerheads. The simplest method is to install flow-control aerators that use 0.5 to 1.0 gpm of water. These devices are designed to fit faucets with threaded spouts. Since faucet diameters and thread sizes vary widely, an adaptor may be necessary. Installing flow-control aerators is relatively simple. Just remove the old aerator by turning it counterclockwise with a large pair of pliers. Then install the flow-control aerator by turning it clockwise onto the spout until it is snug. Replacing a typical 3 gpm faucet with 2 gpm models will save approximately 1,000 gallons of water per year for each person in the home, with even larger savings possible if lower-flow aerators are installed.

CLOTHES WASHERS

Conventional, top-loading clothes washers use about 40–50 gallons of water per load. Great strides have recently been made to improve the reliability and ease of front-loading automatic clothes washers, which use less water and energy. Front-loaders are more efficient and wash with much less water and detergent. The tumbling action of the laundry reduces water requirements for equivalent load sizes and for cleanliness. Water savings of 40 percent are easily accomplished with the switch to front-loading washers. They also greatly lower energy use through reduced water heating and less dryer time.

Retrofit programs for clothes washers typically focus on educating users about the advantages of front-loaders to highlight voluntary incentives or rebate programs that provide economic incentives for homeowners. Many communities have rebate programs

Front-loading clothes washers are a popular choice for community rebate programs.

that typically offer $100 to $300 rebates toward the purchase of front-loading clothes washers.

DISHWASHERS

Retrofit programs for dishwashers are far less common than those targeting clothes washers because the amount of water to be saved is much less. Still, some communities have initiated rebate programs as an incentive to install more water-efficient dishwasher models that use as little as 4.5 gallons per load (gpl) compared to older units using up to 14 gpl. The result is a savings of several hundred gallons of water per year for each person in the home which, when combined with energy savings, provides quick repayment for new machines.

Reducing Water Loss

Water loss is typically defined as the amount of water remaining after the known billed and unbilled water consumption is subtracted from the water delivered from the source. Water use data from the U.S. Geological Survey indicates that about 15 percent of water withdrawn in the United States is lost. These water losses can be separated into apparent (also called "paper" losses) and real components.

Apparent water losses include unmetered uses such as water used by fire departments and in public buildings. Water theft may also occur from meter tampering, illegal fire hydrant openings, and illegal connections. In most cases, these water uses account for only 1 to 2 percent of the total water use and represent only a minor component of water loss. Water meter inaccuracies may also result in apparent water losses. Meter under-registration occurs primarily from meter slowdown with age and from meter malfunction at low flows. Meter accuracy is essential in assessing total system water loss and in collecting accurate revenues. An active meter replacement and repair program is vital for good water management.

Most water losses usually occur from actual leakage at joints, valves, service connections, and pipe breaks. An active and ongoing leak detection program, as described in the next section, is critical for reducing water losses from system leakage.

Dishwasher rebate programs focus on replacing older dishwashers with models that include a water-conserving setting (Eco Wash, in this case).

Water loss is typically defined as the amount of water left after the known billed and unbilled water consumption is subtracted from the water delivered from the source.

Reducing water loss relies on a thorough water audit, often conducted by firms that specialize in this process. A water audit starts with collecting and analyzing available information and records on how water was used and lost within the system to create initial estimates of water loss. Flow measurements are utilized to help determine how water is being used in the system and which areas have the greatest leak potential. The primary recording devices, master meters, and industrial meters are tested for accuracy, pump efficiencies are checked, and leaks are quantified and pinpointed for repair. An analysis of all the data helps determine how water is being lost in the system and defines the problem so that cost-effective measures can be taken. Field measurements should be made, where possible, to improve estimates that are part of the water audit. The combined estimates and field measures can be used to develop an accurate water audit over several years and can be steadily improved with additional measures over time.

The overall benefit of a thorough water audit and resulting water loss program increases with greater

system water loss. One study found that a utility with a water loss between 10 and 15 percent can typically reduce that loss by 10 to 30 percent, but a utility with a loss of greater than 25 percent can typically reduce that loss by 50 to 60 percent following a water audit and water loss program.

LEAK DETECTION

One of the most important field measures related to water audits and water loss control is a leak detection survey. Leaks occur because of corrosion, soil movement, vibrations, and temperature stresses. The extent of damage varies with age, material, and geographic location. Internal damage resulting in leaks in mains, joints, and valves can be caused by pressure surges (for example, water hammer), and internal chemical corrosion of pipes from the distribution water itself.

Leak detection and management offers the water supplier several advantages. The water conserved by fixing leaks is available for other system use and is especially critical during times of shortage (droughts) or in areas where supply is needed for community growth and development. Early detection of leaks can also reduce liability and costs associated with large leaks. Finally, leak repairs may save the water purveyor tens or even hundreds of thousands of dollars in reduced water treatment and transmission costs.

In addition to actually looking for larger leaks, most leak detection programs rely on various acoustic methods to locate leaks. Different listening devices can be tailored to the type of distribution system to listen for signs of leaking water that can then be pinpointed. One of the most common is a relatively inexpensive and rugged geophone that works much like a doctor's stethoscope. These surveys can often be conducted by a water utility using its own personnel, but they can be very time-consuming. However, such devices often are not able to quantify the size of the leak and thus may not prioritize it for repair.

More sensitive but expensive devices include correlators. In this case, sensors called accelerometers are placed at two locations on the pipe to detect a leak between them. Correlators can detect very small leaks and pinpoint their location more accurately and from farther away than a geophone, but they may be prohibitively expensive for small water purveyors. Correlators also are less accurate on non-metallic distribution lines.

Other types of leakage tests include the closed meter test and the dye test. The former consists of isolating one or more sections of a pipe, shutting off all service pipes, and measuring the pressure drop in the isolated section of the pipe. The dye test involves injecting a harmless vegetable dye, under pressure, into the leaking section of the water main or service pipe. With all service pipes closed off, the dye travels toward the leak. This may be the only way to detect a leaking pipe that is located in a streambed. Leaks may also be detected by a comparison of day and night flow. This is done by comparing the measured ratio of day to night flow to typical values for what this ratio should be.

Substantial amounts of water can be conserved by performing leakage surveys and repairs using the methods outlined above. The individual conducting the survey must rely on skill gained through experience, common sense, patience, and hard work, if these techniques are to be successful. Once water loss is reduced,

GLENN COWLES, PA RURAL WATER ASSOCIATION

An active leak detection program is critical for reducing water loss.

it is essential that periodic leak detection and water loss programs be sustained to keep water losses low.

One successful leak detection program was carried out in Gallitzin, a small town in western Pennsylvania. The Gallitzin Water Authority services approximately 1,000 connections, or 2,000 people. In the mid 1990s, the system was experiencing water losses exceeding 70 percent. In November 1994 the system was using an average of 309,929 gallons per day (over 150 gallons per person per day)!

The Gallitzin Water Authority instituted a comprehensive water leak detection and corrosion control program. Through the use of a leak detector, the authority found approximately 95 percent of its leaks, while outside contractors identified the remaining 5 percent. Through the assistance of the Pennsylvania Department of Environmental Protection Small Water Systems Outreach Program, the authority received training to repair distribution system leaks, replace meters, and improve customer billing. The authority also has improved the capacity of surface water sources.

By November 1998 the Gallitzin Water Authority delivered an average of 127,893 gallons per day to the town—down from 309,929 gallons per day in November 1994. As a result, the city saved $5,000 on total annual chemical costs and $20,000 on total annual power costs from 1994 to 1998. The significant savings helped the authority keep water rates down as well as extended the life expectancy of equipment, saved on purchased water costs during drought conditions, and improved customer satisfaction.

Comprehensive Water Conservation Programs: Case Studies

The concepts described here have been used in many communities and institutions around the country. Below are detailed descriptions of one community and one institution that represent model efforts to create comprehensive water conservation programs.

COMMUNITY EXAMPLE—OLYMPIA, WASHINGTON

Olympia, capital of Washington State, receives over 50 inches of rain annually, has had a water conservation program since 1997, and has expanded the program every year. Why would Olympia need such a program? The reason is the growth Olympia is experiencing and the rising demand on the area's natural resources, including water. Even though Olympia receives over 50 inches of annual rainfall, the months of July and August typically receive only 2 inches of rain and correspond to the season when there is the highest demand for water.

Key aspects of Olympia's water conservation program include:

- Annual rain barrel sales at a discounted price
- Free irrigation checkups for high water users
- Efficient washing machine rebates
- Education and seminar information

According to the community, the programs are working because (1) overall water use has declined since the inception of the program even though the population has increased in the midst of a drought, and (2) more and more households are letting their yards go brown during the peak summer months.

The "Sleeping Lawn" program was instituted to educate and encourage residents not to water their lawns during the summer months. This has resulted in brown lawns displaying Sleeping Lawn signs, which would not have been the case a few years previously.

Although the city can fine for overuse of water, it has an innovative program to encourage compliance instead of levying fines. Through the use of night-time drive-arounds as well as examination of water billing records, the city attempts to find the largest water users and then inform them of the various programs available to assist them in lowering their water bills. Most customers opt to find out more and in fact reduce their water consumption 17-20 percent by following the actions recommended by city conservation specialists.

The city programs are not limited to residential users but also include programs designed specifically to reduce water use at new and existing commercial and government buildings. With the Water Smart Technology program, businesses and government offices can receive rebates when they install approved water-efficient fixtures. For example, through this program, Olympia businesses have received rebates for replacing water-cooled ice machines with air-cooled models, collectively saving over 2 million gallons of water every year.

Through educational programs like the Sleeping Lawn, the annual rain barrel sale event, the commercially oriented Water Smart Technology program, and partnering with local businesses and volunteers to build one waterwise garden a year at a local school, the city is building broad awareness of the need for water conservation.

Washington State's new "green building law" requires schools, universities, and other public buildings to be built to meet energy efficiency, water conservation, and other environmental standards; it was approved in March 2005. The city continues to investigate new ways and programs to broaden both the reach and the effectiveness of its water conservation efforts. Water conservation is viewed as a must in order to ensure that a high-quality water supply is available for Olympia residents in the near and distant future, as well as protect local freshwater habitats and the fish and wildlife that depend on them.

INSTITUTIONAL EXAMPLE—ELIZABETHTOWN COLLEGE, PENNSYLVANIA

Elizabethtown College is an independent-residence college in Lancaster County. The need to make the most efficient use of financial resources, concern for the environment, and a severe drought from 1999 to 2002 in Lancaster County prompted college administrators to embark on an action plan to use water more efficiently by reducing water use.

The goals of Elizabethtown College's Institutional Water Conservation program are: saving money, preserving water resources, and serving as good stewards of the environment. The college provided ways for the entire campus community to participate in water conservation as well as to develop and share ideas for future ways to conserve water.

Highlights of Elizabethtown College's water conservation plan include the following:

- In summer 2001, all antiquated toilets, urinals, and associated flush valves were changed to 1.5 gallon per flush (gpf) fixtures. This project replaced 444 toilets and 70 urinals. Projected annual savings in water and sewer costs was anticipated at approximately $40,000, yielding a 2.7 year payback.
- That same summer, top-loading clothes washers were replaced with front-load washers. The new 32 front-load washers resulted in a daily savings of almost 1,000 gallons of water.
- A "metered" automatic irrigation system was installed rather than a "timed" system to reduce water used to irrigate the athletic fields and the Centennial Garden.
- Students living in the six dormitories participated in a friendly competition called "water wars." Water usage in the residence halls was measured over a two-week period. Students kept their water use to a minimum through shorter showers, not letting water run while brushing their teeth and shaving, and washing a full load of clothing rather than one or two articles. Royer Hall students lowered their daily water usage by 12 gallons per student to win the competition.

The creative programs carried out by Elizabethtown College demonstrated to surrounding communities that the college recognizes water as a valued resource and is committed to conserving it. The programs' primary benefit has been reduced costs while still ensuring sufficient water for everyone to use. The costs of the plumbing project were $108,000, which produced an annual savings of $40,000.

Conclusions

Because water conservation programs can significantly affect future water supply needs, the traditional emphasis of water supply planning on developing new water supply sources needs to be altered. When existing water supplies are made more efficient through conservation, the need for finding new supplies can

ELIZABETHTOWN COLLEGE

Elizabethtown College in Lancaster County initiated a comprehensive water conservation program in 2001. It has saved the College approximately $40,000 per year.

be significantly reduced. A complete community water conservation program, as set forth in this guide and conscientiously applied over a three- to five-year period, can be expected to result in water savings of 10 to 20 percent or more.

It is clear that water conservation must be more consistently emphasized by decision makers at all levels of government. Implementing a tailored set of simple and inexpensive water conservation practices can reap significant environmental, social, and monetary rewards.

Sources of Further Information

SELECTED WEB SITES

American Water Works Association—WaterWiser: a water efficiency clearinghouse, www.waterwiser.org

California Department of Water Resources, Water Use Efficiency, www.owue.water.ca.gov

U.S. Environmental Protection Agency—WaterSense: clearinghouse for information on water efficiency, www.epa.gov/watersense/

Penn State Cooperative Extension—water conservation and drought information for Pennsylvania, water.cas.psu.edu/

Pennsylvania Department of Environmental Protection, Water Conservation Resource Center, www.depweb.state.pa.us (type "water conservation" in search box)

Tuscon, Arizona— water conservation Web site: sample ordinances and other educational materials, www.tucsonaz.gov/water/conservation.htm

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