WATER
CONSERVATION

RETROFITTING APARTMENT BUILDINGS TO CONSERVE WATER

A Guide for Managers, Engineers, and Contractors

PATH
Partnership for Advancing Technology in Housing

PD&R
U.S. Department of Housing and Urban Development
Office of Policy Development and Research

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U.S. Department of Housing and Urban Development
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INTRODUCTION

This guidebook is intended to assist property owners and their agents (managers, engineers, constractors, maintenance staff) in reducing water use in apartment buildings. Although the primary benefit of conserving water will be a reduction in the costs of operating the building, secondary benefits may include higher property values, some energy savings, and improved relations with residents.

This guidebook explains available options, provides a framework to work with, and summarizes what you need to know to select the water conservation retrofit strategies that best suit the property in question.

What is a Retrofit Strategy?

Water conservation strategies are generally divided into those that attempt to modify people's behavior (education programs, financial incentives) and those that depend on "hardware" modifications, such as the repair or replacement of water-using fixtures and appliances. This guidebook refers to hardware measures as retrofit strategies.

Can I Use this Guidebook for Any Type of Property?

This guidebook has a narrow focus: residential multi-family rental properties with two or more units (apartment buildings). Other types of properties, such as single-family homes, condominiums, commercial sites, institutions (schools, hospitals, and the like), and industrial facilities have specific requirements and needs. There are other publications that address water conservation for these types of properties. Some of them are listed in Appendix A.

Retrofit

To provide with parts, devices, or equipment not in existence or available at time of original manufacture. To install or fit a device for use in an existing structure, especially an older dwelling.

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Retrofitting in Six Steps

Ready to proceed with your retrofitting project? There is no single correct way to do it. Common sense and practicality go a long way, and it helps to have a well-structured plan of action. This book outlines a six-step approach, developed in consultation with some of the country's leading water conservation experts.

Step 1. Information Gathering

An old adage among water engineers is that you never have too much data; indeed, you seldom have enough information to answer all your questions. An essential first step in a successful retrofitting program is the collection of as much information as possible on water-related matters.

Step 2. Water Audit

Not unlike an accounting audit, a water audit seeks to define in detail where water is being used and how much is being used at each location.

Step 3. Water Savings Assessment

How much is too much? Attainable water savings, if any, need to be determined for each water use.

Step 4. Strategy Selection

There are many retrofit alternatives; the top 20 in terms of cost-effectiveness (most savings for each dollar spent) are presented here, with tips on selecting the most appropriate for your particular property.

Step 5. Implementation Plan

Knowing how to conserve water is important, but no water (or money) is saved until retrofits are in place.

Step 6. Periodic Monitoring

No conservation measure is long lasting unless accompanied by proper monitoring and follow-ups.

STEP 1: INFORMATION GATHERING

Gathering information for a retrofit project may be easy if you are the building manager. If building management hired you for this project, you will need to work with them to extract relevant data from their files, and in some cases from their memory.

It is important to identify people familiar with building operations. These include building engineers or superintendents (if any), maintenance supervisors, and those who pay the water, sewer, and energy bills. In buildings with submetering (individual metering of water service to each apartment), it is important to contact those in charge of billing residents.

What Information Am I Looking For?

If you have been charged with retrofitting the building for water conservation you are probably familiar with water-using fixtures and equipment and do not need a lot of detailed explanations. Sticking to the basics, you will need to identify the following water-using fixtures, appliances, and equipment:

Indoors: toilets, showerheads, faucets, dishwashers, in-unit clothes washers

Outdoors: hose bibs (outdoor faucets with threaded ends on which hoses may be installed), swimming pools, jacuzzis, ponds, fountains, sprinklers, drip irrigation systems

Common areas: clothes washers in laundry facilities, toilets/urinals in common-area restrooms.

You should understand the building's plumbing system and know all about its water-using fixtures, appliances, and equipment. You will need to identify local and state regulations pertaining to water use. Lastly, you should have as complete a picture of water-related costs as possible, including sewer costs and water meter charges.

What Do I Do With All This Data?

Start preparing for more data. You soon will be conducting a water audit that is going to generate more detailed information on water use. Before you conduct the audit, however, there are a few things you should do with the information you have:

From water/sewer bills, separate the volumes of water used indoors, outdoors, and in common areas; this is only feasible when separate water meters are used.

From water/sewer bills, determine seasonal fluctuations in water use. In areas where

Useful Water Units

- *1 cubic foot (cf) = 7.48 gallons*
- *1 ccf (commonly used by water utilities as "one unit") = 100 cf = 748 gallons*
- *1 liter = 0.26 gallons*

there is no irrigation in winter, the difference between winter and summer use may approximate the volume of water used for irrigation.

From water/sewer bills, define the rate structure and identify fixed and variable costs. Is there a flat rate for each unit of water used? Does the cost per unit increase or decrease after a certain usage? Are there fixed costs such as meter charges that do not depend on usage? Are there seasonal rate changes? On what basis are sewer charges computed?

Using make and model from inventories of water-using fixtures/appliances/equipment, determine manufacturers' flush volumes (toilets, urinals), flow rates (faucets, showerheads, sprinklers, drip systems), or water use per cycle (dishwashers, clothes washers).

Using inventory of planted materials and rainfall and evapotranspiration or "ET" data, determine current irrigation requirements.

Not sure how to do this? The section on Strategy Selection provides more details, as well as a definition of ET.

It is also a good idea to contact the property's water utility at this point. Many utilities have water conservation divisions that can provide guidance on retrofit projects.

They may offer free water audits for indoor and outdoor water uses, and have special incentive programs to promote water conservation, such as rebates for the installation of ultra-low flush toilets, high efficiency clothes washers, or efficient irrigation systems. Some utilities will provide free low-flow showerheads, faucet aerators, toilet tank displacement devices and leak-detection tablets.

A partial list of incentive programs from a number of water utilities throughout the United States is presented in Appendix B.

Check List of Information You'll Need

- Plumbing drawings showing pipe sizes and layout (water and sewer), connection(s) to utility water mains, location of water meter(s), location of backflow prevention devices, and fixture/appliance hook-ups. Finding drawings for old buildings may be a challenge, and if they are found they may be outdated (changes may have taken place that are not reflected in the drawings). In the absence of construction or "As-Built" drawings, sketches should be developed roughly outlining the size and location of the items identified above.
- Inventory of plumbing fixtures: how many toilets, showerheads, faucets, and urinals are there in the property. Make and model will be useful; record water usage (flush volume or flow rate) where available.
- Inventory of water-using appliances: dishwashers and clothes washers. Make and model may be useful.
- Inventory of water-using equipment: pools, spas, ponds, fountains, hose bibs, irrigation system(s).
- Irrigation system plans, landscape plans, maintenance records pertaining to the irrigation system.
- Inventory of irrigation system components: controller/timer, valves, backflow prevention devices, manual shutoff valves.
- Local (city, county) and state regulations relevant to retrofit programs. Identify any restrictions or constraints on submetering, gray water systems or building plumbing. Health departments and building-code officials are the typical source of regulations. Local water utilities also should be aware of pertinent regulations.
- Rainfall and evapotranspiration (ET) data to assess irrigation requirements.
- Water/sewer bills for the past three years (go back further if there were any unusual circumstances in the past three years, such as a drought or limitations on water or sewer use).
- If the property has submetering, figure out how residents are charged for water. Is there a formula for allocating common area water use? How do rates charged residents compare to water utility rates?
- Results of any previous water audits, surveys, or studies on water use in the building.

STEP 2: WATER AUDIT

A water audit is a detailed examination of where and how much water is used. Some prefer the term "demand analysis." You will be collecting a lot of information and possibly taking many measurements. It is important to be systematic, thorough, and well organized. Developing simple data collection forms that you can easily reproduce, fill out, and refer to may be helpful. Sample data forms are provided at the end of this section. Do not hesitate to create your own: every property has different requirements.

Conducting the Water Audit

Allow sufficient time for a complete audit. Depending on the size of the property and the complexity of its water systems, an audit could take a few hours or several days. Equip yourself with the necessary tools, considering that during the water audit you will:

- Walk through the entire property with someone who is familiar with the location of all water-using fixtures/appliances/equipment.
- Verify the data in your inventories.
- Note any leaks in toilets (use leak detection tablets), showerheads, faucets, hose bibs, pool fill valves, irrigation system valves, and any other water-using equipment. Quantify the volume of the leak if possible, in gallons per minute or per hour.
- Measure flush volumes in all toilets; if there are many identical toilets that do not leak and have not been altered with tank inserts (displacement devices, water level adjustments, quick-closing flapper valves), one measurement may be considered representative of the bunch. Treat leaky and altered toilets separately. Unsure how to measure a toilet flush volume? A measurement procedure is outlined in Appendix C.
- Measure flow rates in showerheads, faucets (bathroom and kitchen), and hose bibs (outdoor faucets). You may have manufacturers' design flow rates in your inventory, but measure flow rates anyway. Actual flow rates are affected by water pressure, condition of the plumbing, and age of the fixture. Faucets may be equipped with aerators; if so, measure flow rates with and without the aerators (more data!). Unsure how to measure flow rates? A measurement procedure is outlined in Appendix D.
- Measure the square footage of landscaped areas and update or revise landscape and irrigation plans.
- Identify irrigation system controllers/timers and determine the number of stations served by each controller. Figure out how often each station is activated (once a day, once every three days?) and for how long. Determine if there are rain or moisture sensors that determine

Useful Terms

- *Gallons per flush or gpf. Volume of water used every time a toilet is flushed.*
- *Gallons per minute or gpm. Rate at which water flows out of a fixture.*

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system activation; how many months in a year is the irrigation system active?

- Turn on each watering station in the irrigation system and (yes, you might get wet):
    - Inspect all water delivery devices (sprinkler heads, bubblers, drip emitters, etc.) and note malfunctions, wetting of paved areas, lack of coverage in landscaped areas (if any), consistency of coverage.
    - Sketch out on site plans the area irrigated by each device.
    - Conduct spot checks of irrigation depth after a prescribed watering period to see if the plant materials are being watered properly (consult gardening handbooks for appropriate watering depths for each plant type).
- Measure water pressure at one or more outdoor locations; most hardware stores sell simple pressure gages in their gardening sections. A gage can be screwed-on at a convenient hose bib and by opening the faucet you get a reading of water pressure in pounds per square inch (psi). Expect water pressures between 30 and 60 psi. Pressures outside this range are worth noting.
- Identify the make/model of clothes washers and determine their water use per cycle (the easiest way is probably to check with the washer manufacturer).
- Identify the make/model of dishwashers and determine their water use per cycle. Check to see if appliance is on the list of "Energy Star" appliances published by the U.S. Environmental Protection Agency.

Do I Have Enough Data Now?

For the moment you should have enough information to understand where the water on the bills is going. This may be a good time to:

- Organize the data, perhaps prepare a few summary tables, graphs, or charts.
- Clean up your sketches and site plans.
- Make a list of repairs that are needed right away.
- List important observations revealed by the walk-through such as underutilized common areas, wasteful outdoor water use (car washing, sidewalk cleaning, irrigation during wet season), very old fixtures, low water pressure, etc.

Facts About Clothes Washers

- *"Standard" efficiency units may use upwards of 35 gallons per cycle.*
- *The water use of high-efficiency or "Energy Star" washers can vary significantly: a study conducted for the Southern California Edison Company in December 2000 found volumes ranging from 15.4 gallons per cycle to 27.4 gallons per cycle.*

Sample Water Audit Data Form – Indoor

Water Demand Analysis – Indoors

Property: (name and/or address) ______________________________

Date: ______________________________ Apartment Number: ______________________________

Type of Unit (Circle One): Studio 1BR 2BR 3BR

Toilets

	Make/Model	Design Flush Volume (gpf)	Measured Flush Volume (gpf)
1.			
2.			
3.			

Showerheads

	Measured Flow Rate (gpm)
1.	
2.	

Faucets

	Measured Flow Rate (gpm)	
	With Aerator	Without Aerator
1.		
2.		
3.		
4.		
5.		

Dishwasher

	Make/Model	Efficiency Settings? (Y/N)	Water Use per Cycle (gallons)
1.			

In-Unit Clothes Washer

	Make/Model	Standard or High Efficiency?	Water Use per Cycle (gallons)
1.			

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Sample Water Audit Data Form – Outdoor

Water Demand Analysis – Outdoors
Property: (name and/or address) ____
Date: ____

Square Footage of Landscaped Areas/Turf (Refer to Site Plan for Location of numbered Areas)

Area Number	Length (feet)	Width (feet)	Area in sq ft (LxW)
1			
2			
3			
4			

Flowerbeds

Area Number	Length (feet)	Width (feet)	Area in sq ft (LxW)
5			
6			
7			

Plant Type 1

Area Number	Length (feet)	Width (feet)	Area in sq ft (LxW)
8			
9			

Plant Type 2

Area Number	Length (feet)	Width (feet)	Area in sq ft (LxW)
10			
11			
12			

Sprinkler System Data (Locate system controllers, sprinkler heads on site plans)

	Stations	No. of Sprinklers	Irrigated Area (sq ft)
Controller A	A1		
	A2		
	A3		
	A4		
Controller B	B1		
	B2		
Deficient sprinkler heads: (identify by station number)			
Under-irrigated areas: (identify by area number)			
Over-irrigated areas: (identify by area number)			
Leaky valves: (identify by station number)			
Anti-siphon valve placement: (identify any valves that are not at least one foot higher than highest sprinkler head in loop)			

Outdoor Faucets (Hose Bibs)

	Flow Rate (gpm)
1	
2	
3	

STEP 3: WATER SAVINGS ASSESSMENT

Now that you know how water is used in the property, you need to assess conservation potential—where and how much water can be saved. This section deals strictly with the water-saving aspect of conservation. The question of cost, i.e. how much will be saved on water bills and how much needs to be spent to then start saving, will be addressed in the next section.

Flush volumes and flow rates higher than the values shown below present an opportunity for conservation. Note that small variations (say, within ten percent of the values shown) may reflect inaccuracies in measurement or slight malfunctions of water-conserving fixtures. Some ultra-low flush toilets, for example, are supposed to flush 1.6 gallons but may actually flush somewhere between 1.6 and 2.0 gallons, depending on the water level in the tank and the quality of the flapper value. If the fixture is already rated (designed for) 1.6 gpf, you should adjust the water level or replace the flapper valve rather than replace the toilet.

Clothes washers are either standard or high-efficiency. Standard efficiency clothes washers generally use 35–45 gallons of water per normal cycle. High-efficiency clothes

Clothes Washer Use

A recent (2001) national study of laundry water use in multi-housing found that residents with in-unit clothes washers used 3.3 times more water for laundry than residents in apartments with common-area laundry facilities. The conversion from in-unit to common area washers, if feasible, presents a clear opportunity for conservation.

Volumes of Water Used by Water-Conserving Fixtures

Fixture	Maximum Water Used	Comments
Toilets	1.6 gpf	The Energy Policy Act of 1992 (EP Act) established a national manufacturing standard of 1.6 gpf for most toilets. That means that if you are buying a toilet most of the models you consider will be 1.6 gpf fixtures.
Showerheads	2.5 gpm per EP Act	Showerheads installed prior to 1993 are usually rated above 2.5 gpm, often between 3 and 5 gpm. Actual water use during showers, with either standard or low-flow showerheads, depends on individual preferences. Properly designed low-flow showerheads are available to provide the quality of service found in higher-volume models.
Bathroom Faucets Kitchen Faucets	2.2 gpm 2.5 gpm per EP Act	Pre-1993 faucets are usually rated at 3 to 5 gpm; lower flow rates (between 1 and 2 gpm) can be achieved by installing screw-on aerators.
Urinals	1.0 gpf per EP Act	Low-flow urinals are usually of the washout or siphon-jet types; at least two models of waterless urinals are also available.

washers use from 15 to 25 gallons per normal cycle. Replacement of standard efficiency washers presents a clear opportunity for conservation.

Dishwashers use from 4.5 to 10 gallons per cycle. The older models are in the 7-to-10 gallon per cycle range; some newer models are more efficient and use right around 5 gallons per cycle. An Ohio State University study found that washing a load of dishes by hand required on the average 16 gallons of water. Installation of dishwashers, where feasible, presents a clear opportunity for conservation.

Potential for outdoor water conservation exists if any of the following holds true:

- Is car washing allowed in the property?
- If the property has irrigated landscaped areas:
    - Are sprinklers used?
    - Are soil moisture or rain sensors used to defer irrigation?
    - Are there large lawn areas?
    - Are there narrow strips of turf?
    - Are there plants and trees known to consume large volumes of water?
- Does the property have ponds or fountains without a recirculating water system?
- Does the property have a single water meter for indoor and outdoor water uses?

How Much Water Can Be Saved Indoors?

Now you get to use the data you collected and do a little "number crunching." To calculate potential water savings from indoor uses you need data on frequency of fixture/appliance use (i.e. how often are toilets flushed, how long are faucets and showerheads used, how many loads of washing are done). Very few properties have such data available and developing this information is a complex and time-consuming process. In all likelihood you will have to use the "educated guesses" provided below. Unfortunately there are no definitive frequency-of-use averages for fixtures/appliances in multi-family rental properties. The "educated guesses" below were derived from data on single-family use and some small-scale studies on multi-family use. If you would like to review the research on which these numbers are based you can check *Retrofit Water Conservation Strategies for Multi-Family Housing* at http://www.pathnet.org/publications/water.pdf.

Toilet Use

Unless you have information to the contrary, assume 5 flushes per person per day. If an apartment has one 3.5 gallon per flush toilet and houses two people, you may calculate daily toilet water use in that apartment as follows:

Daily toilet water use = (2 people) x (5 flushes/person) x (3.5 gallons/flush) = 35 gallons

Water can be saved from toilet use in a number of ways:

- **Replace toilet:** A new fixture would have a flush volume of 1.6 gpf. If the toilet in the example above were replaced, 1.9 gallons per flush would be saved, or 19 gallons in one day for that particular apartment.
- **Insert displacement device:** Generally you should consider this option only for toilets with large tanks (3.5 gallons or larger); the volume of water saved will depend on the device inserted. An aver-

age savings from displacement devices of 0.3 gallons per flush is a reasonable estimate. For ten flushes a day the displacement device would save 3 gallons.

- **Install quick-closing flapper valve:** The flapper valve is the mechanism that lets water into the toilet bowl when the flushing lever is pushed, and closes to end the flushing process. The volume of water saved from installing these devices depends on the before and after flush volumes. If no better data is available, you may assume that on the average 0.4 gallons per flush are saved. For ten flushes a day the quick-closing flapper would save on the average 4 gallons.
- **Install water level adjustment:** Special flushing levers are available that offer the option of a partial or a full flush. Assume that such devices will save roughly the same as a displacement device, or 0.3 gallons per flush.
- **Repair leaky toilets:** You should have identified the number of leaky toilets during the water audit. The volume of water that can be saved from repairing those leaks can vary depending on the nature of each leak; some toilets have been recorded to leak over 100 gallons a day. If there is no accurate information on the nature of each leak, it is safe to assume an average savings of about 5 gallons a day per toilet that gets fixed.

Showerhead Use

Unless you have information to the contrary, assume 5 minutes of showerhead usage per person per day. Assume also that replacing a non-conserving showerhead with a low-flow fixture will save on the average 0.75 gallons per minute at the normal usage rate (not full open).

Faucet Use

Water savings from installing aerators on bathroom and kitchen faucets can be estimated to average 0.7 gallons per minute at normal usage rates. How many minutes a day are faucets used? It will depend among other things on whether the apartment has a dishwasher or not. For a rough estimate of water savings assume 8 minutes of faucet use per person per day for units with a dishwasher, 10 minutes otherwise.

Clothes Washing

Water savings from replacing in-unit clothes washers with high efficiency models will depend on the water use of the before and after machines, which can be obtained from the manufacturers. If these numbers are hard to come by you may use an estimated savings of 15 gallons per load. The other question remaining is how many loads of washing do apartment dwellers typically do per day or per week? You may be able to come up with a good estimate for the property in question. If not, assume 0.35 loads (cycles) per person per day to roughly estimate water savings.

Note that the calculation in the box to the right is not per machine but per number of affected residents. If you plan to replace 50 machines, for example, you would figure out the number of people residing in those 50 units. When you insert that number in the equation above you obtain the total daily water savings from the 50 machines.

Water savings from replacing common area clothes washers with high-efficiency units will also depend on the water use of the before and after machines. The frequency of

Toilet Savings

Daily toilet water use = (number of residents) x (5 minutes/resident) x (0.75 gallons/minute)

Showerhead Savings

Daily water savings = (number of residents) x (5 minutes/resident) x (0.75 gallons/minute)

Faucet Use Savings

For Units with Dishwashers:

Daily water savings = (number of residents) x (8 minutes/resident) x (0.70 gallons/minute)

For Units without Dishwashers:

Daily water savings = (number of residents) x (10 minutes/resident) x (0.70 gallons/minute)

In-Unit Clothes Washer Savings

Daily water savings = (number of residents) x (0.35 cycles/resident) x (15 gallons/cycle)

Common Area Clothes Washer Savings

Daily water savings = (number of residents) x (0.10 cycles/resident) x (15 gallons/cycle)

Converting In-Unit to Common Area Clothes Washers

Current in-unit water use = (number of residents) x (0.35 cycles/resident) x (35 gallons/cycle)

Future water use = (number of residents) x (0.10 cycles/resident) x (20 gallons/cycle)

Daily water savings = current water use – future water use

use for the common area machines may be available, especially if they are coin-operated washers. If that is the case, add up the number of daily cycles for all machines in the laundry facility and multiply by the anticipated savings per cycle to obtain daily water savings. If the frequency of use is not available, an average of 0.1 cycles per person per day can be used (based on a recent study in Toronto, Canada, on 945 apartments).

The number of residents used to compute common area clothes washer savings should be the number of people residing in units without clothes washers.

If you were to make the transition from in-unit clothes washers to common area laundry facilities, the estimated water savings can be computed using the information provided above. You may start by calculating current daily water use from in-unit machines; if the volume of water used per cycle is not known, use 35 gallons per cycle as a reasonable approximation for standard efficiency machines.

Dish Washing

Dishwashers use less water than hand washing. Although definitive figures for apartment buildings are not available, an estimated average savings of 2 gallons per person per day is reasonable, based on data from studies of single-family water use.

How Much Water Can Be Saved Outdoors?

Water savings from outdoor water use are difficult to generalize, as each property has its own set of conditions, types of equipment, and irrigation practices. Water use patterns will also differ significantly between hot, arid climates of the south and southwest and more temperate and "wet" northern areas. For properties with extensive landscaping, you may consider getting help from a landscape architect or an irrigation or landscaping company to assess the property's outdoor water requirements. Want to tackle the assessment yourself? The following guidelines should prove useful:

- Assess how much water outdoor faucets or hose bibs use. Is car washing allowed on the premises? Are hoses used for irrigation? In either case you may consider restricting faucet use by installing a fixture that requires a special key to activate the faucet. Water use at those locations may be curtailed by as much as 50 percent with restrictive devices.
- If the property has irrigated landscaped areas, try to determine how much water is used in irrigation. You may compare water usage in months with and without irrigation, for example, July and February. The difference in usage may be attributable to irrigation, assuming similar levels of occupancy and no other special circumstances that can affect water usage.
- Are sprinklers used for irrigation? Consider that drip irrigation systems could use 25 to 75 percent less water than sprinklers.
- Are soil moisture or rain sensors used to adjust irrigation schedules? Consider that proper adjustment of irrigation schedules may reduce irrigation use by 5 to 10 percent.
- Are there large lawn areas on the property? Consider that to provide one inch of water to an area of one thousand square feet (roughly the size of half a singles tennis court) requires 624 gallons. Throughout the year, a lawn in California may get 30 inches of irriga-

tion water (or 18,720 gallons for the thousand square foot area) on top of what it gets from rainfall, more in some places. Reducing lawn areas is a powerful conservation tool.

- Are there narrow strips of turf on the property? A study in northern California found that narrow strips frequently use as much as four times the amount of water such an area would normally require. Eliminating narrow strips of turf is one of the most effective conservation measures.
- Are there non-native plants on the property that may use large volumes of water? Studies conducted in California, Arizona, and Texas found that replacing conventional landscapes with low water use and native plants reduced outdoor water use from 19 percent (North Marin, California) to 43 percent (Austin, Texas). These studies were conducted in single-family settings and the water savings may not apply to your area or to multi-family settings in general. They are indicative, however, of a significant conservation potential from the use of native plants with low water consumption.
- Does the property have ponds or fountains without a recirculating system? Consider that a recirculation system will limit water use to the replacement of water that evaporates from the pond or fountain. This is a small volume of water compared to the total volume needed to refill the entire pond/fountain.
- Does the property have a single meter for indoor and outdoor water uses? Appreciation of the amounts of water saved by common areas may lead to the implementation of conservation measures. While separate meters by themselves do not save any water, increased awareness may reduce outdoor water use by 5 to 10 percent.

The second tip above suggested you figure out how much of the water on the property's bill goes to irrigation. But do you know if that is the proper volume of water to irrigate the type of landscaping on the property? Perhaps the landscaped areas are over-irrigated and water is being wasted. You want to find out if irrigation schedules are adjusted seasonally. Properties with extensive landscaped areas may use computers with special software to monitor sensors and control the amount of water applied to turf and various plant types; computer modems may be linked to weatherstations that provide evapotranspiration (ET) data.

What is Evapotranspiration or ET?

ET refers to the evaporation of water from the soil and water transpiration through plant surfaces. ET values in inches of water per day (or any other time period) indicate how much water should be applied to make up for the losses to the atmosphere. Some of it may be made up by rain, the rest has to be provided through irrigation. Each type of planted material has its own coefficient indicating what fraction of the base ET value will provide sufficient water to its roots.

Austin Weather Station
08/12/01–08/18/01

Date	Eto (in)	Tmax (F)	Tmin (F)	Rain (in)	Wind 4am (mph)	Wind 4pm (mph)
8/12/01	0.23	99	77	0.03	1.04	3.35
8/13/01	0.22	99	75	0.02	1.82	3.21
8/14/01	0.14	91	74	0.04	0.75	2.45
8/15/01	0.21	98	70	0.03	0.40	3.02
8/16/01	0.19	97	77	0.00	1.47	3.73
8/17/01	0.20	97	74	0.00	0.40	3.25
8/18/01	0.24	100	76	0.00	2.44	4.29
7 Day Summary	**1.43**	**97**	**75**	**0.12**	**1.19**	**3.33**

Irving Weather Station
08/12/01–08/18/01

Date	Eto (in)	Tmax (F)	Tmin (F)	Rain (in)	Wind 4am (mph)	Wind 4pm (mph)
8/12/01	0.25	100	82	0.02	0.23	0.48
8/13/01	0.16	91	80	0.01	0.00	2.03
8/14/01	0.27	95	80	0.00	0.00	2.92
8/15/01	0.26	100	78	0.00	2.84	5.56
8/16/01	0.13	89	77	0.04	6.67	0.02
8/17/01	0.07	83	73	1.13	0.57	0.02
8/18/01	0.20	95	75	0.00	0.00	0.86
7 Day Summary	**1.34**	**93**	**78**	**1.20**	**1.47**	**1.70**

WATER CONSERVATION

ET values change significantly from one location to the next. Locations with hot, dry weather have higher ET values.

Irrigation requirements (ET minus rain) can vary substantially within the same region. Data from the nearest weather station should be used. Consider, for example, the data from weather stations in Austin and Irving (Texas) for one week during the summer of 2001 (from Texas ET, a service of the Texas A&M University System).

While temperatures and base ET values were similar in both weather stations, the irrigation requirement (ET minus rain) was 1.31 inches for Austin and only 0.14 inches for Irving during that week. One rainy day in Irving significantly reduced irrigation requirements in that area.

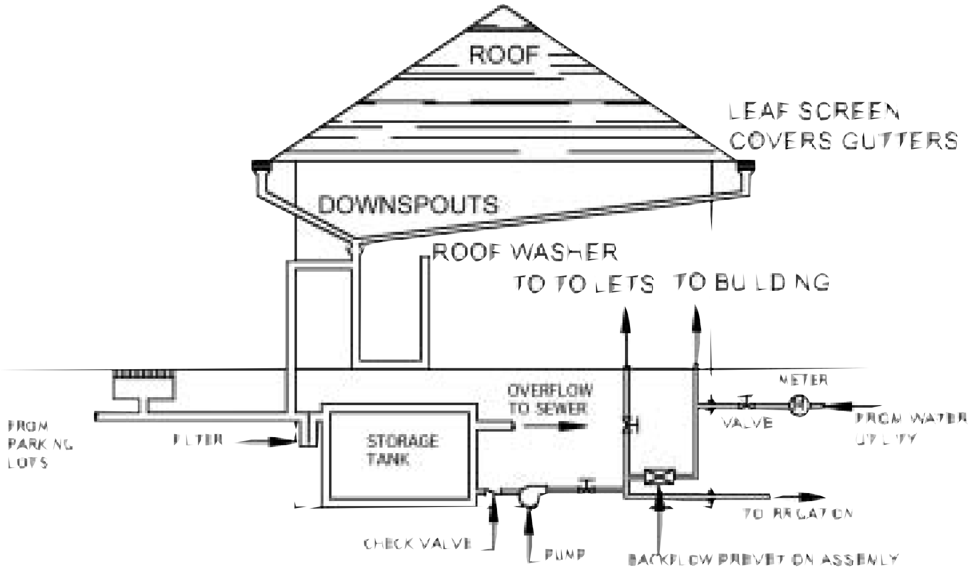
Getting a bit too complicated? Irrigation is indeed a complex matter. If irrigation water use at the property in question is more than 20 percent of the total water use, it would be advisable to have a professional review the landscape layout, irrigation system characteristics, and irrigation monitoring and scheduling.

Will Submetering Conserve Water?

Submetering, or charging residents for water based on volume of water used, is listed here as a water conservation retrofit strategy although its conservation potential has yet to be conclusively demonstrated. Companies that implement submetering services claim water use can be reduced by 10 to 40 percent through individual billing of each apartment unit. One realty company that owns over 75,000 apartment units throughout the country reported average water savings from submetering of between 20 and 30 percent of total use. Submetering studies in Seattle showed unpredictable and highly variable water savings, with some buildings showing good savings and others showing an increase in water use. Better data may soon be available from an ongoing submetering study at the national level, sponsored by several water utilities.

In some states and local jurisdictions, utility regulations prevent apartment owners and managers from charging residents directly for their water usage. Before considering submetering or some other method of allocating portions of the property's water bill among residents, you should check local and state regulations or consult your water provider.

The volume of water saved through submetering, if any, will depend on a number of factors including the cost of water and socioeconomic and demographic factors (location, income level, age of residents, etc.). You should consult submetering companies in your area and assess their claims of water savings carefully. Property owners who recently implemented submetering systems also would be good sources of information. Keep in mind that the first few months after implementation may not be indicative of long-term patterns of water use; it would be best to look at programs that have been in place at least a year or two.



Typical Rainwater Collection System

How Much Water Will Less Traditional Water Systems Save?

Below are descriptions of three non-traditional water strategies and their water conservation potential. Please refer to the list of relevant publications in Appendix A for more detailed information.

Rainwater Collection

Rainwater collection or rainwater harvesting technology makes use of the "free" water that falls to the ground as precipitation. A rainwater harvesting system concentrates and collects rain falling on roofs and grounds for direct use and storage; water may be collected or harvested from concrete patios, driveways and other paved areas. The water may be used for landscape irrigation and in some cases for toilet flushing. Local regulations will impact the possible uses of the rainwater collected.

Successful implementation of large-scale rainwater harvesting systems requires a suitable climate that affords periodic rainfall throughout the year. Low rainfall and/or extended dry periods limit the reliability and effectiveness of a rainwater harvesting system. The most economically viable systems are likely to have small storage capacities that supplement rather than replace water supplies from local utilities.

Rainwater harvesting is a common practice in some parts of the world and is gaining acceptance in the United States, particularly in Hawaii, the Southwest, and Texas, where summer rain is common. The Water Conservation Division of Austin, Texas, provides rebates for the installation of rainwater systems and indicates that construction of cisterns has increased significantly in Texas in recent years. Albuquerque, New Mexico, provides a free 27-page publication entitled *Rainwater Harvesting, Supply from the Sky*, which includes detailed guidelines on how to design and implement such a system. *The*

Is a Rainwater System Feasible?

Start by looking at the possible uses of rainwater:

- *Is there substantial landscaping on the property?*
- *Is it feasible to install separate piping for toilets at a relatively low cost?*

If the answer is yes to either question, the next important consideration is rainfall. Distribution is more important than quantity and summer rain is highly desirable, especially if you plan to use this water for irrigation.

The next step would be the sizing of the storage tank and the preliminary design of the collection and distribution systems.

What is Gray Water?

Gray water is untreated wastewater that has not been contaminated by any toilet discharge, affected by infectious, contaminated or unhealthy bodily wastes, and presents no threat from contamination by unhealthful processing, manufacturing, or operating wastes.

The California Water Code (Section 14875-14877.3)

Is a Gray Water System Feasible?

First determine whether local utilities and health officials allow such a system. In some cases the state may allow gray water systems while the municipality does not. Then look at possible end uses such as toilet flushing and irrigation. Regulations come into play, as most states allow only underground irrigation (no sprinklers) with gray water.

Second, is it economically viable to change the property's plumbing system? This would require major structural work and is unlikely to be viable in older mid- and high-rise properties unless a major renovation is under way.

Texas Guide to Rainwater Harvesting, published by the Texas Water Development Board, provides similar information.

The volume of water saved by the installation of a rainwater collection system will depend on a number of factors. The amount of rainfall, the area of the catchment surface, and the runoff coefficient of the catchment surface (how much of the water falling on the surface makes it to storage), will determine the available water supply. The storage capacity of the collection tanks and the capacity of the filters, pumps, and distribution system will determine how much of the collected water is used.

Gray Water

Gray water is generally defined as water from the bath, shower, clothes washers, and bathroom sinks. In a water recycling system the "used" water is taken to an on-site treatment facility where solids, soaps, and bacteria are settled out or removed. The treated water is stored and/or distributed to end uses that may include irrigation and toilet flushing. Aside from the treatment facilities, gray water systems require supply pipes separate from the potable water piping.

The use of gray water is strictly regulated in most states. The primary concern of regulators and health officials is that gray water may result in water quality problems that pose a threat to public health. Regulations invariably prohibit gray water systems from being connected to potable water systems; cross-connections are typically avoided with air-gaps (a physical opening to the atmosphere between the two systems that does not allow flow from one system to enter the other). Regulations also preclude the use of water containing hazardous wastes or water that comes from the soiling of diapers or similar garments. Storage tanks for gray water usually require a cover to prevent contamination and mosquito breeding. Some regulations also address maintenance requirements. Some of the location-specific limitations/constraints are listed in Appendix E.

Gray water systems can save a lot of water. Toilet flushing alone can represent from a quarter to a third of total water use, as data from your water audit will indicate. If the property has extensive landscaping, the gray water system can provide some of the irrigation water as well.

Hybrid Collection-Recycling Systems

Hybrid systems use both rainwater and gray water from bathroom sinks, showers, and clothes washers as their source of water. The source water is typically treated and then distributed to irrigation systems and/or toilets. Excess water is discharged to the sewer. These systems are subject to the same regulatory constraints imposed on individual rainwater collection and water recycling systems. Water savings for hybrid systems will be higher than those for individual rainwater collection and water recycling systems, because they have two sources of supply.

STEP 4: STRATEGY SELECTION

Indoor Retrofit Strategies

- Quick payback strategies
  - Low-flow faucet aerators
  - Low-flow showerheads
  - Toilet inserts
  - Leak detection and repair
- Utility financed strategies
  - Toilets through direct-install programs
  - Install devices available free of charge in water conservation kits
- Strategies involving utility rebates
- Strategies involving manufacturer discounts
- Submetering

Outdoor Retrofit Strategies

- Eliminate narrow strips of turf
- Reduce lawn areas
- Use separate water meters
- Install soil moisture or rain sensors
- Install special hose bibs
- Replace sprinklers with drip irrigation systems
- Landscape with native plants

Alternative Strategies

- Install rainwater collection systems
- Recycle water for landscape
- Install hybrid rainwater collection and recycling systems

You are now aware of several ways in which water can be saved, and have a rough idea of how much you can reduce water consumption. It is time to decide which strategy makes the most sense, and that generally means how much is it going to cost. Conserving water for altruistic reasons is commendable, and protecting the environment and preserving our water resources should be everyone's concern. But the possibility of conserving water to save money is probably what got you this job in the first place, and it is certainly going to be high in the property owner's list of priorities.

A study conducted in parallel with the development of this guidebook (*Retrofit Water Conservation Strategies for Multi-Family Housing*, available online from HUD at http://www.pathnet.org/publications/water.pdf) defined the most cost-effective retrofit alternatives for apartment buildings. The top 20 measures are listed in the box on the left. Most of them were addressed in the previous section in terms of water savings. All of them are addressed in this section in terms of cost of implementation.

WATER CONSERVATION

Water Utility Incentives

- *Installation of ultra-low flush toilets at no cost to the property owner*
- *Rebates on owner-installed toilets*
- *Rebates on efficient irrigation systems up to pre-established limits*
- *Rebates for the installation of high-efficiency clothes washers*

See Appendix B for a listing of 27 incentive programs throughout the country. Contact your local utilities for current information.

How Much Is It Going to Cost?

The costs of implementing water conservation strategies include capital costs (materials, equipment), installation costs (labor), and in some cases operation and maintenance costs. If you are an independent contractor, your costs (planning and design) should also be included as part of what the property owner will want to recover from savings in water and energy bills.

Material and labor costs vary from one region to another. If you want accurate costs that are directly applicable to the property in question, some research would be advisable. Contact local hardware stores, plumbers, retrofit specialists, and appliance manufacturers to get cost information. Or you can use the cost ranges presented in Table 1 on page 19 to make preliminary assessments. Also keep in mind that actual costs may vary.

One fact cannot be stressed enough: costs for the property in question may differ substantially from those presented in Table 1. Costs depend on owner preferences, labor and material costs at a particular location, and on whether in-house or outside labor is used. Labor rates at some locations may be half of those quoted. Material costs can have wide ranges. Showerheads, for example, can be purchased for as little as $2 each, but there are models that cost over $20. Flapper valves for toilets can cost anywhere from $2 to $10. In some cases small devices such as showerheads, aerators, and toilet displacement devices can be obtained free of charge from the water utility. The incentive programs offered by the local water utility can play a significant role in the decision-making process.

Submetering costs vary widely from one region to another, even from one property to the next. Property owners have a number of options when considering a submetering system:

- Hire a large company with offices nationwide
- Hire a local contractor specialized in submetering services
- Implement the systems on their own, as some of the larger property owners have done
- Use a combination of the above.

A large apartment company, owners of more than 250 apartment communities nationwide, reportedly tested all of the available alternatives and concluded that soliciting bids among local contractors suited their needs best. Other property owners may reach different conclusions.

What About Other Alternatives?

Cost estimates for implementing alternative water strategies are presented on page 20.

TABLE 1: ESTIMATED COSTS OF IMPLEMENTATION FOR RETROFIT STRATEGIES

Retrofit Strategy	Cost per Individual Retrofit
Install low-flow faucet aerators	$2
Install low-flow showerheads	$5 – $17
Install toilet displacement devices	$1
Install quick-closing flappers in toilets	$14 – $22
Adjust water level in toilets	$20 – $32
Detect and repair toilet leaks	$11 – $29
Detect and repair faucet leaks	$6
Detect and repair showerhead leaks	$6 – $10
Install toilets through direct-install programs	Costs paid by utility
Install free aerators, showerheads, toilet inserts	$12 installation cost per set for each apartment unit
Install toilets through rebate programs	Utility pays rebate amount, property owner pays remainder plus installation
Install clothes washers through rebate programs	Cost to property owner depends on amount of rebate, cost of washer selected: consider only incremental cost of high-efficiency washers (cost above that of standard efficiency washers)
Install toilets through high volume discounts	$110 – $200
Install clothes washers through high volume discounts	Incremental costs depend on washer selected; there is great variability in prices, roughly from $600 to $1,600 per high-efficiency machine.
Submetering	$225 to $500 per apartment unit, $2 – $3 per month per account for operation and maintenance
Eliminate narrow strips of turf	$60 per hundred square feet
Reduce lawn areas	$300 per thousand square feet
Use separate water meters for outdoor uses	$100 + for installed meter, $200 or more per year for meter charges
Install soil moisture or rain sensors	$80 – $120
Install restrictors on hose bibs	$28
Replace sprinklers with drip systems	$1 – $1.50 per square foot, about $720 per year per thousand square foot for maintenance
Landscape with native plants	$3 – $6 per square foot of landscaped area

The costs presented above are based several assumptions. Device or material costs were obtained from large manufacturers/providers throughout the United States. Labor costs were assumed at $36 per hour for a laborer and $60 per hour for a technician or a plumber. The times required to complete the various tasks were approximated from literature on the subject and/or information from professionals in the field.

WATER CONSERVATION

Rainwater Collection Systems

The cost of rainwater collection systems can vary widely, depending primarily on the size and complexity of the system. One of the most costly components is the water storage tank; underground cisterns can easily cost from $2 to $4 per gallon of storage, even more in some areas. Plastic or fiberglass tanks installed above ground may cost under $0.50 per gallon of storage, and above-surface ponds can be used to store water at lower cost. O&M costs will include periodic cleaning and disinfection of the cistern, filter replacement, valve and pump maintenance, and electricity costs for pump operation. Again, the O&M costs will depend on the design of the system and may vary widely. You should request cost estimates from companies that specialize in the installation of such systems; their representatives may even assist you with system design and offer cost saving ideas.

One important consideration when assessing costs of rainwater systems is the possibility that water storage may be required for flood control purposes. Some states require that buildings above a certain size provide storm detention facilities to reduce the chance of flooding and prevent erosion. If the costs of water storage tanks are covered by a separate project, rainwater systems become much more cost effective.

Gray Water Systems

The cost of gray water systems are very site-specific, and in all cases relatively high when compared to the cost of other retrofit alternatives. One apartment building in Ottawa reported $3,750 per unit for a gray water system that generated 33 gallons of gray water a day per unit. Another building in Vancouver reported $6,000 per unit for a system that can provide up to 274 gallons a day per unit. A gray water system planned (but not implemented) for an apartment complex in Los Angeles would have cost about $4,900 per unit and would have generated about 32 gallons a day per unit. Those costs did not include re-plumbing or operation and maintenance, both of which may be significant.

Gray water systems are likely to be viable only under special circumstances such as an impending property renovation, extremely limited capacity at local wastewater treatment plants, or very extensive irrigation. You would be well advised to request cost estimates from companies that specialize in the installation of water recycling systems; two such companies are included in the Resources section of this guidebook.

Hybrid Collection-Recycling Systems

Costs for hybrid systems will be similar to those for individual rainwater collection and water recycling systems. The hybrid systems tend to be more cost effective, as some facilities (piping, pumps, valves) can be shared. The hybrid system also removes concerns about quantity and distribution of rainfall, because recycling component can take up the slack in times of low precipitation.

Selecting the Right Strategies

Top reasons for selecting an alternative include:

- No cost to the property owner — if you have access to utility-financed strategies you should take advantage of them if at all possible

- Quick payback periods — the installation of low-flow showerheads, faucet aerators, and toilet displacement devices, as well as leak repair, generally pay for themselves in two years or less.

Selection of other alternatives will require some additional "number crunching." One of the simpler approaches is to determine each alternative's benefit/cost ratio and use that as the selection criterion. A benefit/cost ratio of 1.0 implies that the benefits match the costs; values higher than 1.0 imply that

Table 2: How to Estimate a Strategy's Benefits and Costs

1. Define the gallons of water saved per year by the implementation of the strategy; if you have gallons saved per day per device (from the calculations outlined in the Water Savings Assessment section of this guidebook), multiply by number of devices and by 365 (days in a year).

2. Define the estimated number of years that you expect the strategy to provide water savings. The following values are suggested; a maximum life of 20 years was assumed for the longer-lasting retrofit strategies (you may use your own, especially if you have data on how long certain fixtures typically last):

Toilets	20	Reduce lawn areas	20
Showerheads	10	Install moisture sensors	10
Aerators	10	Replace sprinklers with drip	10
Toilet displacement devices	5	Landscape with native plants	20
Toilet flapper valves	5	Flow restrictors on hose bibs	10
Toilet level adjustment	2	Separate meters	20
Clothes washers	15	Submetering	10
Leak repair toilets, faucets	2	Rainwater collection	20
Leak repair showerheads	4	Water recycling	20
Eliminate strips of turf	20	Hybrid system	20

3. Define approximate dollar savings per gallon of water conserved; your review of water/sewer bills should have given you the cost of each gallon of water; if you have the costs per "ccf" of water remember that each ccf represents 748 gallons. Be careful with your cost figures; sewer costs are usually tied to water usage, but not always; if you have separate meters for outdoor use there may not be sewage charges on outdoor uses. For clothes washers you should include energy savings.

4. Define implementation costs for strategy, including planning and preparation costs. Remember to add operation and maintenance costs to the few strategies that require it; multiply the annual O&M costs by the number of years the strategy is expected to provide savings. If rebates are involved, reduce the costs by the appropriate amount.
   - Total Costs = Preparation and planning + materials + labor + (O&M x Years) – (Rebates)

5. Now you can develop benefit/cost ratios as follows:
   - Benefits/Costs = (Gallons saved per year) x (Years) x (Dollars saved per gallon)/(Total costs)

benefits outweigh costs, and the higher the value the faster the strategy will pay for itself. Table 2 provides a quick and rough estimate of benefits and costs.

After conducting this process for each alternative under consideration you will be able to rank them in order of cost-effectiveness. It is important to note that the numbers you obtain will provide a relative ranking of strategies and not necessarily a true cost picture due to the following simplifying assumptions that were made:

- Volume of water saved per year was assumed constant; in reality these volumes may vary from year to year.
- The number of years that the strategy is assumed to provide water savings is a rough estimate that may differ from property to property.
- The dollar value of water savings was assumed constant; it actually depends on the cost of water, sewer, and energy, which may increase over time.
- The calculation of total costs neglects to take into account inflation and escalation of O&M costs over the years.

The relative ranking of strategies may also neglect some subjective albeit very real costs. The possible transition from in-unit to common area clothes washers, for example, could result in resident dissatisfaction due to increased expenditures for laundry and decreased levels of convenience; in-unit washer/dryer usually rank among the most highly favored apartment amenities. Resident dissatisfaction may adversely affect occupancy rates thereby impacting the property owner's bottom line.

STEP 5: IMPLEMENTATION PLAN

It was a long, difficult process but you have finally decided which retrofit strategies to pursue and have the property owner's approval. Now you should take a little time to develop a plan of action that will help you keep costs down, minimize disruption to residents, and expedite implementation so you can start conserving water right away.

Retrofitting Indoors

Indoor strategies you may have selected include leak detection and repair, installation of water-conserving devices (aerators, low-flow showerheads, toilet inserts), installation of ultra-low flush toilets and/or high-efficiency clothes washers, and submetering.

A few points to keep in mind:

- Residents should be informed of upcoming changes to their fixtures and appliances, or to the way in which they are billed for water. The notification should emphasize the positive aspects of water conservation to encourage residents' active participants in conservation efforts.
- Purchase or acquire all small devices (aerators, low-flow showerheads, toilet inserts) before installation, and get a few spares. Coordinate with your local water utility to acquire free devices where available.
- Ask maintenance staff to detect and repair all indoor leaks; do not wait for residents to report leaks. In some cases it may be more cost-effective to contract out this work. If you do, make sure someone verifies the work completed. Figure out how many apartments can be inspected and fixed per day and go through all housing units as rapidly as possible. It may be wise for the property owner to repeat this process every year.
- Ask maintenance staff to install faucet aerators, low-flow showerheads, and toilet inserts; do not give the devices to residents to install. Consider contracting out the work.
- Acquiring toilets requires some planning. You will want to use the same model toilet throughout, which may result in an order too large for local providers to satisfy right away. Getting all the toilets at once also implies being able to store them. You may want to figure out how many toilets can be installed per day or per week and program daily or weekly deliveries. Purchasing a large number of toilets represents a significant expenditure; the property owner may want to proceed in stages, such as retrofitting one wing of a building first and another wing six months or a year later. If rebates or direct-install programs are involved you will need to coordinate with the water

utility. Some utilities have lists of toilets they approve for rebates; others have lists of contractors available to perform installations. Consider contracting out the work.

- Acquiring clothes washers also requires careful planning. If you are transitioning from in-unit to common area laundry you will be reducing the number of washers in the building and will need to dispose of the old machines. They may be sold on the open market or for scrap; in either case transport will have to be arranged. If you are switching in-unit washers, a staged approach may again be advisable, considering individual washers cost more than $600. Coordinate with the water utility when rebates are involved.
- Submetering is a fairly complicated process best handled by people with experience. Even if you decide to handle it in-house you would be well advised to retain a consultant to guide you through the implementation. Legal advice is also important to ensure you comply with all regulations.

Retrofitting Outdoors

Outdoor strategies you may have selected include eliminating narrow strips of turf, reducing lawn areas, using separate water meters for irrigation, installing soil moisture or rain sensors, installing restrictors on hose bibs, replacing sprinklers with drip systems, and replacing traditional landscapes with native plants.

The most important point to remember is that landscaping/irrigation work should be handled by experienced personnel, whether in-house or on contract. You do not want to pay for someone's learning curve on this type of project. Use any resources offered by the local water utility; they may be able to conduct the outdoor water audit and help you decide what changes are most appropriate. They also may help you with guidelines for implementation.

Alternative Water Systems

The key to these systems is good design. Once the decision to proceed with some type of alternative water system is made, a professional should be retained to design the system. The designer's end product should be detailed drawings specifying the location, dimensions, and materials used for every component of the system. With the detailed drawings in hand you should be able to get bids from general contractors for the implementation of the system.

STEP 6: PERIODIC MONITORING

You have now retrofitted the property for water conservation. Congratulations! Maintaining the level of water savings you retrofitted for, however, is going to require some additional work. (The work of the conservationist is never done!)

The experience of many property owners who have retrofitted for water conservation found that after a few years (four to six, more in some cases) water use starts to creep up again. New toilets may start leaking, perhaps some faucet aerators were removed, toilet inserts reached their life expectancy, or personnel changes in the maintenance staff may have affected irrigation practices.

Implementation of a periodic monitoring program is an important step in the retrofitting sequence. You should leave in place the instruments by which retrofit performance is periodically evaluated. Such instruments may include:

- Determination of indoor water use per capita or per housing unit for each billing cycle: make sure building management knows how to arrive at these figures from the water/sewer bills and their occupancy records. Building management needs to know the volume of water that was used pre-retrofit, the post-retrofit expectations, and the point at which they need to reassess water use.
- Determination of outdoor water use: presumably the property is now equipped with a separate meter for outdoor water uses. Management should be aware of expected seasonal fluctuations as they track this water use, and they should have an acceptable range of water consumption for each billing cycle.
- Simplified audit procedures for indoor and outdoor water use: maintenance personnel should be trained on how to assess water use; procedures for reporting non-conserving practices or events should be established if they are not already in place.

The property owner needs to be aware that continued savings of water and money are only possible through the careful monitoring of water use and the development of a water conservation ethic.

WATER CONSERVATION ETHIC

Multi-family rental properties that have higher-than-average water consumption generally share one or more of the following characteristics:

- Residents seldom report leaks
- Property owners rarely (if ever) provide water conservation tips to residents
- Housing units have a poor plumbing maintenance history; management waits until a tenant complains that something is not working
- Property managers and maintenance staff have no understanding of the consequences of excessive indoor and outdoor water use
- Residents see no relationship between the amount of water they use and their cost to live in the property

The development of a water conservation ethic is essential to the long-term success of any retrofit strategy. Ensuring that none of the above characteristics are present will protect the volume and dependability of water savings.

RETROFIT RESOURCES

Below are resources to contact for more information about the water conservation strategies covered in this guidebook.

Customized Retrofit Kits

Niagara Conservation–Cedar Knolls, New Jersey

Gray Water Systems

Equaris Corporation–Plymouth, Maine

Oasis Designs–Santa Barbara, California

Landscape Irrigation

Best Management Partners–El Cerrito, California

Civil & Environmental Consultants, Inc.– Pittsburgh and Export, Pennsylvania; Cincinnati and Columbus, Ohio; Indianapolis, Indiana; Nashville, Tennessee; Downers Grove, Illinois; and Chesterfield, Missouri

James P. Channi Irrigation Design & Consultants, Inc.–Parma, Ohio

JBK Landscape, Inc.–Los Angeles, California

Keesan Water Management, Inc.–Denver, Colorado

Northern Rain Irrigation Contractors–Greendell, New Jersey

Water Management, Inc.–Alexandria, Virginia

Rainwater Systems

Captured Rainwater Company LC–Blanco, Texas

High Plains Nursery–Amarillo, Texas

Lonestar Exteriors and Collection Systems–Austin, Texas

Matt Bachardy Building Design–Wimberley, Texas

Tank Town–West Dripping Springs, Texas

Submetering

American Water & Energy Savers–Boca Raton, Florida

Aquacraft, Inc. - Boulder, Colorado

Aquameter–Columbus, Ohio

Best Management Partners–El Cerrito, California

Commercial Water–Miami, Florida

Minol MTR–Addison, Texas and Mountlake Terrace, Washington

National Exemption Service, Inc.–Largo, Florida

Omega Utilities Service–Indianapolis, Indiana

Schlumberger RMS, Inc.–Norcross, Georgia

Water Management, Inc.–Alexandria, Virginia

Wellspring International–San Diego, California

Water Savings Analysis

A & N Technical Services, Inc.–Encinitas, California

Aquacraft, Inc.–Boulder, Colorado

Best Management Partners–El Cerrito, California

Maddous Water Management–Alamo, California

National Exemption Service, Inc.–Largo, Florida

Schlumberger RMS, Inc.–Norcross, Georgia

Water Resources Engineering, Inc.,–San Francisco, California

Woodcock & Associates, Inc.–Wayland, Massachusetts

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APPENDICES

APPENDIX A. LIST OF RELATED PUBLICATIONS

Following is a list of publications that address topics related to water conservation for residential and non-residential settings. Guidebooks similar to this one are presented first, followed by more technical research papers. This list is by no means exhaustive and is intended to present a sampling of available literature on the subject.

GUIDEBOOKS

A Water Conservation Guide for Commercial, Institutional and Industrial Users
New Mexico Office of the State Engineer, Water Use and Conservation Bureau, July 1999.

A Water Conservation Guide For Public Utilities
New Mexico Office of the State Engineer, Water Use and Conservation Bureau, March 2001.

Drip Irrigation Guide
East Bay Municipal Utility District, Oakland, California, 1997.

Handbook of Water Use and Conservation
Vickers, Amy. Waterplow Press, Amherst, Massachusetts, 2001.

How to Conserve Water and Use It Effectively
U.S. Environmental Protection Agency, Office of Water, 1998.

Humanure Handbook: A Guide to Composting Human Manure
Jenkins Publishing, Grove City, Pennsylvania, July 1999.

Landscaping With Native Plants
Bowman, Cynthia. U.S. Environmental Protection Agency, January 2000.

Low Volume Irrigation Design and Installation Guide
City of Albuquerque, New Mexico, Water Conservation Office.

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Rainwater Harvesting, Supply From The Sky
City of Albuquerque, New Mexico, Water Resources Division.

Rainwater Harvesting: The Desert House
Desert Botanical Garden, Phoenix, Arizona, 1999.

The Complete How To Guide To Xeriscaping
City of Albuquerque, New Mexico, Water Conservation Office.

Xeriscape 101: A Step-By-Step Guide to Creating a Water-wise Yard
New Mexico Office of the State Engineer.

RESEARCH

Process Approach for Measuring Residential Water Use and Assessing Conservation Effectiveness
Mayer, P.W. and DeOreo, W.B. Journal of the American Water Works Association, 1995.

Residential End Uses of Water
Mayer, P. W., et al. American Water Works Association Research Foundation, 1999.

Residential Water Use Patterns
Baxter, J. W., Bowen, P. T., Harp, J. F., and Shull, R. D. American Water Works Association Research Foundation, 1993.

Retrofit Realities
Deoreo, W.B., Dietemann, A., Skeel, T., Mayer, P.W., Lewis, D.M., and Smith J. Journal of the American Water Works Association, March 2001.

The Impact of Water Conserving Plumbing Fixtures on Institutional and Multi-Family Water Use: Case Studies of Two Sites in Tampa, Florida
Report prepared for the City of Tampa Water Department, Water Conservation Section, by Ayres Associates, October 1993.

The Impact of Water Conserving Plumbing Fixtures on Residential Water Use Characteristics: A Case Study in Tampa, Florida
Report prepared for the City of Tampa Water Department, Water Conservation Section, by Stevens Institute of Technology and Ayres Associates, March 1993.

Water Saved by Single-Family Xeriscapes
Nelson, J.O. and Kruta, J.C. American Water Works National Conference, June 1994.

APPENDIX B.
WATER CONSERVATION INCENTIVES

Below are 27 localities that currently (or recently) offer water conservation incentives. Incentives change over time, so check with your local water utility for the most recent listing.

Albuquerque, New Mexico
Atlanta, Georgia
Austin, Texas
Boston, Massachusetts
Cary, North Carolina
Columbus, Ohio
Corvallis, Oregon
El Paso, Texas
Eugene, Oregon
Greensboro, North Carolina
Houston, Texas
Los Angeles, California
Marin County, California
Miami-Dade County, Florida
New York City, New York
North Miami Beach, Florida
Oakland, California
Phoenix, Arizona
San Antonio, Texas
San Diego, California
San Jose, California
Santa Clara County Water District, California
Santa Monica, California
Santa Rosa, California
Seattle, Washington
Tampa Bay, Florida
Tempe, Arizona

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Albuquerque, New Mexico

- **Ultra-low Flush Toilet (ULFT) Rebate Program:** Multi-family residential units receive a $75 rebate per toilet.
- **Residential Audit Program:** City reviews water use patterns and billing, checks for leaks, and assesses outdoor landscaping and sprinkler systems. Also installs of 2.5 gpm showerheads, high-efficiency faucet aerators, auto-shut off hose nozzles, and a toilet fill tube diverter or displacement device if needed.
- **High-Efficiency Clothes Washer Rebate Program:** $100 for each washer replaced.
- **Landscape Rebate Program:** Water bill credit of $0.25 for every square foot of qualifying landscape, to a maximum rebate of $700. Low-and medium-water-use plants must cover fifty percent of the project area at maturity. An inspector must approve the application before commencement of work.
- **Rainwater Harvesting:** Booklet titled *Rainwater Harvesting, Supply From The Sky* gives system design and construction information.
- City prohibits landscape watering between 10 a.m. and 6 p.m. April through October.
- A modest summer rate surcharge is added to water rates.

Atlanta, Georgia (DeKalb County)

- **Watering Restrictions:** No watering between 10 a.m. and 10 p.m., seven days a week. Odd numbered addresses water only odd days between 10 a.m. and 10 p.m., even numbered addresses water only even days between 10 a.m. and 10 p.m.
- **Xeriscape Program:** Landscape consultants visit residential sites and make water conservation recommendations; xeriscape brochures are made available to customers.
- **Low-flow Showerhead Program:** A free low-flow showerhead program is scheduled to be in effect by 2004.

Austin, Texas

- Free ULFT's and $30 installation credit, or rebates from $60 to $100.
- Free low-flow showerheads to replace older models.
- Information on submetering.
- **Clothes Washers:** Up to $250 rebate for replacing standard washers with high efficiency washers; this rebate applies to washers that are installed in common area laundry rooms.
- **Wash-Wise Program:** Up to $100 rebates to apartment and multi-family housing that are water customers; rebate is for in-unit water and energy efficient front-loading commercial clothes washers.
- **Rainwater Harvesting Program:** Rebate up to $500 on the cost of installing a rainwater harvesting system.
- Information on gray water systems.
- **Whole System Audit:** Free evaluation on all aspects of water consumption.
- **Irrigation System Rebates:** up to $150 for certain controllers, rain shutoff devices, pressure reducer value, and certain types of sprinkler heads.
- **Conservation Rate Structure:** Base unit water rate is based on peak and off-peak times of year.
- Revised Plumbing Code will require all new apartments to be plumbed for submetering.

- In 2003, a Texas state law will take effect requiring all water utilities to directly meter or submeter on all new properties.

Boston, Massachusetts

- Water conservation kits offered free to customers and include a low-flow showerhead, two faucet aerators, one toilet tank dam, and leak detection dye tablets.
- **Outdoor Water Use Efficiency:** The Massachusetts Water Resources Authority offers informational materials to customers.

Cary, North Carolina

- **Reclaimed Water System:** Provides non-potable reclaimed water for irrigation systems within the local retail service area.
- **Conservation Rate Structure:** Charges a higher unit rate to residential customers as level of consumption increases.
- **Watering Restrictions:** Odd/even day watering.
- **Water Waste Ordinance:** Prohibits wasteful outdoor watering that falls directly onto impervious surfaces.
- **Rain Sensor Ordinance:** Requires all irrigation systems to install a rain sensor.

Columbus, Ohio

- **Indoor Water Conservation Kit:** Offered free to customers, kits include two faucet aerators, one toilet tank displacement bag, leak detection tablets, and installation instructions.
- **Outdoor Water Conservation Kit:** Offered free to customers, kits include water savings tips and water gages (water grass no more than 1 inch per week).
- **High Bill Inspection (HBI) Program:** Indoor and outdoor water audits offered to customers concerned about high bills.
- **Submetering:** Information about submetering systems is made available to customers on request; implementation is up to the customer.

Corvallis, Oregon

- Perform water audits and give out water savings fixtures (showerheads, faucet aerators, toilet flappers, and toilet displacement devices).
- **Clothes Washer Rebate Program:** Offers $50 for the purchase and installation of a high efficiency clothes washer.
- **ULFT Rebate Program:** $25 rebate.

El Paso, Texas

- **Clothes Washer Rebate:** $200 for a horizontal-axis washing machine.
- **ULFT Rebate:** 75 percent rebate up to $100.
- **Turf Rebate Program:** Incentive to convert only turf areas that are already established to water efficient landscape designs and incorporate low water use plants and common sense horticulture practices that save water.

Eugene, Oregon

- Free low-flow showerheads and toilet flappers to customers.
- **ULFT Rebate Program:** $25 for the first toilet and $10 for each additional toilet
- Rebate for the purchase of a high efficiency clothes washer.

Greensboro, North Carolina

- Provide free low-flow showerheads and toilet flappers to complexes built prior to 1994.

Houston, Texas

- Water Conservation Kits that include toilet displacement bag, toilet tank, leak detection dye tablets, flow restrictor.

Los Angeles, California

- **ULFT Program:** The Metropolitan Water District (MWD) offers a rebate of $60 for replacing non-conserving toilets with ULFT's; the Los Angeles Department of Water and Power (LADWP) offers free ULFTs in exchange for non-ULFTs or $75 rebates for ULFTs.
- **Residential Clothes Washer Program:** MWD, in partnership with energy utilities, offers rebates from $85–$150 for installing a high efficiency clothes washer; the LADWP offers $150 in rebates for in-unit high efficiency washers and $250 for common area coin/card operated high efficiency washers.
- LADWP offers free 2.0 gpm showerheads and 1.0 gpm faucet aerators.
- **Conservation Rate Structure:** The base unit price for water is higher in the warm (summer) months and lower in the cooler (winter) months.

Marin County, California

- **ULFT Rebate Program:** $75 rebate.
- **Energy Star Clothes Washer Rebate Program:** $75 rebate to customers.
- **Customer Assistance Program:** Consultation of indoor water use; replaces high-water use fixtures (showerheads, aerators) free of cost.
- **Irrigation System Consultation Check:** During the summer months the top 20 percent of water users qualify for a consultation check. This entails looking for leaks and/or breaks in the system.
- A Time of Scale Practice is in the works, which will require installation of 1.6 gpf toilets before selling property.

Miami-Dade County, Florida

- Water conservation kits.

New York City, New York

- Free low-flow showerheads and toilet flappers in home water savings kits.

North Miami Beach, Florida

- **Showerhead Exchange Program:** Provides 2.5 gpm showerheads, 1.5 gpm faucet aerators, and toilet leak detection tablets.

Oakland, California; East Bay Municipal Utility District (EBMUD)

- Free on-site surveys of indoor and outdoor water use.
- Free showerheads and faucet aerators offered if existing fixtures are not low-flow models; toilet inserts also offered.
- **Landscape Program:** Must have separate outside meter to qualify for rebate. A representative will perform an audit on ways to enhance savings outdoors. If any of these suggestions are completed the utility will provide a rebate of 50–100 percent of the cost, includes rain sensors, drip systems etc.
- **Clothes Washer Rebates:** $150 for purchasing a residential high-efficiency Energy Star® rated clothes washers for in-unit facilities.

- **Commercial Clothes Washer Rebate:** $50 for purchasing a high-efficiency machine that meets Consortium for Energy Efficiency (CEE) standards for common laundry facilities.
- **Toilet Replacement Program:** ULFT rebates up to $50 per toilet replaced.
- **Direct ULFT Installation Program:** Free installation of ULFT's to replace higher-flush toilets.
- National Submetering Study, 2001–2002; managed by Richard Bennett of EBMUD and sponsored by several water utilities.

Phoenix, Arizona

- Perform on-site water audits and provide, when appropriate, free replacement showerheads.
- Recommend other measures and project savings from those measures.

San Antonio, Texas

- **ULFT Rebate Program:** $75 per toilet replaced.
- **Clothes Washer Rebate Program:** San Antonio Water System offers $100 and the CPS also offers $100 credit rebate for a possible total rebate amount of $200.
- **Xeriscape Program:** $0.10 per square foot for planning and installing a water saver landscape with a minimum conversion of 1,000 square feet ($100) and a maximum rebate of $500. If over 50 percent of the landscape is planted in turf only half credit will be given.

San Diego, California

- **ULFT Program:** Rebates for replacing a non-conserving toilet with a ULFT range from $60–$100 in the San Diego area: the Padre Dam Municipal Water District offers a rebate of $75; MWD offers a $60 rebate that may be complemented by local water utilities; the Helix Water District and the San Diego County Water Authority offer $75 and will pick up old toilets free of charge.
- **Horizontal-Axis Washing Machine Vouchers:** Vouchers up to $300 off the cost of new high-efficiency washing machines. The Padre Dam Municipal Water District and San Diego County Water Authority offer $125; MWD, in partnership with energy utilities, offers rebates of $85–$150; the Helix Water District offers up to $300 off the price of a coin-operated washer.
- **Residential Water Use Survey Program:** The Helix Water District offers the services of an expert surveyor who reviews indoor and outdoor water use for the entire complex and offers water-saving suggestions; low-flow showerheads and faucet aerators are provided free of charge. The Padre Dam Municipal Water District offers a similar service to multi-family accounts with above average annual water use.
- **Landscape Assistance Program:** Multi-family properties with at least one acre of landscaping qualify for an evaluation of water use. A surveyor will conduct an audit either by telephone or in person to determine water conservation opportunities. The same program is offered through the Helix Water District, the Padre Dam Municipal Water District, and the San Diego County Water Authority.

- **Public Information Program:** A speaker will come out to a meeting with the residents and cover water conservation topics tailored to their interests.

San Jose, California

- Water audits offered through San Jose Water.
- $40 cash back per ULFT installed with free delivery.

Santa Clara County Water District, California

- **ULFT Rebate Program:** Customer pays $15 per toilet, includes installation.
- **Survey/Audit Program:** Includes irrigation inspection for sites with less than one acre of landscaping; includes installation of showerheads, faucet aerators, toilet flappers, and/or toilet displacement devices.
- **Irrigation Technical Assistance Program (ITAP):** A large landscape audit program free for sites with more than one acre of landscaping.
- **Clothes Washer Rebate Program:** Amount depends on what city the complex is in.
- Free showerheads and faucet aerators can be ordered over the phone or on the internet.

Santa Monica, California

- **Direct-Install Program for Toilets:** Direct installation of ULFTs for $35 per toilet.
- **Tank Type ULFT Rebate Program:** Choose a tank type ultra low flow toilet (1.6 gallons per flush) to install from the city's list of approved water-saving fixtures for a $75 rebate.
- **Flushometer Valve Type ULFT Rebate Program:** Rebate of $150 for retrofitting flushometer valve (no tank) type toilets. The bowl must be replaced with a 1.6 gallons per flush bowl and the valve retrofitted with a 1.6 gallons per flush retrofit kit.
- Helpful water savings tips.
- Landscape ordinance regulating amount of turf, plant species, and irrigation systems.

Santa Rosa, California

- Offers free informational publications on landscape conservation.
- **Direct-Install Program:** Will pay the cost of materials and labor when participating plumbing contractors change toilet(s), showerheads and faucet aerators to low-flow models.
- **"Go Low-Flow" Plumbing Incentive Program:** Replace a minimum of one high flush-volume toilet with a low-flow model (1.6 gallons per flush), as well as change any showerheads and faucet aerators that do not meet the current flow-rate standards. Old toilet(s) need to be recycled at Waste Management and receive a rebate.
- **Horizontal-Axis (H-axis) Coin-Operated Clothes Washing Machine Rebate Program:** Rebate of $450 per top-loading coin-operated washing machine that is replaced with water conserving H-axis models.
- **Efficient Landscape Water Management Rebate Program:** Customers irrigating with city water through a dedicated irrigation meter can apply each year. Eligible customers can earn $500 for each acre-foot (325,851 gallons) of water savings below their Efficient Irrigation Goal each year.

Seattle, Washington

- $40 to $100 for replacing water-wasting toilet with a ULFT, depending on income and area.
- Free showerheads and toilet flappers to customers.
- **Laundry Wise Program:** Rebates between $50 and $150 per machine depending on property location.
- $250 rebate per coin-operated laundry machine.
- Information on submetering
- **Water Efficient Irrigation:** Funding for up to 50 percent of new equipment such as rain sensors and irrigation controllers
- **Home Water Saver Apartment/Condominium Program:** Program aimed at the multi-family residential sector, offering installation of low-flow showerheads and faucet aerators; aerators and low-flow showerheads remain available to apartment buildings free of charge upon request

Tampa Bay, Florida

- **Toilet Rebate Program:** Rebates to customers who replace high flush toilets with ULFT's; up to $100 for first toilet, $80 for second, and $60 for third; rebates are per apartment unit
- **Free Low-flow Fixtures:** Include a showerhead (2.5 gpm) and faucet aerators
- Free rain sensors
- **Irrigation Evaluation and Rebate Program:** Surveyor evaluates irrigation system and suggests ways to improve water efficiency; if suggested retrofits are completed, up to $3,500 rebated
- According to Florida state law, all new irrigation systems must include a rain sensor

Tempe, Arizona

- Water conservation kits that include a low-flow showerhead, 2 faucet aerators, a toilet dam, a toilet tummy, toilet tank bank, leak detection tablets, Teflon tape to install showerhead, and a water displacement bag
- Rebates for ultra-low flush toilets
- Rebates for low water use landscaping

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APPENDIX C. TOILET FLUSH VOLUME

Suggested Measurement Procedures

You can approximate a toilet's flush volume by measuring the volume of water that goes from the toilet tank into the toilet bowl when the flushing lever is pushed. All you need is a tape measure or long ruler to measure the length, width, and height of the "block" of water inside the tank. Note that the "height" of the flushed water is not the total depth: some water remains at the bottom of the tank during the flushing. You will need to measure both the total depth when the tank is full and the depth when the tank is at its lowest fill level. The difference of these two measurements represents the height of the flushed volume of water.

If you measure the length, width, and height of the water column in inches, the flush volume in gallons may be obtained from:

Flush Volume (gallons) =
(length) x (width) x
(full depth-near empty depth) x 0.0043

The 0.0043 is the conversion factor from cubic inches to gallons. If your tank is not a perfect rectangle take the average length and width. If there is a displacement device inside the tank you will need to figure out its volume and subtract it from the volume of the column of water.

A more exact measurement of flush volume requires that you take into account the water that is coming into the tank as it is draining. You will need a stop watch to measure the time it takes for the tank to drain and to fill back up (two separate measurements). The flush volume is then calculated by:

Flush Volume (gallons) = (length) x (width) x (full depth – near empty depth) x 0.0043 x [1 + (t1/t2)]

Where:

t1 = time from trip of handle to close of flapper (seconds)

t2 = time from close of flapper to refill of tank (seconds)

APPENDIX D. SHOWERHEAD/FAUCET FLOW RATES

SUGGESTED MEASUREMENT PROCEDURES

The term "flow rate" refers to a volume of fluid divided by a period of time. Engineers use units of "cubic feet (volume) per second (time)" or "million gallons (volume) per day (time)." When measuring flow rates from faucets and showerheads, a more convenient unit is "gallons (volume) per minute (time)" or "gpm."

By far the easiest way to measure flow rates from faucets and showerheads is to use flow-measuring bags, available in most hardware stores or from water utilities. These are simple plastic bags like the ones you would use at the produce section of the supermarket. The difference is that they come with markings that allow you to read flow rates directly. Most bags come with instructions on how to use them. Typically they call for 5-second measurements.

To measure flow rates using the flow measuring bags you will need the bag and a watch that allows you to measure seconds elapsed. Digital watches work best. If no watch is available, you can still use the bags but your measurements may be less accurate; just count slowly from one to five when you have to measure time.

- The measuring procedure is as follows:
- Gather the top of the bag around the shower pipe/faucet stem so that all water from the fixture goes into the bag. Hold the bag in place loosely so that air may escape while filling.
- In one quick motion turn the faucet/showerhead on. Open the fixture to maximum flow. For the showerhead it is always easier to have a second set of helping hands.
- Let water run for exactly 5 seconds and turn it off.
- Observe the water level in the bag. The nearest graduation line shows the flow rate, usually in gallons per minute (check bag to make sure).
- When you are new to these measurements (the first few times) you may not time the filling of the bag properly, or you may shut off the water too soon or not soon enough. It is advisable to repeat the measurement three or four times to make sure you are getting a consistent reading.

If the flow measuring bags are not available, you may use any container and fill it for a set number of seconds. You then have to measure the volume of water in the container, perhaps with a large measuring cup from the kitchen. Or you could buy a graduated cylinder at the hardware store. Because the measured volume has to be translated to gpm it is advisable to use a convenient filling period, such as five or six seconds. If you use five seconds, multiply the volume in gallons by 12 to get gpm; if you use six seconds, multiply the volume in gallons by 10.

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APPENDIX E. GRAY WATER REGULATIONS

Gray Water Regulations

Permits are required in most states for the implementation of gray water systems, usually from local or county authorities. Thirty-six states have explicit gray water regulations, as noted on the table that follows. The primary concern of regulators and health officials is that gray water may result in water quality problems that pose a threat to public health. Regulations invariably prohibit gray water systems from being connected to potable water systems; cross-connections are typically avoided with air-gaps (a physical opening to the atmosphere between the two systems that does not allow flow from one system to enter the other). Regulations typically preclude the use of water containing hazardous wastes or water that comes from the soiling of diapers or similar garments. Storage tanks for gray water usually require a cover. Some regulations also address maintenance requirements. Some of the location-specific limitations/constraints are listed in the table that follows, compiled from 1999 data in the *Humanure Handbook: A Guide to Composting,* Appendix 3–State Regulations-Gray Water (Jenkins, 1996).

Gray Water Regulations, Page 1 of 4

State	Applicable State/Code	Limitations/Constraints
Alabama	State Health Board, Chapter 420-3-1; 402-3-1.27	An effluent distribution line of 50 linear feet shall be used to dispose of gray water.
Alaska	Alaska Administration Code 72.990 defines gray water	None
Arizona	Arizona Department of Environmental Quality Bulletin Number 12; Arizona Administration Code Title 18, Chapter 9, Article 7.	Gray water may be used only for drip or flood irrigation, not for spray irrigation; system requires approval by Arizona Department of Environmental Quality.
Arkansas	Department of Health Alternative Systems Manual	Case-by-case
California	California Administration Code (Uniform Plumbing Code), Appendix G	Gray water may be used only for subsurface irrigation; administrative authority must approve system.
Colorado	Department of Public Health, Chapter 25, Article 10	Gray water systems shall meet at least all minimum design and construction standards for septic tank systems based on the amount and character of wastes for the fixtures and the number of persons served.
Connecticut	Public Health Code Section 19-13-B103b and f; Technical Standards.	Shall be constructed with a septic tank and leaching system at least one-half the capacity specified for the required residential sewage disposal system.
Delaware	No existing regulations	None
Florida	Title XXIX, of the Florida Administrative Code, Public Health Chapter 381.0065	The minimum effective capacity of the gray water retention tank shall be 250 gallons, with such system receiving not more than 75 gallons of flow per day.
Georgia	Rules of the Department of Human Resources, Public Health, Chapter 290-5-26	The minimum effective capacity of the gray water retention tank shall be 500 gallons.
Hawaii	Hawaii Administrative Rules, Chapter 11-62	Design of gray water systems for dwelling units shall be based on a minimum gray water flow of 150 gallons per day per bedroom; gray water tanks, when required, shall be sized with no less than a 600 gallon capacity.
Idaho	IDAPA 16, Title 01, Chapter 03; Technical Guidance Manual Section 10	Current Idaho rules permit gray water systems only as experimental systems

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Gray Water Regulations, Page 2 of 4

State	Applicable State/Code	Limitations/Constraints
Illinois	No existing regulations	Governed under experimental systems.
Indiana	No existing regulations	None
Iowa	No existing regulations	None
Kansas	Kansas Administrative Regulations Chapter 25, Article 5	County health departments have authority to grant variances for alternative onsite wastewater treatment and disposal systems.
Kentucky	902 Administration Regulations 10:085, Section 2(13)	Gray water: in Section 2(13) means wastewater generated by water-using fixtures and appliances, excluding the toilet and the garbage disposal.
Louisiana	No existing regulations	None
Maine	Maine Subsurface Waste Water Disposal Rules 144A CMR 241	Gray water includes only separated laundry disposal systems.
Maryland	Innovative & Alternative Program	Innovative gray water designs are currently allowed on a case-by-case basis.
Massachusetts	310 CMR 15.000, Title 5	A filter system specifically approved by the Department can be used instead of a septic tank. Non-traditional gray water systems, such as those which use constructed wetlands or evapotranspiration beds, are approved on a piloting, site-specific basis.
Michigan	Michigan has one of the oldest existing guidelines for composting toilets and gray water systems. However, as there is no statewide sanitary code, the 46 local health departments define the criteria for onsite sewage disposal and “each county runs its own show.”	Alternative systems and gray water systems should be tested by the National Sanitation Foundation (NSF) under Standard 41 testing protocol or by an equivalent independent testing agency and procedure. Lacking this testing procedure, the local health department should require performance data prior to approval.
Minnesota	Chapter 7080.9010, Alternative and Experimental Systems	Use of alternative systems is allowed only in areas where a standard system cannot be installed or is not the most suitable treatment.
Mississippi	No existing regulations	None
Missouri	Missouri Laws for On-Site Disposal Systems, Chapter 701, Section 701.025	There are no design recommendations or regulations governing gray water systems.

Gray Water Regulations, Page 3 of 4

State	Applicable State/Code	Limitations/Constraints
Montana	Circular WQB 5. Minimum Design Standards for On-Site Alternative Sewage Treatment and Disposal Systems	Gray water must be disposed of through a septic tank and drainfield system.
Nebraska	Title 124, Rules and Regulations for Design, Operation and Maintenance of Onsite Wastewater Treatment Systems.	Gray water is defined, but no systems are necessarily allowed under Title 124.
Nevada	Nevada Administrative Code 444.750	A system that uses gray water for underground irrigation may be used only for a single-family dwelling (this 1998 statute may have been modified, as some of Las Vegas largest hotels use gray water for irrigation).
New Hampshire	Chapter Env-WS 1022 deals with alternative systems	Before an innovative/alternative waste treatment system may be used the technology shall be evaluated and approved in an Innovative Technology Approval
New Jersey	New Jersey Administrative Code 7:9A	Administrative authority must approve systems.
New Mexico	20 New Mexico Administrative Code 7.3 Subpart 1, Part 107.AF	System must run through a septic tank and be used only for subsurface irrigation.
New York	Public Health Law 201(1)(1) Appendix 75-A	Gray water systems shall be designed upon a flow of 75 gpd/bedroom.
North Carolina	No existing regulations	None
North Dakota	Chapter 62-03-16-91.6	Gray water systems shall pass through a septic or other approved sedimentation tank prior to its discharge into soil or other system; surface application requires special approval.
Ohio	No existing regulations	Director of Health approval required; must be tested to show results of the system are equivalent to those obtained by sewage disposal.
Oklahoma	Oklahoma Administration Code 252:640 deals with alternative systems	Department of Environmental Quality approval required.
Oregon	Revised Statute 447.115; Oregon Administration Rules Chapter 340,	Environmental Quality Commission approval required.

WATER CONSERVATION

Gray Water Regulations, Page 4 of 4

State	Applicable State/Code	Limitations/Constraints
Pennsylvania	Division 71 Title 25, Chapter 73	Liquid wastes, including kitchen and laundry wastes and water softener backwash, shall be discharged to a treatment tank.
Rhode Island	Gray water defined under Chapter 12-120-002	None
South Carolina	No existing regulations, gray water defined under Chapter 61-56	A permit applicant could elect to install separate systems to handle gray water.
South Dakota	Chapter 74:53:01:10	Design of gray water systems shall be based on a minimum gray water flow of 25 gallons per day per person. Three days retention time shall be provided for each gray water tank.
Tennessee	No existing regulations	None
Texas	Subchapter H: 285.80	Comprehensive state rules have not been adopted. Each system has to be approved by the city or county health department
Utah	No existing regulations, R317-502-3 deals with alternative systems	Department of Environmental Quality approval required.
Vermont	No existing regulations. Innovative systems are regulated under Chapter 1 of Environmental Protection Rules.	Alternative systems are allowed in Vermont only if a backup, in ground conventional (septic) system is installed.
Virginia	No existing regulations	None
Washington	Washington Administration Code 246-272 Section B	Gray water may be used for subsurface irrigation only.
West Virginia	Title 64, Interpretive Rules Board of Health, Series 47	Those houses served by a gray water disposal system must have a house sewer of not more than two inches in diameter. Houses served by gray water disposal systems shall not have garbage disposal units. Manufactured gray water disposal systems must be approved by the director.
Wisconsin	No existing regulations	None
Wyoming	No existing regulations	None

U.S. Department of Housing and Urban Development

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