SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Water Efficiency and Self-Conducted Water Audits at Commercial and Institutional Facilities

A Guide for Facility Managers

SECOND EDITION

South Florida Water Management District
Water Supply Development Section

West Palm Beach, Florida

sfwmd.gov

Acknowledgements

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For questions or concerns regarding this guide, its use, or reproduction, please contact Robert Wanvestraut, Senior Conservation Analyst of the South Florida Water Management District, at 561-682-2054 or rwanvest@sfwmd.gov.

WATER EFFICIENCY AND SELF-CONDUCTED WATER AUDITS AT COMMERCIAL AND INSTITUTIONAL FACILITIES

A GUIDE FOR FACILITY MANAGERS

Second Edition

South Florida Water Management District
Water Supply Development Section
West Palm Beach, Florida

July 2013

Is this Guide for You?

This guide highlights common opportunities to improve water efficiency and lower operating costs in commercial and institutional facilities. It has been designed for use by commercial and institutional facility managers, property owners, and building maintenance professionals *anywhere*. Facility management professionals will be thoroughly introduced to the concept of water efficiency improvement and guided, step-by-step, on how to identify operational areas where immediate and long-term water efficiency improvements at their facilities.

Although it is applicable to users in all areas, the guidebook does contain references to external resources and information specific to Florida. Florida-specific references and information are set apart from the main text in orange boxes to avoid confusion.

For example, while the principals of water efficient landscaping are the same everywhere (plants should be selected according to the local climate and site-specific conditions), the guidebook identifies organizations and web links to organizations which focus on plants adapted to Florida's climate. Users from areas outside of Florida should be able to equivalent resources for their areas fairly easily.

Notice to Florida Green Lodging Program Applicants

As part of your application, Florida Green Lodging Program Applicants are only required to conduct the **BASIC** water audit procedures for applicable areas of water use at your property, with the following exceptions (NOT required): *Irrigation System Distribution Uniformity, Application Rate and Calibration – Basic Audit* and the *Facility Leak Detection Audit.*

The worksheets associated the following applicable procedures are what you will submit to the Florida Green Lodging Program:

- The Basic Facility Header Sheet
- Meters and Submeters – Basic Audit
- Examining Utility Bills and Estimating Daily Facility Water Use – Basic Audit
- General Domestic Water Use – Basic Audit
- Commercial-Grade Kitchen Water Use – Basic Audit
- Cooling Tower Water Use – Basic Audit
- Irrigation Schedule and Controller– Basic Audit
- Irrigation System and Landscape Survey – Basic Audit
- Rain and Soil Moisture Sensor Survey – Basic Audit

For questions on how to complete an audit exercise and to request free flow-gauge bags (see page 46), available while supplies last, please contact:

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Contents

Appendices

Tables

Worksheets

Note:

- For printing purposes, see Appendix C for all worksheets.
- Many of the worksheets related to irrigation are combined into a single **Irrigation and Landscape Audit Worksheet** with an associated Cheat Sheet at the end of Appendix C.

Abbreviations and Acronyms

ADA	Americans with Disabilities Act
AHRI	Air Conditioning, Heating, and Refrigeration Institute
ASME	American Society of Mechanical Engineers
BMP	best management practices
ccf	hundred cubic feet
CEE	Consortium for Energy Efficiency
CFWC	Conserve Florida Water Clearinghouse
CI	commercial and institutional facilities
COC	cycle of concentration
DU	distribution uniformity
EF	energy factor
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
FDEP	Florida Department of Environmental Protection
FSTC	Food Service Technology Center
ft^2	square foot
ft^3	cubic foot
g	grams
gal	gallons
gpf	gallons per flush
gpm	gallons per minute
gps	gallons per second
HET	high efficiency toilet
HVAC	heating, ventilation, and air conditioning
IFAS	University of Florida Institute of Food and Agricultural Sciences
IPC	International Plumbing Code
Kgal	thousand gallons
kWh	kilowatt hour
L	liters
LEED	Leadership in Energy and Environmental Design
MEF	modified energy factor
mg	milligrams
NSPC	National Standard Plumbing Code
psi	pounds per square inch
RS	rain sensor
SMS	soil moisture sensor
SWAT	Smart Water Application Technology
TDS	total dissolved solids
USGS	United States Geological Survey
UPC	Uniform Plumbing Code
WF	water factor

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Introduction

For most of us, water comes out of the tap in a seemingly unlimited supply whenever it is needed. In reality, water is limited and increasing demands have increased pressure on available supplies. Moreover, much of our water is unusable without expensive and energy-intensive processing.

The combination of limited supplies and growing demands makes increasing water efficiency key to future water security.

Using water efficiently, also known as water conservation, reduces the amount of water needed for a specific use and is a prudent component of water resource management. The goal of water use efficiency measures is to accomplish a desired task using the minimum amount of water **without harming existing systems and processes and meeting users' performance expectations.**

Increasing water efficiency benefits individual users as well as the community, region, and environment. Individual benefits include lower water and sewer bills, lower energy costs for heating and pumping water, and reduced chemical use.

On the local and regional levels, reducing water demand increases the available supply to support new economic growth without the time or cost of developing new water sources.

Increased water use efficiency also supports environmental restoration and protection. Reduced demand decreases the competition for water among urban, agricultural, and environmental needs. Water saved through efficiency measures can be used to meet new needs, in effect expanding current water supplies while protecting the environment by reducing both runoff and the need for wastewater disposal.

Florida Focus

Water links the environment, economy, and quality of life for South Florida. Just as abundant water gives vitality to our region, the lack of water can strain natural resources, stifle economic growth, and disrupt our daily routines. While this guide can be useful nearly anywhere, certain aspects focus on Florida. You can find Florida-specific information throughout the guide in orange boxes like this one.

What is Water Conservation?

Water conservation, also known as water use efficiency, is an integral part of water supply planning and water resource management. Water conservation is defined as the beneficial reduction in water use, waste, and loss.

Water conservation is becoming a viable alternative and complement to developing new water supplies. While short-term water restrictions imposed during a water shortage can temporarily relieve pressure on water sources, lasting water conservation involves a combination of retrofits, new water-saving appliances, maintenance of infrastructure, and a collective water conservation ethic focused on resource use, allocation, and protection.

Why We Are Doing This

Commercial and institutional (CI) facilities use large amounts of water for various purposes. Increasing water efficiency among these facilities can greatly reduce overall water use.

This guide and the associated computer resources have been created to:

- Familiarize you, the facility managers and building maintenance professionals, with the concept of water efficiency improvement
- Help your organization increase water efficiency within your facilities by implementing a water efficiency program
- Help you identify immediate- and long-term opportunities for water efficiency improvements at your facilities
- Highlight potential benefits and savings
- Introduce you to conservation agencies, organizations, technologies, and techniques
- Help foster a permanent ethic of efficiency improvement

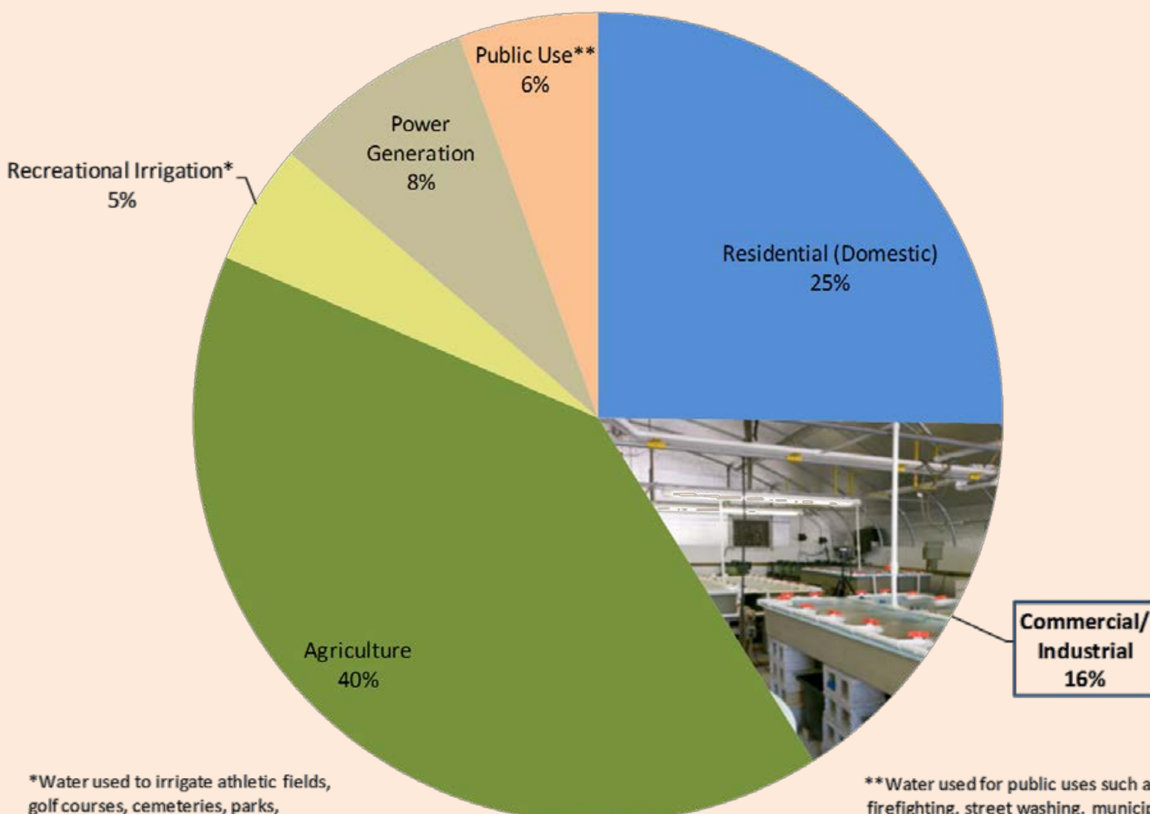
How to Initiate a Water Use Efficiency Improvement Program

To be successful, a water use efficiency improvement program needs to be based on a well-constructed plan. The steps toward creating such a plan include:

1. Assessing (auditing) the current water use situation
2. Creating a plan in response to the audit

Florida Focus

According to the U.S. Geological Survey (USGS), commercial and industrial facilities in Florida consume over 1 billion gallons of fresh water each day (USGS 2009). This is approximately 16 percent of the total fresh water used in the state.



*Water used to irrigate athletic fields, golf courses, cemeteries, parks, common public and highway areas, and some lawns

**Water used for public uses such as firefighting, street washing, municipal parks and pools, water utility process and distribution system loss.

3. Executing the plan (start with the "low hanging fruit" and move on to more intensive changes)
4. Monitoring and tracking progress, expenses, and savings

This guide will help you take the first step, assessing the current water use situation, by providing you with all you need to know to conduct a thorough water audit of your facility. If you are ready to go further and create an action plan, this guide and the associated calculators will also help estimate potential costs, savings, and payback periods for efficiency upgrades.

What is a Water Audit?

A water audit (also known as an assessment) is a systematic survey of all water-using fixtures, appliances, equipment, and practices at a facility or campus. **A thorough water use audit is the basis of a water use efficiency improvement plan and sets the foundation for the entire effort.**

Specifically, a water audit can:

- Identify leaks, areas of excessive consumption, and other opportunities for efficiency improvements
- Identify the degradation of previously efficient devices
- Form the basis of efficiency improvement and investment planning (identifies best returns on investment)
- Provide a benchmark for measuring water efficiency program successes

The bulk of this guide provides steps for conducting thorough audits of all points of water use at your facility.

Without conducting a thorough audit, you may:

- Direct resource dollars toward areas with slow or low returns
- Inadvertently replace fixtures or appliances that are already operating efficiently
- *Not* identify high efficiency items that have become less efficient over time or those that have had older replacement parts added during routine maintenance
- Bypass leak detection
- Bypass wasteful behavior identification

In commercial and institutional facilities, water use and its audits can be divided into four categories:

- **Water use meters and leak detection:** Basic check for hidden but potentially significant leaks
- **Domestic indoor:** Water use for bathrooms and kitchens
- **Non-domestic indoor:** Water use other than bathrooms and kitchens, such as air cooling
- **Outdoor:** Primarily landscape irrigation, but can include features like ornamental fountains

These categories are covered in detail in the subsequent sections of this guide. **Box 1** lists the audit procedures covered in this guide, as well as some additional exercises designed to help you understand water use and plan efficiency improvement efforts at your facility.

Box 1. Audit Procedures

Water Use Meters and Leak Detection
- Meters and Submeters
- Facility Leaks
- Examining Utility Bills and Estimating Daily Facility Water Use

Domestic Indoor Water Use
- General Domestic Water Use
- Commercial-Grade Kitchens

Non-Domestic Indoor Water Use
- Cooling Towers

Outdoor Irrigation and Landscaping
- Irrigation Schedule and Controller
- Irrigation System and Landscape Survey
- Rain and Soil Moisture Sensor Survey
- Irrigation System Distribution Uniformity, Application Rate and Calibration

Strengthening Decision Making Power for Efficiency Improvement Planning
- Creating a Facility Water Balance
- Determining the True Cost of Water
- Historical Water Use Profile
- Identifying On-Site Alternative Water Sources

Ensuring Program Success and Savings into the Future

Establishing a successful water efficiency or conservation program within an organization or facility requires effort and commitment. It is not necessary for a facility manager to have full backing before attempting to increase the facility's water use efficiency. In fact, having preliminary calculations of potential savings may help earn managerial support. However, although measureable gains can be made by a dedicated facility manager independently, this commitment should come from all levels of an organization to be most effective.

Completing the water audits described in this guide and implementing an efficiency improvement program are solid steps toward creating a water efficient environment at your facility. In addition to the physical and process changes identified by the audits, additional savings can be achieved through behavioral changes and raising employee awareness of your company's commitment to conservation.

In addition, helping employees understand the true cost of water and its impact on the operating costs of your company can act as an incentive to addressing inefficient or wasteful uses and can lead to additional conservation options. Strategically placed signage serves to highlight the company's commitment and remind employees and visitors of simple actions they can do to use water more efficiently. It is also beneficial to appoint a ground-level employee as a Water Conservation Program Officer to help maintain posted signs and repeat the business's conservation message.

The following are examples of some actions that should to be taken throughout the organization to achieve success.

Management

- Establish specific major goals for the program
- Establish a Water Conservation Program Officer who has authority to implement program elements
- Provide needed resources for program implementation
- Issue an organization-wide directive stating the organization's goals and commitment to water conservation
- Foster program participation – get the word out that water conservation is important and that employees need to be involved
- Recognize and reward achievements
- Publicize the success of your program to both internal and external stakeholders

Water Conservation Program Officer

- Create the water conservation plan
- Establish specific, quantifiable water conservation goals
- Research previous efforts to determine what has been accomplished or attempted and the reasons for success or failure
- Establish a water conservation budget and secure management backing
- Schedule and conduct on-site audits of organization facilities and equipment
- Develop and promote employee activities focusing on saving water
- Evaluate the program on a regular basis to determine what is or is not working and adapt appropriately
- Report water conservation successes and challenges regularly to top management

Facility Personnel

- Work with the Water Conservation Program Officer to conduct water efficiency audits
- Incorporate water conservation principles in routine preventative maintenance
- Contribute to fostering a conservation ethic within the organization
- Submit ideas for improving water use efficiency to the Water Conservation Program Officer
- Encourage other employees to reduce water use

Water Use in CI Facilities

Understanding how and how much water is used at your facility is an important first step toward knowing how to budget time and money for improving efficiency. **Box 2** identifies some potential water uses found within various facilities.

Box 2. Examples of water uses in commercial and institutional facilities (EPA 2009)
Indoor (Domestic) Water
Kitchens, cafeterias, staff rooms
- Faucets
- Distilled/drinking water
- Ice machines
- Dishwashers
- Garbage disposals
- Food preparation
Restrooms and showers
- Faucets
- Toilets and urinals
- Showers
Laundry – washing machines
Sanitation
- Facility cleaning
- Sterilization/autoclaves
- Equipment washing
- Dust control
- Container washing
Processes – photographic and x-ray processing, silk screening, dry cleaning, printing, etc.
Cooling and Heating
Cooling towers/evaporative coolers
Boilers and steam systems
Once-through cooling
- Air conditioners
- Air compressors
- Hydraulic equipment
- Degreasers
- Rectifiers
Vacuum pumps
Outdoor Water Use
Irrigation
Pools and spas
Decorative water features

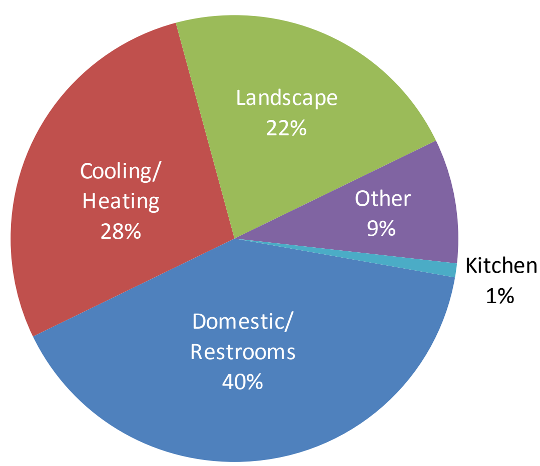
Typical Water Use by Facility Type

How water is used depends greatly on the activities occurring at your facility. For example, a much higher percentage of water use in office buildings is for domestic purposes in comparison to a facility that uses water in creating a product.

Office Buildings

Restroom/domestic, cooling and heating, and landscape use account for approximately 90 percent of the water use in a typical office building. Effective conservation measures for office buildings often include:

- Bathroom fixture replacement
- Public education promoting conservation among building tenants
- Cooling tower efficiency retrofits such as improved system controls
- Irrigation efficiency measures such as weather- or moisture-based irrigation controllers and landscaping changes using native or climate adaptive plants

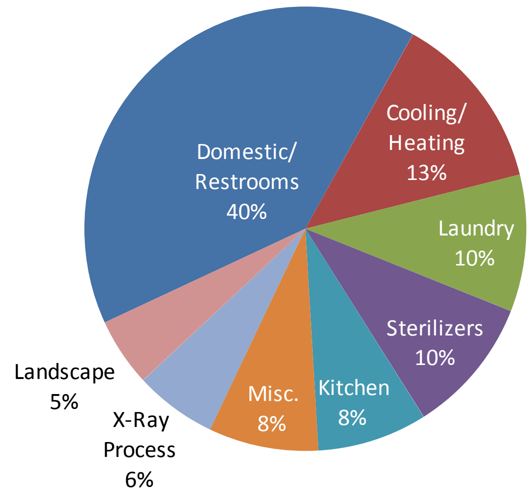


Source: City of San Jose, Environmental Services Department

Hospitals

Domestic/restroom uses account for 40 percent of water use in hospitals. Additionally, hospitals use a large percentage of water for processes such as x-ray development, sterilization, and laundry. Effective water efficiency measures for hospitals may include:

- Bathroom fixture replacement
- Cooling tower efficiency retrofits
- Laundry equipment and process changes
- Condensate return systems for sterilizers
- Conversion from x-rays to digital imaging

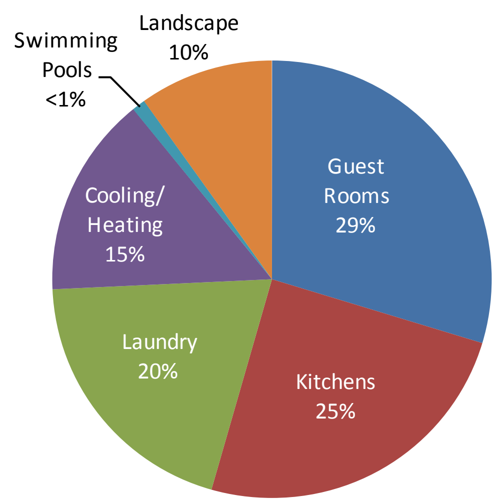


Source: City of San Jose, Environmental Services Department

Hotels and Motels

The combination of guestroom use, kitchens, and laundries accounts for 75 percent of water use in hotels and motels. Water efficiency measures may include:

- Bathroom fixture replacement
- Laundry equipment and process changes
- Guest conservation awareness programs to promote less frequent linen exchanges to reduce laundry

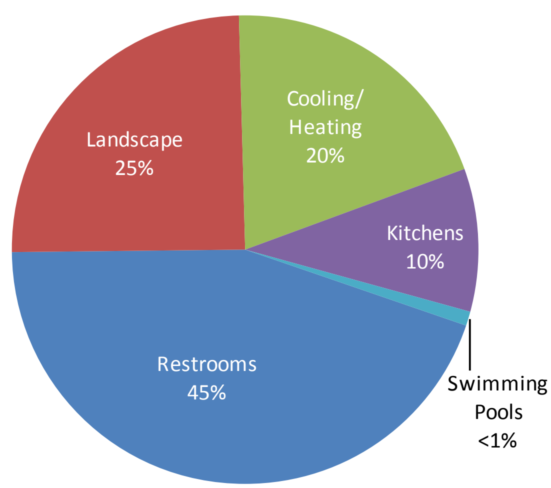


Source: City of San Jose, Environmental Services Department

Schools

Nearly half of the water used in schools is related to restrooms. Other large uses include landscaping and heating and cooling. Because of these uses, effective conservation measures often include:

- Bathroom fixture replacement
- Cooling tower efficiency retrofits
- Irrigation efficiency measures such as weather- or moisture-based irrigation controllers

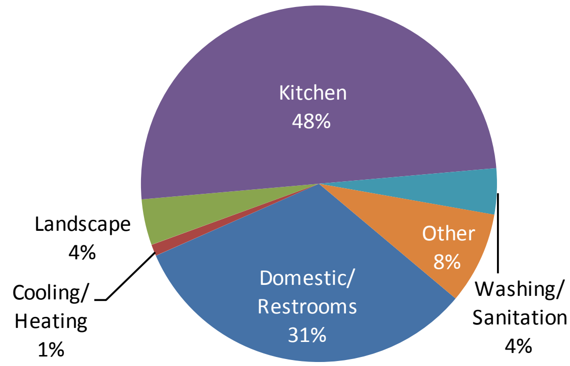


Source: City of San Jose, Environmental Services Department

Restaurants

Kitchen use accounts for just under half of the water used in restaurants with domestic/ restroom use accounting for almost a third. Water use efficiency measures applicable to restaurants include:

- Water efficiency training and information for kitchen staff
- Use air-cooled equipment such as icemakers
- Bathroom fixture replacement
- Water efficient appliances and best management practices during their use

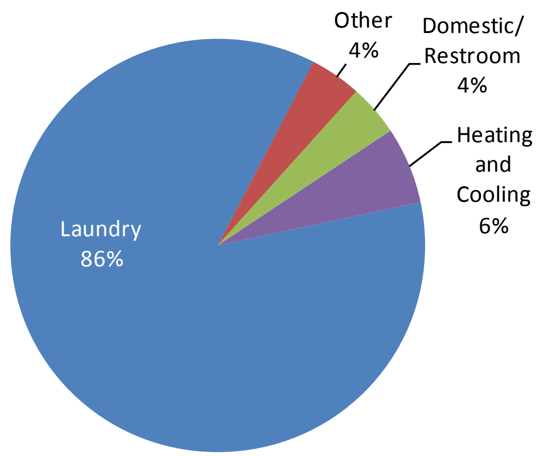


Source: EPA WaterSense Water Efficiency in the Commercial and Institutional Sector, 2009

Laundries

Virtually all water use in laundries is in the wash process. Possible efficiency measures include:

- Replace conventional washing machines with high efficiency front-load machines
- Install a reclaim system to capture rinse water for use in the wash cycle
- Install a continuous-batch washer for large laundry operations

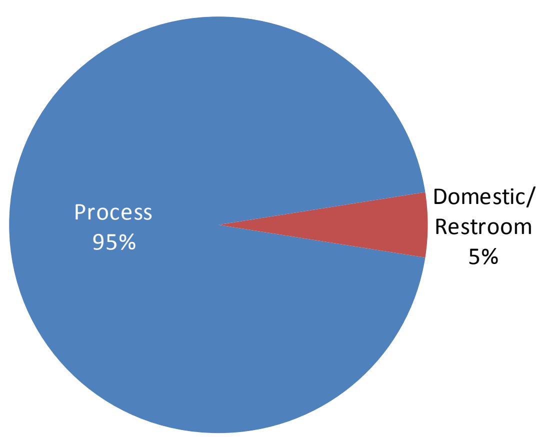


Source: EPA WaterSense Water Efficiency in the Commercial and Institutional Sector, 2009

Car Washes

As with laundries, virtually all water use in car washes relates to the cleaning process. Car wash water use reduction can be achieved by the following:

- Install a recycling system for wash water
- Increase conveyor speed to reduce the rinse cycle
- Maintain equipment to ensure nozzles are properly set and not excessively worn



Source: EPA WaterSense Water Efficiency in the Commercial and Institutional Sector, 2009

Benchmarks

In studying water use and efficiency potential, conservation professionals tie water use to several benchmarks used to compare CI facilities. Benchmarks are not necessarily targets, but they can be used to make quick and crude determinations of whether a facility's water use is far from the 'typical' use of similar facilities. Examples of benchmarks include gallons per day per number of tables in a restaurant or per number of beds in a hospital. For commercial buildings, the most popular benchmark is the number of "employees" (**Table 1**). Estimates of gallons of water used in individual commercial buildings vary widely depending on the source, ranging from 25 to 137 gallons of water per employee per day (Dziegielewski 2000, NCDENR 2009).

Table 1. Benchmarks for annual water use in various facility types.

Facility Type	Benchmark
Hotels/Motels	0.079–0.165 Kgal/ft^2 30.2–39.5 Kgal/room
Nursing/ Assisted Living	0.062–0.101 Kgal/ft^2 32.8–40.7 Kgal/bed 25.4–39.6 Kgal/apartment
Restaurants	0.17–0.21 Kgal/ft^2 10.6–14.3 Kgal/seat
Schools	0.012–0.019 Kgal/ft^2 1.7–2.7 Kgal/student

Kgal: thousand gallons
Source: Colorado WaterWise Council (2007)

Regardless of the benchmark, each facility's water use will vary depending on factors such as the age and location of the structure, number of non-employee visitors, the number of part-time employees, the number of full-time employees not regularly remaining on-site, and the presence and size of water-using equipment such as cooling towers, cafeterias, and irrigated areas.

Another benchmark increasingly used by conservation professionals hinges on the square footage of heated/cooled space. The Florida Department of Environmental Protection's (FDEP) Conserve Florida Water Clearinghouse (CFWC) used this benchmark with buildings categorized by subsectors defined by Florida's Department of Revenue. The aggregate result for the entire commercial sector was 4.03 gallons per square foot (gal/ft^2) per month or 0.103 gal/ft^2 per day (CFWC 2009).

Potential Water Savings

Many CI facilities can significantly improve water efficiency. One study found the average potential water savings from conservation measures ranged from 15 to 50 percent, with 15 to 35 percent being the most typical savings (Dziegielewski 2000). The actual savings depend largely on when the building was constructed or when any conservation/efficiency improvement efforts were made with the oldest buildings offering the greatest potential savings.

Some general factors for water conservation in CI facilities include:

- Vigorous attention to leaks and routine leak detection exercises can save a facility tens to hundreds of thousands of gallons of water per year
- Sub-meters should be used when practical, especially at all large consumption points (irrigation systems, cooling towers, commercial-grade kitchens, etc.)
- Cooling towers are often the single greatest point of water consumption and should be managed to achieve optimum efficiency

Increasing water use efficiency at a CI facility makes good business sense. It can **reduce your operating costs, secure future water supplies, and enhance your public image**. In many areas, water and sewer rates are increasing faster than those for energy, making investment in water efficiency a smart decision.

Increased water efficiency can reduce your facility's operating costs beyond the costs for potable water and wastewater. The true cost of water (NMSE 1999, Seneviratne 2007) for your facility may include:

- Energy for heating water
- Energy and expenses for chemical treatments for cooling towers
- Waste charges for removal of oil, grease, and solids
- Charges for biological oxygen demand
- Waste testing
- Process water pretreatments
- Depreciation of water-using equipment

Table 2 shows the potential water savings from retrofitting various fixtures and appliances in non-residential structures. The bottom line is that **increasing water efficiency can reduce operating costs and enhance profitability.**

Table 2. Estimated potential water savings achieved by retrofitting various fixtures and appliances in non-residential structures.

Fixture Type	Estimated potential water savings
Toilets (tank and valve types)	20–65%
Urinals	50–100%
Faucets	
0.5 gpm[1] aerator	30–75%
Sensor control	10–50%
Shower-heads	20–30%
Elimination of once-through equipment[2]	95–100%
Commercial dishwashers	15–50%
Ice machines[3]	15–20% or 85–90%

1. gpm (gallons per minute)
2. includes cooling towers
3. 15 to 20 percent if replacing an air-cooled unit; 85 to 95 percent if replacing a water-cooled unit (AWUWCD 2006)

Best Management Practices

Many best management practices (BMPs) for improving water use efficiency are applicable to specific facility types. BMPs are not thoroughly discussed in this guide, but a list of BMPs for commercial buildings is included as **Appendix B**. Although beginning an approach to improving efficiency by simply referring to a BMP checklist may be tempting, this would be misguided. As stated earlier, if you do not conduct a thorough facility water audit, you will not develop a holistic understanding of water use at your facility, you may overlook efficiency improvement opportunities, and it can lead to wasted financial resources. For more information, see the discussion on page 13, *What is a Water Audit?*

Conservation Standards and Resources

Federal water efficiency standards for plumbing are antiquated (**Box 3**) and should not be relied upon for guidance toward achieving maximum water use efficiency. However several governmental and nongovernmental organizations provide information on water and energy efficient products and practices. Examples include:

- **Alliance for Water Efficiency:** Information on national green building standards and codes for water-using fixtures and appliances and water meters. Also provides free downloads of the *WaterSmart Guidebook for Businesses* to help CI facilities improve water efficiency (www.allianceforwaterefficiency.org)

- **WaterSense:** Water efficiency products, programs, and practices with lists of high efficiency qualified products (www.epa.gov/WaterSense)
- **Consortium for Energy Efficiency:** Energy-efficient products and services (www.cee1.org)
- **ENERGY STAR:** Information on energy-efficient products and practices, including lists of qualified products (www.energystar.gov)
- **Food Service Technology Center:** Industy leader in commercial kitchen energy efficiency and appliance performance (www.fishnick.com)

Recommendations on How to Proceed

While it is recommended that you read through this entire guide, we recognize that may not be practical for everyone. At the very least, you should read and understand the content presented in this introduction. This section provides fundamental information on water use in CI facilities, the audit process, why water audits are beneficial, what you need to get started, as well as other general information on increasing water efficiency at your facility.

Parts I, II, and III contain the detailed procedures for conducting water use audits and evaluating the results. These three sections were written for those tasked specifically with performing the audit, but it is also beneficial and highly recommended that facility managers and others tasked with making the decisions on implementing efficiency measures identified by the audit become familiar with the audit process.

After reading through the remaining sections you may feel that you lack either the resources or expertise to conduct the audit yourself. If so, additional help is available. Some professional engineering firms specialize in improving water and energy efficiency for the CI sector. Many of these firms are able to provide comprehensive, detailed, and accurate reviews of current water use and outline improvement options. These firms will likely also offer recommendations based on best management practices specifically designed for your individual facility. Additionally, some firms may assist in implementing the recommendations and base their fees on the actual savings achieved. In short, a professionally conducted audit can be a sound investment.

Box 3. Energy Policy Act of 1992

The Energy Policy Act of 1992 became effective on January 1, 1994, and has become the accepted baseline for measuring the savings of new water-conserving fixtures as well as establishing the baseline for water conservation performance under programs such as the United States Green Building Council's LEED rating program and the Environmental Protection Agency's WaterSense program. Performance standards for these efficiency programs are higher than the water use rates of the 1992 Energy Policy Act (below).

Energy Policy Act Flow Rates

Fixture	Flow Rate
Toilets	1.6 gallons per flush
Urinals	1.0 gallons per flush
Showerheads	2.5 gpm @ 80 psi or 2.2 gpm @ 60 psi
Lavatory Faucets*	2.2 gpm @ 60 psi
Kitchen Faucets	2.2 gpm @ 60 psi

* Superseded by national plumbing codes (UPC, IPC, and NSPC), that limit "public" lavatory faucets to 0.5 gpm.

How to Use this Guide

Is this Guide for You?

As stated earlier, a thorough water audit is the basis for your water use efficiency improvement plan. This audit sets the foundation for the entire effort. This guide will help a facility manager identify and perform numerous water efficiency improvements.

The heart of this guide, the audit steps, is intended for facility managers, building maintenance professionals, and others interested in increasing water efficiency in CI facilities **anywhere**. Although there are specific references to certain Florida-based resources (see the *Florida Focus* boxes), they are supplemental to the tasks. The tasks themselves can be applied in any state. Moreover, a driven facility manager should be able to find resources equivalent to those in the Florida Focus boxes relevant to their state or region. Managers of various types of commercial and institutional facilities should benefit greatly from this guide. This includes, but is not limited to, facility managers of:

- Office buildings
- Retail shops
- Restaurants/bars
- Lodging facilities
- Schools
- Museums
- Churches
- Some medical facilities
- Municipal buildings

This guide highlights common improvement opportunities and provides information to understand the potential efficiency gains and benefits available to CI facilities. It is highly comprehensive and can guide you through most, if not all, potential areas to increase water efficiency. It is designed to walk you through self-conducted water audit procedures and help you begin the journey toward improving water use efficiency.

In some situations, the findings of an audit procedure will uncover the need for a more in-depth analysis. In some cases, assistance from a specialized professional may be warranted.

Audit Levels

The audit procedures in this guide cover indoor and outdoor water use in an easy-to-follow, thorough format. They are organized into three parts, based on intensity and comprehensiveness, as described in **Box 4**. This structure was designed to accommodate managers with varying degrees of experience in facility water use and efficiency.

As a user of this guide, you are not necessarily expected to commit to completing all tasks. You can decide which procedures to complete. This provides you with greater flexibility and expands your opportunities to discover areas to improve efficiency.

You may want to briefly review the entire guidebook before starting any audit procedure. To save time and effort, it is highly recommended that you **review the Basic Audit and Advanced Audit procedures for a given water use before beginning any specific field work.** Otherwise, you may need to revisit areas of your facility to collect data required for more advanced levels. In some cases, the Advanced Audit procedures may not require a significant amount of additional time or effort beyond the information collected for the Basic Audit. For example, information for the Basic Audit and Advanced Audit procedures for assessing your facility's cooling tower can be done in a single visit.

Box 4. Audit Categories in this Guide.

BASIC AUDIT PROCEDURES

All facility types can and should complete all Basic Audit procedures. They require the least experience in conservation and efficiency improvement analysis and require the least amount of time to complete. These procedures typically uncover the "lowest hanging fruit" in terms of efficiency gains.

ADVANCED AUDIT PROCEDURES

Advanced Audit procedures are also appropriate for all facility types. Some guide you through the process of collecting quantitative data that you enter into the associated spreadsheets. Built-in formulas within the spreadsheets will perform the necessary calculations for you. The results provide the basis for more powerful analysis and decision making. These procedures require more than basic familiarity with certain equipment or machinery operations and may require outside expert assistance. You should attempt to conduct all Advanced Audit procedures as completely as possible to determine if and where you need assistance.

FURTHER EFFICIENCY IMPROVEMENT ANALYSES

Further Efficiency Improvement Analyses guide you to look beyond general efficiency improvements. These activities will help you create a comprehensive and quantifiable profile of current water use and potential efficiency improvements. These activities are essential to create a full-scale improvement program.

Audit Organization and Associated Spreadsheets

Each audit procedure in this guide is divided into four sections. The first, **Background and Description**, provides general relevant information and describes the procedure. The second, **Audit Objectives**, explains the purpose of the procedure. The third, **Audit Steps**, lists the steps to complete the procedure. The fourth, **Post-Audit Considerations and Additional Steps**, provides information to help you evaluate your results and includes some suggestions for future actions.

In addition to these four sections, many procedures include one or more worksheets for recording information. Within the guide, these worksheets are near the end of their associated procedures. They are also collected in **Appendix C**, where most are repeated to ease double-sided printing and reduce the number of pages you need to carry as you perform your facility audit.

Eight companion spreadsheets in Microsoft Excel format are available for download from the South Florida Water Management District's website[1] with this guide. Six were developed specifically to accompany this guide and two were developed by ENERGY STAR. The spreadsheets perform all necessary calculations for the associated audits. Audit procedures that have a companion spreadsheet also have an additional section, **Spreadsheet Guidance**. These sections provide step-by-step guidance on how to use each companion spreadsheet, including exactly what field data are needed for each and how to properly enter all information.

[1] www.sfwmd.gov

The companion spreadsheets are:

- Daily Water Use
- Domestic Plumbing Fixtures
- ENERGY STAR's Commercial/Residential Appliance Savings Calculator
- ENERGY STAR's Commercial Kitchen Equipment
- Supplemental Commercial Kitchen Equipment
- Cooling Towers
- Irrigation Water Use
- Facility-Wide Water Use Efficiency Analysis

For the six spreadsheets designed specifically for this guidebook (those not created by ENERGY STAR), data are entered in white-shaded cells and the gray cells show the calculated results (**Figure 1**). Data cannot be entered into the gray cells. For the gold cells labeled "Select one," you must choose an option from the dropdown menu for the calculations in the worksheet to function.

Each of the non-ENERGY STAR spreadsheets includes a *Utility Rate Input* tab. After entering your facility's billing data on this tab (**Figure 2**), the information is transferred to other tabs as necessary for your convenience. All other tabs require you to input data specific to each audit.

The calculators associated with this guide were developed for estimating purposes only. Actual savings may vary based on use and other factors.

As explained earlier, gray-shaded cells are calculated values. These cells use values you enter in the white-shaded cells in a formula to provide an output. If you see an error indicator in an output cell (**Figure 3**), one of the white input cells contains an error. Two common mistakes can lead to an error: (1) a text value was entered into a cell expecting a numeric value; or (2) one of the white input or gold drop-down menu cells that provides a value into the error cell does not have a value. This can include values or cells on the *Utility Rate Input* tab; for example, you may have forgotten to select the billing rate increment or to enter the cost per 1,000 gallons of water.

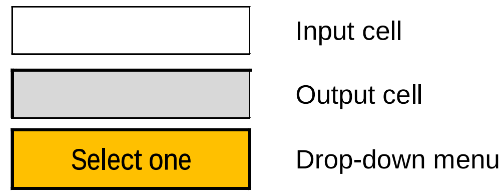


Figure 1. The three cell types used in the spreadsheets accompanying this guide.

Billing Data Input			
1. Select Billing Unit (1000 gals or ccfs) >>>>>		Select one	
2. Utility cost potable water per	unit	$0.00	
3. Utility cost sewer water per	unit	$0.00	
4. Select Water Heat Type >>>>	Select one		
5. Enter Gas Cost per Therm	$0.00		
5. Enter Electric Cost per kWh	$0.00		
6. Heater Efficiency:	Gas	0.0	%
Suggested default heat efficiencies:			
Gas	59 %	Elect.	92.7 %

Figure 2. The *Billing Data Input* table.

#DIV/0!
#VALUE!
Possible error indicators in Microsoft Excel

Figure 3. Error message you may encounter when using the associated spreadsheets.

Tips for Easier Data Entry

Many audit procedures in this manual require you to enter data into the Microsoft Excel spreadsheets that complement this guide. In some cases, your entry may be repeated on several lines. Microsoft Excel's 'drag' feature allows you to easily copy the contents of a selected cell to other adjacent cells. This can save you some time and will work for text or numeric data, but can easily lead to errors.

Figure 4 shows an example of the 'drag' feature with a **text data entry**. The user is repeating the entry "Manual" in the four cells below the one selected by following these steps:

1. Type the word "Manual" in the first cell.
2. Click the cell with the information to copy.
3. Place the cursor (mouse) over the lower right-hand corner of the highlighted cell until a plus sign is visible (**Figure 4a**).
4. Once the gray plus sign appears, click and hold the left mouse button.
5. While still holding the mouse button, drag the cursor down to cover the cells where the repeated information is to appear (**Figure 4b**).
6. Once all the cells are covered, release the mouse and all cells will have the same information as the originally selected cell (**Figure 4c**).

Be watchful of the results when dragging **numerical data** in the Excel spreadsheets. Selecting more than one cell at a time can change the data. This is illustrated by **Figure 5**.

In addition, the drag feature will not work with the gold drop-down menu cells.

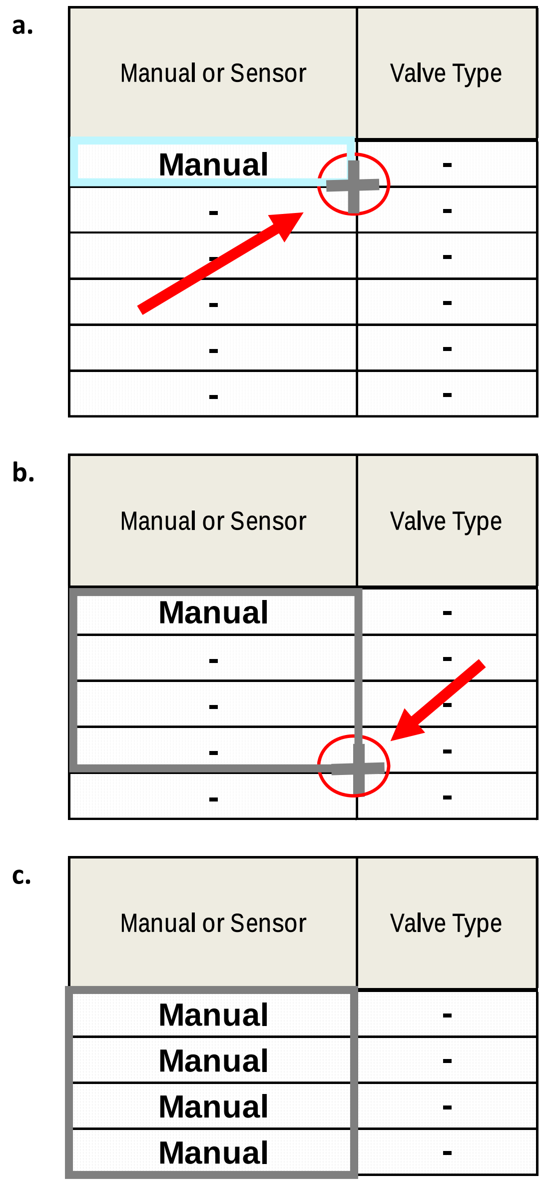
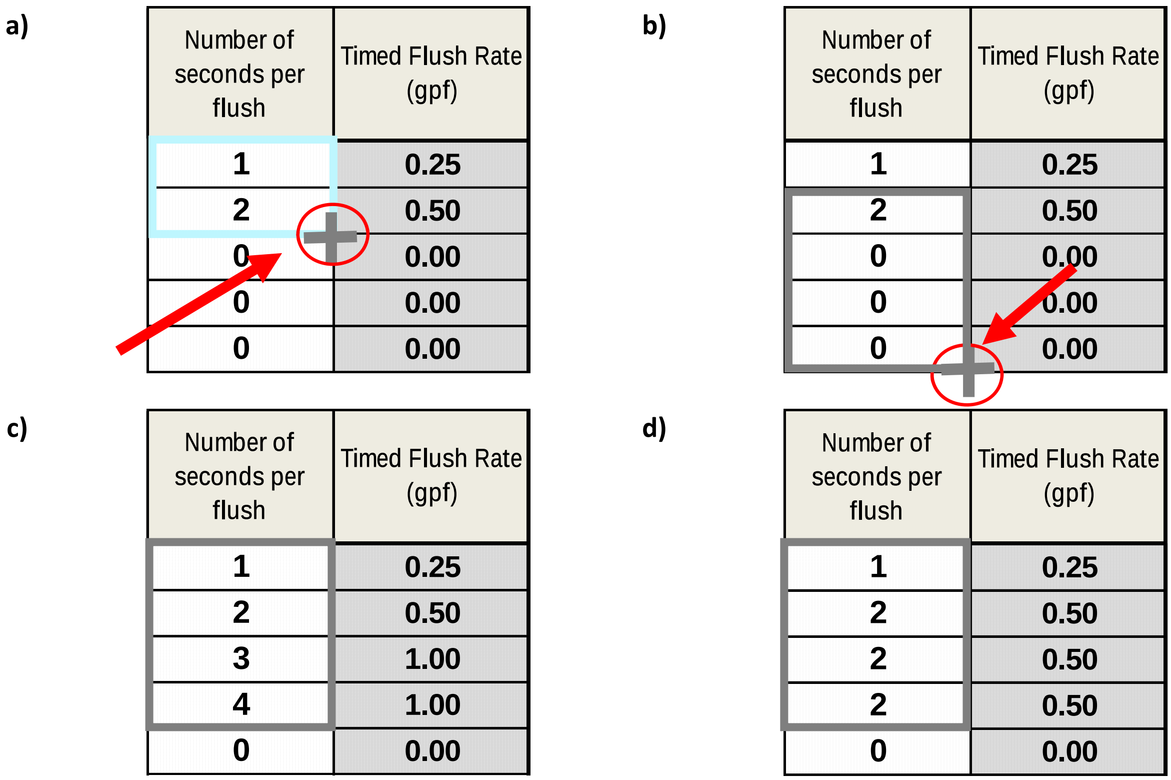


Figure 4. Steps to drag data from one cell and repeat it in several other cells. **a)** The cell containing the data to be repeated in the next few cells has been selected (clicked) and the cursor is hovered over the lower right corner of that cell until a gray non-arrowed plus sign appears. **b)** The mouse button is clicked, held down, and dragged over the cells where the data will be repeated. **c)** The mouse button is released, which populates the cells with the data in the originally selected cell.

Figure 5 shows an example of incorrectly 'dragging' **numeric data entry**. The functionality here is nearly same as for the text 'drag' function, except that if you select more than one cell, Microsoft Excel will think you want to sequentially increase the value.

In this example, the user wants to only repeat the value "2" in the next two cells, but has initially selected the first two cells in the column. Therefore, the values increase from 1 to 4 instead of repeating the 2.



a)

Number of seconds per flush	Timed Flush Rate (gpf)
1	0.25
2	0.50
0	0.00
0	0.00
0	0.00

b)

Number of seconds per flush	Timed Flush Rate (gpf)
1	0.25
2	0.50
0	0.00
0	0.00
0	0.00

c)

Number of seconds per flush	Timed Flush Rate (gpf)
1	0.25
2	0.50
3	1.00
4	1.00
0	0.00

d)

Number of seconds per flush	Timed Flush Rate (gpf)
1	0.25
2	0.50
2	0.50
2	0.50
0	0.00

Figure 5. Dragging numeric data from one cell to repeat it in several other cells. **a)** The user has erroneously selected the first two cells in the column, when they actually only wanted to repeat the second one (the "2"). **b)** The mouse button is clicked, held down, and dragged over the cells where the data will be repeated. **c)** The mouse button is released, which sequentially increased the values in the cells below the initially selected cell. **d)** Shows what the user actually wanted to do, which would have occurred if only initially the first cell was selected.

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Part I. Basic Audits

Overview

The procedures contained in this part describe the tasks required to complete the Basic Audits of many aspects of water use. Each task is an independent procedure and those that do not apply to your facility can be omitted.

Basic Facility Information Header Sheet

Before starting a facility audit, you may find it helpful to collect some basic information on the facility. A header sheet has been created for this purpose and can be found on page 28. Aspects of the header sheet will be described in more detail in the audit procedures.

Basic Facility Header Sheet

Site Name			
Address			
Facility Ops. Manager Name & Contact Info.			
Auditor Name(s) & Contact Info.			
Date of Audit			
Buildings and Years Built			
Population Breakdown			
Full-time Employees Population #1	Males______________	Females___________	
Full-time Employees Population #2	Males______________	Females___________	
Visitor Group #1	Males______________	Females___________	
Visitor Group #2	Males______________	Females___________	
Visitor frequency and duration			
Months Per Year of Operation			
Water Provider & Billing Rate			
Gas Provider & Billing Rate			
Electricity Provider & Billing Rate			
Cooling Towers			
Cooling Capacity			
Typical Operating Tonnage			
Hours Per Day of Operation			
Days Per Month of Operation			
Months Per Year of Operation			
Are Sewer Credits Received?			
Irrigation System? Submetered?			
Other large or significant points of on-site water use? (commercial kitchen, vehicle washes, etc.)			

METER AND SUBMETER – BASIC AUDIT

Background and Description

Nearly all facilities have meters to measure the amount of incoming water. This procedure will help you become acquainted with the meters and any submeters present in your facility.

Utility water lines connected to CI facilities are metered for billing purposes. The main meter records how much water is going to the facility and is usually found along a road at the property line. The utility charges a "water" rate per unit volume as recorded by this meter, typically in 1,000 gallon or 100 cubic foot (abbreviated ccf and equal to 748 gallons) increments.

Two of the most common types of meters are the straight-reading meter and the digital meter. The straight-reading meter is the most common type and resembles a car odometer. It is a round-reading meter with several separate dials and must be read in person. Digital meters have a display like a digital clock and some can be read remotely.

Meters come in different sizes depending on the size and demands of the facility. Typically, meters serving CI facilities are larger than residential ones. Additionally, CI facilities usually have more than one incoming meter.

Facilities that have on-site wells are not charged by a utility for the water. However, incoming water may be metered to conform to a consumptive use permit.

Facilities also are typically charged a "sewer" or "wastewater" rate to account for the costs for collecting, treating, and disposing of the water that has been used. The wastewater volume charged is usually roughly equal to the incoming water volume, even though some water may have been consumed on-site, such as for irrigation and cooling tower operations.

In some cases, CI customers have irrigation and cooling tower water metered separately (submetered) to receive sewer credits and avoid wastewater charges for water that does not return to the utility plant for treatment.

Your facility also may have submeters to measure other internal water uses, such as ice production. This is most common in industrial and product processing facilities but may also be applicable to some commercial facilities. Using submeters at all practical points of consumption within your facility is recommended since they can provide valuable water use data and may help you avoid unnecessary sewer or wastewater charges.

A facility manager should know what areas of their facility each meter or submeter records usage for. If necessary, matching meters or submeters to certain parts of a facility is fairly easy to do if at least two people are working together and each has a two-way radio or cell phone. It also helps if it is done while no one inside the facility is operating water-using equipment. One person can wait by the meters, while the other is in a restroom. The meters should not be turning until the person in the restroom opens the faucets and flushes a toilet. This can also help identify the location of a leak if one of the meters is recording use during non-work hours or during a leak test (see page 33). In addition, knowing which areas of the facility each meter records use for can help identify and measure the effect of efficiency improvement activities.

In some cases, the irrigation system is supplied by a nonpotable source, such as reclaimed water. When irrigation water comes from a reclaimed water pipe, the pipe will be purple.

Audit Objectives

This procedure will help you become familiar with the location(s) and type(s) of meters and submeters at your facility. You do not need to know how to read a meter for this exercise.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (on page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Contact your facility's water supply utility and request a list of all meters at the facility including the account numbers, sizes, and dates the meters were last tested by the utility.
3. If possible, locate construction blueprints and/or sketch a map of meter locations.
4. Prepare and examine **Worksheet 1: Meters and Submeters**.
5. Locate all meters and submeters in the facility.
6. Note the meter type (see **Appendix A**).
7. If there are multiple domestic meters:
    a. Position one person by the meters while the other is in one of the restrooms
    b. While on two-way radios, have the person in the restroom open faucet valves and flush a toilet
    c. Mark the restroom location correlated to the meter that turns when the toilet is flushed
    d. Do this for each major wing of each building or until all meters have been correlated to an area
8. Note the date of last accuracy calibrations for each meter and submeter if known. If not known, your facility's water utility may have this on record.
9. Refer to the Post-Audit Considerations and Additional Activities subsection of this section.

Post-Audit Considerations and Additional Activities

With regular use and age, water meter accuracy deteriorates. Inaccurate readings can result in improper use charges and render the meter useless for water use accounting and leak detection. In most cases, failures lead to meters under-registering flow.

You may want to contact your local regulatory agency for specific meter testing intervals. However, the American Water Works Association has developed recommendations for meter testing based on their size (**Table 3**).

Meter accuracy tests can be performed in-house, but only by experienced technicians. Some common testing methods include the following (Livelli 2007):

- **Known volume:** Compares flow to a known-volume container with the volume measured by the meter.
- **Ultrasonic Clamp-On Meters:** Transducers clamped onto the pipe measure flow rates by comparing the time difference between ultrasonic pulses moving with and against flow. These readings are then compared against the meter's readings.
- **Insertion Probes:** Measure fluid velocity within the pipe's internal cross section.
- **Reference Meter in Series:** A second meter installed on the pipe for comparison against the utility meter.

Each testing method has inherent strengths and weaknesses. They should be reviewed by the facility manager prior to arranging a test.

For additional information on meters and submeters, see the "Metering of Individual Units" section of the *WaterSmart Guidebook* (EBMUD 2008)[1]. For more information on meter testing and calibration, see *Verifying Flowmeter Accuracy* (Livelli 2010)[2].

Table 3. Recommended testing intervals for various water meter sizes.

Meter Size	Testing Interval
½ and ⅝ inch	Every 10 years
¾ inch	Every 8 years
1 inch	Every 6 years
1½ and 2 inches	Every 4 years

Source: AWWA 1999

[1] www.allianceforwaterefficiency.org/WaterSmart_Guidebook_for_Businesses.aspx or go to www.allianceforwaterefficiency.org and enter "WaterSmart Guidebook" into the search bar.
[2] www.flowcontrolnetwork.com/articles/verifying-flowmeter-accuracy or go to www.flowcontrolnetwork.com, enter "Verifying Flowmeter Accuracy" in the search bar, and look for the September 26, 2010, article by G. Livelli.

Worksheet 1. Meters and Submeters

Meter/Submeter Number & Location	Type (see Appendix A)	Pipe Size (inches)	Date of Last Accuracy Check & Calibration	Records Used for Which Areas of Building or Campus

FACILITY LEAK DETECTION – BASIC AUDIT

Background and Description

Leaks can be a major source of lost water. Even seemingly minor leaks can waste large amounts of water (**Table 4**). Repairing them can save significant amounts of water and money. A pipe with a fracture the thickness of a dime (1/32 of an inch) under 60 pounds per square inch (psi) can lose approximately 6,300 gallons of water per month. For this reason, leak detection needs to be part of your facility's routine maintenance.

Leaks are often hidden underground or within a wall. Detecting them requires deliberate focus. The principle way to detect a hidden leak is to observe flow into the facility as recorded by the utility water meters while all water consuming activities are inactive. With all machinery shut down and valves and faucets closed, there should be no water use recorded by the main inflow meter unless a leak is present. This type of observation should occur during non-working hours. You will need to make arrangements for all known water-consuming devices, including heating, ventilation, and air conditioning (HVAC) systems (unless separately metered), to be shut down for 15 minutes to an hour (an hour is recommended).

If the HVAC system or other water-using device must remain on during the testing period, the process is more complicated. Estimates or measurements of the devices' water use must be subtracted from the main meter reading to calculate the down-time flow measurement. Water use by building systems or specific machinery can be estimated from consumption rates provided by a system maintenance contract vendor or device manufacturer.

Shutting down the building's cooling tower may also be difficult or undesirable. One way around this is to have one person manually lift and holds the tower's water level float regulator; inflow will stop but the cooling system will continue operating. Another person is required to examine the meter during this time to record flow. Using two-way radios or cell phones may help carry out this task.

Meters come in many sizes depending on the water needs of the facility. There are also many types of meters, and each type is read differently. **Appendix A** provides instructions on how to read various meter types.

Audit Objectives

This procedure will guide you through a basic leak detection test for your entire facility.

Table 4. Amount of water lost at various leakage rates.

Drips per Second	Gallons per Day	Gallons per Year
1	8.64	3,154
2	17.3	6,308
3	25.9	9,462
4	34.6	12,616
5	43.2	15,770

Five drips per second is a steady stream
Source: AWWA: WaterWiser 2008

***Florida Green Lodging Applicants:**

This *Facility Leak Detection – Basic Audit* is **optional** as part of your application. For more information on this program, see page iv.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Prepare and examine **Worksheet 2: Facility Leak Detection**.
3. Ensure all water-using devices that can be are shut down.
4. Locate the inflow meter(s) to the facility. There may be more than one location.
5. For each meter, record the meter reading and time at the beginning of the shutdown period (*Initial Reading*).
6. Wait, ideally 24 hours, or at least 20 to 60 minutes.*
7. Record the meter reading and time at the end of the shutdown period (*End Reading*).
8. Account for water consumption by any device left on during the shutdown period.
9. Subtract the Initial Reading from the End Reading. The difference should be zero if all equipment has been shut down.
10. Repeat steps 3 and 8 for at least two trials and for all separately metered work areas or equipment.
11. Refer to the Post-Audit Considerations and Additional Activities subsection of this section.

*If all water consuming devices are shut down, a 20 minute test (or waiting period) will probably be enough to reveal most leaks. If it is impossible to shut down all water consuming devices, you will need to estimate the water use of the devices left running and subtract this amount from the recorded flow. In this case, a longer test or waiting period (60 minutes or more) is recommended.

Post-Audit Considerations and Additional Activities

If the facility was completely shut down and no water-using machinery was left on, there should have been no change in the meter. If the facility was not completely shut down, the metered consumption should be within 10 percent of the estimated flow after accounting for any water-consuming devices left on. A discrepancy of more than 10 percent indicates a leak may be present (PWB 2010).

The *General Domestic Water Use* and *Commercial-Grade Kitchen Water Use* audits include facility walk-throughs that should uncover leaks in toilets and any visible leaks in plumbing fixtures and appliances. Therefore, this leak detection test should be repeated after you finish those Basic and Advanced Audits. If the unaccounted for water remains above 10 percent after all visible leaks have been addressed, a professional conservation or engineering consultant may be needed to help identify the location of the leak. This leak test procedure should be repeated monthly.

Submeters should be used wherever and whenever practical and read at least monthly. Common locations for submeters are commercial kitchens, irrigation systems, and cooling towers. Average costs associated with installing a new meter are as follows:

Meter	$700 to $1,800
Transmitter	$600 to $1,200
Installation	$500 to $1,500
Total cost range	**$1,800 to $4,500**

You may also want to determine your facility's water use on a typical day. Do this by recording the main meter reading at the beginning or end of the work day (*Initial Reading*) and again 24 hours later (*End Reading*). This should be done on a day when no abnormal water consumption is occurring and can be repeated on a day when the facility's irrigation system is set to run. For the most accurate results, a 24-hour meter reading should be taken each day for a full week. The *Examining Utility Bills & Estimating Daily Facility Water Use – Basic Audit* section of this guidebook (page 36) can guide you.

Using a meter, typical daily water consumption at a facility can be calculated as follows:

$$\text{Typical Daily Water Consumption} = \text{End Meter Value} - \text{Initial Meter Value}$$

Worksheet 2. Facility Leak Detection

Meter Location Type	______________________ ______________________				
Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down	Leaks/Other Observations

Meter Location Type	______________________ ______________________				
Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down	Leaks/Other Observations

Meter Location Type	______________________ ______________________				
Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down	Leaks/Other Observations

Transfer this information to the *Daily Water Use* Microsoft Excel spreadsheet associated with this guide.

EXAMINING UTILITY BILLS & ESTIMATING DAILY FACILITY WATER USE – BASIC AUDIT

Background and Description

Examining Your Facility's Water Bill

Under any scenario, having copies of your facility's water bills for at least the previous year will be helpful for performing a water use audit (2 or 3 years of billing data is ideal). Water utility billing can be hard to understand and therefore difficult to quantify.

It is important to keep in mind that many facilities have more than one inflow pipe. Each is billed separately and can have different billing rates depending on the water source (potable versus reclaimed) and inflow pipe size (usually measured in inches).

Base fees are usually included with your water bill and typically vary depending on the size of the inflow pipe. Determining this is usually not very difficult.

The first real hurdle is determining the unit increment your utility charges. All utilities charge a "water" rate per unit volume. This is either in 1,000 gallon or 100 cubic foot (abbreviated ccf and equal to 748 gallons) increments.

There are also usually separate rates for incoming potable water and sewer water (which is used water returned to the treatment system). There can also be inclined rate structures that differ for each incoming pipe size. Essentially, under an inclined structure, the more you use, the more each billing increment costs (**Table 5**). For commercial use, these are most often applied to irrigation water use. Every utility is different, which necessitates a close examination of your facility's bill. This can be a valuable exercise.

Table 5. An example of an inclining block rate structure.

Gallon Range	Charge per 1,000 Gallons
0-10,000	$3.01
11,000-15,000	$3.86
16,000-25,000	$5.06
>25,000	$6.58

When determining your facility's daily water use, the first step is to determine the daily water consumption. This is relatively simple: the number of gallons used during the billing cycle is divided by the number of days in the billing cycle. Things like base service fees and inclined rates should be kept in mind and noted if you take the additional step of calculating your daily water costs (which would be total cost over the billing cycle divided by the number of days in the billing cycle).

One final note of significance: as you move forward and attempt to quantify water and dollar savings, be sure not to include base fees, as these will not change regardless of how much water is saved. On the bright side, if your utility implements an inclined block rate structure, investments toward water savings will be paid back to your facility at the highest block rate of your facility's use. For example, using the example rates in **Table 5**, if your bills indicate your facility used approximately 120,000 gallons for irrigation during the last four billing cycles, each 1,000 gallons of water not used will save the facility $6.58.

Examining Your Facility's Power Bills

The need to examine your facility's gas and electric bill may not be immediately apparent. However, consider how much of a facility's water use is tied to energy use. Energy, whether in the form of gas (usually charged in Therms) or electricity (usually charged in kilowatt hours [kWh]), is used to move, treat, and heat water. For this reason, water use reductions by certain fixtures and equipment such as faucets and showerheads, for example, will also lower your facility's power bill. This expense should be part of your calculations when considering investment costs and payback (or investment recovery) periods.

If you decide to make these calculations, the spreadsheet calculators associated with this guide can help you account for energy savings if the billing rates are known.

Determining Daily Water Use

Determining how much water your facility consumes on a regular basis is important for understanding overall water consumption. It is also a key benchmark for measuring efficiency improvements. Knowing how much water is used indoors versus outdoors is also important. Estimating water uses in these two general areas is the focus of this procedure.

In terms of determining a facility's total water use, the simplest audit scenario is a facility without an irrigation system. In this scenario, you only need to review your utility billing records, which will state the amount of water your facility consumes.

Determining total outdoor water use is usually less straightforward than indoor use. This is because irrigation water can come from various sources (e.g., potable, reclaimed, self-supplied wells, retention ponds) and is not always metered or submetered. Potable water supplied by a public water supply utility is always metered, as is reclaimed water (look for a purple pipe: purple signifies reclaimed water). Water from a pond or retention area is usually not metered.

While it may be difficult, determining the volume and cost of water consumed outdoors is important. Irrigation can be a significant part of a facility's total water use. If the irrigation water source is potable water, reducing the outdoor water demand or increasing the efficiency of the irrigation system will reduce water costs. In addition, your facility may be able to save money by taking advantage of sewer water credits for irrigation water (see page 29 for more on sewer credits). Knowing the volume and cost of water used for irrigation can help you prioritize your efficiency improvements. Irrigation may be a low priority if your facility draws water from surficial wells or retention ponds, but this priority may shift quickly if using more expensive reclaimed water becomes required or is necessary to avoid other water use restrictions.

Knowing the irrigation system's water use also is necessary to create a facility water balance (described on page 154). This can help you further prioritize your resources for improving water efficiency.

If your irrigation system uses reclaimed water or potable water and is metered or submetered, determining indoor and outdoor water use is only a matter of examining recent billing records. Under these scenarios, keep in mind the number of days the system runs each week to determine an accurate volume for each individual time the irrigation system operates. If obtaining bills is difficult, consecutive meter readings before and after an irrigation event will show how much water is used per event.

If the irrigation system uses potable water that is not delivered and metered separately from the domestic supply line and is not submetered off of the main incoming line, only the facility's total water use and expense are obvious. You can, however, still separate indoor and outdoor water use and expenses by recording the metered water use on the main meter at the beginning and end of a day when an irrigation event occurs and on another day when the irrigation system is not used. If these two days are otherwise typical for the facility, the difference between the volumes of water used on each day will show indoor and outdoor water use.

Audit Objectives

The procedures below will help you:

- Become familiar with your water and power bills, billing rates, and billing structures
- Estimate daily indoor water use
- Estimate volume of water used by your facility's irrigation system
- Estimate cost of water used indoors and to irrigate your facility's landscape
- Estimate the sewer credit that may be available to your facility if using potable water for irrigation

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Gather your utility bills or request utility bills (water and power used to heat water, gas or electric) from your facility's accounts payable office.
3. Determine the cost per one billing unit of water (1,000 gallons or ccf) and for electricity (kWh or Therms).
4. Follow the sequence and lead questions in **Box 5: Flowcharts for Determining Daily Water Use and Cost**.
5. Calculate estimates of daily water use and cost as per the equations on **Worksheet 3** unless prompted to use the *Daily Water Use* tab in the *Daily Water Use spreadsheet* after running through the questions on **Worksheet 3**.
6. If prompted, use the *Daily Water Use* tab in the *Daily Water Use spreadsheet* and continue to the next step.
7. Locate the facility's main meter.
8. Using **Box 5**, Step 7, record meter readings at the same time each day for **at least** two days, providing that one day is scheduled for irrigation system use and the other is not. Five consecutive days are recommended.
9. Transfer the data you recorded on **Box 5**, Step 7 to the *Daily Use* spreadsheet.
10. Examine the spreadsheet's two output tables (labeled *Non-Irrigation Water Use* and *Irrigation Water Use*).
11. Refer to the Post-Audit Considerations and Additional Activities subsection (page 39).

Notes:
It is left to your discretion whether to first subtract basic hookup fees before calculating daily water costs. On one hand, this could be considered as part of the cost of water for your facility. On the other hand, increasing water use efficiency or conservation will not affect those fees. Either way, it is important to keep accurate notations of your decision.

For estimating the cost of irrigation water use, under a simple scenario (such as where irrigation water is metered separately from potable water), the calculation is:

$$\text{Daily irrigation water cost} = \frac{\text{Reclaimed water costs/billing cycle}}{\text{Number of days in billing cycle}}$$

Another way to approach this is as follows:

$$\text{Irrigation water cost per watering event} = \frac{\text{Reclaimed water costs/billing cycle}}{\text{Number of days during billing cycle when the irrigation system was engaged}}$$

Post-Audit Considerations and Additional Activities

Water use efficiency improvements typically cost less and have sooner payback periods (which is the time required to repay or recover the cost of an investment) than those for energy. However, it is always a good idea to evaluate costs versus returns before investing. When you do this, be sure to:

- Calculate estimated savings using the correct increment (1,000 gallons or 1 ccf = 748 gallons)
- Determine if water savings will be accompanied by energy savings
- Calculate estimated saving based on the proper savings rate (for your facility's inflow pipe size and typically the highest per unit use rate if an inclined block rate is used)
- Not include base fees in savings calculations

As discussed earlier, local utilities sometimes award sewer credits against a facility's water use bill. This lowers the facility's water bill by the volume of water consumed on-site for cooling towers, irrigation, and similar uses that do not return water to a treatment facility.

For non-metered systems that use water from a well or retention pond, determining the volume of water applied during an irrigation event can be difficult. You may need to contact a professional with the skills and expertise to calculate your irrigation system's water application rate and total application volume

You may want to review the *Historical Water Use Profile* section of this guide, beginning on page 160.

Box 5. Flowcharts for Determining Daily Water Use and Cost

Preliminarily, request copies of your facility's water billing records from the accounts payable office. Then, starting with #1 below, examine the following seven scenarios to determine which one applies to your facility based on irrigation, water source, and submeters. After identifying the appropriate scenario, complete **Worksheet 3** to determine daily water use and daily water cost.

1. Q: *Does the facility have an irrigation system?*

If no (Indoor water use only):

$$\text{Daily water use} = \frac{\text{Total water use (gals)}}{\text{Number days in billing cycle}} \qquad \text{Daily water cost} = \frac{\text{Total cost for billing cycle}}{\text{Number days in billing cycle}}$$

If yes: **Continue to 2**.

2. The facility has an irrigation system.

Q: *Is the irrigation system water self-supplied?*

If yes (irrigation water is supplied by a well or pond):

Indoor Water Use:

$$\text{Daily water use} = \frac{\text{Metered use (gals)}}{\text{Number days in billing cycle}} \qquad \text{Daily water cost} = \frac{\text{Total water and sewer costs}}{\text{Number days in billing cycle}}$$

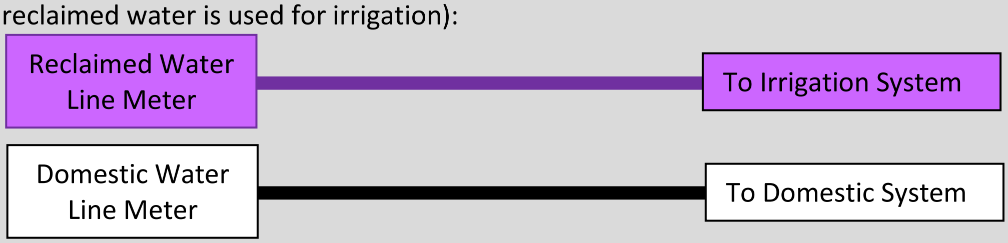
Outdoor Water Use: Determined by a professional

If no: **Continue to 3**.

3. The facility has an irrigation system and it is supplied by potable or reclaimed water (not a well or pond).

Q: *Is reclaimed or reuse water used to supply the irrigation system?*

If yes (reclaimed water is used for irrigation):



Indoor Water Use:

$$\text{Daily water use} = \frac{\text{Metered potable use (gals)}}{\text{Number days in billing cycle}} \qquad \text{Daily water cost} = \frac{\text{Total water and sewer costs}}{\text{Number days in billing cycle}}$$

Outdoor Water Use:

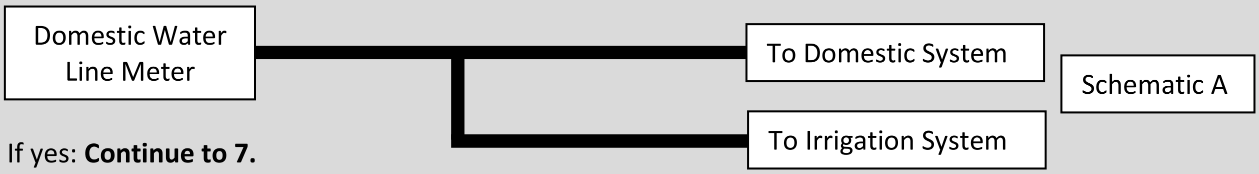
$$\text{Daily water use} = \frac{\text{Metered reclaimed use (gals)}}{\text{Number days in billing cycle}} \qquad \text{Daily water cost} = \frac{\text{Reclaimed water costs}}{\text{Number days in billing cycle}}$$

If no (reclaimed water is not used): **Continue to 4.**

Box 5 (Continued)

4. The facility has an irrigation system that is supplied by potable water.

Q: *Are irrigation water use and domestic water use recorded by the same meter as in the schematic below?*

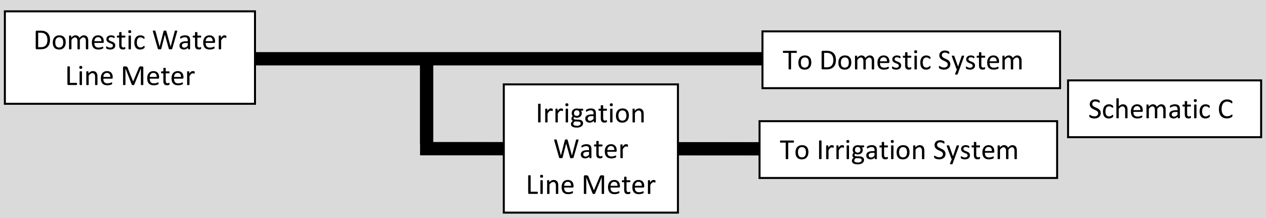


If yes: **Continue to 7.**

If no, (the irrigation water use and domestic water use are not recorded by the same meter) the irrigation line can be either metered independently from the main domestic inflow as in:

Continue to 5 for this scenario.

Or, it can be submetered off of the main domestic inflow, as in the schematic below. If it is submetered off the main, **continue to 6**.



5. Irrigation is supplied by potable water and is metered separately from the main domestic inflow line.

Use for Schematic B (from above).

Indoor Water Use:

$$\text{Daily indoor water use} = \frac{\text{Metered potable use (gals)}}{\text{Number days in billing cycle}}$$

$$\text{Daily indoor water cost} = \frac{\text{Total water and sewer costs}}{\text{Number days in billing cycle}}$$

Outdoor Water Use:

$$\text{Daily outdoor water use} = \frac{\text{Metered irrigation use (gals)}}{\text{Number days in billing cycle}}$$

$$\text{Daily outdoor water cost} = \frac{\text{Total irrigation water costs}}{\text{Number days in billing cycle}}$$

Box 5 (Continued)

6. Irrigation is not metered completely separately from domestic inflow.

Use for Schematic C (from above).

Indoor Water Use:

$$\text{Daily water use} = \frac{\text{Total facility metered use} - \text{Submetered potable use (gals)}}{\text{Number days in billing cycle}}$$

$$\text{Daily water cost} = \frac{\text{Total water costs}}{\text{Number days in billing cycle}}$$

Outdoor Water Use:

$$\text{Daily water use} = \frac{\text{Submetered irrigation use}}{\text{Number days in billing cycle}}$$

$$\text{Daily water cost} = \frac{\text{(Total water costs - Submetered gals) multiplied by cost per gallon}}{\text{Number days in billing cycle}}$$

7. The irrigation water use and domestic water use are recorded by the same meter.
Use the table below and refer to the Spreadsheet Guidance subsection on page 44.

Use for Schematic A (from above).

* The *Irrigation Schedule and Controller – Basic Audit* (page 86) within this guide provides instructions for determining the number of times per week the irrigation system is set to run.

	Date and Time of Initial Reading	Meter Reading	Date and Time of End reading	End Meter Reading	Irrigation System Used? (Yes or No)
Day 1					
Day 2					
Day 3					
Day 4					
Day 5					

There should be a 24-hour lapse between readings.

Refer to the Spreadsheet Guidance subsection (page 44) for more information.

Worksheet 3. Examining Utility Bills & Estimating Daily Facility Water Use

Based on your property and the seven possible scenarios outlined above:

Daily Indoor Water Use = ________gallons **Daily Outdoor Water Use = ________gallons**

Daily Indoor Water Cost = $____________ **Daily Outdoor Water Cost = $____________**

Spreadsheet Guidance

Use the *Daily Water Use* spreadsheet **only** if your facility's irrigation system uses potable water without an irrigation submeter. This will calculate the average number of gallons used on irrigation and non-irrigation days.

Two additional output tables (*Non-Irrigation Water Use* and *Irrigation Water Use*) are below the *Meter Data Input* table on the *Daily Water Use* tab. Those two tables calculate your facility's costs (in dollars) for irrigation and indoor water use and your potential sewer credit.

Questions to Answer and Field Data You Will Need to Collect To Use the Calculator:

- Utility rate information (Potable and Sewer Water Costs)
- Is there an irrigation system?
- What is the water source?
- Is it submetered?
- Meter readings

Utility rate data (cost of potable and sewer water, and cost of energy) is entered in the *Utility Rate Input* tab. Refer to page 23 for an explanation on how to enter utility rate and billing data. After completing **Worksheet 3**, transfer the data to the *Daily Water Use* tab of the *Daily Water Use spreadsheet*. All data is entered in white-shaded cells; the gray cells show calculated results. Be sure to select an option from the dropdown menus in the gold cells labeled "Select one," otherwise the calculation in the worksheet will not function.

Each pair of meter readings should be separated by 24 hours. **Figure 6** shows an example of audit information to be entered into the *Daily Water Use* tab of the *Daily Water Use spreadsheet*.

For each 24-hour reading, indicate whether an irrigation event occurred using the dropdown menu in the "Irrigation System Used?" column of the *Meter Data Input Table*.

	Date and Time of Initial Reading	Meter Reading	Date and Time of End reading	End Meter Reading	Irrigation System Used? (Yes or No)
Day 1	4/28/13 0615	52200	4/29/13 0615	62250	N
Day 2	4/29/13 0615	62250	4/30/13 0615	98300	N
Day 3	4/31/13 0615	109350	4/31/13 0615	12950	Y
Day 4					
Day 5					

Figure 6. An example of the meter data table from **Worksheet 3**.

GENERAL DOMESTIC WATER USE – BASIC AUDIT

Background and Description

This audit requires a physical walk-through of your entire facility to identify all points of water use and possible losses due to leaks. All water-using fixtures, appliances, and equipment (except for ambient air conditioning and commercial-grade kitchen equipment) should be documented during your walk-through using these procedures. This includes faucets, showerheads, toilets, urinals, appliances, and leaks.

While doing your walk-through, document any behaviors or work policies you observe that may be changed to help improve efficiency. Employee input may help with this.

Table 6 shows the water use rates for common indoor water fixtures and appliances over time and associated with some current efficiency standards. This table can be referenced, along with building age and a historical review of past fixture improvement efforts, to determine expected fixture water use rates. The information in **Table 6** is meant to be a precursor to a full-facility audit and cannot take the place of a thorough walk-through. The building's year of construction should not be used to definitively assume what year model fixtures or appliances are present, but is a helpful starting point.

The Basic Audit indoor water use documentation must include flow rates for all fixtures and appliances, as this is how their efficiency is determined. Most fixtures and appliances will bear an etching or stamp indicating its flow rate, usually in gallons per minute (gpm) for faucets and showerheads and gallons per flush (gpf) for toilets and urinals, which should be recorded. However, stamps or etchings on fixtures (china) can fade with time and some older models may have no markings.

Most significantly, flow rates can change with time for various reasons (discussed later). Therefore, **all fixture flow rates must be verified**.

Table 6. Gallons per use of common residential indoor water fixtures and appliances.

	Toilets (per flush)		Shower-heads (per min.)	Faucets (per min.)	Urinals (per flush)	Dish-washers[1] (per load)	Clothes Washers[1] (per load)
	Tank	Flush Valve					
Pre 1984	5.0 – 7.0	5.0 – 7.0	5.0 – 8.0	4.0 – 7.0	5.0	14	56
1984 – 1994	3.5 – 4.5	3.5 – 4.5	2.75 – 4.0	2.75 – 3.0	1.5 – 4.5	10.5 – 12	39 – 51
Post 1994[2]	1.60	1.60	2.5	2.5	1.0	10.5	27[3]
WaterSense[4] Maximum	1.28	–	2.0	1.5	0.5	–	–
Highest Efficiency	0.8 – 1.0	1.28	1.2 – 1.5	0.5 – 1.0	0[5] – 0.125	4.5 – 6.5	16 – 22

1. Residential
2. Current federal standard for all fixtures; dishwashers and clothes washers are not covered
3. Post 1998
4. See page 19
5. Waterless urinals are only recommended under specific conditions

Flow/Flush Rate Verification

The importance of verifying the flow or flush rates of all fixtures cannot be overstated. This is because the efficiency of any device can erode with time through use. Additionally, faulty maintenance or repair will affect efficiency. Therefore, it cannot be assumed that all equipment is performing at its original efficiency. Secondarily, flow verification can help direct repair and replacement efforts toward the least efficient fixtures.

Flow Verification of Faucets and Showerheads

Perform a **timed-flow test** (**Box 6**) to verify the flow rate of all faucets and showerheads. This test determines the time required to fill a known-volume cup or pitcher. For most lavatory and kitchen faucets, a measuring cup or similar container that measures in either cups or pints should be sufficient. For showerheads, a measuring container in quarts may be needed.

Metered faucets are those that remain open for a set time. Newer metered faucets are triggered by an electronic motion sensor; older ones use a spring mechanism and are still very common. Flow from these faucets is engaged when the user depresses a spring. The valve remains open until the spring has expanded back to its original extension. Timing and volume of flow for all metered faucets should be verified. as both the flow rate and the amount of time during the flow cycle can change as the valve and aerator are worn over time.

Convert the recorded time to gallons per minute using the calculation in **Box 6** or check **Table 8** (page 63), which shows the conversion of seconds of flow to gallons per minute for containers of several common sizes. Note: the *Domestic Plumbing Fixtures* calculator associated with the *General Domestic Water Use – Advanced Audit* does this conversion automatically. **Table 8** supplements **Worksheet 4** and **Worksheet 5**.

Some companies produce flow-gauge bags (**Figure 7**) that are marked in liters and gallons. Simply hold the bag under the faucet or showerhead for a certain amount of time (usually 5 seconds). The graduated side of the bag will tell you the rate of flow in gallons (or liters) per minute. The conversion is done for you.

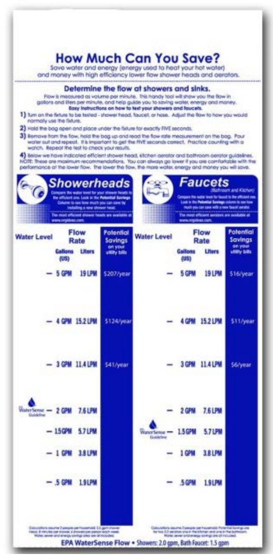


Figure 7. A flow-gauge bag.

Box 6. Timed-Flow Test Using a Measure

1. Identify a container, such as a kitchen measuring cup.
2. Using a stopwatch, record the time each faucet requires to fill the container.
3. Refer to **Table 8** on page 63 to convert the time required to fill the container or perform the following calculation:

This example is for a 0.25 gallon (quart) container that filled in 12 seconds:

$$\frac{0.25\ \text{gallons}}{12\ \text{seconds}} \times 60\ \text{seconds} = 1.25\ \text{gallons/minute}$$

Record the flow rate as marked (stamped or etched) on the fixture itself in the "Marked Flow Rate" column on **Worksheet 4** and **Worksheet 5**. Compare the measured flow rate of each fixture against the federal, WaterSense, and high efficiency standards indicated on **Worksheet 4** and **Worksheet 5**.

Flush Verification of Toilets and Urinals

A toilet can often flush at a rate different from what is marked on the fixture. This can happen as internal components degrade, if incorrect replacement parts are installed during maintenance, or when calibration adjustments have been made to diaphragm toilets. With time, the diaphragm weep hole can become partially clogged or worn, which requires more time to close and allows more water to run until the seal is complete. For these reasons, **all toilets and urinals must have their flush rates verified.**

Your verification method will depend on the type of toilet you have. The first method described here is for valve-flush toilets and the second is for tank toilets.

The **valve-flush toilet timed-flush method** (**Box 7**) tends to be very accurate because commercial flush valves flush at approximately 25 gallons per minute (gpm) or 0.42 gallons per second (gps), and urinals flush at approximately 15 gpm or 0.25 gallons per flush (gpf) (WMI 2009). However, it will not be necessary for you to perform this math. **Table 9** on page 64 shows the conversion of seconds during a flush to gallons per flush for toilets and urinals.

Table 9 supplements **Worksheet 6** and **Worksheet 7**. As previously stated, the *Domestic Plumbing Fixtures* calculator associated with the Advanced Audit does this calculation automatically.

The **tank toilet flow verification method** (**Box 8**) verifies the flush volume by measuring the internal volume of the water tank when full. This is a conservative estimate since it does not account for water used when the flapper is open during the flush or the water used to refill the bowl after the flush cycle is complete. To calculate a more accurate use volume, add 15 percent of the measured volume.

Table 10 on page 64 shows the conversion of cubic inches to gallons per flush for tank toilets. Some allowance for error may be necessary if the tank is not completely rectangular. **Table 10** is supplemental to **Worksheet 6**.

Box 7. Valve-Flush Toilet Timed-Flush Test

1. Flush the toilet or urinal and count the number of seconds that elapse during the flush.
2. Multiply that number by 0.42 for toilets or 0.25 for urinals according to the following formula:
3. Seconds flushing x 0.42 (for toilets) or 0.25 (for urinals) = ____ gallons per flush

Box 8. Tank Toilet Flow Verification (Volumetric Method)

1. Mark the water height inside the tank with a waterproof marker.
2. Flush the toilet and mark where the water level drops just before it begins to refill, since some tanks do not use their entire contents for a single flush.
3. Measure the internal dimensions (in inches) of the tank from where the water level drops to and up to the fill line.
4. Convert square inches to gallons using the following formula:

Tank height x width x length x 0.004329 = _____ gallons

$1\ in^3 = 0.004329$ gallons

Leaks

As you evaluate your facility's fixtures, be on the lookout for leaks. In some cases leaks can be heard but not seen. All fixtures, appliances, machinery, outdoor hose bibs, and conduits should be visually inspected for signs of leaks during this procedure.

In addition, tank-toilets must undergo a dye test for leaks (**Box 9**). Flappers degrade and leak due to chlorine compounds used in water treatment. A leaking flapper valve in a toilet can leak at a rate of 5 drips per second or 15,000 gallons per year.

Box 9. Dye Test for Tank Toilet Leak Detection

1. Use food coloring or dye tabs found at a hardware store specifically for this purpose (do not use any other type of dye).
2. Put the dyeing agent into the toilet tank.
3. Wait 15 to 20 minutes while ensuring there is no use of the toilet during that time. If the dye appears in the toilet bowl, the flapper has a leak.
4. Flush the toilet after each test to prevent staining.
5. Record locations where leaks are found in the space provided on **Worksheet 5**.

Notes on Selected Indoor Water Uses

- This procedure includes surveying kitchens or breakrooms using **residential-grade** devices only. If necessary, review the *Commercial-Grade Kitchen Water Use – Basic Audit* (beginning on page 66) before accounting for kitchen water use.
- Cooling towers can be the largest water consumption point in a commercial building and therefore have a separate audit in this guide beginning on page 76.
- If your facility has a vehicle washing area, it should be documented in this section. At a minimum, vehicle washing areas should have hoses with self-cancelling, hand-trigger nozzles. Larger-scale fleet wash systems are available that recycle and reuse final rinse water.

Audit Objectives

This procedure will help you better understand where and how water is consumed throughout the facility. You also will learn how the fixtures and appliances at your facility compare to federal and "efficiency" water use standards.

As a result of the procedure, you will have valuable information for determining outdated fixtures. However, the Basic Audit activities are non-quantitative. The *General Domestic Water Use – Advanced Audit* will build on the information you collect here and will allow you to see quantitatively the current use, potential savings, and payback periods for efficiency-increasing investments.

At the end of this section, completed sample worksheets are provided with example information for your reference. The actual worksheets follow the samples.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Determine if and when any fixture upgrades or replacements have occurred (refer to **Table 6**, page 45).
3. Assemble the following:
   a. Several copies of **Worksheet 4** through **Worksheet 8**
   b. A stopwatch
   c. A calculator (optional in field)
   d. A flow-gauge bag or a measuring cup or pitcher of a known volume – one marked in cups or pints is suggested for lavatory and kitchen faucets and one in quarts or gallons may be needed for showerheads
   e. Toilet test dye tablets or a packet of food coloring
   f. A ruler or tape measure
   g. Waterproof marker, pen, or pencil
   h. A hand towel (especially if testing showerheads)
4. For all fixtures, note the etching or stamp that indicates the flow rate on **Worksheet 4** through **Worksheet 7**.
5. Test the flow rate of each fixture, other than toilets and urinals, using the timed flow test (**Box 6**, page 46).
6. Record the time required to fill the measuring cup or flow-gauge bag on **Worksheet 4** (faucets) and **Worksheet 5** (showerheads).
7. Indicate whether each faucet is located in a lavatory using a check mark in the second column of the faucet worksheet. (Best management practices for lavatory faucets are distinct from other types of faucets. Also, this information is needed when using the spreadsheet calculator for the related Advanced Audit analysis, if conducted.)
8. For all flush valve toilets and urinals, conduct a timed-flush test (**Box 7**, page 47).
9. Record the flush times on **Worksheet 6** (toilets) or **Worksheet 7** (urinals).
10. Conduct a dye test (**Box 9**, page 48) on all tank toilets. You may consider running ahead and dropping dye tabs in all tank toilets then circling back to the first one since the dye tabs typically take 15–20 minutes to dissolve and trace a leak. Alternatively, you can check all fixtures, note leaks and drop tabs in the tanks, and then circle back just to check the toilets for the evidence of flapper leaks by looking for the dye in the bowl.
11. Record results of dye tests in the space provided on **Worksheet 6**.
12. For kitchens and breakrooms containing only residential-grade appliances and fixtures:
    a. Document all fixtures, conducting timed-flow tests as needed
    b. Document all water-using appliances (e.g., dishwashers, ice machines), noting the make, model, and whether an ENERGY STAR label is present
    c. Indicate on **Worksheet 8** (appliances) whether the model is ENERGY STAR qualified
13. Document other water-using appliances on **Worksheet 8** (with the exception of commercial kitchen equipment), noting the make and model, and look for the ENERGY STAR label.
14. Identify any and all leaks encountered during the walk-through.
15. Document work habits or policies that may be hampering water use efficiency and those that may improve it.

Steps 16 and 17 should be done after all field work has been completed.

16. Compare the measured flow rate of each fixture against the federal, WaterSense (if applicable), and high efficiency standards for that fixture type as provided on the appropriate worksheet. High efficiency standards are summarized at the bottom of each worksheet associated with this procedure. Record whether the fixture requires maintenance (to return it to its rated efficiency), replacement (for a more efficient model), or no action (already efficient) in the space provided in the worksheet.
17. Use **Table 8** through **Table 10** (pages 63–64) to convert all flows and flush times to gallons per minute and record the water use in gallons per minute or gallons per flush for each fixture in the 'Calculated Rate' column on **Worksheet 4** through **Worksheet 7**. (The spreadsheets associated with the *General Domestic Water Use – Advanced Audit* will complete these calculations for you.)
18. Refer to the *Post-Audit Considerations and Additional Activities* below for more information.

Post-Audit Considerations and Additional Activities

Depending on the age of the basic restroom plumbing fixtures (toilets, urinals, faucet aerators) in your facility, **a switch to high efficiency fixtures can save approximately 2,000 gallons per year per full-time employee**. The payback period for replacing older, less efficient fixtures with new, efficient models is typically very short (1 to 4 years) and often less than 2.5 years (Dziegielewski 2000).

Consider replacing all fixtures and appliances that use more water than the current federal standards (**Box 3**) or were purchased before 1994, although there are some exceptions (described below) to this recommendation.

Two resources for researching and comparing appliances are ENERGY STAR and the Consortium for Energy Efficiency (CEE). ENERGY STAR is a joint program of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy established to provide information on energy-efficient products and practices. The ENERGY STAR website[1] is highly informative and practical and includes a full list of ENERGY STAR-qualified products.

The Consortium for Energy Efficiency[2] is a nonprofit organization established to promote the manufacture and purchase of energy-efficient products and services. The CEE maintains a "Whole Building Performance" approach to efficiency for commercial buildings. CEE members include utilities, research organizations, and state energy offices in the United States and Canada. Collaborative partners include manufacturers, retailers, the U.S. Department of Energy, and the EPA.

Specific considerations for most common indoor fixtures and appliances are provided below.

Toilets

General Recommendations

Regulatory plumbing standards vary by state. Florida mandated the installation of 3.5 gallons per flush (gpf) toilets in all new construction as of 1984, and 1.6 gpf toilets as of 1994. The 'general' recommendation for improving water use efficiency of toilets is as follows: all existing toilets designed to flush higher than 1.6 gpf or installed prior to 1994 should be considered for replacement with approved WaterSense models, which use 1.28 gpf or less.

WaterSense-labeled 1.28 gpf tank/bowl high efficiency toilets (HETs) meet the same drainline flow requirements as 1.6 gpf models. The EPA Water Sense program is creating a 1.28 gpf HET certification for the valve/bowl combinations used in many commercial applications. Although this replacement measure should be successful in most buildings, in retrofit applications, it is suggested that drainlines first be inspected for defects, root intrusions, sagging, or other physical conditions that could result in clogging with lower flush volumes. In

[1] www.energystar.gov
[2] www.cee1.org

addition, new research is evaluating the potential for blockage for flush valve/bowl combinations with rates less than 1 gpf. These valve/bowl combinations are not recommended at this time for retrofit purposes.

You may want to test the performance of a small number of 1.28 gpf fixtures in your facility before proceeding with a full-scale replacement program. If drainage problems occur while using 1.28 gpf models, 1.6 gpf toilets should be used.

Alternatively, any toilet flush-valves (flushometers) designed to flush using 1.6 gpf, but using more water, should be repaired to flush at the intended rate.

Flush valve toilets should be retrofitted with piston-operated flush valves. Piston valves generally require less maintenance, offer more precise performance, and last longer. In addition, the housing for piston-operated valves will not accept replacement parts for older, high volume flushing toilets, while diaphragm valve toilets can. Installing a 1.28 gpf flush valve on an existing 1.6 gpf fixture may result in poor performance and potentially serious maintenance issues. To save water and ensure acceptable performance, both the toilet and flush valve need to be retrofitted.

Dual flush flush-valves may not always be the best allocation of resource dollars. In most cases, men will choose to use a urinal instead of a toilet when given the choice. Additionally, some women have complained the low volume flush of some commercial dual-flush valves does not always remove all paper materials in the bowl after use. There is currently no WaterSense approved dual flush flush-valve, but there may be one in the future.

Mismatching Flush Valves and Fixtures

Typically, replacement parts for older and newer diaphragm flush valves are interchangeable. Therefore, when a low flow (efficient) flush valve is repaired using high flow (inefficient) parts, the low flow china operates as a high flow one. This can happen in a reversed scenario as well. Mismatching flush valves and fixtures can be problematic. However, this is not always the case. Mismatched valve-china combinations that perform acceptably are more common for urinals than for toilets, but some 3.5 gpf china fixtures will perform adequately with 1.6 gpf flush valves.

Using a low flow valve on an older fixture is not recommended. However, if this combination is already installed and not creating performance problems, it is up to you and your facility maintenance team whether to leave them in place.

These types of occurrences illustrate the need for water audits as they may be difficult to identify without conducting a full audit.

Toilet Retrofit Kits

Tank toilet retrofit ‘kits,’ which replace the internal toilet tank hardware to yield lower volume flushes, are not recommended because these kits may not be compatible with the shape and design of the existing bowl. Performance can be compromised, leading the user to flush more than once per use. Additionally, installing these devices can void the fixture’s warranty.

Some kits convert the toilet to a dual flush system (not to be confused with dual flush toilets where the china and stock internal flushing hardware were designed together). The flush volume (especially for the low volume flush) may not adequately remove all material in a bowl designed to flush at more than 3 gpf, resulting in the user flushing multiple times or ignoring the low volume flush altogether. In addition, the high volume flush resulting from the use of these kits may still remain above 3 gallons.

Urinals

General Recommendations

Regulatory plumbing standards vary by state. Florida mandated the installation of 1.5 gpf urinals in all new construction as of 1984, and 1.0 gpf urinals as of 1994. The 'general' recommendation for improving water use efficiency of urinals is as follows: all existing urinals designed to flush higher than 1.0 gpf or installed prior to 1994 should be considered for replacement with approved WaterSense models, which use 0.5 gpf or less.

Pint-flush (1/8 gpf) Urinals

The most efficient urinals are pint or 1/8 gpf models. Many of these models have achieved the WaterSense label. Pint flush urinals offer many advantages when considering water-saving options for urinal use. To function properly, 1/8 gpf urinal flush valves must be used with an appropriately designed china fixture. Existing 1.0 gpf or greater urinals cannot be properly retrofitted with 1/8 gpf flush valves. **Both the china fixture and flush valve must be replaced**.

Retrofit

In many cases it is possible to retrofit existing 1.0 gpf urinals to flush at 0.5 gpf. This can be done by either replacing the old 1.0 gpf flush valve or diaphragm in the existing flush valve with a 0.5 gpf equivalent. If the flush valve is to be replaced, change it to a piston type valve for the reasons stated in the section on toilets. Although this retrofit is usually successful, you may want to test the desired retrofit flush valve/diaphragm with a small group of urinal fixtures in your facility before proceeding with a full scale retrofit program to assure proper performance.

Waterless Urinals

Waterless urinals can save up to 40,000 gallons of water per urinal per year, but special maintenance is required to avoid odor and plumbing issues. Issues to consider with waterless urinals include:

- **Maintenance Procedures:** The exact maintenance required varies by manufacturer and the trap mechanism. Thoroughly review the maintenance procedures for the waterless urinals you are considering and consult with your facility maintenance staff to ensure proper care of the urinals is practical and achievable before making a final decision.
- **Maintenance Cost:** Include the maintenance material costs associated with the particular urinal you are considering to determine if the retrofit will be cost effective.
- **Plumbing System Issues:** To properly maintain drain line integrity, it is essential to maintain the urinal according to the manufacturer's specifications, including periodically flushing the drain with water. Improper waterless urinal maintenance can lead to plumbing issues, such as drain clogs or corrosion.
- **Users' Needs:** Be sure to consider whether the urinal will maintain your facility's compliance with the Americans with Disabilities Act (ADA).

Faucets

Aerators

Today, 0.5 gpm aerators are the standard for public lavatory faucets (ASME A112.18.1-2005). Because there is often little or no difference between commercial and residential lavatory faucets, it is quite likely that many lavatory faucets in commercial or public facilities will have high flow aerators installed. Lavatory faucets with flow rates greater than 0.5 gpm should have their aerators replaced with 0.5 gpm models. The low cost of these items makes them a sound investment at nearly any frequency of use. Additionally, consideration should be given to replacing aerators in non-lavatory sinks (such as a kitchen sink in an employee breakroom with aerators that flow at 1.0 gpm to 1.5 gpm). Low flow aerators may not be appropriate for other faucets that have a single specified function, such as those used to fill mop buckets or wash large items.

Metered Faucets

Metered faucets should use no more than 0.25 gallons per use. Therefore, metered faucets are not, by default, held to a specific flow rate so long as the timing and flow rate do not exceed 0.25 gallons per on-off cycle. When a 0.5 gpm aerator is used, the flow cycle can be as long as 30 seconds and not exceed this limit. Conversely, an aerator flowing at 1.0 gpm should cycle off after 15 seconds. **Table 11** (page 65) shows the total volume output of metered faucets based on seconds of flow and aerator gallons per minute.

Showerheads

The WaterSense specification for showerheads is no more than 2.0 gpm while delivering a satisfactory experience to the user. Any showerhead using more than 2.0 gpm should be replaced with a high efficiency WaterSense labeled model (2.0 gpm, maximum). WaterSense labeled showerheads with flow rates of 1.75 gpm and 1.5 gpm are available and effective.

Be cautious when considering showerheads that use less than 1.75 gpm in non-residential facilities due to a potential increase for scalding issues with some thermostatic tempering shower valves.

Residential-Grade Clothes Washers

If your facility uses a residential-grade clothes washer, consider replacing it with a model qualified by ENERGY STAR or CEE when the current one reaches the end of its service life. Efficient models use 35–50 percent less water and approximately 50 percent less energy than conventional ones[1]. Under the CEE and ENERGY STAR qualification systems, the clothing's moisture content at the end of washing, which is a function of the spin cycles and affects the amount of drying needed, is an efficiency marker. This is known as the Modified Energy Factor or MEF; the higher the number, the more efficient. Models qualified by these groups can wash at least 2 cubic feet (ft^3) of laundry per kilowatt hour (kWh) (the current federal standard is 1.26). They also use 6 gallons of water or less to wash 1 ft^3 of laundry (the current federal standard is 9.5). The water factor (WF) is the descriptor used to describe this quality; the lower the number the more efficient. ENERGY STAR[2] and CEE[3] maintain lists of qualified models on their websites.

Residential-Grade Kitchen Dishwashers

If your facility uses a residential-grade dishwasher, consider replacing it with a model qualified by ENERGY STAR[2] or CEE[3] when the current one reaches the end of its service life. ENERGY STAR- or CEE-qualified models are both energy and water efficient. This is significant because most dishwasher energy use goes towards heating water. The energy factor (EF), which measures the number of cycles a dishwasher can run with 1 kWh of electricity, for CEE-qualified models is 0.75. The water requirement is no more than 4.25 gallons per cycle (load). ENERGY STAR also has a qualifying water requirement of 4.25 gallons (or less) per cycle, for standard size models, and 3.5 gallons (or less) for compact models. The federal minimum standard for dishwashers is 6.5 gallons per cycle for standard size models, and 4.5 gallons (or less) for compact models.

Ice Machines

One of the most important considerations to make when purchasing an ice machine is that it is properly sized for the anticipated demand. Purchasing a unit with a production capacity far beyond what will reasonably be needed will waste both water and energy and will cost more to operate.

At 100 percent efficiency, it takes almost 12 gallons of water to make 100 pounds of ice. However, the amount of water actually needed to make this much ice ranges from 18 to

[1] www.cuwcc.org/smartrebates-res-fixtures.aspx

[2] www.energystar.gov

[3] www.cee1.org

200 gallons for most ice machines. Water-cooled machines are typically far less efficient than air-cooled models and there are currently no ENERGY STAR-qualified water-cooled models. Even for air-cooled machines, some inefficiency occurs when minerals are rinsed free from ice trays. This inefficiency can be reduced, but is not completely avoidable (AWE 2010). In general, 'efficient' ice machines should use close to 20 gallons of water per 100 pounds of ice production (AWUWCD 2006). Ice machines with the ENERGY STAR[2] rating or "qualified" by the CEE[3] and Food Service Technology Center (FSTC)[1] are, on average, 15 percent more energy efficient and 10 percent more water efficient than standard models. Each year, these models can **save approximately $110–$400 on utility bills and approximately 2,500 to over 10,000 gallons of water**.

Much of the operating cost of an ice machine depends on where the displaced heat from the chilled water is released. Some machines release this heat in the same room as the machine itself, adding to the burden of the building's air conditioning system, while others have remote heads that release the heat outdoors or in spaces without air conditioning This additional expense is not factored in these calculations, but should be considered during your efficiency improvement planning process.

The shape and quality of the ice also matters. Models that produce ice flakes or disks use approximately 30 percent less water than the average cube-making machines. Some ice machines are designed to produce ice cubes free of air bubbles and with a 'frosted' appearance. These models produce smooth and clear ice by freezing and partially thawing the ice while it is produced. From an efficiency standpoint, this is seen as a wasteful practice as the inherent quality of the ice is equal to 'rough' appearing ice yet requires more water.

Another consideration is the machine's method of cooling. While the cost of air-cooled and water-cooled ice-making equipment is almost equal, air-cooled models save water and energy (**Table 7**). For energy conservation, the most efficient ice makers have remote air-cooled condensers that expel heat outside the workspace. Placing the condenser outside the building does not add to the burden for the air conditioning system.

Additional savings are possible by retrofitting air-cooled machines with a heat exchange unit. This technology uses the machine's rejected water from the cold plate to pre-cool the incoming potable supply, thus reducing the energy required to freeze the incoming water.

For more on ice machines, see page 68

Air Versus Water-Cooled Equipment

In most cases and as previously mentioned with ice machines, air-cooled equipment is favored over water-cooled equipment in terms of water efficiency. There may be trade-offs with energy efficiency, so refer to the ENERGY STAR[2] or CEE[3] websites for guidance or consult with the equipment manufacturer to discuss the most efficient option for your facility.

Under most circumstances, water-cooled equipment should operate on a closed-loop system. Equipment with a once-through system should be retrofitted to operate as a closed-loop if possible. If not, it may be possible to use the outflow for another purpose, such as to offset cooling tower makeup water. On-site alternative water sources are described further later this guide (see page 163).

[1] www.fishnick.com

[2] www.energystar.gov

[3] www.cee1.org

Table 7. Comparison of water and energy use, consumption, and cost of standard and efficient ice machines[1]

Performance	Standard Water-Cooled Model	Standard Air-Cooled Model	Energy and Water Efficient Air-Cooled Model
Energy Consumption (kWh/100 lbs ice)	6	7.6	5.6
Water Consumption (gals/100 lbs ice)	156	28	20
Annual Energy Use (kWh)[2]	9,855	12,483	9,198
Annual Water Use (gals)[2]	256,230	45,990	32,850
Annual Energy Cost[3]	$986	$1,248	$920
Annual Water & Sewer Cost[4]	$1,713	$307	$220
Total Annual Utility Cost	$2,699	$1,555	$1,140

Source: Food Service Technology Center, 2011

1. Assumptions are 550 pound capacity machine versus Tier III ENERGY STAR certified model
2. Annual energy use based on 75% duty cycle, 365 days per year
3. Energy costs based on $0.10/kWh
4. Water and sewer costs are based on $2 per ccf and $3 per ccf, respectively.

For More Information

To learn more about improving water use efficiency in a commercial building, including alternative on-site water sources, see the *WaterSmart Guidebook – A Water-Use Efficiency Plan Review Guide for New Businesses* (EBMUD 2008)[1]. This resource contains a wealth of best management practices and information on water-saving technologies.

Additional Information on national green building standards and codes for water-using fixtures and appliances and water meters can be found on the website of the Alliance for Water Efficiency[2].

Advanced Audit Preview

Completing this Basic Audit will provide valuable information in terms of which fixtures in your facility are obsolete. However, the data is not quantitative and limits your ability to conduct further analysis. The *Domestic Water Use – Advanced Audit* (beginning on page 114) builds on this audit and will allow you to quantitatively measure current use, potential savings, and payback periods for investments.

There should be no additional field work necessary to complete the Advanced Audit. Furthermore, all necessary calculations are done by the accompanying Microsoft Excel spreadsheets (*Domestic Plumbing Fixtures* and ENERGY STAR's *Commercial/Residential Appliance Savings Calculator*).

[1] www.allianceforwaterefficiency.org/WaterSmart_Guidebook_for_Businesses.aspx or go to www.allianceforwaterefficiency.org and enter "WaterSmart Guidebook" into the search bar
[2] www.allianceforwaterefficiency.org and enter "green building standards and codes" into the search bar

Sample Worksheets

The following sample worksheets have been provided for each fixture type to aid your audit. As you perform your facility walk-through, be sure to indicate individual fixtures in group lavatories. Suggested fixture identification methods include initiating a count at "A" or "1"with the fixture closest to the door or beginning to the left upon entering. See the sample worksheets below.

Sample worksheets are shown with mock data. They are for illustrative purposes only. When printing worksheets for use in the field, see **Appendix C**, where they are repeated to ease double-sided printing and reduce the number of pages you need to carry as you perform your facility audit.

Sample **Worksheet 4: Faucets**

Building Name Building 2A Flow measurement container (Circle one) Cups/ Pints/ Quarts/Flowbag

Location	Lav. Fac. (?) ✓	User Group	Manual, Sensor, or Spring	Metered (Sensor or Spring) Seconds of Flow	Flow Rate: Marked Flow Rate (gpm)	Flow Rate – Timed: Num. Cups/ Pints/ Quarts	Flow Rate – Timed: Num. Secs.	Flow Rate – Timed: Calc. Rate or Flowbag (gpm)	NA=No Action R=Replace M=Maint.	Leaks? Other Comments
Rm 403B 1	✓	Male staff	Spring	6	2.2	2	3	2.5	NA	Closest to door
Rm 403B 2	✓	Male staff	Spring	6	2.2	2	3	2.5	M	Handle leak
Rm 403B 3	✓	Male staff	Spring	17	2.2	2	3	2.5	M	Farthest from door Long flow

Sample **Worksheet 5: Showerheads**

Building Name Building 2A **Flow measurement container (Circle one) Cups/ Pints/ Quarts/Flowbag**

Location	User Group	Flow Rate: Marked Flow rate (in gpm)	Flow Rate – Timed: Num. Cups/ Pints/ Quarts	Flow Rate – Timed: Num. Secs.	Flow Rate – Timed: Calc. Rate or Flowbag (gpm)	Standards Check* NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
Rm 403A 1	Female staff	?			3.0	R	Closest to door
Rm 403A 2	Female staff	?			2.75	R	Leaking
Rm 403A 3	Female staff	?			3.0	R	
Rm 403A 4	Female staff	?			3.0	R	Farthest from door

Sample **Worksheet 6: Toilets**

Building Name __Building 2A____

Location	User Group	Manual, or Sensor	Tank or Valve	Valve Flush Rate (in gpf)	China Flush Rate (in gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
Rm 403B 1	Male Staff	Sensor	Val	1.6	3.5	7			Closest to door
Rm 403B 2	Male Staff	Sensor	Val	?	3.5	8			Farthest from door

Sample **Worksheet 7: Urinals**

Building Name ___Building 2A_______

Location	User Group	Manual, or Sensor	Valve Flush Rate (in gpf)	China Flush Rate (in gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
Rm 403B 1	Male Staff	Manual	1.0	1.0	3			Closest to door
Rm 403B 2	Male Staff	Manual	1.0	1.0	5			Handle leak
Rm 403B 3	Male Staff	Manual	1.0	1.0	8			Farthest from door

Worksheet 4. Faucets

Building Name ____________ Flow measurement container (Circle one): Cups/Pints/Quarts/Flowbag

					Flow Rate					
						Timed				
Location	Lav. Fac. (?) ✓	User Group	Manual, Sensor, or Spring	Metered (Sensor or Spring) Seconds of Flow	Marked Flow Rate (gpm)	Num. Cups/ Pints/ Quarts	Num. Secs.	Calc. Rate or Flowbag (gpm)	NA=No Action R=Replace M=Maint.	Leaks? Other Comments
Totals										

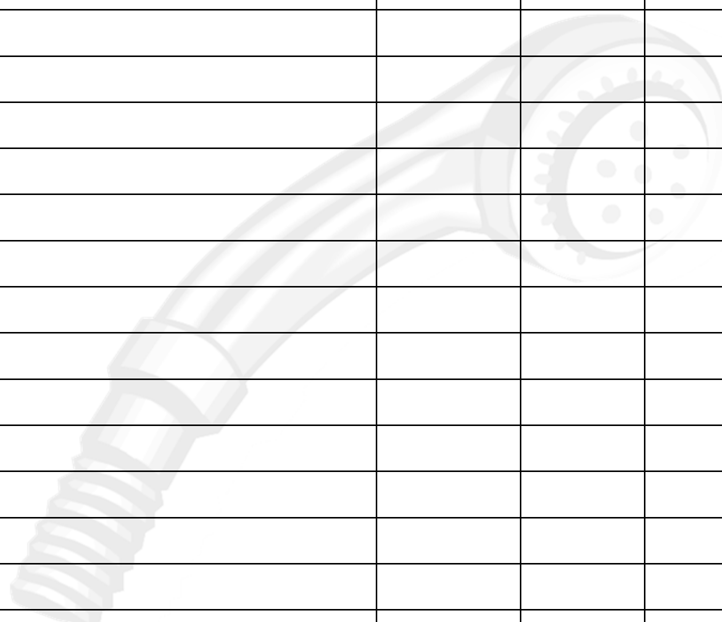
***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

** Place a check mark in the second column (**Lav. Fac. ?**) if the faucet is located in a lavatory. Leave blank otherwise. **

Worksheet 5.   Showerheads

Building Name _____________ Flow measurement container (Circle one)   Cups/ Pints/ Quarts/Flowbag



Location	Flow Rate				NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
		Timed				
	Marked Flow rate (gpm)	Num. Cups/ Pints/ Quarts	Num. Secs.	Calc. Rate or Flowbag (gpm)		
Totals						

***High efficiency standards:** Toilets, 1.28 gpf: Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at "A" or "1" with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 6. Toilets

Building Name ___________________

Location	User Group	Manual or Sensor	Tank* or Valve	Marked Valve Flush Rate (gpf)	Marked China Flush Rate (gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Dye Test Results? Other Comments
Totals									

* For tank toilets, record measurement in square inches of the tank volume.

Tank length x width x height (of water fill) = Volume

***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals:, 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 7. Urinals

Building Name ___________________

Location	User Group	Manual or Sensor	Marked Valve Flush Rate (gpf)	Marked China Flush Rate (gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
Totals								

***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at "A" or "1" with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 8. Appliances

Dishwasher	Location		**Make/ Model**	**Quantity**	**Racks washed per day or week**	**Building hot water fuel type**	**Booster water heater fuel type**	**Operating days per year**	**ENERGY STAR Qualified?**
		Under Counter							
		Door Type							
Low Temp.		Single Tank Conveyor							
Or High Temp.		Multi Tank Conveyor							
Leaks or Other Comments									

Ice Machine	Location	**Make/ Model**	**Quantity**	**Harvest rate (pounds ice per day)**	**Potable water use (gallon per 100 pounds ice)**	**Operating days per year**	**ENERGY STAR Qualified?**
	Ice Making Head						
	Remote Condensing Unit /Split System						
	Self Contained Unit						
Leaks or Other Comments							

Clothes Washer	Location How is water for each unit heated?	**Make/ Model**	**Quantity**	**Average number of loads per week**	**Type of water heating**	**Type of clothes dryer**	**Electric or Gas Drier**	**ENERGY STAR Qualified?**
	Electric Heat							
	Gas Heat							
Leaks or Other Comments								

Supplemental Tables to the General Domestic Water Use Field Survey

Table 8 shows the conversion of seconds of flow to gallons per minute for containers of several common sizes. Use the tables with the timed-flow test (**Box 6**, page 46). The *Domestic Plumbing Fixtures* spreadsheet associated with this guide will do the calculation for you after you enter the measuring cup size and seconds to fill it.

Table 8. Conversions to gallons per minute for containers of several common sizes.

Cups per second to gallons per minute

Cups \ Seconds	1	2	3	4	5	6	7	8	9	10
1	3.75	1.88	1.25	0.94	0.75	0.63	0.54	0.47	0.42	0.38
2	7.50	3.75	2.50	1.88	1.50	1.25	1.07	0.94	0.83	0.75
3	11.25	5.63	3.75	2.81	2.25	1.88	1.61	1.41	1.25	1.13
4	15.00	7.50	5.00	3.75	3.00	2.50	2.14	1.88	1.67	1.50
5	18.75	9.38	6.25	4.69	3.75	3.13	2.68	2.34	2.08	1.88
6	22.50	11.25	7.50	5.63	4.50	3.75	3.21	2.81	2.50	2.25
7	26.25	13.13	8.75	6.56	5.25	4.38	3.75	3.28	2.92	2.63
8	30.00	15.00	10.00	7.50	6.00	5.00	4.29	3.75	3.33	3.00

Pints per second to gallons per minute

Pints \ Seconds	1	2	3	4	5	6	7	8	9	10
1	7.50	3.75	2.50	1.88	1.50	1.25	1.07	0.94	0.83	0.75
2	15.00	7.50	5.00	3.75	3.00	2.50	2.14	1.88	1.67	1.50
3	22.50	11.25	7.50	5.63	4.50	3.75	3.21	2.81	2.50	2.25
4	30.00	15.00	10.00	7.50	6.00	5.00	4.29	3.75	3.33	3.00
5	37.50	18.75	12.50	9.38	7.50	6.25	5.36	4.69	4.17	3.75
6	45.00	22.50	15.00	11.25	9.00	7.50	6.43	5.63	5.00	4.50
7	52.50	26.25	17.50	13.13	10.50	8.75	7.50	6.56	5.83	5.25
8	60.00	30.00	20.00	15.00	12.00	10.00	8.57	7.50	6.67	6.00

Quarts per second to gallons per minute

Quarts \ Seconds	1	2	3	4	5	6	7	8	9	10
1	15.00	7.50	5.00	3.75	3.00	2.50	2.14	1.88	1.67	1.50
2	30.00	15.00	10.00	7.50	6.00	5.00	4.29	3.75	3.33	3.00
3	45.00	22.50	15.00	11.25	9.00	7.50	6.43	5.63	5.00	4.50
4	60.00	30.00	20.00	15.00	12.00	10.00	8.57	7.50	6.67	6.00
5	75.00	37.50	25.00	18.75	15.00	12.50	10.71	9.38	8.33	7.50
6	90.00	45.00	30.00	22.50	18.00	15.00	12.86	11.25	10.00	9.00
7	105.00	52.50	35.00	26.25	21.00	17.50	15.00	13.13	11.67	10.50
8	120.00	60.00	40.00	30.00	24.00	20.00	17.14	15.00	13.33	12.00

Table 9. Flush volume flow rate calculator for the valve-flush, timed-flush test[1].

Fixture	Number of Seconds Flushing	Flow Rate in Gallons per Minute	Gallons per Flush
Toilet	1	25	0.42
	2	25	0.83
	3	25	1.25
	4	25	1.67
	5	25	2.08
	6	25	2.50
	7	25	2.92
	8	25	3.33
	9	25	3.75
Urinal	1	15	0.25
	2	15	0.50
	3	15	0.75
	4	15	1.00
	5	15	1.25
	6	15	1.50
	7	15	1.75
	8	15	2.00
	9	15	2.25

Table 10. Tank flush volumetric calculator.

Cubic Inches	Gallons		Cubic Inches	Gallons
300	1.30		700	3.03
350	1.52		750	3.25
375	1.62		800	3.46
400	1.73		850	3.68
450	1.95		900	3.90
500	2.16		1000	4.33
550	2.38		1100	4.76
600	2.60		1150	4.98
650	2.81		1200	5.19

Cubic inches = Tank fill height x width x length

[1] If you use the *Domestic Plumbing Fixtures* spreadsheet, it will complete this calculation for you.

Table 11. Metered faucet flows and total gallons per cycle. Metered faucet water use efficiency is not gauged or limited by a maximum flow rate. These faucets should use no more than 0.25 gallons per use (blue squares).

		Flow Cycle (in seconds)														
		2	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**
	0.5	0.02	0.03	0.05	0.07	0.08	0.10	0.12	0.13	0.15	0.17	0.18	0.20	0.22	0.23	0.25
	1.0	0.02	0.07	0.10	0.13	0.17	0.20	0.23	0.27	0.30	0.33	0.37	0.40	0.43	0.47	0.50
Gallons	**1.5**	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75
per	**2.0**	0.07	0.13	0.20	0.27	0.33	0.40	0.47	0.53	0.60	0.67	0.73	0.80	0.87	0.93	1.00
Minute	**2.2**	0.07	0.15	0.22	0.29	0.37	0.44	0.51	0.59	0.66	0.73	0.81	0.88	0.95	1.03	1.10
	2.5	0.08	0.17	0.25	0.33	0.42	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25
	3.0	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	1.50
	3.5	0.12	0.23	0.35	0.47	0.58	0.70	0.82	0.93	1.05	1.17	1.28	1.40	1.52	1.63	1.75

COMMERCIAL-GRADE KITCHEN WATER USE – BASIC AUDIT

Background and Description

Most commercial buildings have some type of kitchen area. Those with residential-grade fixtures and appliances are covered in the *General Domestic Water Use – Basic* and *Advanced Audits* (pages 45 and 114). This section will help you assess water-using equipment if your facility has a commercial kitchen or cafeteria

As with the *General Domestic Water Use – Basic Audit*, you will conduct a facility walk-through to identify all points of water use and leaks but for this audit, it is through your facility's commercial kitchen. Common points of water use include simple hand washing sinks, large dedicated sinks (pot filling, pot washing, etc.), pre-rinse spray valves, dishwashers, ice machines, steam cookers, combination ovens, and large-scale garbage disposal units. Some kitchens have restrooms for use by kitchen staff only; other have clothes washers for aprons and cleaning rags. Uses and best management practices for all these items are provided in the *Post-Audit Considerations and Additional Activities* subsection.

All water-using fixtures and appliances or equipment should be documented (including flow-rate verification tests for simple fixture and pre-rinse spray valves.) during the walk-through. Timed-flow test results should be converted to gallons per minute using the methods from the *General Domestic Water Use – Basic Audit* (see **Box 6**, page 46 for a review of that methodology). As you perform the walk-through, keep an eye (and ear) out for any leaks.

Behavior and habits in commercial kitchens can greatly affect water use. Reviewing the best management practices (see *Post-Audit Considerations* and **Appendix B**) with kitchen staff can greatly increase water efficiency.

Commercial-grade kitchens (usually associated with large cafeterias) may have restrooms accessible only to kitchen staff. If this is the case, perform the timed-flow, timed-flush, and toilet dye tests as necessary (steps 10 through 14 in the procedure below). Additional copies of **Worksheet 4** through **Worksheet 7** may be needed.

Audit Objectives

This procedure will help you better understand where and how water is consumed in your facility's commercial kitchens.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Assemble the following:
   a. Several copies of **Worksheet 9** and **Worksheet 10**
   b. Stopwatch
   c. Calculator
   d. A measuring cup or pitcher of a known volume (quarter, half, or full gallon is easiest)
   e. A packet of food coloring
3. For all fixtures (faucets, pre-rinse spray valves, etc.), note the etching or stamp indicating the flow rate.
4. Conduct a timed-flow test for each fixture (lavatory or hand washing faucets, toilets, and urinals, if applicable, and pre-rinse spray valves) using a known-volume cup or pitcher (see page 46 to review the methodology). Pot filling, pot washing, and other 'work' sinks do not need to be tested as it is not recommended to install low flow aerators on these types of sinks.
5. Convert the timed flow to gallons per minute (see page 63).

6. Compare the measured flow rate (timed flows) of each fixture against the high efficiency or WaterSense (if applicable) standard for that fixture type on the worksheet.
7. For all appliances (dishwashers, ice machines, etc.), note the make, model, whether an ENERGY STAR label is present. Indicate this on **Worksheet 9**.
8. Note the water use as listed on the appliance itself, in its owner/user guide, or by contacting the manufacturer.
9. Make note of all leaks encountered.

If the kitchen has a restroom for kitchen staff, proceed to steps 10 through 14, if not, skip to step 15.

10. Determine flush volumes for all toilets and urinals (see page 47).
11. Determine flow rates for all bathroom faucets (see page 46).
12. Convert the timed flows to gallons per minute (see page 63).
13. Compare the measured flow rate of each fixture against the federal, WaterSense (if applicable), and high efficiency standards for that fixture type. Record whether the fixture requires maintenance, replacement, or no action in the space provided for comments on the worksheet.
14. Conduct a dye test on all tank toilets (see page 48).

15. Refer to the *Post-Audit Considerations and Additional Activities* subsection below.

Post-Audit Considerations and Additional Activities

Recommendations for restroom fixtures are discussed on page 50.

For all water-using appliances and machinery, consider replacing non-ENERGY STAR-qualified appliances with more efficient models when the current appliances reach the end of their useful life. ENERGY STAR's website[1] provides information on qualified appliances.

You may also want to explore the Food Service Technology Center (FSTC) website for detailed explanations of specific commercial kitchen equipment, ventilation, water heating, and building energy efficiency, including lighting and HVAC. FSTC is the industry leader in commercial kitchen energy efficiency and appliance performance and has developed standard testing methodologies for appliance and system performance. FSTC also has a library of performance reports for all major types of commercial-grade kitchen appliances[2].

Specific considerations for some common fixtures and appliances are provided below.

Faucets

It is not recommended to retrofit low flow aerators on commercial kitchen sinks except those used exclusively for hand washing. Hand washing station faucets should be fitted with 0.5 gallon per minute (gpm) aerators.

Metered faucets are those that remain open for a set amount time. Metered faucets should use no more than 0.25 gallons per use. Therefore, metered faucets are not, by default, held to a specific flow rate so long as the timing and flow rate do not exceed 0.25 gallons per on-off cycle. When a 0.5 gpm aerator is used, the flow cycle can be as long as 30 seconds and not exceed this limit. Conversely, an aerator flowing at 1.0 gpm should cycle off after 15 seconds. **Table 11** (page 65) shows the total volume output of metered faucets based on seconds of flow and aerator gallons per minute.

[1] For information on the most efficient residential and commercial kitchen equipment, visit www.energystar.gov. For commercial food service best management practices, see www.energystar.gov/index.cfm?c=healthcare.fisher_nickel_feb_2005 or search for "Best Practices — How to Achieve the Most Efficient Use of Water in Commercial Food Service Facilities" in the ENERGY STAR website search bar.

[2] See the "Appliance Reports" page under the "Publications" tab on www.fishnick.com.

Pre-Rinse Spray Valves

Pre-rinse spray valves are hand-operated devices used to remove food and grease from dinnerware before it is placed in a dishwasher. Common flow rates for these devices are 2.5 to 4 gpm. With normal use, they can consume more water than the dishwashers. Low flow models use 1.6 gpm or less.

Replacing an older pre-rinse spray valve with a low flow model is one of the most cost-effective water and energy saving measures for commercial kitchens. **Making this change can save up to $600 a year** and 120 gallons of water for every 2 hours of use (FSTC 2010). WaterSense has not released standards for pre-rinse spray valves, but the FSTC website[1] lists low flow models that have passed its performance criteria and offer significant savings.

Pre-rinse spray valve

Commercial Dishwashers

Commercial dishwashers use heated water (180°F or higher) or chemicals to remove and clean food debris from dinnerware. Machines using heated water are referred to as "high temp" machines. Those that use chemicals are known as "low temp" machines.

According to ENERGY STAR, a commercial dishwasher in a typical facility serving 300 meals per day can consume 600 gallons of water per day. Operations serving 600 meals per day may use 1,000 gallons per day. This makes it important to select the size and type of machine that best suits the needs of your facility's kitchen.

Commercial dishwasher

When replacing your facility's current dishwasher at the end of its useful life, purchase ENERGY STAR-qualified models to save water and energy. Also, try to avoid "fill-and-dump" machines (they dump all of the water after each load). If you facility does choose a fill and dump unit, it should not use more than 1.2 gallons per rack; other types of dishwashers use less than 0.9 gallons per rack (AWUWCD 2006). **ENERGY STAR-qualified commercial dishwashers[2] save approximately $900 per year on energy and $200 per year on water** (52,000 gallons per year less water use than standard models).

Ice Machines

At 100 percent efficiency, it takes 11.97 gallons of water to make 100 pounds of ice. However, to make this much ice, a typical machine will use 18 to 200 gallons of water. Water-cooled machines are typically far less efficient than air cooled-models. Even for air-cooled machines, some inefficiency occurs when minerals are rinsed free from ice trays. This inefficiency can be reduced, but is not completely avoidable

[1] See www.fishnick.com/equipment/sprayvalves or go to www.fishnick.com and enter "pre-rinse spray valves" in the search bar.

[2] For more information on commercial dishwashers, including certified product lists, see www.energystar.gov and click "Find ENERGY STAR Products," then click the "Business and Government" tab. Next click "Commercial Dishwashers." A list of qualified models can be found by clicking "Qualified Commercial Dishwashers," under the "Commercial Dishwasher Resources" banner.

(AWE 2010). In general, 'efficient' ice machines should use approximately 20 gallons of water per 100 pounds of ice production (AWUWCD 2006). Ice machines with the ENERGY STAR rating or a "qualified" rating by the FSTC and CEE are, on average, 15 percent more energy efficient and 10 percent more water efficient than standard models. Each year, these models can **save approximately $110–$400 on utility bills and approximately 2,500 to more than 10,000 gallons of water,** depending on size and production demand.

One of the most important considerations when purchasing an ice machine is that it is properly sized for the anticipated demand. Purchasing a unit with a production capacity far beyond what is needed will waste both water and energy and will cost more to operate.

Much of the operating cost of an ice machine depends on where the displaced heat from the chilled water is released. Some machines release this heat in the same room as the machine itself, adding to the burden of the building's air conditioning system while others have remote heads that release the heat outdoors or in spaces without air conditioning This additional expense is not factored in these calculations, but should be considered during your efficiency planning process.

The shape and quality of the ice also matters. Models that produce ice flakes or disks use approximately 30 percent water less than those that make ice cubes. Some ice machines are designed to produce ice cubes free of air bubbles and a 'frosted' appearance. These models produce smooth and clear ice by freezing and partially thawing the ice while it is produced. From an efficiency standpoint, this is seen as a wasteful practice as the inherent quality of the ice is equal to 'rough' appearing ice yet requires more water.

Another consideration is the type of cooling. While the cost of air-cooled and water-cooled equipment is almost equal, air cooling saves water and energy (see **Table 6**). Water-cooled ice machines require 72 to 240 gallons of water per 100 pounds of ice produced and there are currently no ENERGY STAR-qualified water-cooled ice machines. From an energy conservation perspective, the most efficient ice machines have remote air-cooled condensers that expel heat outside the air conditioned workspace. Placing the condenser outside the building does not add to the burden for the air conditioning system.

Additional energy savings are possible by retrofitting air-cooled machines with a heat exchange unit. Heat exchange units use the machine's rejected water from the cold plate to pre-cool the incoming potable supply, thus reducing the energy required to freeze the incoming water.

For more information on commercial ice machines, including certified product lists, check the ENERGY STAR[1] and the FSTC[2] website.

Self-contained ice machine

[1] Go to www.energystar.gov and click on "Find ENERGY STAR Products." Click the "Business and Government" tab and then "Commercial Ice Machines." A list of qualified models can be found by clicking "Qualified Commercial Ice Machines," under the "Commercial Ice Machine Resources" banner.

[2] From www.fishnick.com, click the "Save Water" tab, and then click "Ice Machines."

Steam Cookers

Steam cookers (also known as steamers) are highly energy efficient. However, some steamers consume up to 40 gallons of water per hour. Most of their water use occurs when excess steam is expelled from the cooking cavity and condensed by a stream of cold water. This is done to meet building plumbing codes. Newer models use half the condensing water as older ones. Some timer-controlled cookers switch to a standby mode after a set cook time to reduce water use.

Newer boilerless compartment steamers, known as connectionless steamers (though some are connected to water supplies), save a significant amount of water over older models. Connectionless steamers consume less water than boiler types by operating within a closed system that does not have a boiler and drain (FSTC 2010). They have a water reservoir below the bottom rack where boiling water generates steam, which condenses on the food above. Most of the excess steam is captured and returned to the reservoir; only a small amount escapes through a vent. Connectionless steamers do not require a condensate drain or accompanying condensate-cooling water and also do not require periodic descaling.

ENERGY STAR-qualified steam cookers must meet a minimum cooking efficiency of 50 percent (electric) and 38 percent (gas) with maximum idle energy rates for a given pan capacity. ENERGY STAR-qualified connectionless steamers use approximately 2 gallons of water per hour, compared to 25 to 35 gallons by standard models. These efficient models can **save more than 500 gallons of water per day (for a typical restaurant) and approximately $1,000 a year** in water and sewer costs over a regular boiler type.

Steam cooker

When your facility is considering replacing its steamer, refer to the ENERGY STAR website[1] for a list of qualified steamers or check the FSTC[2] list. Also, refer to the Commercial Kitchen section of **Appendix B**, Best Management Practices.

Combination Ovens

Combination ovens (also known as combis) are popular and versatile commercial kitchen appliances. However, they can also be water guzzlers, consuming up to 40 gallons per hour. Older models used a boiler to maintain humidity and a continuous stream of water to cool the drained water. Boilerless combis use much less water since they spray a fine mist of water on the heat exchangers to maintain humidity in the cooking cavity. Most boilerless combis can **save more than 100,000 gallons of water per year** over boiler-type combis (FSTC 2010). However, energy and water efficient combis with boilers are now being produced.

A combination oven

[1] Go to www.energystar.gov and click on “Find ENERGY STAR Products.” Click the “Business and Government” tab and then “Commercial Steam Cookers.” A list of qualified models can be found by clicking “Qualified Steam Cookers,” under the “Steam Cookers Resources” banner.

[2] From www.fishnick.com, click the “Save Water” tab, and then click “Steamers.” A list of FSTC-qualified models can be found by clicking “Steamer Rebates” under the “Related Links” banner.

Each type of combi (boiler or boilerless) offers advantages that should be considered by your facility's kitchen manager based on the kitchen's needs. When your facility is ready to replace its combi, try to select a replacement from the FSTC's list of qualified models[1]. For optimum operating efficiency of your facility's combi, refer to the Commercial Kitchen section of **Appendix B** and the FSTC website.

Garbage Disposal Units and Scraping Troughs

Garbage disposal units (grinders) grind leftover food from dishware in a mixing chamber where water is added to send the food pulp to the sewer. These units can use 5 to 8 gpm during operation. Scraping troughs carry food scraps and other waste to the disposal, using approximately 3 to 5 gpm (NMSE 1999, Vickers 2001).

Grinders and troughs can be made more efficient, saving your facility water and money. If a grinder is used, it should be equipped with a solenoid to shut off the water flow when not needed. Adding a pulper to strain food waste from the grinder stream and compact it into a solid mass for disposal reduces the treatment burden of local utilities.

Pulpers can recirculate up to 75 percent of the water used to transport and strain food waste from the trough slough (EBMUD 2008). When recirculating water, pulpers can consume up to 8 gpm if the overflow level is improperly set, and 1 to 2 gpm when set properly. **Table 12** shows the amount of water consumed due to improper settings.

Commercial kitchen food pulper

Kitchens may opt to use garbage strainers instead of disposal units. Garbage strainers use a strainer basket and circulate water to pre-rinse dishware and collect food particles. Strainers use approximately 2 gpm (Vickers 2001).

In many cases, even in kitchens with high use, these types of units can be eliminated. Replacing them with water bins can be viable and efficient. This has the additional benefit of removing organic material, especially larger food debris containing fats and oils which can be collected and put into a trash bin or composed. This further reduces the burden for water treatment facilities.

If disposals and troughs cannot be eliminated, they should use only cold water and operate with a timer, shutting down after every 15 minutes of use (EBMUD 2008). You may wish to work with your facility's kitchen supervisor to review the many options available for increasing water use efficiency. **Table 13** compares four food waste disposal methods.

Water bin for utensils and dishes

[1]Visit www.fishnick.com/saveenergy/rebates/combis.pdf or www.fishnick.com and click "Combination Oven" under the "Save Water" tab, then click "Combination Oven Rebates" under the "Related Links" banner.

Table 12. An example of the water consumption by a food pulper with a flow setting above what is necessary and when the same device runs longer than needed for various periods.

	Excess Water Consumption During Normal Operations with Improper Overflow Setting			Water Consumption Occurring when Left on Longer than Necessary		
	1 Hour	2 Hours	3 Hours	0.5 Hour	1 Hours	2 Hours
Gals/day	300	600	900	210	420	840
Gals/month	6,000	12,000	18,000	4,200	8,400	16,800
Cost/month	$60	$120	$180	$40	$85	$170
Annual Cost	$575	$1,150	$1,700	$400	$800	$1,600

Based on the assumption that the pulper requires the highest amount of overflow water setting (2 gpm; the range is 1 to 2 gpm) and is currently set 5 gallons over this amount. The actual range of excessive flow can be as high as 6 gallons.

Table 13. A comparison of food waste disposal methods.

	Grinder	Pulper	Strainer	Bin
Solids to Sewer	Yes	No	No	No
Recirculate	No	Yes	No	N/A
Strain Solids	No	Yes	Yes	Yes
Compost Production	No	Yes	Yes	No
Solid Waste Production	No	Yes	Yes	No
Flow Restrictor	Yes	No	N/A	N/A
Horsepower	1–10	3–10	0	0
GPM* (potable only)	3–8	1–2	0	0
Sluice Trough GPM	2–15	2–15	0	0

*GPM: gallons per minute

Equipment with Once-Through or Single Pass Cooling Systems

Once-through (or single pass) cooling systems route water through a chiller once before discharging water to the sewer. In some cases, this water does not contact actual products and remains at or near potable standards. Welding machines, x-ray devices, condensers, ice machines, and some air-conditioners are some examples of common once-through machinery. Some considerations to improve water use efficiency of once-through machinery include the following (may not be possible in all cases):

- Replace water-cooled models with air-cooled ones
- Modify the equipment to recirculate water
- Tap into existing chilled water loops
- Identify a second use for the effluent (see page 163 of this guide)

For More Information

To learn more about improving water use efficiency, see the ENERGY STAR[1] and CEE[2] websites.

[1] Go to www.energystar.gov/index.cfm?c=healthcare.fisher_nickel_feb_2005 or www.energystar.gov and search for "Best Practices — How to Achieve the Most Efficient Use of Water in Commercial Food Service Facilities."
[2] Visit the CEE Kitchen Initiative at www.cee1.org/com/com-kit/com-kit-main.php3 or go to www.cee1.org and enter "Commercial kitchens" in the search bar.

Advanced Audit Preview

This Basic Audit provides valuable information on fixtures in your facility that are obsolete. However, the results are not quantitative and limit your ability to conduct further analysis. The *Commercial-Grade Kitchen Water Use – Advanced Audit* (page 129) builds on this audit and allows you to quantitatively measure current use, potential savings, and payback periods.

There should be no additional field work necessary to complete the Advanced Audit procedure. Furthermore, all necessary calculations are done by the accompanying Microsoft Excel spreadsheets (*ENERGY STAR's Commercial Kitchen Equipment* and *Supplemental Commercial Kitchen Equipment*).

Worksheet 9. Commercial-Grade Kitchen Appliances

Dishwasher	Location		**Make/ Model**	**Quantity**	**Racks washed per day**	**Building hot water fuel type**	**Booster water heater fuel type**	**Operating days per year**	**ENERGY STAR Qualified?**
		Under Counter							
		Door Type							
Low Temp.		Single Tank Conveyor							
Or High Temp.		Multi Tank Conveyor							
Leaks or Other Comments									

Ice Machine	Location	**Make/ Model**	**Quantity**	**Harvest rate (pounds ice per day)**	**Potable water use (gallon per 100 pounds ice)**	**Operating days per year**	**ENERGY STAR Qualified?**
	Ice Making Head						
	Remote Condensing Unit /Split System						
	Self-Contained Unit						
Leaks or Other Comments							

Steam Cooker	Location	**Make/ Model**	**Quantity**	**Pounds of food cooked per day per unit**	**Number of pans per unit**	**Operating hours per day**	**Operating days per year**	**ENERGY STAR Qualified?**
	Electric							
	Natural Gas							
Leaks or Other Comments								

Clothes Washer	Location How is water for each unit heated?	**Make/ Model**	**Quantity**	**Average number of loads per week**	**Type of water heating**	**Type of clothes dryer**	**Electric or Gas Drier**	**ENERGY STAR Qualified?**
	Electric Heat							
	Gas Heat							
Leaks or Other Comments								

Combi Oven	Location	**Make/ Model**	**Quantity**	**Operating hours per day**	**Operating days per year**	**Pounds of food cooked per day per oven**
	Electric Heat					
	Gas Heat					
Leaks or Other Comments						

See Worksheet 10 for Commercial-Grade Kitchen Fixtures.

Worksheet 10. Commercial-Grade Kitchen Fixtures

Location	Hand Faucet	Pre-Rinse Spray Valve	Marked (gpm)	Timed			Leaks? Comments
				Num. of Cups/ Pints/ Quarts.	Num. Secs.	Calc. Rate (gpm)	

See Worksheet 9 for Commercial-Grade Kitchen Appliances.

COOLING TOWER WATER USE – BASIC AUDIT

Background and Description

Air cooling systems are necessary for many commercial and industrial facilities. Most of these systems use cooling towers (**Figure 8**), which can be a facility's highest point of water consumption. For this reason, special attention and guidance is provided for evaluating cooling tower operations.

The cooling system of a building extracts heat from the air and transfers it away from building occupants and equipment. The system's air handling unit uses heat exchange coils to absorb heat from the air. The coils are initially filled with cool water supplied by a chiller unit. The cool chiller water absorbs the heat and the resulting cool air is distributed throughout the building. The process heats the water, which returns to the chiller where a series of heat transfers occur that take advantage of the properties of different gases. The final transfer within the chiller sends the heat into condenser water that is routed to the cooling tower.

The warmed water from the chiller reaches the cooling tower where the temperature is lowered using evaporation. The water flows over heat exchangers where it is exposed to moving air. The resulting evaporation cools the remaining water. Evaporation is very efficient at cooling the condenser water, but is where water is lost from the system. The cool water that was not lost to evaporation returns to the chiller to repeat the process.

Figure 8. A large capacity cooling tower.

Cooling towers consume 2.4 gallons of water per minute of operation per 100 tons of operating load for every 10 degrees of cooling through evaporation (Vickers 2001). In other words, for every ton-hour (3.5 kWh) of cooling, 1.44 gallons of water are evaporated. This is the largest point of water loss from the system and cannot be avoided.

As water evaporates, it leaves behind whatever was dissolved in it. The concentrations of these dissolved solids and other chemicals increase in the cooling tower until the water must be drained (bled) from the system to avoid corrosion and other problems. This is the second largest point of water loss from the system.

The rate the water is bled from the system (also known as "blowdown") depends on many factors and is the major opportunity for water conservation related to cooling towers. The volume of water that is evaporated and bled from the system must be made up by the addition of water, which is usually chemically treated to allow it to maintain higher concentrations of dissolved minerals, reduce system wear, and maintain efficiency. The volume of makeup water can be calculated as:

$$\mathbf{M = E + B}$$

Where: M = Makeup, E = Evaporation losses, and B = Bleed-off (Vickers 2001)

The third point of water loss from a cooling tower is "drift", which refers to small drops of water drawn away from the tower by the exhaust air. Drift does not usually account for large amounts of water and can be almost eliminated by installing baffle-like devices, called drift eliminators.

The number of times water is run through the cooling tower before being bled depends on the concentration of dissolved solids in the recirculation water relative to the concentration of dissolved solids in the makeup water; this is known as the concentration ratio or the cycles of concentration (COCs). This is the primary metric for measuring operating efficiency.

A cooling tower that is not properly maintained will consume more water and chemicals than one which is clean and tuned. Poor maintenance will also reduce capacity and lead to energy waste.

A well-maintained tower with correctly pre-treated water will not readily show signs of leaking, corrosion, mineral precipitation, or biological fouling on the heat exchangers or elsewhere (Seneviratne 2007). **Figure 9** shows examples of cooling tower corrosion, biofouling, and other signs of wear. If any of these conditions are present, it is likely the tower is running inefficiently, consuming more water and treatment chemicals than necessary, and shortening the life expectancy of the unit. While the absence of these indicators does not mean the tower is running at its optimum efficiency, it does indicate the maintenance regime is meeting the tower's basic needs. These parameters will be checked in this procedure.

In many areas, CI customers are eligible to receive sewer credits to account for water consumed on-site that does not return to the utility plant for post-use treatment. To receive credits for cooling tower water consumption, the tower must be submetered. Accurate and timely reporting of submetered volumes is often necessary to receive credit for water not returned for treatment. In addition, submeters are vital for determining the running efficiency of cooling towers.

Audit Objectives

This procedure will guide you through the steps to:

- Examine and evaluate the general condition of your facility's cooling tower
- Determine whether sewer credits are available and are being applied to your facility
- Inquire with your vendor about the current COCs of your tower(s)
- Ascertain water savings if COCs can be increased to a least 5

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Prepare and examine Worksheet 11: Cooling Tower Water Use.
3. Locate your facility's cooling tower, they are usually on the roof or behind the building.
4. Determine if the cooling tower is equipped with feedline and drainline (makeup and bleed-off) submeters.
5. Determine if the cooling tower is equipped with conductivity meters.
6. Carefully examine the tower and note signs of the following (refer to Figure 9):
    a. visible leaks (check all seals, ducts, conduits, tower casings, and pumps)
    b. corrosion
    c. mineral precipitate scaling on the heat exchangers or elsewhere
    d. algae or slime
    e. excessive drift
7. Contact your water utility provider to determine whether the provider offers sewer credit discounts for cooling tower water use and whether or not your facility is currently taking advantage of these credits, if they are available.
8. Ask your cooling tower vendor how many COCs your tower(s) is currently operating at.
9. Ask your cooling tower vendor to ensure the make-up float and valve are operating at the optimal level. You may want to observe him/her as the inspection is performed.

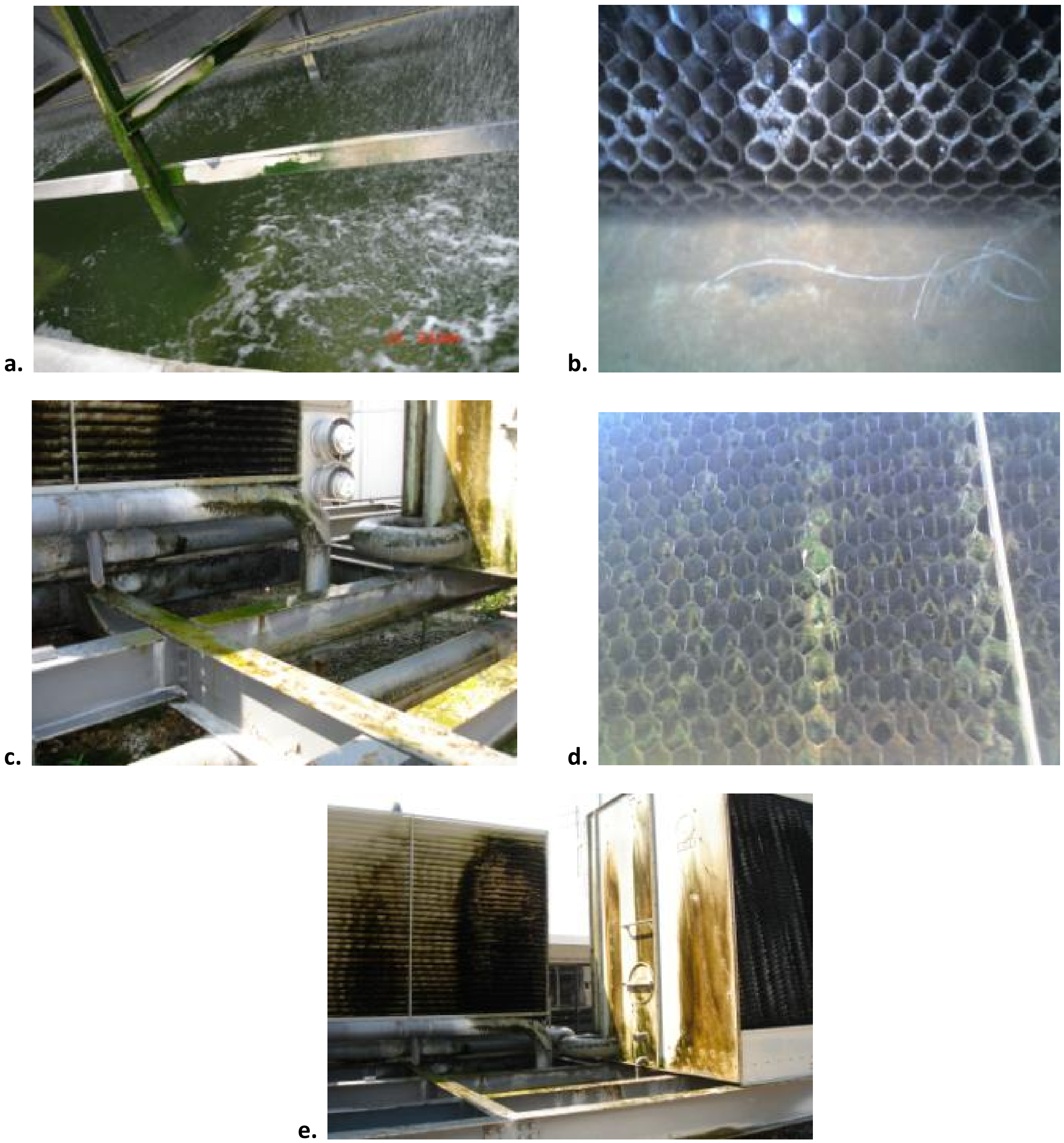


Figure 9. Cooling tower wear and tear. **a)** Algae growth in the well. **b and c)** Biofoul and scale. **d)** Excessive algae and biofouling. **e)** Excessive corrosion and fouling (*Photos courtesy of Tom Bednar, Equipoise Water).*

Post-Audit Considerations and Additional Activities

Cooling tower systems should be inspected monthly and cleaned at least every six months. In addition, the drainage system should be inspected, operated, and flushed each month (EEQM 2010). If any leaks are observed, notify building maintenance or the cooling tower's maintenance vendor. They should also be contacted if more than minimal corrosion, precipitation, or biological growth is observed on or around the cooling tower.

The Eco-Efficiency for the Queensland Manufacturers project's paper *Cooling Tower Efficiency – F9* provides the following hierarchy of opportunities to identify and prioritize water efficiency opportunities in relation to cooling towers (EEQM 2010):

1. Reduce water loss
2. Reduce blowdown (bleed)
3. Alternative Water Supplies
4. Reuse blowdown

Water loss reduction is achieved primarily by identifying and addressing leaks, reducing drift and splash, and optimizing overflow.

Blowdown reduction is achieved by increasing the cycles of concentration. Your maintenance vendor may be able to increase the cycles of concentration of your tower(s) and greatly improve your water use efficiency if he understands you are interested in this goal.

Most towers run between two and three cycles, but will still perform optimally at five to six cycles. Increasing the cycles to at least five will reduce water use for cooling by approximately 15 to 40 percent. For many facilities, this can save hundreds of thousands of gallons of water per year. See **Table 14** to estimate approximately how much water your tower can save by increasing its cycles of concentration.

Many vendors do not manage towers with water 'efficiency' in mind. Instead, they are often interested in maintaining the system in a way that will provide reliability and is most simple and convenient from a management standpoint. This is not a dishonest practice on

Table 14. Water savings from increased concentration ratios in cooling towers.

	Concentration Ratio											
	After Increasing Cycles											
Before Increasing Cycles	2	3	4	5	6	7	8	9	10	12	15	20
1.5	33%	50%	56%	58%	60%	61%	62%	63%	63%	64%	64%	65%
2		25%	33%	38%	40%	42%	43%	44%	44%	45%	46%	47%
3			11%	17%	20%	22%	24%	25%	26%	27%	29%	30%
4				6%	10%	13%	14%	16%	17%	18%	20%	21%
5					4%	7%	9%	10%	11%	13%	14%	16%
6						3%	5%	6%	7%	9%	11%	12%
7							2%	4%	5%	6%	8%	10%
8								2%	3%	5%	6%	8%
9									1%	3%	5%	6%
10										2%	4%	5%
12											2%	4%
15												2%

Increases are expressed as a percentage of total cooling tower water use (Vickers 2001).

their part, as they are typically contracted to ensure the tower is operating reliably and continually. However, the vendor is not the one paying your facility's water bill. Moreover, achieving maximum efficiency may require a shift in the chemical treatment regime and closer attention to the details of your system.

Some vendors may feel this added goal is not within their own interest and may try to dissuade you from pursuing it. However, a skilled vendor should be able to find the correct chemical balance for your water source and tower to raise your operating cycles of concentration in a manner that is both cost effective and safe for the equipment.

Alternative water supplies can be used to reduce or offset potable water used to make-up demand. Alternative water supply options include reclaimed water, process water, condensate water from the cooling (or boiler) system itself, or rainwater. New or additional chemical treatments may be needed if alternative sources are used. Your vendor should be consulted if this option is considered. The *Identifying Alternative On-Site Water Sources* section of this guidebook (page 163) contains additional explanations and references regarding cooling tower condensate.

Reusing cooling tower blowdown may be possible before being released to the sewer system. Potential uses include toilet and urinal flushing (additional treatment may be required), landscape irrigation (may require dilution with potable or rainwater due to salt content or additional treatment), process work, and some cleaning applications (health risk assessment may be required and the impacts of corrosion should be considered).

If the cooling tower is not submetered, your facility may be paying unnecessary sewer charges for evaporated water. This can add tens to hundreds of thousands of gallons of water charges per month, depending on the cooling tower's size and operating efficiency. It is highly recommended that a cooling tower be submetered separately at the feedline and the drainline. The difference between these two meters represents evaporated water and thus the makeup water volume, though some utilities only require a meter on the make-up line to receive sewer water credits. Meters can be purchased and installed for $1,800 to $4,500 and can pay for themselves in less than a year. For more information, see the *Meter and Submeter – Basic Audit* (page 29).

Conductivity meters and controllers are recommended for all cooling towers to continuously monitor the level of total dissolved solids in the water. Also, be sure to ask your maintenance vendor to validate probe readings and maintain clean probes. For large cooling towers and those adding acid, install a pH controller to measure pH levels, which also helps prevent buildup of solids. These measures also save energy and are relatively inexpensive, typically costing $1,500 to $3,000 installed.

Once-through cooling systems should be evaluated for replacement or retrofit to a closed-loop system. If the system cannot be converted to a closed-loop system, it may be possible to reuse the water. See the *Identifying On-Site Alternative Water Sources* section (page 163) for more information.

The most basic cooling tower efficiency measures are summarized below (NMSE 1999, Vickers 2001, Seneviratne 2007, EBMUD 2008, IAPMO 2012):

1. Discuss your facility's prioritization of water conservation with your vendor. Request estimates of treatment chemicals and bleed-off volumes and discuss concentration ratio goals.
2. Set the system to shut down during off hours.
3. Use the lowest quality water supply available.
4. Reduce bleed-off by increasing the cycles of concentration (COCs) (see *Cooling Tower Water Use – Advanced Audit* [page 139] for a more thorough explanation of COCs). Operate on not less than 5 COCs for

makeup water having a total hardness of less than 11 grams per gallon (g/gal) (188 milligrams per liter [mg/L]), expressed as calcium carbonate. Operate on not less than 3.5 COCs for makeup water having a total hardness equal to or exceeding 11 g/gal (188 mg/L), expressed as calcium carbonate. Increasing the COCs from 2 to 5 results in a water savings of approximately 38 percent (Refer to **Table 14**).

5. Install feedline and drainline flow meters and monitor use.
6. Operate bleed-off continuously rather than by batch by setting the bleed-off timer at shorter intervals or by setting the low end conductivity just below the bleed-off start level. This change will reduce large fluctuations in conductivity in the system.
7. Install conductivity controls to allow close monitoring of water consumption and to verify optimum operating efficiency.
8. Have meters read regularly and consistently. Keep a log containing – at a minimum – makeup, bleed-off, and evaporation volumes; dissolved solid concentrations; and operating COCs.
9. Consider adding a sidestream water softener or filter to the system.
10. Consider adding a high efficiency drift eliminator, which can reduce drift to 0.002 percent of circulating water volume.
11. Evaluate alternative on-site sources of makeup water.

Additional information on high efficiency specifications for HVAC systems can be found on the Consortium for Energy Efficiency website[1].

Advanced Audit Preview

The *Cooling Tower Water Use – Advanced Audit* (page 139) and the associated spreadsheet allow you to calculate makeup, bleed-off, evaporation, concentration ratio (cycles), and monetary savings associated with potential sewer credits (in dollars). It also has calculations for the monthly production volume of condensate water, which can be used to supplement makeup water.

[1] Go to www.cee1.org/com/hecac/hecac-main.php3 or www.cee1.org and select “Commercial HVAC”

Worksheet 11. Cooling Tower Water Use – Basic Audit

Cooling Tower General Observations

a) Cooling tower location ___________________________________

b) Tons of cooling capacity (if known) _________________________

c) Are flow meters or submeters present on feedlines (circle one)? YES / NO

d) Are flow meters or submeters present on drainlines (circle one)? YES / NO

e) Is the tower a closed loop (not once through) (circle one)? YES / NO

f) At how many cycles is the tower currently be run at?
(you may have to consult with your maintenance vendor). ________

g) Looking at Table 14, what percentage of total water use would be saved if the cycles of concentration were increased from the current level to five or six? ________

h) Indicate the visible condition of the cooling tower:

	None	*Very little	Some	A lot	Where?
Noticeable leaks					
Noticeable corrosion					
Mineral precipitate scaling on the heat exchangers, condenser tubes, or elsewhere					
Algae or slime (biofouling)					
Drift (misting)					

*This would account for a small amount at the interface where the air hits the corrugated heat exchangers, condenser tubes, etc.

Overview of Outdoor Water Use

This section of the guide presents challenges and solutions for improving irrigation efficiency. They can be applied anywhere, but in some cases there are specific 'call out' references to certain Florida-based resources. These resources are only supplemental to the general tasks. Similar information should be available for most areas.

For this guide, almost all of the irrigation system and landscaping audit activities fall under the basic level. For these activities, extensive familiarity with irrigation systems is not required. However, you will need to perform certain procedures while the system is operating. This requires knowledge of how to use the timer or controller to manually engage the system. For assistance, refer to the owner's guide for the controller or secure the assistance of your facility's irrigation contractor. Alternatively, some procedures can be conducted during a scheduled irrigation event, but this is recommended only as a last resort.

Box 10. Outdoor Water Use Audit Structure and Recommendations

There are two main points of focus related to auditing outdoor irrigation and landscaping: the irrigation controller/timer and the irrigation zones/stations. The procedures for each of these are as follows:

Irrigation controller/timer

- Irrigation Schedule and Controller – Basic Audit
- Rain/Soil Moisture Sensor – Basic Audit and Advanced Audit

Irrigation zones/stations

- Irrigation System and Landscape Survey – Basic Audit and Advanced Audit
- Irrigation System Distribution Uniformity, Application Rate and Calibration – Basic Audit

In general, you will be investigating the most basic settings of the controller as well as the landscape plantings and irrigation hardware in each zone. Although presented separately for descriptive purposes, you may be able to perform multiple audit procedures at one time as you survey each zone. For this reason, the irrigation and landscape worksheets have been combined for your convenience in the **Irrigation and Landscape Audit Worksheet** in Appendix C**.**

Some of the tasks can be accomplished with greater ease if there are at least two people working together, possibly using two-way radios or cell phones, with one person at the irrigation controller turning each zone on and off and one surveying the landscaped areas one zone at a time.

Irrigation Blueprint or Hand-drawn Sketch
Blueprints of the irrigation system would be helpful when conducting the audit procedures, but are not necessary. If irrigation line blueprints are not available, a simple sketch of the property showing the irrigation zones/stations should be created and used (see page 86).

Considerations for Efficient Outdoor Irrigation and Landscaping

Water for irrigation may come from various sources, including potable and reclaimed water, self-supplied wells, and retention ponds. Regardless of the source, water should be used efficiently and increasing efficiency can reduce operating expenses in many cases.

Water Efficient Irrigation

Irrigation systems are not always necessary, but in some cases they are vital. When in place, they should be used in the most efficient manner and employ the most appropriate water delivery hardware and controllers.

In all cases, an irrigation system should be considered as supplemental to natural rain. All systems require monitoring and regular maintenance to continue operating efficiently.

Water Efficient Landscaping

The amount of irrigation required depends in part on the landscape materials used. Plants should be selected according to the local climate and site-specific conditions, such as the soil's water holding capacity and the available sun and shade. Once in place, plants should be managed and cared for to most efficiently use water, pesticides, and fertilizers.

How Much Water Should Be Applied During an Irrigation Event?

The objective of irrigation is to supplement natural rainfall to meet the planted material's water needs. The correct amount or irrigation depends on the rate of evapotranspiration (ET), which is the combination of evaporation from soil and transpiration from plants. ET is a function of the plant species and growth cycle, humidity, wind, temperature, and soil moisture (Ramey 2004).

Florida Focus

Figure 10 shows the water needs of a typical South Florida lawn by month due to ET, the actual average monthly rainfall in Florida over a recent 41-year period, and the amount of water consequently needed to meet the lawn's ET demand. These are averages and your specific site conditions may vary.

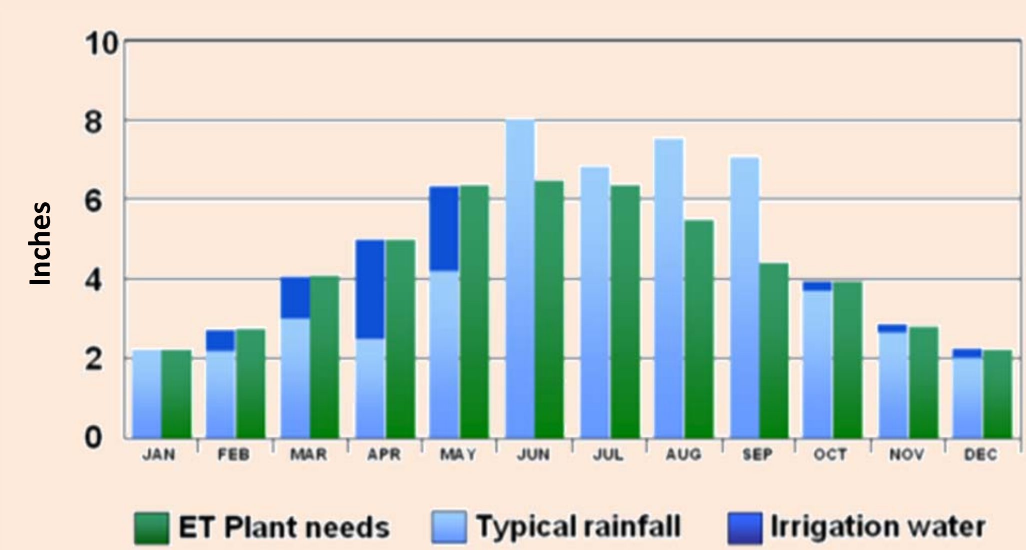


Figure 10. Monthly evapotranspiration (ET) demand, rainfall, and supplemental irrigation needs of a typical South Florida lawn.

In addition to ET, soil water holding capacity affects how much you should water. The amount of water soil holds depends upon various factors, including soil structure and texture. Sandy soils can hold approximately 1 inch of water in the top 12 inches of soil. Medium textured soils and soils containing clay (fine sandy loam, silt loam, silty clay loam) can hold twice as much water as sandy soils (**Table 15**) and do not drain nearly as fast. Therefore, they require less frequent watering.

In general, less frequent, deeper watering is better for plants and more efficient than frequent, shallow watering. For sandy soils, applying ½ to ¾ inches of water will thoroughly wet the root zone and will encourage deeper rooting, which increases drought tolerance (Trenholm et al. 2006).

Excessive watering (beyond ¾ inches in one event) creates soil moisture beyond the turfgrass roots and carries away fertilizers and other agrichemicals.

Florida Focus

Many parts of Florida have sandy soils, which can hold approximately 1 inch of water in the top 12 inches of soil. As per the University of Florida's Institute of Food and Agricultural Sciences (IFAS), irrigation applications should not exceed 0.75 inches of water during an irrigation event (Trenholm et al. 2006). At this rate, one irrigation event per week would equal 3 inches per month and two weekly irrigation events would amount to 6 inches per month.

The nine Florida-Friendly Landscaping Principles provide guidance for efficient landscaping in the state. The principles and related information can be found in *A Guide to Florida-Friendly Landscaping* by Florida Yards & Neighborhoods.

Table 15. Range of water holding capacity for different soil textures.

Texture Class	Water Holding Capacity (inches/foot of soil)
Coarse sand	0.25 – 0.75
Fine sand	0.75 – 1.00
Sandy loam	1.10 – 1.20
Fine sandy loam	1.25 – 1.40
Silt loam	1.50 – 2.00
Silty clay loam	2.00 – 2.50
Silty clay	1.80 – 2.00
Clay	1.20 – 1.50

Source: Plant & Soil Sciences eLibrary, 2013.

IRRIGATION SCHEDULE AND CONTROLLER – BASIC AUDIT

Background and Description

Automatic irrigation systems operate according to a timer or central controller. A timer runs on a preset schedule that directs water to each zone (sometimes referred to as a "station") for a specified time. Most central controllers run according to a schedule, although some are governed by climactic factors or on-site moisture conditions. Most work best with electric valves instead of indexing valves.

Computerized irrigation controller

The improper setting or functioning of an irrigation timer or controller can result in wasting large amounts of water and perhaps put a facility at risk for a fine for irrigating outside of any local watering rules.

Because the controller sets every zone of the system in motion, it is important to become familiar with it. Most controllers have a manual 'On/Off' switch that can be used to engage each zone or station of the system. Once you understand how this works, you can begin to investigate the entire system. Even if you are not prepared to make adjustments to the runtimes, it is helpful to know for how many minutes each zone is set to irrigate. This can help you begin to create a mental picture of your facility's outdoor water use. Most controllers have a dial or a pad that is used to select the settings for each zone or station; some have a key pad with up and down arrows. You should be able to view the settings for each zone by turning the dial or pressing either the up or down arrow button on the key pad to view the runtime durations of each zone/station. If you are unsure of how to perform this operation, consult your irrigation contractor. If you move on to some of the other outdoor audits in this guidebook, you will be able to make some decisions as to whether these runtimes are appropriate.

If possible, locate your facility's irrigation system blueprint. However, unless the building is new, the original zone map may not be accurate. It is very common for zones to be added or removed as part of system repairs or other modifications. Therefore, a good first step is to confirm the accuracy of the facility's irrigation system blueprint or to sketch a zone map. This is done by manually engaging each zone one at a time and indicating the location of the zone on either the original blueprint or on a sketch of your own. The easiest way to do this is to have someone out in the field covering the parts of the property you cannot see from the irrigation controller. By using two-way radios or cell phones, you can collaborate to create a map similar to **Figure 11**.

Florida Focus

Your local municipality or water management district may issue irrigation variances under certain conditions. These variances usually do not grant more time for irrigation, but allow the irrigation to occur at times other than those prescribed for the area. Consult with your local governing agency directly if you think a variance could benefit your facility.

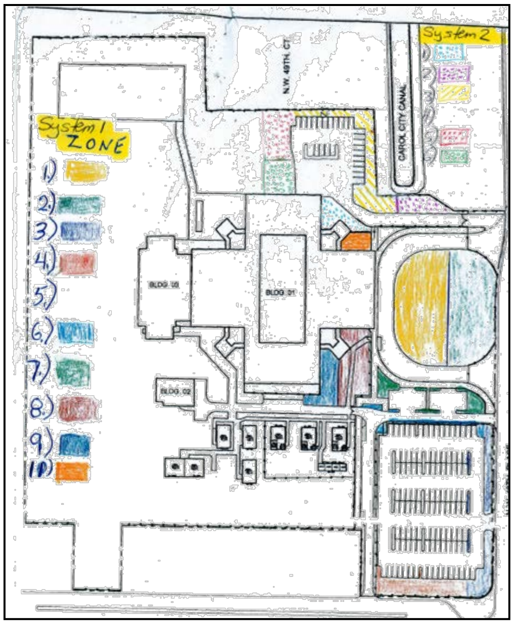


Figure 11. A sketched irrigation zone map. This example shows a system with two separate controllers labeled System 1 and System 2.

Audit Objectives

In this procedure, you will locate the irrigation controller or timer and ensure it is set to run in compliance with local watering rules. The procedure will guide you through the steps to:

- Gain or increase familiarity with your facility's irrigation controller location
- Document the irrigation runtimes for each zone (or station)
- Confirm the accuracy of the original irrigation system blueprint (if zones are indicated) or create a sketch of the facility's irrigation system zones
- Confirm the system is set to run in compliance with local watering restrictions

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine **Worksheet 12**: **Irrigation Schedule and Controller – Basic Audit**.
3. Locate the irrigation system's control box.
4. Locate the facility's irrigation system zone blueprint or sketch the layout of the property and building footprint.
5. Manually turn the main dial on the controller to view and record the runtimes for each zone.
6. Manually engage each zone, one at a time.*
7. As each zone turns is activated, indicate on your blueprint or sketch which areas are engaging.
8. Clearly label the number of each zone on the blueprint or sketch.
9. Check with your local code enforcement office or water management district to determine the permitted watering days and hours for the facility's location. Record these days and times on **Worksheet 12**.
10. If familiar with using the controller, read and record the days the system is set to run on the worksheet. If you are not familiar with it, either secure assistance from an irrigation contractor or observe and record the days and hours the system runs over the next week.
11. Compare the days the system runs to the permitted irrigation days in the local watering rules.
12. For large properties, you may want to check with your head office to determine if an irrigation variance for the property already exists.

* If there are local watering restrictions in your area, you may want to post a sign in front of the building close to where the street address can be read indicating the irrigation system is being tested.

Post-Audit Considerations and Additional Activities

Make copies of the sketch of the irrigation system zones. Keep one as a master copy and use one or more others to assist you as your conduct other investigations of the irrigation system and landscape.

If the controller is activating the system outside of the permitted watering days and times, it should be reset to operate as permitted. Consult with your facility's irrigation contractor if necessary.

Worksheet 12. Irrigation Schedule and Controller – Basic Audit

	Sun.	Mon.	Tue.	Wed.	Thurs.	Fri.	Sat.
Permitted Irrigation Days/Hours							
Current Setting (Days/Hours)							

Is the current run schedule in accordance with local permitted watering days?......Yes No

Zone/Station Number	Runtime Duration (in minutes)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Zone/Station Number	Runtime Duration (in minutes)
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	

All "No" responses should be reviewed for corrective action.
Refer to the Post-Audit Considerations and Additional Activities section.

IRRIGATION SYSTEM AND LANDSCAPE SURVEY – BASIC AUDIT

Background and Description

An irrigation system should be managed and used only to meet the needs of the landscaped plant material supplemental to what falls naturally as rain. To do this properly, the system should be:

- Designed with efficiency in mind
- Managed with respect to the types of plant material and soil in the landscape and the local climate
- Maintained to ensure all parts are functioning with integrity

This audit procedure will provide you with a basic understanding of how to evaluate your facility's landscape and irrigation system and the guidance required to improve the system's efficiency.

Irrigation Sprinklers

In general, irrigation sprinklers can be divided into one of three main categories:

- **Rotors**, high volume emitters used to irrigate lawns or turfgrass (**Figure 12a**).
- **Sprayheads**, designed to irrigate turf or lawns, are also often used to irrigate plants and shrubs if equipped with a low flow nozzle. However, sprayheads do not efficiently deliver water to planted beds as wind easily diverts the flow to unintended areas. This is not considered a best management practice and should be avoided (**Figure 12b**).
- **Micro-irrigation sprinklers**, such as drip lines or bubblers, are among the most efficient means to irrigate planted beds, trees, and shrubs. This is the only type of sprinkler that should be used in planting beds (**Figure 12c** and **d**).

a.


b.


c.


d.


Figure 12. The three main categories of irrigation sprinklers: **a**) rotor, **b**) sprayhead emitter, and **c and d**) micro-irrigation emitters.

General Plant Types

For the purposes of this procedure, general vegetation type is divided into two broad categories: (1) turfgrass, and (2) annuals, perennials, and shrubs. Turfgrass is usually planted in open areas, borders and as filler within the landscape, has higher irrigation requirements, and should be irrigated with rotors. In some cases, such as oddly shaped areas, sprayheads may be a better option, but this is an exception and not the rule. Annuals, perennials, and shrubs are usually planted in beds, have lower irrigation requirements and runtimes, and should be irrigated using micro-irrigation hardware.

Irrigation System Inefficiencies and Maintenance Issues

All irrigation systems need maintenance over time. Even seemingly small breaks can result in wasting large amounts of water. The most common types of breakdowns are often easily identified and remedied. Moreover, the cost to correct most of these system failures is generally low. This irrigation system and landscape survey will help you inspect and identify the most common system failures and sources of inefficient water use.

System inefficiencies can be divided into three categories: Operational Factors, Maintenance Factors, and System Design Factors (**Table 16**) (SFWMD 2009).

Operational Factors

Operational Factors are dictated by how the user operates the system and affect its normal function within its current design and plant materials. These factors include how often the system is set to run, how long each station or zone is set to run, and whether the system has a cut-off device, such as a rain or soil moisture sensor. Addressing the Operational Factors described below often, though not always, involves no cost or field labor and can deliver same-day water savings.

Table 16. Operational, Maintenance, and System Design Factors commonly affecting irrigation system efficiencies.

Operational Factors
• Timer/controller schedules • Rain/soil moisture sensor operation
Maintenance Factors
• Poor sprinkler wetting patterns • Obstructed sprinklers • Broken sprinkler head/risers • Leaks • Clogged sprinklers
System Design Factors
• Mixed irrigation zones (two or more plant types irrigated in the same zone) • Irrigation of mature or established plants that can survive without supplemental water • Sprinkler types not matching general plant type • Mismatching of sprinklers (uneven precipitation rate)

Timer/Controller Schedule Set Incorrectly

A timer or controller directs the system to operate according to a user-defined schedule. The schedule should be set to ensure each zone or station receives an adequate amount of water based on local climate and plant species (no more than 0.75 inches per irrigation event in Florida for turf) within the parameters of any local watering restrictions. The procedures to ascertain your system's current timer settings and application rate are addressed in the *Irrigation Schedule and Controller – Basic Audit* (page 86) and *Irrigation System Distribution Uniformity and Application Rate – Basic Audit* (page 104).

Rain/Soil Moisture Sensor Operation

In some areas, such as Florida, rain and soil moisture sensors are required by law. They interrupt a scheduled irrigation event based on local conditions. These sensors can wear after a few years of normal use and should be checked regularly. It is also crucial to ensure the sensor is properly connected to the timer/controller. Guidance on determining the functionality of these devices is provided in the *Rain and Soil Moisture Survey Basic and Advanced Audits* (pages 99 and 150).

Maintenance Factors

Maintenance Factors relate to the integrity of the system's hardware. These factors are typically inexpensive to address and significantly improve efficiency relative to the effort and investment required. However, Maintenance Factors, such as those below, are susceptible to normal wear and tear and need to be checked as part of a monthly system maintenance regime.

Sprinkler Head Problems

With time, sprinkler heads may experience a variety of issues that will limit their efficiency. A poor wetting pattern, such as watering of paved or other non-landscaped surfaces (**Figure 13**), may result from sprinkler heads settling into the soil or if they have been bumped or stepped on. In most cases, a slight adjustment is all that is needed to redirect the spray over the intended area. Iron-stained structure walls are a sign that a sprinkler is too close to the wall or the angle needs adjusting. If the head is broken, a "geyser" (**Figure 14**) will be seen while the irrigation system is operating and it may be necessary to replace the head entirely. Sprinklers can also become obstructed by plants, tall turf, and other items. This can be fixed by clearing the area around the sprinkler head or raising it several inches. Finally, sprayheads can become clogged (**Figure 15**), which can be often be fixed simply by manually removing dirt from the emitter nozzle with your thumb or a small brush. If this does not work, you may need to flush the lateral lines or clean the screen filters.

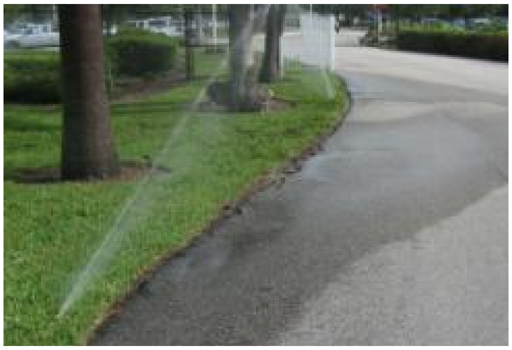


Figure 13. Sprinklers with a poor wetting pattern.

Figure 14. Broken sprinkler head creating a "geyser."

Figure 15. Clogged sprayhead, the area between the two dashed red lines is not receiving water.

Leaks/Broken Pipes

As with most irrigation equipment, pipes can settle into the soil unevenly with time. They are also subject to weather extremes, vehicle traffic, and jolts of water pressure. These stresses can cause line breaks even in newer systems. Leaks are most easily detected when the irrigation system is metered separately from the main inflow. If the meter is turning and the system is not engaged, there is probably a leak. The same meter can be used to receive sewer credits for irrigation water (see page 29). You may also see puddling (**Figure 16**) or water seeping up from below the ground surface.

Figure 16. Broken piping underground causing puddling and erosion.

System Design Factors

System Design Factors, once addressed, will optimize the system's efficiency and application uniformity into the future with little or no further maintenance. Improving system design faults usually requires more planning and investment than fixing Operational or Maintenance Factors. Some of the System Design Factors described here can be easily addressed at little or no cost, while others may require some planning and investment.

Mixed Irrigation Zones

Plant beds generally require less water than lawn areas and should be irrigated separately because these plant types typically have very different irrigation needs. However, many irrigation systems contain zones with turf and other plants irrigated by the same sprinklers (**Figure 17**). This results in either overwatering plants and shrubs or underwatering turf. The inefficiency of this design results in excessive water use, unnecessary plant and turf mortality, and higher costs. In some instances, this may be fixed by permanently capping heads where the plant material is fully established, because these areas may not need irrigation supplemental to rainfall in other cases the zone should be divided.

Figure 17. Shrub and turf areas irrigated within the same zone.

Irrigation of Mature or Established Plants

Many plant species do not require irrigation beyond natural rainfall after they have become established or reach maturity (UF-IFAS 2009, FYN 2009). Irrigation can often be discontinued in the areas containing these plants.

In some cases, during the dryer times of the year, some plant species may enter a dormant period during which they will not appear healthy and lush. This is normal for many species, including those adapted to Florida's growing conditions. Their vibrancy will return once natural conditions incite a new growth period. Many species should even be able to withstand short-term droughts without the need for supplemental irrigation if they have been properly selected for the site, are properly established, and are maintained according to best management practices (FYN 2009).

Not All Areas Need Irrigation

Some areas of your facility may never be seen or used and do not need to be irrigated (**Figure 18**). Examples include narrow, non-traffic alleys and areas behind dumpsters. The irrigation system in these areas can be permanently capped off.

Sprinkler Types Not Matching General Plant Type

Sprinklers should be installed and used only in zones containing the plant material for which they were designed. In general, the three types of sprinklers should be used for the following plant materials:

- **Rotors** – lawns or turfgrass
- **Spray heads** – designed for lawns or turfgrass, but often equipped with a low flow nozzle to irrigate plants and shrubs (this should be avoided where practical)
- **Micro-irrigation sprinklers** (drip lines, microjets, or bubblers) – plants and shrubs; this is the only type of sprinkler that should be used in planting beds

Mismatching Sprinklers and Uneven Precipitation Rates

All sprinkler heads within a zone/station should emit water at the same flow rate. This ensures water is evenly spread over the entire zone. Mismatched sprinklers within a zone lead to excessive amounts of water being applied in some areas or not enough in other areas. Mismatched precipitation rates from sprinklers may be caused by: (1) mixing sprinkler types or brands in a single zone, (2) improper replacement of worn nozzles, or (3) errors in installation or design.

Mulch

The proper use of mulch can be an easy and inexpensive way to save water. A 3 inch layer of biodegradable mulch should be applied to all planting beds to inhibit weed growth (reducing the need for herbicides), add nutrients to the soil, and allow water applied during an irrigation event to remain available longer for plant uptake (**Figure 19**).

Figure 18. A small, non-recreational, non-traffic area that does not require irrigation.

Figure 19. A mulched plant bed.

Audit Objectives

This procedure entails inspecting each zone of the irrigation system and observing their landscaping materials. You may perform multiple irrigation and landscape audit procedures at one time as you survey each zone. You will need to manually engage the system one zone at a time, which will require some familiarity with the controller or timer. If necessary, see the operator's manual for the timer or controller or contact your facility's irrigation contractor.

This procedure will allow you to:

- Identify the general vegetation type(s) in each zone/station
- Identify the type(s) of sprinkler heads in each zone.
- Determine exactly where repairs, improvement efforts, and interventions should be directed
- Identify areas containing mature and established plants that no longer require irrigation

Audit Steps

1. Fill out the parts of the Basic Facility Header Sheet (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine the Irrigation System and Landscape Survey – Basic Audit portion of the Irrigation and Landscape Audit Worksheet and refer to the Irrigation and Landscape Cheat Sheet, both in Appendix C.
3. Locate irrigation line blueprints or create a simple sketch of the property.
4. Manually turn on the irrigation system one zone/station at a time or wait for a scheduled irrigation event.
5. Move methodically from zone to zone while the system is operating, completing the Irrigation System and Landscape Survey section of the Irrigation and Landscape Audit Worksheet for each zone.
6. Note visible leaks in exposed irrigation lines and look for puddles and other soggy areas that may indicate an underground leak.

Post-Audit Considerations and Additional Activities

In general, all "no" responses on the Irrigation and Landscape Audit Worksheet indicate areas for remedial action.

Each irrigation zone should consist of plants with similar watering requirements. After assessing the general plant type(s) in each zone, it should be apparent which zones contain plants with similar and different needs. This is simplified for the audit. At an absolute minimum, turfgrass should not be within the same zone as other plants. Rectifying a mixed irrigation zone may require major work to redesign the irrigation system or convert lawn areas to planting beds (or vice versa). Plants with different irrigation needs can be close to each other – even side by side, but they should be irrigated separately.

Adding a 3 inch layer of mulch to all annual, perennial tree and shrub planted areas is an inexpensive, cost-effective efficiency improvement measure that should be done immediately.

During this audit, you should have identified any areas within the landscape that are unnecessarily being irrigated. Significant reductions in water use are possible by eliminating or reducing irrigation of mature perennial plants, trees, and shrubs. In some cases, this determination is obvious, such as if the trees or shrubs have been in the landscape for several years. In other cases, the species' ability to resist drought or level of maturity may not be apparent.

If the plants are well suited to the local growing conditions (light, soil, natural rainfall, etc.) and have been in the landscape for at least 1 year under normal conditions, or 18 months under dry conditions, irrigation may not be needed (UF-IFAS 2009). Your county extension office or local botanical garden may be able to help you with this decision for almost any species. If irrigation is not necessary, cap the irrigation line to the bed during the onset of the rainy season followed by close monitoring for signs of stress in the next dry season.

Other zones or parts of zones that do not need irrigation include areas not used, viewed, or visited by facility staff or the public, such as a narrow, non-traffic alleyway or an area behind a dumpster. These areas can be permanently capped.

Florida Focus

During most of Florida's normal weather conditions, turfgrass only needs two days or less of irrigation per week (Trenholm et al. 2006).

This audit highlights sources of inefficiency in the irrigation system related to the sprinkler heads. Cleaning, adjusting, and replacing faulty or inappropriate sprinkler heads are inexpensive and extremely cost-effective ways to improve water use efficiency. Using spray heads with low flow nozzles for plants and shrubs is inefficient. All plant beds containing annuals, perennials, and young trees and shrubs should have micro-irrigation (bubblers, drip tubing, or drip emitters) hardware only. Micro-irrigation hardware should be installed in plant beds as sprayheads age and become ineffective, and in general, in all future system upgrades and redesigns.

For major irrigation system redesigns, consult an irrigation specialist certified in irrigation system design by a professional trade group, such as the Irrigation Association[1]. Be sure to discuss your facility's interest in water conservation and efficiency in your consultation. If a wider review and redesign of the irrigation system and landscape is necessary, the irrigation system auditor or designer should not be affiliated with the contractor installing the system to eliminate possible conflicts of interest. The facility's intention to use separate contractors should be made clear and up front.

Mismatched precipitation rates often occur when the same sized rotor nozzle is used in all sprinklers throughout the entire zone. When the wrong nozzle is applied, it is possible to have a 180 degree head emitting the same volume of water as a 360 degree head when it should be half as much. To avoid this, a contractor should change nozzles to achieve matched precipitation.

Determining appropriate irrigation needs for each zone has been simplified for this process. Among annuals and perennials, there is a wide variety in species with differing needs. Once the decision has been made to separate turfgrass from annuals and perennials, further consideration should be given to ensuring that annual and perennial species are grouped appropriately according to their light, soil, and irrigation needs. This may require planning future landscape choices or relying on the skills of a trained horticulturist.

Advanced Audit Preview

To maximize the efficiency of water and fertilizer use, plants within a landscape should be grouped according to their needs. A landscape should also maximize the use of plants suited for the local growing and environmental conditions. Well-selected plants will have low irrigation and fertilizer needs. The *Irrigation System and Landscape Survey – Advanced Audit* (beginning on page 146) will help you achieve these goals.

Florida Focus

Several free, downloadable resources are helpful for identifying plants appropriate for specific conditions in Florida and will help you decide if specific plants in the landscape can tolerate short-term droughts. These include the following:

- A Guide to Florida-Friendly Landscaping – www.floridayards.org/landscape/FYN-Handbook.pdf or go to www.floridayards.org, click "Florida-friendly Landscaping 101," scroll down to the "Downloadable Resources" section, and click "A Guide to Florida-friendly Landscaping."
- South Florida Water Management District WaterWise Plant Guide www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/ww0_waterwise_all.pdf**Error! Hyperlink reference not valid.**, or go to www.sfwmd.gov and enter "WaterWise Plant Guide" into the search bar.
- St. Johns River Water Management District WaterWise Landscapes www.floridaswater.com/waterwiselandscapes/index.html or go to www.floridaswater.com and search for "WaterWise landscapes."

The Florida Irrigation Society (www.fisstate.org) can provide a list of certified irrigation system designers and other contractors.

[1] www.irrigation.org

Florida Focus

The runtimes for each zone should be adjusted in accordance with the ranges suggested in **Table 17**. For local species and those with similar growing requirements, runtimes can be set toward the lower end of the range if any supplemental irrigation is needed. Also, for sandier soils, set the run durations toward the lower end of the range.

If in doubt of the water needs of a specific plant or the facility's soil type, set irrigation timers toward the higher end of the suggested range. This should be suitable for most plants in years of average to near-average weather patterns. Plants that do not remain healthy within these parameters may not be well-suited for the local environment and may need to be replaced.

If you are interested in fine-tuning the runtimes to meet the water requirements of specific plants in Florida, the following resources will be helpful:

- A Guide to Florida-Friendly Landscaping (www.floridayards.org/landscape/FYN-Handbook.pdf)
- Florida Yards and Neighborhoods (fyn.ifas.ufl.edu)
- South Florida Water Management District WaterWise Plant Guide (www.sfwmd.gov and enter "WaterWise Plant Guide" into the search bar)
- St. Johns River Water Management District WaterWise Landscapes (www.floridaswater.com/waterwiselandscapes/index.html)

Table 17. Runtime ranges (in minutes) for irrigation sprinkler types based on vegetation and seasonal needs.

Sprinkler Type		Winter	Fall	Spring	Summer	Most-Suited Vegetation
Rotors	**Ideal**	<10	30	40	45	Turfgrass
	Range	0–20	20–40	35–55	40–60	
Sprayheads*	**Ideal**	0	15	20	25	Turfgrass
	Range	0–10	10–20	15–20	20–30	
Micro-irrigation		15–35	15–35	15–35	15–35	Annuals and Perennials

Source: Green Industry Best Management Practices (GI BMPs) (FDEP 2008)

*Sprayheads are designed to irrigate turf or lawns, but are often used to irrigate plants and shrubs if they are equipped with a low flow nozzle. This practice is not recommended. Only micro-irrigation should be used in plant beds.

Irrigation and Landscape Field Audit Worksheet

	Irrigation Need	If Annuals or Perennials; Trees/Shrubs			General Plant Type		Sprinkler Types				Sprinkler Functinality	
	See Cheatsheet Note 1	See Cheatsheet Notes 2 - 4			See Cheatsheet Note 5		See Cheatsheet Notes 6 - 8				See Cheatsheet Note 9	
Zone	Does this zone 'need' irrigation at all?*	Trees/ Shrubs recently installed?*	Is there adequate mulch? (3")*	Is mico-irrigation used?*	Turf, Annual/ Perennial, or Trees/ Shrubs	More than one gen. plant type in zone?*	Indicate type: Rotor; Sprayhead; or Micro	All same type throughout zone?*	All same Brand throughout zone?*	Sprinker type matches plants?*	Indicate Clogged; Tilted; Obstructed; Broken heads	Wetting pattern covering only the intended area?*

See the Landscape and Irrigation Cheatsheet for section-by-section explanations. Also refer to Guidebook page 90.
***All "No" responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each relevant audit procedure.**

*This is page 1 of 2 of the **Irrigation and Landscape Audit Worksheet**. See **Appendix C** for the complete worksheet and the associated cheatsheet.

RAIN AND SOIL MOISTURE SENSOR SURVEY – BASIC AUDIT

Background and Description

Various devices exist to detect weather or soil conditions to help prevent unnecessary operation of the irrigation system. These include rain sensors and soil moisture surveys. The proper use of this technology can significantly reduce your facility's irrigation water use.

Rain Sensors

A rain sensor (RS, **Figure 20**) or rain switch is a device that disables an irrigation system's timer or controller during or shortly after a rain event, provided a minimum amount of rain has fallen. Presumably, this amount should have been enough to meet the needs of the plant material. The amount of rain needed to interrupt irrigation is set by the user. When functioning properly, a RS can save 15 to 34 percent of water used for irrigation.

As with most outdoor technology, rain sensors require maintenance every few years. Many sensors rely on the swelling of wet cork to depress a switch to trigger the interruption. The cork can become brittle with time, causing the sensor to malfunction. In some cases, the irrigation controller may not be properly set to accept the interruption signal from the sensor due to operator error or a system reset, which can happen after a power outage or an electrical storm.

Figure 20. A standard rain sensor.

Another consideration for a rain sensor to work properly is its placement. Sensors must be in a location away from a building eave, gutter downspout, tree, or other structure that would impede rainfall in the area of the sensor. **Figure 21** shows examples of the improper placement of rain sensors.

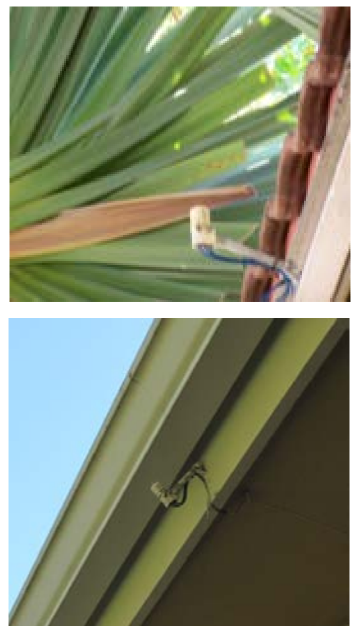


Figure 21. Rain sensors installed in places where normal rainfall is likely to be obstructed.

> ***Florida Focus***
>
> Florida Statute 373.62, which focuses on water conservation, requires "*any person who purchases and installs an automatic landscape irrigation system must properly install, maintain, and operate technology that inhibits or interrupts the operation of (the) system during periods of sufficient moisture.*" The required technology includes but is not limited to rain sensors and soil moisture sensors. The law mandates this technology for all buildings regardless of the year it was built.

Soil Moisture Sensors

Soil moisture sensors (SMS) (**Figure 22**), are buried several inches below ground and measure the amount of water in the soil. These sensors interrupt a scheduled watering event if the soil moisture level is above a set threshold. Studies in Florida found that properly installed and maintained SMSs can save 60 to 70 percent of water compared to irrigation systems without a sensor (McCready et al. 2009).

SMSs are more difficult to install properly than rain sensors and must be placed in an area representative of the average conditions within the irrigated area (**Figure 23**). An SMS should be installed at the midpoint of any on-site slope, equally distant from the nearest sprinkler heads and away from a building eave, gutter downspout, tree, or other structure that would impede rain and sunlight in the area of the sensor since these factors can affect the drying rate of the soil. In large irrigated areas, more than one unit may be needed.

Figure 22. A soil moisture sensor.

Correctly wiring the soil moisture sensors to the timer or controller can be complicated, but is necessary for the system to function (**Figure 24**).

Given these and other considerations, it is recommended that SMSs be installed by a licensed or certified irrigation professional.

Audit Objectives

This procedure will direct you through the necessary steps to identify and visually inspect the rain or soil moisture sensor connected to your facility's irrigation system.

Figure 23. A demonstration of properly burying a soil moisture sensor.

Figure 24. A demonstration of proper wiring of a soil moisture sensor.

Photographs in this section are courtesy of Michael Gutierrez, University of Florida, Tropical Research and Education Center.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine **Worksheet 13** and refer to the Irrigation and Landscape Cheat Sheet, both in Appendix C.
3. Determine if the irrigation system is governed by a rain sensor or a soil moisture sensor. If not, one should be added.
4. Complete **Worksheet 13** in accordance with the type of sensor.
5. All "No" responses should be reviewed for corrective action. Refer to the *Post-Audit Considerations and Additional Activities*.

Post-Audit Considerations and Additional Activities

If a rain sensor is visibly damaged, it will need to be repaired or replaced. In some cases, the cork insert can be replaced without purchasing an entire new unit. Replacing a broken rain sensor or moving it to a more appropriate location is an inexpensive measure and should be done to comply with any applicable local or state laws (Florida has such a law).

If an SMS was installed in an area that does not represent the average conditions of the zone or landscape, it should be moved to a more appropriate location by an irrigation specialist. If the location of the SMS cannot be determined, contact the vendor who installed the unit.

Smart Controllers

In addition to these sensor-based technologies, "Smart Water Application Technology" or "SWAT" irrigation controllers (**Figure 25**) can further increase irrigation efficiency. These controllers allow scheduled irrigation events to occur only when soil moisture drops to a user-determined threshold below which plants would be stressed. While this threshold can be generalized, it actually depends on plant species, soil type, and local weather conditions.

Many SWAT controllers can be fine-tuned for each irrigation zone to meet the thresholds of individual plant species under changing weather conditions. Some receive satellite-fed weather data to account for evapotranspiration, while others have on-site weather sensors (**Figure 26**). Some controllers can even cancel irrigation events if a storm event is approaching the site.

The investment in SWAT irrigation controllers is worthwhile, but should be made in conjunction with a review of the entire irrigation system. If your budget allows, you may want to have your system reviewed and possibly redesigned for maximum efficiency by an irrigation system designer who is certified by a trade group, such as the Irrigation Association[1]. Ideally, the designer should not be affiliated with the contractor installing the system to avoid potential conflicts of interest. Your facility's intention to use separate contractors should be made up front.

Florida Focus

In Florida, SWAT controllers may make your facility eligible for a variance from local watering restrictions. Typically, variances are reviewed on a case-by-case basis, and local watering rules may vary.

The Florida Irrigation Society (www.fisstate.org) can provide a list of certified irrigation system designers and other contractors.

[1] www.irrigation.org

Figure 25. A smart irrigation system control box.

Figure 26. An advanced climate sensor for a smart irrigation system.

Advanced Audit Preview

Even if sensors appear to be working properly, they may not be. The *Rain and Soil Moisture Survey – Advanced Audit* (page 150) will help you determine whether your facility's interrupter device is functioning correctly. **Table 18** shows the potential savings from a properly functioning rain sensor and soil moisture sensor.

Florida Focus

Table 18. Potential savings from a properly functioning rain sensor and soil moisture sensor based on conditions in Florida.

Number of Irrigation Days Permitted Per Week as per Local Watering Restrictions	Number of Possible Annual Irrigation Events	Number of Annual Events Potentially Interrupted	
		Rain Sensor	Soil Moisture Sensor
2	104	21	67
3	156	23	101

Savings rates used: rain sensor 20%; soil moisture sensor 65%. These conservative estimates are based on Cardenas-Lailhacar et al. (2010) and McCready et al. (2009).

Worksheet 13. Rain and Soil Moisture Sensor Survey

Rain Sensor Survey – Basic Audit		
See Cheatsheet Notes 11 - 13.		
Rain Sensor Location ________________________________		
Is the sensor located away from all building eves, gutter downspouts, trees, or other structures that would impede rainfall?	Yes	No
Is the sensor located close to an air conditioning condensate line or another source of water than may saturate the sensor?	Yes	No
Visually inspect the sensor		
Does the cork look fresh and soft, not brittle and dry?	Yes	No
Do the wires look intact?	Yes	No

Rain Sensor Survey –Advanced Audit		
Did the sensor successfully interrupt the irrigation event?	Yes	No

Soil Moisture Sensor Survey – Basic Audit		
See Cheatsheet Notes 14 - 16.		
Soil Moisture Sensor Location		
Is the sensor located away from all building eves, gutter downspouts, trees, or other structures that would impede rainfall?	Yes	No
Is the sensor located close to an air conditioning condensate line or another source of water than may saturate the sensor?	Yes	No
Is the sensor located at or near the mid-point of an on-site slope?	Yes	No
Is the sensor located equidistant from the closest group of sprinkler heads?	Yes	No
Soil Moisture Sensor Survey – Advanced Audit		
Did the sensor successfully interrupt the irrigation event?	Yes	No

See the Landscape and Irrigation Cheatsheet in Appendix C for further explanation. Also refer to Guidebook pages 99 and 150.

All "No" responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each applicable audit procedure.

IRRIGATION SYSTEM DISTRIBUTION UNIFORMITY, APPLICATION RATE AND CALIBRATION – BASIC AUDIT*

Background and Description

This audit procedure consists of two sections. The first focuses on whether the irrigation system applies water evenly over the irrigated areas (distribution uniformity). The second will guide you through the steps to determine how much water is applied by the irrigation system in inches per hour so it can be calibrated to deliver a specific amount of water during each irrigation event. These two exercises are presented together because they can be done simultaneously.

This audit procedure is best suited to open areas of high volume irrigation, such as lawns or athletic play areas. These areas account for most irrigation water use in many irrigated landscapes.

System Distribution Uniformity

Distribution uniformity (DU) is a measure of how evenly water is applied over an irrigated area and is one of the most significant parameters to determine a system's efficiency (Rainbird Irrigation 2010). A system with good DU mimics rainfall by applying water evenly across the landscape and saturating the active root zone. Poor DU can result in brown or wilted patches of grass among an otherwise healthy looking lawn. To remedy this situation, irrigation contractors typically increase the irrigation runtime of a zone with wilted spots. This can improve conditions in the patchy areas, but at the expense of excessive watering of formerly healthy areas and can increase the occurrence of weeds and fungus.

Figure 27 illustrates soil profiles at various levels of saturation following an irrigation event. In **Figure 27a**, the sprinkler heads evenly deliver water to all areas of the lawn, sufficiently saturating the root zone. This can be achieved by ensuring the heads are properly spaced or that each has an adequate throw radius. **Figure 27b** shows a lawn with uneven water distribution with patchy areas that do not receive enough water. Many lawns operate under the third or fourth scenario (**Figure 27c and d**). These occur often after the irrigation runtime has been increased to ensure the patchy areas receive enough water, while other areas consequently receive too much. All water percolating below the root zone is wasted. While the appearance of the lawn may meet expectations, excessive costs are incurred due to wasted water, increased frequency of fertilizer applications (since excessive water leads to increased leaching), and an increased need for weed and fungus control.

When tested by certified professional irrigation designers and landscape architects, DU is expressed as a percentage of maximum efficiency. The value results from a series of calculations that account for plant watering needs, soil type, and detailed spacing measurements. A trained professional is able to determine which areas or zones require adjustments or modifications, as well as the specific adjustments or modifications needed to increase the DU to an acceptable level. Such calculations and determinations are complex, require expertise, and are therefore outside the scope of this guide. This section's audit procedure is a simplified version of the test done as part of an irrigation system evaluation.

***Florida Green Lodging Applicants:**

This *Irrigation System Distribution Uniformity, Application Rate and Calibration – Basic Audit* is **optional** as part of your application. For more information on this program, see page iv.

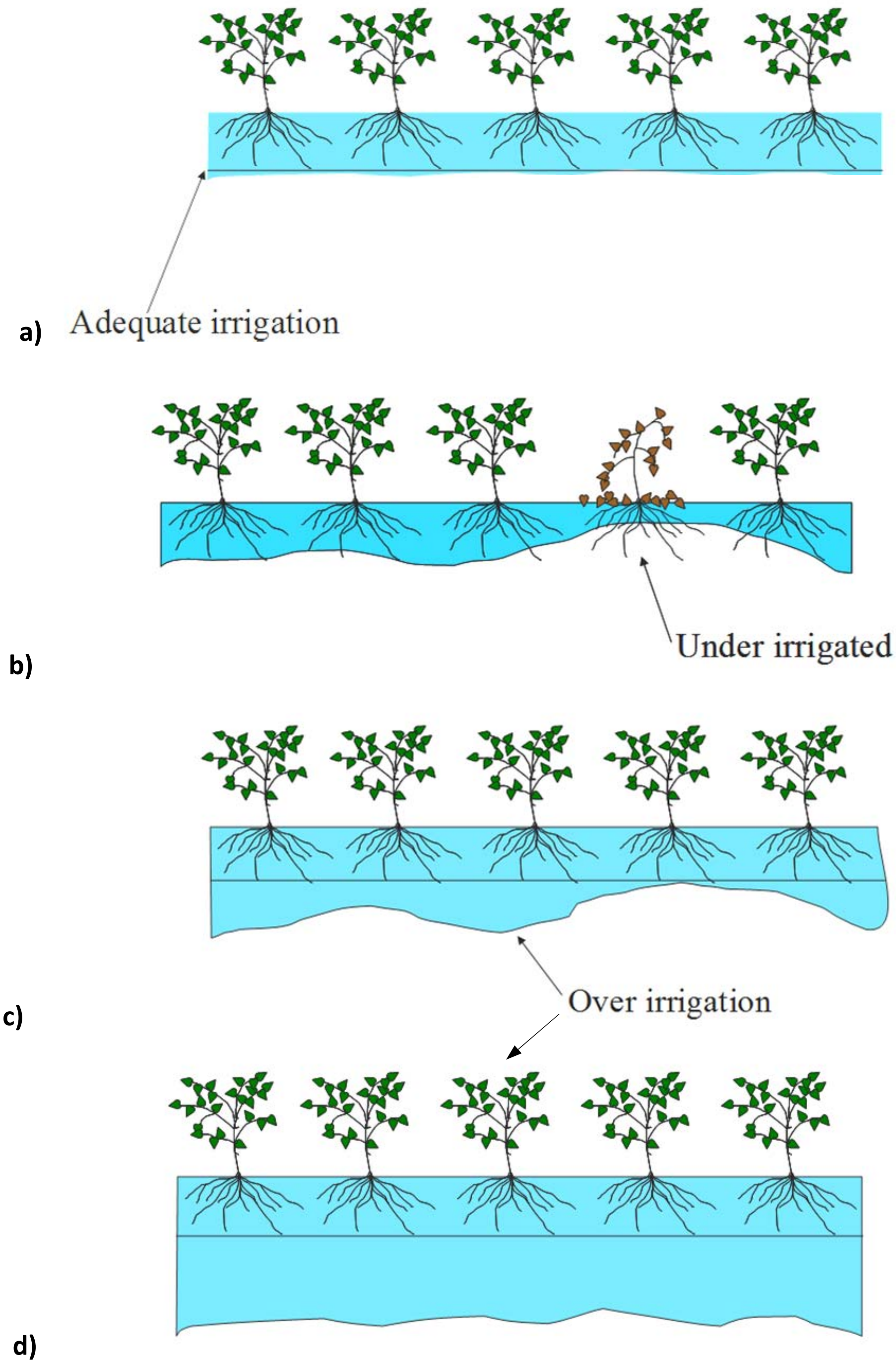


Figure 27. Irrigated soil profiles. **a)** An adequately irrigated soil profile with high distribution uniformity (DU) and a root zone that is fully saturated without further precolation. **b)** An inadequately irrigated soil profile with low DU and a root zone that is fully saturated only in some areas. **c)** An inadequately irrigated soil profile with low DU; the root zone is fully saturated but excess water has percolated below it. **d)** An inadequately irrigated soil profile with moderate DU but a large excess of water percolating beyond the root zone.

Catch-Can Test for Determining Distribution Uniformity

This section's audit procedure is a simplified version of catch-can test, which is routinely done as part of a full irrigation system evaluation and will help you assess its overall distribution uniformity. This process begins by placing cans or plastic cups in each irrigation zone (station) as shown in **Figure 28**. The cups will catch water emitted by the sprinklers during an irrigation event. The depth of the water in each cup shows how much water that spot received.

In a perfect system, each cup in any given zone will collect the same amount of water. However, in most cases, some variation in the amount of water collected will occur. Differences greater than 40 percent indicate an inefficient DU for the zone (Palm Beach County Soil and Water Conservation District, personal communication).

Creating a rough sketch of the irrigated area and the pattern of the catch-cans can help serve as a template to record the depths of water collected in each cup. This will help identify areas of excessive or deficient water delivery.

If you are not planning on determining the application rate of your irrigation system, the type of catch-can (or cup) you use does not matter so long as they are all the same and approximately 3 to 6 inches in diameter (Trenholm et al. 2009).

Figure 28. A catch-can test used to determine distribution uniformity.

System Application Rate Calibration

The second part of this section's procedure involves calculating the average depth of collected water in each zone. If the duration of the irrigation event is known, the average depth can be converted to inches per hour. This is the metric used to measure and calibrate water application in irrigation settings.

Running the irrigation system for 15 minutes makes for easy calculations because multiplying by 4 gives you the hourly application rate. For example, if you collected ¼ inch of water in 15 minutes, then ¼ x 4 = 1 inch per hour (application rate).

Once the irrigation application rate (in inches per hour) is known, the runtime for the zone can be calibrated so that the irrigation system applies a user-determined amount of water during each irrigation event, reducing over- or underwatering and increasing the efficiency of the system overall. So if your system is putting out 1 inch of water hour and you want to apply ¾ inches of water during each irrigation event, you can run the system for 45 minutes.

Ideally, the catch-can test should be conducted using straight-sided containers (for example, tuna or soup cans) if you are planning on determining the application rate of the irrigation system. If you start with straight-sided containers, measure the depth directly in the can. However, it may be easier to get a large number of plastic cups (**Figure 29a**). If you use plastic cups or similar containers with sloped sides, you will need to transfer the water in each cup to a straight-sided container with the same diameter opening as the cups (**Figure 29b**) before measuring the depth (**Figure 29c**). This will more accurately measure the true depth of irrigation. The straight-sided can must be emptied between each measurement.

a. b. c.

Figure 29. Measuring water collected during a catch-can test.

How Much Water Does My Lawn Need?

The amount of water your lawn needs per week depends on the species of grass, the soil type, the local climate, and the season. The goal of efficient lawn watering is to apply enough water to saturate the top 6 inches of soil, where the active root zone is located (see **Figure 27a**), but not apply more water than is required to complete that saturation.

As a rule of thumb, this should require ¾ to 2 inches of water, but again this is highly variable and will change even for the same site according to the season. **Your local county extension office or botanic garden may be able to help you make a determination for your facility's lawn.** Knowing the application rate of your lawn is the first step in applying just the amount of water your lawn needs.

The *Irrigation Water Use* Microsoft Excel spreadsheet associated with this guide contains a set of tables that will complete the necessary calculations once you enter the field measurements.

Table 17 (page 97) lists general runtimes for each major emitter type for Florida. Those runtimes should deliver an adequate amount of water during each irrigation event. The Application Rate and Calibration procedure will guide you through the steps to determine more precise runtimes to deliver enough water to each zone based on the application rate you measured for your facility's irrigation system.

Audit Objectives

This procedure will:

- Familiarize you with the concept of distribution uniformity (DU) and allow you to determine if each zone in the irrigation system delivers an adequate DU
- Guide you through the steps to determine the application rate of the irrigation system
- Provide direction for calibrating the system to apply an adequate and efficient amount of water per irrigation event

This audit procedure is most suited to open areas of high volume, water-using vegetation, such as lawns or athletic play areas.

It is critical to perform this simplified catch-can test while there is no wind or rain, and the test must be conducted in each zone. If there are multiple identical zones (same number and type of sprinkler heads, same general type of vegetation, and same runtimes, such as in large recreation areas or athletic play areas) you can conduct the test on one or two such zones and apply those measurements to the other similar zones as a short cut.

Audit Steps

Steps 1 through 11 describe the process to determine if the system has a high (efficient) or low (inefficient) DU. Steps 12 through 15 will help you determine the irrigation application rate (in inches per hour) so the system can be calibrated.

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Assemble the following:
    a. A sketch of the irrigated area
    b. Plastic cups
    c. At least one straight-sided can (tuna, soup, etc.) with a similar diameter as that of the opening of the plastic cups
    d. A waterproof marker
    e. A calculator
    f. A ruler
3. Sketch the shape of the irrigated space being tested on a sheet of paper and the approximate locations of the catch-cans.
4. Completely remove the top of the straight-sided can.
5. Number each cup using the waterproof marker.
6. Place a cup 1 foot from each emitter and another cup approximately half-way between each pair of emitters. If more cups are available, they can also be placed in a line between sprinkler heads (see **Figure 28**). Be aware that the irrigated space may be very irregularly shaped. This will need to be repeated for each zone, one zone at a time.
7. Mark the position of each numbered cup on the sketch.
8. Engage the system for at least 15 minutes.
9. For each cup in each zone, pour the water into the straight-sided can and measure the depth the nearest ⅛ inch. This test depends on the accuracy of the depth measurement, so this should be done with care. Empty the straight-sided can after each measurement.
10. Record the depth beside each cup number on the sketch of the irrigated area.
11. Examine the distribution of water depths on the sketch and identify areas with high or low application rates. A difference of more than 40 percent is the threshold indicator.
12. For each zone, find the average collected water depth by adding the depths in each container as measured in the straight-sided can and divide the total by the number of containers.
13. Use the *Irrigation App. Rate Calibration* tab in the *Irrigation Water Use* spreadsheet to determine the irrigation rate in inches per hour. Guidance for this spreadsheet begins on page 110.
14. Decide on the desired application (recall that ½ to ¾ inches per watering event should be enough to saturate the root zone in most Florida soils).
15. Once a desired application rate has been designated, enter the average depth for each zone into the space provided in the *Irrigation App. Rate Calibration* tab. The output (gray cells) will indicate the runtimes needed for each zone to deliver your irrigation depth. As a reminder, to determine a desired application depth, the appropriate season must be considered.

Post-Audit Considerations and Additional Activities

Some easily remedied factors that lead to a poor DU are tilted, blocked, sunken or clogged sprinkler heads, mismatched heads in a zone, and poor pressure regulation. Simple adjustments, cleaning, or maintenance may improve the DU. During the *Irrigation System and Landscape Survey – Basic Audit* (page 90), these easily remedied factors (problems with proper sprinkler head function) should have been identified and corrected.

Another factor that can lead to poor DU is the layout of the heads. An irrigation system designed with head-to-head coverage will have a very high (efficient) DU. This means the sprinkler heads are spaced so the water from one sprinkler completely covers the distance to the next closest sprinkler (Vickers 2001, SJRWMD 2009) (**Figure 30**).

Other factors, such as ill-suited irrigation piping diameter can also contribute to poor DU. Therefore, if this procedure indicates a zone has a poor DU and all sprinkler heads seem to be functioning correctly and at the same precipitation rate (they are all the same type and brand), additional adjustments to the system design may be necessary.

This means you may need to consult an irrigation professional. If so, contact an individual certified by a trade group, such as the Irrigation Association[1]. Such an individual will be able to evaluate the complete system. The evaluator should not be affiliated with the contractor who would make modifications to the system to avoid possible conflicts of interest. Your facility's intention to use separate contractors should be made clear and up front.

Florida Focus

The Florida Irrigation Society (www.fisstate.org) can provide a list of certified irrigation system designers and other contractors.

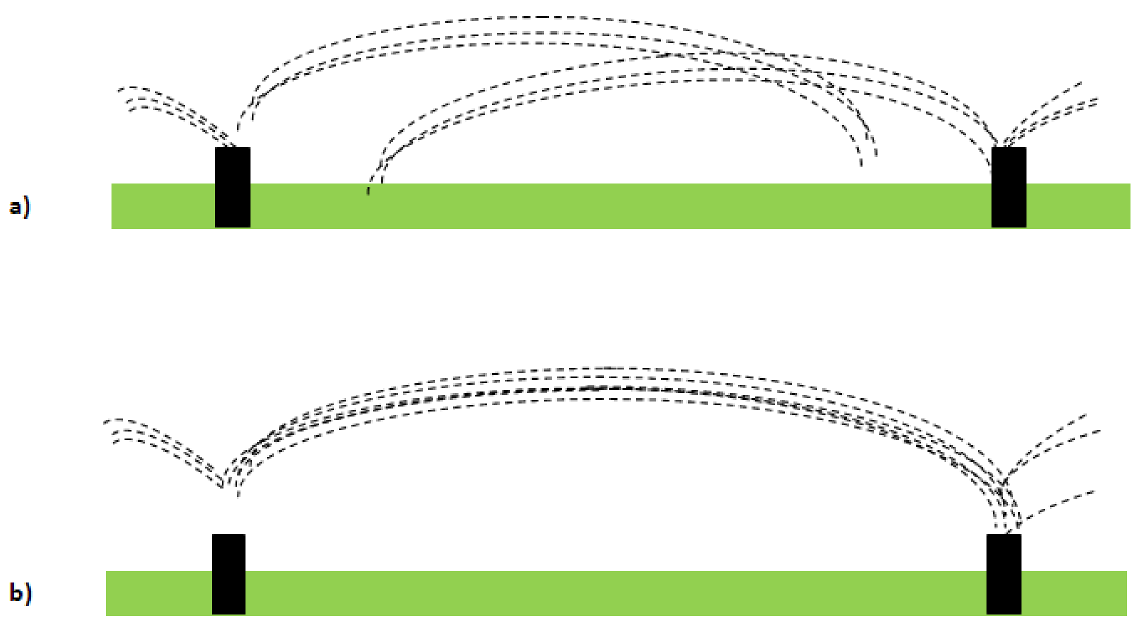


Figure 30. Sprinkler coverage diagrams. **a)** An irrigation system without head-to-head sprinkler coverage (inefficient water application). **b)** An irrigation system with head-to-head sprinkler coverage (highly efficient water application).

[1] www.irrigation.org

Spreadsheet Guidance

Evaluating Distribution Uniformity: There is no spreadsheet associated with the procedure.

Determining Irrigation Application Rate and System Calibration: After determining the average depth of water in the catch-cans in each zone, transfer the data from your site sketch to the *Irrigation App. Rate Calibration* tab in the *Irrigation Water Use* spreadsheet. Data is entered in the white cells and the gray cells show the calculated results. You will also need to select the desired irrigation application from the gold dropdown menus for the calculations to function. Your local extension office or botanic garden may be able to help you determine this. Next, select the number of minutes the irrigation system ran during the test for each zone from the dropdown menu. In the next column, select the average water depth for the cups of each zone to the nearest ⅛ inch (**Figure 31**).

Questions to Answer and Field Data You Will Need to Collect for this Calculator

- The amount of water you wish to apply in each zone, also known as the application depth (in inches)
- Runtime, in minutes, each zone ran during this test
- The average depth of water collected in all cans in each zone

The calculator will output the current irrigation rate in inches per hour and the time each zone should be set to deliver the amount of irrigation water you wish to apply. Use these times to adjust the system's controller/timer as necessary to calibrate your facility's irrigation system.

For more information, see *How to Calibrate Your Sprinkler System*[1].

Florida Focus

As per the University of Florida's Institute of Food and Agricultural Sciences (IFAS), ¾ inches of water during a single irrigation event should be more than adequate to thoroughly saturate the active root zone of turfgrass. This is because the sandy soils in most parts of Florida can hold approximately 1 inch of water in the top 12 inches of soil while the root zone of most turfgrass lies in the top 4 to 6 inches (Trenholm et al. 2006).

Applying ¾ inches of water during one weekly irrigation event equals 3 inches per month and two weekly irrigation events amount to 6 inches per month. Soils with more clay or organic matter can hold moisture better than sandier soils and may require less frequent watering.

A simple schedule of ½ to ¾ inches of water per irrigation event should be sufficient for most grasses in Florida under normal rainfall conditions. Making seasonal adjustments to your irrigation system's timer may be warranted since turfgrass is dormant during winter. For more information on how to adjust your irrigation timer for seasonality and under drought conditions, see the following IFAS publications:

- Watering Your Florida Lawn (edis.ifas.ufl.edu/lh025)
- How to Calibrate Your Sprinkler System (edis.ifas.ufl.edu/lh026)
- Managing Your Florida Lawn Under Drought Conditions (edis.ifas.ufl.edu/ep078)

[1] University of Florida's IFAS Extension – edis.ifas.ufl.edu/lh026 or go to edis.ifas.ufl.edu and enter "How to Calibrate Your Sprinkler System" in the search field.

Catch-Can Irrigation Rate Determination				
	Minutes of runtime for this zone*	Average water depth in catch-can (in inches)	Application Rate (inches per hour)	Set the Zone to Run for this Time
Zone 1	20	4/8	1.5	20
Zone 2	20	3/8	1.1	27
Zone 3	20	3/8	1.1	27
Zone 4	20	3/8	1.1	27
Zone 5	20	4/8	1.5	20
Zone 6	20	5/8	1.9	16
Zone 7	Select One	Select One 1/8 2/8 3/8 4/8 5/8 6/8 7/8	X	X
Zone 8	Select One		X	X
Zone 9	Select One		X	X
Zone 10	Select One		X	X
Zone 11	Select One	Select One	X	X
Zone 12	Select One	Select One	X	X

*This is how long the zone was running while the cups were filling with water.

Figure 31. An example of the *Irrigation App. Rate Calibration* tab in the *Irrigation Water Use* spreadsheet.

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Part II. Advanced Audits

Overview

The Advanced Audit procedures call for you to take a second look at some of the areas covered in the Basic Audits. Some of these advanced procedures will help you quantify potential water and monetary expenses and savings, and payback periods resulting from the implementation of efficiency improvement measures. Other procedures in this section are meant to help expose additional areas where efficiency improvements can be found.

As you move through these procedures, you may find it necessary to consult with additional resources or an external professional (landscape or irrigation specialist, or cooling tower maintenance professional, for example). For the most part, however, if you were able to move through the basic procedures, you should be able to tackle the advanced ones.

GENERAL DOMESTIC WATER USE – ADVANCED AUDIT

Background and Description

During the *Basic Domestic Water Use – Basic Audit* (page 45) walk-through, you identified leakage, inefficient and obsolete fixtures and appliances in your facility. This Advanced Audit will guide you through the process of understanding use, savings, and payback periods for your organization's investments in water efficiency. This is achieved by combining frequency-of-use information with the flow rate information collected during the Basic Audit indoor water use survey.

This Advanced Audit will help you identify which specific fixtures at your facility will yield the quickest and greatest returns on investment if they are replaced or retrofitted.

Frequency-of-use data accounts for the number of times and how long a device is used per day or month. For appliances like residential-grade dishwashers, the best way to get frequency of use data may be to ask those who use it.

The additional information you need for this procedure can be completed after your Basic Audit facility walk-through is complete. **There should be no additional field work necessary to complete the Advanced Audit procedure.** Furthermore, all necessary calculations are done by the accompanying Microsoft Excel spreadsheets: *Domestic Plumbing Fixtures*, ENERGY STAR's *Commercial/Residential Appliance Savings Calculator*, and ENERGY STAR's *Commercial Kitchen Equipment.*

Audit Objectives

This procedure will help you:

- Quantify water consumption by the most common water-using fixtures and appliances
- Develop a simple payback period for investments in new water efficient technology

Audit Steps[1]

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Assemble **Worksheet 4** through **Worksheet 8**.

Domestic Plumbing Fixtures Spreadsheet

Utility Rate and Population Data Tab

3. Ensure the following utility and billing information has been entered into the spreadsheet:
    a. Water utility rate information: potable and sewer water costs
    b. Power utility rate information: gas (therms) and electricity costs (kWh)

    Refer to page 23 for information on the *Billing Data Input Table*.

[1] These audit steps will guide you through the use of several spreadsheets associated with this guide. For general information on the calculators and spreadsheets, see *Audit Organization and Associated Spreadsheets* starting on page 22. For more specific help with the calculators related to this audit, see the *Spreadsheet Guidance* section starting on page 116.

4. Enter the following information into the *Facility Population Data Input* table:
   a. The names of up to two primary full-time groups (e.g., students and faculty; office staff and sales-floor staff)
   b. The number of males and females in the full-time groups
   c. The number of days per week and weeks per year the site is used
   d. Number of times each full-time person is expected to use a restroom per day (default value is three)
   e. Number of times (estimate based on daily traffic) common-gender (or unisex) restrooms may be used (a common-gender lavatory is available for use by both men and women)[1]
   f. Number of visitors on the site per day (customers, clients, night school attendees, etc.)
   g. The percent (estimate) of females in the daily visitor population (the default is 50%)

   After you enter data in the *Utility Rate and Population Data* tab, the same data will automatically transfer to the other tabs of the spreadsheet as necessary.

5. Enter the following information into the *Efficiency Fixture Properties* table:
   a. Water use rates of efficient fixtures (gallons per flush or gallons per minute)
   b. Cost to replace inefficient fixtures with efficient models
   c. Cost to perform maintenance on the fixture (for fixtures that only require maintenance to perform at an acceptable efficiency level; usually 10 percent of replacement cost)
   d. Indication of whether hot water is used by each fixture (this allows the calculator to account for energy savings related to heating less water that occur when efficient fixtures are used)
   e. The size of the cup used to measure flow for each fixture (for faucets and showerheads only)

6. Enter current fixture water use and frequency of use rates for each fixture type. The necessary input data are summarized for each fixture below.

Toilets Tab

7. Enter the following into the fields provided on the *Toilet* tab of this calculator:
   a. Location (restroom number or descriptor, such as 2nd floor, with some indication of which fixture within the restroom, such as a letter "A" for the fixture closest to the door)
   b. User group (e.g., Male Faculty)
   c. Indication of whether visitors use this restroom fixture
   d. Indication of the toilet type (valve or tank)
   e. Volume of the tank water used per year (if applicable)
   f. Number of seconds of flow per flush (for valve toilets)
   g. Marked flow (not required for calculations)
   h. Recommended action (no action, replace, maintenance) for each fixture based on field observations and comparison of current flow rate versus the efficiency flow rate (see pages 19 and 45).
   i. Indication of acceptance of the default use frequency (see explanation of "Default Override Option" on page 122)
   j. Default override value (see page 122)

8. Examine the output tables.

[1] Common (unisex) restroom uses per person per day cannot be greater than the total number of restroom uses per day.

Urinal Tab

9. The *Urinal* tab entry fields are nearly identical to the *Toilet* tab except that it does not have data entry fields related to tank toilets. Refer to Step 7.

Lavatory Faucets

10. Lavatory faucet use is tied to restroom use and is a function of population size and make up. For lavatory faucets, enter the following:
    a. Average seconds per use for manual faucets
    b. Location (restroom number or descriptor, such as 2nd floor, with some indication of which fixture within the restroom, such as a letter "A" for the fixture closest to the door)
    c. User group (e.g., Male Faculty)
    d. Indication of whether visitors use this restroom fixture
    e. Marked flow (not required for calculations)
    f. Manual or metered faucet indicator (not required for calculations)
    g. Metered flow time (on-off cycle in seconds)
    h. Number of seconds required to fill the flow measuring cup (indicated in the *Efficiency Fixture Properties* table in the *Utility Rate and Population Data* tab)
    i. Recommended action (no action, replace, maintenance) for each fixture based on field observations and comparison of current flow rate versus the efficiency flow rate (see pages 19 and 45).
    j. Indication of acceptance of the default use frequency (see "Default Override Option" explanation on page 122)
    k. Default override value (see page 122)
11. Examine the output tables.

Non-Lavatory Faucets

12. The inputs for this tab are nearly identical to those of the *Lavatory Faucets* tab. However, non-lavatory faucet use is not tied to restroom use. Therefore, the *Non-Lav. Faucets* tab requires you to estimate the number of uses each fixture receives per day and does not have a default use frequency. Refer to Step 10.

Residential/Commercial Dishwasher Water Use Via ENERGY STAR's Commercial/Residential Appliance Savings Calculator

13. Examine **Worksheet 8** and ENERGY STAR's *Appliance Savings Calculator*.
14. Enter the following into the fields provided on the INPUTS tab:
    a. A determination of whether the comparison is for commercial or residential model appliances
    b. The state (location) of the facility (average power and water rates will appear as defaults)
    c. Electric rate ($/kWh) for the facility (if known)
    d. Gas rate ($/therms) for the facility (if known)
    e. Water rate: cost of potable and sewer water (combined) in 1,000 gallon increments[1] for the facility (if known)
    f. Number of units
    g. Type of unit (standard or compact)
    h. Average number of cycles (loads) per week
    i. Type of water heating (electric or gas)

[1] If your facility's water is billed in ccfs (or 100 cubic foot increments), add the potable and sewer water rate for 1 ccf and divde by 748. Multiply this value by 1,000. The result is the water and sewer rate in $ per 1,000 gallons.

j. Additional consumption data, assumptions, and other use characteristics can be entered on the INPUTS tab and on the Dishwasher Calcs tab.

15. Examine the annual and life cycle costs and savings output table on the RESULTS tab.

Ice Machine Water Use via ENERGY STAR's Commercial Kitchen Equipment Savings Calculator

16. Examine **Worksheet 8** and ENERGY STAR's *Commercial Kitchen Equipment Savings* spreadsheet and enter the following into the fields provided:
    a. A determination of whether the comparison is for commercial or residential model appliances
    b. The state (location) of the facility (average power and water rates will appear as defaults)
    c. Electric rate ($/kWh) for the facility (if known)
    d. Gas rate ($/therms) for the facility (if known)
    e. Water rate: cost of potable and sewer water (combined) in 1,000 gallon increments[1] for the facility (if known)
    f. The type of machine (i.e., ice making head, remote condensing unit/slit system, self-contained unit)
    g. Ice harvest rate (pounds of ice per day)

    Default values are provided for the following (these values can be overridden by the user):
    - Potable water use (gallons per 100 lbs ice produced)
    - Operating days per year
    - Additional cost per unit for ENERGY STAR model over a conventional one

17. Examine the Results Summary tab.

Residential Clothes Washer Water Use via ENERGY STAR's Commercial/Residential Appliance Savings Calculator

18. Examine **Worksheet 8** and ENERGY STAR's *Commercial/Residential Appliance Savings Calculator.*
19. Select "Residential" from a drop-down menu (this is the same calculator to estimate commercial clothes washers)
20. Enter the following into the fields provided:
    a. A determination of whether the comparison is for commercial or residential model appliances
    b. The state (location) of the facility (average power and water rates will appear as defaults)
    c. Electric rate ($/kWh) for the facility (if known)
    d. Gas rate ($/therms) for the facility (if known)
    e. Water rate: cost of potable and sewer water (combined) in 1,000 gallon increments[1] for the facility (if known)
    f. Number of units
    g. Average number of cycles (loads) per week
    h. Type of water heating (electric or gas)
    i. Type of dryer (electric or gas)
    j. Additional consumption data, assumptions, and other use characteristics can be entered on the INPUTS tab and on the Dishwasher Calcs tab.

16. Examine the RESULTS tab.

[1] If your facility's water is billed in ccfs (or 100 cubic foot increments), add the potable and sewer water rate for 1 ccf and divde by 748. Multiply this value by 1,000. The result is the water and sewer rate in $ per 1,000 gallons.

Post-Audit Considerations and Additional Activities

The payback period associated with retrofitting or replacing certain fixtures or appliances is a function of the cost, water savings per use, and the frequency of use. Typically, **measures with a payback period of 4 years or less are considered feasible**; however, many water efficiency measures recuperate the investment much sooner – in some cases, less than a year. **Refer to the Post-Audit Considerations and Additional Activities section of *General Domestic Water Use – Basic Audit*** (page 50) for detailed information on efficient fixtures and appliances and in conjunction with the payback period calculations for each fixture type as calculated in the *Domestic Plumbing Fixtures* calculator.

Spreadsheet Guidance

Three Microsoft Excel spreadsheets are used as part of the *General Domestic Water Use – Advanced Audit*. They are:

I. *Domestic Plumbing Fixtures* – covering toilets, urinals, faucets, and showerheads based on the population dynamics of the facility (see page 118)
II. ENERGY STAR's *Commercial/Residential Appliance Savings* calculator (see page 124)
III. ENERGY STAR's *Commercial Kitchen Equipment* calculator, used to evaluate ice machines (see page 126)

The following sections provide information and details on using these calculator spreadsheets.

I. Domestic Plumbing Fixtures Spreadsheet

General

For all tabs in this spreadsheet, data is entered in the white cells and the gray cells show the calculated results. You must choose an option from the dropdown menus presented in the gold cells labeled "Select one" or the calculations will not function.

Utility Rate and Population Data Tab

You need only to enter utility billing data once on the *Utility Rate and Population Data* tab. This information will be used by all other tabs. Refer to the *Audit Organization and Associated Spreadsheets* section of this guide (page 22) for an explanation on how to enter this data. All other tabs require you to input other data specific to each fixture.

After billing data has been entered, two additional sets of information are needed to run this calculator. The first relates to the efficiency levels and costs of new fixtures being considered as alternatives (replacements, retrofits or maintenance) to those currently being used. The second relates to the population (number and gender) of the people working at and visiting the facility.

Several assumptions based on the number and gender of the facility occupants govern the calculations for fixture use. The *Domestic Plumbing Fixtures* spreadsheet will estimate your facility's indoor plumbing fixture water use and potential savings assuming efficiency improvement measures are implemented based on the assumptions listed below and the flow and flush rates you recorded during the *General Domestic Water Use – Basic Audit* facility survey:

- People in commercial facilities use restrooms three times per day[1]
- Males use urinals twice per day and toilets once
- Females use toilets three times per day
- Each toilet or urinal use is accompanied by faucet use
- Half of all visitors to a facility will use a lavatory

[1] You can change this assumption in the savings calculator.

Facility Population Data Input		Population Size	Days/week on site	Weeks/year on site	Work Days per Year
Enter Name Population Group 1	Students				
Enter Name Population Group 2	Staff				
Enter Number of	MALE Students	122	5	40	200
Enter Number of	FEMALE Students	140	5	40	200
Enter Number of	MALE Staff	12	5	40	200
Enter Number of	FEMALE Staff	16	5	40	200
Enter Number of	VISITORS	47	3	10	30
	Percentage of female VISITORS [1.]	50			
Restroom uses/day/FULL-TIME person [2.]	3.0				
Common (unisex) restroom uses/day	2.5	per	individual Students		
Common (unisex) restroom uses/day	2.5	per	individual Staff		

1. Default is 50 (percent).
2. Default is 3. This is the number of times each fixture in these restrooms will be used.

Figure 32. The *Facility Population Data Input* table in the *Utility Rate and Population Data* tab of the *Domestic Plumbing Fixtures* calculator.

- All fixtures within a single lavatory are assumed to be used equally each day
- All lavatory use in a facility is distributed equally[1]

Questions to Answer and Field Data You Will Need to Collect to Complete this Tab

(There are three tables)

1. **Billing Data Input Table (Utility Rate and Population Data tab)**
   - Water utility rate information: potable and sewer water costs
   - Power utility rate information: gas (therms) and electricity costs (kWh)

   Refer to page 23 for information on the *Billing Data Input Table*.

2. **Facility Population Data Input Table (Utility Rate and Population Data tab) (Figure 32)**
   - The names of up to two primary full-time groups (e.g., students and faculty; office staff and sales-floor staff)
   - The number of males and females in the full-time groups
   - The number of days per week and weeks per year the site is used
   - Number of times each full-time person is expected to use a restroom per day (default values is three in 8 hours, but can be changed by the user)
   - Number of times (based on an estimate daily foot-traffic) common-gender (or unisex) restrooms may be used (a common-gender lavatory is available for use by men and women)[2]

[1] You may redistribute lavatory use based on your facility's layout or other factors. For example, certain lavatories near primary entrances may be used more than others. So long as the total lavatory use (total population x 3, unless changed by the user) remains constant, any redistribution will provide a valid estimate of use and savings. The calculator will guide you toward keeping this total lavatory use close to the expected total (population x 3, unless changed by the user).

[2] In some facilities, unisex (or common) restrooms are used in favor of or in addition to gender-specific restrooms. The way to think about is would be as follows: of the three times each person in the facility population uses a lavatory, half (or 1.5) of those times the use will occur in a common lavatory. This estimation is necessary for the calculator to properly estimate the use frequency of each fixture in each restroom on a daily basis.

- Number of visitors at the site per day (customers, clients, night school attendees, etc.)
- The percent (estimate) of females in the daily visitor population (the default is 50 percent)

In the example in **Figure 32**, each classroom of this elementary school has its own common (or unisex) restroom. The user estimated that, of the 3 times each student uses a lavatory each day, 2.5 of those uses (on average) will occur in the in-classroom lavatory. The user has accounted for some use (0.5 times per student per day) to occur in the gender-specific lavatories near the school's cafeteria and recreational areas.

3. **Efficiency Fixture Properties Table (Utility Rate and Population Data tab) (Figure 33)**
   - Water use rates of efficient fixtures (gallons per flush or gallons per minute)
   - Cost to replace each fixture type
   - Cost to perform maintenance on each fixture type (for fixtures that only require maintenance to perform at an acceptable efficiency level; usually 10 percent of cost annually)
   - Indication of hot water use for each fixture (this allows the calculator to account for energy savings related to heating less water that occur when efficient fixtures are used)
   - Indication of how the flow of faucets and showerheads was measured: flowbag or measuring cup.
   - If a measuring cup was used, the size of the cup used to measure flow for each fixture (this allows the calculator to convert the seconds of flow required to fill the cup during the field survey to flow rate in gallons per minute for each fixture)

After you enter data in the *Utility Rate and Population Data* tab, the same data will automatically transfer to the other tabs as necessary.

As discussed earlier, the flow rate for faucets and showerheads is measured either by recording the time required to fill a known-volume container or by using a flow-gauge bag (or flowbag). You must indicate the measurement method you used during the field survey by selecting from a dropdown menu in a gold cell located in the *Efficiency Fixture Properties* table on this tab (*Utility Rate and Population Data*). In the example in **Figure 33**, the faucets and showerheads use hot water, the flow rates of the faucets were measured using a two-cup container, and a half-gallon container was used for the showerheads. If a flowbag is used, the result is given in gallons per minute from a graduated scale on the bag. Select "Flowbag" from the drop-down menu to indicate if you used this measurement method.

Efficiency Fixture Properties (see table below for efficiency rates)	Toilets	Urinals	Lavatory Faucets	Non-Lavatory Faucets	Shower-heads
	gals/flush	gals/flush	gals/min	gals/min	gals/min
Enter High Efficiency Water Use Rate	1.28	0.125	0.50	1.50	2.00
Replacement Cost	$240	$250	$4	$4	$15
Adjustment/ Maintenance Cost	$24	$25	$1	$1	$1
Do these faucetsuse hot water? Select Y or N			Y	Y	Y
Select the size of the cup used to measure flow of this fixture. *			2 cup container	2 cup container	Half gallon

Figure 33. Indicating which fixtures use hot water and the size of the container used to measure flow in the *Efficiency Fixture Properties* table on the *Utility Rate and Population Data* tab of the *Domestic Plumbing Fixtures* calculator.

Once flow rate measurement methods have been selected, proceed to the individual fixture tabs. There is one tab for each fixture type (toilets, urinals, lavatory faucets, non-lavatory faucets, and showerheads). On each of these tabs, enter the data you collected during the full-facility survey. Some of the data entry on the individual fixture tabs is the same for all fixture tabs, but each tab also has several unique fields. The following explanation covers data entry for the individual fixture tabs.

Data Entry Fields Common to All Fixture Tabs of the Domestic Plumbing Fixtures Spreadsheet

For each fixture-type tab (toilets, faucets, showerheads), enter the data collected in the field into a series of cells similar to those shown in **Figure 34**.

Questions to Answer and Field Data You Will Need to Collect for Each Fixture

(This information is required for each fixture in all tabs)

- Location (restroom number or descriptor, such as 2nd floor, with some indication of which fixture within the restroom, such as "a" for the fixture closest to the door)
- The User Group (for example, males of a population such as Male Faculty)
- Indicate whether visitors use this restroom fixture

The white cells accept data typed directly into them. Entries in the 'User Group' and 'Visitor Use' fields are selected from dropdown menus.

In the example shown in **Figure 34**, the evaluator marked each toilet with a lowercase letter starting with "a" to indicate the one closest to the door. This will be helpful later to identify exact fixtures with leaks or other problems.

Toilets Tab

Below is a description of the fields and required information specific to the *Toilets* tab.

Questions to Answer and Field Data You Will Need to Collect for this Tab

- An indication of the toilet type (valve or tank)
- The volume of the tank (if applicable)
- The number of seconds of flow per flush (for valve toilets)
- The marked flow (not required for calculations)
- The recommended action (No action, Replace, or Maintenance) for each fixture based on your field observations and comparison of current flow rate versus the efficiency flow rate (see pages 19 and 45). Selecting "Maintenance" assumes the toilet was designed to use 1.6 gpf and will flush at that rate after routine work is done. All toilets flushing at rates greater than 1.6 gpf should NOT be maintenance; they should be replaced.
- Indication of acceptance of the Default Use-Frequency (see "Default Override Option" below)
- The default override value (see "Default Override Option" below)

Toilet Location	User Group	Visitor Use?	Valve type: Manual or Sensor
120B – a	MALE Office Worker	Fixture Used by Male Visitors	Manual
120B - b	MALE Office Worker	Fixture Used by Male Visitors	Manual
220B - a	MALE Office Worker	No Visitor Use	Manual
220B - b	MALE Office Worker	No Visitor Use	Manual

Figure 34. Fixture data entry in the *Domestic Plumbing Fixtures* calculator. These fields are common to toilets, urinals, lavatory and non-lavatory faucets, and showerheads.

Toilet (Tank/ Valve)	For Tanks Volume (cubic inches)	For Flush Valves Number of seconds per flush	Measured Gallons per flush	Marked gpf
Flush Valve		8	3.33	3.50
Flush Valve		9	3.75	3.50
Tank	500		2.16	3.50
Tank	370		1.60	1.60

Figure 35. Fixture frequency of use data entry in the *Domestic Plumbing Fixtures* calculator. This is consistent with data entry for the *Toilets* and *Urinals* tabs.

Toilet Location	Recommended Action	Override Default Use Frequency?	Total Calculated Uses Per Day	Override Use (User Input)
120B - a	Replace	Override	20.0	40.0
120B - b	Replace	Override	20.0	40.0
220B - a	No Action	Use Default	12.0	
220B - b	Maintenance	Use Default	12.0	

Figure 36. The calculated frequency of use data and user override of the default calculation in the *Domestic Plumbing Fixtures* calculator. This is consistent with data entry for toilets, urinals, and lavatory faucets.

Figure 35 shows the toilet flow specific information. The calculator uses this data to compute the gallons used per flush (gray cells).

__Default Override Option__

The calculator automatically multiplies the full-time population size times three (unless you changed the number of restroom uses per person per day) and the visitor population by 0.5 to estimate the total number of restroom uses per day. This total is then divided evenly among each lavatory fixture[1]. For the example in **Figure 36**, an even distribution of lavatory use by the population and the fact that fixtures in room 220B are not used by visitors, means each fixture in lavatory 120B is used 20 times a day while each one in 220B is used 12 times a day.

If a lavatory is used more or less frequently than the average, you can override the assigned use rate for the fixtures in that lavatory. In the example, the fixtures in lavatory 120B are used more frequently because they are closest to the cafeteria. Therefore, the evaluator selected "Override" from the "Override Default Use Frequency" column for that fixture and changed the calculated use of 20 times per day per fixture to 40 in the "Override Use" column (**Figure 36**).

The calculator determined this population (full-time and visitors) will use the toilets an average of 353 times per day. However, since the evaluator increased the use of the toilets in lavatory 120B, the calculator now registers a total of 393 uses per day (353 + 20 + 20). The evaluator must reduce the number of uses of other toilets at the facility by 40 to keep the total number of daily toilet uses at the predicted rate for the total population. This can be split over several other lavatories and the total does not have to be exact, but it should be close to the calculated total use count. A "Total Fixture Use Counter" (**Figure 37**) is at the top of the spreadsheet page to help you manage this task.

Based on the population size and gender split, total toilet uses should be	353
Your current total is	393

Figure 37. Total fixture-type use by the population versus the use total as adjusted by the user in the individual fixture tabs of the *Domestic Plumbing Fixtures* calculator.

[1] Full-time and visitor males calculated use of urinals is 2:1 over toilets

Summary Output Table										
Fixture	Fixtures Exceeding Efficiency Flow	Units Require Maintenance	Units Should be Replaced	Total Replacement Costs	Total Mainenance Costs	Total Cost Estimate (Repairs + Maint.)	Annual Potential Savings (gallons)	Annual Potential Water Savings ($$)	Annual Potential Energy Savings ($$)	Payback Period (in months)
Toilets	40	44	0	$0	$1,056	$1,056	357,687	$3,140	N/A	4.0
Urinals	8	6	0	$0	$150	$150	28,688	$252	N/A	7.1
Lavatory Faucets	42	0	42	$168	$0	$168	104,711	$919	$1,034	1.0
Non-Lav. Faucets	28	0	37	$148	$0	$148	20,187	$177	$199	4.7
Showerheads	0	0	0	$0	$0	$0	0	$0	$0	0.0
					Totals	$1,522	511,273	$4,488	$1,233	3.2

Figure 38. An example of the *Summary Output Table* in the *Domestic Plumbing Fixtures* calculator.

After adjusting individual fixture usage, the output is ready for review. The *Summary Output Tab* (**Figure 38**) shows the total cost, water savings, and payback period if all inefficient fixtures are replaced with efficient ones.

In addition to the *Summary Output Table*, there is a *Detailed Output Table* to the right of the data input section that includes some of the raw data used to calculate the output on the *Summary Output* tab.

Urinals Tab

The *Urinals* tab is nearly identical to the *Toilets* tab. The only difference is that it does not have data entry fields related to 'tank' toilets.

Lavatory and Non-Lavatory Faucets Tabs

There are two faucet tabs, one for restroom faucets and one for non-lavatory faucets. Lavatory faucet use is tied to restroom use and population size unlike non-lavatory faucet use. The *Lav. Faucets* tab generates a calculated use per day for each fixture just as with the other lavatory fixtures. The *Non-Lav. Faucets* tab requires you to enter an estimate for the number of uses each fixture receives per day.

Questions to Answer and Field Data You Will Need to Collect for these Tabs

Most of the data inputs for lavatory and non-lavatory faucets are the same as for the other fixtures. The common fields are: Location, User Group, Indication of Visitor Use, Marked Flow, Recommended Action, Acceptance of the Default Use-Frequency, and the Default Override Value.

In addition to the common input fields listed above, there are several fields unique to the faucet and showerhead tabs. They are:

- An indication of whether the faucet is operated manually or is metered; in the column titled, "Manual or Metered" (not required for calculations)
- Estimated number of seconds per use for all manually operated faucets (15–20 seconds are common durations)
- Number of seconds of metered auto-flow (sensor or spring)
- Number of seconds required to fill the flow-rate measuring cup or flowbag (indicated in the *Efficiency Fixture Properties* table in the *Utility Rate and Population Data* tab)

The average time (in seconds) per use of all manually operated lavatory faucets is entered in a stand-alone cell (**Figure 39**). This can vary by facility type. For example the accepted time for an office building is 15 seconds per use, but you may want to change this for an elementary school or other setting.

Average seconds per use for MANUAL faucets >>>>>>	**15**

Figure 39. Average seconds per use for all manually operated faucets on the *Lav. Faucets* tab of the *Domestic Plumbing Fixtures* savings calculator.

Marked gpm	Manual or Metered Faucet?	METERED Faucet Flow TIME (in seconds)
2.2	Manual	
2.2	Metered	40
2.2	Metered	20

Figure 40. Manual or metered faucet flow time in the *Lav. Faucets* tab of the *Domestic Plumbing Fixtures* savings calculator.

Many facilities have both metered and unmetered faucets. If the faucet is metered (has a timed-sensor or spring-action flow action), enter the number of seconds water flows during a single use cycle in the Metered Faucet Flow Time column (**Figure 40**). If the faucet is manually operated, the default value discussed above will be used by the calculator. You do not have to enter this value for every manually operated lavatory faucet.

For non-lavatory sinks, you will need to estimate the average time used and frequency of use for each. This is because non-lavatory sinks can be used for various purposes and can require more or less frequent uses than the typical hand washing done at lavatory sinks.

For metered sinks, the flow rate of the aerator (in gallons per minute) may exceed the commercial best management practice of 0.5 gpm, but not be considered in excess of what is considered 'efficient.' This is because metered faucets are not, by default, held to a specific flow rate, so long as the timing and flow rate does not exceed 0.25 gallons per on-off cycle. For further information, see page 52.

Showerheads Tab

This tab functions identically to the *Non-Lav. Faucets* tab. Most of the data inputs for this tab are the same as for the other fixtures. The common fields are: Location, User Group, Indication of Visitor Use, Marked Flow, and Recommended Action. You will also enter the recorded flow rate data into the appropriate fields as explained above and the approximate number of uses per fixture per day.

II. ENERGY STAR's Commercial/ Residential Appliance Savings Calculator

Due to expense and service life, it is not recommended to replace high priced water-using appliances before the end of their useful life. Therefore, the initial assumption when using this calculator is your facility's current appliance or appliances need to be replaced and you are evaluating whether to purchase an efficient one qualified by ENERGY STAR or a conventional one.

The *Appliance Savings Calculator* is a cost-to-own (or life-cycle cost) calculator created by ENERGY STAR. In keeping with the scope of this guide, clothes washers and dishwashers are of particular interest and are evaluated using this calculator. However, the calculator also evaluates the following appliances (some of which are not water using):

- Air purifiers
- Dehumidifiers
- Refrigerators
- Freezers

This calculator was developed by the U.S. Environmental Protection Agency and Department of Energy to estimate the water and energy consumption and operating costs of new ENERGY STAR-qualified products (using average costs and consumption rates of all qualified products). These rates are compared to the average consumption rates of non-qualified new products. The difference between the consumption rates equals the potential savings. Actual savings may vary based on use and other factors.

The spreadsheet calculates life-cycle costs and savings of an ENERGY STAR-rated model and a conventional one based on a combination of user inputs and industry averages for water and energy consumption and replacement costs for

Commercial or residential use	Commercial
Location	Florida
Electric rate ($/kWh)	$0.0995
Gas rate ($/therm)	$1.05
Water rate ($/thousand gallons)	$6.98

Figure 41. Initial input fields for the ENERGY STAR *Appliance Savings Calculator*.

	Quantity	Type of dishwasher	Average number of cycles per week	Building hot water fuel type	Rated electricity consumption (kWh/year)	Rated water consumption (gallons/cycle)	Additional cost per unit for ENERGY STAR model
Dishwasher	1	standard	9.0	electric	273	3.75	$10

Figure 42. Basic fields on the *Inputs* tab of the ENERGY STAR *Appliance Savings Calculator*.

conventional and ENERGY STAR-rated machines. These averages appear as default values and are preloaded into the calculator.

Basic default data appears on the INPUTS tab. In addition, each appliance type has its own tab showing detailed default data and operational assumptions used in the calculation engine. By replacing default information with data on a specific model, you can tailor the output to compare conventional models to ENERGY STAR-rated replacements.

Initial Data You Will Need to Use the ENERGY STAR Appliance Savings Calculator

- Whether the comparison is for commercial or residential model appliances
- The state where the facility is located (average power and water rates will appear as defaults)
- Electric rate ($/kWh) for the facility (if known)
- Gas rate ($/therms) for the facility (if known)
- Water rate: cost of potable and sewer water (combined) in 1,000 gallon increments[1] for the facility (if known)

Figure 41 shows the initial input fields for the ENERGY STAR *Appliance Savings Calculator*. Default average rates for each state can be used or overridden by the actual rates for the facility. Next, enter as much data as you have available to best reflect your facility, including:

- Number of units under consideration for replacement
- Type of unit
- Number of cycles (loads) per week
- Other use frequency indicators

Figure 42 shows the basic input fields for the calculator's INPUTS tab. Default average values can be used or you can enter values for a specific model. The RESULTS tab shows the calculated savings.

To modify the calculator to show life-cycle costs of a specific model, ENERGY STAR maintains lists of qualified models of each appliance type on its webpage. The annual energy use (kWh/year), water use (gallons per cycle), energy factor (EF), water factor (WF)[2], and other information are available at no cost from the ENERGY STAR webpage. To access this information, go to www.energystar.gov, click "Products," and then click "Find ENERGY STAR Products." Click "For Your Home" or "Business & Government" then click the appliance of interest under the "Appliances" heading. For

[1] If your facility's water is billed in ccfs (or 100 cubic feet increments), add the potable and sewer water rate for 1 ccf and divide by 748. Then, multiply this value by 1,000 and you will have the water and sewer rate in $ per 1,000 gallons.

[2] See page 52 for an explanation of energy factor and water factor.

Results Detail

	Quantity	Annual							
		Savings				Consumption by ENERGY STAR unit(s)			Emissions reduction (pounds of CO2)
		Electricity (kWh)	Gas (therms)	Water (gallons)	Total cost savings	Electricity (kWh)	Gas (therms)	Water (gallons)	
Air Purifier (Cleaner)	0		-	-			-	-	
Clothes Washer	2	868	0.0	12,447	$206	935	0.0	9,131	1,337
Dehumidifier	0		-	-			-	-	
Dishwasher	1	178	0.0	1,287	$32	594	0.0	1,755	275
Freezer	0		-	-			-	-	
Refrigerator									
- Standard	0		-	-			-	-	
- Compact	0		-	-			-	-	
Total	3	1,046	0.0	13,734	$238	1,529	0.0	10,886	1,612

Results Detail

	% Savings with ENERGY STAR			Total additional purchase price	Simple payback period for additional initial cost (years)	Assumed equipment lifetime (years)	Life Cycle	
	Electricity	Gas	Water				Total cost savings	Net cost savings
Air Purifier (Cleaner)		-	-			9		
Clothes Washer	48%	-	58%	$300	1.5	11	$1,805	$1,505
Dehumidifier		-	-			12		
Dishwasher	23%	-	42%	$10	0.3	10	$257	$247
Freezer		-	-			12		
Refrigerator								
- Standard		-	-			12		
- Compact		-	-			12		
Total	41%	-	56%	$310	1.3	-	$2,063	$1,753

Figure 43. Results table of ENERGY STAR's *Commercial/Residential Appliance Savings* calculator (split in two for illustrative purposes).

each type of appliance, information on qualified ENERGY STAR models is provided on a separate page. On the right side of each appliance-specific page, under the Resources banner, you can download the lists of ENERGY STAR-qualified models containing the itemized consumption factors.

The output table (**Figure 43**) provides results based on the input data. This example shows results for a facility that has a residential model dishwasher and two residential model clothes washers.

III. Ice Machines, via ENERGY STAR's Commercial Kitchen Equipment Calculator

ENERGY STAR's *Commercial Kitchen Equipment* calculator can be used to estimate potential water use and savings for many water-using appliances, including ice machines. With respect to general indoor water use, ice machines can be found in many commercial and institutional facilities, in addition to commercial kitchens.

As with other water-using appliances, the initial assumption when using this calculator is your facility's current unit has reached the end of its useful life and you are evaluating whether to replace it with an efficient, ENERGY STAR-qualified model or a conventional one. This calculator allows you to compare life-cycle costs and savings of ENERGY STAR-rated models to conventional ones based on your inputs and industry averages for water and energy consumption and replacement costs for conventional and ENERGY STAR-rated machines. These averages appear as default values and are preloaded in the calculation engine of the calculator (where the formulas and background calculations occur). See the *General Assumptions* tab for more information on the calculation engine for this spreadsheet, its operational assumptions, and model-type averages.

ENERGY STAR maintains lists of qualified models on its webpage. The list of ice machines contains the following information for each qualified model, which can be entered into the calculator:

- Company name
- Brand name
- Model name/number
- Equipment type
- Ice type
- Ice making technology
- Harvest rate (lbs ice/day)
- Energy use (kWh/100 lbs ice)
- Potable water use (gal/100 lbs ice)

To see this information, go to the ENERGY STAR website[1], click “Products,” and then click “Find ENERGY STAR Products.” Click “Business and Government,” then click “Commercial Ice Machine.” On the right side of the page, under the Commercial Ice Machines Resources banner, you can download a listing of qualified models under the subheading “Qualified Commercial Ice Machines.”

Questions to Answer and Field Data You Will Need to Collect for this Tab

- Water utility rate information: potable and sewer water rates for 1,000 gallons[2]
- Power utility rate information: gas (therms) and electricity costs (kWh)
- The type of machine (ice-making head, remote condensing unit/slit system, or self-contained unit)
- Ice harvest rate (pounds of ice per day)
- Potable water use (gallons per 100 lbs of ice produced)
- Operating days per year
- Additional cost per unit for ENERGY STAR model over a conventional one

Figure 44 shows the utility rate input information in ENERGY STAR’s *Commercial Kitchen Equipment* calculator. **Figure 45** shows the machine type and use characteristics input information in the calculator for ice machines.

The *Results Summary* output table (**Figure 46**) of the calculator shows savings in kilowatts or therms, water in gallons, the total annual and lifetime costs, and a simple investment recovery or payback period of an ENERGY STAR-rated model versus a conventional model based on the national average defaults and the user inputs.

The FSTC[3] also maintains life-cycle and energy savings calculators for ice machines and other appliances.

[1] www.energystar.gov

[2] If your facility’s water is billed in ccfs (or 100 cubic feet increments), add the potable and sewer water rate for 1 ccf and divide by 748. Multiply this value by 1,000 and you will have the water and sewer rate in $ per 1,000 gallons.

[3] www.fishnick.com/saveenergy/tools/calculators/

Electric rate ($/kWh)	$0.1000
Gas rate ($/therm)	$1.0000
Water rate ($/thousand gallons)	$10.00

Figure 44. Utility rate input information in ENERGY STAR's *Commercial Kitchen Equipment* calculator.

Ice Machine	Quantity	Harvest rate (pounds ice per day)	Potable water use (gallon per 100 pounds ice)	Operating days per year	Additional cost per unit for ENERGY STAR model
Ice Making Head	1	706	19.6	365	$140
Remote Condensing Unit/Split System	0	1,000	18.5	100	$0
Self Contained Unit	0	137	33.7	365	$0

Figure 45. Example of the machine type and use characteristics input information for an ice machine in ENERGY STAR's *Commercial Kitchen Equipment* calculator.

	Quantity	Annual							
		Savings				Consumption by ENERGY STAR unit(s)			Emissions reduction (pounds of CO2)
		Electricity (kWh)	Gas (therms)	Water (thousand gallons)	Total cost savings	Electricity (kWh)	Gas (therms)	Water (thousand gallons)	
Dishwasher	0								
Freezer	0		-	-			-	-	
Fryer	0			-				-	
Griddle	0			-				-	
Hot Food Holding Cabinet	0		-	-			-	-	
Ice Machine	1	1,197	-	1	$121	10,618	-	38	1,844
Oven	0			-				-	
Refrigerator	0		-	-			-	-	
Steam Cooker	0								
Total	1	1,197	0	1	$121	10,618	0	38	1,844

% Savings with ENERGY STAR			Total additional purchase price for ENERGY STAR unit(s)	Simple payback period for additional initial cost (years)	Life Cycle	
Electricity	Gas	Water			Total cost savings	Net cost savings
10%	-	3%	$140	1.2	$969	$829
10%	-	3%	$140	1.2	$969	$829

Figure 46. Example output table (split in half for illustration purposes) of ENERGY STAR's *Commercial Kitchen Equipment* calculator for an ice machine.

COMMERCIAL-GRADE KITCHEN WATER USE – ADVANCED AUDIT

Background and Description

The water use rates of most fixtures and appliances should have been documented during the *Commercial-Grade Kitchen – Basic Audit* (page 66). For small kitchens and breakrooms, this is not difficult. However, it is more complex for larger, commercial-grade kitchens.

The aim of this exercise is to identify and quantify potential savings that can be gained through implementing efficiency measures. The results will provide valuable information when it comes time to make decisions regarding improving water efficiency. The emphasis of this procedure is to measure how often fixtures, appliances, and machinery in your facility's commercial-grade kitchen are used. This will help you assess which measures will yield the quickest and greatest returns on investment.

Water consumption in a commercial-grade kitchen depends on the number of meals prepared per day the water use equipment in the kitchen and the habits of the kitchen staff. It may be helpful to consult with the kitchen manager to assess certain levels of water use. In addition, you may also want to observe the kitchen's operations during a meal. A few things to look for include whether the dishwasher is left on for the duration of a shift or if it is shut off periodically; if meat is defrosted under a stream of running water and, if it is, for how long; approximately how many loads or racks of dishes are placed in the dishwasher in an hour; how many seconds does the staff spend using the pre-rinse spray valve for each dish rack; and how often and for how long at a time are the steam cookers and combination ovens used.

Much of the operating cost of an ice machine depends on where the displaced heat from the chilled water is released. Some machines release this heat in the same room as the machine itself, adding to the burden of the building's air conditioning system. Others have remote heads that release the heat outdoors or in spaces without air conditioning. For more information, see the ice machine discussion on page 69.

Although estimating water savings in a commercial-grade kitchen may sound challenging, the objective will be to gain educated estimates, and the effort will be worthwhile since there are often many efficiency improvement opportunities. The associated spreadsheets will help make these calculations.

Audit Objectives

The following procedure will help you:

- Quantify water savings by the most common water-using fixtures and appliances used in a kitchen or cafeteria
- Develop a simple payback period estimate from investments in new water efficient technology

Audit Steps

These audit steps will guide you through the use of several spreadsheets associated with this guide. For general information on the calculators and spreadsheets that accompany this guide, see *Audit Organization and Associated Spreadsheets* starting on page 22. For more specific help with the calculators related to this audit, see the Spreadsheet Guidance section starting on page 132.

ENERGY STAR's Commercial Kitchen Equipment Calculator

1. Enter utility water and energy billing rate data.
2. Enter the quantity for each type of equipment at the facility.
3. Refer to **Worksheet 9: Commercial-Grade Kitchen Appliances**, completed during the facility survey for information to input into the calculator.
4. Refer to the ENERGY STAR website (www.energystar.gov) for current lists of qualified models of all types of commercial kitchen equipment. These lists include the following information that will be input into the calculator:
   a. Annual energy use (kWh/year)
   b. Annual water use (gallons/year)
   c. Water factor (WF)
   d. Energy factor (EF)
   e. Modified energy factor (MEF)
   f. Federal standard (MEF)
   g. % better than federal standard

   The lists also contain brief descriptions of all relevant performance indicators such as those above.
5. Confirm or amend the default values for equipment character and use frequency data. This information should have been recorded on **Worksheet 9**.
   a. For dishwashers:
      i. Low or high temperature models
      ii. Type (door, single tank, or multi-tank)
      iii. Racks washed per day
      iv. Hot water fuel (gas or electric)
      v. Booster water heater fuel type (if applicable) (gas or electric)
      vi. Operating days per year
   b. For ice machines:
      i. Type (head, remote unit/split, self-contained)
      ii. Harvest rate (pounds ice per day)
      iii. Potable water use (gallons per 100 pounds ice)
      iv. Operating days per year
   c. For steam cookers:
      i. Type (electric or gas)
      ii. Pounds of food cooked per day per unit
      iii. Number of pans per unit
      iv. Operating hours per day
      v. Operating days per year
6. Examine the *Results Summary* tab.

Supplemental Commercial Kitchen Equipment Calculator

7. Assemble **Worksheet 9** and **Worksheet 10**.

Utility Billing Data Input Tab

8. Confirm the following utility and billing information has been entered into the *Utility Billing Data Input* tab of the *Supplemental Commercial Kitchen Equipment* spreadsheet.
   a. Water utility rate information: potable and sewer water costs
   b. Power utility rate information: gas (therms) and electricity costs (KWh)

   Refer to page 23 for information on the *Billing Data Input* table.

Hand Washing Faucets Tab

9. Examine the *Hand Washing Faucets* tab.
10. Enter the following data:

    Efficiency Fixture Properties table
    a. Water use rates of efficient fixtures (gallons per minute)
    b. Cost to replace the fixture
    c. Cost to perform maintenance on the fixture (for fixtures that only require maintenance to perform at an acceptable efficiency level, usually 10 percent of cost annually)
    d. Indication of hot water use for each fixture (this allows the calculator to account for energy savings related to heating less water that occur when efficient fixtures are used)
    e. The size of the cup used to measure flow for each fixture (this allows the calculator to convert the seconds of flow required to fill the cup during the field survey to flow rate in gallons per minute for each fixture)

    Fixture Use Data table
    a. Faucet location
    b. Indication of whether faucet operation is manual or by sensor (not required for calculations)
    c. Number seconds per use or number of seconds of auto-flow (sensor or spring)
    d. The number of seconds required to fill the flow measuring cup (the size of which was indicated in the *Efficiency Fixture Properties* table)

Pre-Rinse Spray Valves Tab

11. Enter the following data:

    Efficiency Fixture Properties table
    a. Water use rates of efficient fixtures (gallons per minute)
    b. Cost to perform maintenance on the fixture (for fixtures that only require maintenance to perform at an acceptable efficiency level, usually 10 percent of cost annually)
    c. Indication of hot water use for each fixture (this allows the calculator to account for energy savings related to heating less water that occur when efficient fixtures are used)
    d. The size of the cup used to measure flow for each fixture (this allows the calculator to convert the seconds of flow required to fill the cup during the field survey to flow rate in gallons per minute for each fixture)

    Fixture Use Data table
    a. Location of fixture
    b. Marked water use in gallons per minute (not necessary for calculations)
    c. Number of seconds used per rack
    d. Number of hours of use per day
    e. Number of work-days per year
    f. Number of seconds to fill flow measuring cup or flow rate (in gallons per minute) if a flowbag was used to measure flow rate.

Combi Ovens

12. Enter the following data:
    a. Number of combi cookers
    b. Use pattern information (hours and days of operation)
    c. Pounds of food cooked per day
    d. Fuel type
    e. Cost per combi oven
13. Examine the output tables.

Post-Audit Considerations and Additional Activities

As old equipment needs to be replaced, investing in more efficient replacements is strongly recommended. See the ENERGY STAR[1] and FSTC[2] websites for lists of efficient models.

Before retrofitting or replacing existing and operational fixtures or appliances, you will need to consider the length of the payback period for your facility's investment in more efficient replacements. This is a function of the cost and savings per use and the use frequency.

Typically, measures with a payback period of 20 years or less are considered feasible; however, many water efficiency measures recuperate their initial investment much sooner. **Refer to the Post-Audit Considerations and Additional Activities section in the *Commercial-Grade Kitchen Water Use – Basic Audit*** (page 66) for information on specific appliance types.

Spreadsheet Guidance

There are two spreadsheets used to calculate water use and potential savings in a commercial kitchen:

I. ENERGY STAR's *Commercial Kitchen Equipment*

II. Supplemental Commercial Kitchen Equipment Calculator

ENERGY STAR's *Commercial Kitchen Equipment* calculator can provide cost and savings estimates for:

- Commercial dishwashers
- Ice machines
- Steam cookers
- Commercial ovens
- Refrigerators
- Freezers
- Fryers
- Griddles
- Hot food holding cabinets

This section provides guidance on using ENERGY STAR's *Commercial Kitchen Equipment* calculator for water-using equipment and is followed by guidance on the *Supplemental Commercial Kitchen Calculator* that was developed to calculate savings for combination ovens, pre-rinse spray valves, and hand washing faucets.

I. ENERGY STAR's Commercial Kitchen Equipment Calculator

Due to expense and the length of service life, it is recommended to replace high priced water-using appliances only after the end of their useful life. Therefore, the initial assumption is your facility's current model has reached the end of its useful life and you are evaluating whether to replace it with an efficient one qualified by ENERGY STAR or a conventional one.

ENERGY STAR's *Commercial Kitchen Equipment* calculator is a cost-to-own (or life-cycle cost) calculator created by ENERGY STAR. It is designed to help you decide which type of model will cost less to own and operate. This

[1] www.energystar.gov
[2] www.fishnick.com

calculator allows you to compare life-cycle costs and savings of an ENERGY STAR-rated model and a conventional one based on a combination of your inputs and industry averages for water and energy consumption and replacement costs for conventional and ENERGY STAR-rated machines. These averages appear as default values and are preloaded in the calculation engine (where the formulas and background calculations occur) of the calculator. See the tab for each appliance type for more information on its calculation engine, its operational assumptions, and model-type averages.

ENERGY STAR maintains current listings of qualified models of all types of commercial kitchen equipment on its webpage. These listings contain information, such as, but not limited to, the following:

- Annual energy use (kWh/year)
- Annual water use (gallons/year)
- Water factor (WF)
- Energy factor (EF)
- Modified energy factor (MEF)
- Federal standard (MEF)
- % better than federal standard

The listings also contain brief descriptions of all relevant performance indicators such as those above.

Data from **Worksheet 9** is used in conjunction with the ENERGY STAR calculator.

<u>Using ENERGY STAR's Commercial Kitchen Equipment Calculator</u>

The calculator has only one tab where data is entered, it is titled *Inputs*. You can enter your utility costs for water (as the sum of potable and sewer water), electricity (in kWh), and gas (therms), or select the 'average' rates for your state (**Figure 47**).

For each piece of equipment, enter the **number of units** in your facility's kitchen. This will automatically cause the rest of the input table for that piece of equipment to be populated with industry average values. You can then accept or override those values. **Figure 48** shows the input table for a 'Door Type' dishwasher after 1 was entered into the Quantity column.

<u>Questions to Answer and Field Data You Will Need to Collect for this Calculator</u>

1. **For dishwashers:**
   - Low or high temperature models
   - Type (door, single tank, or multi-tank)
   - Racks washed per day
   - Hot water fuel (gas or electric)
   - Booster water heater fuel type (if applicable) (gas or electric)
   - Operating days per year

2. **For ice machines:**
   - Type (head, remote unit/split, self-contained)
   - Harvest rate (pounds ice per day)
   - Potable water use (gallons per 100 pounds ice)
   - Operating days per year

3. **For steam cookers:**
   - Type (electric or gas)
   - Pounds of food cooked per day per unit
   - Number of pans per unit
   - Operating hours per day
   - Operating days per year

The output table is found on the *Results Summary* tab. **Figure 49** shows an example of the results. The *Results Detail* tab shows specific savings for each product and more detail on life cycle savings.

Location	U.S. average
Electric rate ($/kWh)	$0.1000
Gas rate ($/therm)	$1.0000
Water rate ($/thousand gallons)	$10.00

Figure 47. Utility billing data for ENERGY STAR's *Commercial Kitchen Equipment* calculator.

Dishwasher			Quantity	Racks washed per day	Building hot water fuel type	Booster water heater fuel type	Operating days per year	Additional cost per unit for ENERGY STAR model
	Low Temp.	Under Counter	0	75	natural gas	N/A	200	$530
		Door Type	0	280	electric	N/A	365	$530
		Single Tank Conveyor	0	400	electric	N/A	365	$170
		Multi Tank Conveyor	0	600	electric	N/A	365	$0
	High Temp.	Under Counter	0	75	electric	natural gas	365	$1,000
		Door Type	1	280	electric	natural gas	365	$500
		Single Tank Conveyor	0	400	electric	natural gas	365	$270
		Multi Tank Conveyor	0	600	electric	natural gas	365	$0

Figure 48. Example of an input data table for a dishwasher in ENERGY STAR's *Commercial Kitchen Equipment* calculator.

	Quantity	Annual							
		Savings				Consumption by ENERGY STAR unit(s)			Emissions reduction (pounds of CO2)
		Electricity (kWh)	Gas (therms)	Water (thousand gallons)	Total cost savings	Electricity (kWh)	Gas (therms)	Water (thousand gallons)	
Dishwasher	1	9,072	206	50	$1,373	19,436	398	97	16,376
Freezer	0		-	-			-	-	
Fryer	0			-				-	
Griddle	0			-				-	
Hot Food Holding Cabinet	0		-	-			-	-	
Ice Machine	2	2,394	-	2	$242	21,236	-	38	7,374
Oven	0			-				-	
Refrigerator	0		-	-			-	-	
Steam Cooker	1	9,774	0	162	$1,961	8,045	0	13	15,051
Total	4	21,240	206	214	$3,575	48,717	398	148	38,802

% Savings with ENERGY STAR			Total additional purchase price for ENERGY STAR unit(s)	Simple payback period for additional initial cost (years)	Life Cycle	
Electricity	Gas	Water			Total cost savings	Net cost savings
32%	34%	34%	$500	0.4	$20,590	$20,090
10%	-	6%	$280	1.2	$1,937	$1,657
55%	-	93%	$1,500	0.8	$23,526	$22,026
30%	34%	59%	$2,280	0.6	$46,054	$43,774

Figure 49. Output table of ENERGY STAR's *Commercial Kitchen Equipment* calculator. The figure is split for illustration purposes.

II. The Supplemental Commercial Kitchen Equipment Calculator

Pre-rinse spray valves, hand washing faucets, and combination ovens (combis) are not included in ENERGY STAR's *Commercial Kitchen Equipment* calculator. Therefore, the *Supplemental Commercial Kitchen Equipment Calculator* was developed to evaluate these pieces of equipment.

Kitchen faucets used exclusively for hand washing should be equipped with efficiency aerators using 0.5 gpm. This is a 75 percent reduction from conventional faucet aerators. Faucets used for other purposes should not be fitted with efficiency aerators. The *Supplemental Commercial Kitchen Equipment Calculator* spreadsheet also includes a tab to calculate water use and savings resulting from replacing inefficient aerators in hand washing faucets.

Utility Billing Data Tab

Questions to Answer and Field Data You Will Need to Collect for this Tab

- Water utility rate information: potable and sewer water costs
- Power utility rate information: gas (therms) and electricity costs (kWh)

Refer to page 23 for information on the *Billing Data Input* table.

After you enter data in the *Utility Billing Data* tab, the same data will automatically transfer to the other tabs as necessary.

Hand Washing Faucets Tab

Questions to Answer and Field Data You Will Need to Collect for this Tab

There are two input tables on this tab: *Efficiency Fixture Properties* and *Fixture Use Data Table*.

1. Efficiency Fixture Properties Table (Figure 50)

- Water use rates of efficient fixtures (gallons per flush or gallons per minute)
- Cost to replace the fixture

Efficiency Fixture Properties	
Enter High Efficiency Water Use Rate >>	0.50
Possible Rates: 1.0 gals/min, 0.5 gals/min	
Replacement Cost	$3
Adjustment/ Maintenance Cost	
Do these facuets use hot water?	
Enter Y or N	Y
Select timed flow measuring cup size	Flowbag

Figure 50. The *Efficiency Fixture Properties* table.

- Cost to perform maintenance on the fixture (for fixtures that only require maintenance to perform at an acceptable efficiency level; usually 10 percent of cost annually)
- Indication of hot water use for each fixture (this allows the calculator to account for energy savings related to heating less water that occur when efficient fixtures are used)
- The size of the cup used to measure flow for each fixture (this allows the calculator to convert the seconds of flow required to fill the cup during the field survey to flow rate in gallons per minute for each fixture)

2. Fixture Use Data Table (Figure 51)

- Faucet location
- An indication of whether the faucet is manual or sensor operated (not required for calculations)
- Number seconds per use or number of seconds of auto-flow (sensor or spring)
- The number of seconds required to fill the flow measuring cup (the size of which was indicated in the *Efficiency Fixture Properties* table)

If the faucet has a timed-sensor or spring-action flow, enter the number of seconds water flowed during a single use in the Number Seconds per Use or Number of Seconds of Auto-flow (sensor or spring) column. If the faucet is manually operated, enter 15 into this field as a default value. Since a flowbag was used to measure the flow rate of the faucets in this

Handwashing Faucet Location	Manual or Sensor	Number Seconds per Use or Number of Seconds of Auto-flow (sensor or spring)	Marked gpm	Enter FLOWBAG Measured gallons/minute	Number Work-days per year	Number of Fixture Uses Per Day
Closest to north door	**Manual**	**20.00**	**2.20**	**2.50**	**260**	**20**
Closest to east door	**Manual**	**20.00**	**2.20**	**2.25**	**260**	**20**

Figure 51. Example *Fixture Use Data Table* with manual or sensor indicator fields and number of seconds of auto-faucet flow.

Summary Output Table								
Fixture	Fixtures Exceeding Efficiency Flow	Total Replacement Costs	Total Maintenance Costs	Total Cost Estimate	Annual Potential Savings (gallons)	Annual Potential Water Savings ($$)	Annual Potential Energy Savings ($$)	Investment Recovery Period (in months)
Non-Lav Faucets	**2**	**$5**	**$0**	**$5**	**4,680**	**$26**	**$46**	**0.8**
	0	**Require Maintenance**						
	2	**Should be Replaced**			**Detailed output table at RIGHT**			

Figure 52. *Summary Output Table* for the *Hand Washing Faucets* tab.

example, the rate in gallons per minute is entered directly into the table. The number of workdays per year is also entered into this table. Finally, the user estimated each faucet is used 20 times per day based on the number of employees and the length of the workday (**Figure 51**).

An example *Summary Output Table* for this tab is shown in **Figure 52.**

Pre-Rinse Spray Valve Tab

The *Pre-Rinse Spray Valve* tab is very similar to the *Hand Washing Faucets* tab. Entering efficiency fixture water use rates, maintenance and replacement costs, and indicating hot water use follow the same steps. The output summary table is also identical (see **Figure 52**). The primary difference is that you need to enter frequency of use assumptions for each spray valve.

<u>Questions to Answer and Field Data You Will Need to Collect for this Tab</u>
(there are two input tables)

1. **Efficiency Fixture Properties Table**
   (Identical to that of the hand washing faucet, see **Figure 50**)

2. **Fixture Use Data Table**
   (Similar to that of the *Hand Washing Faucet* tab, see **Figure 51,** with the exception of the use frequency data which should be based on your estimates, see **Figure 53**)
   - Seconds used per rack
   - Number of racks per hour
   - Number of hours of use per day
   - Number of work days per year

   Figure 53 shows a completed input example.

The *Summary Output Table* for this tab is identical to that of the *Hand Washing Faucet* tab (see **Figure 52**). The results include the total cost, water savings, and payback period if all inefficient fixtures are replaced with efficient ones.

Seconds Used per Rack	Number Racks per Hour	Number Hours of Use per Day	Number Work-days per year
10	**75**	**4**	**260**

Figure 53. An example of use frequency data entry in the *Pre-Rinse Spray Valves* tab.

Combination Ovens Tab

The *Combi Oven* tab allows you to compare life-cycle costs and savings of an efficient model and a conventional one based on your inputs and default values. The calculator is designed to help you decide which model will cost less to own and operate assuming your current model has reached the end of its useful life. The FSTC maintains a list of efficient machines on their website[1].

The calculator used in this spreadsheet was developed by the FSTC and the South Florida Water Management District from the ENERGY STAR steam cooker calculator. This calculator uses national averages for water and energy per-unit costs (gallons and kilowatts, respectively), and industry averages for water and energy consumption rates and replacement costs as default values for conventional and efficient machines. These default values are preloaded in the calculator and show the typical life-cycle costs of a conventional model and those of an efficient one. See the *Combi Oven Assumptions* tab for more information on the calculation engine for this tab (where the formulas and background calculations occur), its operational assumptions, and model-type averages.

The modifications to the calculator associated with this guidebook allow you to override some of the default values to make the calculations more specific to your facility.

[1] To find energy and water consumption information on a specific unit qualified by the FSTC, go to www.fishnick.com, click "Save Energy," then "Rebates," and then see the links under "Qualifying Products List" or "Individual Products Lists" and look for "Commercial Combination Ovens."

Questions to Answer and Field Data You Will Need to Collect for this Tab (Figure 54)

- Number of combi ovens
- Operating hours per day
- Operating days per year
- Pounds of food cooked per day per oven
- Fuel type
- Cost per oven

Two output tables show the calculated results. The *Annual and Life Cycle Costs and Savings Output* table shows a breakdown of all water and energy consumption and expenses (annual and over the life of the unit). The *Summary of Benefits Output Table* (**Figure 55**) lists some of the benefits of an efficient model over a conventional model.

Other Commercial-Grade Kitchen Calculators

In addition to the ENERGY STAR savings calculator[2], FSTC[3] has savings calculators for many of the water-using appliances mentioned in this guide. Additionally, the U.S. Department of Energy has energy savings calculators on their webpage[4]. You may want to explore these other calculators to see which best fits your needs.

[2] Available at www.energystar.gov, click "Find ENERGY STAR Products," then "Business & Government." Next click "Commercial Kitchen Package" and "Commercial Kitchen Equipment Savings Calculator" under the "Commercial Kitchen Package Resources" banner.

[3] Go to www.fishnick.com/saveenergy/tools/calculators or www.fishnick.com and enter "life cycle energy cost calculators" into the search bar.

[4] Go to www1.eere.energy.gov/femp/technologies/eep_eccalculators.html

Model and Frequency of Use Input Table

1	Enter number of combi ovens	1	
2	Enter operating hours per day	12	
3	Enter operating days per year	365	
4	Enter pounds of food cooked per day per oven	200	
5	Select Fuel type	Natural Gas	
		Conventional Model	ENERGY STAR Model
6	Cost per combi oven	$10,099	$15,816

Figure 54. An example of the *Model and Frequency of Use Input Table* on the *Combi Oven* tab of the *Supplemental Commercial Kitchen Equipment* calculator.

Additional purchase cost for Energy Efficient equipment	$3,824
Life cycle savings	$24,418
Net life cycle savings (life cycle savings - additional cost)	$20,594
Simple payback of additional cost (years)	1.5
Life cycle energy saved (kWh)	217,895
Life cycle air pollution reduction (lbs of CO_2)	335,558
Air pollution reduction equivalence (number of cars removed from the road for a year)	27.9
Air pollution reduction equivalence (acres of forest)	34.6
Lifetime savings as a percent of purchase price	139.4%

Figure 55. An example of the *Summary of Benefits Output Table.*

COOLING TOWER WATER USE – ADVANCED AUDIT

Background and Description

As stated for the *Cooling Tower Water Use – Basic Audit*, the absence of leaks, corrosion, mineral precipitation, or biological scum indicates only that the basic maintenance regime for the cooling tower is effective. It does not mean the system is running optimally or at a high level of efficiency.

This procedure directs you through an audit of the cooling tower's efficiency by examining the tower's concentration ratio and quantifying the volumes of makeup, bleed-off, and evaporation. In addition, potential savings from increasing cycles of concentration will be calculated, as well as the potential volume of condensate water created by the system's air handling unit.
From a water conservation perspective, a cooling tower's operating efficiency is measured in terms of cycles of concentration (COCs) or concentration ratio. This is a measure of the accumulated dissolved solids in the cooling tower's water relative to that of the makeup water. This is expressed mathematically as follows (Vickers 2001):

$$CR = CB \div CM$$

Where: CR = concentration ratio,
CB = TDS concentration of blow-down water, and
CM = TDS concentration of makeup water

A clean and well-maintained cooling tower

Evaporated water leaves behind dissolved mineral content. The rate at which water must be bled from the system is therefore affected by the amount of total dissolved solids (TDS) in the makeup water when it entered the system and its ability to accept additional minerals as water is lost through evaporation. Water pretreatment and treatment regimes, such as softening, sidestream filtration, and chemical adjustments to pH levels, can allow cooling tower water to maintain higher levels of TDS concentrations before bleeding. Some newer technologies and chemical additives even claim to achieve zero or near zero bleed.

Concentration ratios can also be calculated in systems not equipped to monitor the concentration of dissolved solids in cooling tower water if submeters are in place to measure makeup and blow-down water volumes over a specific period as follows (Vickers 2001):

$$CR = M \div B$$

Where: CR = concentration ratio,
M = volume of makeup water, and
B = volume of blow-down water

Running a cooling tower at a minimum of five cycles of concentration can save tens to hundreds of thousands of gallons of water per year, depending on cooling tonnage and hours of use. However, speak to your vendor about optimizing efficiency with respect to the hardness of your make up water. **Table 14** (page 79) shows the percent of water that can be saved by increasing the number of cycles.

A by-product of cooling towers is the volume of high quality condensate water formed in the air handling unit of the cooling system. This water is typically drained to the sewer, but can be used to supplement cooling tower makeup. Condensate water is low in TDS so it requires little to no pretreatment for dissolved solids, but may require treatment to control biological buildup. Depending on the temperature, humidity, and the amount of cooling generated, cooling towers can produce 0.1 to 0.3 gallons of condensate per ton of air conditioning for every hour of operation (Building Green 2010). The spreadsheet that accompanies this guide will calculate the potential volume of condensate water formed by your facility's cooling tower. The *Identifying Alternative On-Site Water Sources* section of this guidebook (page 163) contains additional explanations and references regarding cooling tower condensate.

The benefits of submeters on cooling towers to obtain sewer credits was discussed briefly in the *Cooling Tower Water Use – Basic Audit* (page 76) and in the *Meters and Submeters – Basic Audit* (page 29). The accompanying spreadsheet will calculate your facility's potential sewer credit to account for cooling tower water consumption.

Audit Objectives

This procedure will guide you through the steps to quantify the following:

- Volumes of water consumed by the cooling tower through makeup, bleed-off (or blowdown), and evaporation
- Current concentration ratio (or cycles of concentration)
- Percent and volume of water (and dollars) saved if the cooling tower's concentration ratio is increased
- Potential sewer credit
- Volume of condensate production (potential make-up water supplement)

Some familiarity with cooling tower operations is necessary to conduct these audit steps. It may be helpful or necessary to work with your facility's cooling tower maintenance vendor or a water conservation professional.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Prepare and examine both pages of **Worksheet 14: Cooling Water Tower Use – Advanced Audit**. Identify the table set that will be used based on the type of meters associated with the tower. An explanation of the two table sets and how to determine which to use are provided in the *Spreadsheet Guidance* section (page 144).
3. Enter utility water rate information and cooling tower operations data in the *Utility Rates & Cooling Tower Ops* tab. Specifically, enter the following information:
    a. Billing rate for potable and sewer water
    b. Water billing increments (1,000 gallons or hundred cubic feet [ccf])
4. Enter the following cooling tower operational data in the *Cooling Tower Operation Use Times* table:
    a. Cooling tower cooling tonnage
    b. Hours per day of operation
    c. Days per month of operation
    d. Potential percentage reduction in water consumption
5. Transfer data from the flow meter or conductivity meter (**Worksheet 14**) onto the appropriate tab.
6. Examine the output tables.

Post-Audit Considerations and Additional Activities

Measuring a cooling tower's efficiency in terms of its concentration ratio is believed to be a stronger and more robust approach to water use reduction than modifying a building's target temperature. This also avoids problems with inconsistent indoor air temperatures, allows buildings to maintain desired humidity levels, and can be achieved while indoor temperatures remain the same.

Increasing a cooling tower's concentration ratio to approximately five or six cycles should lower your facility's expenses by reducing how much water is consumed and reducing chemical pretreatment costs. These savings should be factored into efficiency improvement decision making. The Further Efficiency Improvement Analyses activity, *Determine the True Cost of Water* (page 158), examines this process further.

Three things facilities should consider to reduce cooling tower water use:

- Be as energy efficient as possible – reducing the heat load to the tower reduces water use
- Consider hybrid towers and tower combinations that have options for wet or dry cooling if weather permits
- Consider geothermal (ground cooling) and even air-cooled units for smaller sites

For a more complete discussion of cooling tower best management practices and additional efficiency measures, refer to the Thermodynamic Processes and Alternative On-Site Water Sources sections of the *WaterSmart Guidebook* (EBMUD 2008)[1].

[1] Available through www.allianceforwaterefficiency.org/WaterSmart_Guidebook_for_Businesses.aspx or go to www.allianceforwaterefficiency.org and enter, "WaterSmart Guidebook" into the search bar.

Worksheet 14. Cooling Tower Water Use – Advanced Audit

Use one of the two table sets below.

Table Set 1: Use if the cooling tower is equipped with makeup and bleed-off meters.

1. Enter average or 'typical' load in tons >>>	
2. Enter hrs/day of operation>>>	
3. Enter days/month operation	

***Refer to** Error! Reference source not found. **on page 79 in the guide to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 5.**

4. Enter that percentage here >>>>> ______ %

Table Set 1: WATER CONSUMPTION CALCULATIONS	Meter Data Input Table Date	Time	Hours between Readings		Make-Up Meter Reading	Bleed-Off Meter Reading
Day 1				Begin		
				End		
Day 2				Begin		
				End		
Day 3				Begin		
				End		

Transfer this information to the *Cooling Towers* spreadsheet.

Table Set 2 is on the following page.

Worksheet 14. Cooling Tower Water Use – Advanced Audit (continued)

Table Set 2: Use if the cooling tower is equipped with conductivity meters or another means to calculate dissolved solid concentrations in makeup and bleed-off water.

1. Enter tons of cooling >>>	
2. Enter hrs/day of operation>>>	
3. Enter days/month operation	

***Refer to** Error! Reference source not found. **on page 79 in the guide to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 5.**

4. Enter that percentage here >>>>>		%

Table Set 2: WATER CONSUMPTION CALCULATIONS	Date	Make-Up Concentration (TDS)	Bleed-off Concentration (TDS)

Transfer this information to the *Cooling Towers* spreadsheet.

Spreadsheet Guidance

Questions to Answer and Field Data You Will Need to Collect for this Calculator:

- Utility water rates
- Typical operating load (in tons)
- Tower operating hours per day and days per month

Meter data (make-up and blowdown or conductivity) are not necessary to use the *Cooling Tower* spreadsheet, but they should be referenced if available to strengthen the calculator's results. Using either meter-recorded data or the basic data listed above, the *Cooling Tower* spreadsheet will calculate the following:

- Potential water use reduction from increasing cycles of concentration
- Potential sewer credit from installing a submeter
- Potential make-up water condensate-related savings (gallons and dollars)

As with all other spreadsheets associated with this guidebook, data is entered in white cells, the gray cells show the calculated results, and gold cells contain dropdown menus. The gold cells are initially labeled "Select one" and an option must be chosen for the worksheet calculations to function. Utility billing data should be entered into the *Utility Rate Input Table* on the *Utility Rates & Cooling Tower Ops* tab as per the instructions in the *Audit Organization and Associated Spreadsheets* section of this guide (page 22).

Next, background information on the cooling tower and its use frequency should be entered into the *Cooling Tower Operational Use Times* table on the *Utility Rates & Cooling Tower Ops* tab. If flow or conductivity data is available, refer to **Table 14** (page 79) to see the percent reduction in water consumption that will occur if the concentration ratio is increased (**Figure 56**). You will first need to enter the meter data into the calculator to determine your tower's current cycles of concentration.

Transfer the recorded meter data from **Worksheet 14** to one of two tabs depending on whether the cooling tower has flow meters or conductivity meters. The *Flow Meter* tab is used if the cooling tower is equipped with makeup and bleed-off meters. To use this tab, you will need two successive meter readings to determine the volumes of makeup and bleed water consumed between readings, as well as the number of hours between meter readings. If the cooling tower is equipped with conductivity meters or another means to calculate dissolved solid concentrations in makeup and bleed-off water, then the *Conductivity Meters* tab should be used. **If no meters are on the tower (thus no meter data to enter), the calculator will generate estimates based on the cooling tower's size and daily hours of operation.**

Utility Rate Input Table			
1. Select Billing Unit (1000 gals or ccfs) >>>>>		1000 gals	
2. Utility cost potable water per	1000 gals	$3.98	
3. Utility cost sewer water per	1000 gals	$4.56	

Cooling Tower Operational Use Times		
4. Enter average or 'typical' load in tons >>>	250	
5. Enter hrs/day of operation>>>	24	
6. Enter days/month operation	30	
7. Enter number of months/year operation		12

***Refer to page 79 in the guide to see the percent reduction in water consumption that would occur if the concentration ratio was increased from current levels to at least 5.**		
8. Enter that percentage here >>>>>	**18**	**%**

Figure 56. An example of the input tables on the *Utility Rates & Cooling Tower Ops* tab in the *Cooling Tower* spreadsheet associated with this guide.

IRRIGATION SYSTEM AND LANDSCAPE SURVEY – ADVANCED AUDIT

Background and Description

Well-planned landscapes (**Figure 57**) using properly selected plants should be able to survive with little to no irrigation. Key elements for a landscape that does not require much irrigation are plants that are naturally adapted to the local environment and a highly efficient irrigation system to deliver the water.

Plants selected for your facility's landscape should have growth requirements that match the local environmental conditions as closely as possible. This principle is known as "Right Plant, Right Place" and requires some familiarity with plants, the use of plant reference materials, and attention to local growing conditions (FYN 2009). Once plants are chosen, they should be grouped according to their light and water needs. In addition, exotic invasive species should be avoided because they can spread rapidly and threaten native plants and habitats.

As stated earlier, many mature plants do not require irrigation after they become established or reach maturity. Once all plants in a zone are established, irrigation to that area can be discontinued provided they are maintained with best management practices, such as the proper use of mulch. These species should be able to withstand short-term droughts without supplemental irrigation. Some species may enter a dormant period or lose their leaves if drought conditions persist, at which time, supplemental irrigation may be required.

Another element of the Right Plant, Right Place concept is the prudent use of ground covers requiring high volume irrigation. Turfgrass is a typical choice for ground cover, but requires irrigation to remain visibly vibrant. However, it can be "trained" to require less water (for more on this process, refer to the Florida-friendly Landscaping mentioned in the box below). Turfgrass is valuable for controlling soil erosion and in recreation areas for outdoor gatherings or activities (**Figure 58**). In other situations, such as narrow strips of landscape, better options are available from a water-conservation perspective (**Figure 59** and **Figure 60**)

As you review your facility's landscape, assess whether the plants are compatible within the current irrigation zone and regime. Also, look for opportunities for irrigation efficiency improvements in the overall landscape. Your local agricultural extension office may be able to provide assistance.

Florida Focus

As an example, research on 27 shrub species by the University of Florida's Institute of Food and Agriculture Science suggests regular irrigation can be discontinued between 12 and 28 weeks after planting. To become established young shrubs need 3 liters (0.75 gallons) of irrigation every 8 days in northern and central Florida, and every 4 days in southern Florida under normal rainfall conditions. However, shrubs should be monitored for symptoms of water stress during the first 2 years after planting, with supplemental water applied as necessary (UF-IFAS 2009). During the establishment period, these areas should be outfitted with micro-irrigation, which can increase water efficiency by up to 90 percent.

For facilities located in Florida, the following free resources may be helpful:

- A Guide to Florida-Friendly Landscaping (www.floridayards.org/landscape/FYN-Handbook.pdf)
- WaterWise Plant Guide (www.sfwmd.gov and enter "WaterWise Plant Guide" into the search bar)
- Florida Exotic Pest Plant Council (www.fleppc.org)

Figure 57. Landscapes that compliment the local environment and make use of plants with growing requirements that can be met by the local environment.

Figure 58. Prudent uses of turfgrass, such as drainage swales and recreation areas.

Figure 59. An area of grass that could be converted to a planted bed.

Figure 60. A landscape bed using low irrigation needing plants instead of turfgrass.

Audit Objectives

This procedure requires you to survey each of your facility's irrigation zones. You may perform multiple irrigation and landscape audit procedures at one time as you survey each zone. For this reason, most irrigation and landscape audit worksheets have been consolidated and appear together on the **Irrigation and Landscape Audit Worksheet** in **Appendix C**

The procedure will help you identify:

- Areas where plants with similar and dissimilar growth requirements are located within each zone/station of the landscape
- Areas where turfgrass may be changed to planting beds to reduce irrigation needs

Florida Focus

The Florida Exotic Pest Plant Council (FLEPP, www.fleppc.org) maintains lists of invasive and nuisance plants categorized by threat level.

A horticultural or landscape professional should be able to design a Florida-friendly, water-efficient landscape for your facility. Alternatively, see some of the resources mentioned previously or contact a professional at one of the following institutions who may be able to answer your questions free of charge:

- University of Florida's Institute of Food and Agricultural Sciences (IFAS, www.ifas.ufl.edu)
- University of Florida, Department of Horticulture (hort.ifas.ufl.edu)
- Your local botanical garden or county extension agent (extension.ifas.ufl.edu/map)

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine the Irrigation System and Landscape Survey – Advanced Audit portion of the **Irrigation and Landscape Audit Worksheet** (you will need one copy per zone) and refer to the Irrigation and Landscape Cheat Sheet, both in Appendix C.
3. Evaluate zones containing turfgrass; decide whether the area is providing a function (such as recreation, soil retention, etc.) or whether it can be replanted with species with lower irrigation requirements.
4. Download one of the previously recommended plant resource materials. You may be able to further refine your plantings to better group plants based on light, water, and fertilizer requirements beyond the 'general' plant types (turfgrass, annuals/perennials, trees/shrubs).
5. Complete the Irrigation System and Landscape Survey – Advanced Audit section of the **Irrigation and Landscape Audit Worksheet** (Appendix C).

Post-Audit Considerations and Additional Activities

It may be feasible to use some of your facility's landscaping budget to replace turfgrass in areas not actively controlling soil erosion or used for recreation with plants, trees, or shrubs selected based on local growing conditions. Once these plants become established (usually after 1 to 3 years), they should not require irrigation to supplement natural rainfall, except perhaps during extended periods of drought.

Trees and shrubs may have difficulty growing in areas where top soil was removed and replaced with fill during the facility's construction or in areas with thin soil layers overlying bedrock. A preliminary soil investigation and appropriately matched plant species will help prevent the loss of trees and shrubs. Consulting with a certified landscape designer or horticultural expert is advised. Be sure to request verification of the expert's industry certification status. This measure is worth the investment of time and money since it can lead to the complete elimination of irrigation to one or more zones.

If invasive species are found on the facility's property, they should be eradicated. Most states maintain lists of invasive species.

If you have questions related to these considerations, contact a horticultural or landscape professional, or your local botanical garden or county agricultural extension office.

Irrigation and Landscape Field Audit Worksheet

	Prudent Use of Turf? See Cheatsheet Note 10		Plants in Plantbeds See note at right >	Using a plant guide book, such as the WaterWise Plant Guide, for your area, identify all non-turfgrass plant material.
Zone	Does the zone contain turf?	If turf is present, does it serve purpose? (Swale, recreation area, erosion control etc.)*	Do all plants in this zone have similar light & irrigation needs?*	Additional Notes
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

See the Landscape and Irrigation Cheatsheet for section-by-section explanations. Also refer to Guidebook page 146.
***All "No" responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each relevant audit procedure.**

*This is page 2 of 2 of the **Irrigation and Landscape Audit Worksheet**. See **Appendix C** for the complete worksheet and the associated cheatsheet.

RAIN AND SOIL MOISTURE SENSOR SURVEY – ADVANCED AUDIT

Background and Description

The visible appearance of a sensor does not provide an accurate indicator of how well it works. The best way to truly test a rain or soil moisture sensor is to manually engage the irrigation system and slowly pour water over the sensor (or overlying soil). In this test, the sensor should stop the irrigation event.

Rain sensors should be relatively easy to locate, but because soil moisture sensors are buried, their locations may not be known. You may need to contact the vendor who installed the units. If the sensor cannot be located, its operating condition can be determined on a day when heavy rain occurs or by turning on the system manually before a scheduled irrigation event. If the sensor is working correctly, the irrigation system should be interrupted by the rain.

For either sensor type, familiarity with the timer or controller is required to manually engage the system. If you are not familiar with how to work the timer or controller, you may want to contact your facility's irrigation contractor or conduct the test during a scheduled irrigation event.

Audit Objectives

This procedure will guide you through the steps to test the functionality of your facility's irrigation system interrupter sensor.

Rain sensors typically have a test switch that should interrupt the system when depressed manually. This shows whether the circuitry of the sensor works, but does not the test the reactivity of the sensor to the environment and is therefore not an adequate test of functionality.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine the **Rain Sensor Survey** and **Soil Moisture Sensor Survey – Advanced Audit** portions of **Worksheet 13** (page 103) and refer to the Irrigation and Landscape Cheat Sheet, both in Appendix C.
3. Locate the irrigation cut-off sensor (rain sensor or soil moisture sensor).
4. Engage the irrigation system manually or conduct this test during a regularly scheduled irrigation event under dry conditions.
5. Once the system is engaged, slowly pour water over the rain sensor or over the soil above the soil moisture survey.
6. Observe the system's reaction and record the result on **Worksheet 13**.
7. If the soil moisture sensor could not be located do one of the following:
   a. Turn on the system manually to saturate the soil before an irrigation event is scheduled to occur and observe whether the system turns on at the scheduled time (it should not).
   b. Observe the system on a day when a heavy rain occurs and when an irrigation system is scheduled to engage (it should not engage after a heavy rain).
8. The irrigation system should not engage automatically after the soil was soaked, whether by rain or after the system was turned on manually earlier the same day. If the system engages, the sensor is not functioning properly or should have its wiring and threshold point checked.

Post-Audit Considerations and Additional Activities

If the irrigation event was interrupted after water was poured over the sensor or after the ground surrounding the SMS was soaked (either after you engaged the system manually or after a heavy rain), then the sensor is operating properly. If the irrigation event was not interrupted, check to ensure it is properly wired to the timer or controller. If the wiring seems intact, the problem may be that the timer/controller is not set to accept the cut-off signal from the sensor. Reset the timer/controller to accept the sensor's signal and repeat the test. You may need to allow time for the sensor to dry before repeating this test. If the sensor still fails to shut off the system, the sensor may need to be replaced.

Florida Focus

If the irrigation event continued after soaking the SMS as described in this audit procedure and it needs to be replaced, you should do this immediately. This is an inexpensive improvement measure and a functioning sensor is necessary to comply with Florida law.

For additional information on how to install, operate, and maintain an SMS, see the *Field Guide to Soil Moisture Sensor Use in Florida* (SJRWMD 2008, available from www.sjrwmd.com/floridawaterstar/pdfs/SMS_field_guide.pdf).

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Part III. Further Efficiency Improvement Analyses: Strengthening Decision Making Power for Efficiency Improvement Planning

Overview

The procedures for Further Efficiency Improvement Analyses will give you more information to support decision making for planning efficiency improvements. Specifically, these procedures provide direction on more intensive investigations into unaccounted-for water through the creation of a full-facility water balance.

A facility water balance, along with two additional activities (Historical Water Use and the True Cost of Water) will help you more completely understand water use and the cost of water at your facility.

The final procedure in this section will provide background information for identifying potential alternative on-site water sources and highlight the major considerations that must be understood when evaluating their use.

Collectively, these analyses are invaluable tools for creating long-range, lasting water efficiency improvement plans and decisions.

CREATING A FACILITY WATER BALANCE

Background and Description

The most thorough way to identify potential areas for water efficiency improvements is to develop a complete understanding of how your facility uses water. A facility water balance accounts for all water use, from its source to its use by all fixtures, machinery, irrigation, cooling towers, known leaks, and wastewater discharges.

A facility water balance is a powerful tool for identifying and evaluating efficiency improvements and is worth the time needed for its creation. For this reason, creating and interpreting facility water balances is usually a part of a water use audit package conducted by professional conservation or engineering firms. These firms can also provide uncommon suggestions to improve efficiency and can recommend measures that will bring the greatest return on investment. However, a motivated building manager should be able to create a workable model, especially in a commercial building. This procedure will help you create a tabular and graphic representation of your facility's water balance.

Creating a water balance for an office building is usually relatively simple, since water use is typically limited to a few areas. Under certain conditions, estimates of sanitation (restrooms) water use and calculated values for cooling tower water consumption and landscape irrigation are relatively easy to generate. These estimates should have been made during the Basic Audit and Advanced Audit procedures. To complete the facility water balance, all points of water consumption should be accounted for, including any points that were not "quantified" in previous procedures, such as water fountains, breakroom coffee makers, custodial services, and vehicle washing (NCDENR 2009, PWB 2010).

The *Facility Water Balance* tab in the *Further Efficiency Improvement Analysis* spreadsheet contains a table similar to **Figure 61**. When this table is populated, the spreadsheet will show the facility's water use as a pie chart.

Submetering is the most effective means of determining the water use rate of cooling towers, irrigation systems, and commercial-grade kitchens (Vickers 2001). When this is not possible, estimates are necessary as discussed in previous sections of this guidebook.

For any specific water-using appliance, you can refer to the owner's manual or contact the device manufacturer for water use information. The rates can be multiplied by use frequencies for your facility to yield a usable estimate. It may be helpful or necessary to meet with floor-level staff to discuss how often the devices in their areas are used.

Audit Objectives

This procedure will guide you through the steps necessary to create a facility water balance.

Water Use	Gallons per year
Boiler make-up	
Cooling Tower make-up	477,000
Processes and equipment Operations	
Steamcleaning	
Materials transport	
Domestic (restrooms, breakrooms)	
Toilets	1,289,000
Urinals	332,000
Faucets	120,000
Showerhead	26,000
Other Faucets	
Residential Dishwasher	
Commercial-Grade Kitchen	
Pre-Rinse Spray Valves	
Dishwashers	
Ice machines	47,000
Commercial Clothes washers	
Vehicle fleet wash	
Once-through cooling	
Landscape Irrigation	655,000
Breakroom water use	
Other (Enter water use type)	
Known leaks	
Total	2,946,000
*Water purchased + well pumpage	3,028,000
Unaccounted for	82,000

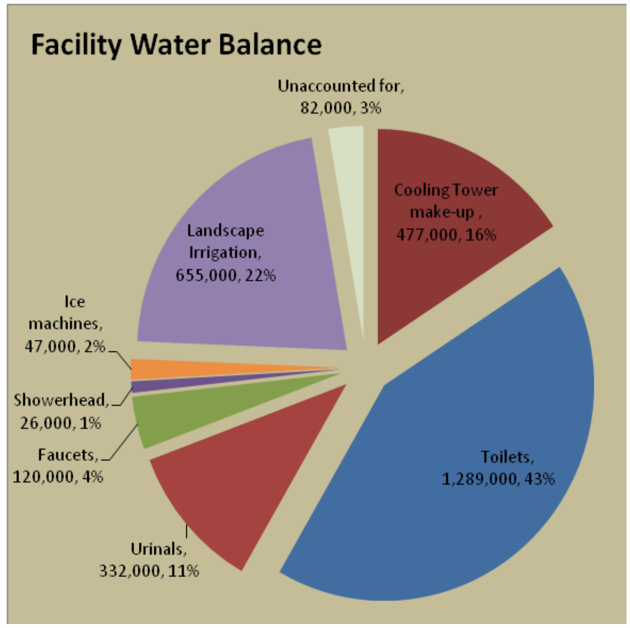

Figure 61. Example table and pie chart from the *Further Efficiency Improvement Analysis* spreadsheet showing the water balance of a commercial building.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine **Worksheet 15: Facility Water Balance** and the *Facility Water Balance* tab in the *Further Efficiency Improvement Analysis* spreadsheet.
3. If all of the Advanced Audit activities in this guidebook have been completed, you should be able to complete most, if not all of the table on the *Facility Water Balance* tab in the *Further Efficiency Improvement Analysis* spreadsheet.
4. Estimates of use should be made for all consumption that has not been previously measured or calculated. This could include anything from water use for washing vehicles to brewing coffee.

Post-Audit Considerations and Additional Activities

The total metered inflow from your facility water bill should equal the sum of all outflows and consumption. The difference between the inflow volume (which is typically metered) and the sum of all outflow volumes (which may consist of metered volumes and calculated estimates) constitutes your facility's unaccounted-for water. The unaccounted-for water volumes may consist of an outflow that was not previously calculated, as well as unknown leaks or errors in some consumption estimates. A difference between total metered flow and all accounted-for water use of 10 percent or less of total volume is likely due to measurement or calculation errors and is considered acceptable. Differences greater than the expected 10 percent represent discrepancies beyond the error of most consumption calculations and suggest a leak is present or a legitimate consumption point was overlooked or underestimated (PWB 2010).

The water balance can also show large or excessive water use volumes by your facility in areas that were not previously recognized or where underestimated. These areas may be targets for improving efficiency since a small improvement in such an area can account for a large volume of water. You can also compare your facility to typical use by industry shown in the *Introduction* of this guide (page 15).

Spreadsheet Guidance

After completing **Worksheet 15**, transfer the data to the *Facility Water Balance* tab of the *Further Efficiency Improvement Analysis* spreadsheet. The spreadsheet will calculate unaccounted for water and create a pie chart similar to that in **Figure 61** illustrating water use at your facility.

Worksheet 15.   Facility Water Balance

Water Use	Gallons per Month/Quarter/year
Boiler make-up	
Cooling tower make-up	
Processes and equipment operations	
Steam cleaning	
Materials transport	
Domestic (restrooms, breakrooms)	
Toilets	
Urinals	
Faucets	
Showerhead	
Other faucets (Non-Lavatory)	
Residential dishwasher	
Commercial-grade kitchen	
Pre-rinse spray valves	
Dishwashers	
Ice machines	
Commercial clothes washers	
Vehicle fleet wash	
Once-through cooling	
Landscape irrigation	
Breakroom water use	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Known leaks	
***Water purchased + well pumpage**	

*Enter Metered Volume

DETERMINE THE TRUE COST OF WATER AT A FACILITY

Background and Description

For many facilities, the true cost of water can be almost twice as much as the actual water and sewer charges. For example, buildings that rely on cooling towers pay for chemical treatments needed to maintain desirable water quality in the system; water used in facility processes may need to be treated to remove chemicals before it is released to the sewer system; and buildings that use heated water have added energy expenses tied to water use (NMSE 1999, Seneviratne 2007). **Figure 62** (taken from the *True Cost of Water* tab in the *Further Efficiency Improvement Analysis* spreadsheet associated with this guide) is an example of an office building's true cost of water.

When evaluating the cost of potable and sewer water, only the incremental cost should be used (i.e., the cost per 1,000 gallons or 1 ccf). This is because efficiency improvement measures do not affect base costs or hook-up fees.

Audit Objectives

This procedure will guide you through the steps to determine the true cost of water for your facility.

Expense Factor	Cost ($)
Potable Water	$9,204
Sewer	$9,989
Pretreatment chemicals (if applicable)	$0
Cooling Tower Water Treatment	$4,000
Other (Electricity for irrigation pump)	$0
Other (Electricity for heating)	$4,500
Other (User Defined)	$0
Other (User Defined)	$0
Total Cost of water over Expense Period	$27,693
Total Cost of water (Annually)	$27,693
Cost of water (Potable & Sewer alone) per 1000 gallon	$6.25
True Cost of water per 1000 gallons*	$7.29

**Accounts for the indirect costs in the table above, but not base charges*

Figure 62. An example of the output table on the *True Cost of Water* tab.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine the *True Cost of Water* tab in the *Further Efficiency Improvement Analysis* spreadsheet.
3. On the *Utility Rate Data Input* tab, enter cost per unit for potable and sewer water (do not include base costs).

4. Assemble a year's worth of bills and expenses related to water consumption from your facility's records or accounts payable; or request this information from the facility's corporate office. Some common examples of expenses are:
    a. Pretreatment chemicals (if applicable)
    b. Cooling tower chemical treatment
    c. Electricity to pump water from an on-site well
    d. Pretreatment filtration of well water
    e. Electricity for heating water
5. Enter these charges into the *True Cost of Water* tab.
6. Examine the true cost of water for your facility and compare it to the direct cost for potable and sewer water.

Post-Audit Considerations and Additional Activities

The calculation of the true cost of water should be as detailed as your available data allows. For example, you may be able to incorporate the depreciation of pretreatment machinery or irrigation well pumps. The objective is to arrive at a cost that includes the most significant direct and indirect expenses relating to water use to more accurately calculate cost savings that could result from efficiency improvements. The true cost of water should be used whenever you evaluate potential investments in improving water use efficiency.

Spreadsheet Guidance

Utility rate data (cost of potable and sewer water and energy) were previously entered in the *Utility Rate Data Input* tab in this spreadsheet. If you have not entered this information, refer to the *How to Use this Guide* section on page 23 for an explanation.

Within the *True Cost of Water* tab, identify the expense period for which the costs are reflective by selecting either "Quarter" or "Year" from a dropdown menu. This will depend on the billing data you have available and how frequently your facility is billed for water. An annual cost analysis is optimal to account for seasonal effects on water use, but shorter periods also can be analyzed.

Once you finish adding the requested billing data to the tab, the cost for potable and sewer water usage over the expense period will be calculated and displayed in the output table (**Figure 62**). The resulting costs for potable and sewer water should only include charges that can be reduced as efficiency increases; no base charges are reflected in this table.

Enter the costs for all expenses related to water use, such as pretreatment chemical expenses and electricity. The final output will show the true cost per 1,000 gallons of water your facility uses versus the direct cost for potable and sewer water expenses alone.

HISTORICAL WATER USE PROFILE

Background and Description

Creating a historic water use profile for your facility can highlight seasonal fluctuations in potable and sewer water use and reveal spikes or drops in consumption, as well as potential leaks. Related expenses, such as those associated with chemicals for water treatment, can be tracked in tandem with water use. This profile can provide a standard when planning future efficiency improvements or to compare initial water use to conditions after efficiency measures have been put into place.

A historical water use profile can be easy to create if you have access to your facility's utility bills. Typically, one to three years of data are gathered and viewed graphically. The *Further Efficiency Improvement Analysis* spreadsheet contains a table similar to **Figure 63** on the *Historical Water Use* tab. When this table is populated, the spreadsheet will produce a graphic representation of the facility's water use and some related expenses. **Figure 64** and **Figure 65** provide examples of the graphs resulting from an office building's historical water use profile. In the example, the office building's cooling tower was submetered to receive sewer credits and began experiencing a leak in November.

If your billing data is quarterly and does not show monthly usage, then divide each quarter by three to get the average water use for each month in that quarter. Do not sum the total annual use and divide by 12, because this would lose any seasonal trends.

Audit Objectives

This procedure will guide you through the steps to create a graphic representation of your facility's water use, potentially including additional water-related expenses.

*^Date	* Potable or Well Water Inflow	* Utility Sewer Water Outflow	Cooling tower chemical expenses ($)
Mar-09	45,000	20,000	$40
Apr-09	47,000	22,000	$44
May-09	48,000	22,000	$44
Jun-09	52,000	26,000	$52
Jul-09	58,000	28,000	$56
Aug-09	57,000	27,000	$54
Sep-09	50,000	25,000	$50
Oct-09	47,000	22,000	$50
Nov-09	99,000	50,000	$45
Dec-09	98,000	49,000	$45
Jan-10	98,000	49,000	$40
Feb-10	99,000	50,000	$40

Figure 63. Example input table for an office building's historic water use profile.

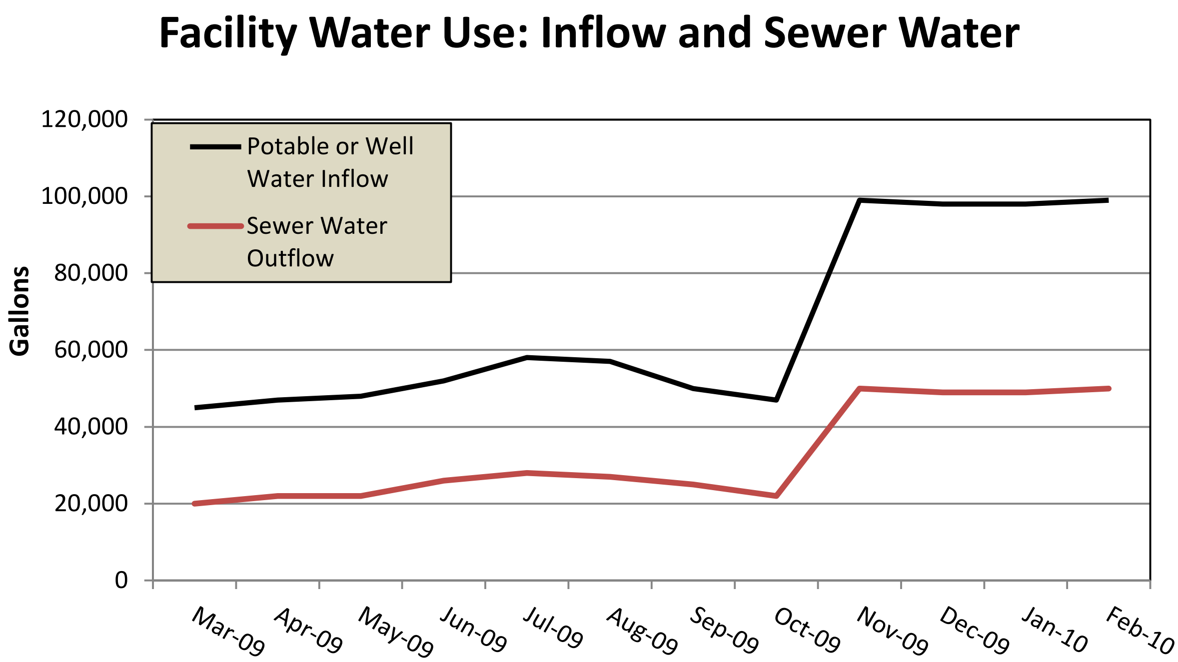

Figure 64. Example facility water use based on an office building's historic water use profile.

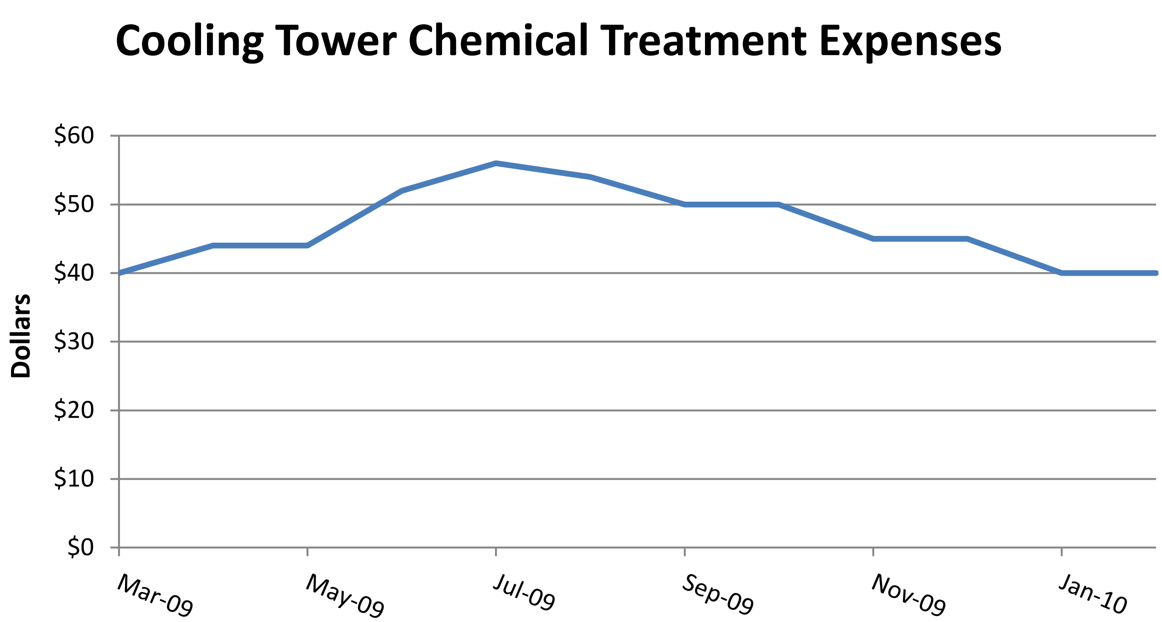

Figure 65. Example facility cooling tower chemical expenses based on an office building's historic water use profile.

Audit Steps

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Assemble water and sewer utility bills from the past 1 to 3 years.
3. Assemble at least a year of expenses related to water consumption. Some examples are cooling tower chemical treatment, electricity to pump water from an on-site well, pretreatment filtration of well water, and electricity for heating water.
4. Separate the use and utility billing data on a per-month basis.
5. Examine a water bill to determine the utility billing units.
6. On the *Utility Rate Data Input* tab, enter cost per unit for potable and sewer water (do not include base costs).
7. Examine the *Historic Water Use Profile* tab on the *Further Efficiency Improvement Analysis* spreadsheet.
8. Enter the water use data into the *Historical Water Use Data Input* table (in ccfs or gallons, depending on the selected billing unit).
9. Examine the graphs produced.

Post-Audit Considerations and Additional Activities

After examining the graphs of your facility's water use, consider any seasonal or annual variations or spikes or drops in water use that you see. If they cannot be explained by the operations of the facility, they may be areas where further investigation is needed. Once this profile has been created, subsequent water use and related expenses should be added, and notations should be made to monitor when efficiency improvements are made. In this way, the profile serves as a benchmark against which the impacts of those efforts are measured.

Spreadsheet Guidance

Utility rate data (cost of potable and sewer water and energy) are entered in the *Utility Rate Data Input* tab. If you have not entered this information, refer to the *How to Use this Guide* section on page 23 for an explanation.

To complete this audit, refer to the *Historic Water Use Profile* tab on the *Further Efficiency Improvement Analysis* spreadsheet. In the input table, enter the billing periods, inflow meter records, outflow meter records, and cooling tower chemical expenses.

IDENTIFYING ON-SITE ALTERNATIVE WATER SOURCES

Background and Description

Many buildings have the opportunity to develop and use alternative on-site water sources, and numerous case studies document significant water and financial savings (NMSE 1999). However, evaluating the feasibility of developing alternative water sources can only be done on a case-by-case basis. Considerations during such an evaluation include relevant health and safety requirements; the volume, quality, and reliability of the source; possible pretreatment requirements; and suitability for possible uses within the facility. Guidance for a feasibility analysis of any system at a specific facility is beyond the scope of this guidebook. If your facility is considering such an analysis, consider contacting a conservation or engineering consulting firm.

Possible sources of on-site alternative water include the following:

- Harvested rainwater
- Water from once-through cooling equipment
- Boiler condensate
- Condensate from air handling units
- Fountain drain water
- Cooling tower blowdown
- On-site treated gray water and wastewater
- Internally recycled water (last rinse water becomes next load's wash water)

These alternative on-site water sources produce water at a range of qualities creating various opportunities for use. Potential uses include:

- Cooling tower makeup
- Boiler makeup
- Landscape irrigation
- Sanitation (toilet and urinal flushing)
- Makeup water for ornamental ponds or fountains
- Swimming pools
- Laundry water
- Manufacturing processes
- Materials transport

Due to the complexity of this topic, this section is primarily intended as educational. Estimates of potential water created by only two of these sources, condensate from the cooling system and rain from the facility's roof, will be determined on the *On-Site Alternative Water Sources* tab of the *Further Efficiency Improvement Analysis* spreadsheet.

The *Cooling Tower Water Use – Advanced Audit* (page 139) includes a calculator to estimate condensate from cooling system air handling units. A similar, though abridged, calculator has been included on the *On-Site Alternative Water Sources* tab of the *Further Efficiency Improvement Analysis* spreadsheet. Cooling tower air handling units can produce significant volumes of water that can be used to offset cooling tower makeup needs. Moreover, this source is extremely low in total dissolved solids, thus requiring little pretreatment for solids, but may require some biological control.

The second alternative water source estimation procedure involves calculating potentially harvested rain water. Harvested rain water can be used for many nonpotable purposes, such as vehicle washing, supplementing irrigation water, providing makeup water for fountains, and for use in some manufacturing processes not requiring high quality water. Each 1,000 square feet of a building's roof area can collect approximately 500 gallons of water from 1 inch of rain.

Audit Objectives

Storage containers for harvested rainwater

You will:

- Become more acquainted with the concept of utilizing on-site alternative water sources
- Estimate the volume of water that could be collected at your facility via two sources (the cooling system's air handling unit and rainwater harvested from the facility's roof)

Audit Steps

Before beginning, you may want to review the Alternate On-Site Water Sources section of the *WaterSmart Guidebook* (EBMUD 2008)[1].

1. Fill out the parts of the **Basic Facility Header Sheet** (page 28) that you think will apply to this audit procedure and any others you want to conduct.
2. Examine the *On-Site Alternative Water Sources* tab on the *Further Efficiency Improvement Analysis* spreadsheet.
3. Enter the number of cooling tons of the facility's cooling tower, the hours per day it operates, and the days per month it operates into the first input table.
4. Examine the output.
5. Enter the building's roof area in square feet into the second input table.
6. Examine the output in conjunction with the average rainfall for your location (See **Table 19** for average rainfall data for some locations in Florida).

[1] Available through www.allianceforwaterefficiency.org/WaterSmart_Guidebook_for_Businesses.aspx or go to www.allianceforwaterefficiency.org and enter, "WaterSmart Guidebook" into the search bar.

Post-Audit Considerations and Additional Activities

Table 19 provides an example of the rainwater harvesting potential for facilities in Florida. Similar information should be available for most areas.

If you feel there is potential to capitalize on any of the potential on-site water sources at the facility, contact a professional engineering firm to discuss site-specific considerations and costs associated with the capture, storage, and use of the alternative water.

Spreadsheet Guidance

Utility rate data (cost of potable and sewer water and energy) should have been previously entered in the *Utility Rate Data Input* tab. If you have not entered this information, refer to the *How to Use this Guide* section on page 23 for an explanation.

For this audit, refer to the *On-Site Alternative Water Sources* tab on the *Further Efficiency Improvement Analysis* spreadsheet. There are two input/output tables on this tab. The first pertains to the amount of condensate water potentially created by the cooling system's air handling unit that can be used to supplement cooling tower make-up. Enter the number of typical cooling tons of your facility's cooling tower and the number of hours per day and days per month it operates. The output consists of potential savings in gallons and dollars.

The second input/output table pertains to potential gallons of rainwater than can be harvested from your facility's roof during a 1 inch rain event and annually. Enter the building's roof area in square feet and the number of inches of rain received in the city closest to your own (for Florida locations, check **Table 19**; information for other areas can be found by searching online). An abridged version of this table, titled Local Rainfall Averages, has been provided on the *On-Site Alternative Water Sources* tab of the spreadsheet for this purpose. The potential gallons captured and the subsequent savings shown are absolute potentials. The actual savings available to your facility depends on the size of the storage tank and how rapidly the water is used and may be less than the absolute potential amount. However, if the absolute amount appears to be substantial, you may want to contact a professional engineering firm to discuss site-specific considerations and costs associated with rainwater capture, storage, and use.

Florida Focus

Table 19. Average monthly rainfall for selected Florida locations.

Location	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Arcadia	2.2	2.6	2.7	2.1	4.3	7.8	8.3	7.3	7.4	4.0	2.0	2.2	52.9
Daytona Bch.	2.4	3.1	3.0	2.3	3.4	6.4	5.5	6.3	6.7	4.6	2.6	2.2	48.5
Fort Myers	1.9	2.1	2.9	1.5	4.1	8.7	8.6	8.6	8.6	3.9	1.4	1.6	53.9
Gainesville	3.3	3.9	3.7	3.0	4.2	6.6	7.1	8.0	5.6	2.3	2.0	3.2	52.8
Jacksonville	3.1	3.5	3.7	3.3	4.9	5.4	6.5	7.2	7.3	3.4	2.0	2.6	52.8
Key West	1.7	1.9	1.3	1.5	3.2	5.0	3.7	4.8	6.5	4.8	3.2	1.7	39.4
Lake City	3.8	3.9	4.2	3.5	4.6	6.7	6.8	7.0	5.7	2.4	2.3	3.5	54.4
Lakeland	2.3	2.8	3.5	2.4	4.2	6.1	7.3	7.5	5.8	2.4	1.9	1.9	48.3
Miami	2.1	2.1	1.9	3.1	6.5	9.2	6.0	7.0	8.1	7.1	5.7	7.9	57.6
Pensacola	5.1	5.0	6.1	4.8	4.3	7.1	7.2	6.4	6.8	3.4	3.9	5.4	65.5
Tallahassee	4.5	4.6	4.6	4.4	4.4	5.5	6.9	5.5	5.9	2.7	2.8	4.1	55.8
Tampa	2.6	3.5	3.9	2.2	4.7	7.0	7.9	8.4	7.1	3.1	2.2	2.7	55.3

Source: University of Florida, Institute of Food and Agricultural Sciences.

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Appendix A. How to Read Your Water Meter

Water meters in the U.S. typically measure volume in gallons or cubic feet. One cubic foot equals 7.48 gallons and 100 cubic feet equals 748 gallons. Water charges are typically based on 100 cubic feet or on 1,000 gallon units. There are two basic types of water meters -- the straight-reading meter, which resembles an odometer in a car, and the round-reading meter, which has several separate dials. The "straight-reading" meter is by far the most common.

How to Read a Straight-Reading Meter

In the meter shown in **Figure A-1**, the reading is taken from the figures shown under the words CUBIC FEET. The meter reads 81710.03, which is the total number of cubic feet of water recorded since the meter was installed. If the utility bills in units of 100 cubic feet, it would read this meter as simply 817.

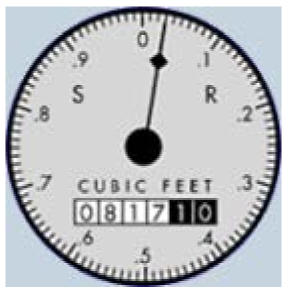

Figure A-1. Simple dial meter in cubic feet.

The meter shown in **Figure A-2** is new, hence the reading for this meter is 0.00. The small blue triangle (just to the right of the "35") is the low-flow indicator. This triangle will spin if any water is flowing through the meter. This indicator can be useful in leak detection.

Figure A-2. Simple dial meter with triangle spin flow indicator.

The meter in **Figure A-3**, also gauging cubic feet, is a good example of a situation where the final number has already "turned over." The correct reading on this meter is 2425.92 cubic feet. On most meters, the final digit will turn over once the big sweep hand has passed the 0.6 mark. Note that the size of the meter is usually printed on the dial. The meter in **Figure A-3** is a ⅝-inch meter, as shown on the dial.

Figure A-3. Simple dial meter with turned over number.

How to Read a Round-Reading Meter

The older style meter in **Figure A-4** is much less common; however, some of these meters are still in service. This type of meter has several small dials and is a little more difficult to read than the straight-reading meter. The dials are marked off in divisions of 10, and are read much like a clock, except that the hand on every other dial turns counterclockwise, with the FOOT dial reading clockwise.

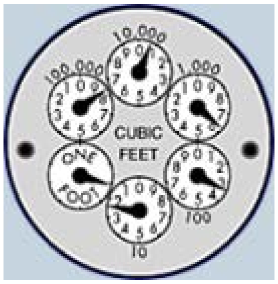

Figure A-4. Multi-dial older meter.

To read this meter, begin with the 100,000 dial and read each dial around the meter to the one foot dial. If the hand is between numbers, use the lower number. Therefore, the dials at right register 806323.

Information source: http://www.h2ouse.net/resources/meter/index.cfm

Appendix B. Best Management Practices for Commercial and Institutional Buildings

Action or Measure	Present/ Active Currently	Action Currently Under Way, but Incomplete	Implement in Near Future	Not Applicable	Comments
Indoor Domestic Water Use					
All tank toilets have been checked for leaks					
All toilets and urinals flush rates have been verified via flush-cycle timer test					
All fixture leaks repaired					
All facility-wide leaks repaired					
All plumbing fixtures are high efficiency 1.28 gallons per flush (WaterSense whenever possible)					
Toilets					
Urinals					
Faucet aerators					
Showerheads					
All tankless toilets have piston flush valves					
All older tank toilets have been outfitted with water displacement devices such as bags or small filled plastic bottles					
Carpet cleaning uses dry methods (powder or steam)					
Ensure all pipes are insulated					
Meters and Submeters					
Meters have been checked for accuracy					
Use the lowest-quality water supply available					
Someone on-site can read meters					
Routine meter reading regime established (irrigation)					

Action or Measure	Present/ Active Currently	Action Currently Under Way, but Incomplete	Implement in Near Future	Not Applicable	Comments
Routine meter reading regime established (main incoming)					
Routine meter reading regime established (cooling tower)					
Monitor pressure and reduce all areas to 60 psi					
Cooling Towers					
Cooling tower is free of leaks; check all seals pumps, casings, and ducts; check monthly					
Cooling towers have submeters (makeup and blow-down)					
Cooling tower cycles are at least five for makeup with a total hardness of less than 11 grams per gallon (188 milligrams per liter [mg/L])					
Cooling tower cycles are at least five for makeup with a total hardness equal to or exceeding 11 grams/gallon (188 mg/L)					
Cooling towers have conductivity meters					
Cooling tower meters monitoring routine regularly scheduled					
Cooling towers are set to shut down during off-hours (typically 21:30 - 5:00 for an 8am to 6pm workday)					
Use of side-stream filtration considered					
Use of sulfuric acid considered					
A regular visual inspection routine is scheduled					
The make-up float should be inspected to ensure it is performing at the optimal level					

Action or Measure	Present/ Active Currently	Action Currently Under Way, but Incomplete	Implement in Near Future	Not Applicable	Comments
The water distribution feedline is checked and ensured to be clean and maintains even, consistent flow across the cooling system (this includes across multiple towers)					
Conductivity probes should be cleaned monthly to ensure reduce unnecessary blowdown					
The blowdown line should be cleaned monthly to avoid biofouling					
Cooling tower is cleaned routinely monthly					
Outdoor Irrigation					
Irrigation timer set only during non-restricted hours					
Shut-off sensor is in place and functioning (rain or soil moisture)					
Micro-irrigation is used in non-turf areas					
Irrigation has been eliminated in zones with mature or established plants or shrubs					
Sprinkler head wetting patterns hit only intended areas					
All broken heads repaired					
Irrigation schedule adjusted for seasonal needs (less frequently in cooler and rainy seasons)					
Turf areas reduced to recreation areas and for erosion control only					
Adequate mulch used (3 inches) in all planting beds (non-turf areas)					
Drought-tolerant plants, trees, and shrubs have replaced areas where non-recreation or soil erosion turf was previously					

Action or Measure	Present/ Active Currently	Action Currently Under Way, but Incomplete	Implement in Near Future	Not Applicable	Comments
Florida - Friendly Landscaping Principles are observed					
Outdoor (Other)					
All hoses have self-cancelling shut-off handle valves					
Wash vehicles only when needed and on permeable surfaces					
Vehicle washing done ”as required”, not on a schedule					
Window cleaning done ”as required”, not on a schedule					
Alternative On-site Water Development					
Potential for on-site water development examined for the following:					
Water from once-through cooling equipment					
Boiler condensate					
Condensate from air handling unit					
Fountain drainwater					
Cooling tower blowdown					
On-site treated gray and wastewater					
Internally recycled water (Last rinse water becomes next load’s wash water)					
Potential for rain harvesting examined					
Commercial-Grade Kitchens					
The kitchen is metered separately					
All faucets are free of leaks					
All Pre-Rinse Spray Valves are 1.60 gals/min or less					

Action or Measure	Present/ Active Currently	Action Currently Under Way, but Incomplete	Implement in Near Future	Not Applicable	Comments
Dishwasher is run at manufacturer's specifications and using a pressure regulator if necessary					
Dishwasher is run only for full racks					
Dishwasher is free from leaks					
Conveyor-type dishwashers are run only when dishes are on the belt (sensors can be installed to ensure this)					
Steam cookers are ENERGY STAR or Food Service Technology Center (FSTC) qualified					
"Steam doors" are used to prevent water loss from evaporation					
Final rinse water is used to prewash the next load or in the garbage disposer (if not disconnected)					
Water-flow scraping troughs (usually 3-5 gals/min) are replaced with bins filled with soapy water or used on demand (not constantly)					
Ice machines are ENERGY STAR or Food Service Technology Center (FSTC) qualified					
Ice machines are selected to be size-appropriate for anticipated demands					
Ice machines have, or have been retrofitted with a heat exchange unit					
Ice machines make flakes (not cubes)					
Ice machines are not single pass or water-cooled; they have been retrofitted to reticulate chilled water or use an existing remote air-cooled condenser					
All continuous flow equipment is shut down between use					

Action or Measure	Present/ Active Currently	Action Currently Under Way, but Incomplete	Implement in Near Future	Not Applicable	Comments
Consider sweeping and mopping instead of spray-washing					
Frozen food is thawed in a microwave or refrigerator, not under running water					
Water is not used to melt ice					
All kitchen handwashing sinks have low-flow aerators and/or are foot-peddle or sensor-activated					
Keep steamer doors closed when in operation					
Use only as many cooking compartments as are needed					
Use the cook-timer and set to run standby when not cooking					
Reduce the use of standby time to only what is needed					
Fix leaks and keep clean for maximum efficiency					
Reduce water use of combination ovens by running them in convection mode between active cooking and whenever practical					
Use the combi mode only when necessary					
Turn the combi oven down when not in use					
Cook only when fully loaded					
Always close doors fully					
Miscellaneous					
Conservation Officer has been designated					
Conservation objectives communicated to all staff					
Signage posed to encourage water and energy conservation					

Appendix C. Worksheets

The Basic Facility Header Sheet and all worksheets from the guidebook are duplicated in this appendix. Single-page worksheets are repeated to ease double-sided printing of these pages. Most of the worksheets related to irrigation (with the exception of Worksheet 12) are combined into a single double-page Irrigation and Landscape Audit Worksheet and accompanied by the Irrigation and Landscape Cheat Sheet. It is the authors' hope that this will reduce the amount of paper you need to carry with you as you perform the audits described in this guidebook.

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Basic Facility Header Sheet

Site Name			
Address			
Facility Ops. Manager Name & Contact Info.			
Auditor Name(s) & Contact Info.			
Date of Audit			
Buildings and Years Built			
Population Breakdown			
Full-time Employees Population #1	Males_____________	Females___________	
Full-time Employees Population #2	Males_____________	Females___________	
Visitor Group #1	Males_____________	Females___________	
Visitor Group #2	Males_____________	Females___________	
Visitor frequency and duration			
Months Per Year of Operation			
Water Provider & Billing Rate			
Gas Provider & Billing Rate			
Electricity Provider & Billing Rate			
Cooling Towers			
Cooling Capacity			
Typical Operating Tonnage			
Hours Per Day of Operation			
Days Per Month of Operation			
Months Per Year of Operation			
Are Sewer Credits Received?			
Irrigation System? Submetered?			
Other large or significant points of on-site water use? (commercial kitchen, vehicle washes, etc.)			

Basic Facility Header Sheet

Site Name			
Address			
Facility Ops. Manager Name & Contact Info.			
Auditor Name(s) & Contact Info.			
Date of Audit			
Buildings and Years Built			
Population Breakdown			
Full-time Employees Population #1	Males_____________	Females___________	
Full-time Employees Population #2	Males_____________	Females___________	
Visitor Group #1	Males_____________	Females___________	
Visitor Group #2	Males_____________	Females___________	
Visitor frequency and duration			
Months Per Year of Operation			
Water Provider & Billing Rate			
Gas Provider & Billing Rate			
Electricity Provider & Billing Rate			
Cooling Towers			
Cooling Capacity			
Typical Operating Tonnage			
Hours Per Day of Operation			
Days Per Month of Operation			
Months Per Year of Operation			
Are Sewer Credits Received?			
Irrigation System? Submetered?			
Other large or significant points of on-site water use? (commercial kitchen, vehicle washes, etc.)			

Worksheet 1. Meters and Submeters

Meter/Submeter Number & Location	Type (see Appendix A)	Pipe Size (inches)	Date of Last Accuracy Check & Calibration	Records Used for Which Areas of Building or Campus

Worksheet 1. Meters and Submeters

Meter/Submeter Number & Location	Type (see Appendix A)	Pipe Size (inches)	Date of Last Accuracy Check & Calibration	Records Used for Which Areas of Building or Campus

Worksheet 2. Facility Leak Detection

Meter Location Type	______________________ ______________________				
Date and Time	**Initial Meter Reading**	**Date and Time**	**End Meter Reading**	**Known Water Consumption During Shut-Down**	**Leaks/Other Observations**

Meter Location Type	______________________ ______________________				
Date and Time	**Initial Meter Reading**	**Date and Time**	**End Meter Reading**	**Known Water Consumption During Shut-Down**	**Leaks/Other Observations**

Meter Location Type	______________________ ______________________				
Date and Time	**Initial Meter Reading**	**Date and Time**	**End Meter Reading**	**Known Water Consumption During Shut-Down**	**Leaks/Other Observations**

Transfer this information to the *Daily Water Use* Microsoft Excel spreadsheet associated with this guide.

Worksheet 2. Facility Leak Detection

Meter Location Type	________________________ ________________________				
Date and Time	**Initial Meter Reading**	**Date and Time**	**End Meter Reading**	**Known Water Consumption During Shut-Down**	**Leaks/Other Observations**

Meter Location Type	________________________ ________________________				
Date and Time	**Initial Meter Reading**	**Date and Time**	**End Meter Reading**	**Known Water Consumption During Shut-Down**	**Leaks/Other Observations**

Meter Location Type	________________________ ________________________				
Date and Time	**Initial Meter Reading**	**Date and Time**	**End Meter Reading**	**Known Water Consumption During Shut-Down**	**Leaks/Other Observations**

Transfer this information to the *Daily Water Use* Microsoft Excel spreadsheet associated with this guide.

Worksheet 3. Examining Utility Bills & Estimating Daily Facility Water Use

Based on your property and the seven possible scenarios outlined above:

Daily Indoor Water Use = ________gallons **Daily Outdoor Water Use = ________gallons**

Daily Indoor Water Cost = $____________ **Daily Outdoor Water Cost = $____________**

Refer to Box 5 (page 40) for guidance on calculating the daily water use and daily water cost.

Worksheet 3. Examining Utility Bills & Estimating Daily Facility Water Use

Based on your property and the seven possible scenarios outlined above:

Daily Indoor Water Use = ________gallons **Daily Outdoor Water Use = ________gallons**

Daily Indoor Water Cost = $____________ **Daily Outdoor Water Cost = $____________**

Refer to Box 5 (page 40) for guidance on calculating the daily water use and daily water cost.

Worksheet 4. Faucets

Building Name ____________ Flow measurement container (Circle one): Cups/Pints/Quarts/Flowbag

Location	Lav. Fac. (?) ✓	User Group	Manual, Sensor, or Spring	Metered (Sensor or Spring) Seconds of Flow	Flow Rate				NA=No Action R=Replace M=Maint.	Leaks? Other Comments
					Marked Flow Rate (gpm)	Timed				
						Num. Cups/ Pints/ Quarts	Num. Secs.	Calc. Rate or Flowbag (gpm)		
Totals										

***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at "A" or "1" with the fixture closest to the door or beginning to the left upon entering the room.

** Place a check mark in the second column (**Lav. Fac. ?**) if the faucet is located in a lavatory. Leave blank otherwise. **

Worksheet 4. Faucets

Building Name ____________ Flow measurement container (Circle one): Cups/Pints/Quarts/Flowbag

Location	Lav. Fac. (?) ✓	User Group	Manual, Sensor, or Spring	Metered (Sensor or Spring) Seconds of Flow	Flow Rate				NA=No Action R=Replace M=Maint.	Leaks? Other Comments
					Marked Flow Rate (gpm)	Timed				
						Num. Cups/ Pints/ Quarts	Num. Secs.	Calc. Rate or Flowbag (gpm)		
Totals										

***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

** Place a check mark in the second column (**Lav. Fac. ?**) if the faucet is located in a lavatory. Leave blank otherwise. **

Worksheet 5. Showerheads

Building Name ____________ Flow measurement container (Circle one) Cups/ Pints/ Quarts/Flowbag

Location	Flow Rate				NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
		Timed				
	Marked Flow rate (gpm)	Num. Cups/ Pints/ Quarts	Num. Secs.	Calc. Rate or Flowbag (gpm)		
Totals						

***High efficiency standards:** Toilets, 1.28 gpf: Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 5. Showerheads

Building Name _____________ Flow measurement container (Circle one) Cups/ Pints/ Quarts/Flowbag

	Flow Rate					
		Timed				
Location	Marked Flow rate (gpm)	Num. Cups/ Pints/ Quarts	Num. Secs.	Calc. Rate or Flowbag (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
Totals						

***High efficiency standards:** Toilets, 1.28 gpf: Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 6. Toilets

Building Name ________________

Location	User Group	Manual or Sensor	Tank* or Valve	Marked Valve Flush Rate (gpf)	Marked China Flush Rate (gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Dye Test Results? Other Comments
Totals									

* For tank toilets, record measurement in square inches of the tank volume.
Tank length x width x height (of water fill) = Volume
***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals:, 0.5 gpf; Showerheads: 2.0 gpm.
Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 6. Toilets

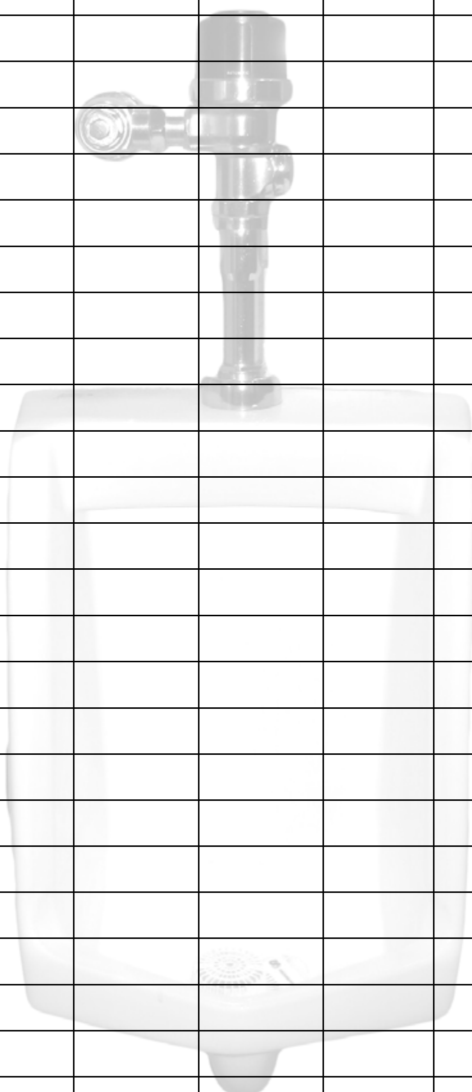
Building Name ___________________

Location	User Group	Manual or Sensor	Tank* or Valve	Marked Valve Flush Rate (gpf)	Marked China Flush Rate (gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Dye Test Results? Other Comments
Totals									

* For tank toilets, record measurement in square inches of the tank volume.
Tank length x width x height (of water fill) = Volume
***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals:, 0.5 gpf; Showerheads: 2.0 gpm.
Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 7. Urinals

Building Name ________________



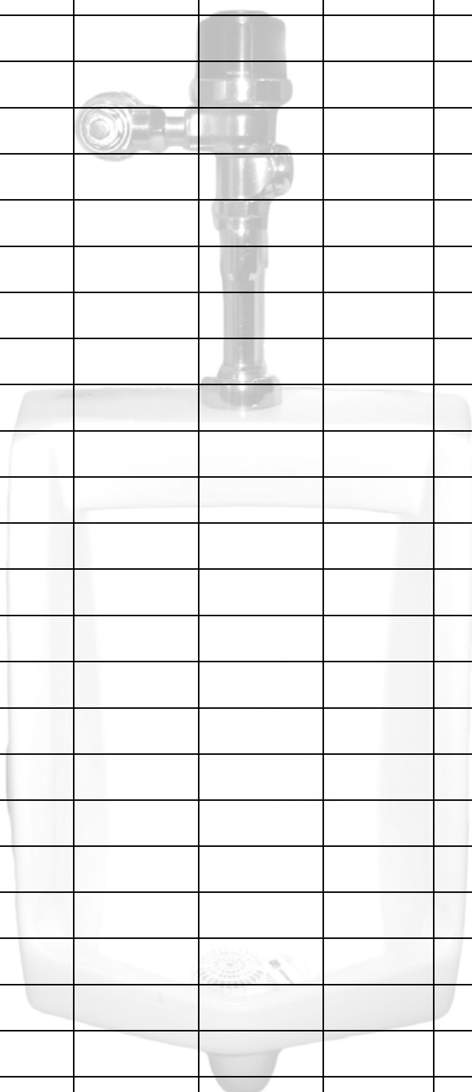
Location	User Group	Manual or Sensor	Marked Valve Flush Rate (gpf)	Marked China Flush Rate (gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
Totals								

***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at "A" or "1" with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 7. Urinals

Building Name ________________



Location	User Group	Manual or Sensor	Marked Valve Flush Rate (gpf)	Marked China Flush Rate (gpf)	Timed Flush Num. Secs.	Calc. Rate (gpm)	NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
Totals								

***High efficiency standards:** Toilets: 1.28 gpf; Lavatory Faucets: 0.5 gpm; Res. Kitchen Faucets: 1.5 gpm; Urinals: 0.5 gpf; Showerheads: 2.0 gpm.

Be sure to indicate individual fixtures in group lavatories as in: Toilet 1, Toilet 2, etc. Suggested methods include initiating a count at “A” or “1” with the fixture closest to the door or beginning to the left upon entering the room.

Worksheet 8. Appliances

Dishwasher	Location		**Make/ Model**	**Quantity**	**Racks washed per day or week**	**Building hot water fuel type**	**Booster water heater fuel type**	**Operating days per year**	**ENERGY STAR Qualified?**
		Under Counter							
		Door Type							
Low Temp.		Single Tank Conveyor							
Or High Temp.		Multi Tank Conveyor							
Leaks or Other Comments									

Ice Machine	Location	**Make/ Model**	**Quantity**	**Harvest rate (pounds ice per day)**	**Potable water use (gallon per 100 pounds ice)**	**Operating days per year**	**ENERGY STAR Qualified?**
	Ice Making Head						
	Remote Condensing Unit /Split System						
	Self Contained Unit						
Leaks or Other Comments							

Clothes Washer	Location How is water for each unit heated?	**Make/ Model**	**Quantity**	**Average number of loads per week**	**Type of water heating**	**Type of clothes dryer**	**Electric or Gas Drier**	**ENERGY STAR Qualified?**
	Electric Heat							
	Gas Heat							
Leaks or Other Comments								

Worksheet 8. Appliances

Dishwasher	Location		**Make/ Model**	**Quantity**	**Racks washed per day or week**	**Building hot water fuel type**	**Booster water heater fuel type**	**Operating days per year**	**ENERGY STAR Qualified?**
		Under Counter							
		Door Type							
Low Temp.		Single Tank Conveyor							
Or High Temp.		Multi Tank Conveyor							
Leaks or Other Comments									

Ice Machine	Location	**Make/ Model**	**Quantity**	**Harvest rate (pounds ice per day)**	**Potable water use (gallon per 100 pounds ice)**	**Operating days per year**	**ENERGY STAR Qualified?**
	Ice Making Head						
	Remote Condensing Unit /Split System						
	Self Contained Unit						
Leaks or Other Comments							

Clothes Washer	Location How is water for each unit heated?	**Make/ Model**	**Quantity**	**Average number of loads per week**	**Type of water heating**	**Type of clothes dryer**	**Electric or Gas Drier**	**ENERGY STAR Qualified?**
	Electric Heat							
	Gas Heat							
Leaks or Other Comments								

Worksheet 9. Commercial-Grade Kitchen Appliances

Dishwasher	Location		**Make/ Model**	**Quantity**	**Racks washed per day**	**Building hot water fuel type**	**Booster water heater fuel type**	**Operating days per year**	**ENERGY STAR Qualified?**
		Under Counter							
		Door Type							
Low Temp.		Single Tank Conveyor							
Or High Temp.		Multi Tank Conveyor							
Leaks or Other Comments									

Ice Machine	Location	**Make/ Model**	**Quantity**	**Harvest rate (pounds ice per day)**	**Potable water use (gallon per 100 pounds ice)**	**Operating days per year**	**ENERGY STAR Qualified?**
	Ice Making Head						
	Remote Condensing Unit /Split System						
	Self Contained Unit						
Leaks or Other Comments							

Steam Cooker	Location	**Make/ Model**	**Quantity**	**Pounds of food cooked per day per unit**	**Number of pans per unit**	**Operating hours per day**	**Operating days per year**	**ENERGY STAR Qualified?**
	Electric							
	Natural Gas							
Leaks or Other Comments								

Clothes Washer	Location How is water for each unit heated?	**Make/ Model**	**Quantity**	**Average number of loads per week**	**Type of water heating**	**Type of clothes dryer**	**Electric or Gas Drier**	**ENERGY STAR Qualified?**
	Electric Heat							
	Gas Heat							
Leaks or Other Comments								

Combi Oven	Location	**Make/ Model**	**Quantity**	**Operating hours per day**	**Operating days per year**	**Pounds of food cooked per day per oven**
	Electric Heat					
	Gas Heat					
Leaks or Other Comments						

See Worksheet 10 for Commercial-Grade Kitchen Fixtures.

Worksheet 9. Commercial-Grade Kitchen Appliances

Dishwasher	Location			Make/ Model	Quantity	Racks washed per day	Building hot water fuel type	Booster water heater fuel type	Operating days per year	ENERGY STAR Qualified?
			Under Counter							
			Door Type							
Low Temp.			Single Tank Conveyor							
Or High Temp.			Multi Tank Conveyor							
Leaks or Other Comments										

Ice Machine	Location		Make/ Model	Quantity	Harvest rate (pounds ice per day)	Potable water use (gallon per 100 pounds ice)	Operating days per year	ENERGY STAR Qualified?
		Ice Making Head						
		Remote Condensing Unit /Split System						
		Self Contained Unit						
Leaks or Other Comments								

Steam Cooker	Location		Make/ Model	Quantity	Pounds of food cooked per day per unit	Number of pans per unit	Operating hours per day	Operating days per year	ENERGY STAR Qualified?
		Electric							
		Natural Gas							
Leaks or Other Comments									

Clothes Washer	Location	How is water for each unit heated?	Make/ Model	Quantity	Average number of loads per week	Type of water heating	Type of clothes dryer	Electric or Gas Drier	ENERGY STAR Qualified?
		Electric Heat							
		Gas Heat							
Leaks or Other Comments									

Combi Oven	Location		Make/ Model	Quantity	Operating hours per day	Operating days per year	Pounds of food cooked per day per oven
		Electric Heat					
		Gas Heat					
Leaks or Other Comments							

See Worksheet 10 for Commercial-Grade Kitchen Fixtures.

Worksheet 10. Commercial-Grade Kitchen Fixtures

Location	Hand Faucet	Pre-Rinse Spray Valve	Marked (gpm)	Timed			Leaks? Comments
				Num. of Cups/ Pints/ Quarts.	Num. Secs.	Calc. Rate (gpm)	

See Worksheet 9 for Commercial-Grade Kitchen Appliances.

Worksheet 10. Commercial-Grade Kitchen Fixtures

Location	Hand Faucet	Pre-Rinse Spray Valve	Marked (gpm)	Timed			Leaks? Comments
				Num. of Cups/ Pints/ Quarts.	Num. Secs.	Calc. Rate (gpm)	

See Worksheet 9 for Commercial-Grade Kitchen Appliances.

Worksheet 11. Cooling Tower Water Use – Basic Audit

Cooling Tower General Observations

a) Cooling tower location ___________________________________

b) Tons of cooling capacity (if known) _________________________

c) Are flow meters or submeters present on feedlines (circle one)? YES / NO

d) Are flow meters or submeters present on drainlines (circle one)? YES / NO

e) Is the tower a closed loop (not once through) (circle one)? YES / NO

f) At how many cycles is the tower currently be run at?
(you may have to consult with your maintenance vendor). ________

g) Looking at Table 14, what percentage of total water use would be saved if the cycles of concentration were increased from the current level to five or six? ________

h) Indicate the visible condition of the cooling tower:

	None	*Very little	Some	A lot	Where?
Noticeable leaks					
Noticeable corrosion					
Mineral precipitate scaling on the heat exchangers, condenser tubes, or elsewhere					
Algae or slime (biofouling)					
Drift (misting)					

*This would account for a small amount at the interface where the air hits the corrugated heat exchangers, condenser tubes, etc.

Worksheet 11. Cooling Tower Water Use – Basic Audit

Cooling Tower General Observations

a) Cooling tower location ___________________________________

b) Tons of cooling capacity (if known) _________________________

c) Are flow meters or submeters present on feedlines (circle one)? YES / NO

d) Are flow meters or submeters present on drainlines (circle one)? YES / NO

e) Is the tower a closed loop (not once through) (circle one)? YES / NO

f) At how many cycles is the tower currently be run at?
(you may have to consult with your maintenance vendor). ________

g) Looking at Table 14, what percentage of total water use would be saved if the cycles of concentration were increased from the current level to five or six? ________

h) Indicate the visible condition of the cooling tower:

	None	*Very little	Some	A lot	Where?
Noticeable leaks					
Noticeable corrosion					
Mineral precipitate scaling on the heat exchangers, condenser tubes, or elsewhere					
Algae or slime (biofouling)					
Drift (misting)					

*This would account for a small amount at the interface where the air hits the corrugated heat exchangers, condenser tubes, etc.

Worksheet 12 Irrigation Schedule and Controller – Basic Audit

	Sun.	Mon.	Tue.	Wed.	Thurs.	Fri.	Sat.
Permitted Irrigation Days/Hours							
Current Setting (Days/Hours)							

Is the current run schedule in accordance with local permitted watering days?......Yes No

Zone/Station Number	Runtime Duration (in minutes)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Zone/Station Number	Runtime Duration (in minutes)
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	

All "No" responses should be reviewed for corrective action.
Refer to the Post-Audit Considerations and Additional Activities section.

Worksheet 12 Irrigation Schedule and Controller – Basic Audit

	Sun.	Mon.	Tue.	Wed.	Thurs.	Fri.	Sat.
Permitted Irrigation Days/Hours							
Current Setting (Days/Hours)							

Is the current run schedule in accordance with local permitted watering days?......Yes No

Zone/Station Number	Runtime Duration (in minutes)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Zone/Station Number	Runtime Duration (in minutes)
13	
14	
15	
16	
17	
18	
19	
20	
21	
22	
23	
24	

All "No" responses should be reviewed for corrective action.
Refer to the Post-Audit Considerations and Additional Activities section.

Worksheet 13 Rain and Soil Moisture Sensor Survey

Rain Sensor Survey – Basic Audit		
See Cheatsheet Notes 11 - 13.		
Rain Sensor Location ________________________________		
Is the sensor located away from all building eves, gutter downspouts, trees, or other structures that would impede rainfall?	Yes	No
Is the sensor located close to an air conditioning condensate line or another source of water than may saturate the sensor?	Yes	No
Visually inspect the sensor		
Does the cork look fresh and soft, not brittle and dry?	Yes	No
Do the wires look intact?	Yes	No

Rain Sensor Survey –Advanced Audit		
Did the sensor successfully interrupt the irrigation event?	Yes	No

Soil Moisture Sensor Survey – Basic Audit		
See Cheatsheet Notes 14 - 16.		
Soil Moisture Sensor Location		
Is the sensor located away from all building eves, gutter downspouts, trees, or other structures that would impede rainfall?	Yes	No
Is the sensor located close to an air conditioning condensate line or another source of water than may saturate the sensor?	Yes	No
Is the sensor located at or near the mid-point of an on-site slope?	Yes	No
Is the sensor located equidistant from the closest group of sprinkler heads?	Yes	No
Soil Moisture Sensor Survey – Advanced Audit		
Did the sensor successfully interrupt the irrigation event?	Yes	No

See the Landscape and Irrigation Cheatsheet in Appendix C for further explanation. Also refer to Guidebook pages 99 and 150.

All “No” responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each applicable audit procedure.

Worksheet 13 Rain and Soil Moisture Sensor Survey

Rain Sensor Survey – Basic Audit		
See Cheatsheet Notes 11 - 13.		
Rain Sensor Location ________________________________		
Is the sensor located away from all building eves, gutter downspouts, trees, or other structures that would impede rainfall?	Yes	No
Is the sensor located close to an air conditioning condensate line or another source of water than may saturate the sensor?	Yes	No
Visually inspect the sensor		
Does the cork look fresh and soft, not brittle and dry?	Yes	No
Do the wires look intact?	Yes	No

Rain Sensor Survey –Advanced Audit		
Did the sensor successfully interrupt the irrigation event?	Yes	No

Soil Moisture Sensor Survey – Basic Audit		
See Cheatsheet Notes 14 - 16.		
Soil Moisture Sensor Location		
Is the sensor located away from all building eves, gutter downspouts, trees, or other structures that would impede rainfall?	Yes	No
Is the sensor located close to an air conditioning condensate line or another source of water than may saturate the sensor?	Yes	No
Is the sensor located at or near the mid-point of an on-site slope?	Yes	No
Is the sensor located equidistant from the closest group of sprinkler heads?	Yes	No
Soil Moisture Sensor Survey – Advanced Audit		
Did the sensor successfully interrupt the irrigation event?	Yes	No

See the Landscape and Irrigation Cheatsheet in Appendix C for further explanation. Also refer to Guidebook pages 99 and 150.

All "No" responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each applicable audit procedure.

Worksheet 14. Cooling Tower Water Use – Advanced Audit

Use one of the two table sets below.

Table Set 1: Use if the cooling tower is equipped with makeup and bleed-off meters.

1. Enter average or 'typical' load in tons >>>	
2. Enter hrs/day of operation>>>	
3. Enter days/month operation	

***Refer to** Error! Reference source not found. **on page 79 in the guide to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 5.**

4. Enter that percentage here >>>>>		%

	Meter Data Input Table					
Table Set 1: WATER CONSUMPTION CALCULATIONS	**Date**	**Time**	**Hours between Readings**		**Make-Up Meter Reading**	**Bleed-Off Meter Reading**
Day 1				Begin		
				End		
Day 2				Begin		
				End		
Day 3				Begin		
				End		

Transfer this information to the *Cooling Towers* spreadsheet.

Table Set 2 is on the following page.

Worksheet 14. Cooling Tower Water Use – Advanced Audit (continued)

Table Set 2: Use if the cooling tower is equipped with conductivity meters or another means to calculate dissolved solid concentrations in makeup and bleed-off water.

1. Enter tons of cooling >>>	
2. Enter hrs/day of operation>>>	
3. Enter days/month operation	

***Refer to** Error! Reference source not found. **on page 79 in the guide to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 5.**

4. Enter that percentage here >>>>> ______ %

Table Set 2: WATER CONSUMPTION CALCULATIONS	Date	Make-Up Concentration (TDS)	Bleed-off Concentration (TDS)

Transfer this information to the *Cooling Towers* spreadsheet.

Worksheet 15. Facility Water Balance

Water Use	Gallons per Month/Quarter/year
Boiler make-up	
Cooling tower make-up	
Processes and equipment operations	
Steam cleaning	
Materials transport	
Domestic (restrooms, breakrooms)	
Toilets	
Urinals	
Faucets	
Showerhead	
Other faucets (Non-Lavatory)	
Residential dishwasher	
Commercial-grade kitchen	
Pre-rinse spray valves	
Dishwashers	
Ice machines	
Commercial clothes washers	
Vehicle fleet wash	
Once-through cooling	
Landscape irrigation	
Breakroom water use	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Known leaks	
***Water purchased + well pumpage**	

*Enter Metered Volume

Worksheet 15. Facility Water Balance

Water Use	Gallons per Month/Quarter/year
Boiler make-up	
Cooling tower make-up	
Processes and equipment operations	
Steam cleaning	
Materials transport	
Domestic (restrooms, breakrooms)	
Toilets	
Urinals	
Faucets	
Showerhead	
Other faucets (Non-Lavatory)	
Residential dishwasher	
Commercial-grade kitchen	
Pre-rinse spray valves	
Dishwashers	
Ice machines	
Commercial clothes washers	
Vehicle fleet wash	
Once-through cooling	
Landscape irrigation	
Breakroom water use	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Other:	
Known leaks	
***Water purchased + well pumpage**	

*Enter Metered Volume

Irrigation and Landscape Field Audit Worksheet

	Irrigation Need	If Annuals or Perennials; Trees/Shrubs			General Plant Type		Sprinkler Types				Sprinkler Functinality	
	See Cheatsheet Note 1	See Cheatsheet Notes 2 - 4			See Cheatsheet Note 5		See Cheatsheet Notes 6 - 8				See Cheatsheet Note 9	
Zone	Does this zone 'need' irrigation at all?*	Trees/ Shrubs recently installed?*	Is there adequate mulch? (3")*	Is mico-irrigation used?*	Turf, Annual/ Perennial, or Trees/ Shrubs	More than one gen. plant type in zone?*	Indicate type: Rotor; Sprayhead; or Micro	All same type throughout zone?*	All same Brand throughout zone?*	Sprinker type matches plants?*	Indicate Clogged; Tilted; Obstructed; Broken heads	Wetting pattern covering only the intended area?*

See the Landscape and Irrigation Cheatsheet for section-by-section explanations. Also refer to Guidebook page 90.
***All "No" responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each relevant audit procedure.**

Irrigation and Landscape Field Audit Worksheet

	Prudent Use of Turf? See Cheatsheet Note 10		Plants in Plantbeds See note at right >	Using a plant guide book, such as the WaterWise Plant Guide, for your area, identify all non-turfgrass plant material.
Zone	Does the zone contain turf?	If turf is present, does it serve purpose? (Swale, recreation area, erosion control etc.)*	Do all plants in this zone have similar light & irrigation needs?*	Additional Notes
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

See the Landscape and Irrigation Cheatsheet for section-by-section explanations. Also refer to Guidebook page 146.

***All “No” responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each relevant audit procedure.**

Irrigation and Landscape Cheat Sheet

The notes below correspond to a line on the Irrigation and Landscape Audit Worksheet indicated by the number preceding each notation.

This cheat sheet is not meant to take the place of the Post-Audit sections of the Irrigation and Landscape audit procedures. It is meant to serve as a quick reference. The Post-Audit sections of each relevant procedure should be reviewed after conducting the survey.

In general, you will be investigating the most basic settings of the controller as well as the landscape plantings and irrigation hardware in each zone. **Although presented separately for descriptive purposes, you will be performing more than one audit procedure concurrently (by default) as you survey each zone.** For this reason, the irrigation and landscape worksheets have been combined for your convenience.

1- Zones or parts of zones that may not necessitate irrigation include areas with mature trees and shrubs, areas not used, viewed or visited by facility staff or the general public, such as a narrow, non-traffic alleyway or an area behind a dumpster etc. Be sure to investigate the watering needs of small shrubs before removing them from the irrigation system.
2- Zones with annual or perennial plants should have approximately 3 inches of mulch; zones dominated by trees/shrubs may also benefit from a mulch layer.
3- If they are mature or were installed more than one year ago, they may not require irrigation. This zone should be further evaluated for removal from the irrigation system.
4- Microirrigation is the only class of sprinkler which should be used for annuals, perennials, trees and shrubs.
5- There should be only type one per zone. The three 'General' plant types are: turfgrass; annuals/perennials; trees/shrubs.
6- Rotors and sprayheads should be used for lawns or turfgrass (sprayheads are not recommended for irrigation of plants and shrubs); only microirrigation should be used for plants and shrubs. See the next page for photos of each.
7- There should be only one.
8- Matched brands are more likely to have matched application rates.*
9- If the emitters are spraying impervious areas or structures, they should be adjusted to maintain patterns covering only the landscaped material.
10- Turfgrass has high irrigation requirements. It should be used to fulfill needs such as recreational areas or in swales, etc. and should not be used as a space filler.
11- Rain sensors should not be located under anything which could impede rainfall or allow water from source other than rain to fall upon it.
12- The cork should be fresh and spongy. They typically last between two and three years. The wires should be connected, unafraid, and protected from the elements.
13- Soil moisture sensors should not be located in an area where rainfall could be impeded or where water from a source other than rain could cause soil moisture in the immediate area to increase.
14- Soil moisture sensors should be located near the mid-point of any on-site slope in an open area among vegetation with the highest watering requirements.
15- Soil moisture sensors should be located equidistant from sprinkler heads.

* Irrigation sprinklers do not always clearly indicate their flow rate in gallons per minute. Determining the precipitation rate of installed sprinklers requires a high level of familiarity with irrigation equipment or requires substantial time and effort for research. This is not part of this simplified audit. Instead, check all sprinkler heads in the zone to ensure they are the same type (rotor, spray, or micro) and the same brand. While being the same type and brand does not necessarily indicate uniformity of precipitation rate, more than one type or brand in a zone most likely means water is delivered unevenly.

(Continued on next page)

Photos of Common Irrigation Sprinklers

Rotor used to irrigate
open areas of turf.

Sprayhead emitters.

Micro-irrigation emitter.

Another example of
a micro-irrigation emitter.

Florida Focus

Runtime ranges for irrigation sprinkler types based on vegetation and seasonal needs.

Sprinkler Type		Winter	Fall	Spring	Summer	Most-Suited Vegetation
Rotors	**Ideal**	<10	30	40	45	Turfgrass
	Range	0 – 20	20 – 40	35 – 55	40 – 60	
Sprayheads*	**Ideal**	0	15	20	25	Turfgrass
	Range	0 – 10	10 – 20	15 – 20	20 – 30	
Micro-irrigation		15 – 35	15 – 35	15 – 35	15 – 35	Annuals and Perennials

Source: Green Industry Best Management Practices (GI BMPs) (DEP 2008)
*Sprayheads are actually designed to irrigate turf or lawns, but are often used to irrigate plants and shrubs if they are equipped with a low-flow nozzle. This practice is not recommended. Only micro-irrigation should be used in plant beds.

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