

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

A Guide for Facility Managers



South Florida Water Management District
Water Supply Development Section

West Palm Beach, Florida

This page intentionally left blank.

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

A GUIDE FOR FACILITY MANAGERS



**South Florida Water Management District
Water Supply Development Section
West Palm Beach, Florida
August 2011
Updated April 2012**

Is this Guide for You?

This guide highlights common opportunities to improve water efficiency in commercial and institutional facilities. It is also intended to provide information on potential efficiency gains and the benefits they can provide.

The heart of this manual, the audit steps, is intended for facility managers, building maintenance professionals, and others interested in increasing water efficiency in commercial and institutional facilities. This guide will assist a facility manager identify and perform numerous water efficiency improvements.

This manual is highly comprehensive and can be used as a guide to identify operational areas where increased water efficiency may be possible. Managers will likely find this information useful for making decisions regarding how to budget for potential water efficiency improvements and the expected returns on such investments.

Acknowledgements

This manual has been prepared by Robert Wanvestraut, Water Conservation Analyst, South Florida Water Management District (District), with the assistance and support of the District's Water Supply Development Division: Natalie Schneider, Dawn Rose, Jesus Rodriguez, Nestor Garrido, Jane Bucca, and David Allen. Nathan Yates, also of the District, provided technical editing and document formatting support.

An external committee reviewed the material for technical completeness, accuracy, and general guidance. The commitment, efforts, and assistance of the following individuals are greatly appreciated:

- Kathy Scott, Southwest Florida Water Management District
- Bill Hoffman, Water Management Inc., formerly of the Texas Water Development Board
- Russ Horner, Water Management Inc.
- David DeMaio, Palm Beach County Soil and Water Conservation District
- Max Castaneda, St. Johns River Water Management District
- Maribel Balbin, Office of Sustainability, Miami-Dade County

Appreciation is also extended to the following individuals and organizations for their assistance:

- David Zabrowsky, Food Technology and Service Center
- Lauren Mattison, Cadmus Group, Inc., Consultant to ENERGY STAR
- Mary McCready, University of Florida/Miami-Dade County Extension Service
- Michael Gutierrez, University of Florida, Tropical Research and Education Center
- California Urban Water Conservation Council

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

Contents

I. Introduction	1
Background.....	1
Why We Are Doing This.....	2
How to Initiate a Water Use Efficiency Improvement Program	3
What is a Water Use Audit?	3
Ensuring Program Success and Savings into the Future.....	4
Water Use in CI Facilities	5
Typical Water Use by Facility Type.....	7
Benchmarks	10
Potential Savings	10
Best Management Practices.....	11
Conservation Standards and Resources	11
Recommendations on How to Proceed.....	12
II. How to Use this Manual	13
Is this Manual for You?	13
Audit Levels and Sections	13
Audit Organization and Associated Spreadsheets	14
Tips for Easier Data Entry	16
III. Level One and Level Two Audits	19
Overview.....	19
Meter and Submeter Audit – Level One.....	20
Facility Leak Detection – Level One.....	23
Estimating Daily Facility Water Use – Level One.....	26
General Domestic Water Use – Level One	31
General Domestic Water Use – Level Two	50
Commercial-Grade Kitchen Water Use Audit – Level One.....	68
Commercial-Grade Kitchen Water Use Audit – Level Two.....	77
Cooling Tower Water Use – Level One.....	88
Cooling Tower Water Use – Level Two.....	93

Contents

IV. Outdoor Irrigation and Landscaping	101
General Overview	101
Considerations for Efficient Outdoor Irrigation and Landscaping	102
Irrigation Schedule and Controller – Level One	104
Irrigation Schedule and Controller – Level Two	107
Irrigation System and Landscape Survey – Level One	111
Irrigation System and Landscape Survey – Level Two.....	119
Rain and Soil Moisture Survey – Level One.....	123
Rain and Soil Moisture Survey – Level Two.....	128
Irrigation System Distribution Uniformity, Application Rate and Calibration Audit – Level One.....	131
V. Level Three: Strengthening Decision-Making Power for Efficiency Improvement Planning	139
General Overview	139
Creating a Facility Water Balance – Level Three	140
Determine the True Cost of Water at a Facility – Level Three	144
Historical Water Use Profile – Level Three.....	146
Identifying On-Site Alternative Water Sources – Level Three.....	149
VI. Related Resources	153
References Cited.....	153
Resources for Water Use and Savings Calculators	155
Additional Resources and Websites	156

Appendices

- Appendix A. How to Read Your Water Meter
- Appendix B. Best Management Practices for Commercial and Institutional Buildings
- Appendix C. Worksheets

Tables

Table 1.	Benchmarks for annual water use in various facility types.....	10
Table 2.	Estimated potential water savings achieved by retrofitting various fixtures and appliances in non-residential structures.	11
Table 3.	Recommended testing intervals for various water meter sizes.....	21
Table 4.	Amount of water lost at various leakage rates.	23
Table 5.	Gallons per use of common residential indoor water fixtures and appliances.	31
Table 6.	Comparison of water and energy use, consumption, and cost of standard and efficient ice machines.....	40
Table 7.	Conversions to gallons per minute for containers of several common sizes.....	48
Table 8.	Flush volume flow rate calculator for the valve-flush, timed-flush test	49
Table 9.	Tank flush volumetric calculator.	49
Table 10.	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.	73
Table 11.	A comparison of food waste disposal methods.	74
Table 12.	Water savings from increased concentration ratios in cooling towers.	94
Table 13.	Runtime ranges (in minutes) for irrigation sprinkler types based on vegetation and seasonal needs.	107
Table 14.	Operational and system design factors commonly affecting irrigation system efficiencies.	111
Table 15.	Potential savings from a properly functioning rain sensor and soil moisture sensor.....	126
Table 16.	Average monthly rainfall for selected Florida locations.	151

Worksheets

Worksheet 1. Meters and Submeters..... 22

Worksheet 2. Facility Leak Audit – Level One..... 25

Worksheet 3. Estimating Irrigation Water Use – Level One..... 30

Worksheet 4. Faucets 43

Worksheet 5. Toilets..... 44

Worksheet 6. Urinals 45

Worksheet 7. Showerheads..... 46

Worksheet 8. Appliances 47

Worksheet 9. Commercial-Grade Kitchen Appliances..... 75

Worksheet 10. Commercial-Grade Kitchen Fixtures 76

Worksheet 11. Cooling Tower Water Use – Level One 92

Worksheet 12. Cooling Tower Water Use – Level Two 99

Worksheet 13. Irrigation Schedule and Controller – Level One 106

Worksheet 14. Irrigation Schedule and Controller – Level Two 110

Worksheet 15. Irrigation System and Landscape Survey – Level One..... 117

Worksheet 16. Irrigation System and Landscape Survey – Level Two 122

Worksheet 17. Rain & Soil Moisture Sensor Survey – Level One 127

Worksheet 18. Rain and Soil Moisture Sensor Survey – Level Two..... 130

Worksheet 19. Facility Water Balance..... 143

Note: For printing purposes, see Appendix C for all worksheets.

Abbreviations and Acronyms

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

This page intentionally left blank.

I. Introduction

Background

Water links the environment, economy, and quality of life in South Florida. Just as abundant water gives vitality to our region, a lack of water strains natural resources, stifles economic growth, and disrupts our daily routines.

We are surrounded by water, which may make Florida seem an unlikely place for water shortages. However, much of that water is unusable without expensive and energy-intensive processing. Therefore, groundwater fulfills most of the region's water needs.

Groundwater is limited and explosive population growth in recent decades has increased pressure on the available supply. With increasing use, salt water from the ocean is able to infiltrate into the groundwater, making it undrinkable.

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

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 our community, region, state, 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, regional, and state 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. Consistently applied and lasting water conservation practices are and will continue to be a vital component to successfully meet South Florida's water needs.

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.

I. Introduction

Why We Are Doing This

Commercial and industrial facilities (CI) in Florida use large amounts of water. According to the U.S. Geological Survey, they consume over 1 billion gallons of fresh water each day (USGS 2009). This is approximately 16 percent of the total fresh water used in Florida (**Figure 1**). Increasing water efficiency among these facilities can greatly reduce overall water use.

As part of the South Florida Water Management District's mission to protect the regional water supply, this manual 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 short- 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

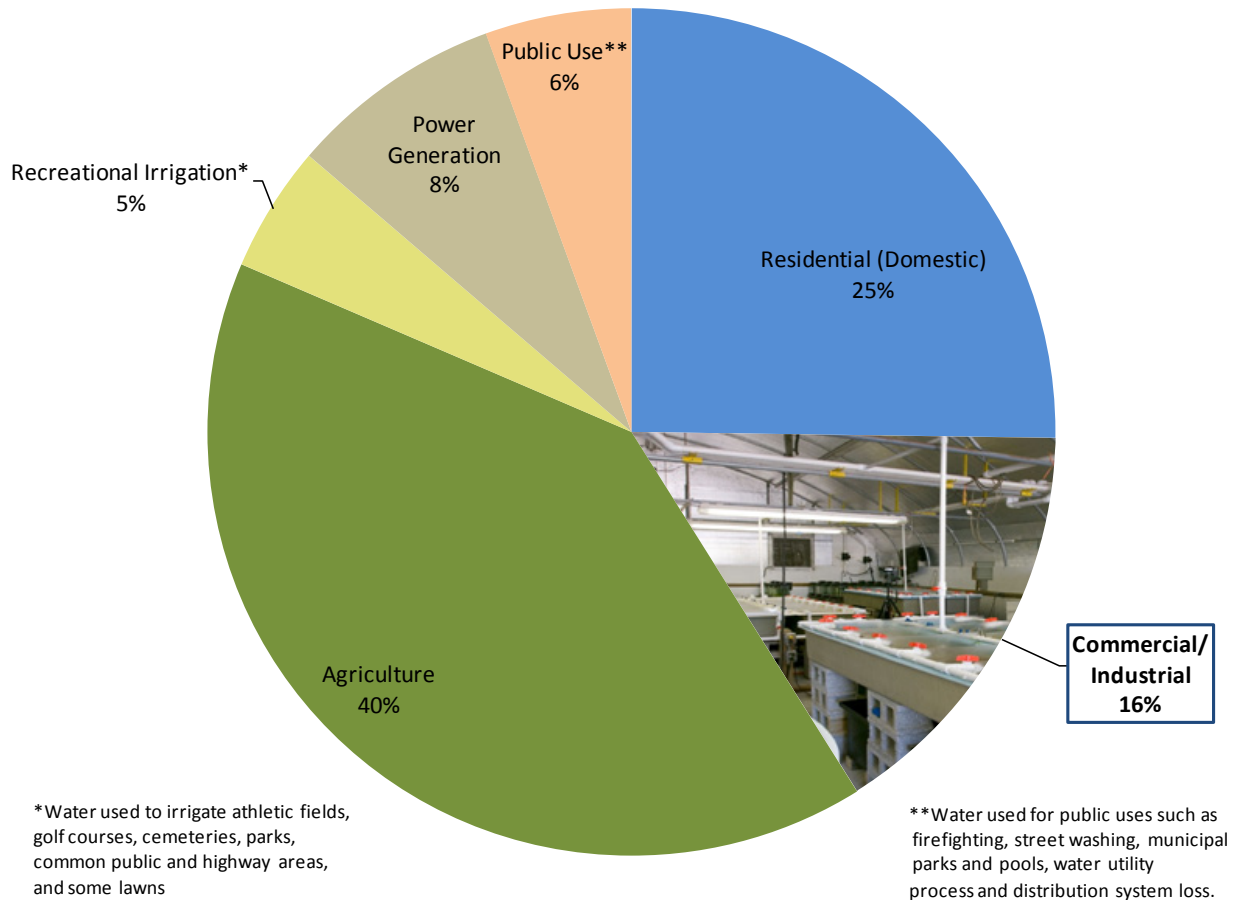


Figure 1. Water use in Florida (USGS 2009).

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 the current water use situation (which is the point of this manual)
2. Creating a plan in response to the audit
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

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 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 erosion 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 manual provides guidance on conducting thorough water use 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:

- ◆ **Full-facility water use 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 manual. An overview of the audit procedures covered in this guide are outlined in **Box 1**.



I. Introduction

Box 1. Audit Procedures

Full-Facility Water Use

Meters and Submeters	Level One
Facility Leaks	Level One
Estimating Daily Facility Water Use	Level One
General Domestic Water Use	Level One and Level Two
Commercial-Grade Kitchens	Level One and Level Two
Cooling Towers	Level One and Level Two

Outdoor Irrigation and Landscaping

Irrigation Schedule and Controller	Level One and Level Two
Irrigation System and Landscape Survey	Level One and Level Two
Rain and Soil Moisture Sensor Survey	Level One and Level Two
Irrigation System Distribution Uniformity, Application Rate and Calibration	Level One

Strengthening Decision Making Power for Efficiency Improvement Planning

Creating a Facility Water Balance	Level Three
Determining the True Cost of Water	Level Three
Historical Water Use Profile	Level Three
Identifying On-Site Alternative Water Sources	Level Three

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 attain full backing before attempting to increase water use efficiency at a facility. In fact, having preliminary calculations of potential savings may help earn managerial support. 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.

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

Management

- ◆ Establish specific major goals for the program

- ◆ Establish a Water Conservation Manager 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

Facilities 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 Manager
- ◆ Encourage other employees to reduce water use

Completing the water audits described in this document is a solid step toward creating a water

efficient environment at your facility. In addition to the physical and process changes identified by the water use audit, 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 to the operating costs of your company can also 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 Conservation Officer to help maintain posted signs and repeat the business's conservation message.

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.

I. Introduction

Box 2. Examples of water uses in commercial and institutional facilities (EPA 2009)	
Indoor (Domestic) Water	
Kitchens, cafeterias, staff rooms <ul style="list-style-type: none"> • Faucets • Distilled/drinking water • Ice machines • Dishwashers • Garbage disposals • Food preparation Restrooms and showers <ul style="list-style-type: none"> • Faucets • Toilets and urinals • Showers 	Laundry – washing machines Sanitation <ul style="list-style-type: none"> • Facility cleaning • Sterilization/autoclaves • Equipment washing • Dust control • Container washing Processes – photographic and x-ray processing
Cooling and Heating	Outdoor Water Use
Cooling towers/evaporative coolers Boilers and steam systems Once-through cooling <ul style="list-style-type: none"> • Air conditioners • Air compressors • Hydraulic equipment • Degreasers • Rectifiers • Vacuum pumps 	Irrigation Pools and spas Decorative water features

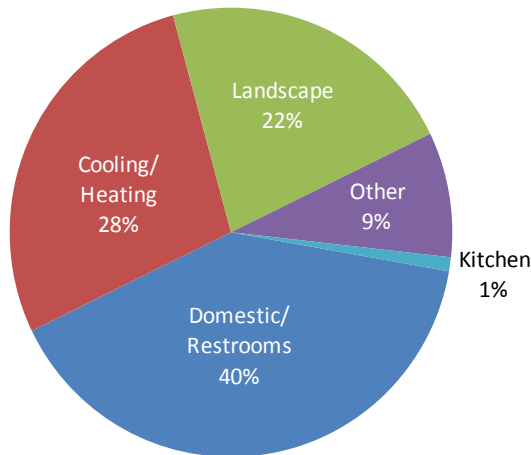
Typical Water Use by Facility Type

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 (**Figure 2**). 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



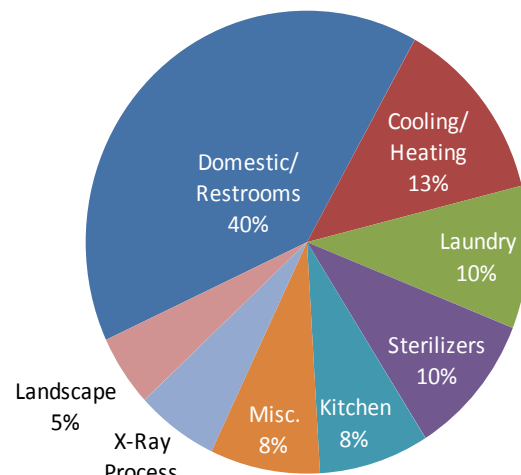
Source: City of San Jose, Environmental Services Department

Figure 2. Water usage in office buildings

Hospitals

Domestic/restroom uses account for 40 percent of water use in hospitals (**Figure 3**). Additionally, hospitals use a large percentage of water for processes such as x-ray development, sterilization, and laundry. Effective water efficiency measures for hospitals 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

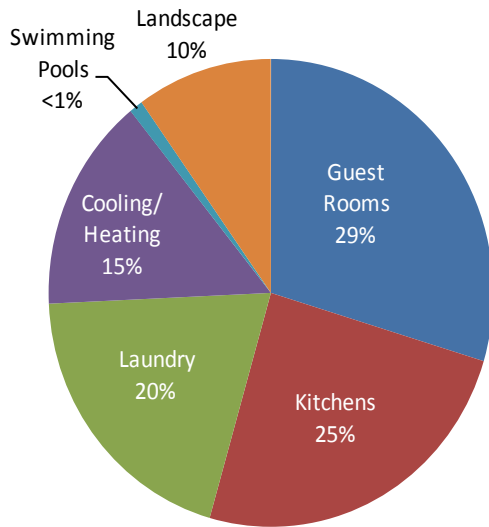
Figure 3. Water usage in hospitals

I. Introduction

Hotels and Motels

The combination of guestroom use, kitchens, and laundries accounts for 75 percent of water use in hotels and motels (**Figure 4**). Water efficiency measures include:

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



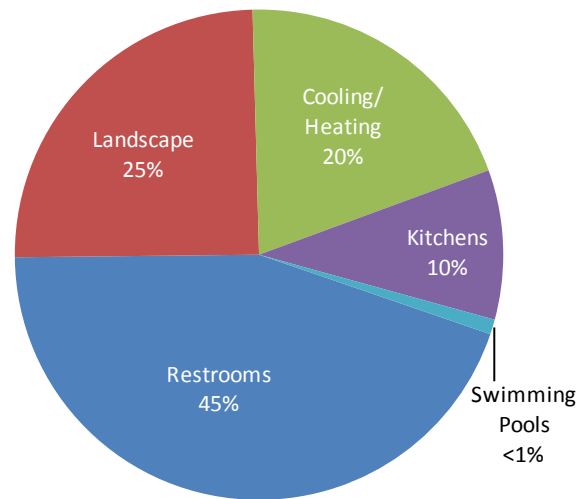
Source: City of San Jose, Environmental Services Department

Figure 4. Water usage in hotels and motels

Schools

Nearly half of the water used in schools is related to restrooms (**Figure 5**). 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

Figure 5. Water usage in schools

Conservation Tip

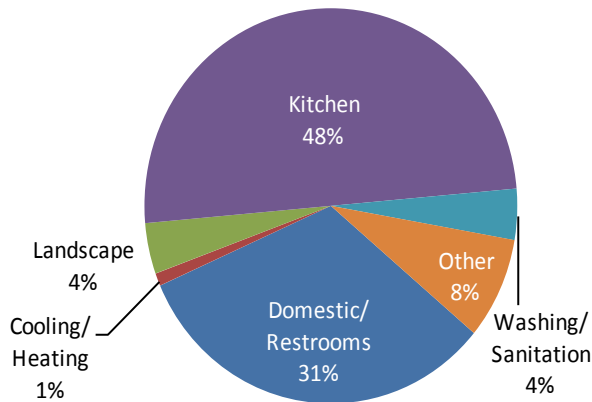
Always use a self-canceling hose nozzle when watering by hand or washing a car. An unattended hose can waste 6 gallons of water every minute.



Restaurants

Kitchen use accounts for just under half of the water used in restaurants with domestic/restroom use accounting for almost a third (**Figure 6**). 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



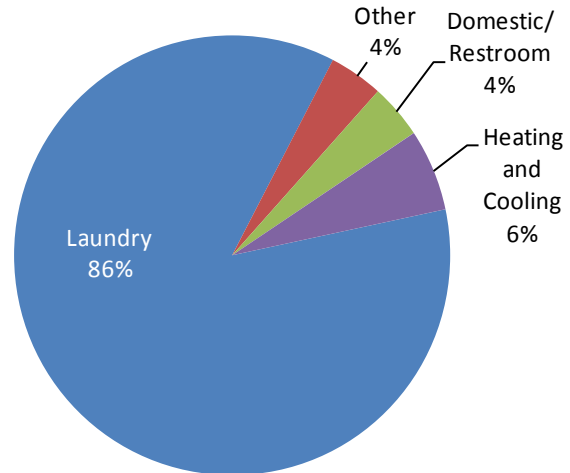
Source: EPA WaterSense Water Efficiency in the Commercial and Institutional Sector, 2009

Figure 6. Water usage in restaurants

Laundries

Virtually all water use in laundries is utilized in the wash process (**Figure 7**). 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



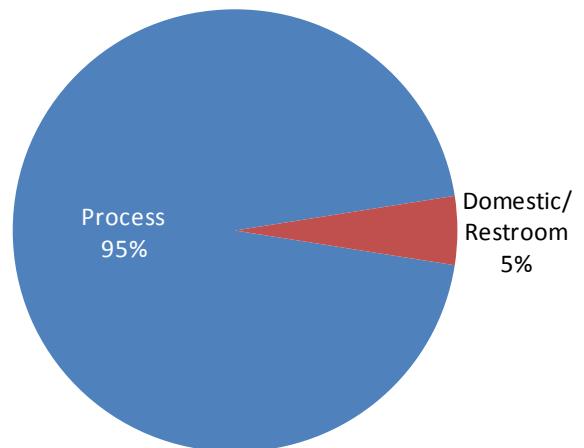
Source: EPA WaterSense Water Efficiency in the Commercial and Institutional Sector, 2009

Figure 7. Water usage in laundries

Car Washes

As with laundries, virtually all water use in car washes relates to the cleaning process (**Figure 8**). 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

Figure 8. Water usage in car washes

I. Introduction

Benchmarks

In studying water use and efficiency potential, conservation professionals tie water use to several benchmarks used to compare CI 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).

Another benchmark increasing in acceptance 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/ft²) per month or 0.103 gal/ft² per day (CFWC 2009).

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

Facility Type	Benchmark
Hotels/Motels	0.079–0.165 thousand gallons (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

Source: Colorado WaterWise Council (2007)

Regardless of the benchmark, each facility’s water use will vary depending on various factors, including 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.

Potential 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 savings potential.

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 parts of Florida, 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, solids, and 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 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 manual, 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.

Conservation Standards and Resources

Federal water efficiency standards for plumbing are antiquated (**Box 3**), but 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:** Industry leader in commercial kitchen energy efficiency and appliance performance (www.fishnick.com)

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), which limit "public" lavatory faucets to 0.5 gpm.

Recommendations on How to Proceed

While it is recommended that you read through this entire manual, we recognize that may not be possible 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.

Sections III, IV, and V contain the detailed procedures for conducting the water use audits and evaluating the results to determine potential water savings along with the cost effectiveness of the efficiency measures identified by the audit. These three sections were written for those tasked specifically with performing the water use audit, but it is also beneficial and

highly recommended that facility managers and others tasked with making the decisions on implementing the 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, other resources are 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.

II. How to Use this Manual

Is this Manual for You?

As stated earlier, a thorough water audit is the basis of your efficiency improvement plan and sets the foundation of the entire effort. The heart of this manual, the audit steps, is intended for facility managers, building maintenance professionals, and others interested in increasing water efficiency in CI facilities. This guide will help a facility manager identify and perform numerous water efficiency improvements.

Managers of various types of commercial and institutional facilities should benefit greatly from this manual. 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 manual 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 lead to the need for a more in-depth analysis. In these cases, a more specialized, professional evaluator is warranted.

Audit Levels and Sections

The audit procedures in this manual cover indoor and outdoor water use in an easy-to-follow, thorough format. The procedures have been divided into levels progressing in intensity and comprehensiveness (**Box 4**). The level-based structure was designed to accommodate managers with various degrees of experience in facility water use and efficiency.

As a user of the manual, you are not expected to commit to completing all tasks at a certain level. You can decide which procedures to complete at each level. This provides you with greater flexibility and expands your opportunities to discover areas to improve efficiency.

You may want to lightly review the entire manual before starting any audit procedure. To save time and effort, it is highly recommended that you **review the Level One and Level Two audit procedures 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 Level Two procedures may not require a significant amount of additional time or effort beyond Level One. For example, information for the Level One and Level Two procedures for assessing your facility's cooling tower can be done in a single visit.

Box 4. A brief description of the procedures found in the three levels

LEVEL ONE

All facility types can and should complete all Level One 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.

LEVEL TWO

Level Two 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 Level Two activities as completely as possible to determine if and where you need assistance.

LEVEL THREE

Level Three procedures guide you beyond basic efficiency improvements. These activities help 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.

Chapter Organization and Associated Spreadsheets

Each audit procedure in this manual is divided into three subsections. The first provides background information and a description of the procedure. The second outlines the steps of the audit procedure. The third provides information to help you evaluate the results and includes some suggested future actions.

Many of the procedures include one or more worksheets for recording information. Within the manual, these worksheets are at 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.

Nine companion spreadsheets in Microsoft Excel format are available for download from the District’s website with this manual. Six were

developed specifically to accompany this manual and three were developed by ENERGY STAR. The spreadsheets perform all necessary calculations for Level Two and Level Three audits. References to which spreadsheet to use occur with the appropriate procedure.

The companion spreadsheets are:

- ◆ Meters, Leaks, and Daily Water Use
- ◆ Domestic Plumbing Fixtures
- ◆ ENERGY STAR’s Residential Dishwashers
- ◆ ENERGY STAR’s Residential Clothes Washers
- ◆ ENERGY STAR’s Commercial Kitchen Equipment
- ◆ Supplemental Commercial Kitchen Equipment
- ◆ Cooling Towers
- ◆ Irrigation Water Use
- ◆ Level Three Facility-Wide Water Use Analysis

Guidance is provided for using all nine companion spreadsheets as part of the individual sections.

For the six spreadsheets designed specifically for this manual (those not created by ENERGY STAR), data is entered in white-shaded cells and the gray cells show the calculated results (Figure 9). 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 you enter your facility’s billing data on this tab (Figure 10), 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 calculator associated with this manual was 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, 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.

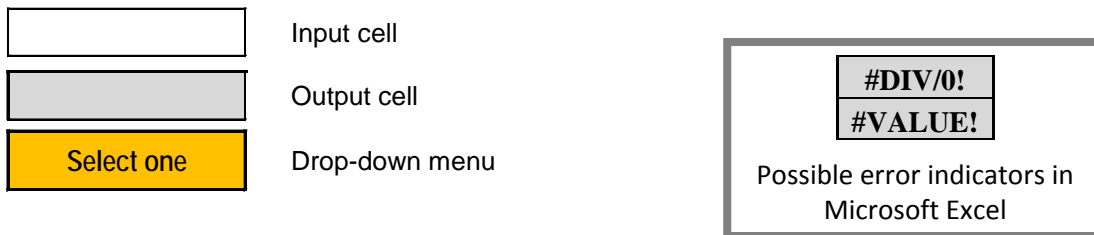


Figure 9. The three cell types used in the spreadsheets accompanying this manual.

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 10. The *Billing Data Input* table.

II. How to Use this Manual

Tips for Easier Data Entry

Most Level Two procedures require you to enter data into Microsoft Excel spreadsheets that complement this manual. 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 11 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 11a**).
- 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 11b**).
- 6) Once all the cells are covered, release the mouse and all cells will have the same information as the originally selected cell (**Figure 11c**).

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 12**.

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

a.

Manual or Sensor	Valve Type
Manual	-
-	-
-	-
-	-
-	-
-	-

b.

Manual or Sensor	Valve Type
Manual	-
-	-
-	-
-	-
-	-

c.

Manual or Sensor	Valve Type
Manual	-
Manual	-
Manual	-
Manual	-

Figure 11. 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-hand 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 12 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.

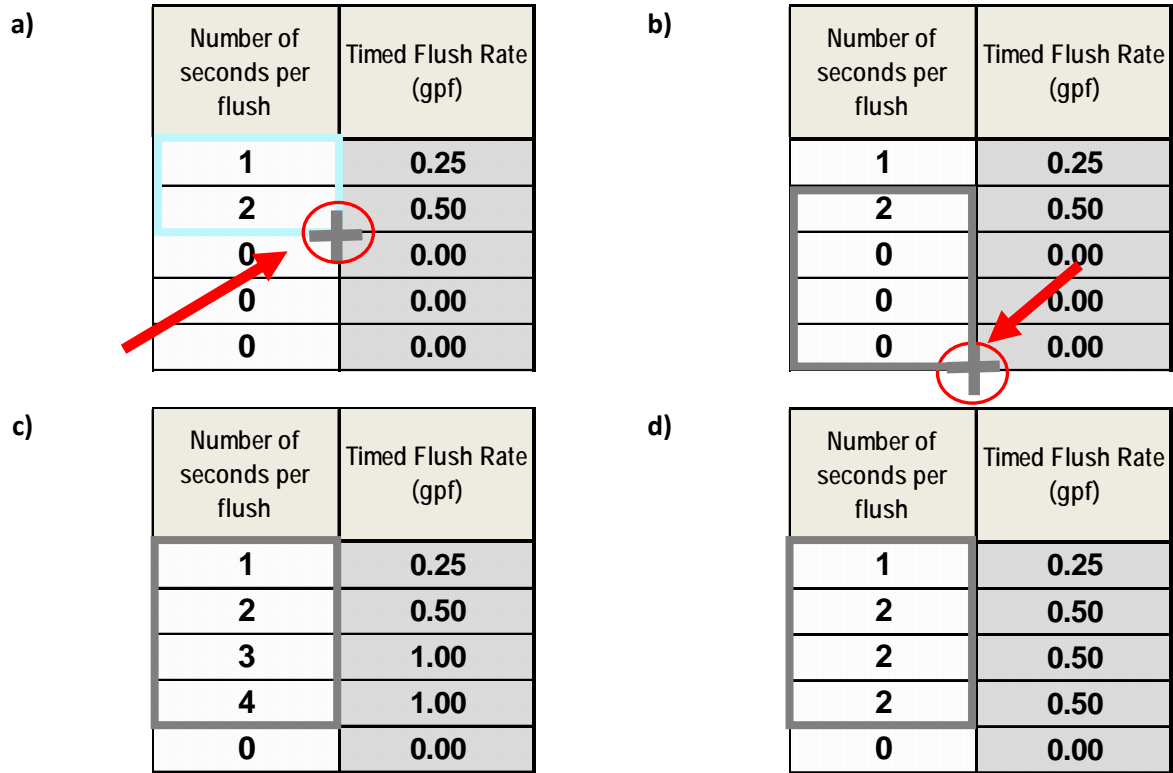


Figure 12. Dragging numeric data from one cell to repeat it in several other cells. **a)** The user has erroneously selected the first two cells in the column, when they actually only wanted to repeat the second one (the “2”). **b)** The mouse button is clicked, held down, and dragged over the cells where the data will be repeated. **c)** The mouse button is released, which sequentially increased the values of the populates 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.

This page intentionally left blank.

III. Level One and Level Two Audits

Overview

The procedures contained in this section describe the tasks required to complete the water audit. Each task is an independent procedure and those that do not apply to your facility can be omitted.



METER AND SUBMETER AUDIT – LEVEL ONE

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 facilities are metered. These meters are used for billing purposes. The utility charges a “water” rate per unit volume, which is typically in 1,000 gallon or 100 cubic foot (abbreviated ccf and equal to 748 gallons) increments.

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 consumption permit.

Facilities also are typically charged a “sewer” or “wastewater” rate to account for the costs for treating the water has been used. The wastewater volume is usually equal to the incoming 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 (Vickers 2001).

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 be applicable to some commercial facilities. Utilizing submeters at all practical points of consumption within your facility is recommended since they can provide valuable water use data and can 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. This can help identify the location of a leak if one of the meters is recording use during non-work hours or during a leak test. In addition, knowing what areas of the facility each meter records use for can help identify and measure the effect of efficiency improvement activities.

Audit Procedure

The procedure below 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. 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.
2. Prepare and examine Worksheet 1: Meters and Submeters.
3. Locate all meters and submeters in the facility.
4. Note the meter type (see Appendix A).
5. Note the date of last accuracy calibrations for each meter and submeter if known. If not known, the local water utility may have this on record.

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 2007)².



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

Meter Size	Testing Interval
½ and ¾ inch	Every 10 years
¾ inch	Every 8 years
1 inch	Every 6 years
1.5 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/issuearticle.asp?ArticleID=196 or go to www.flowcontrolnetwork.com, click on “Archive Articles,” and scroll to “July 2007, Verifying Flowmeter Accuracy.”

FACILITY LEAK DETECTION – LEVEL ONE

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 of only 1/32 inches in diameter (about the thickness of a dime) 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, 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).

An alternative method avoids shutting down the building’s cooling tower, which can be difficult or undesirable. If one person manually lifts 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.

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.

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 a variety of meter types.

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

Audit Procedure

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

Audit Steps

1. Prepare and examine Worksheet 2.
2. Ensure all water-using devices that can be are shut down.
3. Locate the inflow meter(s) to the facility. There may be more than one location.
4. For each meter, record the meter reading and time at the beginning of the shutdown period (*Initial Reading*).
5. Wait 15 to 60 minutes.*
6. Record the meter reading and time at the end of the shutdown period (*End Reading*).
7. Account for water consumption by any device left on during the shutdown period.
8. Subtract the Initial Reading from the End Reading. The difference should be zero if all equipment has been shut down.
9. Repeat steps 3 and 8 for at least two trials and all separately metered work areas or equipment.

*If all water consuming devices are shut down, a 15 minute test (or waiting period) will probably be sufficient 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 Audit should uncover leaks in toilets and any visible leaks. Therefore, this test should be repeated after the full-facility walk-through described in the Indoor Water Use (Level One and Level Two) and Commercial-Grade Kitchens (Level One and Level Two) sections are complete. 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. Ballpark costs associated with meters 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 Estimating Daily Facility Water Use – Level I (page 26) section of this manual 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 Audit – Level One

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Transfer this information to the Microsoft Excel spreadsheet associated with this manual.

ESTIMATING DAILY FACILITY WATER USE – LEVEL ONE

Background and Description

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.

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. In addition, your facility may be able to save money by taking advantage of sewer water credits for irrigation water (see page 20 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 full-facility water balance (described on page 140). 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 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 and is not separately metered or submetered, only the facility's total water use and expense is obvious, but you can still separate indoor and outdoor water use and expense. This is done 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.

Under any scenario, having copies of the facility water bills for the previous year will be helpful in performing a water use audit.

Figure 13 summarizes the steps you will need to follow to measure your facility's indoor versus outdoor water use.

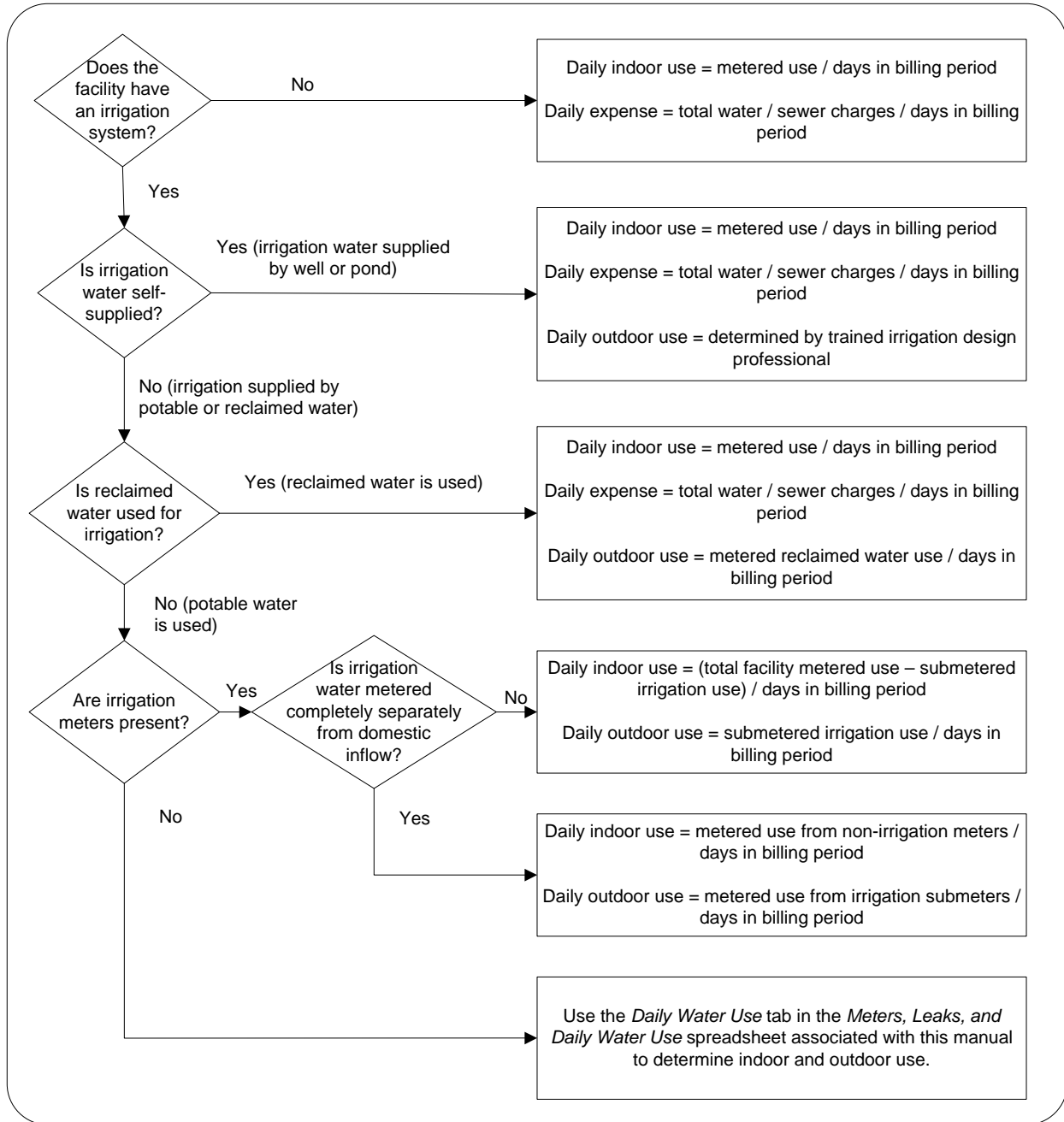


Figure 13. Flowchart for quantifying indoor versus outdoor water use.

Spreadsheet Guidance

Use the *Meters, Leaks, and Daily Water Use* spreadsheet **only** if your facility’s irrigation system uses potable water without an irrigation submeter (see Figure 13).

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?

Estimating Daily Facility Water Use – Level One

- ◆ 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 15 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 *Meters, Leaks and 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 14** shows an example of audit information to be entered into the *Daily Water Use* tab of the *Meters, Leaks and Daily Water Use* spreadsheet.

	Date and Time of Reading	Initial Meter Reading	Date and Time of End	End Meter Reading
Day 1	4/28/2010 0615	52200	4/29/2010 0615	62250
Day 2	4/29/2010 0615	62250	4/30/2010 0615	98300
Day 3	4/31/2010 0615	109350	5/01/2010 0615	119500
Day 4				
Day 5				

Figure 14. An example of the meter data table from Worksheet 3.

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*. This table 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.



Audit Procedures

The procedures below will help you estimate:

- ◆ Daily indoor water use
- ◆ Volume of water used by your facility's irrigation system
- ◆ Cost of water used indoors and to irrigate your facility's landscape
- ◆ Sewer credit that may be available to your facility if using potable water for irrigation

Audit Steps

1. Examine and prepare Worksheet 3, Estimating Irrigation Water Use.
2. Respond to questions 1 through 3 on the worksheet. You may need to request billing records from your facility's accounts payable office.
3. Refer to **Figure 13** and, if prompted, use the *Daily Water Use* tab in the *Meters, Leaks and Daily Water Use* spreadsheet and continue to the next step.
4. Locate the facility's main meter.
5. Using Worksheet 3, 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.
6. Transfer the data you recorded on Worksheet 3 to the *Meters, Leaks and Daily Use* spreadsheet.
7. Examine the two output tables (labeled *Non-Irrigation Water Use* and *Irrigation Water Use*).

Post-Audit Considerations and Additional Activities

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.

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 section of this manual, beginning on page 146.

Worksheet 3. Estimating Irrigation Water Use – Level One

1. Does the facility have an irrigation system?

If no:

Request copies of the utility billing records from your facility's accounts payable office. Divide the total water use and total cost each by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day. Refer to **Figure 13**.

If yes: Continue to 2.

2. What is the water source of the irrigation system?

If reclaimed or reuse water is used, request copies of the utility billing records for both the potable and reclaimed water accounts from the facility's accounts payable office.

- For the potable water account, divide the total water use and total cost each by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day.
- For the reclaimed water account, divide the total water use and total cost by the number of days the irrigation system was run during the billing cycle. This will yield gallons used and expenses incurred per irrigation event. Refer to **Figure 13**.

If self-supplied (well, canal, retention pond) water is used, an irrigation professional may be able to estimate irrigation water use.

If potable water is used, continue to 3.

3. Is the irrigation line submetered?

If yes:

The irrigation water use volume for the billing period is known from the submeter and can be subtracted from the main meter volume to reveal the indoor water use volume. Then divide the indoor water use volume by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day.

Divide the irrigation water use volume by the number of days the irrigation system was run during the billing cycle.* This will yield gallons used per irrigation event. Refer to **Figure 13**.

If no: Use the table below and refer to the Spreadsheet Guidance subsection on page 27.

**Irrigation Schedule and Controller – Level One section of this manual provides guidance in 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.

GENERAL DOMESTIC WATER USE – LEVEL ONE

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 audit procedures. While doing your walk-through, document any behavioral changes or work policies you observe that may help improve efficiency. Employee input may help you identify possible behaviors and policies that could be changed.

Table 5 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 5** is meant to be a precursor to a full-facility audit and cannot take the place of a thorough walk-through.

The Level One 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, because flow rates can change with time, **all fixture flow rates need to be verified.**

Table 5. 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	4.5 – 1.5	10.5 – 12	39 – 51
Post 1994²	1.60	1.60	2.5	2.5	1.0	10.5	27 ³
WaterSense⁴ Max.	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 11.
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. Secondly, 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 5)** to verify the flow rate of all faucets. 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.

Convert the recorded time to gallons per minute using the calculation in **Box 5** or check **Table 7**, 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 Level Two General Domestic Water Use audit does this conversion automatically. **Table 7** on page 48 supplements Worksheet 4, which is used during the General Domestic Water Use field survey.

Some companies produce flow-gauge bags that are marked in liters and gallons. Simply hold the bag under the faucet or showerhead for a certain amount of time (usually listed on the bag itself) and record the volume.

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



A flow-gauge bag

Box 5. Timed-Flow Test

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 7** on page 48 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:

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

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, 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 is for valve-flush toilets and the second is for tank-toilets.

The **valve-flush toilet timed-flush method (Box 6)** 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). **Table 8** on page 49 shows the conversion of seconds during a flush to gallons per flush for toilets and urinals. **Table 8** supplements Worksheet 5, which is used during the General Domestic Water Use field survey. As stated earlier, the *Domestic Plumbing Fixtures* calculator associated with the Level Two

General Domestic Water Use audit does this calculation automatically.

The **tank toilet flow verification method (Box 7)** verifies the flush volume by measuring the internal volume of the tank occupied by water 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 9 on page 49 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 9** is supplemental to Worksheet 5, which is used during the General Domestic Water Use field survey.

Record the flow rate as marked (stamped or etched) on the fixture itself in the “Marked Flow Rate” column on Worksheet 5. Compare the measured flow rate of each fixture against the rate at which the fixture was designed to flush and the federal, WaterSense, and high-efficiency standards indicated on the worksheet. Record whether the fixture requires maintenance, replacement, or no action in the space provided in the worksheet.

Box 6. 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:

$$\text{Seconds flushing} \times 0.42 \text{ (for toilets)} \text{ OR } 0.25 \text{ (for urinals)} = \text{ ______ gallons per flush}$$

Box 7. 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, since some tanks do not use their entire contents for a single flush.
3. Measure the internal dimensions 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:

$$\text{Tank height} \times \text{width} \times \text{length} \times 0.004329 = \text{ ______ gallons}$$

$$1 \text{ in}^3 = 0.004329 \text{ gallons}$$

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 (**Box 8**) for leaks. 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 8. 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 kitchens or breakrooms using **residential-grade** devices only. If necessary, review the Commercial-Grade Kitchen section of this manual (beginning on page 68) before accounting for kitchen water use.
- ◆ Cooling towers can be the largest water consumption point in a commercial building and therefore have a separate section in this manual beginning on page 88.
- ◆ 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.

Audit Procedure

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 Level One activities are non-quantitative. The General Domestic Water Use Level Two section will build on the information you collect here and will allow you to see quantitatively the current use, potential savings, and investment recovery 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. Determine the age of the building(s) to be included in the full-facility survey.
2. Determine if and when any fixture upgrades or replacements have occurred (refer to **Table 5**, page 31).
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
4. For all fixtures, note the etching or stamp that indicates the flow rate.
5. Test the flow rate of each fixture, other than toilets and urinals, using the timed flow test (**Box 5**, page 32).
6. Record the time required to fill the measuring cup or flow-gauge bag on Worksheet 4 (faucets) and Worksheet 7 (showerheads).
7. For all flush valve toilets and urinals, conduct a timed-flush test (**Box 6**, page 33).
8. Record the flush times on Worksheet 5 (toilets) or Worksheet 6 (urinals).
9. Conduct a dye test (**Box 8**, page 34) on all tank toilets.
10. Record results of dye tests in the space provided on Worksheet 5.
11. Document all water-using appliances, noting the make and model, and look for the ENERGY STAR label.
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 and model, and look for the ENERGY STAR label.
 - c. Indicate on Worksheet 8 whether the model is ENERGY STAR qualified.
13. Identify any and all leaks encountered during the walk-through.
14. Document work habits or policies that may be hampering water use efficiency and those that may improve it.

Steps 15 and 16 should be done after all field work has been completed.

15. 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, replacement, or no action in the space provided in the worksheet.
16. Use **Table 7** through **Table 9** (pages 48–49) 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.

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 investment recovery period for replacing older, less efficient fixtures with new efficient models is typically very short – 1 to 4 years, but most 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. ENERGY STAR¹ is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy established to provide information on energy-efficient products and practices. The ENERGY STAR website is highly informative and practical and includes a full list of ENERGY STAR qualified products.

The Consortium for Energy Efficiency (CEE)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 U.S. Environmental Protection Agency.

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

Toilets

General Recommendations

Regulatory plumbing standards in Florida mandated the installation of 3.5 gallon per flush (gpf) toilets and 1.5 gpf urinals in all new construction as of 1984, and 1.6 gpf toilets and 1.0 gpf urinals as of 1994. All existing toilets flushing 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.

The 1.28 gpf toilets are specified to meet the same drainage standards as the 1.6 gpf models, but this technology has not been thoroughly field-tested in commercial applications. Although the retrofit is expected to be successful in most buildings, ***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.

The most efficient WaterSense tank toilets today use 0.8 gpf. Replacing 1.6 gpf models with 0.8 gpf fixtures will cut water use for toilet flushing in half. However, the length of the investment recovery period for replacing these toilets depends on the frequency of use. If your budget is limited, consider replacing more frequently used toilets first.

Flush valve toilets should be retrofitted with piston-operated flush valves. Piston valves generally require less maintenance, offer more

¹ www.energystar.gov

² www.cee1.org

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. To save water and maintain acceptable performance, both the toilet and flush valve need to be retrofitted. Installation of a 1.28 gpf flush valve on an existing 1.6 gpf fixture will result in poor performance and potentially serious maintenance issues.

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

It may not always be possible to determine the flow or flush rate each toilet was designed to use. Stamps or etchings on fixtures (china) can fade with time and some older models may have no markings at all.

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 and often does 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 in place and not creating performance problems, it is left to you and your

facility maintenance team whether to leave them in place.

Toilet Retrofit Kits

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. 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

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 flush valve or replacing the diaphragm in the existing flush valve. 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.

Pint-flush (1/8 gpf) Urinals

Pint or 1/8 gpf 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.**

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).

Faucet Aerators

Today, 0.5 gpm aerators are the standard for public lavatory faucets (ASME A112.18.1-2005). Self-canceling (sensor-timed) faucets should use no more than 0.25 gallons per use. 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 break room with aerators that flow at 1.5 gpm or less.

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 2.5 gpm should be replaced with a high-efficiency model (2.0 gpm). It may also be cost effective to replace 2.5 gpm showerheads with high-efficiency models if they are used frequently. 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 ones¹. 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

¹ <http://www.cuwcc.org/smartrebates-res-fixtures.aspx>

groups can wash at least 2 cubic feet 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 cubic foot 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 STAR¹ and CEE² 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 or CEE when the current one reaches the end of its service life. ENERGY STAR¹ or CEE² 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 4.25 gallons per cycle (load). ENERGY STAR also has a qualifying water requirement of 4.25 gallons per cycle. The federal minimum standard for dishwashers is 6.5 gallons per cycle.

Ice Machines

In general, ice machines should not use more than 20 gallons per 100 pounds of ice production (AWUWCD 2006). Ice machines with the ENERGY STAR¹ rating or “qualified” by the CEE² and Food Service and Technology Center (FSTC)³ 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.**

The shape of the ice also matters. Models that produce ice flakes or disks are more efficient than the average cube-making machines. Flake- or disk-making models use approximately 30 percent less water than cube-making machines.

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 (**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 models. 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.

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 STAR¹ or CEE² 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 in the Level Three section of this manual (see page 149)

¹ www.energystar.gov

² www.cee1.org

³ www.fishnick.com

Table 6. Comparison of water and energy use, consumption, and cost of standard and efficient ice machines¹

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 lb 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 Efficiency².

Level Two Teaser

Completing this Level One Inventory 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 Level Two section builds on this audit and will allow you to quantitatively measure current use, potential savings, and investment recovery periods for investments.

There should be no additional field work necessary to complete the Level Two audit procedure. Furthermore, all necessary calculations are done by the accompanying Microsoft Excel spreadsheets (*Domestic Plumbing Fixtures*, *ENERGY STAR's Residential Dishwashers*, and *ENERGY STAR's Residential Clothes Washers*).

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



Conservation Tip

Replacing faucet aerators and shower heads are inexpensive ways to conserve water and energy. Consider EPA WaterSense shower heads that flow at 2.0 gpm or less for all showers. Lavatory faucet aerators used primarily for handwashing can have aerators installed that use only 0.5 gpm.



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.

Worksheet 4: Faucets

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

Location	User Group	Manual, Sensor, Spring	If sensor or Spring: Seconds of Flow	Flow Rate			NA=No Action R=Replace M=Mainten.	Leaks? Other Comments
				Marked Flow rate (in gpm)	Timed			
					Num. Cups/ Pints/ Quarts	Num. Secs.		
Rm 403B 1	Male Staff	Spring	15	2.2	2	4		Closest to door
Rm 403B 2	Male Staff	Spring	19	2.2	2	4		Handle leak
Rm 403B 3	Male Staff	Spring	17	2.2	2	4		Farthest from door

General Domestic Water Use – Level One

Worksheet 5: 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

Worksheet 6: 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 7: Showerheads

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

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

Worksheet 4. Faucets

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

Location	Lav. Fac. (?) ✓	User Group	Manual, Sensor, or Spring	If 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.		
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. 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? 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. 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
	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.

Worksheet 8. 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?
Low Temp. Or High Temp.	Under Counter							
	Door Type							
	Single Tank Conveyor							
	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 7 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 5**). The *Domestic Plumbing Fixtures* spreadsheet will do the calculation for you after you enter the measuring cup size and seconds to fill it.

Table 7. Conversions to gallons per minute for containers of several common sizes.

Cups per second to gallons per minute

Seconds \ Cups	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

Seconds \ Pints	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

Seconds \ Quarts	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 8. 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 9. 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 height x width x length

¹ The *Domestic Plumbing Fixtures* spreadsheet will complete this calculation for you.

GENERAL DOMESTIC WATER USE – LEVEL TWO

Background and Description

With the Level One walk-through audit, you identified inefficient and obsolete fixtures and appliances in your facility. The Level Two General Domestic Water Use audit will guide you through the process of understanding use, savings, and investment recovery 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 Level One indoor water use survey.

This Level Two audit will help you know which fixtures 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 Level One facility walk-through is complete. **There should be no additional field work necessary to complete the Level Two audit procedure.** Furthermore, all necessary calculations are done by the accompanying Microsoft Excel spreadsheets (*Domestic Plumbing Fixtures*, *ENERGY STAR’s Residential Dishwashers*, *ENERGY STAR’s Residential Clothes Washers*, and *ENERGY STAR’s Commercial Kitchen Equipment*).

Spreadsheet Guidance

Four Microsoft Excel spreadsheets are used as part of the Level Two General Domestic Water Use Audit. They are:

1. *Domestic Plumbing Fixtures* – covering toilets, urinals, faucets, and showerheads based on the population dynamics of the facility
2. *ENERGY STAR’s Residential Dishwasher* calculator
3. *ENERGY STAR’s Residential Clothes Washer* calculator
4. *ENERGY STAR’s Commercial Kitchen Equipment* calculator, used to evaluate ice machines

1. 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 manual (page 14) 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 efficiency 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 Level I General Domestic Water Use 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
- ◆ All fixtures within a single lavatory are assumed to undergo an equal number of daily uses
- ◆ All lavatories in a facility are used equally ²

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 14 for information on the Billing Data Input Table.

2. Facility Population Data Input Table (Utility Rate and Population Data tab) (Figure 15)

- ◆ 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)
- ◆ Number of visitors on 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)

¹ You can change this assumption in the savings calculator.

² This may not be true, but making this assumption is a valid initial step toward allocating use by the total population. You may redistribute lavatory use based on your facility's layout or other factors. For example, certain lavatories near primary entrances may have greater use 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).

General Domestic Water Use – Level Two

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	Faculty				
Enter Number of	MALE Students	122	5	40	200
Enter Number of	FEMALE Students	140	5	40	200
Enter Number of	MALE Faculty	12	5	40	200
Enter Number of	FEMALE Faculty	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				
Common (unisex) restroom uses/day	5				

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

Figure 15. The *Facility Population Data Input* table in the *Utility Rate and Population Data* tab of the *Domestic Plumbing Fixtures* calculator.

3. Efficiency Fixture Properties Table (Utility Rate and Population Data tab) (Figure 16)

- ◆ 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)
- ◆ 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 16**, 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 faucets use 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 16. 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 17**.

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

(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 (males of which population, such as Male Faculty)
- ◆ Indication of 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 17**, 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.

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

General Domestic Water Use – Level Two

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 11 and 31). 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)

Figure 18 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 fixture¹. For the example in **Figure 19**, 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 per 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 19**).

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

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

III. Level One and Level Two Audits

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 19. 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.

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 20**) 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 20. 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.

After adjusting individual fixture usage, the output is ready for review. The *Summary Output Table* (**Figure 21**) shows the total cost, water savings, and investment recovery period if all inefficient fixtures are replaced with efficient ones.

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 (\$)	Investment Recovery Period (in months)
Toilets	12	\$2,940	\$0	\$400	333,849	\$2,851	1.7
	0	Require Maintenance					
	12	Should be Replace					

Figure 21. An example of the *Summary Output Table* for each tab in the *Domestic Plumbing Fixtures* calculator.

General Domestic Water Use – Level Two

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 of the summary table.

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 used exclusively for restroom faucets and one for all non-lavatory faucets. Lavatory faucets are separated from non-lavatory because lavatory faucet use is tied to restroom use and population size. 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 this Tab

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 activated by a sensor; in the column titled, "Manual or Sensor" (not required for calculations)
- ◆ Number of seconds per use or number of seconds of auto-flow (sensor or spring)
- ◆ Number of seconds required to fill the flow-rate measuring cup (indicated in the *Efficiency Fixture Properties* table in the *Utility Rate and Population Data* tab)

If the faucet has a timed-sensor or spring-action flow, enter the number of seconds water flows 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 (**Figure 22**).

Manual or Sensor	Number Seconds per Use or Number of Seconds of Auto-flow (sensor or spring)	Marked gpm
Manual	15.0	2.20
Manual	15.0	2.20
Sensor	24.0	2.20
Sensor	11.0	2.20

Figure 22. Manual or sensor indicator fields and number of seconds of auto-faucet flow in the *Lav. Faucets* and *Non-Lav. Faucets* tabs of the *Domestic Plumbing Fixtures* savings calculator.

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 visitors 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.

2. ENERGY STAR's Residential Dishwashers Spreadsheet

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 dishwasher needs to be replaced and you are evaluating whether to purchase an efficient one qualified by ENERGY STAR or a conventional one.

The *ENERGY STAR Residential Dishwashers* 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 money to own and operate. This 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 into the calculator. See the *Assumptions* tab for more information on the calculation engine for this calculator, its operational assumptions, and model-type averages. However, you can override the default values.

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

- ◆ Product brand name
- ◆ Product model number
- ◆ Size
- ◆ Annual energy use (kWh/year)
- ◆ Federal standard (kWh/year)
- ◆ % better than federal standard (kWh/year)
- ◆ Water use (gallons/cycle)
- ◆ Energy factor (EF)

To access this information, go to www.energystar.gov, click "**Products**," and then click "**Find ENERGY STAR Products**." Click "**For Your Home**," then click "**Dishwasher**." This page has general information on qualified ENERGY STAR models. On the right side of the page, under the **Dishwasher Resources** banner, you can download a list of qualified models under the subheading "**Qualified Dishwashers**."

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

- ◆ Number of units
- ◆ Electric rate (\$/kWh)
- ◆ Cost of potable and sewer in 1,000 gallon increments ¹
- ◆ Gas rate (\$/therms)
- ◆ Number of cycles (loads) per week
- ◆ Type of water heating
- ◆ Initial cost per unit (estimated retail price)
- ◆ Energy factor ²

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 Energy factor (EF), gallons per load values, and other performance specs for all ENERGY STAR rated models can be found on the *Assumptions* tab in *ENERGY STAR's Residential Dishwasher* spreadsheet.

General Domestic Water Use – Level Two

- ◆ Unit electricity consumption (kWh/year)
- ◆ Unit water consumption (gallons/year)

Figure 23 shows the input fields for the *ENERGY STAR Residential Dishwasher* calculator. Default values can be overridden by the user.

Two output tables (**Figure 24**) provide results based on the input data. The first, *Annual and Life Cycle Costs and Savings*, shows a breakdown of all consumption and expenses (annual and over the life of the unit). The second, *Summary of Benefits*, reviews the benefits of an ENERGY STAR model over a conventional model.

Number of units	1	
Electric rate (\$/kWh)	\$0.109	
Water and sewer rate (\$/1000 gallons)	\$7.500	
Gas rate (\$/therm)	\$1.050	
Number of cycles (loads) per week	4	
Type of water heating	Electric Water Heating ▼	
	ENERGY STAR Qualified Unit	Conventional Unit
Initial cost per unit (estimated retail price)	\$550	\$538
Energy factor (EF)	0.75	0.60
Unit electricity consumption (kWh/year)	294	368
Unit water consumption (gallons/year)	860	1,290

Figure 23. Input table of *ENERGY STAR's Residential Dishwasher* calculator.

III. Level One and Level Two Audits

	1 ENERGY STAR Qualified Unit(s)	1 Conventional Unit(s)	Savings with ENERGY STAR
Annual Operating Costs*			
Electricity cost	\$32	\$40	\$8
Water cost	\$6	\$10	\$3
Gas cost	\$0	\$0	\$0
Total	\$38	\$50	\$11
Life Cycle Costs*			
Operating costs (electricity, gas, water)	\$312	\$404	\$92
Electricity costs	\$260	\$325	\$65
Water costs	\$52	\$78	\$26
Gas costs	\$0	\$0	\$0
Purchase price for 1 unit(s)	\$550	\$538	-\$12
Total	\$862	\$942	\$80
	Simple payback of initial additional cost (years) [†]		1.1

Initial cost difference	\$12
Life cycle savings	\$92
Net life cycle savings (life cycle savings - additional cost)	\$80
Simple payback of additional cost	1.1 years
Life cycle electricity saved	740 kWh
Life cycle air pollution reduction	1,140 lbs of CO₂
Air pollution reduction equivalence	0.10 cars removed from the road for one year
Air pollution reduction equivalence	0.11 acres of forest planted
Savings as a percent of retail price	14%

Figure 24. Output tables of ENERGY STAR's Residential Dishwasher calculator.

3. ENERGY STAR's Residential Clothes Washer Spreadsheet

ENERGY STAR's Residential Clothes Washer spreadsheet is nearly identical to the one for residential dishwashers. Here too, the initial assumption is your facility's current model has reached the end of its useful life and you are deciding whether to replace it with one qualified as efficient by ENERGY STAR or a conventional one. This calculator will compare 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 conventional and ENERGY STAR rated machines. These averages appear as default values and are preloaded in the calculation engine of the calculator, but can be changed by the user. The *Assumptions* tab can be examined for more information on the calculation engine, its operational assumptions, and model-type averages.

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

- ◆ Brand name
- ◆ Model number
- ◆ Load configuration
- ◆ Volume (cubic feet)
- ◆ Annual energy use (kWh/year)
- ◆ Modified energy factor (MEF)
- ◆ Federal standard (MEF)
- ◆ % better than federal standard
- ◆ Annual water use (gallons/year)
- ◆ Water factor (WF)

General Domestic Water Use – Level Two

To access this information, go to www.energystar.gov, click “Products,” and then click “Find ENERGY STAR Products.” Click “Business and Government,” then click “Clothes Washers.” This page has general information on qualified ENERGY STAR models. On the right side of the page, under the **Clothes Washers Resources** banner, you can download a list of qualified models under the subheading “Qualified Clothes Washers.”

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

- ◆ Select “Residential” from a drop-down menu (this is the same calculator used to evaluate commercial clothes washers)
- ◆ Number of units
- ◆ Electric rate (\$/kWh)
- ◆ Cost of potable and sewer in 1,000 gallon increments ¹
- ◆ Gas rate (\$/therms)
- ◆ Number of cycles (loads) per week
- ◆ Type of water heating
- ◆ Type of clothes dryer (electric, gas, none)
- ◆ Initial cost per unit (estimated retail price)
- ◆ Energy factor (see explanation on page 39)

Figure 25 shows the input fields for *ENERGY STAR’s Residential Clothes Washer* calculator. Default values can be overridden by the user.

The output tables are identical to those shown in Figure 24 (page 59) for *ENERGY STAR’s Residential Dishwasher* calculator.

Choose the type of washing machine	Residential	
Number of units	1	
Electric rate (\$/kWh)	\$0.109	
Water and sewer rate (\$/1000 gallons)	\$7.500	
Gas rate (\$/therm)	\$1.050	
Average number of loads per week	7.5	
Type of water heating	Electric Water Heating	
Type of clothes dryer	Electric Dryer	
	ENERGY STAR	Conventional Unit
	Qualified Unit	
Initial cost per unit (estimated retail price)	\$750	\$492

Figure 25. Output tables of *ENERGY STAR’s Residential Clothes Washer* calculator.

¹ If your facility’s water is billed in ccf (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.

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

ENERGY STAR's *Commercial Kitchen Equipment* can be used to calculate 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. Therefore, the use of this calculator is outlined below.

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 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 conventional and ENERGY STAR rated machines. These averages appear as default values and are preloaded in the calculation engine of the calculator. See the *General Assumptions* tab for more information on the calculation engine for this spreadsheet, its operational assumptions, and model-type averages.

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 (see the Ice Machine discussion on page 39). This additional expense is not factored in these calculations, but should be considered during your efficiency planning process.

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 www.energystar.gov, click "**Products**," and then click "**Find ENERGY STAR Products**." Click "**Business and Government**," then click "**Commercial Ice Machine**." This page provides general information on qualified ENERGY STAR models. 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 gallons¹
- ◆ 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 ice produced)

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.

General Domestic Water Use – Level Two

- ◆ Operating days per year
- ◆ Additional cost per unit for ENERGY STAR model over a conventional one

Figure 26 shows the utility rate input information in *ENERGY STAR's Commercial Kitchen Equipment* calculator. **Figure 27** shows the machine type and use characteristics input information in the calculator for ice machines.

Electric rate (\$/kWh)	\$0.1000
Gas rate (\$/therm)	\$1.0000
Water rate (\$/thousand gallons)	\$10.00

Figure 26. 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 27. Example of the machine type and use characteristics input information for an ice machine in *ENERGY STAR's Commercial Kitchen Equipment* calculator.

The Results Summary output table (**Figure 28**) of the calculator shows savings in kilowatts or therms, water in gallons, the total annual and life-time 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.

In addition to the ENERGY STAR calculators, the FSTC¹ maintains life-cycle and energy savings calculators for ice machines and as other appliances.

¹ <http://www.fishnick.com/saveenergy/tools/calculators/>

III. Level One and Level Two Audits

	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 28. Example output table (split in half for illustration purposes) of ENERGY STAR’s Commercial Kitchen Equipment calculator for an ice machine.

Audit Procedure

This procedure will help you:

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

Audit Steps

1. Assemble Worksheet 4 through Worksheet 8.

Domestic Plumbing Fixtures Spreadsheet

Utility Rate and Population Data Tab

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

Refer to page 15 for information on the Billing Data Input Table.

3. Enter the following information into the *Facility Population Data Input* table:
 - ◆ 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 value is three)
 - ◆ 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)
 - ◆ Number of visitors on the site per day (customers, clients, night school attendees, etc.)
 - ◆ 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.

4. Enter the following information into the *Efficiency Fixture Properties* table:
 - ◆ Water use rates of efficient fixtures (gallons per flush or gallons per minute)
 - ◆ Cost to replace the fixture
 - ◆ 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 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)
 - ◆ The size of the cup used to measure flow for each fixture (for faucets and showerheads only)
5. 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

6. Enter the following into the fields provided on the *Toilet* tab of this calculator:
 - ◆ 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)
 - ◆ User group (e.g., Male Faculty)
 - ◆ Indication of whether visitors use this restroom fixture
 - ◆ Indication of the toilet type (valve or tank)
 - ◆ Volume of the tank (if applicable)
 - ◆ Number of seconds of flow per flush (for valve toilets)
 - ◆ Marked flow (not required for calculations)
 - ◆ 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 11 and 31).
 - ◆ Indication of acceptance of the default use frequency (see explanation of “Default Override Option” on page 54)
 - ◆ Default override value (see page 54)
7. Examine the output tables.

Urinal Tab

8. The *Urinal* tab entry fields are identical to the *Toilet* tab except that it does not have data entry fields related to tank toilets. Refer to Step 6.

Lavatory Faucets

9. Lavatory faucets are separated from non-lavatory because lavatory faucet use is tied to restroom use and population size. For lavatory faucets, enter the following:
 - ◆ 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)
 - ◆ User group (e.g., Male Faculty)
 - ◆ Indication of whether visitors use this restroom fixture
 - ◆ Marked flow (not required for calculations)
 - ◆ 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 11 and 31).
 - ◆ Indication of acceptance of the default use frequency (see “Default Override Option” explanation on page 54)
 - ◆ Default override value (see page 54)
 - ◆ Indicate whether faucet operation is manual or by sensor (not required for calculations)
 - ◆ Number of seconds per use or number of seconds of auto-flow (sensor or spring)
 - ◆ 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)
10. Examine the output tables.

Non-Lavatory Faucets

11. 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 9.

Residential Dishwasher Water Use Via ENERGY STAR’s Residential Dishwasher Spreadsheet

12. Examine Worksheet 8 and ENERGY STAR’s Residential Dishwasher spreadsheet:
13. Enter the following into the fields provided:
 - ◆ Number of units
 - ◆ Electric rate (\$/kWh)
 - ◆ Cost of potable and sewer in 1,000 gallon increments^{29F 1}
 - ◆ Gas rate (\$/therms)
 - ◆ Number of cycles (loads) per week
 - ◆ Type of water heating
 - ◆ Initial cost per unit (estimated retail price)
 - ◆ Energy factor (see explanation on page 39)

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. The result is the water and sewer rate in \$ per 1,000 gallons.

General Domestic Water Use – Level Two

- ◆ Unit electricity consumption (kWh/year)
- ◆ Unit water consumption (gallons/year)

14. Examine the Annual and Life Cycle Costs and Savings output table.

Ice Machine Water Use via ENERGY STAR's Residential Clothes Washer Spreadsheet

15. Examine Worksheet 8 and *ENERGY STAR's Residential Clothes Washer* spreadsheet:

16. Enter the following into the fields provided:

- ◆ Water utility rate information: potable and sewer water costs
- ◆ Power utility rate information: gas (therms) and electricity costs (kWh)
- ◆ The type of machine (i.e., ice making head, remote condensing unit/slit system, self-contained unit)
- ◆ 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 Kitchen Equipment Calculator

18. Examine Worksheet 8 and *ENERGY STAR's Residential Dishwasher* spreadsheet:

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:

- ◆ Number of units
- ◆ Number of units
- ◆ Electric rate (\$/kWh)
- ◆ Cost of potable and sewer in 1,000 gallon increments^{24F 1}
- ◆ Gas rate (\$/therms)
- ◆ Number of cycles (loads) per week
- ◆ Type of water heating
- ◆ Type of clothes dryer (electric, gas, none)
- ◆ Initial cost per unit (estimated retail price)
- ◆ Energy factor (see explanation on page 39)

21. Examine the *Results Summary* tab.

¹ If your facility's water is billed in ccf's (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.

Post-Audit Considerations and Additional Activities

The investment recovery 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 an investment recovery period of 4 years or less are considered feasible**; however, many water efficiency measures recuperate the investment much sooner – in some cases, less than 1 year. **Refer to the Post-Audit Considerations and Additional Activities section of General Domestic Water Use – Level One** (page 36) for detailed information on efficient fixtures and appliances and in conjunction with the investment recovery period calculations for each fixture type as calculated in the *Domestic Plumbing Fixtures* calculator.

COMMERCIAL-GRADE KITCHEN WATER USE AUDIT – LEVEL ONE

Background and Description

Most commercial buildings have some type of kitchen area. Those with residential-grade fixtures and appliances were covered in previous sections. This section will help you assess the water-using equipment if your facility has a commercial kitchen or cafeteria

As with the Level One Indoor Water Use Audit, this audit entails a physical facility walk-through to identify all points of water use and leaks. All water-using fixtures and appliances or equipment should be documented (including flow-rate verification tests) during the walk-through. Timed-flows test results should be converted to gallons per minute using the methods from the Level One General Domestic Water Use Audit (see page 32 for a review of that methodology). As you perform your 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 [page 69] 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 9 through 13 in the procedure below). Additional copies of Worksheet 4 through Worksheet 6 may be needed.

Audit Procedures

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

Audit Steps

1. 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
2. For all fixtures (faucets, pre-rinse spray valves, etc.), note the etching or stamp indicating the flow rate.
3. Conduct a timed-flow test for each fixture (lavatory or handwashing faucet and pre-rinse spray valves) using a known-volume cup or pitcher (see page 32 to review the methodology).
4. 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.
5. Convert the timed flow to gallons per minute (see page 48).

6. For all appliances (dishwashers, ice machines, etc.), note the make and model and look for the ENERGY STAR label and indicate this on Worksheet 9.
7. Note the water use as listed on the appliance itself, in its owner/user manual, or by contacting the manufacturer.
8. Make note of all leaks encountered.

If the kitchen has a restroom for kitchen staff, proceed to steps 9 through 13.

9. Determine flush volumes for all toilets and urinals (see page 33).
10. Determine flow rates for all bathroom faucets (see page 32).
11. Convert the timed flows to gallons per minute (see page 48).
12. 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.
13. Conduct a dye test on all tank toilets (see page 34).

Post-Audit Considerations and Additional Activities

Recommendations for restroom fixtures are discussed on page 36.

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. The Energy Star program's website¹ 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 appliances².

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 handwashing. Handwashing station faucets should be fitted with 0.5 gallon per minute (gpm) aerators.

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 range between 2.5 and 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**

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.fishernickel_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.

Commercial-Grade Kitchen Water Use – Level One

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.



Commercial Dishwashers

Commercial dishwashers use heated water (180° F or higher) or chemicals. 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.

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

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

after each load). If your 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).

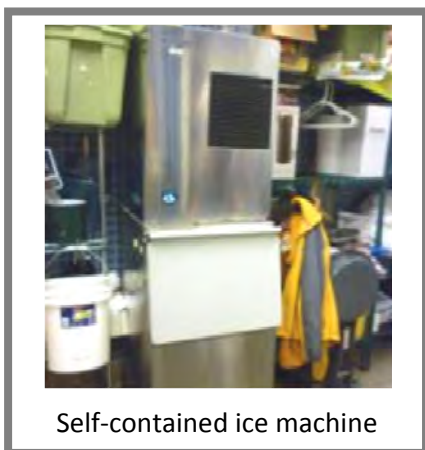


Ice Machines

In general, ice machines should not use more than 20 gallons 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.

The shape of the ice also matters. Models that produce ice flakes or disks use approximately 30 percent water less than those that make ice cubes.

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.



Self-contained ice machine

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 STAR¹ and the FSTC website².

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. The bulk of 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. Connectionless steamers consume less water than boiler types by operating within a closed system that does not have a boiler and drain (FSTC 2010).

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 \$1,000 a year** in water and sewer costs, or 100,000 gallons over a regular boiler type.

When your facility is considering replacing its steamer, refer to the ENERGY STAR website³ for a list of qualified steamers or check the



Steam cooker

³ 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.

FSTC¹ 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 over 100,000 gallons of water per year** over boiler-type combi ovens (FSTC 2010). However, energy and water efficient combis with boilers are now being produced.

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 oven, try to select a replacement from the FSTC's list of qualified models². For optimum operating efficiency of your facility's combi, refer to the Commercial Kitchen section of Appendix B and the FSTC website.



A combination oven

¹ 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.

² 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.

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 gallons of water per minute during operation. Scraping troughs carry food scraps and other waste to the disposal, using approximately 3 to 5 gallons of water per minute (NMSE 1999 and 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 gallons per minute if the overflow level is improperly set, and 1 to 2 gallons per minute when set properly. **Table 10** shows the amount of water consumed due to improper settings.

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 gallons of water per minute (Vickers 2001).



Commercial kitchen food pulper



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 fats and oils, that can burden 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 11** compares four food waste disposal methods.

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 149 of this manual)

Table 10. 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 gallons per minute; the range is 1 to 2) and is currently set 5 gallons over this amount. The actual range of excessive flow can be as high as 6 gallons.

Commercial-Grade Kitchen Water Use – Level One

Table 11. 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

For More Information

To learn more about improving water use efficiency, see the ENERGY STAR¹ and CEE² websites.

Level Two Teaser

This Level One inventory 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 Level Two section builds on this audit and allows you to quantitatively measure current use, potential savings, and investment recovery periods.

There should be no additional field work necessary to complete the Level Two 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*).

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.

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?
Low Temp. Or High Temp.		Under Counter							
		Door Type							
		Single Tank Conveyor							
		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		Make/ Model	Quantity	Average number of loads per week	Type of water heating	Type of clothes dryer	Electric or Gas Drier	ENERGY STAR Qualified?
		How is water for each unit heated?							
		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.

COMMERCIAL-GRADE KITCHEN WATER USE AUDIT – LEVEL TWO

Background and Description

The water use rates of most fixtures and appliances should have been documented during the Commercial-Grade Kitchen Audit – Level One. 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 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 39.

Although estimating water use 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.

Spreadsheet Guidance

There are two spreadsheets used to calculate water use and potential savings in a commercial kitchen:

1. *ENERGY STAR's Commercial Kitchen Equipment*
2. *Supplemental Commercial Kitchen 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

As this manual is focused on improving water use efficiency, the Commercial-Grade Kitchen Appliances Worksheet (Worksheet 9) only contains tables related to water-using equipment. A second spreadsheet addresses appliances and fixtures not in the ENERGY STAR calculator, such as combination ovens (combis), pre-rinse spray valves, and handwashing faucets. The section below 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* developed to calculate savings for combination ovens, pre-rinse spray valves, and handwashing faucets.

1. 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 has been reached. 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 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 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.

Using ENERGY STAR’s Commercial Kitchen Equipment Calculator

The calculator has only one tab where data is entered and 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 selecting the ‘average’ rates for your state (**Figure 29**).

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 30** shows the input table for a ‘Door Type’ dishwasher after 1 was entered into the Quantity column.

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

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 31** 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 29. Utility billing data for ENERGY STAR’s Commercial Kitchen Equipment calculator.

Commercial-Grade Kitchen Water Use – Level Two

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
High Temp.	Multi Tank Conveyor	0	600	electric	N/A	365	\$0
	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 30. 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 31. Output table of *ENERGY STAR's Commercial Kitchen Equipment* calculator. The figure is split for illustration purposes.

2. The Supplemental Commercial Kitchen Equipment Calculator

Pre-rinse spray valves, handwashing 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 handwashing 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 use to calculate water use and savings resulting from replacing inefficient aerators in handwashing 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 14 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.

Handwashing 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 32)

- ◆ Water use rates of efficient fixtures (gallons per flush or gallons per minute)
- ◆ Cost to replace the fixture
- ◆ 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)

Commercial-Grade Kitchen Water Use – Level Two

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 faucets use hot water?	
Enter Y or N	Y
Select timed flow measuring cup size	Flowbag

Figure 32. The *Efficiency Fixture Properties* table.

2. Fixture Use Data Table (Figure 33)

- ◆ 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 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 33**).

An example *Summary Output Table* for this tab is shown in **Figure 34**.

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 33. 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 34. *Summary Output Table* for the *Handwashing Faucets* tab.

Pre-Rinse Spray Valve Tab

The *Pre-Rinse Spray Valve* tab is very similar to the *Handwashing 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 34**). The primary difference is that you need to enter frequency of use assumptions for each spray valve.

Questions to Answer and Field Data You Will Need to Collect for this Tab (there are two input tables)

1. Efficiency Fixture Properties Table

(Identical to that of the handwashing faucet, see above)

2. Fixture Use Data Table

(Similar to that of the handwashing faucet, see **Figure 33**, with the exception of the use frequency data which should be based on your estimates, see **Figure 35**)

- ◆ Seconds used per rack
- ◆ Number of racks per hour
- ◆ Number of hours of use per day
- ◆ Number of work days per year

Figure 35 shows a completed input example.

Seconds Used per Rack	Number Racks per Hour	Number Hours of Use per Day	Number Work-days per year
10	75	4	260

Figure 35. An example of use frequency data entry in the *Pre-Rinse Spray Valves* tab.

The *Summary Output Table* for this tab is identical to that of the *Handwashing Faucet* tab (see **Figure 34**). The results include the total cost, water savings, and investment recovery period if all inefficient fixtures are replaced with efficient ones.

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 website¹.

The calculator used in this spreadsheet was developed by the FSTC and the District from the ENERGY STAR steam cooker calculator. This calculator uses national averages for water and energy per-unit costs

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.”

Commercial-Grade Kitchen Water Use – Level Two

(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, its operational assumptions, and model-type averages.

The modifications to the calculator associated with this manual allow you to override some of the default values to make the calculations more specific to your facility. Specifically, you will need to enter the information below into the *Model and Frequency of Use Input Table* (Figure 36):

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

- ◆ 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 37) lists some of the benefits of an efficient model over a conventional model.

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	<input type="text" value="Natural Gas"/>	
		Conventional Model	ENERGY STAR Model
6	Cost per combi oven	\$10,099	\$15,816

Figure 36. 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 37. An example of the *Summary of Benefits Output Table*.

Other Commercial-Grade Kitchen Calculators

In addition to the ENERGY STAR savings calculator¹, FSTC² has savings calculators for many of the water-using appliances mentioned in this manual. Additionally, the U.S. Department of Energy has energy savings calculators on their webpage³. You may want to explore these other calculators to see which best fits your needs.

Audit Procedure

The following procedure will help you:

- ◆ Quantify water consumption by the most common water-using fixtures and appliances used in a kitchen or cafeteria
- ◆ Develop a simple investment recovery period estimate from investments in new water efficient technology

Audit Steps

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:
 - ◆ 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 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)

¹ 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.

² Go to www.fishnick.com/saveenergy/tools/calculators or www.fishnick.com and enter "life cycle energy cost calculators" into the search bar.

³ <http://www1.eere.energy.gov/calculators/buildings.html>

Commercial-Grade Kitchen Water Use – Level Two

- 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

1. Assemble Worksheet 9 and Worksheet 10.

Utility Billing Data Input Tab

2. Confirm the following utility and billing information has been entered into the *Utility Billing Data Input* tab of the *Supplemental Commercial Kitchen Equipment* spreadsheet.
 - ◆ Water utility rate information: potable and sewer water costs
 - ◆ Power utility rate information: gas (therms) and electricity costs (KWh)Refer to page 13 for information on the *Billing Data Input* table.

Handwashing Faucets Tab

3. Examine the *Handwashing Faucets* tab.
4. Enter the following data:

Efficiency Fixture Properties table (see **Figure 32**)

- ◆ Water use rates of efficient fixtures (gallons per minute)
- ◆ Cost to replace the fixture
- ◆ 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)

Fixture Use Data table (see **Figure 33**)

- ◆ Faucet location
- ◆ Indication of whether faucet operation is manual or by sensor (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)

Pre-Rinse Spray Valves Tab

5. Enter the following data:

Efficiency Fixture Properties table (see **Figure 32**)

- ◆ Water use rates of efficient fixtures (gallons per minute)
- ◆ 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)

Fixture Use Data table (see **Figure 33**)

- ◆ Location of fixture
- ◆ Marked water use in gallons per minute (not necessary for calculations)
- ◆ Number of seconds used per rack
- ◆ Number of hours of use per day
- ◆ Number of work-days per year
- ◆ 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

6. Enter the following data:

- ◆ Number of combi cookers
- ◆ Use pattern information (hours and days of operation)
- ◆ Pounds of food cooked per day
- ◆ Fuel type
- ◆ Cost per combi oven

7. 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 and FSTC 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 investment recovery 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 an investment recovery 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 – Level One** (page 69) for information on specific appliance types.

COOLING TOWER WATER USE – LEVEL ONE

Background and Description

Nearly all CI facilities in Florida have air-cooling machinery. The majority of these systems use cooling towers, which can be a facility's highest point of water consumption. For this reason, special attention and guidance is provided for cooling towers.

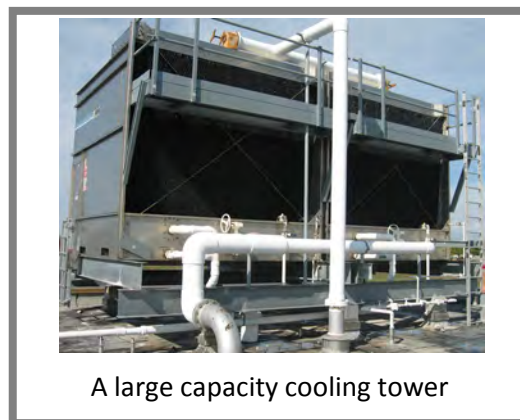
Cooling towers consume 2.4 gallons of water per minute of operation per 100 tons of operating load for every 10 degrees of cooling through evaporation (Vickers 2001). In other words, for every ton-hour (3.5 kWh) of cooling, 1.44 gallons of water are evaporated. These are unavoidable losses.

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. The number of times water is run through the cooling tower before being bled depends on the concentration of dissolved solids in the recirculating 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).

The rate of bleed-off (or 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 reduce system wear and maintain efficiency. The volume of makeup water can be calculated as:

$$M = E + B$$

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



A large capacity cooling tower

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 38** 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 parts of Florida, 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.

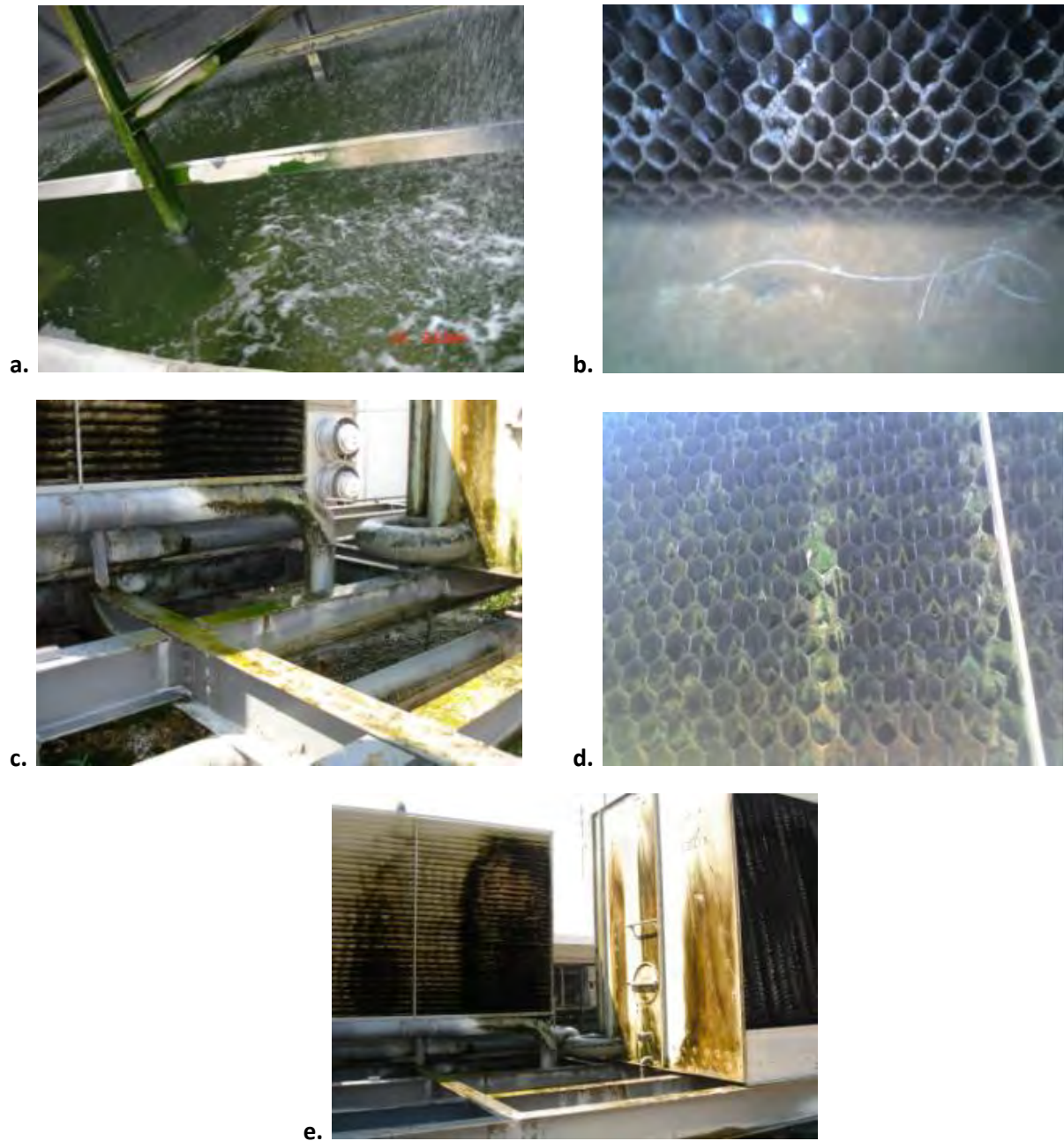


Figure 38. Cooling tower wear and tear. **a)** Algae growth in the well. **b and c)** Biofoul and scale. **d)** Excessive algae and biofouling. **e)** Excessive corrosion and fouling
(Photos courtesy of Tom Bednar, Equipoise Water).

Audit Procedure

This procedure will guide you through the steps to examine and evaluate the general condition of your facility's cooling tower.

Audit Steps

1. Prepare and examine Worksheet 11, Cooling Tower Water Use
2. Locate your facility's cooling tower, they are usually on the roof or behind the building
3. Determine if the cooling tower is equipped with feedline and drainline (makeup and bleed-off) submeters
4. Determine if the cooling tower is equipped with conductivity meters
5. Carefully examine the tower and note signs of the following (refer to **Figure 38**):
 - a. visible leaks
 - b. corrosion
 - c. mineral precipitate scaling on the heat exchangers or elsewhere
 - d. algae or slime
 - e. excessive drift

Post-Audit Considerations and Additional Activities

If the cooling tower is not submetered, your facility may be paying unnecessary sewer charges for evaporated water. This can add up to 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 Audit – Level One (page 20).

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 Alternative Water Sources section (page 149) for more information.

Cooling tower "drift" 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 type of visual inspection described in this section should occur at least twice a year. No leaks should be present. 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.

If a vendor is responsible for tower maintenance, alert them that your facility is prioritizing water conservation. Ask the vendor how many cycles of concentration the tower is currently operating under. 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.

The most basic cooling tower efficiency measures are listed below (Vickers 2001, Seneviratne 2007):

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. Reduce bleed-off by increasing the cycles of concentration (COCs) (see *Cooling Tower Water Use – Level Two* [page 93] for a complete explanation of cycles of concentration). Increasing the COCs from two to five results in a water savings of approximately 38 percent (Refer to **Table 12** in the next section.)
3. Install feedline and drainline flow meters and monitor use.
4. 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.
5. Set the system to shut down during off hours.
6. Install conductivity controls to allow close monitoring of water being consumed and for verification of optimum operating efficiency.
7. 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.
8. Consider adding a sidestream water softener or filter to the system.
9. Consider adding a high-efficiency drift eliminator, which can reduce drift to 0.002 percent of circulating water volume.
10. Evaluate alternative on-site sources of makeup water (NMSE 1999 and EBMUD 2008).

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

Level Two Teaser

The *Cooling Towers* spreadsheet allows 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 – Level One

Cooling Tower General Observations

- a) Cooling tower location _____
- b) Tons of cooling capacity (if known) _____
- c) Are flow meters or submeters present (circle one)? YES / NO
- d) Is the tower a closed loop (not once through) (circle one)? YES / NO
- e) 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)					

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

COOLING TOWER WATER USE – LEVEL TWO

Background and Description

As stated for the Level One 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 = concentration of blow-down water,
and CM = concentration of makeup water

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. **Table 12** shows the percent of water that can be saved by increasing the number of cycles.

Evaporated water leaves behind dissolved mineral content. The concentration ratio 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.

Table 12. Water savings from increased concentration ratios in cooling towers.

		Concentration Ratio											
		After Increasing Cycles											
		2	3	4	5	6	7	8	9	10	12	15	20
Before Increasing Cycles	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).

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 manual will

calculate the potential volume of condensate water formed by your facility's cooling tower. The Alternative On-Site Water Sources section of this manual (page 149) 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 previous section and in the Meters and Submeters section of this manual (page 20). The accompanying spreadsheet will calculate your facility's potential sewer credit to account for cooling tower water consumption.

Spreadsheet Guidance

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

- ◆ Utility water rates
- ◆ Typical operating load of the chiller (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 manual, 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 calculations in the worksheet 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 on page 14.

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 12** on page 94 to see the percent reduction in water consumption that will occur if the concentration ratio is increased (**Figure 39**). You will first need to enter the meter data into the calculator to determine your tower’s current cycles of concentration.

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 tons of Cooling >>>	250
5. Enter hrs/day of operation>>>	24
6. Enter days/month operation	30
7. Enter number of months/year operation	11

*Refer to page # in the manual to see the percent reduction in water consumption that would occur if the concentration ratio was increased from current levels to at least 6.	
8. Enter that percentage here >>>>	18 %

Figure 39. An example of the input tables on the *Utility Rates & Cooling Tower Ops* tab in the *Cooling Tower* spreadsheet associated with this manual.

Cooling Tower Water Use – Level Two

Transfer the recorded meter data from Worksheet 12 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.**

Audit Procedure

The procedure below 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. Confirm utility and billing information has been entered into the *Utility Rates & Cooling Tower Ops* input tab of the *Cooling Tower* spreadsheet.
2. Prepare and examine both pages of Worksheet 12, Cooling Water Tower Use. Identify the table set that will be used based on the type of meters associated with the tower. Explanation of the two table sets and how to determine which to use are provided in the Spreadsheet Guidance section.
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 12) 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 Level Three activity, Determining the True Cost of Water (page 144), 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.

This page intentionally left blank.

Worksheet 12. Cooling Tower Water Use – Level Two

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 tons of cooling >>>	
2. Enter hrs/day of operation>>>	
3. Enter days/month operation	
*Refer to Table 12 on page 94 in the manual to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 6.	
4. Enter that percentage here >>>>	<input style="width: 80px; height: 20px;" type="text"/> %

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 12. Cooling Tower Water Use – Level Two (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 Table 12 on page 94 in the manual to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 6.	
4. Enter that percentage here >>>>>	<input style="width: 80px; height: 20px;" type="text"/> %

Table Set 2: WATER CONSUMPTION CALCULATIONS	Date	Make-Up Concen- tration (TDS)	Bleed-off Concen- tration (TDS)

Transfer this information to the *Cooling Towers* spreadsheet.

IV. Outdoor Irrigation and Landscaping

General Overview

For a typical commercial building in Florida, roughly a quarter of all water consumption occurs through the facility's irrigation system. It is also common for automatic irrigation system timers to be set to deliver twice the amount of supplemental water necessary.

For this manual, almost all of the irrigation system and landscaping audit activities fall under Level One. For these activities, extensive familiarity with irrigation systems is not

required. However, you will need to perform certain audit 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 manual 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 9. Section Structure and Recommendations

There are two main points of focus related to the Outdoor Irrigation and Landscaping audit procedures: 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 – Level One and Level Two
- Rain/Soil Moisture Sensor – Level One and Level Two

Irrigation zones/stations

- Irrigation System and Landscape Survey – Level One and Level Two
- Irrigation System Distribution Uniformity, Application Rate and Calibration Audit – Level One

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 (Worksheet 13 through Worksheet 18) have been combined for your convenience the **Irrigation and Landscape Audit Worksheet** in Appendix C.

Working with a colleague, possibly using two-way radios or cell phones, with one person at the controller turning each zone on and off and one surveying the landscaped areas one zone at a time, may help with completing this task, but is not always necessary if this is not possible.

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.

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 somewhat 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.

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*¹.

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 of 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). **Figure 40** shows the water needs of a typical 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.

As per the University of Florida's Institute of Food and Agricultural Sciences (IFAS), irrigation applications should not exceed 0.75 inches of

¹ Available at 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."

IV. Outdoor Irrigation and Landscaping

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. Many parts of Florida have sandy soils, which can hold approximately 1 inch of water in the top 12 inches of soil. Considering the active root zone for most turf and grass is in the top 4 to 12 inches of soil, an application of 0.5 to 0.75 inches of water is sufficient to thoroughly wet the root zone and

will encourage deeper rooting, which increases drought tolerance (Trenholm et al. 2006). Therefore, less frequent, deeper watering is better for plants and more efficient than infrequent, shallow watering. Excessive watering (beyond 0.75 inches in one event) creates soil moisture beyond the turfgrass roots and carries away fertilizers and other agrichemicals. Soils with more clay or organic matter can hold moisture better than sandier soils and may require less frequent watering.

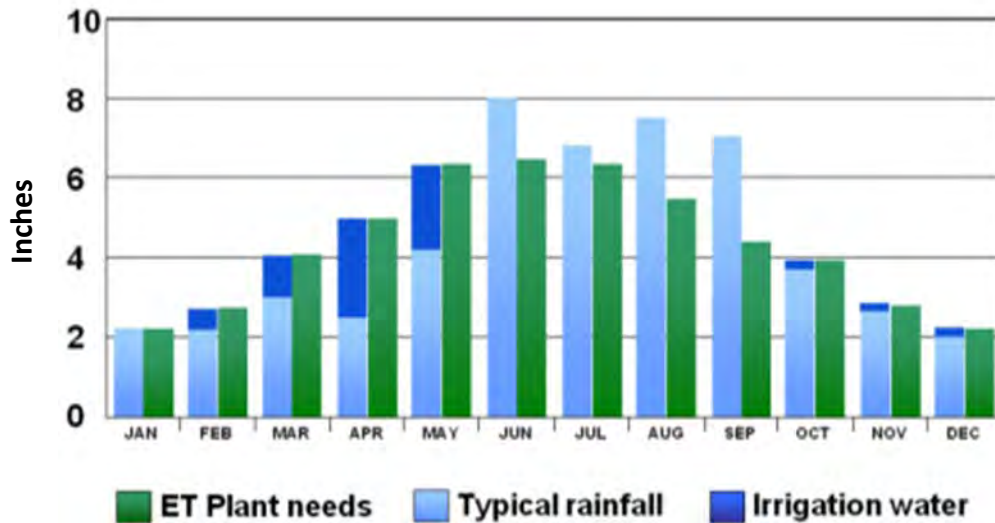


Figure 40. Monthly evapotranspiration (ET) demand, rainfall, and supplemental irrigation needs of a typical Florida lawn.

IRRIGATION SCHEDULE AND CONTROLLER – LEVEL ONE

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.

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 the local watering rules.

Some local municipalities and water management districts issue 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. Variances may be issued under various circumstances – it is best to consult with your local governing agency directly if you think a variance could benefit your facility.



Computerized irrigation controller

Audit Procedure

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
- ◆ Check compliance with local watering rules

Audit Steps

1. Examine Worksheet 13, Irrigation Schedule and Controller – Level One. When in the field conducting the audit, use the Irrigation and Landscape Audit Worksheet and refer to the Irrigation and Landscape Cheat Sheet, both in Appendix C.
2. Check your local municipality’s code enforcement office or water management district website to determine the permitted watering days and hours for the facility’s location. Record these days and times on the worksheet.
3. Locate the irrigation system’s control box.
4. 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.
5. Compare the days the system runs to the permitted irrigation days in the local watering rules.
6. For large properties, you may want to check with your head office to determine if an irrigation variance for the property already exists.

Post-Audit Considerations and Additional Activities

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.

Level Two Teaser

The Level Two procedure will guide you through the steps needed to improve the efficiency of the irrigation system by adjusting the runtimes for each zone so there is a decreased chance of over- or under-watering.

The Irrigation System Distribution Uniformity, Application Rate, and Calibration Audit section of this manual (page 131) provides guidance on measuring an irrigation system's application "rate" so the irrigation runtimes can be adjusted to apply a specific amount of water. The application rate is used to calibrate the irrigation runtime to avoid over- and under-watering.

Conservation Tip

Automatic sprinkler systems are a great tool but can waste a lot of water if set improperly. Make sure your system has a functioning rain or soil moisture sensor (see page 123) and that you adjust your clock throughout the year so your landscape can receive the correct amount of water to achieve optimum plant health.



Worksheet 13. Irrigation Schedule and Controller – Level One

	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

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

For your convenience, this worksheet has been combined with all other irrigation and landscape audit worksheets.

Refer to the Irrigation and Landscape Audit Worksheet and the Irrigation and Landscape Cheat Sheet, both in Appendix C.

IRRIGATION SCHEDULE AND CONTROLLER – LEVEL TWO

Background and Description

An irrigation system should be managed and used only to supplement rainfall. During most of Florida’s normal weather conditions, turfgrass only needs two days or less of irrigation per week (Trenholm et al. 2006).

Well-tuned and efficiently designed irrigation systems can usually meet landscape needs with 40 minutes or less of watering per zone, with less needed during winter months (Trenholm et al. 2006). The winter seasonal range for some parts of Florida can be as low as 0 to 10 minutes for turfgrass. The Irrigation System Distribution Uniformity, Application Rate and Calibration Audit section of this manual (page 131) will help you calculate the actual application rate of the irrigation system and calibrate it to meet the recommended application.

Some established landscape plant materials, including some perennials, trees, and shrubs, may not need irrigation to supplement rainfall except in extreme drought conditions (FYN 2009).

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

- ◆ **Rotors**, used to irrigate lawns or turfgrass (**Figure 41**).
- ◆ **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 42**).
- ◆ **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 43** and **Figure 44**).

Generally, irrigation runtimes for the various sprinkler types should fall within the ranges presented in **Table 13**.

Table 13. 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 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.



Figure 41. Rotor used to irrigate open areas of turf.



Figure 42. Sprayhead emitters.



Figure 43. Micro-irrigation emitter.



Figure 44. Another example of a micro-irrigation emitter.

In this procedure, you will check the runtimes of the irrigation cycles for each zone in the system for compatibility with the general irrigated vegetation type. To do this, you will need some familiarity with the controller or timer. If necessary review the operator's manual for the timer/controller or contact your facility's irrigation contractor.

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.

To potentially save time, review the Irrigation System Distribution Uniformity, Application Rate and Calibration Audit section of this manual (page 131) to determine if you intend to complete that procedure before beginning the procedure below. This later section provides steps to make a more precise estimate of your facility's irrigation system actual application rate (in inches per hour). That procedure results in a more refined measurement of the irrigation system's efficiency, but requires more effort.

Audit Procedure

The procedure below provides the steps to improve the efficiency of the irrigation system's runtimes. You may perform multiple irrigation and landscape audit procedures at one time as you survey each zone. For example you need to record the vegetation type of each zone on the Irrigation and Landscape Audit Worksheet for this procedure and this information is also used as part of the Irrigation System and Landscape Survey (page 111).

Audit Steps

1. Examine Worksheet 14, Irrigation Schedule and Controller – Level Two. When in the field conducting the audit, use the Irrigation and Landscape Audit Worksheet and refer to the Irrigation and Landscape Cheat Sheet, both in Appendix C.
2. Record the vegetation type for each zone on the Irrigation and Landscape Worksheet. This can be done at the same time as the Irrigation System and Landscape Survey (page 111).
3. Examine the runtime settings for each zone as programmed in the timer/controller and record this on the Irrigation and Landscape Audit Worksheet (always using one worksheet per zone).
4. Evaluate and note whether the runtimes are appropriate for each zone's general vegetation type (see **Table 13**).
5. Adjust the controller to ensure all zones are within the recommendations listed in **Table 13**.
6. Monitor plant health over the next several weeks and adjust the controller if needed.

Post-Audit Considerations and Additional Activities

The runtimes for each zone should be adjusted in accordance with the suggested ranges. 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, the following resources will be helpful:

- ◆ A Guide to Florida-Friendly Landscaping¹
- ◆ Florida Yards and Neighborhoods²
- ◆ South Florida Water Management District WaterWise Plant Guide³
- ◆ St. Johns River Water Management District WaterWise Landscapes⁴

¹ Visit 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."

² Go to fyn.ifas.ufl.edu

³ Visit www.sfwmd.gov and enter "WaterWise Plant Guide" into the search bar

⁴ Go to www.floridaswater.com/waterwiselandscapes/index.html or go to www.floridaswater.com and search for "WaterWise landscapes."

Worksheet 14. Irrigation Schedule and Controller – Level Two

All current runtimes in excess of the recommended times should be considered for adjustment. Refer to the Post-Audit Considerations and Additional Activities section before adjusting runtimes.

Irrigation Schedule and Controller - Level II

General plant type(s) (Turfgrass, Annuals, Perennials, Trees/shrubs)		
Current runtime ¹ (minutes)		
Is the current runtime appropriate for the plant, sprinkler type and season?	Yes	No
Appropriate new runtime ²		

1 – The current runtime for each individual zone should be recorded while examining the irrigation controller/timer as part of the current procedure (see Audit Step #3).

2 – Refer to **Table 13** on page 107.

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

For your convenience, this worksheet has been combined with all other irrigation and landscape audit worksheets.

Refer to the Irrigation and Landscape Audit Worksheet and the Irrigation and Landscape Cheat Sheet in Appendix C.

IRRIGATION SYSTEM AND LANDSCAPE SURVEY – LEVEL ONE

Background and Description

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 14**) (SFWMD 2009).

Table 14. Operational, Maintenance and System Design Factors commonly affecting irrigation system efficiencies.

Operational Factors
<ul style="list-style-type: none"> • Clock and controller schedules • Rain/soil moisture sensor operation
Maintenance Factors
<ul style="list-style-type: none"> • Poor sprinkler wetting patterns • Obstructed sprinklers • Broken sprinkler head/risers • Clogged sprinklers
System Design Factors
<ul style="list-style-type: none"> • 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)

Operational Factors are dictated by how the user operates the system and affect its normal function within its current design.

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

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 factors.

Operational Factors Review

System operations are affected by the user within the current design and current plant materials. The 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 operational factors often, though not always, involves no cost or field labor and can deliver same-day water savings.

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 (no more than 0.75 inches per irrigation event) within the parameters of any local watering restrictions. This procedure is addressed in the Irrigation Schedule and

Controller Audit sections (see pages 104 and 107).

Rain/Soil Moisture Sensor Operation

Rain and soil moisture sensors are required by Florida 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 Level One and Level Two Rain and Soil Moisture Survey procedures (pages 123 and 128).

Maintenance Factors Review

Maintenance Factors are usually easy to locate and repair and can potentially save significant amounts of water. However, these factors need to be checked regularly since problems may reappear with normal use and other activities on the landscaped areas.

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 45**), 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 46**) 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 47**), which can be fixed by flushing the lateral lines or cleaning the screen filters.

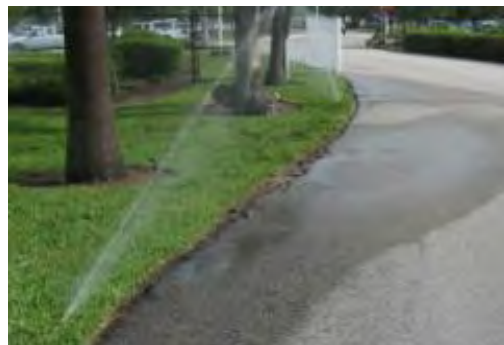


Figure 45. Sprinklers with a poor wetting pattern.



Figure 46. Broken sprinkler head creating a “geyser.”



Figure 47. Clogged sprayhead, the area between the two dashed red lines is not receiving water.

IV. Outdoor Irrigation and Landscaping

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. The same meter can be used to receive sewer credits for irrigation water (see page 20).



System Design Factors Review

Some of the factors below 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. However, many irrigation systems contain zones with turf and other plants irrigated by the same sprinklers. This results in either over-watering plants and shrubs or under-watering 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, as these areas may not need irrigation supplemental to rainfall.



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). 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. 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 are often equipped with a low-flow nozzle to irrigate plants and shrubs (this should be avoided where practical)
- **Micro-irrigation sprinklers** (drip lines or bubblers) – plants and shrubs; this is the

Audit Procedure

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.

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.



This procedure will allow you to:

- ◆ Determine exactly where in the landscape repairs, improvement efforts, and interventions should be directed
- ◆ Identify areas containing mature and established plants that no longer require irrigation

Audit Steps

1. Examine Worksheet 15, Irrigation System and Landscape Survey. When in the field conducting the audit, use 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.
2. Locate irrigation line blueprints or create a simple sketch of the property.
3. Manually turn on the irrigation system one zone/station at a time or wait for a scheduled irrigation event.
4. 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.
5. 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 three-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. Several free, downloadable resources¹ are helpful for identifying plants appropriate for specific conditions and will help you decide if specific plants in the landscape

-
- ¹ - 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/pg_grp_sfwmd_recinfoed/portlet_conservation_pubs/73ec5d84d048fb33e040e88d49523b6b, 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.”

can tolerate short-term droughts. If the plants are tolerant 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 local county extension office or botanic 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 would not need irrigation include 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. These areas can be permanently capped.

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. Groups that provide such certification include

the Florida Irrigation Society¹ and the Irrigation Association². 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.

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. See the Irrigation System and Landscape Survey Level Two (page 119) for more information.

Level Two Teaser

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 – Level Two will help you achieve these goals.

Conservation Tip

Improperly matched irrigation nozzles can lead to over watering some areas while other areas don't receive enough water. Never mix spray heads and rotary nozzles within the same irrigation zone.



¹ www.fisstate.org

² www.irrigation.org

Worksheet 15. Irrigation System and Landscape Survey – Level One

Sprinkler and Plant Types

Sprinkler type(s) ¹ (Rotor, Sprayhead, Microirrigation)		
Are all sprinklers the same type? ²	Yes	No
Are all sprinklers the same brand? ³	Yes	No
Is there more than one 'general' plant type? ⁴	Yes	No
Sprinkler matches plant type? ⁵	Yes	No

Sprinkler functionality

Sprinkler functional problems? (Check all that apply)	Clogged	
	Tilted	
	Obstructed	
	Broken	
All sprinklers have a proper wetting pattern?	Yes	No
Do all areas of zone warrant or necessitate irrigation? ⁶	Yes	No

Annuals & Perennials (if in this zone)

Is there an adequate layer of mulch? ⁷	Yes	No
Trees/shrubs appear to be mature or were installed more than one year ago? ⁸	Yes	No
Is microirrigation used? ⁹	Yes	No

- 1- See page 108 for photos of each.
- 2- There should be only one.
- 3- Matched brands are more likely to have matched application rates. (See note below)
- 4- There should be only one type per zone. The three 'general' plant types: turfgrass; annuals/perennials; trees/shrubs.
- 5- 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.
- 6- Zones or parts of zones that may not need 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.
- 7- 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.
- 8- If they are mature or were installed more than 1 year ago, they may not require irrigation. This zone should be further evaluated for removal from the irrigation system.
- 9- Microirrigation is the only class of sprinkler that should be used for annuals, perennials, trees, and shrubs.

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 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.

For your convenience, this worksheet has been combined with all other irrigation and landscape audit worksheets.

Refer to the Irrigation and Landscape Audit Worksheet and the Irrigation and Landscape Cheat Sheet in Appendix C.

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

IRRIGATION SYSTEM AND LANDSCAPE SURVEY – LEVEL TWO

Background and Description

Well-planned landscapes (**Figure 48**) 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.

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.

Another element of the Right Plant, Right Place concept is the prudent use of ground covers requiring high-volume irrigation. Turfgrass is the typical choice for ground cover in Florida, 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 later). Turfgrass is valuable for controlling soil erosion and in recreation areas for outdoor gatherings or activities (**Figure 49**). In other situations, such as narrow strips of landscape, better options are available from a water-conservation perspective (**Figure 50** and **Figure 51**)

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.

The following free resources may be helpful:

- ◆ A Guide to Florida-Friendly Landscaping¹
- ◆ WaterWise Plant Guide²
- ◆ Florida Exotic Pest Plant Council³

¹ Visit 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.”

² Visit www.sfwmd.gov and enter “WaterWise Plant Guide” into the search bar

³ Go to www.fleppc.org



Figure 48. Landscapes that compliment the local environment and make use of plants with growing requirements that can be met by the local environment.



Figure 49. Prudent uses of turfgrass, such as drainage swales and recreation areas.



Figure 50. An area of grass that could be converted to a planted bed.



Figure 51. A landscape bed using low-irrigation needing plants instead of turfgrass.

Audit Procedure

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.

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

Audit Steps

1. Examine Worksheet 16, Irrigation System and Landscape Survey. When in the field conducting the audit, use 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.
2. Evaluate the 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.
3. 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).
4. Complete the Irrigation System and Landscape Survey – Level Two section on 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 you have questions related to these considerations, contact a horticultural or landscape professional. They 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)¹
- ◆ University of Florida, Department of Horticulture (at IFAS)²
- ◆ Your local botanical garden or county extension agent³

¹ www.ifas.ufl.edu

² hort.ifas.ufl.edu or hort.ifas.ufl.edu/irrigation/index.shtml

³ extension.ifas.ufl.edu/map

Worksheet 16. Irrigation System and Landscape Survey – Level Two

Prudent Use of Turf

Does this zone/station contain turfgrass?	Yes	No
If so, does the zone serve as a recreation area, soil erosion mitigation area, or swale?	Yes	No

On the irrigation system sketch diagram, indicate areas where it may be possible to replace turfgrass with landscape plant materials with lower irrigation requirements.

Using a plant guide book, such as the WaterWise Plant Guide, for each zone, identify all non-turfgrass plant material.

Do all plants being irrigated in this zone have the same light and irrigation needs?	Yes	No
--	-----	----

For your convenience, this worksheet has been combined with all other irrigation and landscape audit worksheets.

Refer to the Irrigation and Landscape Audit Worksheet and the Irrigation and Landscape Cheat Sheet in Appendix C.

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

RAIN AND SOIL MOISTURE SURVEY – LEVEL ONE

Background and Description

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. This procedure will help you ensure your facility’s irrigation system is outfitted with an interrupter device as required by state law.

Rain Sensors

A rain sensor (RS) or rain switch is a device that disables an irrigation system’s timer or controller during or shortly after a rain event. 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



A standard rain sensor

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.

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 52** shows examples of the improper placement of rain sensors.

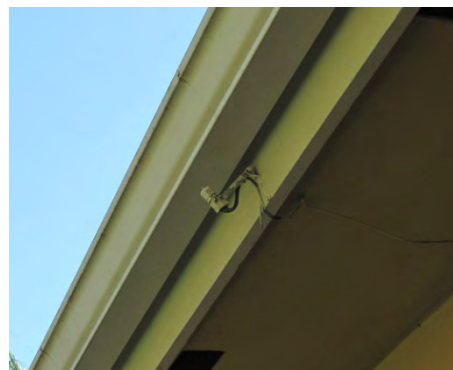


Figure 52. Rain sensors installed in places where normal rainfall is likely to be obstructed.

Soil Moisture Sensors

Soil moisture sensors (SMS) are buried several inches below the surface of the soil 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. Properly installed and maintained SMSes have been shown to save 60 to 70 percent of water compared to irrigation systems without a sensor (McCready et al. 2009).

SMSes 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 53**). 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.

Correctly wiring the soil moisture sensors to the timer or controller can be complicated, but is necessary for the system to function (**Figure 54**).

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

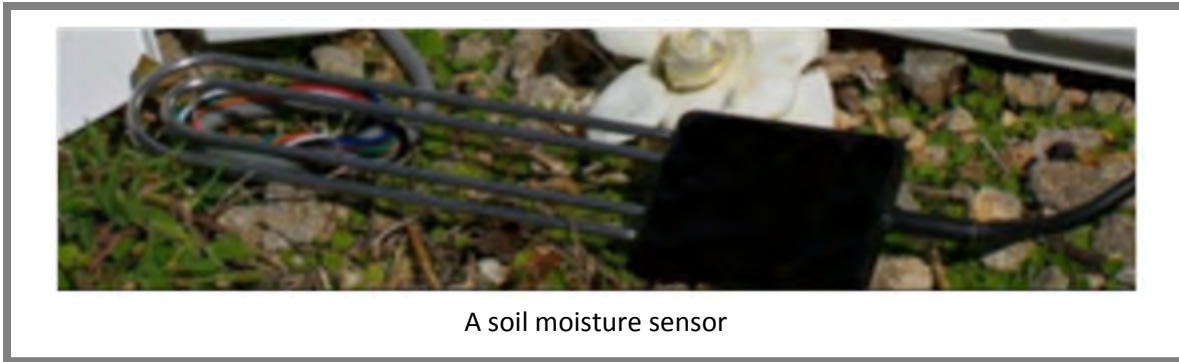


Figure 53. A demonstration of properly burying a soil moisture sensor.



Figure 54. 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 Procedure

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.

Audit Steps

1. Examine Worksheet 17, Rain and Soil Moisture Sensor Survey. When in the field conducting the audit, use 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.
2. Determine if the irrigation system is governed by a rain sensor or a soil moisture sensor. If not, one should be added immediately to be in compliance with state law.
3. Complete the Rain Sensor or Soil Moisture Sensor Survey – Level One section of the Irrigation and Landscape Audit Worksheet in accordance with the type of sensor.
4. All “No” responses should be reviewed for corrective action. Refer to the Post-Audit Considerations and Additional Activities section.

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 relocating it to a more appropriate location are inexpensive measures and should be done immediately to comply with state 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, “SWAT” irrigation controllers or, “Smart Water Application Technology” (**Figure 55**) can sharply 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 56**). Some controllers can even cancel irrigation events if a storm event is approaching the site. These systems 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 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 Florida Irrigation Society¹ or the Irrigation Association². 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.

¹ www.fisstate.org

² www.irrigation.org



Figure 55. A smart irrigation system control box.



Figure 56. An advanced climate sensor for a smart irrigation system.

Level Two Teaser

Even if sensors appear to be working properly, they may not be. The Rain and Soil Moisture Survey – Level Two section will help you determine whether your facility’s interrupter device is functioning correctly. **Table 15** shows the potential savings from a properly functioning rain sensor and soil moisture sensor.

Table 15. Potential savings from a properly functioning rain sensor and soil moisture sensor.

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 based on Cardenas-Lailhacar et al. (2010) and McCready et al. (2009).

Worksheet 17. Rain & Soil Moisture Sensor Survey – Level One

Rain Sensor Survey

Rain Sensor Location _____

Is the sensor located away from all building eaves, 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

Soil Moisture Sensor Survey

Soil Moisture Sensor Location _____

Is the sensor located away from all building eaves, 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

- 1- Rain sensors should not be located under anything that could impede rainfall or allow water from source other than rain to fall upon it.
- 2- 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.
- 3- The cork should be fresh and spongy. They typically last between two and three years.
- 4- The wires should be connected, not frayed, and protected from the elements.
- 5- 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.
- 6- Soil moisture sensors should be located equidistant from sprinkler heads.

For your convenience, this worksheet has been combined with all other irrigation and landscape audit worksheets.

Refer to the Irrigation and Landscape Audit Worksheet and the Irrigation and Landscape Cheat Sheet in Appendix C.

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

RAIN AND SOIL MOISTURE SURVEY – LEVEL TWO

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 location(s) may not be known. If not, you may need to contact the vendor who installed the unit(s). 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 Procedure

The procedure outlined below 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 test the reactivity of the sensor to the environment and is therefore not an adequate test of functionality.

Audit Steps

1. Examine Worksheet 18, Rain and Soil Moisture Sensor Survey – Level Two. When in the field conducting the audit, use 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.
2. Locate the irrigation cut-off sensor (rain sensor or soil moisture sensor).
3. Engage the irrigation system manually or conduct this test during a regularly scheduled irrigation event under dry conditions.
4. Once the system is engaged, slowly pour water over the RS or over the soil above the SMS.
5. Observe the system's reaction and record the result on the Irrigation and Landscape Audit Worksheet.
6. If the soil moisture sensor location could not be determined 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).
7. 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 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 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.

This is an inexpensive efficiency improvement measure and should be done immediately to remain in compliance with state law.

For additional information, see the Field Guide to Soil Moisture Sensor Use in Florida (SJRWMD 2008)¹.



¹ Available from www.sjrwmd.com/floridawaterstar/pdfs/SMS_field_guide.pdf

Worksheet 18. Rain and Soil Moisture Sensor Survey – Level Two

1. Soil Moisture Sensor Location _____

2. Did the sensor successfully interrupt the irrigation event?

Yes	No
<input type="checkbox"/>	<input type="checkbox"/>

For your convenience, this worksheet has been combined with all other irrigation and landscape audit worksheets.

Refer to the Irrigation and Landscape Audit Worksheet and the Irrigation and Landscape Cheat Sheet in Appendix C.

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

IRRIGATION SYSTEM DISTRIBUTION UNIFORMITY, APPLICATION RATE AND CALIBRATION AUDIT – LEVEL ONE

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 other 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 determined by you. These two exercises are presented together because they can be done simultaneously.

It should be noted that this audit procedure is best suited to open areas of high-volume irrigation, such as lawns or athletic play areas. These areas account for the majority of 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 57 illustrates soil profiles at various levels of saturation following an irrigation event. In **Figure 57a**, 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 57b** 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 57c and d**). This occurs 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 manual.

Irrigation System Distribution Uniformity, Application Rate and Calibration Audit – Level One

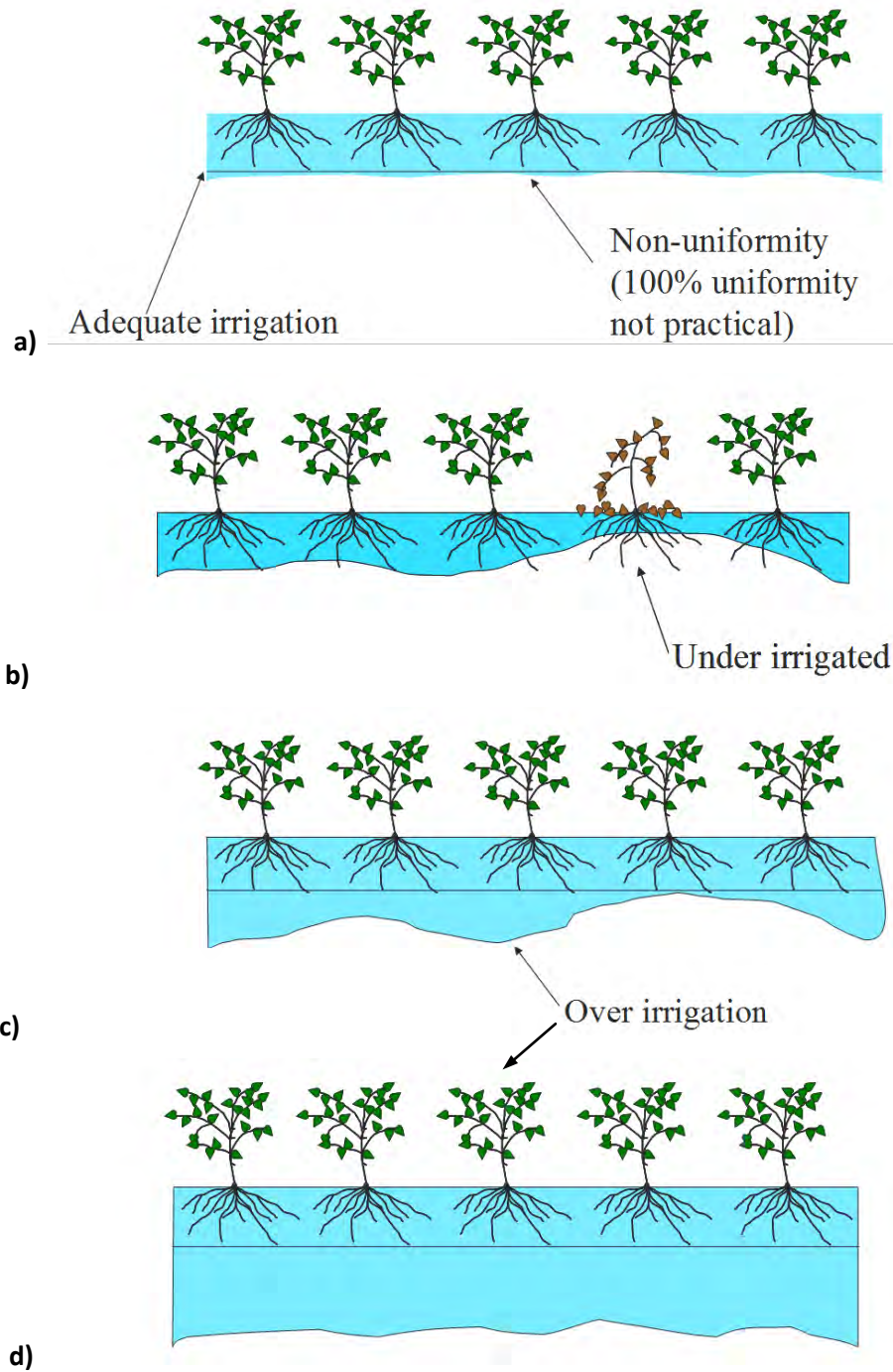


Figure 57. Irrigated soil profiles. **a)** An adequately irrigated soil profile with high distribution uniformity (DU) and a root zone that is fully saturated without further precolation. **b)** An inadequately irrigated soil profile with low DU and a root zone that is fully saturated only in some areas. **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 a catch-can test, which is routinely conducted during an irrigation system evaluation and will help you assess its overall distribution uniformity. This process begins by placing plastic cups in each irrigation zone (station) as shown in **Figure 58**. 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. 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).

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.



Figure 58. 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.

Ideally, the catch-can test should be conducted using straight-sided containers if you are planning on determining the application rate of the irrigation system. However, it will probably be easier to get a large number of plastic cups (**Figure 59a**). 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 (such as a soup or tuna can) with a similar diameter opening as the cups (**Figure 59b**) before measuring the depth (**Figure 59c**). This will more accurately measure the true depth of irrigation. The straight-sided can must be emptied between each measurement.

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 under-watering and increasing the efficiency of the system overall. The *Irrigation Water Use* Microsoft Excel spreadsheet associated with this manual contains a set of tables that will complete the necessary calculations once you enter the field measurements.

The Irrigation Schedule and Controller – Level Two procedure (page 107) lists general runtimes for each major emitter type. 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.

Irrigation System Distribution Uniformity, Application Rate and Calibration Audit – Level One

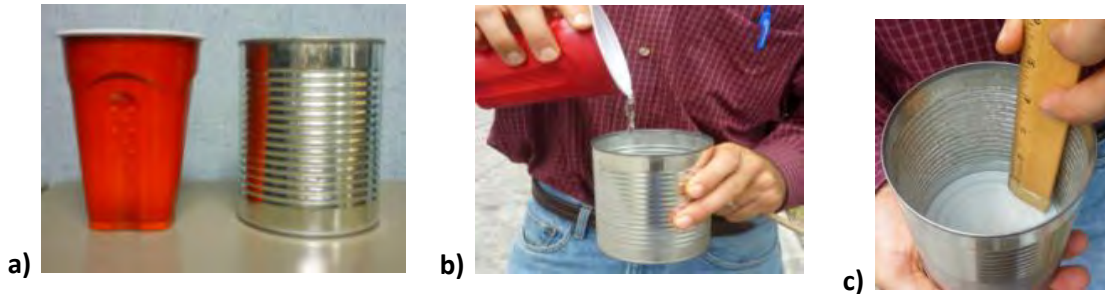


Figure 59. Measuring water collected during a catch-can test.

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. 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 1/8 inch (Figure 60).

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

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	X	X
Zone 8	Select One	1/8	X	X
Zone 9	Select One	2/8	X	X
		3/8		
Zone 10	Select One	4/8	X	X
		5/8		
Zone 11	Select One	6/8	X	X
		7/8		
Zone 12	Select One	Select One	X	X

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

Figure 60. An example of the Irrigation App. Rate Calibration tab in the Irrigation Water Use spreadsheet.

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.

Audit Procedure

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.

Audit Steps

Steps 1 through 10 describe the process to determine if the system has a high (efficient) or low (inefficient) DU. Steps 11 through 14 will help you determine the irrigation application rate (in inches per hour) so the system can be calibrated.

1. 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
2. Sketch the shape of the irrigated space being tested on a sheet of paper and the approximate locations of the catch-cans.
3. Completely remove the top of the straight-sided can.
4. Number each cup using the waterproof marker.
5. Place a cup one foot (30 cm) 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

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.

Irrigation System Distribution Uniformity, Application Rate and Calibration Audit – Level One

between sprinkler heads (see **Figure 58**). 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.

6. Mark the position of each numbered cup on the sketch.
7. Engage the system for at least 15 minutes.
8. For each cup in each zone, pour the water into the straight-sided can and measure the depth the nearest 1/8 inch (0.3 cm). 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.
9. Record the depth beside each cup number on the sketch of the irrigated area.
10. 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.
11. 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.
12. Use the *Irrigation App. Rate Calibration* tab in the *Irrigation Water Use* spreadsheet to determine the irrigation rate in inches per hour.
13. Decide on the desired application (recall that 0.5 to 0.75 inches per watering event should be enough to saturate the root zone in most Florida soils).
14. 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 Level One landscape survey, 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 61**).

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 Florida Irrigation Society¹ or the Irrigation Association². 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.

¹ www.fisstate.org

² www.irrigation.org

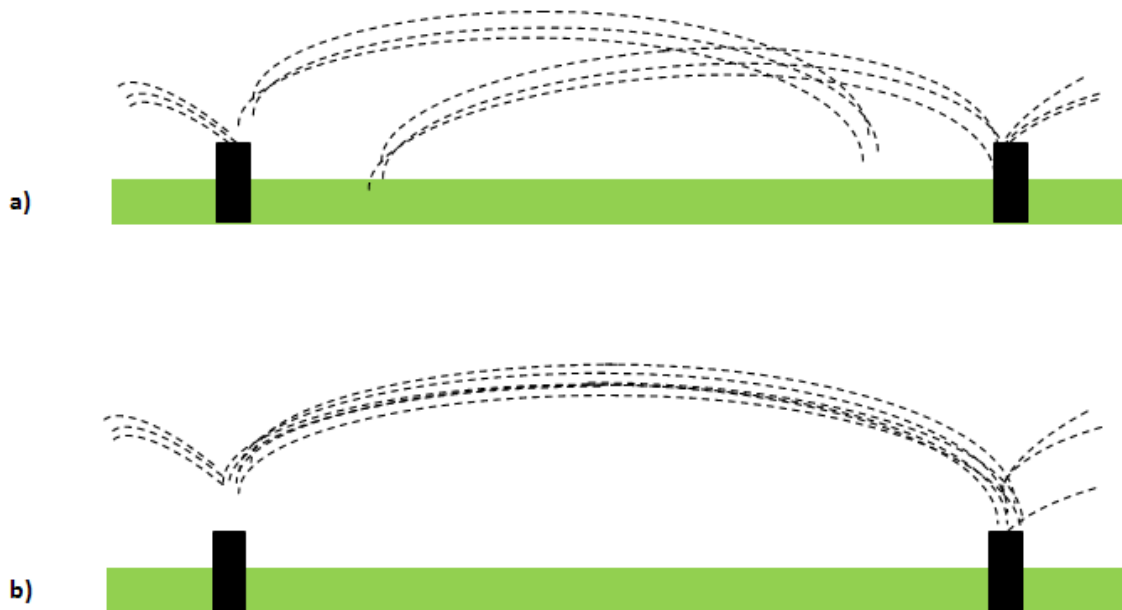


Figure 61. Sprinkler coverage diagrams. **a)** An irrigation system without head-to-head sprinkler coverage (inefficient water application). **b)** An irrigation system with head-to-head sprinkler coverage (highly efficient water application).

As per the University of Florida’s Institute of Food and Agricultural Sciences (IFAS), 0.75 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 0.75 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 0.5 to 0.75 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, the following IFAS publications are recommended:

- ◆ 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)

**Irrigation System Distribution Uniformity,
Application Rate and Calibration Audit - Level One**

This page intentionally left blank.

V. Level Three: Strengthening Decision-Making Power for Efficiency Improvement Planning

General Overview

The Level Three procedures will give you more information to support decision making for planning efficiency improvements. Specifically, Level Three procedures provide direction on more intensive investigations into unaccounted-for water and reduction through the creation of a full-facility water balance.

A facility water balance, along with the products of two additional Level Three 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 Level Three procedure 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, the Level Three procedures are invaluable tools for creating long-range, lasting water efficiency improvement plans and decisions.



CREATING A FACILITY WATER BALANCE – LEVEL THREE

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 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. The procedure below 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 Level One and Level Two 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 and PWB 2010).

The *Facility Water Balance* tab in the *Level III Water Use Analysis* spreadsheet contains a table similar to **Figure 62**. 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 manual.

For any specific water-using appliance, you can refer to the owner's manuals 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.

V. Level Three: Strengthening Decision-Making Power for Efficiency Improvement Planning

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 62. Example table and pie chart from the *Level III Water Use Analysis* spreadsheet showing the water balance of a commercial building.

Spreadsheet Guidance

After completing Worksheet 19, transfer the data to the *Facility Water Balance* tab of the *Level III Water Use Analysis* spreadsheet. The spreadsheet will calculate unaccounted for water and create a pie chart similar to that in **Figure 62** illustrating the water use at the facility.

Audit Procedure

This procedure will guide you through the steps necessary to create a facility water balance.

Audit Steps

1. Examine Worksheet 19 and the *Facility Water Balance* tab in the *Level III Water Use Analysis* spreadsheet.
2. If all of the Level Two activities in this manual have been completed, you should be able to complete the table on the *Facility Water Balance* tab in the *Level III Water Use Analysis* spreadsheet.
3. 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 manual (page 7).

Worksheet 19. 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:	
Other:	
Other:	
Known leaks	
*Water purchased + well pumpage	

*Enter Metered Volume

DETERMINE THE TRUE COST OF WATER AT A FACILITY – LEVEL THREE

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 utilize heated water for any purpose will have added energy expenses tied to water use (NMSE 1999 and Seneviratne 2007). **Figure 63** (taken from the *True Cost of Water* tab in the

Level III Water Use Analysis spreadsheet associated with this manual) 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.

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 Manual" section of this manual on page 14 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 63**). 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.

V. Level Three: Strengthening Decision-Making Power for Efficiency Improvement Planning

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 63. An example of the output table on the *True Cost of Water* tab.

Audit Procedure

This procedure will guide you through the steps to determine the true cost of water for your facility.

Audit Steps

1. Examine the *True Cost of Water* tab in the *Level III Water Use Analysis* spreadsheet.
2. On the *Utility Rate Data Input* tab, enter cost per unit for potable and sewer water (do not include base costs).
3. Assemble one 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
4. Enter these charges into the *True Cost of Water* tab.
5. 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.

HISTORICAL WATER USE PROFILE – LEVEL THREE

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 *Level III Water Use Analysis* spreadsheet contains a

table similar to **Figure 64** 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 65** and **Figure 66** 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.

*^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 64. Example input table for an office building’s historic water use profile.

Facility Water Use: Inflow and Sewer Water

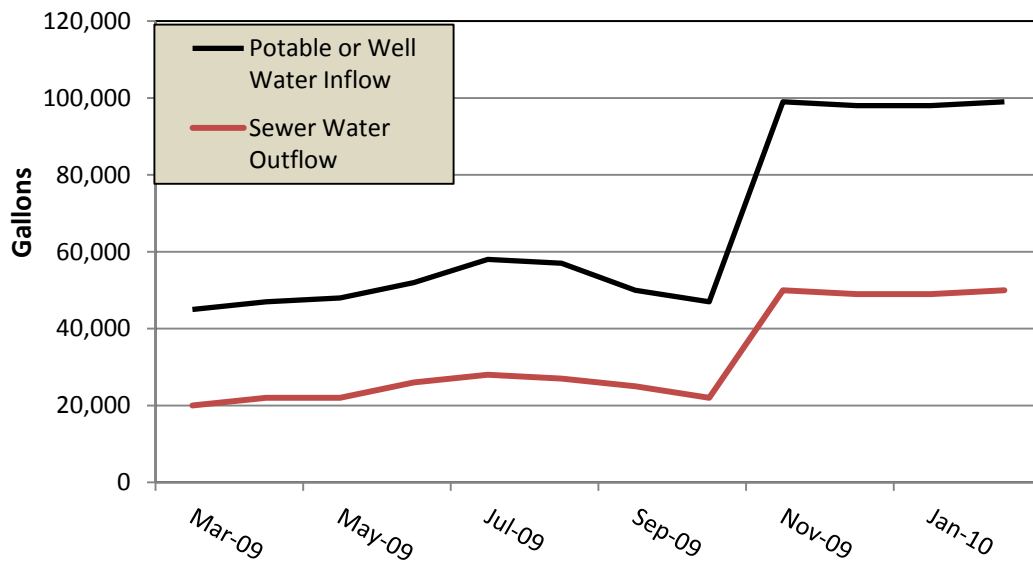


Figure 65. Example facility water use based on an office building’s historic water use profile.

Cooling Tower Chemical Treatment Expenses

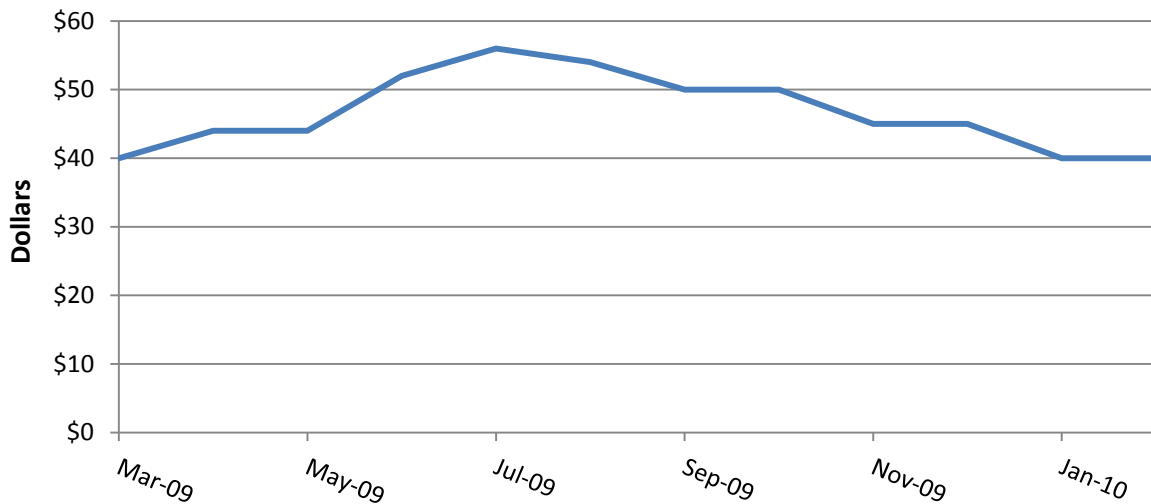


Figure 66. Example facility cooling tower expenses based on an office building’s historic water use profile.

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 Manual” section of this manual on page 14 for an explanation.

To complete this audit, refer to the *Historic Water Use Profile* tab on the *Level III Water Use Analysis* spreadsheet. In the input table, enter the billing periods, inflow meter records, outflow meter records, and cooling tower chemical expenses.

Audit Procedure

This procedure will guide you through the necessary steps to create a graphic representation of your facility’s water use, potentially including additional water-related expenses.

Audit Steps

1. Assemble water and sewer utility bills from the past 1 to 3 years.
2. Assemble at least 1 year’s worth 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.
3. Separate the use and utility billing data on a per-month basis.
4. Examine a water bill to determine the utility billing units.
5. On the *Utility Rate Data Input* tab, enter cost per unit for potable and sewer water (do not include base costs).
6. Examine the *Historic Water Use Profile* tab on the *Level III Water Use Analysis* spreadsheet.
7. Enter the water use data into the *Historical Water Use Data Input* table (in ccfs or gallons, depending on the selected billing unit).
8. 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.

IDENTIFYING ON-SITE ALTERNATIVE WATER SOURCES – LEVEL THREE

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 manual. If your facility is considering such an analysis, consider contacting a conservation or engineering consulting firm.

Possible sources of on-site alternative water include:

- ◆ 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



Storage containers for
harvested rainwater

- ◆ 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 *Level III Water Use Analysis* spreadsheet.

The Cooling Tower Water Use section (page 88) of this manual includes a calculator to estimate condensate from cooling system air handling units. A similar calculator has been included on the *On-Site Alternative Water Sources* tab of the *Level III Water Use 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

Identifying On-Site Alternative Water Sources – Level Three

harvested rain water. Harvested rain water can be used for many non-potable 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.

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 Manual" section of this manual on page 14 for an explanation.

For this audit, refer to the *On-Site Alternative Water Sources* tab on the *Level III Water Use 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 that 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 (listed in **Table 16**). 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.

Audit Procedure

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

1. Before beginning, you may want to review the Alternate On-Site Water Sources section of the *WaterSmart Guidebook* (EBMUD 2008)¹.
2. Examine the *On-Site Alternative Water Sources* tab on the *Level III Water Use 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 parts of Florida as shown in **Table 16**.

Table 16. 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.

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 16 has been included to support a precursory review of your facility's rainwater harvesting potential.

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.

Conservation Tip

Recycled water is available in many communities. Contact your local utility to see if it is available at your facility and, if possible, use recycled water for irrigation or other process needs that do not require treated drinking water.



VI. Related Resources

References Cited

- AWUWCD. 2006. Water Efficient Equipment and Design, A Guide for Non-Residential Construction and Development. Austin Water Utility Water Conservation Division, Austin, TX. www.ci.austin.tx.us/watercon/.
- AWWA. 1999. Testing of Meters – Testing Procedures and Equipment. Manual M6, Meter Selection, Installation Testing and Maintenance. American Water Works Association, Denver, CO.
- Building Green. 2010. Alternative Water Sources: Supply-Side Solutions for Green Buildings. Building Green, LLC. www.buildinggreen.com.
- California Urban Water Conservation Council. 2009. How to Read Your Water Meter. California Urban Water Conservation Council, Sacramento, CA. www.h2ouse.net/resources/meter/index.cfm.
- Cardenas-Lailhacar, B., M. D. Dukes, and G.L. Miller. 2010. Sensor-Based Automation of Irrigation on Bermuda Grass During Dry Weather Conditions, *J. Irrigation and Drainage Eng* 136(3):161-223.
- Colorado WaterWise Council. 2007. Benchmarking Task Force Collaboration for Industrial, Commercial & Institutional Water Conservation, Colorado WaterWise Council. http://coloradowaterwise.org/Resources/Documents/ICI_toolkit/docs/Brendle%20Group%20and%20CWW%20ICI%20Benchmarking%20Study.pdf.
- Dziegielewski, B. (ed). 2000, Commercial and Institutional End Uses of Water. American Water Works Association Research Foundation, Denver, CO.
- EBMUD. 2008. WaterSmart Guidebook, A Water-Use Efficiency Plan Review Guide for New Businesses. East Bay Municipal Utility District, Oakland, CA. www.allianceforwaterefficiency.org/WaterSmart_Guidebook_for_Businesses.aspx.
- EPA. 2009. Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program. U.S. Environmental Protection Agency, Washington, DC. www.epa.gov/WaterSense/docs/ci_whitepaper.pdf.
- FDEP. 2008. Florida Friendly Best Management Practices for Protection of Water Resources by the Green Industries. Florida Department of Environmental Protection, Tallahassee, FL. fyn.ifas.ufl.edu/pdf/grn-ind-bmp-en-12-2008.pdf.
- Florida Statute 373.62. Water Conservation; Automatic Sprinkler Systems. www.leg.state.fl.us/.
- FYN. 2009. Florida Yards and Neighborhoods Handbook. Florida-friendly Landscaping. fyn.ifas.ufl.edu/materials/FYN_Handbook_vSept09.pdf or fyn.ifas.ufl.edu.
- Jones, H.C., Lippi, C.S. and L.E. Trenholm. 2006. Managing Your Florida Lawn Under Drought Conditions. University of Florida, Institute of Food and Agricultural Sciences, Gainesville, FL. edis.ifas.ufl.edu/ep078.
- LEED. 2009. Leadership in Energy and Environmental Design for New Construction and Major Renovations Rating System. United States Green Building Council.
- Livelli, G. 2007. Verifying Flowmeter Accuracy, Calibration Techniques to Ensure Measurement Performance. *Flow Control Network Magazine*, 13(7). www.flowcontrolnetwork.com/issuearticle.asp?ArticleID=196.
- McCready, M.S., M.D. Dukes and G.L. Miller. 2009. Water Conservation Potential of Smart Irrigation Controllers on St. Augustine Grass. *Agricultural Water Management* 96(11):1623-1632.

Related Resources

- Morales, M.A., J.M. Martin and J. P. Heaney. 2009. Methods for Estimating Commercial, Industrial and Institutional Water Use. Proceedings of the Fall 2009 FSAWWA Water Conference, Orlando, FL, Conserve Florida Water Clearinghouse. library.conservefloridawater.org/publications/10327351.pdf.
- NCDENR. 2009. Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities. North Carolina Department of Environment and Natural Resources, Division of Pollution Prevention and Environmental Assistance, Division of Water Resources, Land-of-Sky Regional Council, Raleigh, NC.
- NMSE. 1999. A Water Conservation Guide for Commercial, Institutional and Industrial Users. New Mexico Office of the State Engineer, Santa Fe, NM.
- PWB. 2010. Facility Water Audit Process. Portland Water Bureau, Portland, OR.
- Rainbird Irrigation. 2010. Distribution Uniformity for Sprinkler Irrigation, Rainbird Irrigation, Azusa, CA.
- Ramey, V. 2004. Evaporation and Evapotranspiration. University of Florida, Institute of Food and Agricultural Science, Gainesville, FL. plants.ifas.ufl.edu/guide/evaptran.html.
- Seneviratne, M. 2007. A Practical Approach to Water Conservation for Commercial and Industrial Facilities. Elsevier, Burlington, MA.
- SJRWMD. 2008. Field Guide to Soil Moisture Sensor Use in Florida. St. Johns River Water Management District. Palatka, FL. http://www.sjrwmd.com/floridawaterstar/pdfs/SMS_field_guide.pdf.
- SJRWMD. 2009. In-Ground Irrigation Systems; Design, Use and Maintenance. St. Johns River Water Management District. Palatka, FL. www.sjrwmd.com/waterconservation/education/files/irrigation_brochure_printfile.pdf.
- SFWMD. 2009. Leading by Example Water Conservation Program, Outdoor Audits for District-Owned Facilities. Soil and Water Conservation District, South Florida Water Management District, West Palm Beach, FL.
- Trenholm, L.E., J.B. Unruh and J.L. Cisar. 2006. Watering Your Florida Lawn. University of Florida, Institute of Food and Agricultural Sciences, Gainesville, FL. edis.ifas.ufl.edu/lh025.
- Trenholm, L.E., J.B. Unruh and J.L. Cisar. 2009. How to Calibrate Your Sprinkler System. University of Florida, Institute of Food and Agricultural Sciences, Gainesville, FL. edis.ifas.ufl.edu/lh026.
- TWDB. 2008. Industrial, Commercial, and Institutional Water Conservation. Texas Water Development Board, Austin, TX. www.twdb.state.tx.us/assistance/conservation/municipal/ici.asp.
- TWDB. 2008. School Water Audit. Texas Water Development Board, Austin, TX. www.twdb.state.tx.us/assistance/conservation/municipal/documents/HSwateraudit_withcover.pdf.
- UF-IFAS. 2009. Protocol for Irrigation of Shrubs during Establishment: Establishing Best Management Irrigation Practices for Shrub Establishment in Florida Landscapes. University of Florida, Department of Horticulture, Institute of Food and Agriculture Science, Gainesville, FL. hort.ifas.ufl.edu/ and hort.ifas.ufl.edu/irrigation/index.shtml.
- USGS. 2009. Water Withdrawals, Use, and Trends in Florida 2005: U.S. Geological Survey Scientific Investigations Report 2009-5125, 20p.
- Vickers, A. 2001. Handbook of Water Use and Conservation. Waterplow Press, Amherst, MA
- Vinchesi, B. 2010. Designing Irrigation for Greens and Surrounds. Grounds Maintenance for Golf and Green Industry Professionals. grounds-mag.com/golf_courses/grounds_maintenance_designing_irrigation_greens/.
- WMI. 2009. Indoor Water Audits for District-Owned Facilities. Report by Water Management Inc. for the South Florida Water Management District, West Palm Beach, FL.

Resources for Water Use and Savings Calculators

Bluejay, Michael. Heat energy formulas for Indoor Sanitation and Kitchen Hand-faucets and Pre-Rinse Spray Valves Water Use Calculators.

Combination Oven Water Use and Savings (adapted from ENERGY STAR Water Use and Savings Calculator by Food Service Technology Center for use in this manual).

ENERGY STAR: Residential Dishwasher, Commercial Dishwasher (adapted by South Florida Water Management District for use in this manual).

Food Service and Technology Center: Steam Cooker Water Use and Savings (adapted from ENERGY STAR Water Use and Savings Calculator by Food Service Technology Center for use in this manual).

Hoffman, Bill. Ice Machine Life-Time Water Use (adapted by South Florida Water Management District for use in this manual).

South Florida Water Management District: Meters and Leaks; Daily Water Use, Indoor Sanitation, Cooling Towers; Kitchen Hand-faucets and Pre-rinse Spray Valves; Irrigation Application and Rate Calibration.

Vickers, A. 2001. Handbook of Water Use and Conservation. Waterplow Press, Amherst, MA, for cooling tower water use formulas.

Additional Resources and Websites

- Air-Conditioning, Heating, and Refrigeration Institute. 2010. www.ahridirectory.org.
- Alliance for Water Efficiency. 2010. www.allianceforwaterefficiency.org.
- Bluejay, M. 2010. How to Save Money on Water Heater Use. www.michaelbluejay.com/electricity/waterheaters.html.
- Consortium for Energy Efficiency. 2010. www.cee1.org.
- ENERGY STAR program. 2010. www.energystar.gov.
- Florida-friendly Landscaping Principles. fyn.ifas.ufl.edu; fyn.ifas.ufl.edu/pdf/grn-ind-bmp-en-12-2008.pdf.
- Florida-friendly Landscaping. 2010. www.floridayards.org; www.floridayards.org/landscape/FYN-Handbook.pdf.
- Food Service Technology Center. 2010. www.fishnick.com.
- Green Restaurant Guide. San Francisco Department of Public Health. 2009. www.sfdph.org.
- Miami-Dade Water and Sewer Department. 2008. Water Audit Final Report.
- Minister of the Environment, Canada. 1993, revised 1997. Manual for Conducting Water Audits and Developing Water Efficiency Programs at Federal Facilities, Cat. No. En 40-445/1993E, ISBN 0-662-20334-8.
- Natural Resources Defense Council. 2009. Making Every Drop Work: Increasing Water Efficiency in California's Commercial, Industrial, and Institutional Sector.
- New Hampshire Department of Environmental Service. 2001. Environmental Fact Sheet: Performing a Business or Industry Water Use and Conservation Audit.
- Piper, J. 2008. How Does a Water Audit Work? Facilities Net. www.facilitiesnet.com/green/article/How-Does-a-Water-Audit-Work--9363.
- South Florida Water Management District WaterWise Plant Guide. 2010. www.sfwmd.gov/portal/page/portal/pg_grp_sfwmd_recinfoed/portlet_conservation_pubs/73ec5d84d048fb33e040e88d49523b6b.
- Southwest Florida Water Management District. 2010. Office Building Checklist. www.swfwmd.state.fl.us/conservation/.
- Southwest Florida Water Management District. 2010. School Water Audit (Draft document),
- St. Johns River Water Management District WaterWise Landscapes. 2010. www.sjrwmd.com/waterwiselandscapes/index.html (or go to www.floridaswater.com and enter "WaterWise landscapes" into the search bar).
- St. Johns River Water Management District. Florida Water Star Program. 2010. www.sjrwmd.com/floridawaterstar/index.html.
- WaterSense. Environmental Protection Agency. 2010. www.epa.gov/WaterSense/.

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 = 7.48 gallons and 100 cubic feet = 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.

Appendix A. How to Read Your Water Meter

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 $\frac{5}{8}$ -inch meter, as shown on the dial.



Figure A-3. Simple dial meter with turned over number.

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.

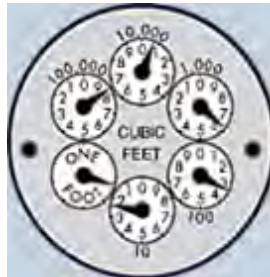


Figure A-4. Multi-dial older meter.

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					

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
Meters and Submeters					
Meters have been checked for accuracy					
Someone on-site can read meters					
Routine meter reading regime established (irrigation)					
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 towers have submeters (makeup and blow-down)					
Cooling towers have conductivity meters					
Cooling tower meters monitoring routine regularly scheduled					
Cooling tower cycles of concentration are at at-least five					
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					
Cooling tower is cleaned routinely at six months					

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
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					
Florida - Friendly Landscaping Principles are observed					

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
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 1.75 gals/min or less					
Dishwasher is run at manufacturer's specifications and using a pressure regulator if necessary					
Dishwasher is run only for full racks					

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
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 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 and Technology Center (FSTC) qualified					
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					
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					

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
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

All indoor worksheets (1 through 11 and 18) from the manual are duplicated in this appendix. Single-page worksheets are repeated to ease double-sided printing of these pages. Worksheets 12 through 17 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 manual.

This page intentionally left blank.

Worksheet 2. Facility Leak Audit – Level One

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Transfer this information to the Microsoft Excel spreadsheet associated with this manual.

Worksheet 2. Facility Leak Audit – Level One

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Meter Location Type	_____			

Date and Time	Initial Meter Reading	Date and Time	End Meter Reading	Known Water Consumption During Shut-Down

Transfer this information to the Microsoft Excel spreadsheet associated with this manual.

Worksheet 3. Estimating Irrigation Water Use – Level One

1. Does the facility have an irrigation system?
If no:
 Request copies of the utility billing records from your facility's accounts payable office. Divide the total water use and total cost each by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day. Refer to **Figure 13**.
If yes: Continue to 2.

2. What is the water source of the irrigation system?
If reclaimed or reuse water is used, request copies of the utility billing records for both the potable and reclaimed water accounts from the facility's accounts payable office.

- For the potable water account, divide the total water use and total cost each by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day.
- For the reclaimed water account, divide the total water use and total cost by the number of days the irrigation system was run during the billing cycle. This will yield gallons used and expenses incurred per irrigation event. Refer to **Figure 13**.

If self-supplied (well, canal, retention pond) water is used, an irrigation professional may be able to estimate irrigation water use.
If potable water is used, continue to 3.

3. Is the irrigation line submetered?
If yes:
 The irrigation water use volume for the billing period is known from the submeter and can be subtracted from the main meter volume to reveal the indoor water use volume. Then divide the indoor water use volume by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day.
 Divide the irrigation water use volume by the number of days the irrigation system was run during the billing cycle.* This will yield gallons used per irrigation event. Refer to **Figure 13**.
If no: Use the table below and refer to the Spreadsheet Guidance subsection on page 27.

**Irrigation Schedule and Controller – Level One section of this manual provides guidance in 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.

Worksheet 3. Estimating Irrigation Water Use – Level One

1. Does the facility have an irrigation system?

If no:
Request copies of the utility billing records from your facility's accounts payable office. Divide the total water use and total cost each by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day. Refer to **Figure 13**.

If yes: Continue to 2.

2. What is the water source of the irrigation system?

If reclaimed or reuse water is used, request copies of the utility billing records for both the potable and reclaimed water accounts from the facility's accounts payable office.

- For the potable water account, divide the total water use and total cost each by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day.
- For the reclaimed water account, divide the total water use and total cost by the number of days the irrigation system was run during the billing cycle. This will yield gallons used and expenses incurred per irrigation event. Refer to **Figure 13**.

If self-supplied (well, canal, retention pond) water is used, an irrigation professional may be able to estimate irrigation water use.

If potable water is used, continue to 3.

3. Is the irrigation line submetered?

If yes:
The irrigation water use volume for the billing period is known from the submeter and can be subtracted from the main meter volume to reveal the indoor water use volume. Then divide the indoor water use volume by the number of days in the billing cycle. This will yield gallons used and expenses incurred per day.

Divide the irrigation water use volume by the number of days the irrigation system was run during the billing cycle.* This will yield gallons used per irrigation event. Refer to **Figure 13**.

If no: Use the table below and refer to the Spreadsheet Guidance subsection on page 27.

**Irrigation Schedule and Controller – Level One section of this manual provides guidance in 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.

Worksheet 4. Faucets

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

Location	Lav. Fac. (?) ✓	User Group	Manual, Sensor, or Spring	If 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.		
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 6. Urinals

Building Name _____

Location	User Group	Manual or Sensor	Valve Flush Rate (gpf)	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 6. Urinals

Building Name _____

Location	User Group	Manual or Sensor	Valve Flush Rate (gpf)	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. 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
	Marked Flow Rate (gpm)	Timed		Calc. Rate or Flowbag (gpm)		
		Num. Cups/ Pints/ Quarts	Num. Secs.			
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. 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
	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.

Worksheet 8. 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?
Low Temp. Or High Temp.		Under Counter							
		Door Type							
		Single Tank Conveyor							
		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		Make/ Model	Quantity	Average number of loads per week	Type of water heating	Type of clothes dryer	Electric or Gas Drier	ENERGY STAR Qualified?
		How is water for each unit heated?							
		Electric Heat							
		Gas Heat							
Leaks or Other Comments									

Worksheet 8. 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?
Low Temp. Or High Temp.		Under Counter							
		Door Type							
		Single Tank Conveyor							
		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		Make/ Model	Quantity	Average number of loads per week	Type of water heating	Type of clothes dryer	Electric or Gas Drier	ENERGY STAR Qualified?
		How is water for each unit heated?							
		Electric Heat							
		Gas Heat							
Leaks or Other Comments									

Worksheet 9. Commercial-Grade Kitchen Water Use

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?
Low Temp. Or High Temp.		Under Counter							
		Door Type							
		Single Tank Conveyor							
		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		Make/ Model	Quantity	Average number of loads per week	Type of water heating	Type of clothes dryer	Electric or Gas Drier	ENERGY STAR Qualified?
		How is water for each unit heated?							
		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 Water Use

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?
Low Temp. Or High Temp.		Under Counter							
		Door Type							
		Single Tank Conveyor							
		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		Make/ Model	Quantity	Average number of loads per week	Type of water heating	Type of clothes dryer	Electric or Gas Drier	ENERGY STAR Qualified?
		How is water for each unit heated?							
		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 – Level One

Cooling Tower General Observations

- a) Cooling tower location _____
- b) Tons of cooling capacity (if known) _____
- c) Are flow meters or submeters present (circle one)? YES / NO
- d) Is the tower a closed loop (not once through) (circle one)? YES / NO
- e) 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)					

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

Worksheet 11. Cooling Tower Water Use – Level One

Cooling Tower General Observations

- a) Cooling tower location _____
- b) Tons of cooling capacity (if known) _____
- c) Are flow meters or submeters present (circle one)? YES / NO
- d) Is the tower a closed loop (not once through) (circle one)? YES / NO
- e) 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)					

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

Worksheet 12. Cooling Tower Water Use – Level Two

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 tons of cooling >>>	
2. Enter hrs/day of operation>>>	
3. Enter days/month operation	
*Refer to Table 12 on page 94 in the manual to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 6.	
4. Enter that percentage here >>>>	<input style="width: 80px; height: 20px;" type="text"/> %

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 12. Cooling Tower Water Use – Level Two (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 Table 12 on page 94 in the manual to see the percent reduction in water consumption that would occur if the concentration ratio was increased from the current level to at least 6.	
4. Enter that percentage here >>>>>	<input style="width: 80px; height: 20px;" type="text"/> %

Table Set 2: WATER CONSUMPTION CALCULATIONS	Date	Make-Up Concen- tration (TDS)	Bleed-off Concen- tration (TDS)

Transfer this information to the *Cooling Towers* spreadsheet.

Irrigation and Landscape Audit Worksheet

Use one sheet per zone.

Zone Number _____

General Location _____

Cheat Sheet Reference
Line Reference

Manual Page Reference

104 Irrigation Schedule and Controller - Level One

	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/hours?	Yes	No
---	-----	----

107 Irrigation Schedule and Controller - Level Two

General Plant Type(s) in this Zone (Turfgrass, Annuals, Perennials, Trees/shrubs)			
Current Runtime Duration for this Zone (minutes)			
Is the current runtime appropriate for the general plant and sprinkler type and season? See the Runtime Table on the Cheat Sheet.	Yes	No	
Appropriate (New) Runtime, if necessary			

111 Irrigation System and Landscape Survey – Level One

Sprinkler and Plant Types

1-	Sprinkler Type(s) in this Zone (Rotor, Sprayhead, Microirrigation)		
2-	Are all sprinklers the same type?	Yes	No
3-	Are all sprinklers the same brand?	Yes	No
	Sprinkler type matches plant type?	Yes	No
4, 5-	Is there more than one general plant type in this zone? See Runtime Table on the Cheat Sheet.	Yes	No

Sprinkler Functionality

	Clogged		
	Tilted		
	Obstructed		
	Broken		
	All sprinklers have a proper wetting pattern?	Yes	No
6-	Do all areas of zone warrant or necessitate irrigation?	Yes	No

Annuals & Perennials (if in this zone)

7-	Is there an adequate layer of mulch?	Yes	No
8-	Trees/shrubs appear to be mature or installed more than one year ago?	Yes	No
9-	Is Microirrigation used?	Yes	No

See the Irrigation and Landscape Cheat Sheet for line-by-line explanations.

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

Irrigation and Landscape Audit Worksheet

Cheat Sheet Reference Manual Page Reference

119 Irrigation System and Landscape Survey – Level Two

Prudent Use of Turf

	Does this zone/station contain turfgrass?	Yes	No
10-	If so, does the zone serve as a recreation area, soil erosion mitigation area, or swale?	Yes	No

On the irrigation system sketch diagram, indicate areas where it may be possible to replace turfgrass with landscape plant materials with lower irrigation requirements.

Using a plant guide book, such as the WaterWise Plant Guide, for your area, identify all non-turfgrass plant material.

Do all plants being irrigated in this zone have the same light and irrigation needs?	Yes	No
--	-----	----

123 Rain Sensor Survey - Level One

Rain Sensor Location

11-	Is the sensor located away from all building eaves, 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

12-	Does the cork look fresh and soft, not brittle and dry?	Yes	No
13-	Do the wires look intact?	Yes	No

128 Rain Sensor Survey - Level Two

Did the sensor successfully interrupt the irrigation event?	Yes	No
---	-----	----

123 Soil Moisture Sensor Survey - Level One

Soil Moisture Sensor Location

14-	Is the sensor located away from all building eaves, 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
15-	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

128 Soil Moisture Sensor Survey - Level Two

16-	Did the sensor successfully interrupt the irrigation event?	Yes	No
-----	---	-----	----

See the Irrigation and Landscape Cheat Sheet for line-by-line explanations.

All "No" responses should be reviewed for corrective action. Refer to the Post-Assessment Considerations and Additional Activities sections of each assessment 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- See reverse of this page for photos of each.
- 2- There should be only one.
- 3- Matched brands are more likely to have matched application rates.*
- 4- There should be only type one per zone. The three 'General' plant types are: turfgrass; annuals/perennials; trees/shrubs.
- 5- 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.
- 6- 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.
- 7- 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.
- 8- 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.
- 9- Microirrigation is the only class of sprinkler which should be used for annuals, perennials, trees and shrubs.
- 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.
- 13- The wires should be connected, unafraid, and protected from the elements.
- 14- 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.
- 15- 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.
- 16- 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.

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.

Worksheet 19. 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:	
Other:	
Other:	
Known leaks	
*Water purchased + well pumpage	

*Enter Metered Volume

Worksheet 19. 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:	
Other:	
Other:	
Known leaks	
*Water purchased + well pumpage	

*Enter Metered Volume





[sfwmd.gov](http://www.sfwmd.gov)

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406
561-686-8800 • 1-800-432-2045
www.sfwmd.gov

MAILING ADDRESS: P.O. Box 24680
West Palm Beach, FL 33416-4680