Guidance on the Efficient Use of Water in Non-Residential Facilities

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Provided by ADDC to non-residential establishments and entities in accordance with its approved Demand Side Management Strategy and in line with the Code of Practice for Efficient Use of Water and Electricity.

شركة أبوظبي للتوزيع
Abu Dhabi Distribution Co.

Disclaimer

Nothing in this manual should be construed as an endorsement of a particular manufacturer or supplier of water equipment or their proprietary approach to water efficiency. The intent of this manual is solely to provide Abu Dhabi non-residential sectors (commercial, government, and institutional) with guidance regarding major water uses within a building and techniques to reduce such water use, while maintaining the functionality of the building or facility. The presence of any reference to a particular brand, manufacturer or model of equipment found in the hyperlinked references should be taken in the context of an illustration of a particular principle and not as a recommendation or endorsement for this equipment.

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Acronyms and Abbreviations

CGI	Commercial, government, and institutional
kg/hour	Kilograms per hour
kg/load	Kilograms per load
kPa	Kilopascals
L/day	Liters per day
L/day/occupied room	Liters per day per occupied room
L/employee/day	Liters per employee per day
L/flush	Liters per flush
L/kg	Liters per kilogram
L/m^2/yr	Liters per square meter per year
L/meal served	Liters per meal served
L/min	Liters per minute
L/student/school day	Liters per student per school day
m^2	Square meters, meter squared
QCC	Abu Dhabi Quality and Conformity Council
RSB	Regulation and Supervision Bureau

1.0 Introduction

1.1 Purpose

In response to a 2011 lecture on the global water crisis, HE General Sheikh Mohammed bin Zayed Al Nahyan, Crown Prince of Abu Dhabi and Deputy Supreme Commander of United Arab Emirates (UAE) Armed Forces, commented that water is more important than oil for the UAE. Indeed, water is a precious and scare resource that must be carefully managed to ensure a secure source exists to sustain the vitality of our nation into the future. The UAE is among the nations in the world with the highest per-capita usage of water—not a desirable distinction for a country with limited freshwater reserves and annual rainfall of only 75 millimeters (mm). There is no doubt that water—a necessity for life—is an extremely valuable commodity in the UAE.

Water is wastefully used for two primary reasons—lack of understanding of its value and lack of knowledge on how to meet daily water needs in an efficient manner. This document will provide guidance on how water can be used efficiently in non-residential facilities—such as offices, operations centers, schools, and retail establishments to meet our needs today while also maintaining adequate supplies of this resource for future generations. It is hoped that the guidance provide herein will be put into use in facilities across the Emirate to realize a measurable reduction in daily water usage.

1.2 Organization

Section 2 of this document provides an overview of water use in non-residential buildings and other facilities, including information on factors that impact consumption, benchmarks for water usage, and steps that facility managers can take to understand water consumption.

Section 3 provides information on water fixtures. Section 3.1 presents a summary of water fixture codes and standards. Sections 3.2 to 3.6 provide information on the types of water fixtures found in most buildings and include estimates of the potential reductions in water consumption that can be achieved by replacing standard fixtures with high-efficiency models. Section 3.7 discusses leakage from water fixtures and plumbing, and Section 3.8 summarizes the best practices associated with water fixtures.

Section 4 discusses kitchen and food service operations. Information is presented on dishwashers and other water using equipment commonly associated with restaurants and large food service operations. That is followed by a summary of best practices related to kitchen and food service operations.

Section 5 addresses laundry operations and focuses on commercial clothes washing machines. Following a description of the different types of clothes washers, a summary of best practices is presented.

Section 6 describes landscape irrigation methods and provides a list of best practices related to landscape design, irrigation system design, and irrigation system operation.

Section 7 provides a list of the references used for this manual.

Appendix A lists best practices by end use and indicates the relative cost (High, Medium, or Low) and savings (High, Medium, or Low) associated with each. **Appendix B** provides a table of linked documents with additional information on the various topics addressed in this manual. **Appendixes C and D** provide information on water use surveys and water audits, respectively.

2.0 Overview of Water Use in Buildings

This section provides general information on water use in non-residential buildings and facilities. Section 2.1 describes the primary factors that determine how much water is used in buildings. Section 2.2 provides an overview of how water is typically used in selected non-residential establishments. Section 2.3 presents water use benchmarks, which can be used to estimate water usage by various types of buildings, and Section 2.4 discusses the importance of water use surveys and audits.

2.1 Factors that Impact Water Use

The amount of water used within a building or facility depends largely on four primary factors:

- Number of persons who occupy the building or use its services.
- Number of hours per day the building is occupied.
- End uses (i.e., specifically how the water is used) in or around the building.
- Efficiency of the water-using fixtures, appliances, and other equipment installed at the building.

Regardless of the setting or circumstances, people use water throughout the day. For this reason, in most facilities, water use increases with the number of persons who work or spend time there. An office building with 100 employees will use much more water than an office building of similar size but with only 20 employees. Likewise, a building that is occupied all of the time (e.g., a hospital) will utilize much more water than a school, which is occupied for only 10 hours per day, 5 days per week.

The term “water fixture” is generally applied to faucets, toilets, bidets, urinals, and showerheads. In terms of end uses, any building that is occupied or used by people will be equipped with water fixtures associated with basic personal hygiene and sanitation (sometimes referred to as “domestic” end uses). Although there are several other end uses for water that are associated with non-residential buildings and facilities, this manual focuses on two categories of non-domestic water use (in addition to water fixtures) that can have a high demand for water—food service operations and laundry operations. Information on other end uses can be found using the links included, and references cited, in this document.

In terms of water usage rate, there is an efficiency associated with each water-using fixture, appliance, or device, and these efficiencies can vary significantly. Older models typically have much higher usage rates (i.e., lower efficiencies) than newer high-efficiency units. Therefore, any program for reducing water consumption at a building or facility must give careful consideration to the efficiencies of the existing equipment and what is available in the market.

2.2 Water End Use Profiles

End use profiles can be helpful in understanding how water is used in typical non-residential buildings and establishments and which specific types of usage account for most of the consumption. An end use profile shows the breakdown, in terms of percentages, of water consumption by the most common end uses.

Figures 2-1 to 2-4 provide end use profiles for water consumption for office buildings, day schools, restaurants, and hotels, respectively.[1] These four types of establishments account for a large portion of non-residential water consumption in most urban areas. The four profiles are based on several water end-use breakdowns reported in the literature and have been adapted to represent conditions in Abu Dhabi.

For the office profile, it is assumed that the building has one or more breakrooms or small kitchens with sink and dishwasher. The school profile applies to day schools that do not board students overnight. The profile for restaurants pertains to full-service establishments that provide meals with dishes and utensils that are washed and re-used. The profile is not representative of fast-food restaurants that provide meals with disposable plates and utensils. The profile for hotels assumes that the hotel has a restaurant and laundry. For hotels with multiple restaurants that serve a significant number of walk-in customers (i.e., persons not staying at the hotel), the restaurant profile can be used in combination with the hotel profile.

[1] Profiles were adapted to Abu Dhabi from the following:

- AWWA Research Foundation. *Commercial and Institutional End Uses of Water*. Denver, Colorado, United States. 2000.
- U.S. Environmental Protection Agency. *Water Efficiency in the Commercial and Institutional Sector: Considerations for a WaterSense Program*. Washington, D.C., United States. August 20, 2009.
- New Mexico Office of the State Engineer. *A Water Conservation Guide for Commercial, Institutional, and Industrial Users*. Albuquerque, New Mexico, United States. July 1999.
- Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003.
- South Florida Water Management District. Water Efficiency and Self-Conducted Water Audits at Commercial and Institutional Facilities: A Guide for Facility Managers (Second Edition). West Palm Beach Florida, United States. July 2013.

Figure 2-1. Water End Use Profile for Office Building

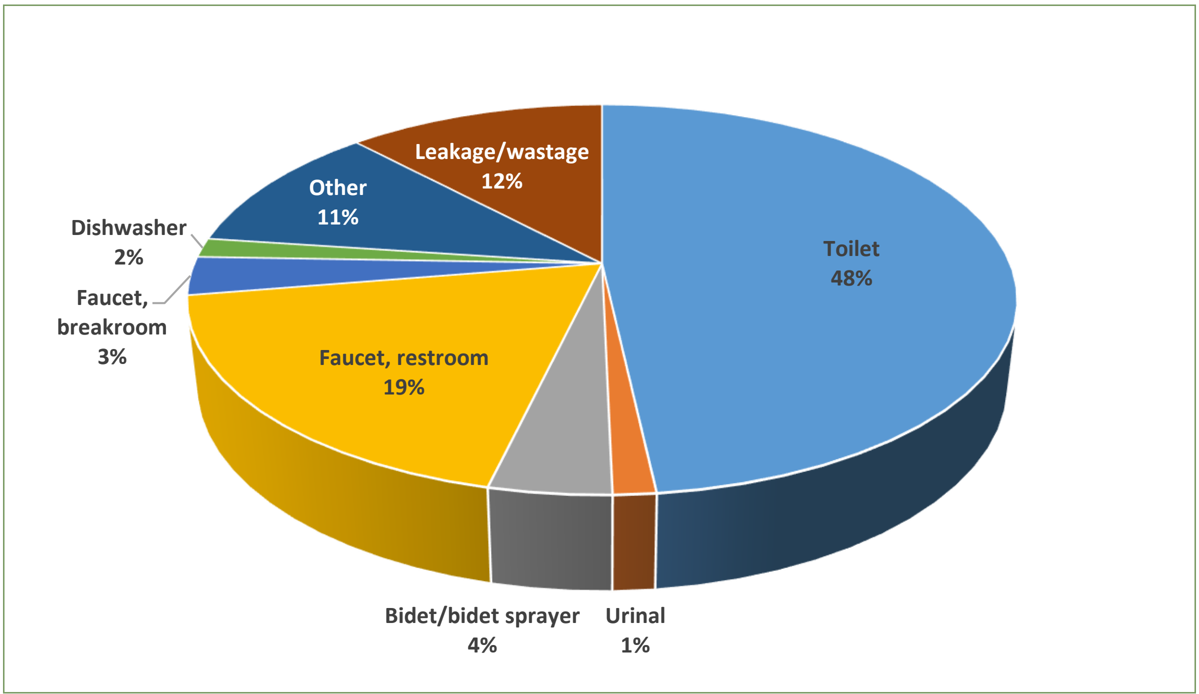


Figure 2-2. Water End Use Profile for Day Schools

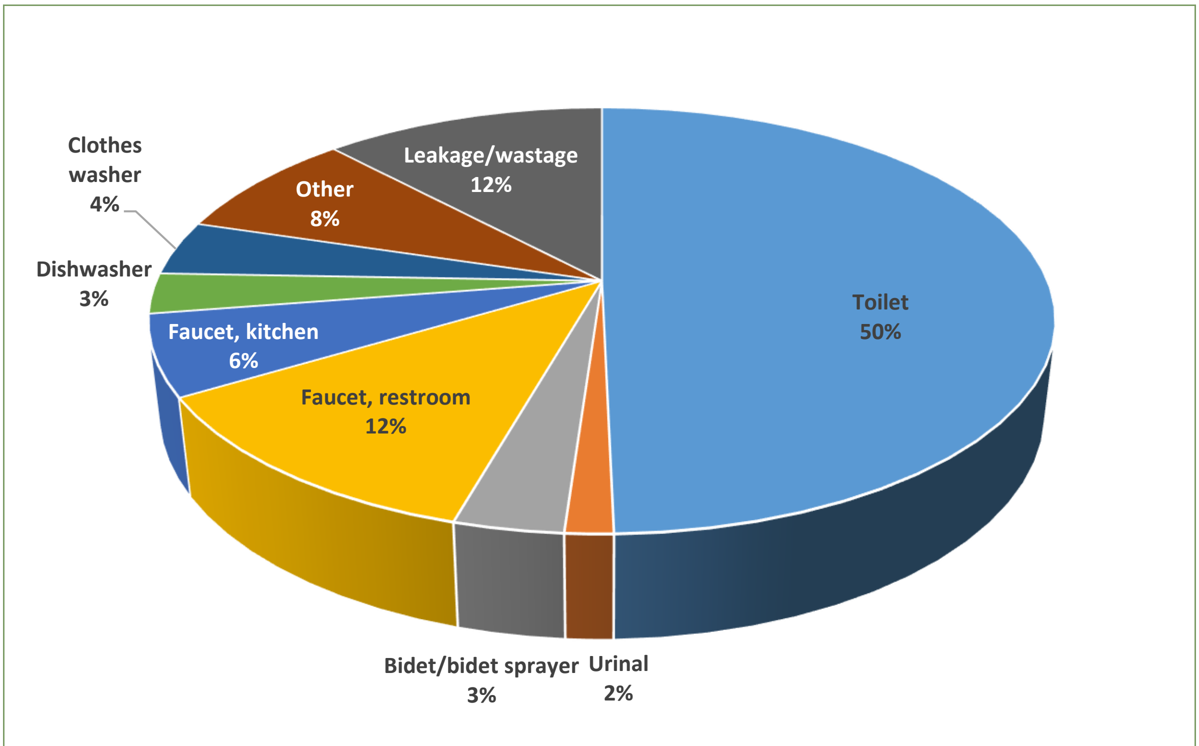


Figure 2-3. Water End Use Profile for Restaurants

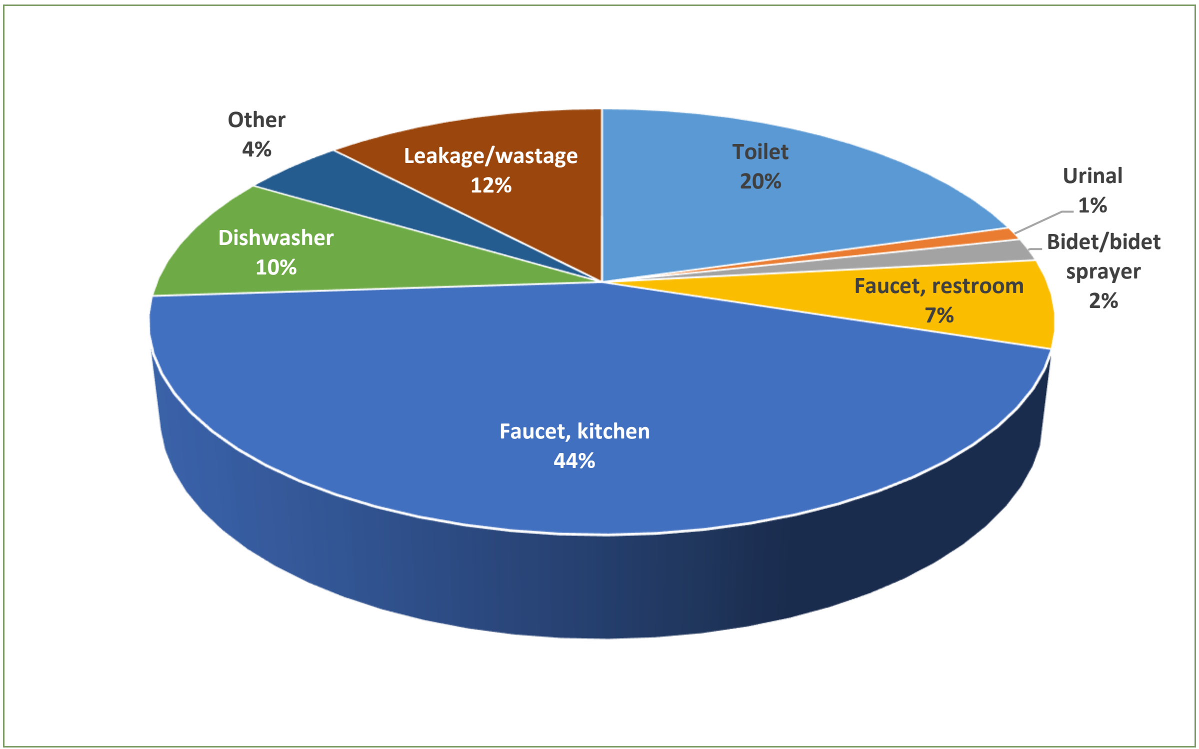
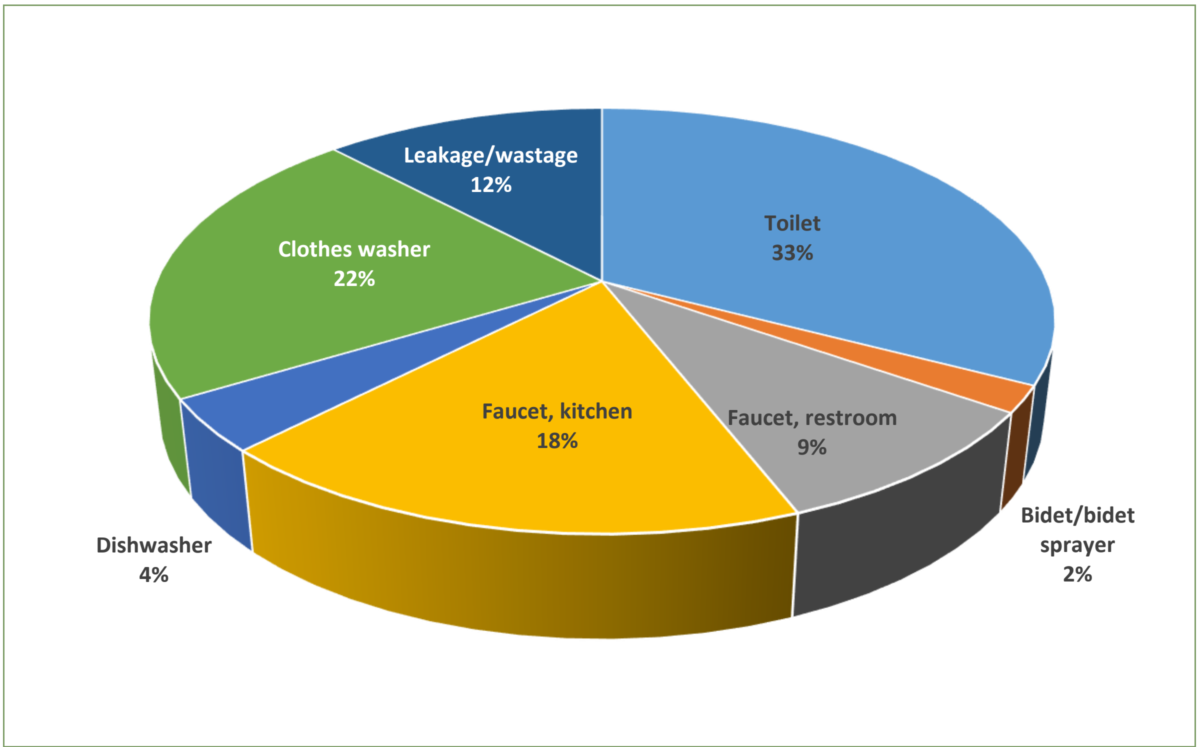


Figure 2-4. Water End Use Profile for Hotels



The actual breakdown of water end uses for a specific building or establishment will differ based on the factors discussed in the previous section. For example, for the profiles presented here, it was assumed that all fixtures and appliances were standard-efficiency. If the building has high-efficiency faucets in the restrooms and standard-efficiency equipment elsewhere, the amount (percentage) of water consumption attributed to the restroom faucets would decrease, and the percentages of water consumption for the other end uses would increase proportionally. For all four profiles, it was assumed that leakage and wastage accounted for 12% of the total consumption. In newer buildings or facilities that have proactive leak detection programs, the amount of leakage would likely be less than 12%.

2.3 Water Use Benchmarks

International studies of non-residential building water use have established benchmarks for estimating how much water a typical facility uses. Each benchmark provides an indication of water consumption in terms of a specific design or operational feature of the facility (e.g., total floor space). A summary of benchmarks for selected non-residential buildings and facilities is shown in **Table 2-1**.

For the facilities listed in Table 2-1, benchmarks are provided in units of liters per square meter of floor space per year (L/m^2/yr). With the exception of shops, the table also includes benchmarks in other units that are specific to the type of facility (i.e., facility-specific units). For example, a benchmark for hotels is shown in units of liters per day per occupied room (L/day/occupied room). In general, the benchmarks in facility-specific units provide better estimates of water consumption because they are specific to the type of establishment. However, the data needed (e.g., number of meals served per day) may not be available. In such cases, the benchmarks based on floor space can be used.

Note that the benchmarks shown in Table 2-1 reflect indoor use only; outdoor water usage for irrigation or other purposes would be in addition to the values listed. Although the benchmarks are useful for planning purposes and for comparison, they are not a substitute for a site-specific evaluation of water consumption, which is discussed in the next section.

Table 2-1. Water Use Benchmarks for Offices and Other Facilities

Type of Facility	Unit	L/day/unit
Hotel 1	per one bed	450–675
Car wash station (CWS)	per manual channel	3,600
Car wash station (CWS)	per automatic channel	10,800
Hospital	per one bed	675
Day clinic	per medical practitioner	450
Day clinic (with dental)	per medical practitioner	675
Common market	per square metre	5
Mosques < 300m^2	per square metre	25
Mosques > 300m^2	per square metre	16
Female praying rooms	per square metre	9
Workers' Housing	per capita	200
Public toilets	per sanitary piece	160–225

Type of Facility	Unit	L/day/unit
Schools	per student	25
Universities	per student	45
Hostel	per student	200
Villa and shabiat	per capita	350
Villa/ shabiat	per small service block	1,100
Villa/ shabiat	per large service block	2,000
Villa/ shabiat	per external majlis	675
Villa/ shabiat	per maid's room	225
Villa/ shabiat	per guard room	450
Villa and shabiat 2	per bedroom	500
Villa and shabiat	swimming pool/m2	18–22
General services3	per plot square metre	0.9
Services in a building	up to 5 floors	750
Services in a building	6–10 floors	1,500
Services in a building4	above 10 floors	3,000
Offices and shops5	per sanitary piece	160–225
Offices and shops	per square metre	4.5
Restaurants	per meal	9
Offices and shops	(per person)	45
Residential flat	Studio	450
Residential flat	1 bedroom	550
Residential flat	2 bedrooms	820
Residential flat	3 bedrooms	1,000
Residential flat	4 bedrooms	1,250
Residential flat	5 bedrooms	1,600
Residential flat	per maid's room	225
Residential flat	per capita	225

Notes

1. Hotel category up to 5 stars; hotels/resorts above 5 stars will be subject to assessment.
2. For the shabiat and villa category, a reduction factor may be applied for every additional bedroom according to the Distribution Company's own criteria.
3. "General services" means water used for internal gardening and general cleaning purposes for a standard-size shabiat and villa.
4. Rates of consumption for buildings higher than 20 floors shall be adjusted proportionally.
5. All consumption rates for sanitary pieces shall be calculated based on water-efficient plumbing fittings, as required by ESTIDAMA.

Source: Regulation and Supervision Bureau, *Guide to Water Supply Regulations*—Issue 3 (2017), Abu Dhabi, UAE. 15 December 2016.

2.4 Water Use Surveys

As a first step in understanding how water is used within a building, it is recommended that facility managers conduct a simple water use survey. This entails doing a walk-through of the building/facility; recording basic information on water using fixtures, appliances, and other equipment; and collecting other information on how water is used. The basic steps to a water survey include the following:

- Conducting an inventory of all water fixtures and appliances, including type, number, and other information that will help determine water usage rates.
  - For faucets and showerheads, the flow rate can be estimated by measuring the time it takes to fill a container of known volume (e.g., 2 liters).
  - For toilets, the flush volume (liters per flush [L/flush]) may be indicated on the toilet. If not, the volume can be estimated by measuring the dimensions of the tank, or by referencing the manufacturer’s literature.
  - Note that all dual-flush toilets can be considered to be high efficiency, and, for many models, the flush volumes are indicated on the toilet.
  - The water usage rate for appliances can generally be determined by referencing the manufacturer’s literature.
- Recording any leakage, particularly from faucets and toilets. (See Section 3.7 for more information on leakage.)
- Asking employees about water use practices.
- Recording other observations that relate to how water is used.

Appendix C provides a survey form and instructions for conducting a water use survey.

Using the Survey Results

The water survey results can be used to determine if the existing fixtures are standard- or high-efficiency by comparing the measured usage rates to the standards listed in **Table 3-1**. The usage rates are typically measured as liters per minute (L/min) for faucets, showerheads, and bidet sprayers, and as L/flush for toilets and urinals. If the measured usage rates are significantly higher than the standards for high-efficiency fixtures, the facility manager should consider replacing the fixtures with high-efficiency models.

The survey results can also be used to calculate a bottom-up estimate of water consumption, which can then be compared to the monthly water bill. If the bottom-up estimate and the average daily consumption based on the water bill are not similar (within about 20%), further investigation is warranted.

For a bottom-up estimate of offices, start with the restrooms. In buildings that do not have a significant level of food service, laundry, or other non-domestic operations that use large quantities of water, the restrooms usually account for most of the water consumption.

In addition, water use in restrooms is generally consistent from one building to the next. The following assumptions can be used to estimate daily water usage for restrooms:

- 2.8 toilet flushes per employee per shift (8-hour period).
- 1.0 urinal flush per employee per shift.
- 0.3 minute of bidet use per employee per shift.
- 1.2 minutes of restroom faucet use per employee per shift.

If the office receives a significant number of visitors each day, and the office provides restroom facilities to visitors, an estimate must also be made of the average number of visitors who use the restroom. In such cases, it should be assumed that each such visitor flushes the toilet once and runs the faucet for about 0.3 minute.

Using the measured usage rates for each type of fixture, and the assumptions listed earlier, the total daily restroom consumption can be estimated. At this point, the estimated daily restroom consumption can be compared to the average daily consumption based on the facility's water bill. For office buildings and other facilities that are equipped with standard water fixtures, and where there are no unusual or water-intensive end uses, the consumption for the restrooms should amount to 70–80% of the average billed consumption. If the building has high-efficiency water fixtures, the contribution from the restrooms is more likely to be 60–70% of the billed consumption. If the estimated consumption for the restrooms is significantly less that these percentages, it is likely that there are other end uses that are consuming a significant amount of water, or there is a significant problem with leakage, or both.

Estimating consumption for the other end uses may not be as straightforward as is the case for water fixtures. If the facility has a breakroom or kitchen, it may be necessary to observe how water is used before an estimate can be determined. For example, the employees may use the breakroom faucet to rinse coffee or tea cups or to wash dishes. In such cases, it will be necessary to measure or estimate how long (minutes per day) the faucet is used. If the facility has a dishwasher, the usage rate (liters per load or washing cycle) can usually be determined from the manufacturer. It is then a matter of multiplying the usage rate by the frequency (i.e., the number of times per day or per week that the dishwasher is run). Information on the amount of water used for cleaning and other purposes can be obtained from the custodial staff.

If the difference between the billed water consumption and the total estimated consumption for all known end uses is more than 20% of the billed consumption, the facility manager should consider having a detailed water audit conducted. Even if the unaccounted for water is less than 20%, a detailed water audit is recommended if the facility plans to embark on a systematic and thorough program to reduce water consumption. The audit results can be used to determine the costs and benefits of various options for reducing water consumption and to set priorities for improving water efficiency. Additional information on water audits can be found in **Appendix D**.

Table 2-2 provides information that can be used to estimate the daily amount of water consumption in restrooms for the four types of facilities discussed in this section: offices, day schools, full-service restaurants, and hotels with restaurants and laundry service. **Table 2-3** provides estimates of the percentage of total water consumption that can be attributed to restrooms in these four types of establishments.

Other operations associated with non-residential buildings and establishments that use significant amounts of water include food service, laundry, and landscape irrigation. Additional information on these types of operations is provided in sections 4, 5, and 6, respectively.

Table 2-2. Parameters for Estimate Water Consumption for Restrooms[a]

Office	
2.8	toilet flushes per employee per shift
1.0	urinal flushes per employee per shift
0.3	minutes of bidet use per employee per shift
1.2	minutes of restroom faucet use per employee per shift
School	
2.2	toilet flushes per student and staff per day
0.7	urinal flushes per student and staff per day
0.3	minutes of bidet use per student and staff per day
0.9	minutes of restroom faucet use per student and staff per day
Restaurant	
2.8	toilet flushes per employee per shift
0.3	toilet flushes per customer per day
1.0	urinal flushes per employee per shift
0.2	urinal flushes per customer per day
0.3	minutes of bidet use per employee per shift
0.05	minutes of bidet use per customer per day
1.2	minutes of restroom faucet use per employee per shift
0.2	minutes of restroom faucet use per customer per day
Hotel	
2.8	toilet flushes per employee per shift
4.0	toilet flushes per occupied per day
1.0	urinal flushes per employee per shift
0.3	minutes of bidet use per employee per shift
0.5	minutes of bidet use per occupied room per day
1.2	minutes of restroom faucet use per employee per shift
1.2	minutes of restroom faucet use per occupied room per day

[a] Adapted from: Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003; and Alliance for Water Efficiency. *Commercial Restroom Water Audits*. Chicago, Illinois, United States. (Undated).

Table 2-3. Restroom Water Consumption as Percentage of Total

Type of Establishment	Restroom % of Total Average Daily Consumption
Office	70–80
Day school	65–75
Restaurant	30–40
Hotel	40–50

Estimating how much water is used in a food service operation can be complex because consumption is a function of the type of food service, the equipment used, and employee practices. **Table 2-4**, which shows the modeled breakdown by end use for a restaurant, provides an idea of this complexity. Water consumption by dishwashers can be estimated from manufacturer's literature and the number of loads washed in a typical day. However, there are several other kitchen activities (e.g., removing food scraps and pre-rinsing dishes) that require collecting detailed data, such as measuring the flow rates of faucets and how long the faucets are running over the course of a day. For large food service operations, it may be necessary to hire a professional to accurately estimate the amount of water consumption.

Table 2-4. Detailed Breakdown of Restaurant Water End Uses

End Use	% of Total
Dishwashing	
Pre-rinse nozzles	6.2
Pot and pan sink	12.4
Garbage disposal	5.6
Dishwasher	17.7
Restrooms	
Employee	13.3
Customer	13.9
Food Preparation	
Preparation sink	1.2
Water used in food	5.1
Icemaker	13.9
General sanitation	
Floor wash	1.5
Other	5.1
Miscellaneous	4.1
Total	100

Source: Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003.

Estimating water consumption by laundry operations is generally straightforward because clothes washing machines account for nearly all of the consumption. Using manufacturer's information on water consumption per load or cycle, and the number of loads washed per day will provide a good estimate. However, laundry staff should also be interviewed to determine if there any other significant uses of water by the laundry operation.

For landscape irrigation, estimating how much water is used is a function of the type and complexity of the system. For small areas that are watered by hand, estimates can be made by measuring the flow rate and duration over a period of time. For larger areas that are irrigated using sprinklers or subsurface emitters, estimating water use is more much difficult. Even if water consumption can be estimated with good accuracy, determining how much water is actually needed requires a knowledge of several factors, such as plant species and climate. For this reason, a professional should be consulted for any complex irrigation system or landscaped area that includes several types of plant species.

3.0 Water Fixtures

This section provides information on the water fixtures found in most buildings. Section 3.1 summarizes the requirements in current local codes and standards for water fixtures. That section is followed by a separate discussion of each type of fixture, including water usage rates and potential savings associated with retrofitting an existing fixture with a high-efficiency model. Finally, Section 3.7 discusses leakage from fixtures and plumbing, and Section 3.8 describes best practices related to water fixtures and their use.

3.1 Water Fixture Codes and Standards

Standards for water-using fixtures are specified in Section 4.02 of the Uniform Plumbing Code of Abu Dhabi Emirate and in the Pearl Rating System for Estidama. The Estidama Standards also have been adopted by the Abu Dhabi Quality and Conformity Council (QCC) as part of the Abu Dhabi Certification Scheme for Efficient Water Fixtures—Assessment and Surveillance Plan. A summary of these standards is shown in **Table 3-1**.

Table 3-1. Standards for Water-Using Fixtures in Abu Dhabi

Fixture type	QCC Rating Class[a]					Plumbing Code	Units for Water Usage Rate
	E	D	C	B	A		
Bathroom faucet, private[a]	6.0	5.0	4.0	3.0	2.0	6.0	L/min
Bathroom faucet, public[a]	No standard	No standard	1.9	1.9[b]	1.9[c]	2.0	L/min
Showerhead[d]	9.5	8.5	7.5	6.5	5.5	10.0	L/min
Kitchen faucet[a]	6.0	5.0	4.0	3.0	2.0	8.0	L/min
Bidets/bidet sprayer[a]	6.0	5.0	4.0	3.0	2.0	8.0	L/min
Toilet, single-flush	Not covered					5.0	L/flush
Toilet, dual-flush[e]			6.0/4.0	4.5/3.0	4.0/2.5	6.0/4.0	L/flush
Urinal					0.5	2.0	L/flush

Sources:
- *Abu Dhabi Quality and Conformity Council. Abu Dhabi Certification Scheme for Efficient Water Fixtures—Assessment and Surveillance Plan*. Abu Dhabi, UAE. January 2014.
- Environment Agency, Abu Dhabi. *Uniform Plumbing Code of Abu Dhabi: An Environmental Guide for Water Supply and Sanitation*. Abu Dhabi, UAE. 2009.

[a] At a pressure of 417.7 kilopascals (kPa).
[b] Self-closing, metered.
[c] Self-closing, infrared sensor operated.
[d] At a pressure of 551.6 kPa.
[e] Heavy flush volume/light flush volume.

The standards shown in Table 3-1 are in terms of water usage rates. The usage rate is generally expressed as the volume per unit of time (e.g., liters per minute) for faucets, showerheads, and bidets/bidet sprayers. For toilets and urinals, the usage rate is expressed as the volume (liters) per flush. By comparing the actual usage rate for a fixture or an appliance to the high-efficiency usage rate, as indicated in Table 3-1, the potential reduction in water consumption can be determined. For example, a standard flow faucet has a flow rate of 11.4 L/min. A low-flow faucet with a flow rate of 6.0 L/min, would have correspond to a reduction of: (11.4 – 6.0)/11.5 = 47%.

The Estidama/QCC standards differentiate between rating classes, where a rating class of A has the highest efficiency, and a rating class of E has the lowest efficiency. The standards also differentiate between types of faucets. The standards for bathroom faucets in public facilities are set at lower flow rates than the corresponding faucets in private residences and locations. The Estidama/QCC standards for kitchen faucets are the same as for private bathroom faucets, whereas the Plumbing Code specifies a higher allowable flow rate for kitchen faucets. Also note that the standards for faucets, shower heads, and bidets correspond to the maximum allowable flow rate (L/min) at a specified water pressure. Fixtures that meet these standards may have slightly higher or lower flow rates, depending on the pressure in the water line at the fixture location. Note that the Estidama/QCC standards are more stringent than the Plumbing Code for most fixtures.

There are limited data on the water usage rates for existing or older water fixtures in Abu Dhabi. **Table 3-2** summarizes the usage rates for older or “standard flow” fixtures in the United States; the usage rates are the same for both the residential and non-residential sectors.

Table 3-2. Water Usage Rates for Standard Flow Fixtures in the U.S.

Fixture	Water Usage Rate	Units for Water Usage Rate
Faucet	11.4	L/min
Showerhead	11.4	L/min
Toilet	13.2	L/flush
Urinal	11.3	L/flush

Source: A. Vickers. *Handbook of Water Use and Conservation*. Waterplow Press, Amherst, Massachusetts, United States. 2001.

Table 3-3 summarizes water usage rates for water fixtures based on two recent studies of water use at villas in Abu Dhabi. Study A was conducted by the Regulation and Supervision Bureau (RSB) in 2013 and involved indirect measurement of fixture usage rates using high-resolution water meters at 150 villas in gated communities. The ages of the villas were not provided, but all were fewer than 15 years old. For Study B, which was conducted by RSB in 2015, direct measurements were made at 45 villas in Abu Dhabi and Al Ain that use at least 600 cubic meters (m^3) of water per month. The ages of the villas were not reported. It is unknown if the usage rates are representative of existing water fixtures at public or private facilities in the Emirate.

The only other known data on water fixture usage rates in Abu Dhabi are from a 2013 building survey conducted by the Executive Affairs Authority, which estimated the average flush volume for toilets in a mix of non-villa buildings as 11.0 L/flush[2].

Table 3-3. Water Usage Rates for Existing Water Fixtures at Villas

Fixture	Water Usage Rate		Units for Water Usage Rate
	Study A[3]	Study B[4]	
Faucet, bathroom	4.2	8.3	L/min
Faucet, kitchen		10.6	L/min
Showerhead	9.2	8.7	L/min
Toilet	6.7	8.1	L/flush
Bidet sprayer	No data	9.4	L/min

Source: A. Vickers. *Handbook of Water Use and Conservation*. Waterplow Press, Amherst, Massachusetts, United States. 2001.

There currently are no standards that specify the usage rates for water-using appliances in Abu Dhabi or the UAE.

3.2 Faucets

Figure 3-1. Faucet

Colony Single Handle 4-Inch Centerset Bathroom Faucet. http://www.americanstandard-us.com/bathroom-faucets/colony-single-control-bathroom-faucet (accessed November 2016)

In terms of water use, faucets or taps are the major water users in most buildings. High-efficiency faucets typically are designed to provide a broad stream of water that simulates a standard flow faucet but with a smaller flow rate. The most common designs use either an aerator, which entrains air in the water stream, or a plate with several small holes through which the water flows in small parallel streams.

Most standard faucets are designed for a flow rate of 11.4 L/min. The savings associated with replacing standard faucets with high-efficiency faucets depend on the actual flow rate for the existing faucet and the rating class of the high-efficiency faucet. For a standard flow rate of 11.4 L/min, high-efficiency private bathroom or kitchen faucets reduce usage by 47% (Class E) to 82% (Class A), as indicated in **Table 3-4**.

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2 Executive Affairs Authority. *Survey data from Comprehensive Cooling Plan Building and Villa Survey*. Abu Dhabi, UAE. September 2013.

3 Regulation & Supervision Bureau. *Residential End Use of Water—Final Report*. Abu Dhabi, UAE. June 2014.

4 Regulation & Supervision Bureau. *In-Home Water Use Audit, Final Project Report*. Abu Dhabi, UAE. January 17, 2016.

Table 3-4. Reductions from Retrofitting Standard Faucets with High-Efficiency Faucets

Faucet Type	Existing Faucet Flow Rate, L/min	High-Efficiency Faucet					
		QCC Rating Class	E	D	C	B	A
Bathroom, private	11.4	Flow rate, L/min	6.0	5.0	4.0	3.0	2.0
		% Reduction	47%	56%	65%	74%	82%
Bathroom, public	11.4	Flow rate, L/min	N/A	N/A	1.9	1.9	1.9
		% Reduction	N/A	N/A	83%	83%	83%
Kitchen	11.4	Flow rate, L/min	6.0	5.0	4.0	3.0	2.0
		% Reduction	47%	56%	65%	74%	82%

N/A = not applicable

For many standard flow faucets, it is possible to reduce the flow rate by inserting an aerator in the tip of the faucet spout. Aerators are inexpensive and typically achieve reductions of about 15%. However, it is also relatively simple to remove the aerator if the user is not satisfied with the flow rate. For this reason, replacing a standard flow faucet with a low-flow model is generally a more effective permanent solution. **Figure 3-2** depicts a faucet aerator.

Figure 3-2. Faucet Aerator

http://www.danco.com/product/1-0-gpm-extra-water-saving-dual-thread-faucet-aerator-in-chrome/ (accessed December 2016)

Some faucets are designed with a self-closing or automatic shutoff feature. The most common type of self-closing faucets use either a metering device or an optical sensor to stop the flow of water. Metering type faucets generally have a push-button design with an adjustable time period. The user pushes the button to start the flow of water, and the faucet turns off automatically after a set period of time, which can be from a few seconds up to about one minute. Faucets with optical sensors (also called photo-sensor) are designed to turn on when an object is placed in front of the faucet outlet and turn off water flow after a set period of time or when the object is moved out of the path of the sensor. An advantage of metering-type faucets over sensor-type faucets is that they do not require electric power. An advantage of sensor-type faucets over metering-type faucets is that sensor-type faucets do not require the user to touch the faucet and, thus, are considered to be more hygienic.

The savings associated with self-closing faucets depend on several factors, including the flow rate, type of use, and the duration of the “on” cycle. Rinsing off hands may take only 5 to 10 seconds; a self-closing faucet could use significantly more water if, for example, the duration is set at 30 seconds. The savings for self-closing faucets become more significant for practices that often entail leaving the water running while it is not actually being used, such as when lathering hands or brushing teeth; whereas a manual faucet would keep running, a properly adjusted self-closing faucet would shut off until the user needs more water. For this reason, it is important for the duration to match the expected type of use. For example, if the faucet is to be used in a public restroom where most of the use is for washing hands, a short duration of 5 to 10 seconds is appropriate.

Faucets are generally designed for a lifetime of at least 15 years[5] and typically require little to no maintenance. However, self-closing faucets tend to have a shorter lifetime due to their more complex design. Faucets may start dripping after several years of use. In most cases, this type of leakage is relatively simple and inexpensive to repair through simple replacement of washers or cartridges.

3.3 Toilets

In many buildings, toilets account for as much as 50% of total indoor water consumption. Given that high-efficiency models can achieve reductions up to 50% in flush volume (amount of water used each time a toilet is flushed), replacing standard toilets with low-flush volume (low-flow) models can result in significant savings in indoor water use. Dual-flush toilets can provide additional savings by allowing the user the option of a light flush for liquid waste.

Figure 3-3. Tankless Toilet

https://www.americanstandard-us.com/bathroom/commercial-toilets/priolo-11-16-gpf-everclean-universal-flushometer-toilet-19672 (accessed December 2016)

Toilets can be broadly classified as those with and without tanks (i.e., tank and tankless toilets); tankless toilets are sometimes referred to as “flush-o-meter” toilets. Toilets with tanks are the more common type and use gravity to move the water from the tank to the bowl to provide the flushing action. Tankless toilets use water line pressure as the flushing mechanism. **Figure 3-3** shows a tankless toilet. Because tankless toilets do not need time to recharge (i.e., there is no need to wait for a tank to fill up), they are commonly found in commercial, government, and institutional (CGI) buildings and public areas where the restrooms get much more usage. However, both types of toilets are available in high-efficiency and dual-flush models, and the rest of this discussion does not differentiate between the two classifications.

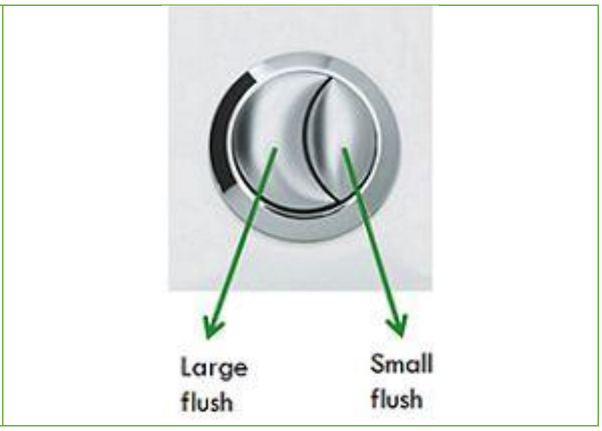
5 A. Vickers. *Handbook of Water Use and Conservation*. Waterplow Press, Amherst, Massachusetts, United States. 2001.

Dual-flush toilets are designed to allow the option of either a light flush to dispose of liquid waste or a heavy flush to dispose of solid waste. Most dual-flush toilets have two buttons, a smaller button for triggering the light flush and a large button for initiating a heavy flush. In some models, both buttons must be pushed simultaneously for the full flush. For dual-flush tankless toilets that have a handle for flushing, the light flush is generally triggered by lifting up on the handle, and the heavy flush by pushing down on the handle. **Figure 3-4** shows a dual-flush toilet, and a close-up of the dual-flush buttons is shown in **Figure 3-5**.

Figure 3-4. Dual-Flush Toilet

ROCA Victoria Model dual-flush toilet. www.roca.com (August 2016)

Figure 3-5. Example of Dual-Flush Toilet Buttons



https://foeme.wordpress.com/2012/01/18/double-flush-toilets-foeme/ (accessed December 2016)

Light flushes typically use about 33% less water than a full or heavy flush. Because light flushes can be used most of the time for most people, the additional savings associated with dual-flush toilets add up quickly. **Tables 3-5** and **3-6** provide examples of the potential savings from high-efficiency single-flush and dual-flush toilets, respectively.

Table 3-5. Example Reductions from Retrofitting Standard Single-Flush Toilets with High-Efficiency Models

Existing Toilet Flush Volume, L/Flush	High-Efficiency Toilet				
	Flush Volume, L/Flush	6.0	5.0	4.5	4.0
12	Percent Reduction	50%	58%	63%	67%
10		40%	50%	55%	60%
8		25%	38%	44%	50%

Table 3-6. Example Reductions from Retrofitting Standard Single-Flush Toilets with High-Efficiency Dual-Flush Models

Existing Toilet Flush Volume, L/Flush	High-Efficiency Dual-Flush Toilet[a]			
	QCC Rating Class	C	B	A
	Flush Volume, L/Flush	6.0/4.0	4.5/3.0	4.0/2.5
12	Percent Reduction*	61%	71%	75%
10		53%	65%	70%
8		42%	56%	63%

[a] Assumes 67% light flush, 33% heavy flush.

When dual-flush toilets are installed, it is important that people use the light flush option. This can be facilitated by installing signs in restrooms that describe how to use the light flush and heavy flush options and remind users to take advantage of the light flush capability.

Some toilets are equipped with an automatic sensor that flushes the toilet after each use. However, this type of toilet is designed as a single-flush unit, and thus, cannot match the potential savings of a dual-flush toilet.

Retrofit devices are available for many toilets as an alternative to retrofitting an existing toilet with a low-flow, high-efficiency model. The two most common types are displacement devices and dams. Displacement devices generally are solid objects that are placed in the toilet tank and occupy space that would otherwise fill with water. Toilet tank dams are flexible panels that are placed in the toilet tank and seal off a portion of the tank from the fill water. Although both types of retrofit devices are inexpensive, their effectiveness depends on the existing toilet's design. In some cases, the reduced volume of flush water does not completely evacuate the contents of the toilet bowl and may require flushing multiple times, which can end up using more water than before the retrofit device was installed. On the other hand, low-flush toilets are specifically designed to enable the complete evacuation of solid waste using a decreased quantity of flush water.

Toilets are generally designed to last at least 20 years and can last up to 50 years.[6] Most toilets do not require much maintenance, other than periodic repair or replacement of the flapper valve, or, in some cases, the flush mechanism. This is described in more detail in Section 3.7 that follows.

6 A. Vickers. *Handbook of Water Use and Conservation*. Waterplow Press, Amherst, Massachusetts, United States. 2001.

3.4 Urinals

High-efficiency urinals can provide significant savings over standard urinals. Although some earlier designs used tanks, virtually all urinals nowadays are of the tankless design. Urinals generally have a lifetime of at least 20 years. **Figure 3-6** depicts a urinal.

Figure 3-6. Urinal

Decorum 0.125 gallon per flush Urinal System with Selectronic Battery-Powered Flush Valve. http://www.americanstandard-us.com/urinals/Decorum-0-125-gpf-Urinal-System-Selectronic-Battery-Powered-Flushometer (accessed November 2016)

Because standard urinals can have flush volumes up to 11.0 L/flush, retrofitting an old urinal with a high-efficiency model (0.5 L/flush) can yield savings up to 95% per flush. **Table 3-7** gives examples of reductions in water use when a standard urinal is replaced with a high-efficiency model. **Table 3-8** provides examples of reductions when a high-efficiency urinal is added where only a standard toilet had existed previously.

Table 3-7. Example of Reductions from Retrofitting Standard Urinal with High-Efficiency Model

Existing Urinal Flush Volume, L/Flush	Urinal Flush Volume, L/Flush	
	2.0	0.50
11	82%	95%
8	75%	94%
6	67%	92%

Table 3-8. Example of Reductions from Replacing a Toilet with a High-Efficiency Urinal

Existing Toilet Flush Volume, L/Flush	Urinal Flush Volume, L/Flush[a]	
	2.0	0.50
12	56%	64%
10	47%	57%
8	33%	46%

[a] Assumes 67% of toilet use is switched to urinal use.

Some urinals are designed to flush automatically. They are more hygienic because they eliminate the need for the user to make physical contact with the urinal.

Waterless urinals are a relatively new technology that uses gravity to dispose of urine. As the name implies, these fixtures do not use water for flushing. However, waterless urinals do require occasional cleaning with water and—for many models—the addition of a proprietary oil that is used to form an odor barrier within the trap of the urinal.

3.5 Showerheads

High-efficiency showerheads are similar in design to high-efficiency faucets in that they are designed to provide a broad stream of water that simulates and provides the same coverage as a standard flow showerhead, but with a smaller flow rate. The most common designs use either an aerator, which entrains air in the water stream, or a plate with several small holes through which the water flows in small parallel streams. **Figure 3-7** shows a low-flow showerhead.

Figure 3-7. Low-Flow Showerhead

http://www.bobvila.com/articles/how-to-choose-a-shower-head/#.WEiAC9UrKM8 (accessed December 2016)

Most standard showerheads are designed for a flow rate of 11.4 L/min. The savings associated with replacing standard showerheads with high-efficiency showerheads depend on the actual flow rate for the existing showerhead and the rating class of the high-efficiency showerhead. **Table 3-9** shows the savings when a standard flow showerhead is replaced with a high-efficiency model.

Table 3-9. Reductions from Retrofitting Standard Showerheads with High-Efficiency Models

Existing Showerhead Flow Rate, L/min	High-Efficiency Showerhead					
	QCC Rating Class	E	D	C	B	A
11.4	Flow rate, L/min	9.5	8.5	7.5	6.5	5.5
	% Reduction	17%	25%	34%	43%	52%

The lifetime and maintenance requirements for showerheads are similar to those of faucets.

3.6 Bidets and Bidet Sprayers

Figure 3-8. Bidet Sprayer

https://www.lowes.com/pd/Brondell-Silver-Handheld-Bidet-Sprayer/4757809 (accessed December 2016)

The flow rates associated with standard flow and high-efficiency bidets and bidet sprayers (also referred to as hose sprayers) are basically the same as for standard and high-efficiency water faucets. Similarly, the savings that can be achieved by replacing standard bidets with high-efficiency models depend on the actual flow rate for the existing faucet and the rating class of the high-efficiency bidets. **Figure 3-8** shows a bidet sprayer. **Table 3-10** shows the savings when a standard flow bidet or bidet sprayer is replaced with a high-efficiency model.

Table 3-10. Reductions from Retrofitting Standard Bidets with High-Efficiency Bidets

Existing Bidet flow rate, L/min	High-Efficiency Bidet/Bidet Sprayer					
	QCC Rating Class	E	D	C	B	A
11.4	Flow rate, L/min	6.0	5.0	4.0	3.0	2.0
	% Reduction	47%	56%	65%	74%	82%

The lifetime and maintenance requirements of bidets and bidet sprayers are similar to those of faucets.

3.7 Leakage

Water leakage is a problem in most buildings, and, if not addressed, can result in the loss of large quantities of water. Average leakage rates in buildings generally range 5–15% of the total indoor water usage.[7,8] In many cases, repairing leaks does not require a significant capital outlay and can be performed by facility maintenance staff. Therefore, routinely checking for leakage should be part of any facility management plan.

The most common sources of leakage in buildings are toilets and faucets. Furthermore, these types of leaks often go unnoticed because the leakage literally goes down the drain. Leakage from plumbing fittings, connections, and damaged piping also occurs, but in most cases is discovered more quickly because the leakage pools on surfaces where it can be seen or—if it occurs on the upper floors of a building—drips from the ceiling.

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7 AWWA Research Foundation. *Commercial and Institutional End Uses of Water*. Denver, Colorado, United States. 2000.

8 Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003.

Toilet Leakage

As toilets with tanks age, the flapper valve or shutoff device, which stops water flow from the tank into the bowl at the end of the flush, can begin leaking. This type of leakage can amount to hundreds of liters per day and can be as high as several thousand liters per day for a single toilet.[9] Because the leakage goes into the toilet bowl, it often continues for weeks or months unnoticed. A simple dye test can be used to determine if the flapper valve or shutoff device is leaking. Replacing flapper valves is relatively simple and inexpensive. If the toilet has another type of shutoff device, replacement is still relatively simple, but is likely to be more expensive.

Toilet Dye Test Procedures

1. Drop a dye tablet or several drops of food coloring in the toilet tank.
2. Wait 15–20 minutes without flushing the toilet.
3. Check the toilet bowl for evidence of coloring from the dye. If the water in the toilet bowl is colored, the shutoff device is leaking.
4. Flush the toilet to prevent the dye from staining the toilet bowl.

Other causes for toilet leakage are a misaligned fill tube, which can direct too much water to the toilet bowl, or an improperly set float valve (the device that shuts off water flow to the tank when it is full). In both cases, the repair is simple and does not require any capital expense.

Faucet Leakage

Even though leakage from faucets is readily visible, it is often ignored because most people do not realize how much it adds up over time. A miniscule leak of one drip per minute amounts to 200 liters per year; a faucet that leaks 1 drip per second loses almost 12,000 liters per year.

How Much Water Does a Leaking Faucet Lose?

Drips per Minute	Liters per Month	Liters per Year
1	16	200
10	164	1,990
20	327	3,980
50	818	9,950
100	1,640	19,900

Leakage from faucets is most often caused by worn-out rubber washers or O-rings inside the unit. Repairing the leak usually entails replacing the washer and/or O-ring, which are inexpensive and should be readily available in plumbing supply shops.

Comprehensive Leak Detection Programs

Leak detection and repair should be a part of any facility management program. Studies of leakage often find that leakage varies significantly from building to building; most buildings have very low leakage rates, but a small percentage have very high leakage

[9] U.S. Environmental Protection Agency. *Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities*. Washington, D.C., United States. October 2012.

rates.[10] Although many facilities respond promptly to major leakage incidents, they often ignore minor or background leakage, which can cost them as much annually as a catastrophic leak that gets immediate attention.

The basic elements of a leak detection program should always include the following:

Routine inspections should be conducted on a monthly basis for all faucets, toilets, other fixtures, and appliances that use water. At least annually, piping that is readily accessible should also be checked, particularly on the ground floor and other parts of the facility, where leakage is more likely to go unnoticed. Water spots in ceilings or puddling of water should be noted and investigated because they often indicate water leakage from sources that may be hidden.

Review of monthly water bills to compare consumption to the previous bill to determine if there have been significant changes in consumption. For buildings or facilities that use water in varying amounts throughout the year, it may be more informative to compare the most recent water bill to the bill for the same period during the previous 1 or 2 years.

Regular reading of water meters during off-hour periods (e.g., overnight) when the facility is unoccupied or water use is at a minimum. If the water meter reading changes significantly over such periods, it likely means there is leakage occurring in the background. In such cases, the facility should undertake a systematic investigation to locate the leakage.

3.8 Water Fixture Usage—Best Practices

The following is a list of best practices for reducing water consumption by water fixtures.

General

- Increase employee awareness of water conservation.
- Install signs encouraging water conservation in employee and customer restrooms.
- Check fixtures regularly for leaks, especially faucets, toilets, showerheads, and urinals; repair leaks as soon as possible.
- Replace old fixtures with high-efficiency models.
- Review and compare water bills for indications of leakage or unexpected increases in usage.

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[10] Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003.

- Take periodic water readings during periods when the building is not in use to determine if background leakage or usage is occurring.

Toilets

- Do not use toilets as a waste basket to dispose of rubbish and other items.
- Use the light flush option when possible.
- Check the sensor on a regular basis to be sure it is working properly and the toilet is not flushing inadvertently. (This applies only to toilets designed for automatic flushing.)

Urinals

- Check the sensor on a regular basis to be sure it is working properly and the urinal is not flushing inadvertently. (This applies only to urinals designed for automatic flushing.)

Faucets, Showerheads, and Bidets

- Do not leave water running when not actually being used (e.g., while applying soap to hands).
- Be sure to turn fixtures off all the way after using.
- Perform monthly check to ensure the sensor is working properly and the flow duration (i.e., how long the faucet runs before shutting off) matches the type of use. (This applies to self-closing faucets.)
- Perform monthly check to ensure that the faucet is shutting off after the specified period of time. (This applies to faucets equipped with a metering device.)
- Limit showering time to no more than 5 minutes when possible.
- Install a recirculation pump in the hot water supply line to minimize the wastage of water associated with allowing hot water to flow until it gets warm.

4.0 Kitchen and Food Service Operations

Kitchens and food service operations (hereafter referred to collectively as food service operations) generally require large amounts of water. Faucets, dishwashers, sprayers, and ice machines account for most of the water usage in non-residential food service operations. Because faucets were discussed previously, this section focuses on the other three types of equipment. Additional information on these and other equipment associated with water use in food service operations can be found at the links provided.

4.1 Commercial Dishwashers

Dishwashers generally account for 25–65% of water consumption in food service operations, depending on the nature of the operation, type of equipment, and the practices used by the food service workers.[11, 12] Commercial dishwashers are manufactured in four basic types: undercounter, stationary rack door, rack conveyor, and flight (**Figure 4-1**). All four types may be designed to use either hot water or chemicals for disinfection. In general, machines that use hot water for disinfection are more efficient with respect to water use.

Undercounter dishwashers are the smallest type and are similar to the dishwashers used in residential homes and apartments. What differentiates commercial models from residential dishwashers is that commercial dishwashers may include a disinfection step in the washing cycle. Office breakrooms and other facilities that do not have a high food service demand often are equipped with this type of unit. Dishes and other items are loaded onto a rack that slides out of the front of the unit.

Stationary rack door dishwashers are the most widely used type in the commercial sector. In addition to being used in many restaurants, this type is also commonly found in schools and medium-size food service operations. This type of dishwasher is usually front-loaded with racks to hold the dishes and utensils.

Conveyor-type dishwashers are designed for hotels, large restaurants, and other large food service operations. Dishes and utensils are loaded onto removable racks, which are then mounted on a conveyor that moves the dishes through the various steps of the washing, disinfection, and drying cycles.

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11 Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003.

12 North Carolina Department of Environment and Natural Resources. *Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities*. Raleigh, North Carolina, United States. May 2009.

Flight-type dishwashers have the highest capacity and are generally used for very large food service operations. Dishes and other items are loaded directly on a conveyor rack that continuously moves through the steps of the washing, disinfection, and drying cycles.

Figure 4-1. Dishwasher Types

Undercounter dishwashers

Eurodib Lamber Energy Start Electronic Undercounter Dishwasher. http://www.costco.com/Eurodib-Lamber-Energy-Start-Electronic-Undercounter-Dishwasher-with-2-Year-Manufacturer-Warranty%7C-F92EKS.product.100086438.html (accessed November 2016)

Stationary rack door dishwashers

Hood Type Dishwasher DW-5000. http://dolphinco.en.ec21.com/Hood_Type_Dishwasher_DW_5000--5263462_5263486.html (accessed November 2016)

Conveyor-type dishwashers

Everest Equipment Company, Conveyor Type Dishwasher. http://www.everestequipments.com/conveyor-type-dishwasher.htm (accessed November 2016)

Flight-type dishwashers

Hobart FT900BD Flight-Type Dishwasher. http://leaserestaurantsupplies.com/index.php/hobart-flight-type-234.html (accessed November 2016)

Table 4-1 summarizes the typical capacity (in terms of number of persons served) and applications for the four categories of commercial dishwashers. **Table 4-2** summarizes the average savings based on a 2010 study conducted in California that compared the median water usage rates for standard-efficiency and high-efficiency dishwashers in the market at the time. The data indicated savings up to 49%. A high-efficiency residential dishwasher, which also can be used for office breakrooms or other very small food service operations, can save up to 42% over a standard-efficiency residential model.[13]

Table 4-1. Summary of Commercial Dishwasher Types

Dishwasher Type	No. of persons served	Applications
Undercounter	Up to 60	Office breakrooms and small food service operations
Stationary door	Up to 150	Schools, restaurants, hospitals, and catering businesses
Conveyor	150 to 300	Hotels, large restaurants, large schools, and universities
Flight	Hundreds to thousands	Very large commercial, institutional, and industrial facilities

Sources:

- U.S. Environmental Protection Agency. *Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities*. Washington, D.C., United States. October 2012.
- North Carolina Department of Environment and Natural Resources. *Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities*. Raleigh, North Carolina, United States. May 2009.

Table 4-2. High-Efficiency Commercial Dishwasher Savings Potential

Dishwasher Type	% Savings[a]
Hot Water Disinfection	
Undercounter	34.2
Stationary door	33.1
Conveyor (single tank)	45.7
Conveyor (multi-tank)	49.4
Flight (single tank)	33.3
Flight (multi-tank)	47.1
Chemical Disinfection	
Undercounter	32.6
Stationary door	10.7
Conveyor (single-tank)	48.4
Conveyor (multi-tank)	7.5
Flight (single-tank)	No data
Flight (multi-tank)	25.0

Source: California Urban Water Conservation Council. *Evaluation of Potential Best Management Practices—Commercial Dishwashers*. Sacramento, California, United States. June 2010.

[a] Based on comparison of median water usage rates of standard- and high-efficiency models available in market.

[13] Executive Affairs Authority. *Demand-Side Management for Electricity and Water Use in Abu Dhabi, Final Report.* Abu Dhabi, UAE. June 2009.

4.2 Pre-Rinse Sprayers

Pre-rinse sprayers are used to remove large food particles and material before the dishes, utensils, and other items are loaded into the dishwasher. Sprayers can either be hand-held or automatic; automatic sprayers are usually designed to operate when the dishwasher is in operation. The water flow rate for automatic sprayers is generally higher than the flow rates for manual sprayers. **Figure 4-2** shows a pre-rinse sprayer.

Figure 4-2. Pre-Rinse Sprayer

Complete 8" Wall-Mount Pre-Rinse Faucet. http://www.signaturehardware.com/complete-8-wall-mount-pre-rinse-faucet-chrome.html (accessed November 2016)

If workers follow best practices, savings of about 35% can be expected when hand-held sprayers are used.[14] However, savings can be lower or much higher, depending on the situation and the cleaning practices of the workers.

4.3 Ice Machines

Ice machines can account for a significant portion of total water use by food service operations. One study of commercial kitchens in the United States estimated that ice machines account for about 19% of water consumption.[15] The amount of water used in ice-making depends on the demand for ice, the type of ice produced, and the design of the ice machine. Machines that produce ice cubes typically use 20–25% more water than machines that produce ice flakes. The additional water used by ice cube machines is due to the need to rinse the minerals off the outside surface of the cubes to produce ice cubes that are clear. Although not common, water-cooled ice machines use much more water than air-cooled ice machines.

An ice machine that is 100% efficient and does not waste any water would require 1.0 liter of water per kilogram (L/kg) of ice produced. Air-cooled flake machines typically require 1.3 to 1.7 L/kg, whereas air-cooled cube machines usually require 1.7 to 2.1 L/kg.

Because ice machines have an average lifetime of only 5 years, there are frequent opportunities to replace existing units with more efficient models. Selection should be based

[14] North Carolina Department of Environment and Natural Resources. *Water Efficiency Manual for Commercial, Industrial, and* Institutional *Facilities*. Raleigh, North Carolina, United States. May 2009.

[15] Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003.

on the reported value for L/kg of ice produced. However, energy efficiency should also be considered, particularly when comparing models with similar water efficiency.

4.4 Kitchen and Food Service Operations—Best Practices

The following is a list of best practices for reducing consumption of water by food service operations:

General

- Replace old water-using appliances and fixtures with high-efficiency models.
- Check all appliances and fixtures routinely for leakage.

Faucets

- Avoid running faucets when the water is not actually being used.
- Do not use faucets to thaw frozen items.

Pre-rinse Sprayers

- Use a hand scraper to remove large food particles from dishes, pots, and utensils to minimize use of pre-rinse and wash-down sprayers.
- Soak pots prior to pre-rinsing or placing in the dishwasher.
- Adjust the height of hand-operated pre-rinse sprayers to minimize the distance from the sprayer to the items being rinsed.

Dishwashers

- Select the type and size that matches the application; note that commercial dishwashers are most efficient when fully loaded.
- Wash dishes in full loads and avoid running the dishwasher for partial loads when possible.
- Ensure that the water rinse pressure and temperature are within manufacturer's recommendations.
- Operate dishwashers at the minimum flow rate and rinse time recommended by the manufacturer.
- Turn off dishwashers when not in use.

Ice Machines

- Replace any water-cooled ice machine with an air-cooled machine.
- Replace ice cube machines (if possible) with machines that produce ice flakes.
- Clean ice machines regularly to avoid buildup of scale and deposits.

Other

- Do not use food waste disposers or grinders that use water.

5.0 Commercial and Institutional Laundry Operations[16, 17, 18]

Clothes washing machines account for nearly all of the water consumption within CGI laundry operations. **Table 5-1** summarizes some of the characteristics of commercial clothes washing machines. Commercial clothes washing machines can be categorized as one of the following: single-load washers, multi-load washers, washer-extractors, and tunnel washers (**Figure 5-1**). Sections 5.1 through 5.4 that follow provide additional details.

Table 5-1. Summary of Commercial Clothes Washer Types

Dishwasher Type	Maximum Weight, kg/load	Savings	Applications
Single-load	Up to 9 kg/load	Up to 37%	Small laundry operations and laundromats
Multi-load	Up to 36 kg/load	No data	Small to medium laundry operations and laundromats
Washer extractor	10 to 360 kg/load	No data	Small to medium hotels and other medium to large laundry operations
Tunnel washer	Up to 900 kg/hour	Up to 50% over washer extractors	Universities, large hotels, prisons, and facilities with very large laundry demands

Source: U.S. Environmental Protection Agency. *Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities*. Washington, D.C., United States. October 2012.

[a] Executive Affairs Authority. *Demand-Side Management for Electricity and Water Use in Abu Dhabi, Final Report*. Abu Dhabi, UAE. June 2009.

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[16] U.S. Environmental Protection Agency. *Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities*. Washington, D.C., United States. October 2012.

[17] North Carolina Department of Environment and Natural Resources. *Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities*. Raleigh, North Carolina, United States. May 2009.

[18] New Mexico Office of the State Engineer. *A Water Conservation Guide for Commercial, Institutional, and Industrial Users.* Albuquerque, New Mexico, United States. July 1999.

Figure 5-1. Laundry Machine Types

Single-Load	**Multi-Load**
 Samsung WF42H5000AW 4.2 cu. ft. Front-Load Washer. http://www.sears.com/samsung-4.2-cu-ft-front-load-washer-white/p-02646322000P?plpSellerId=Sears&prdNo=14&blockNo=14&blockType=G14 (accessed November 2016)	 Maytag, Multi-Load Rigid-Mount Washers. http://www.remlaundry.net/multi-load-rigid-mount-washers (accessed November 2016)
Washer Extractor	**Tunnel Washer**
 Electrolux, Front-loading washer-extractor. http://www.archiexpo.com/prod/electrolux-professional/product-49321-659530.html (accessed November 2016)	 Continental, Tunnel Washer TBS-50. http://www.cleaners-laundry.com/Continental_Tunnel_Washer.html (accessed November 2016)

5.1 Single-Load Washers

Single-load washers are similar to residential washing machines and are classified as top loading or front loading. Front-loading units are more efficient in terms of both energy and water consumption because they use gravity to tumble the laundry, and the laundry does not have to be completely submerged in water; laundry for top-loading washers needs to be completely submerged in water.

5.2 Multi-Load Washers

Multi-load washers are similar to single-load washers but are of larger capacity and generally have more programmable control settings. The larger number of control settings allows the user to adjust the number of cycles, water levels, and other operating parameters to match the load being washed, resulting in reduced water consumption.

5.3 Washer Extractors

Washer extractors are similar to multi-load washers but have even larger capacities and use high-speed spin cycles, resulting in higher efficiency. Washer extractors also have more programmable control options than multi-load washers. For example, washer extractors can be programmed for multiple cycles for rinsing, bleaching, and potential of Hydrogen (pH) adjustment. Washer-extractors are the technology of choice for facilities, such as hotels, that have moderate to large clothes washing requirements.

5.4 Tunnel Washers

Tunnel washers are very large, continuous machines designed with a series of compartments or stages through which the clothing and other laundry items are transported. Tunnel washers are designed to recycle water throughout multiple stages and thus have the highest efficiency. They are used at large hotels, universities, prisons, and other facilities that have very high demand for clothes washing.

5.5 Commercial and Institutional Laundry Operations—Best Practices

For single-load washers, high-efficiency units achieve average savings of about 37% compared to standard- or older low-efficiency units.[19] For multi-load and washer extractors, there are no data on the relative savings when comparing standard units to high-efficiency models. The available information indicates that savings are derived primarily by taking advantage of the programmable controls to customize the washing process to use only the amount of water required to properly clean the articles being washed.

Washer extractors typically use 21–29 liters of water per kilogram of clothing washed. Replacing a washer extractor with a tunnel washer, which typically uses 8–17 liters of water

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[19] Executive Affairs Authority. *Demand-Side Management for Electricity and Water Use in Abu Dhabi, Final Report*. Abu Dhabi, UAE. June 2009.

per kilogram of clothing, yields savings of about 50% in water consumption.[20] The disadvantage of replacing a washer extractor with a tunnel washer is the high initial capital cost.

Further savings can be achieved by retrofitting water recycling or ozone systems on existing washers. Water recycling systems, which reduce water consumption by 10–35%, can be added to single-load, multi-load, and washer extractor machines.[21] Ozone systems generate and use ozone instead of laundry detergent and bleach. In addition to allowing for lower water temperatures (conserving energy), ozone systems reduce water consumption by about 30%.[22] Similar to recycling systems, ozone systems can be added to single-load, multi-load, and washer-extractor machines.

Additional best practices for reducing consumption of water by laundry operations include the following:

- Wash full loads rather than partial loads to the extent possible.
- Separate and wash laundry items according to the number and type of cycles needed.
- Use detergents formulated for high-efficiency washers.
- Consult with laundry chemical suppliers to identify washing and rinsing procedures that minimize water usage.

[20] New Mexico Office of the State Engineer. *A Water Conservation Guide for Commercial, Institutional, and Industrial Users.* Albuquerque, New Mexico, United States. July 1999.

[21] U.S. Environmental Protection Agency. *Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities*. Washington, D.C., United States. October 2012.

[22] Pacific Institute. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Oakland, California, United States. November 2003.

6.0 Landscape Irrigation

Because of the hot arid climate of Abu Dhabi, most plant species require some level of irrigation throughout the year. As a result, water consumption for irrigation can comprise a significant portion of overall water consumption by a building or facility, even when plants are provided only the required amount of water and no more. Furthermore, when plants are over-watered, or when irrigation water is not applied where and when needed, wastage can be significant. When landscaping and irrigation systems are designed and operated properly, the savings in water consumption can be substantial.

This section provides an overview of landscape irrigation methods and presents a list of best practices related landscape design, irrigation system design, and irrigation system operation.

6.1 Landscape Irrigation Methods[23,24]

There are several methods available for irrigating, landscaping, and incorporating into landscape irrigation systems. This section provides an overview of the four most commonly used methods: manual irrigation, flooding, sprinkler or spray irrigation, and micro-irrigation (drip irrigation).

Manual Irrigation

Manual irrigation typically entails using a hand-held hose equipped with a nozzle and spraying the areas that need watering. Manual irrigation has low capital costs but can have high labor costs. It can be used for watering any type of landscaping. However, it is generally the least efficient method and should be used only on a temporary basis until an appropriately designed irrigation system can be installed.

Flooding

Flooding usually involves applying water to furrows excavated between rows of plants or trees. The efficiency of flooding is relatively low compared to all other methods except manual irrigation. Because flooding is mostly used for crop irrigation rather than landscape irrigation, it is not discussed further. It should be noted that the use of bubblers for irrigating trees can technically be classified as flooding, but it is usually considered as a type of micro-irrigation and is discussed later.

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[23] Abu Dhabi Municipality. *Irrigation Manual (Volume I), Design Manual*. Abu Dhabi, UAE. 2014.
[24] U.S. Department of Agriculture. *Irrigation Guide, National Engineering Handbook*. Washington D.C., United States. September 1997.

Sprinkler or Spray Irrigation

Sprinkler or spray irrigation uses a series or matrix of sprinkler heads to apply water to landscaping. The sprinkler heads spray water out above the ground in a circular pattern or a division thereof (usually, half circle or quarter circle). The spacing of sprinkler heads is critical for ensuring efficient irrigation. Although there are many types and designs of sprinkler heads, the two broad classifications are fixed and rotary. Fixed sprinkler heads are stationary and deliver in a constant pattern (e.g., full circle, half circle, or quarter circle). Rotary sprinkler heads use water pressure to rotate the sprayer around the axis of the sprinkler and thereby achieve better coverage than fixed sprinkler heads.

Sprinkler irrigation is most appropriate for irrigating turf and other ground covers because it provides full, or nearly full, coverage of the surrounding area. It is also cost effective, particularly for large areas, and is easily incorporated into an irrigation system. The primary disadvantage of sprinkler irrigation is that evaporation losses can be high, particularly if the sprinkler is operated at midday or in the afternoon. In addition, the efficiency of sprinkler irrigation is much lower for narrow or small areas of landscaping where there is more likely to be significant overspray (i.e., the sprinklers spray water beyond the area that is planted). Also, significant losses can result when sprinkler irrigation is subject to windy conditions.

Micro-Irrigation (Drip Irrigation)

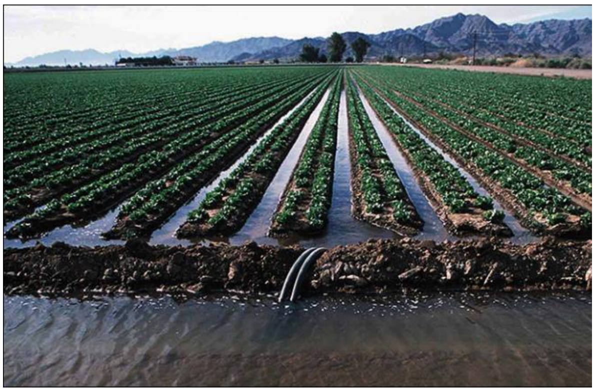
Micro-irrigation, which is also referred to as drip irrigation, is a method for delivering water slowly to a fixed point or small area and utilizes a variety of devices, including drip (or point) emitters, line emitters, micro-sprinklers, and bubblers. Drip emitters are small devices that deliver water to a specific point at very low-flow rates (2–20 liters per hour). They are generally used for irrigating individual plants.

Line emitters are pipes or tubing with small emission points at fixed intervals (e.g., every 15–30 centimeters) along the length of the pipe. Line emitters can be placed in a grid to apply irrigation water evenly over an area, but are also often used to irrigate trees or shrubs where a small number of drip emitters would not be adequate. For example, a line emitter might be placed in a circular layout around a tree.

Micro-sprayers are similar to, but much smaller than, the full-size spray heads discussed previously. They are most appropriate for irrigating small or irregularly-shaped areas with turf or ground covers that would be difficult to irrigate efficiently using full-size sprinkler heads. They can also be used for irrigating flower beds and other small areas with plantings that are short in height.

Bubblers are similar to micro-sprayers in that they deliver water to a small circular area, but the water is discharged in small streams. Bubblers are designed for higher flow rates than the other micro-irrigation devices described previously, and bubblers are used for localized flooding of small areas. The most common application for bubblers is irrigation of trees. When bubblers are used, a basin is constructed around the tree to contain the water.

Figure 6-1. Irrigation Methods

Manual irrigation	Flooding
 Automatic and Manual Irrigation Introduction, Alliance for Water Efficiency. http://www.allianceforwaterefficiency.org/Automatic_and_Manual_Irrigation_Introduction.aspx (accessed November 2016)	 Irrigation: Water for all, MIT. http://12.000.scripts.mit.edu/mission2017/irrigation/ (accessed November 2016)
Sprinkler or spray irrigation	**Micro-irrigation**
 Sprinkler Systems, Landscaping Network https://www.landscapingnetwork.com/sprinklers-systems/ (accessed November 2016)	 Irrigation System, M.R.Agraulic Experts. http://agraulic.com/irrigation.html (accessed November 2016)

The primary advantage of micro-irrigation is that it can achieve very high efficiencies when properly designed and operated. The disadvantages of micro-irrigation include relatively high cost and maintenance requirements due the complexity of design and number of components, which are mostly made of plastic and are easily damaged. In addition, the small orifices used in micro-irrigation devices are subject to clogging.

Subsurface drip irrigation is a type of micro-irrigation in which water is supplied through line emitters that are buried. Subsurface systems deliver water directly to the root zone of the plants being irrigated. The primary advantage of subsurface drip irrigation is that there is virtually no loss of water from evaporation. For this reason, a properly designed and operated subsurface system is potentially the most efficient type of irrigation system.[25] The main disadvantages of subsurface drip irrigation are the high initial cost, and the fact that the system is not readily visible, which makes maintenance more difficult.

6.2 Landscape Design Best Practices

The following is a list of best practices and tips for designing landscape to use water efficiently and minimize water consumption:

- Use a professional landscaper to design any landscaping that will include multiple plant species or cover relatively large areas.
- Use native and drought-tolerant plants when possible.
- Group plant species according to their water needs (i.e., species with low water requirements planted together, species with medium water requirements planted together).
- Avoid long narrow plots that are planted with turf or other groundcover when possible because they are more difficult to irrigate efficiently.
- Avoid plantings that are near heat sources and sinks (to the extent possible).
- Protect landscaped areas from the wind.
- Minimize the use of turf, which is more difficult to irrigate efficiently and—for many species—has high water needs.
- Use artificial turf instead of real turf.
- Consider designing xeriscape or hardscape areas that use little to no vegetation.
- Apply mulch to help retain water in areas with trees or shrubs.
- Avoid plantings on slopes.

6.3 Irrigation System Design Best Practices

The following is a list of best practices for designing irrigation systems that use water efficiently:

- Use a professional to design and install any complex irrigation system.

[25] University of Nebraska—Lincoln Extension. *Advantages and Disadvantages of Subsurface Drip Irrigation (EC776)*. Lincoln, Nebraska, United States. 2005.

- Use an automated system with timers that can be adjusted according to the season and local conditions.
- Design the irrigation system to deliver only what plants need and not more.
- Use micro-irrigation systems to irrigate shrubs, trees, and plants other than turf.
- Use sprinklers to irrigate areas planted with turf.
- Use rotary head sprinklers instead of stationary head sprinklers.
- Minimize overspray of landscaped areas.
- Cover plastic irrigation tubes and piping to minimize exposure to sun, which can degrade the plastic and shorten its lifetime.
- Keep a sketch of the irrigation system layout on file to aid in locating lines and other components that are covered.
- Install separate water meter(s) for irrigation systems that use potable water.

6.4 Irrigation System Operation Best Practices

The following is a list of best practices associated with the operation of landscape irrigation systems.

- Flush all irrigation lines with clean water to remove debris prior to putting the system into operation.
- Irrigate in the morning or evening when evaporation rates are lower.
- Adjust the duration and/or frequency of irrigation cycles according to the season (i.e., longer duration or more frequent cycles in hot season, shorter duration or fewer cycles in cool season).
- Operate irrigation systems with fewer cycles of longer duration rather than more frequent cycles of shorter duration.
- Check irrigation systems regularly for leakage.
- Check irrigation lines, sprinklers, and emitters regularly for clogging and flush with clean water, particularly for micro-irrigation systems.
- Check that irrigation lines, particularly those made of plastic, are not exposed to direct sunlight and cover the lines when necessary.

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Appendix A. Summary of Best Practices

Best Practice	Cost	Savings
Conduct detailed water audit of facility.	H	H
Water Fixtures and Plumbing		
General		
Increase employee awareness of water conservation.	L	L/M
Install signs encouraging water conservation in employee and customer restrooms.	L	L/M
Check fixtures regularly for leaks—especially faucets, toilets, showerheads, and urinals; repair them as soon as possible.	M	M/H
Replace old fixtures with high-efficiency models.	L/M	M/H
Review and compare water bills for indication of leakage or unexpected increases in usage.	L	L/M
Take periodic water readings during periods when the building is not used to determine if background leakage or usage is occurring.	L	L/M
Toilets		
Do not use toilets as a waste basket to dispose of rubbish and other items.	L	L
Use the light flush option when possible.	L	M
Check the sensor on a regular basis to be sure it is working properly and the toilet is not flushing inadvertently. (This applies only to toilets designed for automatic flushing.)	L	L
Urinals		
Check the sensor on a regular basis to be sure it is working properly and the urinal is not flushing inadvertently. (This applies only to urinals designed for automatic flushing.)	L	L
Faucets, Showerheads, and Bidets		
Do not leave water running when not actually being used (e.g., while applying soaps to hands).	L	L
Be sure to turn fixtures all the way off after using.	L	L
For self-closing faucets, routinely check (e.g., monthly) that the sensor is working properly and the flow duration (how long the faucet runs before shutting off) matches the type of use.	L	L/M
For faucets that are equipped with a metering device, routinely check (e.g., monthly), that the faucet is shutting off after the specified period of time.	L	L/M
Limit showering time to no more than 5 minutes when possible.	L	L
Kitchen and Food Service Operations		
General		
Replace old water using appliances and fixtures with high-efficiency models.	M/H	H
Check all appliance and fixtures routinely for leakage.	L	L/M
Faucets		
Avoid running faucets when the water is not actually being used.	L	L
Do not use faucets to thaw frozen items.	L	L

Best Practice	Cost	Savings
Pre-Rinse Sprayers		
Use a hand scraper to remove large food particles from dishes, pots, and utensils to minimize use of pre-rinse and wash-down sprayers.	L	L
Soak pots prior to pre-rinsing or placing in the dishwasher.	L	L
Adjust the height of hand-operated pre-rinse sprayers to minimize the distance from the sprayer to the items being rinsed.	L	L
Dishwashers		
Because commercial dishwashers are most efficient when fully loaded, select the type and size that matches the application.	M/H	M/H
Wash dishes in full loads and avoid running the dishwasher for partial loads when possible.	L	M
Ensure that the water rinse pressure and temperature are within manufacturer’s recommendations.	L	L
Operate dishwashers at the minimum flow rate and rinse time recommended by the manufacturer.	L	L
Turn off dishwashers when not in use.	L	L
Ice Machines		
Replace any water-cooled ice machine with an air-cooled machine.	M	H
Replace ice cube machines with machines that produce ice flakes, if possible.	M	L
Clean ice machines regularly to avoid buildup of scale and deposits.	L	L
Other		
Do not use food waste disposers or grinders that use water.	L	L
Laundry Operations		
Replace existing clothes washing machine with high-efficiency model.	M/H	M/H
Program washing cycle to match load being washed.	L	L/M
Retrofit recycling system.	M/H	M/H
Retrofit ozone system.	M/H	M
Wash full loads rather than partial loads to the extent possible.	L	L/M
Separate and wash laundry items according to the number and type of cycles needed.	L	L/M
Use detergents formulated for high-efficiency washers.	L	L
Consult with laundry chemical suppliers to identify washing and rinsing procedures that minimize water usage.	L/M	L/M
Landscape Design Best Practices		
Use a professional landscaper to design any landscaping that will include multiple plant species or cover relatively large areas.	M/H	M/H
Use native and drought-tolerant plants when possible.	M	H
Group plant species according to their water needs.	L/M	L/M
Avoid planting turf or ground covers in long narrow plots.	L	M
Avoid plantings that are near heat sources and sinks (to the extent possible).	L/M	L/M
Protect landscaped area from the wind.	L/M	L/M
Minimize the use of turf, which is more difficult to irrigate efficiently and, for many species, has high water needs.	L	M
Use artificial turf instead of real turf.	M/H	H

Best Practice	Cost	Savings
Consider designing xeriscape or hardscape areas that use little to no vegetation.	M/H	H
Apply mulch to help retain water in areas with trees or shrubs.	L/M	L
Avoid plantings on slopes.	L	L
Irrigation System Design Best Practices		
Use rotary sprinkler heads instead of stationary sprinkler heads.	M	M
Use a professional to design and install any complex irrigation system.	M/H	M/H
Use an automated system with timers that can be adjusted according to the seasonal and local conditions.	M/H	M/H
Design the irrigation system to deliver only what plants need and not more.	L/M	M/H
Use micro-irrigation systems to irrigate shrubs, trees, and plants other than turf.	M/H	H
Use sprinklers to irrigate areas planted with turf.	M	M
Use rotary head sprinklers instead of stationary head sprinklers	M	M/H
Minimize overspray of landscaped areas (e.g., sprinklers or sprayers deliver water outside area of vegetation).	L/M	L/M
Cover plastic irrigation tubes and piping to minimize exposure to sun, which can degrade the plastic and shorten its lifetime.	L/M	L
Keep a sketch of the irrigation system layout on file to aid in locating lines and other components that are covered.	L	N/A
Install separate water meter(s) for irrigation systems that use potable water.	M	N/A
Irrigation System Operation Best Practices		
Flush all irrigation lines with clean water to remove debris prior to putting the system into operation.	L	N/A
Irrigate in the morning or evening when evaporation rates are lower.	L	L
Adjust the duration and/or frequency of irrigation cycles according to the season (i.e., longer duration or more frequent cycles in hot season, shorter duration or fewer cycles in cool season).	L	M/H
Operate irrigation systems with fewer cycles of longer duration rather than more frequent cycles of shorter duration.	L	L/M
Check irrigation systems regularly for leakage.	L/M	L/M
Check systems regularly for clogging and flush with clean water, particularly for drip irrigation systems.	L/M	L
Check that irrigation lines, particularly those made of plastic, are not exposed to direct sunlight and cover the lines when necessary.	L	N/A

Appendix B. Links to Documents with Additional Information

Topic	Document Title	Link	Location in Document
Water audits	Water Efficiency and Self-Conducted Water Audits at Commercial and Institutional Facilities: A Guide for Facility Managers	http://my.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/water_efficiency_improvement_self_assess_guide.pdf	Entire document
	Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.	http://infohouse.p2ric.org/ref/01/00692.pdf	Chapter 6
	A Water Conservation Guide for Commercial, Institutional, and Industrial Users	http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1014	Section 2
	Waterwise Water Auditor Program, Guidelines and Criteria for Water Audit Analysis and Reporting.	ps://www.watercorporation.com.au/-/media/files/business/becoming-a-waterwise-specialist/waterwise-water-auditors-guidelines-and-criteria.pdf	Section 7
Water fixtures	Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities.	https://www3.epa.gov/watersense/docs/ws-at-work_bmpcommercialandinstitutional_508.pdf	Sections 3.1–3.5
	Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.	http://infohouse.p2ric.org/ref/01/00692.pdf	Chapter 4
	A Water Conservation Guide for Commercial, Institutional, and Industrial Users	http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1014	Section 3
Leakage	Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities.	https://www3.epa.gov/watersense/docs/ws-at-work_bmpcommercialandinstitutional_508.pdf	Section 2.3
	Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.	http://infohouse.p2ric.org/ref/01/00692.pdf	Chapter 4
Kitchen and food service operations	Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities.	https://www3.epa.gov/watersense/docs/ws-at-work_bmpcommercialandinstitutional_508.pdf	Section 4
	Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.	http://infohouse.p2ric.org/ref/01/00692.pdf	Chapter 4

Topic	Document Title	Link	Location in Document
	Commercial Food Service Introduction	http://www.allianceforwaterefficiency.org/Commercial_Food_Service_Introduction.aspx	Entire document
	A Water Conservation Guide for Commercial, Institutional, and Industrial Users	http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1014	Section 3
	Evaluation of Potential Best Management Practices—Commercial Dishwashers	https://www.cuwcc.org/LinkClick.aspx?fileticket=v2NB7CTwk3g%3D&tabid=135&portalid=0&mid=740	Entire document
Laundry operations	Water Sense at Work, Best Management Practices for Commercial and Institutional Facilities.	https://www3.epa.gov/watersense/docs/ws-at-work_bmpcommercialandinstitutional_508.pdf	Section 3.6
	Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.	http://infohouse.p2ric.org/ref/01/00692.pdf	Chapter 4
	Commercial Laundry Facilities Introduction	http://www.allianceforwaterefficiency.org/commercial_laundry.aspx	Entire document
	A Water Conservation Guide for Commercial, Institutional, and Industrial Users	http://www.allianceforwaterefficiency.org/WorkArea/linkit.aspx?LinkIdentifier=id&ItemID=1014	Section 3

Appendix C. Water Use Surveys

Water Use Survey Form

GENERAL INFORMATION ON ESTABLISHMENT AND OPERATION

Name of establishment:	

Operating Hours

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday

Number of employees (FTEs):	
Average No. of visitors per day:	
Estimated No. of visitors who use restroom:	

Water Meters (Complete for each water meter)

Meter No.	Account No.	Location	Areas/facilities served by meter

RESTROOMS (Complete for each restroom)

Location or name:	
No. of employees who use restroom:	

Is restroom used by visitors? ☐ Yes ☐ No

Faucets (Complete for each faucet)

No.	Type	Flow rate (L/min)	Duration (sec)*
1	☐ Manual ☐ Photo-sensor ☐ Metering		
2	☐ Manual ☐ Photo-sensor ☐ Metering		
3	☐ Manual ☐ Photo-sensor ☐ Metering		
4	☐ Manual ☐ Photo-sensor ☐ Metering		

* Metering faucets only.

Toilets

Number of toilets in restroom: ______ Are toilets identical? ☐ Yes ☐ No

Toilet Type and Flush Volume

Type of Toilet	Type of Tank	Flush volume (L/flush)
☐ Single-flush ☐ Dual-flush	☐ Visible ☐ Hidden ☐ Tankless	

Tank Dimensions (Complete if toilet is single flush, tank is visible, and flush volume is unknown)

Length (cm)	Width (cm)	Height (cm)	Location of measurement	Bowl volume (L)
			☐ Inside tank ☐ Outside tank	

Hose Sprayers and Bidets (Complete for each hose sprayer and bidet)

No.	Type of Unit	Flow rate (L/min)
1	☐ Hose sprayer ☐ Bidet	
2	☐ Hose sprayer ☐ Bidet	
3	☐ Hose sprayer ☐ Bidet	
4	☐ Hose sprayer ☐ Bidet	

Urinals (Complete for each urinal)

No.	Flush volume (L/flush)	Does urinal have photo-sensor?
1		☐ Yes ☐ No
2		☐ Yes ☐ No
3		☐ Yes ☐ No
3		☐ Yes ☐ No

Showerheads (Complete for each showerhead)

No.	Type of showerhead	Flow rate (L/min)	Frequency	Duration (min/shower)
1	☐ Fixed ☐ Flexible hose		☐ Times per ☐ Day ☐ Week	
2	☐ Fixed ☐ Flexible hose		☐ Times per ☐ Day ☐ Week	
3	☐ Fixed ☐ Flexible hose		☐ Times per ☐ Day ☐ Week	
4	☐ Fixed ☐ Flexible hose		☐ Times per ☐ Day ☐ Week	

Leakage (Complete for each leak that is visible)

Location of leak	Drops per minute

Number of toilets that are leaking into the bowl:

Additional Comments

BREAKROOMS AND SMALL KITCHENS (Complete for each breakroom or small kitchen)

Faucets (Complete for each faucet)

No.	Type	Flow rate (L/min)	Daily duration (min/day)
1	☐ Manual ☐ Photo-sensor ☐ Metering		
2	☐ Manual ☐ Photo-sensor ☐ Metering		

Dishwashers (Complete for each dishwasher)

Manufacturer	Model	Usage rate (L/load)	Frequency
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week

Sanitation and Cleaning

Estimated volume of water (L):	
Number of times per week:	

Additional Comments

LAUNDRY OPERATIONS

Complete for each laundry operation.

Clothes Washing Machines (Complete for each unit)

Manufacturer	Model	Usage rate (L/load)	Frequency
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week

Other Water Usage

Purpose	Volume of water used (L)	Frequency
		☐ Times per ☐ Day ☐ Week
		☐ Times per ☐ Day ☐ Week
		☐ Times per ☐ Day ☐ Week
		☐ Times per ☐ Day ☐ Week

Additional Comments

FOOD SERVICE OPERATIONS
Complete for each food service operation.

Meals Served

Number of full service meals per day:	
Number of limited service meal per day:	

Dishwasher (Complete for each unit)

Manufacturer	Model	Usage rate (L/load)	Frequency
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week
			☐ Times per ☐ Day ☐ Week

Pre-rinse Sprayers (Complete for each unit)

No.	Type	Flow rate (L/min)	Duration (min/day)
1	☐ Manual ☐ Automatic		
2	☐ Manual ☐ Automatic		

Faucets (Complete for each faucet)

No.	Purpose	Flow rate (L/min)	Duration (min/day)
1			
2			
3			
4			
5			
6			

Estimated volume of water used in food (L/day): ☐

Ice Machines (Complete for each unit)

Manufacturer	Model	Usage rate (L/kg)	Ice production rate (kg/day)

Sanitation and Cleaning

Estimated volume of water (L):	
Number of times per day:	

Other Water Usage (Complete for any other type of water usage not already addressed)

Purpose	Volume of water used (L)	Frequency
		☐ Times per ☐ Day ☐ Week
		☐ Times per ☐ Day ☐ Week
		☐ Times per ☐ Day ☐ Week
		☐ Times per ☐ Day ☐ Week

Additional Comments

LANDSCAPE IRRIGATION
Complete for each irrigated landscape area.

Description and Location

Description or name of landscaped area	Location

Shape and Size

Shape	Length (m)	Width (m)	Estimated Area (m^2)*
☐ Rectangular ☐ Other			

* If not rectangular.

Types of Vegetation

Type	% of total
Turf	
Shrubs	
Flowers/plants	
Other:	

Trees

Type	No. of trees
Palm	
Other	
Other:	
Other:	

Irrigation Method

☐ Manual ☐ Flooding ☐ Sprinkler ☐ Micro-irrigation ☐ Other method

Description of other method:

Irrigation Schedule

	Spring	Summer	Fall	Winter
No. of days per week				
Time of day	☐ Morning ☐ Afternoon ☐ Evening	☐ Morning ☐ Afternoon ☐ Evening	☐ Morning ☐ Afternoon ☐ Evening	☐ Morning ☐ Afternoon ☐ Evening
Duration (min/day)				

Irrigation Flow Rate

Estimated flow rate (L/min): ☐

Method Use to Estimate Flow Rate:

____

____

Additional Comments

____

____

____

____

____

____

____

____

____

OTHER WATER USAGE
Complete for each other activity or process that uses a significant amount of desalinated water.

Description of Activity/Process

____

____

____

Frequency of Activity/Process: ☐ Times per ☐ Day ☐ Week

Volume of water used (L) by Activity/Process during each occurrence: ☐

Additional Comments

____

____

____

____

____

____

____

____

____

Water Use Survey Instructions

GENERAL INFORMATION

- Enter the name of the establishment or facility.
- Enter the number hours that establishment operates on each day of the week.
- Enter the number of full-time equivalent employees (FTEs). For example, if the facility has 30 employees, and they each work a normal workday, enter 30 as the number of FTEs. If the facility has 30 employees, 20 full-time and 10 half-time, the number of FTEs would be 25.
- If the facility has public restrooms, indicate the average number of visitors per day.
- If possible, also estimate the average number of visitors who use the restrooms each day.

WATER METERS

- For each water meter, fill in the meter number, account number, location of the meter, and the areas of the building or the facilities served. The meter number is usually shown directly above the bar code on the water meter. The account number is shown on the monthly water bill from ADDC.
- If there is only one water meter, enter “All” as the areas/facilities served.
- If there is more than one meter and the areas/facilities are not known for any meter, enter “Unknown” for that meter.

RESTROOMS

- Complete the requested information separately for each restroom.
- Enter the name, location or a brief description of the restroom (e.g., second floor, men’s room)
- For the No. of employees who use the restroom, enter the number of FTEs.
- Indicate if the restroom is used by visitors.

Faucets

- Fill in the information for each faucet.
- Check the box to indicate if the faucet type is manual, photo-sensor, or metering. A photo-sensor faucet turns on when an object is placed in front of it and shuts off automatically when the object is removed. A metering faucet typically has a button; the faucet turns on when the button is pushed and shuts off automatically after a certain period of time.
- Determine the flow rate in liters per minute (L/min) by timing how long it takes to fill a 1 or 2-liter volume.
- If it is a metering faucet, measure the duration—the number of seconds (sec) that the faucet runs before it shuts off automatically.

Toilets

- Enter the number of toilets in the restroom and check the box to indicate if the toilets are identical or not.
- If the toilets are identical, fill in the requested information for one toilet in the restroom.
- If there are different types of toilets, fill in the information for each type of toilet.
- Check the box to indicate if the toilet is single flush or dual flush.

- Identify the type of toilet tank by checking one of the boxes to indicate if the toilet tank can be seen (visible), is located behind the wall and cannot be seen (hidden), or if the toilet has a flush-o-meter valve with no tank (tankless).
- Fill in the flush volume in liters per flush (L/flush), if it is known or if it is shown on the toilet. For dual-flush toilets, indicate both volumes (full flush/light flush).
- If the toilet is single flush, the flush volume is unknown, and the tank is accessible, measure the tank dimensions in centimeters (cm).
    - Length—horizontally, across the front of the tank,
    - Width—horizontally, from the front to the back of the tank, and
    - Depth—vertically, from the water fill line (highest level of water) to the bottom of the tank or lowest water line immediately after flushing.
- Indicate if the measurements were made on the inside or outside of the tank. If possible, the measurements should be made on the inside of the tank.
- Finally, estimate the volume of water in liters (L) in the toilet bowl before flushing. For most toilets, the volume in the bowl is between 1 liter and 2 liters.

Hose Sprayers and Bidets

- Fill in the information for each hose sprayer or bidet in the restroom.
- Indicate if the unit is a hose sprayer or bidet.
- Determine the flow rate in L/min by timing how long it takes to fill a 1 or 2-liter volume. Note that even if the units are identical, the flow rates may differ, so it is important to measure each unit.

Urinals

- Enter the number of urinals in the restroom.
- Enter the flush volume in L/flush if it is indicated on the urinal.
- Indicate if the urinal has a photo-sensor that automatically flushes the unit after each use.

Showerheads

- Fill in the information for each showerhead in the restroom.
- Check the boxes to indicate if there is a fixed showerhead, a flexible hose showerhead, or both.
- Determined the flow rate in L/min by timing how long it takes to fill a 1 or 2-liter volume. Note that even if the units are identical, the flow rates may differ, so it is important to measure each unit. If the shower has both a fixed showerhead, and a flexible shower hose, measure and enter the flow rates for each.
- Enter the frequency of showering in number of times per day or per week.
- Estimate the average duration of showering in minutes per shower (min/shower).

Leakage

- Check for visible leakage from the following: faucets, hose sprayers, showerheads, and visible piping.
- If there is leakage (dripping), indicate the location of each leakage point.
- Count the number of drops per minute.

- Also, check each toilet to see if there appears to be water leaking into the toilet bowl. The leaking may be visible and/or make a faint hissing sound. If so, enter the number of toilets with this type of leak.

Additional Comments

- Enter any additional information that would help in understanding how, and how much, water is used in the restroom.

BREAKROOMS and SMALL KITCHENS

- Complete the following information for each breakroom or small kitchen that has running water.
- A small kitchen would be one that is used for activities, such as getting water, making tea or coffee, heating prepared food items, or cleaning dishes and utensils, but is not used for preparing and cooking food. If the kitchen is used for preparing and cooking food, complete the section of the survey form on FOOD SERVICE OPERATIONS instead.

Faucets

- Fill in the information for each faucet.
- Check the box to indicate if the faucet type is manual, photo-sensor, or metering.
- Determine the flow rate in L/min by timing how long it takes to fill a 1- or 2-liter volume.
- Estimate the average daily duration (total length of time that the faucet is used per day) in minutes per day (min/day).

Dishwashers

- If the breakroom or kitchen has a dishwasher, enter the manufacturer’s name, model, and the water usage rate (liters per cycle or load). If the water usage rate is not indicated on the unit, it usually can be obtained online from the manufacturer.
- Enter the frequency of use for each dishwasher by filling in the number of times and check the box to indicate times per day or times per week.

Sanitation and Cleaning

- Estimate the amount of water used for sanitation or cleaning. This can be done using the flow rates (L/min) for the faucet(s) used for cleaning and the estimated time (minutes) that each faucet is running.
- If the cleaning staff uses buckets, determine the volume based on the number of buckets used and the volume of water in a bucket.
- Indicate how many times per week the establishment is cleaned.

Additional Comments

- Enter any additional information that would help in understanding how, and how much, water is used in the breakroom or kitchen.

LAUNDRY OPERATIONS

- Complete for each laundry operation.

Clothes Washing Machines

- Enter the manufacturer's name, model, and the water usage rate (L/load) for each machine. If the water usage rate is not indicated on the unit, it usually can be obtained online from the manufacturer.
- Enter the frequency of use for each clothes washing machine by filling in the number of times and check the box to indicate times per day or times per week.
- If the laundry uses water for other purposes, fill in for each type of water use, the purpose, the estimated volume of water used each time (liters), and the frequency in number of times per day or per week.

Other Water Usage

- If water is used for purposes other than by the clothes washing machines, indicate the purpose for each type of water use, estimated volume (L) of water used, and the frequency in number of times per day or per week.

Additional Comments

- Enter any additional information that would help in understanding how, and how much, water is used in the laundry.

FOOD SERVICE OPERATIONS

- Complete for each food service operation.

Meals Served

- Enter the average number of full service meals prepared per day. Full service means the meal is served with dishes and utensils that are washed and reused after each meal.
- Enter the average number of limited service meals prepared per day. Limited service means a meal that is not full service.

Dishwashers

- For each dishwasher used in the food service operation, enter the manufacturer's name, model, and the water usage rate (L/load). If the water usage rate is not indicated on the unit, it usually can be obtained online from the manufacturer.
- Indicate the frequency of use in number of times per day or number of times per week.

Pre-Rinse Sprayers

- For each pre-rinse sprayer, indicate the type (manual or automatic).
- Measure the flow rate in L/min.
- Estimate the total duration that the sprayer is in use each day (min/day).

Faucets

- For each faucet used in the food service operation, describe the purpose of the use (e.g., pot soaking, food washing and preparation).
- Measure the flow rate of the faucet (L/min) and estimate the duration that the faucet is used for that purpose (min/day).

- If a faucet is used for more than one purpose, enter the information for each purpose on a separate line.

Water Used in Food

- Estimate the average daily total volume of water used (L/day) as an ingredient in the food that is prepared (e.g., the volume of water used to cook rice).
- Do not include water used to rinse food items; that type of use should be included in the previous section on faucets.

Ice Machines

- For each ice machine, enter the manufacturer, model, and the usage rate in liters per kilogram of ice produced (L/kg). If the usage rate is not indicated on the unit, it usually can be obtained online from the manufacturer.
- Estimate how much ice is produced in kilograms per day (kg/day).

Sanitation and Cleaning

- Estimate the amount of water used for sanitation or cleaning. This can be done using the flow rates (L/min) for the faucet(s) used for cleaning and the estimated time (minutes) that the faucet is running.
- If the cleaning staff uses buckets, determine the volume based on the number of buckets used and the volume of water in a bucket.
- Also indicate how many times per day the kitchen or food preparation area is cleaned.

Other Water Usage

- If water is used for purposes other than what has been already described for the food service operation, describe the purpose of each type of water use.
- Estimate the volume of water used (liters).
- Indicate the frequency in number of times per day or per week.

Additional Comments

- Enter any additional information that would help in understanding how, and how much, water is used in the food service operation.

LANDSCAPE IRRIGATION

- Complete for each irrigated landscape area.
- For this survey, an irrigated landscape area is defined in terms of the irrigation method.
- Each area that is irrigated using a different method should be considered a separate landscape area. For example, if a plot is irrigated partially using sprinklers and partly by hand (manual irrigation), the plot should be treated as two landscape areas, with the size of each landscape area defined by the square meters covered by each irrigation method.

Description and Location

- Provide a brief description or name for the area and indicate its location.

Shape and Size

- Check the box to indicate if the area is rectangular or other shape.
- If the area is rectangular, enter the length and width in meters (m).

- If the area is not rectangular, estimate the area in square meters (m^2).

Types of Vegetation

- For each type of vegetation listed, estimated the percentage of the area that is covered by that type of vegetation. Enter zero (0%) for any of the listed types that are not present in the landscaped area. Be sure that the percentages add up to 100%.
- If there is vegetation other that turf, shrubs, or flowers/plants, enter the type of vegetation in the space provided after "Other."

Trees

- Enter the number of palm trees and other types of trees growing in the landscaped area.
- For trees other than palms, enter the type of tree in the space provided after "Other."
- Use a separate line for each other type of tree.

Irrigation Method

- Check the box to indicate which type of irrigation method is used.
- If a method other than those listed is used, check the box for "Other method" and describe the other method in the space provided.

Irrigation Schedule

- For each of the four seasons, enter the number of days per week the landscaped area is irrigated.
- Check the box to indicate the time of day when irrigation occurs. If the area is irrigated more than once per day, check the boxes for each time of day (e.g., Morning and Evening).
- Enter the duration (min/day) that the area is irrigated on those days when irrigation occurs.

Irrigation Flow Rate

- Estimate the irrigation flow rate (L/min) to the landscaped area and describe the method used to estimate the flow rate.
- If the area is irrigated by the manual or flooding method, determine the flow rate in L/min by timing how long it takes to fill a 1- or 2-liter volume.
- If the area is irrigated using a sprinkler or micro-irrigation system, check the system documentation or consult with a professional to determine the flow rate.
- If the area is irrigated with sprinklers, the flow rate can be estimated using a pan placed in the area for a full irrigation cycle. Measure the volume of water (L) collected in the pan, the surface area of the pan (m^2) and the area irrigated by the sprinkler (m^2). The flow rate can be determined as the volume collected, divided by the irrigation cycle duration (min), and multiplied by the ratio of the area irrigated (m^2) by the sprinkler and the surface area (m^2) of the pan. For a more accurate estimation, the pan should be placed in several locations, each for a full cycle, and then the average flow rate for the locations should be calculated.

Additional Comments

- Enter any additional information that would help in understanding how, and how much, water is used in the irrigated landscape area.

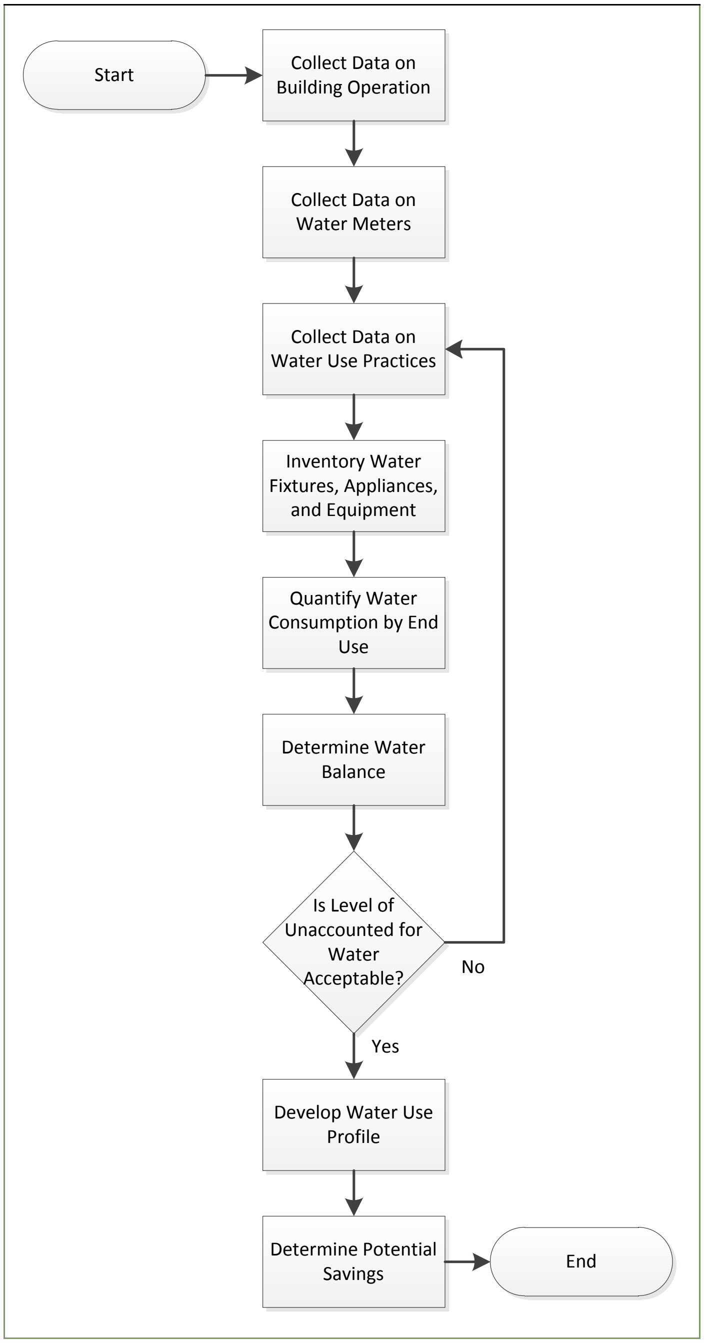
OTHER WATER USAGE

- Use this section to describe any other significant usage of desalinated water at the establishment that is not addressed in the previous sections of the survey.
- For each type of usage, describe how the water is used, indicate the frequency of use, and estimate how much water is used.
- Enter any additional information that would help in understanding how, and how much, water is used in the irrigated landscape area.

Appendix D. Water Audits

Prior to launching any program to improve the efficiency of water use, it is strongly recommended that a detailed water audit be conducted. A water audit provides site-specific information on exactly how water is used within a building and is key to identifying where savings can be achieved. **Figure D-1** is a simplified flow diagram for conducting a water audit.

Figure D-1. Water Audit Flow Diagram.



The basic steps to a water audit are described below.

- Collect Data on Building Operations
  - Including hours of operation, the number and gender of persons who use water at the building.
- Collect Data on Water Meters
  - Locate and identify all water meters that serve the building.
  - Determine which parts of building are served by each water meter.
  - Record current water meter readings and collect historical water meter consumption data.
- Collect Data on Water Use Practices
  - Record information on practices and behaviors that relate to water usage by employees and other persons who use water on the premises.

- Inventory Water Fixtures, Appliances, and Equipment
  - Include each restroom, kitchen, breakroom, utility room, and other parts of the building where water is used.
  - Identify all outdoor uses of water and measure or estimate water usage rates and frequencies.
- For irrigated landscaping, collect data on the size of the irrigated landscaping, plant species and irrigation system design and operation.
  - Note the location of any observed leakage.
- Quantify Water Consumption by End Use
  - Measure the water usage rate (e.g., flow rate, flush volume) of each water fixture, appliance, and any other equipment that uses water.
  - If water usage rates cannot be measured directly, collect whatever information is needed to estimate the usage rates (e.g., appliance manufacturer and model number).
  - Measure leakage rates to the extent possible.
  - Calculate directly, or estimate, daily or annual water consumption for each end use identified.
- Determine Water Balance
  - Sum up daily (or annual) water consumption by end use.
  - Compare the quantified consumption to water meter data.
  - Determine the level of unaccounted for water, which is the difference between the metered consumption and the sum of the consumption by all end uses.
  - If the level of unaccounted for water is greater than 10%, or otherwise unacceptable, investigate leakage and/or collect additional data to better characterize end use consumption
- Develop Water Use Profile
  - Determine the breakdown of water consumption by each type of end use.
- Determine Potential Savings
  - For each end use, determine options for reducing consumption or improving efficiency.
- For example, by replacing existing fixtures and appliances with high-efficiency models, or by changing specific operating practices and water usage behaviors.
  - Estimate benefits and costs of each option.
  - Identify the options that are the most cost-effective.

Table D-1 lists the specific types of data collected for a water audit of an office building or other facility where there are not process-specific or special water uses or needs. See

Appendix B for links to documents that provide additional information on how to conduct a water audit.

Although not part of the audit, the effectiveness and accuracy of a water audit can be greatly increased if the facility is sub-metered. Sub-metering entails dividing the facility's water supply into zones by location or type of end use (e.g., indoor vs. outdoor water use) and installing a water meter for each zone. Sub-metering is particularly effective in identifying the location and magnitude of leakage and other end uses that are more difficult to quantify.

Table D-1. Information Needed for Water Audit

Category	Information to be collected	Notes
General building operation	Days of the week and hours of operation	• Note any seasonal changes in operating schedule
	Number of employees and breakdown by gender (number of males, number of females)	• Differentiate between full-time and part-time employees • Note if any employees board at facility
	Average number of visitors per day	• If building has public bathrooms
Water meters	Parts of building, or end uses, served by each meter	• If available, record the age of the meter and the date when the meter was last calibrated
	Current reading of each meter	
Water use practices	Purpose and frequency of water use by employees during normal operations	Example survey questions could include: • Number of cups of tea or coffee consumed per day • Frequency of restroom usage • If employees utilize the light flush option on dual-flush toilets • If employees brush teeth at facility • If employees eat in, whether they wash dishes or utensils (e.g., after lunch) • Other routine water usage
Water fixtures	Inventory of all water fixtures	
	Faucet flow rate (liters per minute)	• Note if faucet is self-closing (automatic shutoff) • For self-closing faucets, duration of water flow
	Showerhead flow rate (liters per minute)	

Category	Information to be collected	Notes
Water fixtures (continued)	Toilet flush volume (liters per flush)	• If flush volume cannot be determined, estimate volume based on inside dimensions of toilet tank (length, width, and height to water fill line) • Include an estimate of the volume of water in the toilet bowl (typically 1 to 2 liters)
	Dual-flush toilet light flush volume (liters per flush)	
	Dual-flush toilet heavy flush volume (liters per flush)	
	Urinal flush volume (liters per flush)	
	Bidet/bidet sprayer flow rate (liters per minute)	
Water-using appliances	For dishwashing machines: • Manufacturer and model number • Type of machine (e.g., conveyor) • Age or year installed • Water usage rate (liters per load or cycle) • Water usage frequency (loads per day or week)	• If usage rate is not indicated on machine, obtain it from the manufacturer
	For clothes washing machines: • Manufacturer and model number • Type of machine (e.g., washer extractor) • Age or year installed • Water usage rate (liters per load or cycle) • Water usage frequency (loads per day or week)	• If usage rate is not indicated on machine, obtain it from the manufacturer
Leakage	Location of leak	
	Leakage rate	• For dripping faucets or other small leaks, record the number of drops per minute
Other indoor end uses	For each type of usage, the rate, duration, and frequency of water usage	
Irrigated landscaping	Plant species, number, and density of area of coverage	

Category	Information to be collected	Notes
Irrigation systems	Type of system (e.g., drip, spray)	• Information should be recorded for each zone within each irrigation system
	Location of system (plants irrigated)	
	Irrigation rate (liters per minute or hour)	
	Irrigation frequency (cycles per day or week)	
	Irrigation duration (minutes per cycle)	
	Irrigation time (time of day)	
	Seasonal variations in irrigation schedule	
Other outdoor end uses	For each type of usage, the rate, duration, and frequency of water usage	
Water storage tanks	Tank capacity (length, width, depth)	
	Evidence of overflowing or leakage	
	Tank cleaning frequency	