Sustainability "How-To Guide" Series

A Comprehensive Guide to Water Conservation: The Bottom Line Impacts, Challenges and Rewards

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FOREWORD

It is no secret that a focused, well-defined sustainability strategy is beneficial to an organization's bottom line, whether it is a federal, private-sector, military or nonprofit entity. Sustainable practices are not only the right thing to do for the environment; they also benefit the communities in which they are implemented. Sustainability is the business implementation of environmental responsibility.

Sustainability is all around us. Federal, state and local governments are increasingly applying regulatory constraints on design, construction and facility operations standards. Employees expect their employers to act responsibly, and vice versa. Going green is no longer a fad or a trend, but a course of action for individuals and businesses alike – benefiting the triple bottom line of people, planet and profit.

Today's facility manager needs to be able to clearly communicate the benefits and positive economic impact of sustainability and energy-efficient practices, not only to the public, but also to the C-suite. While there is a dramatic need for each of us – and our organizations – to care for the environment, it is just as important that we convey to executives and stakeholders how these initiatives can benefit our company's financial success.

The document in your hands is the result of a partnership between the IFMA Foundation and IFMA, through its Sustainability Committee, each working to fulfill the shared goal of furthering sustainability knowledge. Conducting research like this provides both IFMA and the foundation with great insight into what each can do as an organization to assist the facility management community at large.

It is my hope that you, as a facility professional, will join us in our mission of furthering sustainable practices. This resource is a good place to start.

Tony Keane, CAE
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FOREWORD

IFMA Sustainability Committee (ISC)

The IFMA Sustainability Committee (ISC) is charged with developing and implementing strategic and tactical sustainability initiatives. A current initiative involves working with the IFMA Foundation on the development of a series of "How-To Guides" that will help educate facility management professionals and others with similar interests in a wide variety of topics associated with sustainability and the built environment.

The general objectives of these "How-To Guides" are as follows:

1. To provide data associated with a wide range of subjects related to sustainability, energy savings and the built environment
2. To provide practical information associated with how to implement the steps being recommended
3. To present a business case and return-on-investment (ROI) analysis, wherever possible, justifying each green initiative being discussed
4. To provide information on how to sell management on the implementation of the sustainability technology under discussion
5. To provide case studies of successful examples of implementing each green initiative
6. To provide references and additional resources (e.g., Web sites, articles, glossary) where readers can go for additional information
7. To work with other associations for the purpose of sharing and promoting sustainability content

The guides are reviewed by an editorial board, an advisory board and, in most cases, by invited external reviewers. Once the guides are completed, they are distributed via the IFMA Foundation's Web site (www.ifmafoundation.org) free of charge.

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The mission of the IFMA Foundation is to promote and support scholarships, educational and research opportunities for the advancement of facility management worldwide.

Established in 1990 as a nonprofit, 501(c)(3) corporation, the IFMA Foundation is supported by the generosity of a community of individuals – IFMA members, chapters, councils, corporate sponsors and private contributors – and is proud to be an instrument of information and opportunities for the profession and its representatives.

A separate entity from IFMA, the IFMA Foundation receives no funding from annual membership dues to carry out its mission. Supported by the generosity of the FM community, the IFMA Foundation provides education, research and scholarships for the benefit of FM professionals and students. Foundation contributors share the belief that education and research improve the FM profession.

1 EXECUTIVE SUMMARY

'Expand knowledge of the built environment, in a changing world, through scholarships, education and research'

The Vision Statement of the IFMA Foundation

Green buildings have gone mainstream. Any facility manager who is not prepared will be faced with an outdated, inefficient and expensive building to operate. Most facility managers attempting to green their buildings place their initial focus on energy, and rightly so. Energy is expensive. Some solutions are easy to implement and they offer quick paybacks. However, as the population expands and water supplies decrease, the costs associated with providing potable water will increase, making the sustainable solutions that use water more efficiently just as financially viable as energy solutions. Additionally, water is vital on a global scale due to its necessity for survival, making it just as crucial as energy to the overall impact of a high-performance green building.

The importance of water is further bolstered by Executive Order 13514, signed by President Obama on October 5, 2009. In it, the president mandates that all Federal facilities must become more sustainable and, in doing so, lead the sustainability movement by example. Some of the mandates specifically associated with water conservation are:

- "reducing potable water consumption intensity by 2 percent annually through fiscal year 2020, or 26 percent by the end of fiscal year 2020, relative to a baseline of the agency's water consumption in fiscal year 2007, by implementing water management strategies including water-efficient and low-flow fixtures and efficient cooling towers;
- "reducing agency industrial, landscaping and agricultural water consumption by 2 percent annually or 20 percent by the end of fiscal year 2020 relative to a baseline of the agency's industrial, landscaping and agricultural water consumption in fiscal year 2010;
- "consistent with State law, identifying, promoting, and implementing water reuse strategies that reduce potable water consumption;
- "implementing and achieving the objectives … [related to] stormwater management …" (The White House 2009).

The Introduction of this paper attempts to provide a basic understanding of the current issues surrounding water use. In Part 3 Detailed Findings, several industry experts have contributed their knowledge and expertise of critical issues, benchmarking and evaluation, and reduction of water consumption. Part 4 Making the Business Case highlights the financial payoff of water conservation, and Part 5 Case Studies examines actual organizations that have implemented water conservation programs, as well as the results of their efforts.

Across the nation, building owners and operators are realizing the savings that are possible through implementing water conservation programs. From technological advances in fixtures to capturing rainwater for landscape irrigation, this guide describes a number of strategies that are making these savings possible. In fact, by combining these two strategies, an organization can save up to 43 percent of its current potable water usage, which directly impacts operations and maintenance budgets (Alliance for Sustainable Built Environments 2010).

2 INTRODUCTION

Water is a finite resource. It is not possible to produce more water than what already exists on Earth. Of all the Earth's water, less than 3 percent is fresh water, and only a small fraction of that is actually available to us for water supply needs. Water supplies are also impacted by pollution and climate change. The demand for water is ever increasing. Wise management of this most precious resource is essential if we are to continue to meet the water supply needs of growing populations and economies. Each of us has a role to play in managing this resource.

It is important that everyone become more conscious of efficient water use due to environmental impacts, as well as cost savings. Although water is highly undervalued in most of the United States in dollar terms, the cost will surely increase in the coming years, as it will cost more to extract, purify and pipe to the point of consumption.

Water can be categorized in many ways. For the purposes of this guide, the categories used are domestic, process and outdoor water use. In this guide, domestic water use will include all water used indoors for household or business purposes. A strict definition of domestic water frequently includes outdoor water use, but in this paper we address outdoor water use separately as it pertains to water usage outside the walls of a building. Process water use is also discussed in the third part, which includes water used for industrial processes and building systems, such as cooling towers, boilers and chillers (Building Green LLC 2010).

This guide is designed to review the basics of water use and disposal in commercial buildings. By learning about the fundamentals of water conservation, readers will hopefully be able to implement projects that will help lower water consumption and thus lower water bills, as well as sewer bills that are affected by the amount of discharge. In the process, the impact of water consumption on the world in which we live will be reduced.

3 DETAILED FINDINGS

3.1 Critical Issues

Water is essential for human life. Everyone uses it each day to drink, bathe, cook and clean. In the US, the trend in consumption has been a flat curve for both surface and groundwater consumption since the 1980s (U.S. Geological Survey 2010a). However, pollution of these same sources is constantly an invisible threat. It is necessary to be aware of point and nonpoint source pollution of water systems and what can be done to resolve these problems. Point source pollution can be traced back to the source, while nonpoint source pollution cannot be traced back to the source.

3.1.1 Regulating Water Efficiency

The need for economic growth coupled with the unsustainable use of water in many areas is leading to new regulations that affect water use. In the case of plumbing products, within the United States leading cities and states have already required installation of the most efficient products for new construction and major remodels. Some of these are shown in Table 1.

Table 1: Local water efficiency regulations affecting plumbing products

Location	New code or regulation	Effective date
Miami, Florida	Requires use of WaterSense high-efficiency toilets (HET), lavatory faucets, 1.5 gallons per minute (gpm) (0.095 liters per second (L/s)) kitchen faucets and 1.5 gpm (0.095 L/s) showerheads in new residential and commercial buildings.	January 2009
Los Angeles, California	Change to require HETs, high-efficiency urinals (HEU), 1.5 gpm (0.095 L/s) lavatory faucets, 2.0 gpm (0.13 L/s) showerheads. Urinals must be 0.13 gallons per flush (gpf) (0.49 liters per flush (Lpf)) or less in December 2010.	December 2009
San Francisco, California	Requires all new commercial and residential buildings to meet LEED requirements, including 20% water reduction in 2009 and 30% after 2011.	January 2009
Vancouver, BC	Requires HETs in new single- and two-family homes.	September 2008
California	Statewide adoption of CalGreen building code, which requires water-efficient plumbing in new construction. Plumbing requirements go into effect in July 2011.	July 2011
California and Texas	Requires plumbing fixture manufacturers to offer an increasing percentage of high-efficiency toilets and urinals. By 2014, 100% of toilets must be high-efficiency models.	January 2010 to January 2014
Georgia	State water conservation rules require use of high-efficiency plumbing statewide.	January 2012
International Association of Plumbing and Mechanical Officials (IAPMO) Green Supplement	Requires use of WaterSense toilets, bathroom faucets, showerheads and urinals. In addition, limits total water flow in shower enclosures to 2.0 gpm (0.13 L/s) per 1,800 in^2 (1.16 m^2) of shower floor area.	As adopted by local jurisdictions

Many more of these types of regulations are expected to be enacted in the coming years. Fortunately, plumbing manufacturers have responded with a range of products that meet these requirements without sacrificing performance. In many cases, users cannot tell that they are using a high-efficiency fixture or faucet. However, there is a physical limit to plumbing water efficiency. Sanitary systems need a minimum amount of water to transport solid waste from its source to the wastewater treatment plant. Non-solid waste systems may not have the same requirements. Further reducing the amount of water beyond what these regulations call for may degrade performance of sewer systems. At this time, it is unknown whether this will lead to either widespread or isolated problems.

3.2 Benchmarking and Evaluation

As water becomes scarcer throughout the world, benchmarking and evaluation of baseline water use is becoming a priority. The next few sections detail various performance tracking and benchmarking tools available to facility managers and provide some examples of measures to help conserve water.

A logical place to start is to understand how water is being used. Simply put, water is provided by the utility company or on-site equipment and exits via sanitary sewer systems. Everything in between dictates a building's water efficiency. Within the building and its grounds, water is used for irrigation, domestic (plumbing, drinking, showering) and process applications (HVAC systems and other building systems). The United States Department of Energy states that the two biggest consumers of water in a typical office building are domestic uses (41 percent) and cooling and heating (27 percent). Other water uses include kitchen functions (1 percent), irrigation (20 percent) and once-through cooling (2 percent), with the remainder being used for miscellaneous purposes (U.S. Department of Energy 2009) (Figure 1). Once-through cooling is a process in which cooling water is used only once, but relatively few buildings use this design due to its high water use.

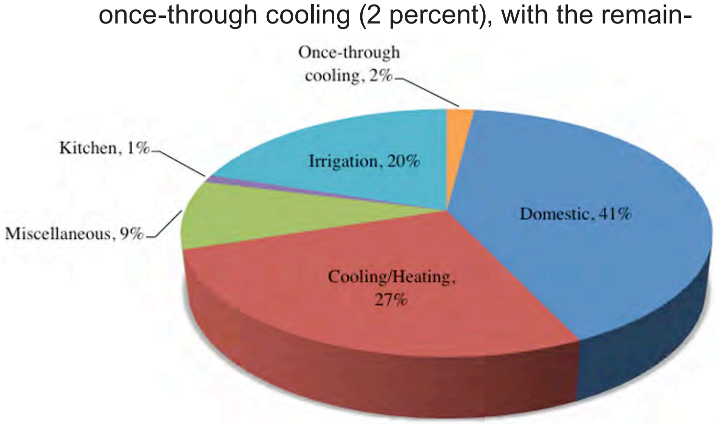

Figure 1: Typical office building water distribution according to the U.S. Department of Energy (2009)

To accurately track and benchmark building water consumption, it is important to consider to what extent a building's water use is metered. Most commercial buildings receiving domestic water from a utility company will have a main meter used for billing purposes. The meter is typically read by the utility company and summarized in monthly utility bills. This meter provides usage information for the entire building and can provide useful information when it comes to tracking a building's overall performance regarding water use. Some buildings may also have separate meters for irrigation and fire system water. If more specific information is needed, sub-metering can be used to track water use of specific areas of a building known to have a high concentration of water consumption. Examples of potential sub-meter locations include irrigation systems, cooling tower make-up systems, plumbing fixtures and fittings, domestic hot water systems, cafeterias, laundry facilities and other process water systems.

The meter information needs to be recorded to provide data that can show trends and provide base information for benchmarking (to be discussed later). Recording meter information is a relatively easy process that can be accomplished through a simple software spreadsheet program, such as Microsoft Excel. The meter reading should occur on a regular basis (weekly or monthly) and be recorded along with the meter location, billing month, consumption and cost. Table 2 is an example of a tabularized record of water consumption on a monthly basis.

Table 2: Example tracking spreadsheet

Main Meter				
Start Date	End Date	Gallons	Liters	Cost
6/30/2009	7/30/2009	414,392	1,566,402	$3,592.78
6/1/2009	6/29/2009	382,228	1,444,822	$3,329.21
4/30/2009	5/31/2009	522,104	1,973,553	$4,484.87
3/31/2009	4/29/2009	454,784	1,719,084	$4,111.25
3/2/2009	3/30/2009	412,148	1,557,919	$3,729.94
1/30/2009	3/1/2009	562,496	2,126,235	$5,068.09
12/31/2008	1/29/2009	388,212	1,467,441	$3,517.20
11/28/2008	12/30/2008	388,212	1,467,441	$3,521.08

Once 12 months of data have been accumulated, it is possible to benchmark a building against other similar buildings to understand how a building stacks up against others. Programs for tracking and benchmarking are available online and include ENERGY STAR Portfolio Manager, the Water Use Baseline Calculator and Watergy 3.0.

3.2.1 ENERGY STAR Portfolio Manager

ENERGY STAR Portfolio Manager is an online tool developed by the United States Environmental Protection Agency. Although it predominately is used for benchmarking energy use in buildings, it also has the capability to track a building's water use. Portfolio Manager allows data from multiple water meters to be input as either indoor, outdoor or sewer use (Roskoski et al 2009). Figure 2 is an example taken from Portfolio Manager's water use section.

Download Meter Data in Excel

Edit Water Use:	Add Meter Entries				
Remove Entry	Start Date (MM/DD/YYYY)	End Date (MM/DD/YYYY)	Water Use (Gallons)	Cost - US Dollars (optional)	Last Updated By
☐	08/01/2008	08/31/2008	1446000.00	$ 6307.62	
☐	07/01/2008	07/31/2008	511000.00	$ 2100.21	
☐	06/01/2008	06/30/2008	478000.00	$ 1964.58	

Figure 2: An example of meter entries in Portfolio Manager (U.S. Department of Energy 2009)

Portfolio Manager requires billing dates and water use (in gallons) as presented in Figure 2, and also has the option to include costs. It is important to note that Portfolio Manager does not compare a building's water consumption with other buildings' water consumption, but rather it provides a means of tracking water consumption.

3.2.2 USGBC Water Use Baseline Calculator

Another way to track a building's water use is with the United States Green Building Council's (USGBC) Water Use Baseline Calculator (Figure 3). This method is limited to plumbing fixtures in buildings and buildings that have sub-metered use of graywater reuse. The calculator uses code compliant plumbing fixture flow rates coupled with building occupancy to determine the estimated baseline for a building. The baseline incorporates use factors of 120 percent or 160 percent depending on the building construction date. If the building was constructed prior to 1993, a factor of 160 percent is used. For construction dates of 1993 and later, a factor of 120 percent is used. These factors compensate for the more stringent water regulations required by the Energy Policy Act of 1992, which reduced the allowable flow rates of plumbing fixtures. Following the baseline calculation, specific benchmarking information about fixture efficiency of the building is put into the calculator to determine how well or poorly it is performing. The results are given in a percentage below the baseline (U.S. Green Building Council 2008).

Table 1. Water Use Baseline - LEED-EB: O&M

Fixture	Daily Uses	Flowrate (gpf)	Duration (Flush)	Occupants	Water Use (gal)
WC (Male)	1	1.6	1	304	486
WC (Female)	3	1.6	1	304	1459
Urinal	2	1.0	1	304	608
Fixture	Daily Uses	Flowrate (gpm)	Duration (sec)	Occupants	Water Use (gal)
Lavatory	3	2.2	15	608	1003
Kitchen Sink	1	2.2	15	608	334
Shower	0.1	2.5	300	608	760
				Total Daily Volume (gal)	4,651
				Annual Work Days	260
				Total Annual Volume (gal)	1,209,312
				Multiply by 120%	1.2
				Calculated Water Use Baseline (gal)	**1,451,174**

Table 2. Sample Building Estimated Water Use

Fixture	Daily Uses	Flowrate (gpf)	Duration (Flush)	Occupants	Water Use (gal)
WC (Male)	1	1.6	1	304	486
WC (Female)	3	1.6	1	304	1459
Urinal	2	1.0	1	304	608
Fixture	Daily Uses	Flowrate (gpm)	Duration (sec)	Occupants	Water Use (gal)
Lavatory	3	0.5	15	608	228
Kitchen Sink	1	2.0	15	608	304
Shower	0.1	2.5	300	608	760
				Total Daily Volume (gal)	3,846
				Annual Work Days	260
				Total Estimated Annual Volume (gal)	**999,856**
				Total Estimated Annual Volume (ccf)	**133,662**

Water Use Summary		
Total Annual Fixture Volume	999,856	Gallons
Total Annual Graywater Fixture Volume	0	Gallons
Total Annual Potable Fixture Volume	999,856	Gallons
Calculated Water Use Baseline	1,451,174	Gallons
LEED Metrics		
Building Floor Area	151,744	SF
Number of Building Occupants	608	FTE
Total Water Used per Occupant	1644.5	Gal/Occ
Total Water Used per Square Foot	6.59	Gal/SF
LEED Credits		
WE Credit 2.1, 10% Reduction*	1,306,057	Gallons
WE Credit 2.2, 20% Reduction**	1,160,940	Gallons
WE Credit 2.3, 30% Reduction	1,015,822	Gallons

** Obtainable by calculation only, or by metering fixture flow.*
*** Obtainable only by metering fixture flow.*

WE Prerequisite 1 - Achieved
31.1% Percent below baseline based on calculations (Table 2)

Figure 3: Water use baseline calculator (U.S. Green Building Council 2008)

3.2.3 Watergy 3.0

The third method is less of a benchmarking tool and more of an analysis of potential conservation projects. Watergy 3.0, a program developed by the United States Department of Energy, is a spreadsheet (Figure 4) that determines the potential for savings using the correlation between water and energy (U.S. Department of Energy 2009). The program requires specific plumbing information to be entered into the calculator. This information includes quantities of water closets, urinals, lavatories and so on, as well as their respective flow rates. It allows for specific inputs to be modified, such as replacement costs for fixtures that are used to calculate payback periods. Figure 4 is a chart showing the output of Watergy 3.0.

The Watergy 3.0 calculator provides a summary of plumbing fixtures and potential conservation methods. For each conservation method, Watergy 3.0 generates an estimate of initial cost and potential annual savings and payback period. The project costs are calculated by user-defined inputs, so if a facility manager has contractor quotes or utilizes a cost estimating resource, such as RS Means, they are able to develop fairly accurate estimates of cost.

Potential Conservation Opportunities

Conservation Method	Number of Installations	Total Initial Cost ($)	Annual Savings ($)			Payback Period* (yrs) *Includes Direct Energy Only
			Direct Water	Direct Energy	Indirect Energy	
Installation of ULF toilets and WATERLESS urinals	13	$4,825	$1,396	-$2	$18	3.46
Installation of automatic faucets	10	$3,300	$388	$6,435	$24	0.48
Installation of faucet aerators	3	$39	$42	$689	$3	0.05
Low Flow showerhead	1	$31	$36	$101	$3	0.23
Boiler blowdown optimization	1	$0	$26	$7,211	$22	0.00
Efficient dishwashers	1	$0	$0	$0	$0	#N/A
Efficient washing machines	0	$0	$0	$0	$0	#N/A
Landscape irrigation optimization	#N/A	$12	$23	$0	$0	Annual
Total (excluding Landscape)		$8,195	$1,888	$14,435	$70	0.50

Figure 4: Sample output of Watergy 3.0 (deMonsabert and Liner 1996)

3.3 Reducing Water Consumption

Water use in commercial buildings can be classified as domestic, process and outdoor. Domestic water use includes water used in kitchens, break rooms, restrooms, water fountains, janitorial functions and laundry facilities. Process water includes water for cooling towers, part of the cooling

Table 3: Water use of plumbing fixtures and faucets

Fixture/faucet type	EPAct 92 standard	EPA WaterSense specification
Toilets (tank-type)	1.6 gallons per flush (gpf) (6.0 liters per flush (Lpf))	1.28 gpf (4.8 Lpf) or less
Toilets (flushometer-type)	1.6 gpf (6.0 Lpf)	1.28 gpf (4.8 Lpf) or less (not part of WaterSense)
Urinals	1.0 gpf (3.8 Lpf)	0.5 gpf (1.9 Lpf) or less
Non-water urinals	n/a	n/a (not part of WaterSense)
Showerheads	2.5 gallons per minute (gpm) (0.16 liters per second (L/s)) at 80 psi	2.0 gpm (7.6 Lpf) (0.13 L/s)
Lavatory faucets, private use	2.2 gpm (0.14 L/s) at 60 psi	1.5 gpm (0.09 L/s)
Lavatory faucets, public use	0.5 gpm (1.9 Lpm)	0.5 gpm (0.03 L/s)
Metering faucets	0.25 gallons per cycle (gpc) (0.95 liters per cycle (Lpc))	0.25 gpc (0.95 Lpc)
Kitchen faucets	2.2 gpm (0.14 L/s)	2.2 gpm (0.14 L/s)

system in many commercial buildings. Outdoor water use includes landscape irrigation. In addition, storm water must be managed, which can be accomplished by reducing runoff from the building site, with rainwater catchment systems and vegetative roofs. Each of these applications is discussed in further detail in the following subsections.

3.4 Reducing Domestic Water Use

Domestic water use is indoor water use for a variety of purposes. This includes water used in kitchens and bathrooms, and water used in drinking fountains. Improving the efficiency of fixtures and educating consumers on methods of conservation are important for water savings in this area. Table 3 summarizes fixtures and faucet types and volume of water use under the EPAct 92 Standard and EPA WaterSense Specification.

National water efficiency standards as defined by the Energy Policy Act of 1992 (EPAct 92) went into effect in January 1994. Since then, it has been illegal to sell plumbing fixtures or faucets that do not meet this standard. At first, plumbing products, especially tank-type toilets, did not perform well. However, engineering advances have been made to improve plumbing fixture performance while at the same time reducing water use. New models improve water efficiency and, sometimes, energy efficiency by 20 percent or more. The initial cost of the new higher efficiency models is in the same range as the better quality older models. Choice of plumbing fixtures for new structures should be driven not by the minimum standards, but rather by the life cycle cost for the building operator.

In 2006, the U.S. Environmental Protection Agency (EPA) created WaterSense, a voluntary product labeling program for water-efficient products. To carry this label, a product must be certified by a third-party test facility to meet the applicable specification. In general, WaterSense products use at least 20 percent less water than comparable products. In addition, the program incorporates performance tests to insure that the products will consistently meet the users' needs. As of early 2010, the EPA has developed WaterSense specifications for high-efficiency toilets (HETs), private-use lavatory ("bathroom") faucets, urinals and showerheads. In addition, the program has requirements for irrigation system designers and for new homes. Plumbing products carrying the WaterSense label are widely available from most manufacturers and at both wholesale and retail outlets.

In addition to fixtures that are more water efficient, non-potable water supplies are now being used to flush toilets. These water supplies include treated reclaimed or recycled municipal wastewater, captured rainwater, and graywater collected from lavatories, showers and laundries. Codes and standards are being developed to allow more widespread use of non-potable water.

3.4.1 Kitchens/Kitchenettes/Break Rooms

Many office buildings today provide kitchen and break room spaces (Figure 5). These spaces include water-consuming appliances. These appliances vary in the amount of water they require and include sinks, ice makers and dishwashers.

Figure 5: Typical break room sink

> **To conserve water, please completely turn off faucet**

Typically, for kitchenette faucets and aerators, a flow rate of 2.2 gpm (0.14 L/s) is used. It is not always warmly accepted to reduce the flow rate below 2.2 gpm (0.14 L/s) because of the periodic need to hand-wash dishes and other activities requiring a more generous flow rate. To conserve water where reducing the flow rate is not an option, employee education and signage regarding simple conservation techniques can be helpful in alerting employees of a company's desire to reduce water consumption. These simple conservation techniques include ensuring that faucets are completely turned off after use and avoiding continuously running water during hand-washing of dishes.

Freestanding ice makers are found in some office break rooms. ENERGY STAR rates and endorses some models for their superior efficiency. ENERGY STAR evaluates ice makers on four criteria: equipment type, harvest rate (lbs ice/day or kg ice/day), energy use limit (kWh/100 lbs or kWh/45 kg ice) and potable water use limit (gal/100 lbs or L/45 kg ice) (U.S. Environmental Protection Agency 2009).

Water conservation can occur by using mechanical dishwashers. According to ENERGY STAR, a dishwasher built before 1994 uses eight more gallons (30.3 liters) than a newer ENERGY STAR rated unit (U.S. Environmental Protection Agency 2009). Assuming a load is run twice a week each week for an entire year, that would amount to 832 gallons (3,149 liters) of water conserved per year.

3.4.2 Restrooms

Restrooms are a necessity in any facility, but they often account for a significant portion of the water used in most commercial, industrial and institutional buildings. There are many solutions available for reducing water consumption in commercial restrooms. Within restrooms, commonly found fixtures include toilets, urinals, showers and baths.

In the early 1990s, 1.6 gallon per flush toilets (6.0 liters) represented nearly a 50 percent reduction of water use from prior models. Unfortunately, such a drastic reduction meant that water-efficient toilets often failed to remove the waste with a single flush. Since then, manufacturers have redesigned the shape of the bowl, the flow path of water through the rim and jet of the toilet, the diameter and glazing of the trapway, and the water volume used to achieve effective performance. Independent tests, such as Veritec's Maximum Performance (MaP) bulk waste removal test, are now routinely performed on most models with results widely available online. While MaP testing only addresses one aspect of toilet performance, manufacturers have responded aggressively with new product innovations that improve all aspects of performance.

A toilet flush can be actuated by manual mechanical levers, push buttons or electronic sensors. New hands-free sensors eliminate the need for human contact with the valve and are much less susceptible to false flushing (Figure 6). Many choices of dual-flush toilets are also available

Figure 6: Flushometer toilet

for commercial and residential uses. Dual flush toilets allow the user to select from two different flush volumes depending on the amount of waste in the bowl. For the purposes of most green building and water efficiency programs, the "effective" flush volume is generally calculated as the weighted average of two "short" flushes and one "full" flush. However, the effective flush volume is only an approximation of actual water use, since actual water consumption depends on the user's selection.

EPA's WaterSense program only applies to tank-type toilets with effective flush volumes of 1.28 gallons (4.8 liters) or less. Flushometer-type toilets used in many commercial settings are yet to be addressed by WaterSense. However many manufacturers make flushometer valves and bowls designed to perform well using 1.28 gallons (4.8 liters). It is not recommended to use a 1.28 gallon (4.8 liters) flushometer on a bowl designed to flush at 1.6 gallons (6.0 liters) because bowls are engineered for optimal performance at their designed flush volume. Just reducing flush volume of old fixtures often leads to incomplete flushes and dissatisfied users. Consult with the fixture manufacturer before making any such changes.

Urinals are designed to remove liquid waste only (Figure 7). There are several types suited for commercial applications including flushing urinals and non-water urinals. Flushing urinals are flushed after each use, either manually by the user or by automatic actuator. Many sizes and shapes are available to accommodate various restroom designs and Americans with Disabilities Act (ADA)

Figure 7: Waterless urinal

requirements. Another option is wall-mounted troughs for simultaneous multiple-person use. They are often seen in high-use applications, such as sports venues; are flushed continuously during the high-use period; and are controlled with a valve and timer – not by the user. Wall-mounted troughs may not be allowed by certain plumbing codes, and can result in significant overuse of water. Finally, wall-mounted non-water urinals for single-person use that require neither flushing nor water supply plumbing are available. Proper maintenance of non-water urinals is essential for long-term performance. Although this technology is nearly 20 years old, its use is now gaining momentum.

As of this guide's publication, only flushing urinals are covered by EPA's WaterSense program. Urinals that flush 0.5 gallons (1.9 liters) or less and meet other criteria are eligible. Currently, many manufacturers offer 0.5 gpf (1.9 Lpf) urinals, and several offer 0.13 gpf (0.5 Lpf) flushing urinals. Non-water urinals offer the largest water and sewer savings.

Both baths and showers are used for personal hygiene. Conventional bathtubs have a water capacity of 40 to 50 gallons (151 to 189 liters). The hospitality sector touts the relaxation and luxury of infinity and whirlpool baths (approximately 90 gallons [340 liters] per fill). Medical facilities and nursing homes may have tubs with a lift to lower patients into the water. Normally this water is used once and then discharged. Generally, bathtubs do not offer significant opportunities for water savings.

Showerheads are available with a variety of spray patterns, water-droplet sizes and aesthetics. Proper mixing valves that are rated for the design flow of the showerhead should be installed in showers to prevent scalding hazards. Both water and energy savings are achievable by using showerheads certified to carry the WaterSense label. These showerheads will use no more than 2.0 gpm (0.13 L/s), or 20 percent less water than a standard showerhead. They also must meet spray pattern and force requirements established in the standard. Safety and emergency showers are not required to meet flow restrictions.

Both shower and bathtub water are used once and typically discharged to sanitary wastewater, but may be collected and reused for landscape irrigation if graywater use is allowed by local codes.

3.4.3 Improving Performance of Hot Water Systems and Hot Water Conservation

Consumers expect that water will be delivered safely, reliably and conveniently. However, how often do people go into a restroom, turn on the tap and do not receive hot water by the time they are done washing their hands? This section will help facility managers evaluate the performance of hot water systems.

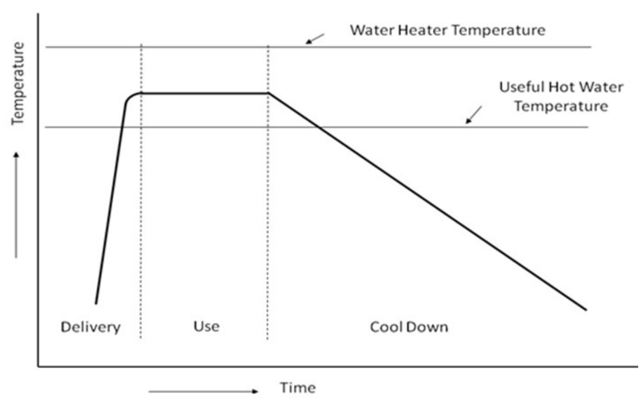

Figure 8: Typical hot water event

Figure 8 shows a typical hot water event. There is a delivery phase, a use phase and a cool down phase. People would like the delivery phase to be short. Most want hot water to arrive immediately after they open the tap; this is possible, but rather expensive. How long does it take for hot water to arrive at the fixtures in a given facility? Anything longer than 10 seconds is considered too long by the American Association of Plumbing Engineers. According to interviews of more than 20,000 people over a period of 10 years conducted by Gary Klein, one of the authors of this paper, well over 90 percent of the people interviewed say they want the time-to-tap to be between two and three seconds. This level of performance is achievable at a reasonable cost.

The use phase is consumption – washing dishes or taking a shower, for example. The simultaneity of the uses and their location within the hot water distribution system determines the size of the water heater and the diameter of the piping, respectively.

When the tap is turned off, the temperature of the water in the pipe starts to cool down, all the way from the water heater to the hot water outlet. It takes about 10 to 15 minutes for the water in uninsulated ½ to ¾ inch (1.2 to 1.9 cm) nominal pipes to cool down from about 120°F (49°C) to 105°F (41°C) when the pipes are located in air temperature between 65°F (18°C) and 70°F (21°C), which is typical for most buildings (Hiller 2005). The water cools down more quickly when the surrounding temperature is colder, such as in a basement, crawl space or outside, or when the pipes are located under or in a concrete slab. The water cools down more slowly when the pipes are in a hot attic in mid-summer or when they are insulated.

The water heater (or boiler) temperature must be high enough to overcome the heat losses in the plumbing from the water heater (or boiler) to the furthest fixture. The resulting temperature can be called the mix-point temperature. The useful hot water temperature needs to be less than the mix-point temperature because there should be some headroom from the mixing point down to the useful hot water temperature point. This is due to variations in desired temperature for any given application on any given day.

It is important to note that standard tankless gas water heaters should not be used if it is a priority to save water discharge, as this type of heater takes about 10 to 30 seconds to get up to temperature, and during this time water runs down the drain. Also, they do not work well with low flow rate faucets and some showerheads.

The ideal hot water distribution system would minimize the time-to-tap, and by doing so, the volume-until-hot. To do this, the system would have the smallest volume of water in the pipe from the source of hot water to the fixture. Sometimes the source of hot water is a water heater; sometimes it is a trunk line. In the ideal hot water distribution system, all the hot water outlets would be close to the water heater that serves them, and there may be more than one water heater per building. For a given piping layout, the system will have the shortest (and smallest volume) buildable trunk line, few or no branches, and the fewest plumbing restrictions.

Most facility managers have not measured the volume or pattern of hot water use for the facility. Without this information, how is it possible to properly size the water heater or the piping? An important clue is that the tables used by plumbing engineers to size hot water systems were developed more than 40 years ago. Flow rates and fill volumes have changed substantially since then. What is worse is that lower flow rate devices are being installed for designs with higher flow rates. This has increased the time-to-tap in the delivery phase and the temperature drop and energy loss during the use phase.

There are two options worth considering that overcome the mismatch between low flow rate fixtures and large diameter plumbing for retrofits in existing buildings. One is to install water heaters very close to the points of use, sized according to the demand at each location. The other is to install on-demand pumps in these same locations to “prime” the branch line with hot water when activated by a user. The pumps can be installed under or behind a sink in the access space. A motion sensor can be used to activate the pump when someone walks into the room.

In new construction, one should plan the plumbing to deliver hot water within a certain amount of time or volume. Time should be about three seconds and volume should be less than 2 cups.

Insulation makes a significant difference in reducing the time-to-tap when the time between hot water events on the same branch or trunk is between 10 and 60 minutes. Insulation, however, may be difficult to retrofit unless there is good access to the hot water piping. In new construction or major renovation, the hot water distribution piping should always be insulated. A good pipe insulation strategy is to aim for equal heat loss per unit length. One simple way to achieve this is to install pipe insulation in which the wall thickness of the pipe insulation is equal to the nominal pipe diameter. At a minimum, this should be done for all pipes larger than ¼ inch (0.6 cm) and up to and including 2 inch (5 cm). Beyond 2 inch (5 cm) pipe, insulation should be installed with at least a 2 inch (5 cm) wall thickness.

Examining the hot water system and evaluating its effectiveness is important when looking at water use and energy use related to water. The structural aspects of the hot water distribution system must be assessed by looking at the interactions among the components, water heaters, piping, fixtures and appliances, to encourage behaviors that are water, energy, time and cost efficient.

3.4.4 Water Fountains

Decorative water fountains can provide an aesthetically pleasing ambiance. They are used everywhere from local malls to the most luxurious hotels on the Las Vegas strip. Although water for the fountains is recirculated, there is still a need for make-up water to compensate for evaporation and spillover.

For outdoor water fountains, the effects of evaporation can be reduced by minimizing operation of the fountain during peak times of the day when the sun is at its highest. Spillover can be minimized by having a fountain with high walls or a large pool area in which the fountain spills into after it is rocketed into the air. Common at many theme parks, certain types of fountains “spill” water onto a slightly sloped surface level with the pedestrian pathways. Ensuring that the slope is maintained properly and not allowed to degrade will help prevent an excessive amount of spillover and conserve water.

In addition to being well-designed, existing water fountains need to be well-maintained. Maintenance items include pump maintenance to ensure proper water levels are being provided. Also, cleaning should occur to minimize or eliminate algae buildup and the formation of calcium deposits that can clog the fountain’s drains and jets.

Regardless of which type of water fountain is present, a facility can conserve water by having one that is well-maintained and well-designed.

3.4.5 Water Reclamation

There are three main types of water designations: white, black and gray. As shown in Table 4, white water refers to potable water and is safe for human consumption. Blackwater is not potable and contains (or may contain) human waste, such as toilet water. The last, graywater, is not potable and not safe to drink, but can be reclaimed for other uses. Examples of graywater include water from sinks or laundry, or captured rainwater.

Table 4: Water type definitions

Water-type definitions	
White	Water that is potable and is safe for consumption.
Gray	Water that is not potable but can be reclaimed for uses other than consumption.
Black	Water that contains (or may contain) human waste and is unsafe for human consumption.

Water reclamation systems may collect and reuse water collected from rainwater, laundering, dishwashing and bathing. This reclaimed water is able to be used in applications such as toilets and urinals and also lends itself to irrigation applications. However, long-term effects of reclaimed water residues in toilets and urinals have not yet been established.

Graywater reuse is not as simple as collecting water in a cistern and redistributing it elsewhere. A water reclamation system requires engineering studies and designs from experienced engineers with knowledge of applicable building codes and standards. The International Plumbing Code (IPC), for example, has specific guidelines that must be adhered to when designing and installing a water reclamation system. For use in irrigation, collected water must first be filtered and stored in either a reservoir or cistern. For use in toilets and urinals, the codes go a bit farther and require that the collection reservoir be at least two times larger than the daily flushing needs with a potable water supply connection for graywater make-up. The IPC also requires the graywater be disinfected and dyed blue or green before the effluent is distributed to the restroom fixtures so that it can be differentiated from potable water (International Code Council 2006).

When considering adopting water reclamation technologies, it is important to check with the respective municipality to determine the legality of installing a graywater system. Some jurisdictions consider graywater to be unsafe for reuse and do not allow for its use in any way since they do not differentiate between blackwater and graywater.

3.5 Domestic Water Use: Janitorial

Water is commonly used for janitorial purposes. This section includes guidance and tips about training staff to recognize and report leaks, proper maintenance procedures for janitor mop and maintenance sinks, and leak prevention. The section concludes with a brief discussion of nontoxic cleaners.

3.5.1 Training Staff to Report Leaks and Incursions

Nearly every occupied building has some type of potable or non-potable water infrastructure that serves restrooms, cafeterias, fire protection and building cooling systems. This does not include mechanical infrastructures, such as chilled and hot water loops, which can also create water hazards. Water leaks and associated damage can create significant challenges for the facility manager. Small drips can quickly escalate to downtime due to cleanup and restoration activities.

To minimize the extent of water damage due to leaks, training staff to identify and report potential and active water leaks can become instrumental. Training should include instructions to describe different situations and how to share details with emergency response personnel, depending on the severity of the situation. Initiating an effective escalation process is a key component in mitigating water leaks. An appropriate course of action needs to be identified and taught to staff to minimize damage. This process should include placing a drip pan, appropriate absorbent materials or barricades to restrict or limit access to the area for anything from small leaks to situations where the equipment or systems are at risk and immediate high-level actions are required. These actions may include immediate water line isolation, fixture closures or closing off the area to building occupants. In extreme cases, evacuation may be required.

A facility's in-house team is usually the first line of defense, beginning with the work or service request coordinator who receives the call. Although facilities personnel are usually trained in reporting building service and repair needs, the best policy is to review routine and emergency response procedures on a regular basis.

One of the largest workforces a facility uses to support its building service needs is custodial resources. These resources provide a wealth of knowledge and insight important to a facility's organization. These individuals are usually very familiar with the building and building occupants, making them valuable allies in assisting an organization in providing quality service performance. Share water leak reporting procedures with all staff and supervisors.

Secondary to custodial staff, use of contract facility personnel is beneficial in reporting water leaks. Most organizations have a crew of contract personnel supporting construction, maintenance or replacement activities. Emergency response teams and security personnel are usually on site 24 hours a day. Conduct periodic training sessions to reiterate reporting procedures, assessing and describing the extent of the leak, and emergency protocols in the event of a catastrophic leak.

Finally, train and educate building occupants. Unless the leak is located in an isolated rooftop mechanical room, building occupants provide an enormous resource to report water leaks. Conduct brown bag informative sessions; place reporting procedures and contact information on the building's Web site; and place posters or informative table tents in common areas.

3.5.2 Janitor Mop and Maintenance Sinks

Considered as eyesores to some, janitorial closets and maintenance sinks are as crucial to maintaining a facility as the central plant or electrical vault. Just like everything else, the rooms that house janitorial paper products and cleaning equipment and supplies require maintenance. Since the majority of janitorial closets house some type of sink or mop station, potential for water leaks is common. Train custodial and maintenance staff to report faucet and valve leaks; defective seals and gaskets; backflow preventers; plugged strainers; and damaged tubs, sinks and basins. It is advantageous for organizations to initiate the same water leak reporting and response procedures they have for the rest of the building within the janitorial closet to minimize damage, hazards and downtime.

3.5.3 Precautionary Activities

Exercising precautionary activities related to water distribution infrastructure repairs, replacement or maintenance can mitigate water leaks. Practices such as conducting pre-maintenance, repair or replacement reviews and inspections can determine the course of action in the event of an unintentional water leak. Identifying and locating water distribution shut-off valves, placing emergency response equipment locally and developing backup plans are all appropriate preventative measures (Beaverton School District 2009).

3.5.4 Using Nontoxic Cleaners

Since the introduction of green cleaning practices and the introduction of Green Seal certification of cleaning supplies, innovative cleaning solutions have minimized, and in some cases eliminated, the use of toxic cleaners. There are many cleaning solution remedies, from baking soda and lemon juice to mixtures of vinegar and water. These alternative, nonabrasive cleaning and cleanser solutions have prevented premature fixture finish and surface damage, and sustained the aesthetics of associated devices, fixtures and components (Green Seal n.d.).

3.6 Domestic Water Use: Laundry Facilities

Another area of intense water use is laundering facilities, particularly in hotels, hospitals and prisons. A commercial facility washing 44 short tons (39,916 kg) of laundry per week consumes about 10,600 kgal (40,125 kL) of water per year (Brown 2009). These figures underscore the importance of implementing water conservation measures or best practices at laundering facilities. To help conserve water and energy, high-efficiency laundry appliances are rated by the EPA's ENERGY STAR program. Appliances that qualify are easily recognizable by the ENERGY STAR logo.

Purchasing a commercial washing machine with the ENERGY STAR label can deliver up to 50 percent savings in water and energy (U.S. Environmental Protection Agency 2009). For smaller machines, the choice of washing machine configuration can impact water use. Some front-loading machines can be 40 to 70 percent more efficient than top-loading machines (Noble-Goodman 2001).

Aside from purchasing new equipment, there are other measures that can help reduce water consumption with minimal capital investment. One is simply educating the employees about proper sorting, machine loading and laundering techniques. Proper machine loading is important because an underfilled or overfilled machine is either wasting water (underfilled) or not cleaning effectively (overfilled). Another strategy is to monitor and record water use. This provides justification of operational changes and allows a facility manager to judge the effectiveness and savings of those operational changes (Brown 2009). These areas may be a good place to incorporate a water sub-meter.

In the hospitality industry, it is becoming more common for delaying laundering of towels and sheets until requested by the guest. Hotels have issued cards that can be displayed on the bed when a guest desires his or her sheets to be cleaned. Additionally, they have instituted practices where guests are told that the cleaning staff will launder a towel left on the bathroom floor but leave a hanging towel for another use.

3.7 Process Water: Cooling Towers

Central plants with chillers usually have cooling towers associated with the cooling process (Figure 9). Thought of as large evaporative coolers, cooling towers are critical to a site's cooling infrastructure and require regular maintenance and inspections. Other associated components such as fans, fan motors, sand filters, valves, media, drift eliminators and automatic water levelers require regular maintenance as well. The system also requires an external power source as well as access to water. Water is one of the primary components that supports the cooling cycle for an effective heat exchange process, which is considered one of the most economical ways to operate large industrial cooling processes. The water must be monitored and treated to minimize the amount of suspended solids or minerals that are part of the cooling process.

Figure 9: Cooling tower

"The water that is drained from cooling equipment to remove mineral build-up is called "blow-down" water or "bleed" water. The cooling equipment that requires blow-down is most often: cooling towers, evaporative condensers, evaporative coolers, evaporative cooled air-conditioners, and central boilers (both steam and hot water). These cooling systems rely on water evaporation to garner the cooling effect (latent heat of evaporation). As the water evaporates, the mineral content (calcium carbonate, magnesium, sodium, salts, etc.) of the remaining water increases in concentration of minerals. If left undiluted, these minerals will cause scaling on equipment surfaces; possibly damaging the system. The blow-down water is usually dumped into the wastewater drain, yet in some cases, this water can be reused for irrigation and other selected uses" (Alliance for Water Efficiency 2009).

The blow-down water can also be recycled through a filtration system, commonly known as a reverse osmosis process. This water can then be reintroduced into the tower as make-up water, reducing the volume of municipal water needed.

3.7.1 Cooling Tower Water Quality

Since cooling tower water is cycled through the cooling process several times, this water is subject to accumulate as much as five times more minerals and suspended solids than "fresh" potable water supplied by the local water provider. The concentration of these minerals is measured as total dissolved solids (TDS). Research has shown that "most potable water in the US has a TDS level of at least 100 to 350 parts per million (ppm), though some … can be as high as 500 ppm" (Alliance for Water Efficiency 2009). Depending on the supply water and the cooling system operation, the blow-down water TDS can range from 500 to 1,300 ppm (Alliance for Water Efficiency 2009). Concentrations this high should be treated before the water damages the equipment.

3.7.2 Alternate Uses for Cooling Tower Water

Be careful when reusing blow-down water due to the high TDS levels. When sufficiently diluted with other types of water, such as potable water or harvested rainwater, it can be used in more situations. Using blow-down water for irrigation systems or vegetation, in general, is usually inadvisable. Since there are high concentrations of dissolved solids, this type of water can be harmful to plants and may also affect the irrigation system.

The most common use of blow-down water is to filter it and reintroduce it into the cooling process. In addition, by using blow-down water in this way, a building is eligible for a credit in the Leadership in Energy and Environmental Design Existing Building – Operations and Maintenance (LEED EBOM) certification process. The LEED EBOM certification program, through the US Green Building Council, awards points for building features that improve energy usage and reduce the environmental impact of existing buildings. Recycling of cooling tower blow-down can help earn LEED points from reduced water use, innovative waste water technology and lessened environmental impact as a result of the reduction of the discharge of toxic chemicals.

3.7.3 Cooling Tower Reclamation Systems

Reclamation systems remove suspended solids from the blow-down water, making it suitable for reuse. This process can also remove water treatment chemicals, reducing the impact to the sanitary sewer system, as well as minimizing the use of additional chemicals to treat make-up water. Some reclamation systems have been known to remove nearly 85 percent of total dissolved solids, 95 percent of the hardness, 98 percent of dissolved organics and 65 percent of the salts (Wastewater Resources Inc. 2007). Once the cycle has been completed, this water can now be an alternate water source for the cooling tower. Most recovery rates range from 60 to 80 percent (Wastewater Resources Inc. 2007). Although this technology is nearly 15 years old, its use is gaining momentum. Facilities that have used these systems have been able to save millions of gallons of water annually, reduce the volume of water treatment chemicals used, extend equipment life cycles and be environmentally conscious.

3.8 Outdoor Water Use: Landscaping

When looking at places to conserve water, one must look outdoors as well. Start with a review of the landscaping. After accounting for the plants on the grounds, informed decisions can be made about which plants to replace, move or let be. Considering that landscaping can use up to 50 percent of total potable water consumption in a facility, it would be foolish to ignore this part of a facility's consumption (Santos 2009).

While swapping out older irrigation heads and

Figure 10: Drip irrigation (left image). Traditional sprinkler systems (right image) can become much more efficient when using electronic controls (Pohly 2010).

controllers is the easiest step in reducing the outdoor water demand, in most cases improving the efficiency of irrigation systems will provide for the greatest demand reductions. Sprinklers should be retrofitted with high-efficiency rotating sprinkler heads rather than impact heads, and sprinklers should be set to prevent overspray. Use drip irrigation systems where there are extreme drought conditions. This will target water right to the roots of the plant, reducing the amount of water lost to evaporation, deep percolation and runoff (Shock 2006). Finally, install smart controllers in the irrigation system, either evapotranspiration (ET) controllers or controllers linked to weather satellites (Figure 10). This will help to ensure water is not wasted due to negligence or human error. Controllers should be set to irrigate in the early morning to reduce evaporation losses (Santos 2009). In many locations, local water utilities provide rebates for purchasing and installing demand reduction alternatives. Contact them to determine the availability and details of their rebate programs.

After taking inventory of the location and type of plants on the grounds, one can begin to consider the type of plants that are best for the grounds. This will help identify the plants that need the most water and can help to determine which ones should be up for replacement first. Another approach is to group plants based on their need for water to help create an effective irrigation strategy. Consider replacing grass with artificial turf where appropriate. Replace high water consumption plants with plants that use little water. In arid areas, consider xeriscaping, which includes designing landscaping specifically to be drought resistant (Santos 2009).

Starting a local composting program can have many benefits, while reducing water consumption. Diverting compostable waste from the landfill not only reduces waste and landfill costs, but it can also enrich landscaping. The waste can be used as mulch to help lock moisture in flower beds or can be added to a composting system to create rich soil for future landscaping (Santos 2009).

3.9 Outdoor Water Use: Reducing Runoff

Reducing the amount of runoff from one's property can have a myriad of positive effects on the environment and the bottom line. Many municipalities have additional charges on water and sewer bills relating to the amount of impervious surfaces that are on a commercial property. These charges are levied in order to help deal with sewer overflows and unnecessary discharge into lakes and streams. These overflows bring sediment and pollutants that need to be extracted by the local water utility.

A few ways to reduce the total runoff from a property include installing:

- A green roof
- A rainwater catchment system
- Pervious pavement or paver systems (Figure 11)
- Rain gardens

For more information on storm water reduction strategies visit: www.epa.gov/oaintrnt/stormwater/stormwater_techniques.htm

Permeable or pervious pavement is concrete that allows water to infiltrate into the ground rather than running off into the sewer system. In general, permeable pavement is more expensive than typical asphalt. However, there are reduced maintenance costs and longer life cycles associated with

Figure 11: Permeable pavement (Gaia Engineering 2008)

permeable options (U.S. Environmental Protection Agency 2000).

Specific landscaping techniques can also help to reduce the amount of erosion and runoff from property. Installing bioretention cells, also referred to as rain gardens, can help catch water before it reaches the sewer. These are "small landscaped, graded areas constructed with a special soil mix" (U.S. Environmental Protection Agency 2010) and water-tolerant plants, which will aid in catching and filtering water. For more information visit: www.epa.gov/owow/nps/bioretention.pdf.

3.10 Outdoor Water Use: Water Capture

Water harvesting systems can be as small as a rain barrel and downspout at a residential home or as large as a customized, multitank system, including filtration, a pump station and electronic controls. These sophisticated systems can be incorporated into new construction plans or retrofitted into existing facilities. The most obvious source for water harvesting is rainfall from building rooftops and parking lots. Other, less obvious options are the condensate from large air conditioning systems and blow-down water from cooling towers, discussed in Part 3.7.2.

The harvested water can be reused for irrigation of plants and turf, green roofs and landscape. It can also be used for general washing purposes, such as the washing of vehicles, machinery, transportation equipment and other systems that do not require the use of potable water. With special piping and treatment considerations incorporated into the building, harvested water can be used for toilet flushing. Typically this option is considered in new construction projects. Check local plumbing codes to determine feasibility.

When installing water harvesting systems in existing buildings, certain applications lend themselves better to a retrofit than others. The obvious items to note in any water harvesting installation would be tank location and controls location, but when retrofitting existing sites it may be easier to do a water harvesting system for landscape irrigation than it would be for flushing toilets. The irrigation system is installed outside and the rework on plantings and landscape in certain areas may be the extent of the plumbing modifications. If doing water harvesting for toilet flushing in an existing building, the task of redoing the plumbing in the entire building is far greater and more expensive than the previous example. The decision of what the water will be used for can help determine if a water harvesting system is feasible for the property or not.

There are five stages of water harvesting: collection, pre-filtration, storage, pumping and control systems, and post-filtration. Each is discussed below.

3.10.1 Collection

When evaluating a rainwater harvesting system, any surface that water may fall on, collect on or be directed by can be used to harvest rainwater. This includes rooftops, parking lots, and landscape and turf areas. Rooftop drains are commonly placed throughout the roof and a system of gutters and downspouts direct the water into the chosen storage tank. In addition, most commercial buildings utilize a rooftop air conditioner, and the discharge condensation water from air conditioning units may be directed to a roof drain. This allows building owners and managers to combine the two water harvesting sources into a single drainage system that runs to the storage tank.

3.10.2 Pre-Filtration

Pre-filtration is the method of filtering the water before it enters the storage vessel. The type and size of rainwater filtering equipment required is a direct function of the surface material and area of collection. Since the best way to filter the water is at the source, any roof drains or screens for filtration that can be used at the point of collection are the best places to start. Most systems today will incorporate a screen filter on the pipe(s) from the collection surface to the storage vessel. These filters can be located above or below ground and usually filter the water to the 400 to 700 micron level. Most of these filters are geared toward smaller, more residential-type flow rates, but some new products are entering the market offering high-volume, commercial-grade, self-cleaning filters. Pre-filtration may be necessary when collecting blow-down water from cooling towers due to the high concentration of minerals in the water.

When collecting water from a parking lot, also called storm water, there is always the potential for hydrocarbons to enter the storage vessel. This may require oil and water, as well as grit, separation and filtration. Oil and water separators can be designed into tanks or as separate systems. The control system may include a hydrocarbon monitor to protect or alert the user should the water become contaminated. Again, the end use of the water should be taken into account when looking at the level of filtration required. Water collected from parking lots and other ground surfaces and held in storage tanks can be treated or used prior to discharging to the storm sewer, reducing the impact on the wastewater treatment plant and local environment.

3.10.3 Storage

Many of today's tank manufacturers provide the industry with below ground (Figure 12) and above ground (Figure 13) tanks. Water storage is usually the largest expense in the entire system and should be viewed as a long-term investment. With the price of water on the rise, the authors view water harvesting projects as the perfect solution for securing an adequate and reliable water system to meet long-term needs.

The main considerations for determining optimal tank size are the site's maximum water collection volume, quantity, frequency of use and budget. The sizing of the tank is the single most important piece of engineering and design as it dictates the effectiveness of a water harvesting system. The goal of the system is mainly to reduce the amount of potable water required for other uses. An improperly sized tank can limit a potable reduction amount, leaving a negative impact on the project. This could take the form of lost LEED points, higher than anticipated water costs and an overall bad reputation for water harvesting systems. It is important to work with a vendor that can back up their system design with calculations. Not only are these required to receive LEED points, but it also promotes a sense of confidence in the future performance of the system.

Access to the water source is another component to look at with tank location, elevation and installation location. In cold weather climates, a system that operates year-round, such as one used to flush toilets, utilizing an above ground tank would risk freezing, making the water unavailable, or worse, backing up the drainage system.

Figure 12: Underground water storage tank

Figure 13: Decorative above ground rainwater catchment tank

3.10.4 Pumping and Control Systems

The pumping station control panel serves as the control center for the entire water harvesting system, as it requires a controller and some level of monitoring for pump operation and protection. A good water harvesting system should run on its own, delivering water to the desired source while consuming the least amount of electricity possible. Most commercial applications are fully automated while residential units may be manually controlled. Any application where the usage of water has a varying flow rate, a variable frequency drive (VFD) controlled pump system is a must (i.e., toilet flushing where a user could flush one toilet per hour or up to 20 toilets at one time).

VFD pumping systems, or demand-based pumping systems as they are frequently called, only deliver the amount of water necessary to satisfy the demand and, in turn, only consume the amount of electricity needed to satisfy that demand. They will respond to varying water needs and will shut down completely when not in use. The end result is a system that regulates a constant pressure to the end user at a variable flow rate without the use of inefficient valves that waste energy. VFDs, combined with a pressure transducer and flow sensor, take in data, evaluate the data and then control the speed of the pump motor.

The pumps used in water harvesting systems are mostly the centrifugal type. They may be submersible or above ground depending on the site requirement or application. When the system has a VFD or multistage pump, the control system evaluates system flow and pressure to determine what speed the motor should spin. When a motor is running at less than the full operating speed (or less flow rate than design point), it is using less electricity to do so, thus reducing the electric bill. In general, it is important to select the most efficient pump that will satisfy the demand of the water distribution system at maximum condition. When coupled with a VFD, the system as a whole becomes very energy efficient over the entire flow range. On average, a VFD pump system can save 25 to 30 percent over its constant speed rival.

Pumping control is only part of the entire water harvesting control panel. There must also be control at the water source to maintain the water level in the storage vessel. The water level is controlled by a level transducer that monitors the height and/or volume of water in the tank, opening or closing fill or diversion valves to maintain the water level. Usually, because of the large up-front investment, storage systems are only made as big as they need to be. Chances are at some point in the year, all the water in the storage vessel will be depleted. When this happens, there are two viable options: engage a backup water supply or wait until there is an influx of harvested water via rainfall, condensate or other source.

Residential system owners tend to forgo a backup or municipal water source in the system, due to the increased price. Commercial system owners will most often integrate a backup water supply into their system since there could potentially be more risk if water is not available. The controls that operate the system with or without backup water need to make the most of the available storage volume for the system to operate correctly and efficiently.

For efficiency's sake, do not have the alternative fill valve on, and avoid filling the tank to the brim. Instead, only fill the tank to the minimum required for pump operation or other specified requirements. This will leave the most room to capture and store the harvested water.

There are two primary concerns when integrating a backup water supply:

- Does the source have the capacity to support the water distribution system at the point of connection to said system?
- What do the local codes require for installation and cross-connection protection?

If the water source can support the water distribution system and is allowed to be directly connected to the harvested water piping, an automated valve can be used to switch from one source to another. If the codes restrict a direct connection, or the secondary water source is not adequate enough to fulfill the demand, the two systems will need to be connected to the storage vessel and re-pressurized by the pump because the tank is vented to the atmosphere. This decision alone can affect the design specification of the pumping and controls of the water harvesting system. Within the pump design, make sure there is a backup pump if the water is being used for critical functions, such as flushing toilets.

Level controls need to shut the system down when the storage tank is out of water, and re-enable itself automatically when water is present, while keeping the greatest tank volume free to harvest water. The level controls must also determine when to allow the backup water to be used and when to switch back to harvested water. A control panel where these adjustments can be made in real time without moving any mechanical parts is of great value. With a digital level sensor integrated into the main operator interface, operators can make adjustments from their control panel, never needing to hire technicians or enter the tank. Also, since the level sensor is digital, owners can have numerous set points instead of numerous mechanical float switches to move or install.

3.10.5 Post-Filtration

Post-filtration can cover both screen filtration and water quality. Post-filtration requirements are often driven by city or state code requirements. For example, when harvesting water for use in a drip irrigation system, a 100 micron auto-flushing filter at the pump station is a critical component, filtering the water before it enters into the irrigation system. This will eliminate the need for manual cleaning of what could be many small irrigation zone filters. When using harvested water in buildings, some city officials will require the use of an ultraviolet (UV) unit, which then requires a very fine screen filter to be placed upstream. The monitoring of filters and controls should be integrated within the water harvesting control system to allow the user to monitor each device and provide an immediate alarm if one fails.

While most residential systems are monitored by the homeowner, commercial systems are often left untouched and expected to function automatically. A self-cleaning, automatic filter should be used in commercial applications. Since water harvesting systems provide water to equipment and systems that may function overnight, such as irrigation, it is important that the filter cleaning happen automatically with no human intervention. The monitoring of the filter and decision when to flush should be controlled by the same water harvesting control panel.

A word of caution: automatic self-flushing filters are not the same as cartridge filters and strainers that may have a blow-off port where someone has connected an automatic valve. Automatic filters reverse flow across the screen and remove debris. The upstream and downstream pressure is monitored by pressure transducers and initiates a flush cycle upon differential pressure, timed interval and volume of water pumped. When sizing a filter, take into consideration the water quality, screen size and flow rate. The pipe connection size to the filter should not be used as a sizing characteristic.

The finer the filter screen, the larger the screen area needed to accommodate the same flow rate. There is nothing worse than having a fine filter sized too small that does not clean itself completely after a flush cycle because it will only be a matter of time before it completely clogs.

Some systems where water is being used inside the building may require dye and chlorine injection. Injecting dye into the water is a way of identifying it as non-potable water in a building plumbing system. Injecting chlorine is a way to kill any bacteria that may be present in the water line. However, injecting both dye and chlorine into the same line is not a good idea, as the chlorine will oxidize the dye and the end result will be water that is neither colored nor chlorinated.

3.11 Outdoor Water Use: Vegetative Roofs

As cities continue to grow, the natural landscape is being replaced with buildings, parking lots and roadways of concrete and asphalt. Open green spaces within city centers are decreasing as the demand for land to build on increases. To a great extent, the rooftops, parking lots and roadways that make up the cityscape are impervious to water. This often results in an overload of the existing drainage and sewer systems and increases the risk of flooding following a heavy rain. Continued development in cities will only add to this problem, increasing the cost of improving the existing sewer infrastructure. Replacing the impervious surface of a conventional roof with a green roof can help to substantially reduce storm water runoff and restore the balance with nature in urban centers.

The term “green roof” is certainly not foreign to most building owners or facility managers who have been involved in the design, development or construction of a new building, or the reroofing of an existing one, in the last 10 years. Green roofs can be defined in two categories: vegetative roofs and highly insulated or highly reflective roofs. Due to their water retaining properties, vegetative roofs will be covered in detail; however, the reader should note that there are other ways to meet “green” roofing requirements, such as through the use of highly insulated or highly reflective roofs. In light of the many recognized benefits vegetative roofs provide, their numbers have grown quickly, and deservedly so. In various parts of the country they are also known as eco roofs or garden roofs.

3.11.1 Benefits of Vegetative Roofs

Beyond the obvious fact that a vegetative roof adds beauty to the often forgotten fifth elevation of a building, there are many advantages they can provide that go well beyond the aesthetics. Not only are vegetative roofs beneficial to the environment, but they can also be wise financial investments for the owner, both in the short- and long-term. From an ecological viewpoint, these types of roofs help to mitigate the urban heat island effect, reduce airborne dust and smog particles, and can create a natural habitat for birds, butterflies and other insects. A vegetative roof can also help achieve U.S. Green Building Council (USGBC) LEED certification through its contribution to storm water runoff reduction, mitigating the urban heat island effect and other recognized benefits.

Vegetative roofs do cost more than a conventional roof assembly. However, their cost can vary based on what one is trying to accomplish. Some vegetative roofs can be rather simple, while others are more complex, and the range in costs reflects this difference. They do, however, provide financial benefits to an owner, such as increased life expectancy of the roof, the potential for the creation of additional useable space and an opportunity to address storm water issues. Additional benefits include added thermal resistance and reduced noise transmission into the building. With respect to the performance of the roof, the added longevity is based on the fact that the roof membrane is buried beneath the growing media and vegetation, protecting it from the harsh climatic conditions and physical abuse to which a typical roof is subjected (Kirby 2009). The storm water related benefits of vegetative roofs are covered in more depth later in the guide.

Vegetative roofs do pose some challenges as well, such as structural support, leak detection/repair, irrigation needs and maintenance. A vegetative roof, depending on the type, can add considerable dead and live loads (weight) to the structure and must be designed accordingly. The buried nature of the roof membrane can make it more difficult to repair a leak, especially if the membrane is not fully bonded to the substrate. Roof membranes bonded to the roof deck can greatly restrict or eliminate the lateral movement of water within the assembly, thereby making it much easier to locate and subsequently make a repair. An irrigation system may be required on a vegetative roof if the climate or choice of vegetation dictates it. And finally, all vegetative roofs will require maintenance (some more than others), and the owner must be made aware of this need and budget for it accordingly.

3.11.2 The Structure of a Vegetative Roof

Simply put, a vegetative roof consists of a roof membrane assembly topped off with a water retention/drainage component, engineered growing media (soil) and plants (specific to the building's location and the type of green roof selected). As with any building, a sound foundation is critical to its long-term success. This analogy holds true regarding the need for a quality roof membrane as the foundation for a quality vegetative roof assembly. No owner would be happy with a lush looking vegetative roof if it leaked. Vegetative roofs are typically divided between two distinct assembly types: intensive (Figure 14) and extensive (Figure 15). The differentiation between these two types

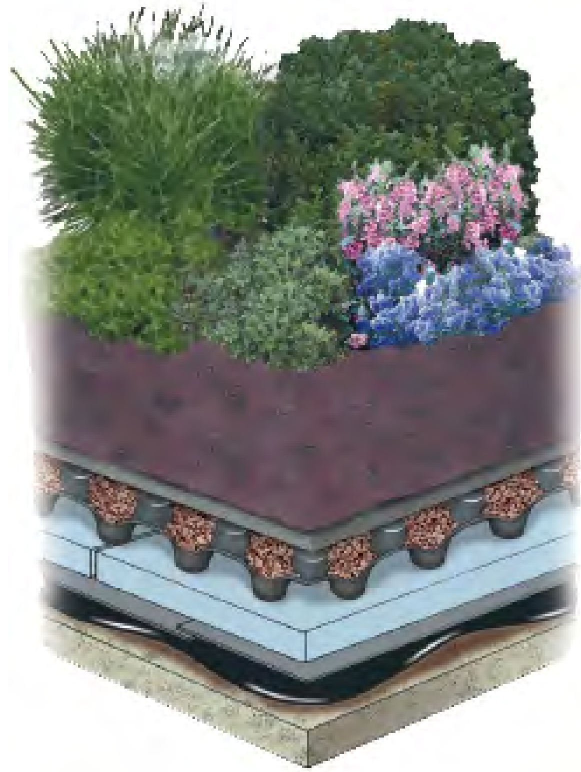

Figure 14: Intensive assembly

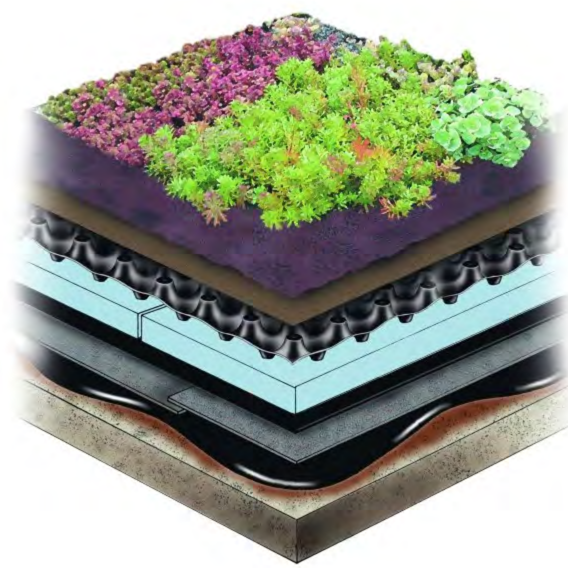

Figure 15: Extensive assembly

is based on their function, or purpose. Intensive assemblies are typically installed to create more usable space on a building, whereas extensive assemblies are installed to take advantage of the technical benefits and subsequent financial benefits they provide.

In major cities across the US, there are many examples of large planted areas on parking structures, many of which are more than 40 years old. These are, in essence, intensive vegetative roofs installed long before the term vegetative roof was coined. Think of a backyard placed on top of a roof, and one gets an idea of what it can incorporate. It is not uncommon for an intensive vegetative roof to include hardscape walkways and patio areas for people to access and enjoy (Figure 16).

Figure 16: Intensive green roof

The depth of soil can vary from 8 inches (20.3 cm) to more than 3 feet (0.91 meters) to accommodate the variety of plants desired: grass, shrubs, bushes and trees. The maintenance aspect of an intensive vegetative roof is like a backyard: there is maintenance required if it is going to look good. That includes mowing the grass, watering and weeding the plants, and pruning shrubs and trees.

The recent surge and acceptance of vegetative roofs is not only due to the diverse benefits they provide, but also the material technology advancements that have resulted in lighter weight vegetative roof assemblies. The use of synthetic drainage components, as well as engineered growing media that is as much as 50 percent less in weight than topsoil (when wet), has lead to the installation of vegetative roof assemblies on structures that would not have been able to take the load otherwise.

Extensive vegetative roofs can be installed with as little as 3 to 4 inches (7.6 to 10.1 cm) of growing media incorporating hardy plant material, such as sedums. Sedums are very drought tolerant plants that, once established, can perform well in a harsh rooftop environment (Figure 17). These roofs can add as little as 15 to 27 lb/sf (33.2-59.6 kg/m^2) of dead load to a roof structure. An extensive vegetative roof provides all of the benefits described earlier, but its primary benefit is its ability to detain and retain storm water.

Figure 17: Extensive vegetative roof

There are two methods by which extensive vegetative roofs are installed. Aside from the roof membrane assembly, the difference is in how the roof drainage and water retention components, engineered growing media and plants are installed above the membrane. The first method, and most common, is the field installed or integrated assembly (Figure 18) where each component of the vegetative roof is put in place one at a time. This takes advantage of the economy of scale and is

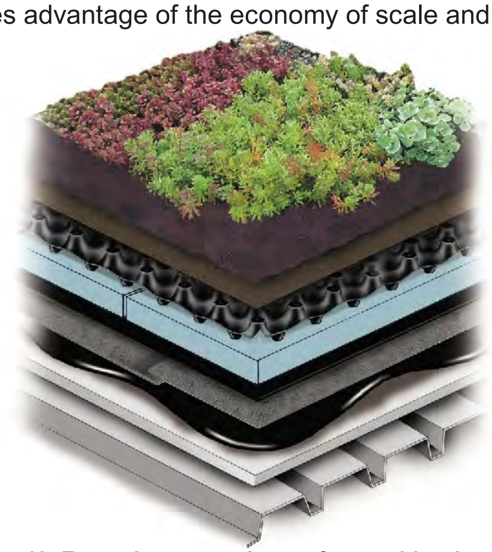

Figure 18: Extensive vegetative roof assembly – integrated

still the least expensive way to install a vegetative roof. The second method involves the delivery of a tray or modular assembly that is preassembled off site with basically the same components and then delivered and installed on the roof (Figure 19). There are several different nuances to each method that are beyond the scope of this paper, yet the pros and cons of both methods should be carefully assessed to determine the best choice for a specific project.

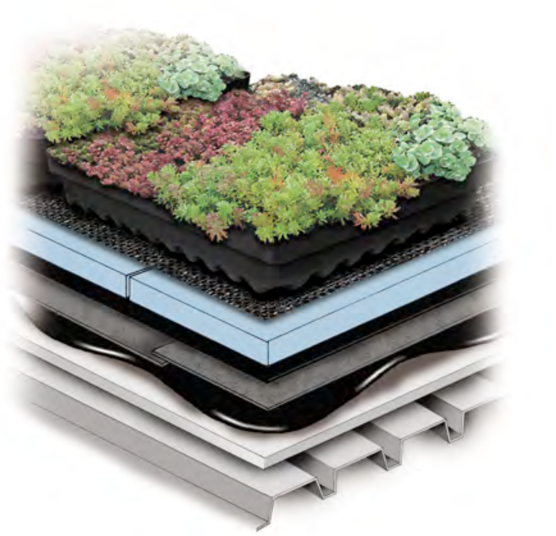

Figure 19: Extensive vegetative roof assembly – modular

Extensive vegetative roofs have proven to be an effective means of delaying the runoff of storm water so that the impact on the existing sewer system is minimized, but more than that, they can significantly reduce the amount of water that drains off the roof. For example, during a typical 24-hour storm event (an event that is expected to occur only once every two years), 2.85 inches (7.23 cm) of rain is expected to fall. A standard extensive vegetative roof with 4 inches (10.2 cm) of growing media with a drainage/water retention component would be capable of retaining approximately 1.35 inches (3.4 cm) of water. Over the course of a year a roof of this design can easily retain more than 50 percent of the rain that falls on it.

It is the detention and retention of rainwater that most municipalities have identified as the vegetative roof's greatest benefit. Municipalities are looking for ways to incentivize developers or building owners to incorporate them into their structures. Incentives range from expediting the permitting process and increasing the allowable surface area maximum to tax relief and other monetary incentives.

In new construction, vegetative roofs have been used as an alternative to generally accepted best management practices (BMPs) to help reduce pollution from nonpoint source pollutants due to urban runoff. Traditional BMPs have included constructing detention ponds and retention basins (Figure 20), which are not very cost effective. Low impact developments (LIDs) are methods that emphasize conservation and the use of on-site natural features to protect water quality, such as rain gardens, cisterns, permeable paving and vegetative roofs. LIDs can be used in new construction as well as renovation or reroofing efforts.

Figure 20: Detention pond

Some vegetative roof providers are now capable of providing very detailed analyses showing just how much water can be held on a roof, taking into account the local climatic conditions and specific performance of the roof components and growing media. With this data, a developer or owner can prove what the vegetative roof's storm water retention would be and therefore be in a better position to determine if other BMPs are needed and what savings can be realized.

Usually there is more than one good reason for installing a vegetative roof on a structure, but that reason can differ from one project to another and can depend on what is important to that owner or what works best with the building. Regardless, in the authors' view, vegetative roofs have proven they are worth the initial additional expense in both the short- and long-term.

4 MAKING THE BUSINESS CASE

Throughout this guide, the authors have identified specific solutions that reduce water usage. This section of the guide looks at the specific benefits those solutions offer to the organization that implements them, as well as the benefits on a global scale.

As shown in Figure 21, 97 percent of the Earth's water is in the oceans – unfit for consumption unless processed. Of the 3 percent that is available, nearly 69 percent of that is imprisoned in the planet's glaciers and polar caps where it cannot be readily accessed. That leaves only 1 percent of the total water available on the Earth as fresh liquid water, and about half of that is groundwater so deep below the Earth's surface that we are currently unable to reach it (U.S. Geological Survey 2010b).

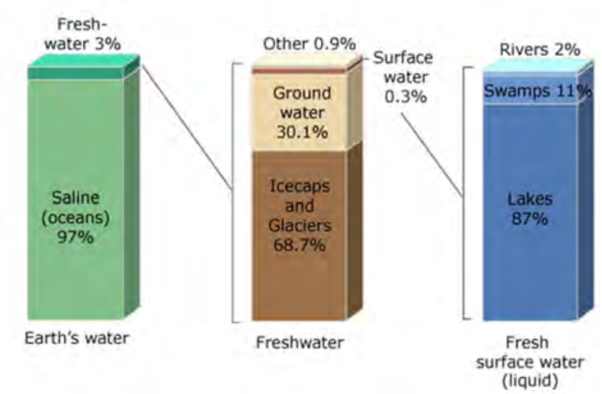

Figure 21: Distribution of Earth's water (U.S. Geological Survey 2010b)

Due to the convenience of modern plumbing, people are using much more water than they did 100 years ago. Also, population growth is increasing most rapidly in the arid southwest US where water is the scarcest. In addition, 30.1 percent of the freshwater used in the United States comes from groundwater (U.S. Geological Survey 2010c). Many people rely on this groundwater, which is being drained faster than the natural cycle can recharge it. Finally, industrial pollution is fouling rivers and lakes while runoff picks up toxic substances as it soaks into the soil where pollutants can permanently poison underground water supplies. All of these factors combined continuously reduce water quality and quantity. Simple economics of supply and demand dictate that the costs of water will rise sharply as supply dwindles.

To provide enough water for all uses through 2030, industry analysts estimate that the world will need to invest as much as $1 trillion (US dollars) per year on applying existing technologies to conserve water, maintain and replace water-related infrastructure, and construct sanitation systems (Rogers 2008).

Without hyperbole, the future of every organization – the future of the world itself – will be highly impacted by the ability of humans to use water more efficiently. While this revelation could have a tremendous impact on our personal water consumption, corporate decision making relies heavily on fiscal responsibility. Therefore, the remainder of this section discusses the cost benefits of water use reduction.

One of the easiest, least expensive and most common ways to reduce water use in buildings is by installing water-efficient plumbing fixtures and faucets. Aerators that restrict flow to 0.5 gallons per minute (0.03 L/s) still provide adequate water for hand washing, while high-efficiency toilets and urinals that meet expectations for performance use much less water doing so. These solutions can have a dramatic impact on operations and maintenance costs, saving as much as 70 percent of domestic water use. Savings would also be realized on both ends: less water coming into the building as influent and less water leaving the building as effluent.

FACT: "A showerhead leaking at 10 drips per minute wastes more than 500 gallons (1,890 liters) per year. That's enough water to wash 60 loads of dishes in your dishwasher" (United States Environmental Protection Agency 2010).

Obviously, drinking fountains and sink faucets would still require potable water, but graywater could replace a huge proportion of a building's overall water usage, creating savings on utility bills and conserving a multitude of natural resources, not just water. By reducing water pulled from and pumped into buildings from municipal sources, less energy is used for pumping water to and from the treatment plants and less energy is used treating the effluent.

Another cost saving can be realized by a building manager through eliminating storm water runoff. Most municipalities charge commercial buildings storm water discharge fees. By retaining storm water on site, a facility manager could eliminate these fees.

Vegetative roofs provide many of the same financial benefits as rainwater harvesting, but instead of gaining graywater to subsidize overall water use, building owners and operators gain useable space, reduce the heat island effect and improve the building's thermal retention through greater insulation.

4.1 Water Efficiency: Savings Waiting To Be Tapped

Many cities now consider water efficiency to be equivalent to, but much less costly than, developing new supplies. Until recently, water-efficiency projects have lacked the widespread appeal of energy conservation projects because the paybacks have not been as attractive. As water costs rise, and water utilities provide incentives for residential and commercial users to invest in water efficiency, these projects are getting a second look.

Water consumption varies widely between different types of buildings. In most cases, a water audit is required to understand how and when water is used in a specific building, and to identify potential savings. For many commercial, industrial and institutional (CII) users, the three main uses of water include process, domestic and outdoor use of water. Table 5 lists some of the strategies that can be employed to reduce water consumption in each of these applications. Product manufacturers and consultants provide equipment and design support to help end users implement these projects.

Table 5: Common CII water-efficiency strategies

Process equipment - cooling towers	Process equipment - other
Use non-potable water for make-up if it is of acceptable quality	Eliminate once-through uses of water
Install flow meters on bleed-off and make-up water lines	○ Ice machines
Allow continuous controlled discharge of water instead of periodic blow-downs	○ Washing machines
Select treatment chemical supplier carefully. Proper operation leads to lower chemical use.	○ Food service equipment
Consider sidestream filtration	Install solenoid valves that shut off water when not in use
Run at a higher cycle of concentration if controls allow	Use rinse water as make-up for washing systems
	Collect and reuse boiler condensate
	Optimize wet scrubbers in industrial applications
Typical savings potential: 20-75%	*Typical savings potential: 10-50%*
Outdoor	**Domestic**
Use locally adapted plants and minimize turf area	Install high-efficiency toilets (HETs) and urinals (HEUs)
Group plants with similar water requirements	Install low-flow faucets and showerheads
Inspect plants and turf daily. Over- or under-watering indicates a system problem.	Check existing fixtures and faucets for leaks and repair immediately
Keep turf long and do not over fertilize	Replace rinse sinks that are designed to run continuously
Install weather-based controls instead of time-based systems	Use high-efficiency prerinse spray valves
Install separate meters for irrigation systems	Locate water heaters near points of use
	Install on-demand pumps in hot water locations with long delays for hot water delivery
	Insulate hot water distribution system piping
Typical savings potential: 25-100%	*Typical savings potential: 20-40%*

In addition, many water uses in CII applications do not require potable water. Municipally supplied reclaimed or recycled wastewater, captured rainwater and graywater are alternative sources of water that can be used (subject to local codes) for landscape irrigation and cooling tower make-up water, and for flushing toilets and urinals. Facility managers should check with local water utilities to determine whether non-potable water sources are available or allowed. Depending on the local environment, average monthly rainfall numbers, evapotranspiration rates and site restrictions, a large cistern can completely eliminate the use of potable water for a site's irrigation needs as well as provide all the water needed for non-potable amenities after fixtures have been replaced with high-efficiency models. Use of non-potable water also helps buildings earn water-efficiency credits in most green building programs.

5 CASE STUDIES

5.1 Introduction

Four case studies are summarized in this section, featuring a variety of different water-efficiency practices. The first two case studies feature city-level water-efficiency efforts. The last two case studies summarize two examples of how water-efficient design helped to achieve LEED certification.

5.2 Water Savings Support City's Sustainability Initiative

"The city of Charleston, S.C., expects to save $18.5 million [US dollars] over 15 years through a performance contract that includes savings on water, energy, and operating costs. Projects include a new irrigation system for the city's many decorative plantings at a recreation complex and four city parks that will reduce water use by 40 percent.

"Lower water usage cuts energy consumption for water treatment and pumping. The projects, which support city sustainability initiatives, will prevent nearly 10,000 tons [8,928 tonnes] of carbon dioxide emissions per year, equivalent to removing more than 1,600 cars from the road for a year" (Van Ess and Kuse 2009). For more information on this case study visit:

www.johnsoncontrols.com/publish/etc/medialib/jci/be/case_studies.Par.85843.File.tmp/CityCharleston_PP_v2.pdf

5.3 Accurate Metering Saves $1.3 Million (US Dollars) per Year

"New accurate water meters, an advanced automated meter reading system, and distribution system upgrades enabled the city of Galveston, Texas, to capture lost water revenue and improve system efficiency. The work also included replacement of large, inefficient motors at two wastewater treatment plants.

"The new meters helped the city capture $1.3 million [US dollars] per year in previously lost revenue, and savings on electricity brought the total benefit to $1.5 million [US dollars] annually. A performance contract, with financing through the State Energy Conservation office at advantageous interest rates, enabled the city to pay for the improvements without issuing bonds or raising taxes" (Van Ess and Kuse 2009). For more information on this case study visit:

www.johnsoncontrols.com/publish/etc/medialib/jci/be/case_studies.Par.74261.File.tmp/Galveston_DLCS.pdf

5.4 Water Efficiency Contributes to LEED Silver Certification

"Parrish Medical Center in Titusville, FL, became the state's first LEED certified outpatient healthcare facility with a design that includes substantial water conservation components. Its green attributes, which earned a LEED silver rating, are part of an effort to create the best healing experience for patient and families.

"Water conservation measures include landscaping with native vegetation that needs 50 percent less watering, using holding ponds to trap rainwater for irrigation, installing low flow plumbing fixtures that use 20 percent less water, and choosing dual flush toilets and waterless urinals that cut water usage by 30 percent.

"Energy features include high efficiency lighting with occupancy and daylighting sensors, high efficiency HVAC with environmentally friendly refrigerants, and an integrated building management system" (Van Ess and Kuse 2009). For more information on this case study visit:

http://www.johnsoncontrols.com/publish/etc/medialib/jci/be/case_studies.Par.39663.File.dat/Parrishcase.pdf

5.5 LEED Platinum Campus Conserves Water and Energy

"The global headquarters campus of Johnson Controls, Inc., in Glendale, WI, has been registered for LEED Platinum status. This 33 acre site [13.35 hectares] includes 258,000 square feet [23,969 m^2] of new and fully renovated office space.

"Energy features include Wisconsin's largest solar photovoltaic field (31,115 SF) [2,891 m^2], reducing greenhouse gas emissions by 1.1 million pounds [49,895 kilograms] per year while generating electricity for the site. In addition, solar heating on 1,330 square feet [123.5 m^2] of roof fulfills nearly all hot water needs. The facility also uses extensive geothermal heating and cooling.

"A 30,000 gallon [113,562 liter] cistern captures rainwater from all new roof surfaces for reuse. Gray water is used to flush toilets, reducing potable water for bathroom fixtures by 77 percent, or 595,000 gallons [2,252,320 liters] per year. All plumbing fixtures are high efficiency units. A three acre [1.2 hectare] parking lot is surfaced with permeable pavers that allow rain and snowmelt to filter through and move via groundwater to a retention pond. The system prevents runoff that used to carry motor oil and other pollutants to storm sewers and waterways. A green roof also helps to reduce runoff" (Van Ess and Kuse 2009). For more information on this case study visit:

www.johnsoncontrols.com/publish/etc/medialib/jci/be/case_studies.Par.16799.File.tmp/Corporate%20Campus%20Case%20Study%2011.17.09.pdf

5.6 Conclusion

Water is a necessity of life. Using water more efficiently in the workplace is one way to protect the world's water resources. For most facility managers, a project's return on investment is a key factor in deciding which efficiency measures are put into place. As water rates increase, water conservation measures will make more and more financial sense. This is especially true considering the link between water and energy.

This guide has offered practical solutions to help reduce domestic, process and outdoor water use in facilities. It has also provided insight for decision makers to prioritize sustainability projects as they relate to the triple bottom line: people, planet and profit. By taking a sustainable approach to facility management, an organization can implement projects that save money, protect potable water sources and help communities thrive.

6 APPENDICES

6.1 Appendix A: References

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6.2 Appendix B: Additional Resources

Additional Case Studies

Alliance for Sustainable Built Environments – Case Studies: www.greenerfacilities.org/Case_Studies.php

Johnson Controls – Water Technology Case Studies: www.johnsoncontrols.com/publish/us/en/products/building_efficiency/case_studies2/watersolutions.html

Environmental Issues Related to Water

The Groundwater Foundation – Sources of Groundwater Contamination: www.groundwater.org/gi/sourcesofgwcontam.html

Ocean Conservancy: www.oceanconservancy.org

Woods Hole Oceanographic Institution: www.whoi.edu/page.do?pid=12049

EPA WaterSense

EPA WaterSense – Businesses: www.epa.gov/watersense/water_efficiency/bus.html

EPA WaterSense – Water Efficiency: www.epa.gov/watersense/water_efficiency/index.html

General Water Information

Alliance for Water Efficiency – AWE Resource Library: www.allianceforwaterefficiency.org/Water_Conservation_Programs_Library_Content_Listing.aspx

Cooling Technology Institute: “What is a (wet, atmospheric) cooling tower?”
www.cti.org/whatis/coolingtower.shtml

USGS – Domestic Water Use: ga.water.usgs.gov/edu/wudo.html

Landscaping

About.com Landscaping – Xeriscaping Plants: Drought Resistant Plants:
landscaping.about.com/cs/cheaplandscaping1/a/xeriscaping.htm

6.3 Appendix C: Glossary

Boiler: Device for generating steam or hot water. More specifically, a boiler is a pressure vessel to transfer heat to a fluid (water or steam) for the purpose of heating a space in a building, providing hot water or steam for a process load.

Domestic water: Water safe for human consumption; includes drinking water.

Drip irrigation: An irrigation technique that delivers small amounts of water directly to the roots of the plant as to severely reduce the amount of water lost to evaporation or runoff.

Evapotranspiration: The process of transferring moisture from the earth to the atmosphere by evaporation of water and transpiration from plants.

Graywater: Domestic wastewater from kitchen, bathroom and laundry sinks, tubs and washing machines.

Growing media/medium: Also known as substrate; a material that is used in a container to grow a plant.

Make-up water: In a cooling application, water added to the water system to replace water lost from the system by evaporation, drift, blow-down and leakage.

Process water: Water used for industrial processes and building systems such as cooling towers, boilers and chillers. It can also refer to water used in operational processes, such as dishwashing, clothes washing and ice making.

Rain garden: A planted depression that is designed to absorb rainwater runoff from impervious urban areas like roofs, driveways, walkways and compacted lawn areas.

Time-to-tap: The amount of time that it takes water to reach the faucet from the water heater.

Total dissolved solids (TDS): A measure of the amount of organic and inorganic material that is in a water sample.

Trapway: The channel in a toilet or urinal that connects the bowl to the waste outlet.

Volume-until-hot: The amount of water that must pass through the system before the water that arrives at the faucet is hot.

Water heater: Device for heating water for domestic use.

Xeriscaping: The principles of xeriscaping address the areas of slope, plants, plant groups, watering methods and soil due to drought.

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