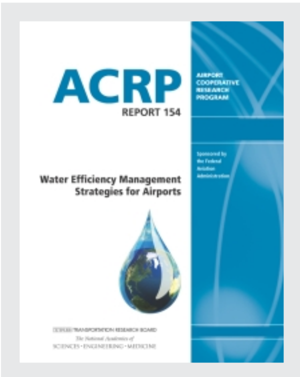

Water Efficiency Management Strategies for Airports

DETAILS

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AIRPORT COOPERATIVE RESEARCH PROGRAM

ACRP REPORT 154

Water Efficiency Management Strategies for Airports

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AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). ACRP carries out applied research on problems that are shared by airport operating agencies and not being adequately addressed by existing federal research programs. ACRP is modeled after the successful National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP). ACRP undertakes research and other technical activities in various airport subject areas, including design, construction, legal, maintenance, operations, safety, policy, planning, human resources, and administration. ACRP provides a forum where airport operators can cooperatively address common operational problems.

ACRP was authorized in December 2003 as part of the Vision 100—Century of Aviation Reauthorization Act. The primary participants in the ACRP are (1) an independent governing board, the ACRP Oversight Committee (AOC), appointed by the Secretary of the U.S. Department of Transportation with representation from airport operating agencies, other stakeholders, and relevant industry organizations such as the Airports Council International-North America (ACI-NA), the American Association of Airport Executives (AAAE), the National Association of State Aviation Officials (NASAO), Airlines for America (A4A), and the Airport Consultants Council (ACC) as vital links to the airport community; (2) TRB as program manager and secretariat for the governing board; and (3) the FAA as program sponsor. In October 2005, the FAA executed a contract with the National Academy of Sciences formally initiating the program.

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Dallas/Fort Worth International Airport, Texas
El Paso International Airport, El Paso, Texas
Hartsfield-Jackson Atlanta International Airport, Atlanta, Georgia
Manchester-Boston Regional Airport, Manchester, New Hampshire
Minneapolis-St. Paul International Airport, Minneapolis, Minnesota
Newport News/Williamsburg International Airport, Newport News, Virginia
Phoenix Sky Harbor International Airport, Phoenix, Arizona
Port Authority of New York and New Jersey, Aviation Department
Raleigh-Durham International Airport, Morrisville, North Carolina
San Diego County Regional Airport Authority, San Diego, California
San Francisco International Airport, San Francisco, California
Santa Monica Municipal Airport, Santa Monica, California
Southwest Oregon Regional Airport, North Bend, Oregon
T.F. Green Airport, Warwick, Rhode Island
Tulsa International Airport, Tulsa, Oklahoma
Victoria Regional Airport, Victoria, Texas

FOREWORD

By Theresia H. Schatz
Staff Officer
Transportation Research Board

ACRP Report 154: Water Efficiency Management Strategies for Airports provides a guidebook and tools that airport operators can use to design and institute a water efficiency management program specific to their facility. This report enables airport operators to understand water uses and usage at airports to generate a baseline water use profile specific to their airport activities, and to define appropriate water use targets. It will also help to evaluate appropriate water efficiency measures including their direct and indirect costs and benefits and develop a water efficiency management action plan. Among the many topics this report addresses are applicable water management tools and practices used worldwide within and outside of the airport industry; methods for collection, management, and analysis of data relevant to airport water management; collaboration and communication with the public and stakeholders, including water providers; program implementation strategies, including motivation for decision makers; infrastructure operation and maintenance considerations; and drought planning considerations.

Large amounts of water are consumed at airports during the course of daily operations to support terminal operations such as restrooms, food service, and heating, ventilating, and air conditioning; airfield services such as deicing, construction, and firefighting; and maintenance activities such as vehicle cleaning and landscaping. These operations can use millions of gallons of water annually. These numbers are significant when one considers that water supplies may be limited, for example, due to drought conditions. Further, water consumption at airports is expected to increase with growing air travel demand, accentuating the importance of increased water efficiency and stewardship. In addition, there are significant amounts of energy associated with water use.

In response, airports have begun to implement common water efficiency measures, such as installing water-efficient fixtures, planting native vegetation, and using non-potable water sources. Although the nature of airport facilities and activity presents opportunities for implementing water efficiency practices, there are also challenges due to a lack of awareness or a lack of guidance in terms of identifying, evaluating, selecting, and implementing the most appropriate practices.

Under ACRP Project 02-59, research was conducted by The Cadmus Group, Inc. in association with CDM Smith, Inc. The research team conducted interviews at 15 airports across the United States, visited six of these airports, and collected detailed information about their water use.

The End Use Water Audit Tool, which can be used to estimate an airport's baseline water footprint, and a Microsoft® Powerpoint presentation, which provides an overview of the guidebook and the toolbox, are provided on the accompanying CD-ROM and are also available on the TRB website by searching for "ACRP Report 154."

CONTENTS

PART 1

Water Efficiency Management Program Guidebook

Introduction

Secure and dependable water resources are essential to the successful operation of any airport. Water is needed for maintaining food and hospitality concessions within the airport complex, operating cooling towers and basic amenities within the terminal area, cleaning and maintaining aircraft and rental cars, and maintaining grassed areas and landscapes. Water efficiency efforts are becoming more critical, even in parts of the country that were historically "water rich," because of the following:

- Climatic changes increasing the probability of variations in water availability from year to year
- Increasingly complex regulations affecting the availability and cost of potable water
- The continued growth and expansion of urban centers

These issues, combined with the expected increase in water demand at airports to accommodate growth in air travel, accentuate the need for comprehensive guidance on developing and implementing a water efficiency program for airports. Despite this need, there is no central resource for water efficiency programs, and there remains a general lack of awareness of water conservation issues and approaches.

This guidebook is designed to help airports evaluate their water use and develop a water efficiency program. To support the development of this guidebook, the research team conducted interviews at 15 airports across the United States. The team visited six of these airports and collected detailed information about their water use. These interviews and site visits provided insight into water use at airports, factors that motivate water efficiency programs, and challenges facility managers may face in evaluating water use at their airports.

Why Is Water Efficiency Important?

Despite improvements in the efficiency of common fixtures such as toilets and showerheads, demand continues to grow for clean and safe water from increasingly stressed water resources. In particular, drought conditions combined with high peak water demand—particularly during the summer season—further stretch the system. As major consumers of water, airports have an obligation to be responsible environmental stewards in the community by increasing the efficiency of their water use and decreasing the amount of energy they spend to heat and pump that water. These changes can lower airports' costs, improving the financial as well as the environmental sustainability of their operations.

When airports expand or renovate facilities, they often are able to incorporate water efficiency into these projects as part of sustainable design. Some airports, however, are finding their expansion plans threatened by lack of available water resources or uncertainty about how the changes will expand their facilities' water footprint. (An airport's *water footprint* is the amount of fresh water it uses to provide its service.) Implementing water efficiency practices can reduce costs and achieve a lower water footprint. For example, improving water efficiency reduces costs associated with both purchasing potable water and discharging water into wastewater systems. Pressure experienced by airports to lower their water use may come from the following:

- Internal goals (e.g., saving money, improving sustainability)
- External agencies (e.g., local regulations, water utilities)
- Members of the public who expect their community institutions to be sustainable stewards and to share in the efforts to deal with droughts and water shortages

Stewardship

Water usage in the City of Atlanta, Georgia, has gained national attention in a legal battle focused on regional controversy over water rights. After record-setting drought conditions in 2007, the Hartsfield-Jackson Atlanta International Airport (ATL) Department of Aviation considers stewardship in the context of water conservation a "must" and has implemented major water conservation initiatives to reduce water consumption by 20 percent by 2020, ensuring long-term access to adequate water resources. As the busiest airport in the country, with over 45 million annual enplanements, and with the world watching, ATL demonstrated its stewardship by reducing consumption by 20.4 percent within 2 years. **Lesson learned:** Conservation targets can be reached when supported by good stewardship.

Factors Affecting Airport Water Management

No two airports are completely alike when it comes to water management; each faces a unique set of challenges. Regional climate is a critical factor, as are the size and type of the airport. Local, regional, state, and federal water laws differ significantly, from water rights issues to requirements for water conservation regulations on new and existing facilities. Every airport either draws water from a separate drinking water system, or is itself a regulated drinking water system. The management of airports is complicated and often fractured. Some are privately owned; some are publicly owned; and some are hybrid enterprises. Similarly, the functions of airports vary greatly, including commercial service, cargo service, reliever, general aviation, private, military, aircraft maintenance and repair, and more. Some facilities are generations old, while others are new and modern; some facilities are sprawling and complex, while others are compact and simple. Airports generally have a steady demand for water, though it obviously varies throughout the day, week, and year and can have peak periods depending on the airport, its location, and use. These differences highlight the need for every airport to develop water efficiency programs with priorities and water use targets appropriate to their specific needs.

One way to characterize water use at an airport is by the type of building or facility in which it is used. Types of airport facilities are shown in Exhibit 1. Within each facility, the airports have several end uses for water, including toilets, faucets, cooling towers, deicing, and fire suppression.

At the airports visited during the development of this guidebook, most of the water was used in the following facilities:

- Terminals
- Rental car centers

Exhibit 1. Types of facilities and end uses.

Facility	Example of End Uses
Terminal	Toilets, urinals, bathroom and kitchen faucets, dishwashers
Office Building	Window cleaning, interior plant watering, toilets, urinals, faucets
Rental Car Center	Fleet vehicle washing, outdoor irrigation
Ground Transportation	Vehicle washing
Parking	Snow removal, street cleaning
Fire and Police Stations	Fleet vehicle washing, fire suppression
Hotel	Toilets, showers, ice machines, swimming pools, spas, laundry
Central Heating/Cooling Plant	Boiler, cooling
Maintenance and Services	Runway rubber removal, employee break rooms, and restrooms
Airline/Aircraft/Cargo	Aircraft cleaning, onboard aircraft water, deicing

- Central heating plants
- Airline, aircraft, and cargo facilities

For example, Manchester-Boston Regional Airport uses approximately 40,000 gallons of water per day. Exhibit 2 shows how the water use is distributed among facilities and end uses.

During the interviews, airports described their motivations for undertaking water efficiency measures. Their motivation included complying with city codes and building permit requirements, the availability of rebate programs, and lower maintenance demands of new end use fixtures.

Exhibit 2. Water use by facility group, area of water use, and end use at Manchester-Boston Regional Airport.

Facility Group	Area	Use	Percentage of Total Use
Terminals	Restrooms	Toilets	31.6
		Urinals	10.8
		Faucets	4.8
	Food Service	Kitchen faucets	16.9
		Pre-rinse spray valves	0.1
		Dishwashers	0.3
		Ice machines	1.3
	Subtotal		*65.8*
Office Buildings	Restrooms	Toilets	1.5
		Urinals	0.2
		Faucets	0.2
	Break rooms	Faucets	0.1
	Subtotal		*2.0*
Fire and Police Stations	Maintenance	Training	2.4
Maintenance and Services	Restrooms	Toilets	1.3
		Urinals	0.0
		Faucets	0.2
	Break rooms	Faucets	0.0
	Other	Other	2.0
	Subtotal		*3.5*
Airlines/Cargo Hangars	Aircraft	Aircraft cleaning	0.0
		Onboard aircraft water	1.3
		Deicing	25.2
	Subtotal		*26.5*
Total			**100.2***

*Total equals more than 100 because of rounding.

These motivations are influenced by factors that airports consistently consider, including resource abundance or scarcity, budget, management priorities, and stakeholder support. Many airports in water-stressed regions have implemented water efficiency measures in response to local or state ordinances to reduce water consumption. Many southern and southwestern airports recognize the need to reduce water consumption due to ongoing and increasingly severe droughts. Staff at airports facing water availability issues—including those subject to municipal or state ordinances—are more likely to know about their water supply and how conservation efforts affect overall water use than staff at airports with dependable water supplies.

Conversely, water is not a constraint in areas like the Pacific Northwest; in fact, it is often plentiful. If the total cost of water to the airports remains low where water is abundant, airports have little incentive to prioritize water efficiency measures over energy efficiency initiatives, facility upgrades, or new construction projects. Airports with dependable water supplies may not need to track their current water use or develop water efficiency programs today. While water efficiency may not be a current concern, some airports should consider developing a baseline of water usage to help respond to new requirements if they arise. Being unprepared may affect their ability to respond to new city or state (or federal) requirements on water efficiency.

Airports are large, complex operations. Even small airports will have several types of buildings, including the following:

- Terminals
- Maintenance facilities
- Fire stations
- Kitchens
- Parking lots

Many will have tenants whose operations may not be directly related to air travel, like hotels and convention centers. For example, Santa Monica Airport's tenants include a local college, restaurants, and an automobile design company.

Airports designing and implementing water efficiency programs must first determine which buildings are under its direct control, which buildings would not be required to comply with new policies, and which buildings the airport would not be permitted to modify. This guidebook, informed by the interviews as well as existing literature, will help facility managers determine the scope of their programs. The guidebook also will emphasize the importance of engaging those tenants and occupants who are not under the direct control of the airport. For example, a new city code may require an airport to reduce overall water use by a percentage on the entire airport property. Facility managers would then need information on tenants' water use and what savings they can achieve. The decision about which areas to include in the airport's water use analysis is important, and the more information that the airport can collect and maintain, the better.

Despite the importance of water to airport operations, airport facility managers face several challenges measuring their water use. Airports often have little data on the water use of their tenants and subtenants and have little control over that use. Tenants often are not directly accountable for their water use and may not pay for water directly. Because the cost of water to airports is typically low relative to other utilities (like electricity), airports are often less concerned about water consumption. They may only interact with their water utility to discuss unusually high water bills. To help overcome these challenges, the tools provided by this guidebook can help airports establish a baseline of their current water use and identify potential water savings.

The interviewed airports consistently consider resource scarcity, budget, management priorities, and stakeholder support when they develop water efficiency programs. Every airport ultimately must consider several issues when it chooses appropriate water efficiency strategies and measures:

- **Resource Abundance or Scarcity.** Airports seeking to implement water efficiency strategies or measures must understand the current condition of their water source. For airports in locations where water is abundant, interested stakeholders will frame conservation as a way to reduce costs, encourage good stewardship, or prepare for possible future state or local requirements. In contrast, airports in locations where water resources are scarce view the issue as one requiring an urgent and immediate response. Airports facing water scarcity have begun implementing water efficiency and conservation measures through both voluntary and compliance-based action but may not have a formal water efficiency management program. This guidebook offers strategies for airports on how to frame the issue of water efficiency and conservation as a proactive approach to efficient operations.
- **Budget.** Airport managers will need to understand their current financial situation, airport needs and priorities, and budgeting flexibility. Further, the airport will need a clear understanding of the cost of implementing water efficiency strategies and measures, as well as ways to calculate potential cost savings. While important in general, this ability to estimate cost savings becomes vital at airports that place a low priority on water efficiency because of financial limitations or water abundance. Several of the airports interviewed for this guidebook experienced challenges securing funding for water efficiency initiatives. Only a few successfully secured financial support. The guidebook offers recommendations on ways to budget for the actions outlined in a water efficiency action plan, as well as how to identify and secure available resources and potential incentives. Further, the guidebook offers strategies for framing the issue of conservation in the context of proactive planning and long-term cost savings.
- **Management Priorities.** Facility managers pursuing water efficiency strategies and measures must be able to frame water efficiency in a way that appeals to the airport's decision makers and stakeholders. Stakeholders interested in water efficiency strategies and measures will need to understand how those strategies and measures fit into ongoing and upcoming initiatives that their airport has proposed or planned. Sustainability may not be a top priority at some airports. The guidebook will help interested stakeholders frame water efficiency as a way to help the airport meet its established priorities.
- **Stakeholder Support.** Airports with extensive support from many groups, including possible funding sources, can implement a comprehensive water efficiency management program with new policies and procedures for water use. Therefore, facility managers must work to engage stakeholders and gain their support. With limited support from individuals or groups outside of the airport administration, like the local government or public advocacy group, an airport may need to rely on an incremental approach and make easy fixes (e.g., small infrastructure/fixture replacements). The guidebook discusses ways to identify internal and external stakeholders in a potential airport water efficiency management program. It also describes how to collaborate with these parties (e.g., water utilities, airport vendors, travelers, airport executive staff, related industries, non-profits). Finally, the guidebook offers strategies on how to use existing stakeholder organizations and workgroups as models for starting the conversation on water efficiency and conservation initiatives.

About This Guidebook

This guidebook is designed to help airports develop water efficiency programs. It will help facility managers understand water use; establish water efficiency targets; design and implement a water efficiency program; and maintain, evaluate, and revise the program over time. It provides general guidance as well as specific suggestions for addressing issues that facility managers may confront.

Supplemental Information

Throughout the guidebook, case studies, informational sidebars, toolbox icons, and sections on specific challenges provide supplemental information:

- Case studies are set apart in shaded boxes and provide specific examples and lessons learned.
- Sidebars provide additional information and suggestions on a topic.
- A toolbox icon in the margin is used to highlight a tool that will be helpful regarding a specific issue or topic. Information on these and additional tools is in Part 2, Water Efficiency Management Toolbox, of this report. For example, the icon in the margin refers to the first tool in the toolbox, the user guide to the End Use Water Audit Tool developed to support this guidebook. Many of the tools so highlighted are in use at airports or other facilities that have implemented water efficiency programs.

- Sections on challenges relevant to the topic are located at the end of each chapter.

Example Airport

Throughout this guidebook, an example airport is used to show how to establish a water use baseline. This airport is a medium hub airport with about 300 flights per day. Of these, about 60 are cargo flights. The airport has three terminal facilities: domestic (main), international, and executive.

- The domestic terminal is 1.5 million square feet and has about 40,000 passengers per day. There are two sets of restrooms (each set comprises one restroom for men and one for women), two sit-down restaurants, and four coffee shops. The terminal has a cooling tower and has about 50,000 square feet of turf landscaping that is watered three times a week. Food service management estimates sit-down meals are served to about one of every five passengers.
- The international terminal is 0.5 million square feet and has about 10,000 passengers per day. It has two sets of restrooms, one sit-down restaurant, and two coffee shops. The terminal has a cooling tower and about 10,000 square feet of turf landscaping that is watered three times a week. Food service management estimates sit-down meals are served to about one of every five passengers.
- The executive terminal has a 12,500-square-foot lounge area with restrooms and is used by 250 persons per day. There is about 3,000 square feet of turf landscaping that is watered three times a week.

Cooling towers and irrigation systems are typically in operation 6 months out of the year. The cooling tower in the main terminal (domestic) has drift eliminators and is operated at six cycles per concentration. Other cooling towers throughout the airport have more standard induced draft systems and are operated at four cycles per concentration.

There are two parking facilities each with about 3,000 square feet of turf landscaping that are watered three times a week. No vehicle washing occurs at these facilities.

There is a shuttle bus waiting area with restrooms that can also be accessed by parking patrons. It can be assumed that about 10 percent of airport passengers use these restrooms. All shuttle vehicles are washed off site.

There is a centralized rental car facility with public restrooms that rents 500 cars per day and has 1,000 square feet of turf landscaping that is watered three times a week. Each returned vehicle is washed. There are five separate employee break rooms with restrooms. There are a total of 75 employees. The vehicle wash bays are about half standard efficiency and about half below par with leakage visible.

There are two airline maintenance facilities (hangars). Each has about 30 employees and restrooms and break rooms. There is a cargo shipping facility with about 50 employees that has restrooms and a break room. There are five small corporate/private hangars associated with the executive terminal; each has a single restroom.

There is a centralized deicing pad managed and operated by airport personnel that is used about 4 months out of the year.

There is a 35,000-square-foot airline kitchen facility with about 50 employees where about 2,000 meals per day are prepared. There is a cooling tower, restrooms, a break room, and the commercial kitchen area.

The aircraft rescue and firefighting (ARFF) facility is staffed 24/7 with 10 personnel per shift. There is a kitchen area and restrooms. There are four firefighting training exercises per year that use about 30,000 gallons of water per event.

The airport authority has an office with 100 employees, restrooms, and a break room. The Federal Aviation Administration (FAA) has an office building and control tower with 30 employees, restrooms, and break rooms.

The airport does not have a centralized heating and cooling facility.

Nearly all restroom fixtures in public areas and offices have 1.6-gallon-per-flush toilets, 1.0-gallon-per-flush urinals, and 1.0-gallon-per-minute faucets. Restroom fixtures in nearly all hangars and maintenance areas have 3.5-gallon-per-flush toilets, 2.0-gallon-per-flush urinals, and 2.0-gallon-per-minute faucets.

Exhibit 3, on the next page, lists the water meters with locations and annual average use in gallons per day (GPD). Some of the meters have designated uses.

Exhibit 3. Annual average metered water use.

Meter #	Location	Classification	GPD
1	Main terminal		40,000
2	Main terminal		80,000
3	Main terminal		5,000
4	Main terminal	Cooling	75,000
5	Main terminal	Irrigation	5,000
6	Main terminal	Irrigation	2,000
7	Main terminal	Irrigation	3,000
8	International terminal		20,000
9	International terminal		10,000
10	International terminal	Cooling	40,000
11	International terminal	Irrigation	2,000
12	International terminal	Irrigation	1,000
13	Executive lounge		1,200
14	East parking		500
15	West parking		500
16	Shuttle facility		5,000
17	Rental car center		7,000
18	Rental car center	Irrigation	200
19	Rental car center	Irrigation	100
20	Rental car center		3,000
21	Hangar 1		1,500
22	Hangar 1		500
23	Hangar 2		500
24	Hangar 2		500
25	Corporate hangars		500
26	Deicing pad		3,000
27	Food services		3,000
28	Food services		2,000
29	Food services		1,000
30	ARFF		1,000
31	Airport office		800
32	FAA office		200
33	FAA tower		100
34	Cargo services		900
35	Cargo services		100
Total			**316,100**

CHAPTER 1

Why Should an Airport Reduce Its Water Usage?

Water is essential to everyday life. Water is used every day for many different reasons, including drinking, cooking, and basic hygiene. Water has many recreational, agricultural, and industrial uses as well. Healthy and clean water is in finite supply on the earth and we need to be cautious about using the fresh water supply faster than the natural water cycle can process it.

Many airports purchase water from public water systems, while others may have their own water supply and operate a public water system in addition to their daily airport activities. Saving water helps keep clean fresh water available for everyone and will keep costs down. Energy is needed to produce, treat, and deliver water; therefore, saving water also saves energy. According to the U.S. Environmental Protection Agency's (U.S. EPA) WaterSense Program "letting your faucet run for five minutes uses about as much energy as letting a 60-watt light bulb run for 14 hours." [EPA WaterSense (2016). Why Water Efficiency? Drops to Watts: Save Water, Save Energy. Retrieved March 14, 2016. www.epa.gov/watersense/our_water/why_water_efficiency.html.]

Water comes from two different source types. Surface water collects on the ground or in a stream, river, or lake. These surface water supplies are replenished through precipitation and lost through evaporation. This type of water supply is more susceptible to changes in the environment such as floods and droughts. The other type of water supply is groundwater. Groundwater is obtained through a drilled well that extracts water from below the ground's surface.

U.S. Geological Survey (USGS) Resources on Water Sources

USGS Water Science School: Surface Water Information: water.usgs.gov/edu/mearthsw.html

USGS WaterWatch (map of real-time stream flow and historical trends for your area): water.usgs.gov/waterwatch/

USGS Water Science School: Groundwater: water.usgs.gov/edu/earthgw.html

The total cost of water to airports includes the rate paid to utilities for water, additional costs associated with water use within the airport (for example, for heating, cooling, or treating water), and the cost of disposing of wastewater. Many airports pay a wastewater bill that is based on the consumption of water. According to U.S. EPA's WaterSense Program, the cost of water and wastewater services over the last 10 years has risen at a rate well above the general inflation (as measured by the consumer price index). These and other utility charges will likely continue to increase in order to pay the cost of keeping water clean and replacing aging water supply systems. Programs to save water can help offset these costs: water efficiency programs can help save money on water, wastewater, and potentially electric and gas bills.

Whether airports purchase water from a public water system or maintain their own water supply, it is important for them to measure their water usage and to plan for the future. Water efficiency programs benefit the environment and public health as well as the airport's bottom line. When water supply levels become too low, the community and the environment are put at serious risk. For example, decreased water levels can lead to higher concentrations of natural and human pollutants. As large water users, the adoption and promotion by airports of water-efficient products, services, and practices can help communities meet water demands, save energy, and reduce stress on our natural resources. It is also an opportunity for airports to be seen as leaders in their communities.

WaterSense at Work highlights some of the benefits of water efficiency for commercial and institutional facilities. The following information may be useful when explaining the reasons why water efficiency at airports should be a high priority:

- **Achieve cost savings.** Improving water efficiency can lower variable costs associated with the operation and maintenance of equipment. When considered together, the cost savings from lower water, wastewater, and energy bills create a greater return on investment and a shorter payback period for an improvement project, while at the same time reducing a facility's impact on local water supplies.
- **Increase competitive advantage.** Demand for green buildings and sustainable products is increasing as consumers become more aware of the environmental impacts of water and energy use. By promoting tangible improvements in a facility's environmental performance, organizations can reinforce their image as a sustainable brand while reducing their environmental impact on the community. Promoting water efficiency not only enhances the public perception of the organization, it also helps differentiate the organization from its competitors.
- **Reduce risk.** Water-efficient facilities can be less vulnerable to fluctuations in water supply by reducing their dependence on limited local water resources. This reduces not only risk but also the burden on associated water and wastewater utility infrastructure, ensuring a more sustainable future water supply for the community.
- **Demonstrate leadership.** Water-efficient organizations can clearly demonstrate their commitment to the community and environmental leadership. By implementing projects that result in real water savings, an organization can share both quantitative and qualitative results.
- **Access opportunities in the green building marketplace.** The principles of water efficiency are becoming ingrained in the commercial real estate market as an integral part of green building and sustainable event planning. In this context, implementing specific measures that

Recognition as a "Green" Leader

The City of Phoenix, Arizona, has long-term goals for water conservation, exceeding the state of Arizona's water conservation requirements and reducing reliance on groundwater. Embracing its connection to the city, the Phoenix Sky Harbor International Airport (PHX) strives to set a positive example as a leader in "green" practices. PHX has demonstrated its commitment to the environment through a long list of water conservation initiatives, including xeriscaping projects that began as early as 20 years ago. Today, all but 12.5 acres of golf course turf on the airport campus use functional landscaping with native plants that require minimal water. When irrigation is needed, PHX uses drip irrigation paired with software programs RainMaster and RainGauge to track water usage, identify water leaks, and react to precipitation.

LEED certification is identified as an important way for PHX to reflect its environmental responsibility to the community and to its 40 million annual passengers. The Aviation Department constructs new buildings with LEED certification in mind and implements water conservation measures wherever possible to meet LEED requirements.

The airport received a Valley Forward Environmental Excellence Award: Water Conservation and Xeriscaping, which recognizes "outstanding contributions to the physical environment." **Lesson learned:** People notice when you act responsibly. [Phoenix Sky Harbor International Airport (2015). Water Conservation. Retrieved July 31, 2015. skyharbor.com/community/waterConservation.html.]

make a facility more water and energy efficient helps an organization earn recognition from local green building programs, the U.S. EPA and U.S. Department of Energy (DOE) ENERGY STAR® program, or the U.S. Green Building Council's LEED® rating system. At the same time, many national, state, and local organizations have instituted environmental requirements for both their own facilities and those where meetings and conferences are held. Hotels, restaurants, and other facilities can strengthen their ability to compete in this growing market niche by undertaking specific water and energy efficiency measures.

Drought Management

It is not feasible to prevent a drought; however, there are steps that airports and communities can take to plan for it. Drought planning is similar to preparing for other types of natural disasters and having a plan in place can often minimize costs as crisis management mode is often expensive. It is important for the airport to stay in contact with its water supplier and know when the city or state institutes water restrictions. The most direct route to reducing water use quickly is to restrict the use of outdoor watering. Airports should develop a plan to cut water use where feasible (e.g., by reducing landscape watering or using reclaimed or recycled water). Airports also should ensure they check to see if the city or state has imposed any restrictions on using recycled water.

There are four basic steps that airports can take to reduce water use in response to a drought:

- Work with the water utility, employees, and customers to raise awareness of the importance of the efficient use of water. Check with the state and the water utility regarding incentives to implement water-saving technology and products, including incentives to replace the landscaping with more drought-tolerant plants.
- In the short run, a low-cost alternative is to change water use behavior. For example, airports can stop irrigating grass areas and landscaping and they can stop washing cars. They also can engage stakeholders and discuss ways they can reduce water consumption during the drought. (For example, finding ways to reduce water use during fire training activities.)
- Replace the landscape sprinklers; if feasible, convert any traditional spray-type sprinklers to rotors, jet sprayers, or a drip system in appropriate areas.
- Upgrade to smart irrigation controllers. New weather-based irrigation controllers have built-in sensors that will monitor the conditions in real time and modify the water used automatically.

The National Integrated Drought Information System (NIDIS) operates the U.S. Drought Portal, which provides information on drought planning, current drought monitoring information, and drought forecasting. In partnership, the American Planning Association, the National Drought Mitigation Center at the University of Nebraska—Lincoln, and the NIDIS developed "Planning and Drought," a comprehensive guide for citizens, planners, and communities.

Example of a Water Use Restriction Announcement

San Diego County uses a Model Drought Response Ordinance, which is designed to help to bring consistency to the response levels and water use restrictions in place in the event of a drought or other regional supply shortages: www.sdcwa.org/model-drought-response-ordinance

This website is designed to allow the water system to share information with its consumers in a timely manner. Airports should check with their water suppliers to see if they utilize something similar.

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Airport Making Strides to Be Water Wise

San Francisco International (SFO) Airport is making great strides to be water wise; so far the airport has reduced the water being used by 14 percent over the past decade. Since January 2015, SFO has decreased the water consumed on a per-passenger basis by 22.3 percent compared to the same time period in 2013. To achieve its goals, SFO has established the SFH_2O Drought Smart program. The airport is encouraging passengers to reduce their water use not only in the airport but also during their visit to California, showing how teamwork can help in the mission. The SFO Water Wise web page is at www.flysfo.com/community-environment/water-conservation. **Lesson learned:** Working together can help solve a problem.

Evaluation of an Airport's Water Efficiency

Leaks

"Leaks are water wasted with no intended use or purpose; once identified, leaks should be the first area to target from a water management perspective. With a few simple steps, a facility can establish a comprehensive leak detection and repair program, which can save water, money, time, and expenses that would otherwise be associated with unmanaged leaks." [U.S. EPA. WaterSense (2016). Getting Started. Retrieved March 14, 2016. www.epa.gov/watersense/commercial/managing_water.html]

A water efficiency program should reduce water use by employing three methods:

- Fixing leaks and reducing water loss
- Replacing high water use fixtures, equipment, and systems with more water-efficient options
- Educating employees and occupants about water efficiency to encourage water-saving behaviors

All three methods require a thorough understanding of water use. The first step in determining the design of an airport's water efficiency program is to determine where the airport's water is going. This can be done in a variety of ways.

One way is to install meters (and perhaps submeters) at critical water use areas. By installing meters, airports can monitor water use and identify high water use areas. In the long run, meters will also allow airports to quickly find and fix leaks. Meters also would enable airports to identify cost-effective water use reduction opportunities and to track project savings.

Installing meters may not be a feasible option at all airports. An alternative approach is to conduct a water audit, estimating the volume of water used across the airport in various functions. While less accurate than meters, the audit can be a cost-effective means of assessing water use and identifying the high water use areas. By establishing an estimate of baseline water use, the audit is an important step in the development of a water efficiency program. A combination of the two approaches also could be used.

Section 1.1 of *WaterSense at Work* highlights some of the benefits of water efficiency for commercial and institutional facilities: The Holiday Inn San Antonio International Airport replaced its toilets and showerheads, installed high-efficiency aerators on its faucets in all guest rooms, and saved 7 million gallons of water a year.

Challenge: Low Priorities for Water Efficiency

During the research portion of this guidance development effort, airport facility managers indicated that more significant cost-saving opportunities are available through the implementation of energy efficiency measures, including electrical wiring retrofits, appliance upgrades, and the installation of LED lights, than through increased water use efficiency. Often energy conservation grants, energy efficiency retrofits, and energy savings challenges are available where assistance for water efficiency/conservation projects is not.

Geographic location and rainfall also influence prioritization of water conservation efforts. Southern and Southwestern airports especially recognize the need to reduce water consumption due to ongoing and increasingly severe droughts or reduction in water availability. Water is adequate in some areas of the Midwest. If water is abundant and the cost of water service remains low, airports may face little incentive to prioritize water efficiency measures over energy or new construction projects.

Cultural differences also may account for the low priority given to water efficiency projects. While some areas report a municipal culture centered on water efficiency and take pride in implementing sustainability initiatives, some airports are located in areas where little value is placed on sustainability, and they do not foresee benefits of improved public relations from water efficiency projects.

CHAPTER 2

Generating a Water Footprint Baseline

This chapter will help airports generate a water footprint baseline. In doing so, it will use the End Use Water Audit Tool that was developed as part of this guidance development effort.

The water footprint has three primary components: *how much* water is being used, *where* water is being used, and *how* water is being used. The footprint of current water usage is the basis from which current water use efficiency can be evaluated and the baseline from which future water use can be monitored.

The biggest challenge faced by airports pursuing water efficiency is a lack of understanding about when, where, and how water is used at their facility. Airports tend to understand how much water is used facility-wide, but not at a more granular level; for example, they may not know how much is used in terminal facility bathrooms, on the tarmac, or in the food concession areas. Without this information, airports cannot adequately prioritize options and target measures that deliver the biggest "bang per buck."

Most airport facilities obtain their water from public water utilities with water service provided through multiple individual meters located throughout the airport campus. Some airports may have water service provided through a few master water meters which then feed water into a system that distributes water throughout the campus.

The first step in developing the airport water footprint is to identify the number of water meters and where they are located. Staff in the finance office responsible for paying the water bills should be able to provide a list of water meters. Facility and maintenance staff should be consulted to identify the location of water meters throughout the airport and match the meters to the list provided from the finance office. In addition, it also will be useful to ask for a summary of monthly water use over the last few years for each meter. Some airports may have water service from more than one water utility. Airports should be sure to get the water bills for all service meters.

Airports with master water meters that supply a distribution system should be able to track the difference in water volume between the water flowing into the airport campus distribution system from the master meters and the volume of water recorded at individual meters throughout the campus. Much like the water distribution system of a water utility, this difference can be attributed to faulty meters, line breaks, and leaking connections. The American Water Works Association (AWWA) offers a free water audit software program that can be used to estimate water loss metrics of the distribution system based upon miles of pipe, number of connections, operating pressure, and other inputs. (The AWWA also has a number of publications on water loss control strategies and best management practices.)

Incentive for a Water Footprint Baseline

Tulsa International Airport (TUL) uses a reliable groundwater water source that is projected to continue providing an adequate supply. Meanwhile, Oklahoma has reported that the state has been plagued by a major drought for more than 5 years. The Oklahoma Water Resources Board has developed a state-wide comprehensive water plan that outlines the state's efforts to reduce water use. If Oklahoma's increasing efforts to conserve water lead to the development of state-wide water reduction requirements, there will be implications for the airport's future planning efforts. The airport could act now to determine its baseline water footprint in order to better respond to potential changes in its relationship with its water resources. **Lesson learned:** Neither water resources nor policy are static; think ahead!

Maintenance staff should be able to identify the meter locations and which buildings (facilities) are served by each meter. The water utility also will know where meters are located. A map of the airport campus is extremely useful in identifying meter locations and associated facilities. Some meters may have special use designations, such as dedicated use for landscape irrigation, cooling systems, or fire protection. Any meters with specific use designations should be noted. Fire protection lines are often tested or flushed out on an annual basis and can result in notable water use across the airport over the course of a year.

Non-sewer Meters

Most water providers charge a sewer service fee based upon the volume of water used. Thus the typical water bill for a water meter will have both a water charge and a sewer charge. Some utilities offer separate billing rates without the sewer charge for meters from which no water results in sewer flows, such as irrigation and fire protection meters.

The next step in establishing the baseline is to quantify the volume of water being used. As noted previously, the finance department can likely provide metered water volumes from utility bills. If records are available for more than one year, an annual average can be calculated that will help normalize the average use for any annual and seasonal variations that may have occurred, such as an unusually wet or dry summer. If records are available on a monthly basis, this will help provide an understanding of seasonal water uses, especially if water used for irrigation and cooling purposes can be isolated.

Exhibit 4 shows an example of the aggregate top-level summary of water use at the example airport described in the Introduction. Further investigations and development of the water footprint expand upon this level of information. Note that in this example the metered water use identified as "general" can include everything from terminals, offices, maintenance facilities, car rental facilities, cooling towers, etc. and represents the majority of water use. Associating meters, and their volume of water used, with specific facilities can help break out this water use among various uses within the airport. Exhibit 5 illustrates the same information as Exhibit 4 but divides the use by facility.

Exhibit 4. Number of meters and average volume.

Meter Use	Number of Meters	Annual Gallons per Day
Cooling	2	115,000
Irrigation	7	13,300
Deicing	1	3,000
General	25	184,800
Total	35	316,100

Exhibit 5. Average volume used by facility type and category.

Facility	Number of Meters	Metered Use in Gallons per Day				Total GPD	GPD by Facility (%)
		Cooling	Irrigation	Deicing	General		
Main terminal	7	75,000	10,000		125,000	210,000	*66.40*
International terminal	5	40,000	3,000		30,000	73,000	*23.10*
Executive lounge	1				1,200	1,200	*0.40*
Airport office	1				800	800	*0.30*
FAA office	1				200	200	*0.06*
FAA tower	1				100	100	*0.03*
Rental car center	4		300		10,000	10,300	*3.30*
Shuttle stop	1				5,000	5,000	*1.60*
East parking	1				500	500	*0.20*
West parking	1				500	500	*0.20*
ARFF	1				1,000	1,000	*0.30*
Airside services	1			3,000		3,000	*0.90*
Hangar 1, Eastern	3				2,000	2,000	*0.60*
Hangar 2, Western	2				1,000	1,000	*0.30*
Corporate hangars	2				500	500	*0.20*
Cargo services	1				1,000	1,000	*0.30*
Flight kitchen	2				6,000	6,000	*1.90*
Total	**35**	**115,000**	**13,300**	**3,000**	**184,800**	**316,100**	***100.00***
GPD by Category (%)		*36.4*	*4.2*	*0.9*	*58.5*	*100.0*	

The level of detail shown in Exhibit 5 may be as far as the estimate of the footprint of water use can go based upon water meter data.

The next step in developing the baseline water footprint goes inside the facilities in an effort to understand in more detail how water is used beyond the meter. At this point the End Use Water Audit Tool can be used to estimate the baseline water footprint. The tool can be used with variable amounts of data and resources depending on the airport goals and objectives. Although the tool has been designed to work across the spectrum of detail and data availability, two major strategies can be implemented: (1) complete the tool with minimal data, at the highest level, to quickly identify major water uses within the airport and major data gaps and (2) complete the tool with detailed end use data to yield a more comprehensive, more detailed water footprint baseline. Obviously, both strategies can be implemented sequentially. The first strategy would be implemented to obtain a relatively quick result and identify major data gaps. Next, the second strategy can be used as more detailed and accurate information is collected. When completing the tool, each version should be saved manually with an appropriate file name (e.g., QuickEstimate or DetailEstimate) so as not to overwrite the results.

For both strategies, the tool can help in approximating the volume of water used for specific end uses within each facility.

Water End Uses

The following list provides the end uses most likely to be found in airport facilities:

- Restrooms
  - Toilets
  - Urinals
  - Faucets

- Food service and flight kitchens
  - Kitchen faucets
  - Ice machines
  - Pre-rinse spray valves
  - Dishwashers
  - Dipper wells
- Landscaping
  - Outdoor irrigation
- Hotel guestrooms
  - Toilets
  - Showers
  - Faucets
- Break rooms
  - Faucets
- Maintenance
  - Cooling
  - Boiler
  - Vehicle washing
  - Laundry
  - Pavement cleaning/runway rubber removal
  - Training
  - Snow removal
- Airline/aircraft/cargo
  - Onboard aircraft water
  - Deicing
  - Fire suppression
- Other
  - Other

Notes for Understanding Water Use

The End Use Water Audit Tool contains a series of scratch sheet templates that can be used to gather data on water use at the airport. The purpose of the tool is to aid in understanding the water usage at airports. It is not necessary to collect end use fixture data in order for this tool to work. The templates are provided to guide the collection of additional data if desired. These templates are not linked to the tool; rather, they are designed to be printed so that the information can be collected during a walk-around at the airport.

The three templates are set up so that data can be collected in different ways depending on how the airport tracks its water usage:

- **Meter Data Template.** This spreadsheet template can be used to organize water meter data by meter. (The next template does it by facility.) For each water meter, data can be recorded by facility and purpose. Rows for 25 meters are provided on the scratch sheet and more rows can be added to the spreadsheet if necessary.
- **Water Use Data Template.** This template can be used to organize water meter data by facility and purpose. (The previous template organizes the data by meter.) For each facility, data can be recorded on the number of meters serving each facility and the water volume. More rows and columns can be added to the spreadsheet if necessary.
- **Fixture Data Template.** This spreadsheet template can be used to collect and organize fixture data prior to entry into the tool as totals in the detailed fixture data tab. A separate sheet should be used for each facility (building) that is being evaluated.

For each of the end uses listed in the Water End Uses section, there is an associated unit of measure that determines the frequency of use and thus the daily volume of water used. For example, water use in restrooms in terminals is associated with the number of passengers, while water use in office and maintenance restrooms is associated with the number of employees. Similarly, water use in food service areas is associated with the number of meals served.

The End Use Water Audit Tool includes a listing of typical airport activities and identifies how these activities align with the Facility Groups used within the tool based upon expected water uses and the metric units associated with each end use. Users are prompted to enter data on the number of associated units of measure for various end uses depending upon the type of facility. (For example, the number of passengers using a terminal each day.) The tool uses default values to provide an initial water use estimate by end use based on the number of the associated units. This information provides an approximation of the distribution of water among various end uses within a particular building. The resulting distribution of water among uses should be reviewed carefully by someone familiar with each facility to determine if these estimates seem reasonable.

The water use efficiency of different end use fixtures and equipment often depends upon the age of the fixture or equipment. Newer fixtures are generally more water efficient, especially those that are regulated by product standards and building codes. The End Use Water Audit Tool has three default levels of efficiency for each end use representing:

- Older, less efficient technology
- Standard efficiency
- The best available technology

A conversation with maintenance staff and a walk-through of each facility should provide a determination of efficiency levels of end uses within the facility. While a complete inventory of all fixtures is not necessary, a sufficient number of fixtures should be examined such that a confident determination can be made regarding the percentage of fixtures within the facility at each level of efficiency.

The assessment of the efficiency level of end uses within a facility is critical to the creation of the baseline water footprint. This current level of efficiency becomes the benchmark from which opportunities for improvement in water use efficiency can be determined, as discussed in Chapter 3. In addition, the establishment of the current efficiency benchmark is the point of comparison for future assessments of water use efficiency. The user guide for Tool 1 in Part 2 provides further guidance on gathering and compiling existing water use data in the End Use Water Audit Tool. These data will help complete the audit and provide inputs to the tool. The user guide also provides key insights on how to consolidate or disaggregate the data so that the tool provides the appropriate level of detail for the water use baseline. In addition, the user guide provides step-by-step instructions on how to manipulate the tool. Finally, it provides insights on how to adjust the initial results of the tool to produce a more accurate water baseline footprint and how to interpret the final results for use in developing the water efficiency program.

General aviation (GA) airports differ from commercial airports because passengers do not generate water use. Rather, at GA airports, the number of employees at the airport is the major factor in predicting water usage. As a result, GA airports can use the End Use Water Audit Tool by excluding the activities at terminals that would consume water based on passenger numbers.

Tenants, Leaseholders, and Third Parties

Many airports have facilities or areas of the campus that are beyond the purview of the airport authority. These areas may be privately owned facilities or facilities under long-term contracts in which the leaseholder is responsible for maintenance and water services. In some instances, the airport authority may have good working relationships with the owners or tenants of the facilities such that access to water use records and site inspections of fixtures and water uses within the facility are possible. In other instances, the airport authority may have no access to the facility or the water use records. The airport authority may have information on the volume of metered water entering the facility but no information on how water is used within the facility or how efficiently it is being used. In these instances, the airport manager will have to determine which facilities to include, or exclude, from the baseline water footprint of the airport.

At some airports, water conservation can be incorporated into tenant management programs. For example, at the Phoenix Sky Harbor International Airport (PHX), airport managers engage tenants in water conservation through the PHX Tenant Improvement Process. The Tenant Improvement Handbook (available on the PHX website skyharbor.com/docs/default-source/default-document-library/ti-handbook-(1).pdf) describes the requirements of the process including the various submittals required for tenants during buildouts. During the plan review process, environmental issues including water conservation will be discussed. As a result of this review, the installation of water-efficient fixtures may be recommended. U.S. EPA's WaterSense Program (see Tool 2) has specific water-efficient fixtures that can be used as a reference for such recommendations.

Challenge: Information Issues

It is essential that airports know how much water they use overall; the cost of that water use (especially during peak demand periods when rates may be highest); and the breakdown of when, where, and how that water is used. The first step in dealing with this challenge is to develop a water footprint baseline. **Solution:** The End Use Water Audit Tool can be the starting point of analysis for any airport, regardless of its goals or motivation. Airport facility managers can establish the number of end uses that apply to their airport and either use available data to quantify consumption, apply the End Use Water Audit Tool to collect the data needed, or use the default assumptions to approximate water use. It is not enough for airport operators to know how much water flows into a facility or flows out of it; they must have some basic understanding of how the water is used, in order to craft an effective water management program.

CHAPTER 3

Defining Targets

This chapter explains how to identify potential targets for water efficiency improvements. It assumes that the airport manager has already developed the baseline water use assessment as described in Chapter 2 and thus has information on where and how water is being used across the airport campus.

By providing estimates of water use by facility and end use, the baseline assessment helps to establish water efficiency targets. The End Use Water Audit Tool shows where water is used and the potential efficiency gains that can be achieved. Measures that airports can take to achieve those potential gains fall into four general categories:

1. Airports can upgrade the water fixtures in restrooms, kitchens, and other facilities. For example, high-efficiency faucets, toilets, and urinals can be installed in restrooms in terminals, car rental centers, and office space throughout the airport.
2. Airports can install water-efficient irrigation systems for landscape irrigation. For lawns, traditional spray irrigation can be replaced with rotors, which apply water more efficiently. Airports can further reduce outdoor use by replacing grass lawns with drought-tolerant landscaping and drip irrigation.
3. Airports can reconfigure or redesign operations to reduce water use in some areas. For example, by increasing the cycles of concentration in cooling towers, airports can lower the amount of water needed to cool the airport. The design of new structures and buildings can reduce the water needed for fire suppression by including valves and cutoffs, limiting the quantity of water needed to flush the system. Reclaimed water can be used in some applications. Water use must be balanced against other needs, including regulatory and operational requirements. Professional expertise will be needed to make these changes. (See the Cooling Towers subsection.)
4. Airports can institute change campaigns to modify water use behaviors. Passengers and employees can be encouraged to use water efficiently and report problems like leaking faucets to maintenance staff. Airport vehicles can be washed less frequently. Water used to test fire suppression systems can be captured and reused for non-potable use.

The first two categories involve technological solutions that reduce the quantity of water used at an end use. The second two categories may involve new technology, too, but they also require changes in operations or behavior. In all cases, these changes affect critical aspects of the airport's operations; therefore, involving stakeholders (as described in Chapter 6) is crucial. In some cases, these changes may only be made as part of long-term capital improvements. But some changes can be implemented immediately without affecting regular airport operations.

Exhibit 6 shows the water use summary from the example airport described in the Introduction. Water use is broken out by facility group, areas of use, and specific end uses. The current water use in gallons per day is shown for each end use within each facility type. The estimates of

Exhibit 6. Example of airport water use footprint by facility group, water use area, and end use.

Facility Group	Areas	End Use	GPD	Total GPD (%)	Optimal GPD	Savings GPD	Savings (%)	Water Use Ratio
Terminals	Restrooms	Toilets	50,150	15.9	40,120	10,030	20.0	1.25
		Urinals	18,806	6.0	2,351	16,455	50.0	8.00
		Faucets	8,358	2.6	4,179	4,179	50.0	2.00
	Food Service	Kitchen faucets	10,000	3.2	5,000	5,000	50.0	2.00
		Pre-rinse spray	400	0.1	256	144	36.0	1.56
		Dishwashers	1,750	0.6	500	1,250	71.4	3.50
		Ice machines	4,375	1.4	600	3,775	86.3	7.29
		Outdoor irrigation	13,111	4.1	271	12,840	97.9	48.36
	Maintenance	Cooling	115,920	36.7	96,600	19,320	16.7	1.20
		Pavement cleaning	376	0.1	251	125	33.3	1.50
	Other	Other	60,758	19.2	40,505	20,253	33.3	1.50
Office buildings	Restrooms	Toilets	540	0.2	432	108	20.0	1.25
		Urinals	203	0.1	25	177	87.5	8.00
		Faucets	90	0.0	45	45	50.0	2.00
	Break rooms	Faucets	45	0.0	11	34	75.0	4.00
	Other	Other	222	0.1	148	74	33.3	1.50
Rental car center	Restrooms	Toilets	478	0.2	240	238	49.8	1.99
		Urinals	169	0.1	14	155	91.7	12.00
		Faucets	75	0.0	25	50	66.7	3.00
	Break rooms	Faucets	25	0.0	6	19	75.0	4.00
	Landscaping	Outdoor irrigation	315	0.1	7	308	97.9	48.36
	Maintenance	Vehicle washing	9,200	2.9	6,900	2,300	25.0	1.33
		Pavement cleaning	2	0.0	1	1	33.3	1.50
	Other	Other	8	0.0	5	3	33.3	1.50
Ground transportation	Restrooms	Toilets	3,200	1.0	2,560	640	20.0	1.25
		Urinals	1,200	0.4	150	1,050	87.5	8.00
		Faucets	533	0.2	267	267	50.0	2.00
	Maintenance	Pavement cleaning	24	0.0	16	8	33.3	1.50
	Other	Other	8	0.0	5	3	33.3	1.50
Parking	Landscaping	Outdoor irrigation	470	0.1	10	460	97.9	48.36
	Maintenance	Pavement cleaning	188	0.1	125	63	33.3	1.50
	Other	Other	360	0.1	240	120	33.3	1.50
Fire and police stations	Restrooms	Toilets	438	0.1	160	278	63.4	2.73
		Urinals	150	0.0	9	141	93.8	16.00
		Faucets	67	0.0	17	50	75.0	4.00
	Break rooms	Faucets	17	0.0	4	13	75.0	4.00
	Maintenance	Vehicle washing	–	0.0	–	–	25.0	1.33
		Training	15	0.0	10	5	33.3	1.50
	Other	Other	278	0.1	185	93	33.3	1.50
Maintenance and services	Restrooms	Toilets	875	0.3	320	555	63.4	2.73
		Urinals	300	0.1	19	281	93.8	16.00
		Faucets	133	0.0	33	100	75.0	4.00
	Break rooms	Faucets	33	0.0	8	25	75.0	4.00
	Maintenance	Pavement cleaning	3	0.0	2	1	33.3	1.50
	Aircraft	Deicing	1,670	0.5	418	1,253	75.0	4.00
	Other	Other	8	0.0	5	3	33.3	1.50
Airlines/Cargo Hangars	Restrooms	Toilets	2,021	0.6	739	1,282	63.4	2.73
		Urinals	693	0.2	43	650	93.8	16.00
		Faucets	308	0.1	77	231	75.0	4.00
	Break rooms	Faucets	77	0.0	19	58	75.0	4.00
	Flight kitchens	Kitchen faucets	2,000	0.6	1,000	1,000	50.0	2.00
		Dishwashers	310	0.1	100	210	67.7	3.10
		Ice machines	1,250	0.4	240	1,010	80.8	5.21
	Maintenance	Cooling	1,814	0.6	1,680	134	7.4	1.08
	Other	Other	2,085	0.7	1,390	695	33.3	1.50
TOTAL			**315,941**	**100.0**	**208,373**	**107,567**	**34.0**	**1.52**

current water use are based upon a review of water use fixtures and the proportion of existing fixtures among the three levels of efficiency for each end use in each facility:

- Older, less efficient technology
- Standard efficiency
- The best available technology

The total estimated water use as shown in Exhibit 6 is within 159 GPD of the actual water use total showed previously in Exhibit 5. The calibration of the tool to the actual water use is described in Part 2, Tool 1.

In addition, the estimated optimal water use is shown, which is based on the flow rates of the best available technology which maximize water use efficiency. The volume of water used with the best available technology provides the target for the airport. The ratio of the current water use to optimal water use, which is shown for each end use for each facility group, is an indication of how much water the airport can save by upgrading fixtures. A water use ratio of 1.0 indicates that the current level of efficiency is optimal, while higher ratios indicate room for improvement in terms of water use efficiency.

In this example, about 28 percent of airport water use occurs in the restrooms throughout the airport. Furthermore, about 18 percent of water use is for restroom toilets, 7 percent for urinals, and 3 percent for faucets in restrooms and break rooms. Most of this water usage occurs in the terminal buildings.

The cooling towers in the terminals use more than one-third (37 percent) of all airport water use. Thus, the terminal restrooms and cooling towers account for about 65 percent of all water use.

On the one hand, the water use ratios indicate that toilets, urinals, and faucets in the non-public locations have poor efficiency levels. On the other hand, the estimated current use volume and estimated savings potential among these fixtures in the maintenance area, fire station, and hangars indicate that the water efficiency gains may not be worth the cost of fixture replacement. For example, replacing the urinal in the maintenance area could save about 5 gallons per day at a cost of $200. But if water costs $3.00 per 1,000 gallons, it would take a long time (i.e., almost 36 years) for the water savings to pay for the upgrade. (As described in the appendix, the payback period can be calculated as the replacement cost divided by the cost of water, divided by the savings per day, then divided by the number of days in a year.)

Alternatively, toilets and urinals are used more frequently in the terminal building than in other buildings; therefore, a potential upgrade could generate savings of about 19,437 gallons per day. At $3.00 per 1,000 gallons, this would save about $58 per day or almost $23,000 per year. (The comparison of the costs and benefits of water efficiency measures and strategies is discussed in Chapter 4.)

Facilities in this example that have landscaping show a water use ratio of 3.75. While landscape irrigation accounts for only about 4 percent of total water use, it shows potential for a significant reduction and warrants further investigation.

Exhibit 6 also shows that about 22 percent of water end use is classified as "other," across all facilities and areas. This suggests that there might be a number of unidentified and/or unclassified end uses. For example, the meter data for the airline facilities are associated with specific buildings but not with any specific end uses within the buildings. Estimates are made of the volume of water used in restrooms based upon the number of employees in the facility, but all other metered water use is assigned to the other (unclassified) use category. Water use estimated for other end uses may include many end uses. Because the volume of use assigned to this category for these facilities is relatively significant, it would be prudent to investigate actual water uses in these buildings in more detail if possible. There may be opportunities for water use reductions (i.e., better efficiency of use), the re-allocation of water volumes to classified uses, or possibly the identification of leakage in these facilities.

Both the efficiency ratios and the estimated potential volume of water savings provides an indication of which end uses in which facilities have the highest potential for cost-efficient replacement of fixtures. In addition, the unidentified "other" water use category in the terminal should be investigated to see if any improvements in water use efficiency can be implemented among the uncategorized uses of water.

Using the Baseline to Identify Potential Areas for Conservation

The baseline estimate of water use will provide insight into where water is used and where airports can conserve water. Water conservation reduces the amount of water withdrawn from water supplies, reduces consumptive use, reduces the loss or waste of water, and improves the efficiency of water use. Conversely, water waste is the excessive use of potable water that is unproductive (Exhibit 7). Drought combined with population growth places a burden on once-adequate water supplies. This chapter provides more information and guidance on how to define water conservation targets.

The following subsections discuss examples of ways to conserve water and eliminate waste in potentially high water use areas.

Landscaping

Maintaining and ensuring the proper setup of a landscape irrigation system will help reduce water waste. Checking regularly for leaks can help save water. In arid climates, replacing lawns with drought-resistant plants can dramatically reduce water use.

Exhibit 7. Spray sprinkler head malfunctioning or improperly located. Dry land around the sprinkler and puddles of water on the parking lot.

Creative Solutions

During a water audit of one of the golf clubs owned by El Paso International Airport (ELP), auditors recommended that the golf course managers refrain from watering the green. Turf is typically excluded from water conservation efforts, and this golf course was designed by a highly acclaimed designer and as such was expected to be of high caliber. The golf course managers sought and were granted permission from the designer to reduce irrigation on the turf. They installed a program to track precipitation on the green to determine the extent to which irrigation could be scaled down. **Lesson learned:** Consider creative and innovative ways to reduce water consumption (or, "It never hurts to ask").

According to the Alliance for Water Efficiency website a few standard practices for maintaining and using in-ground irrigation system are as follows:

- Irrigate hydrozones based upon the plants' water needs
- Install weather-based SMART irrigation controllers
- Regularly inspect the sprinkler heads to make sure they are not damaged or malfunctioning in any way
- Adjust sprinklers so they are not spraying water on paved surfaces
- Install and maintain rain sensors, either wireless or wired, on the irrigation controller if sensors are not built-in
- Have an irrigation professional design, install, and maintain the irrigation system
- Specify in professional services contracts and check regularly that landscaping maintenance employees/contractors follow landscape industry best management practices

Cooling Towers

In many locations, one of the critical water end uses at airports is cooling tower make-up water. By definition, evaporative cooling towers must replace the water lost to evaporation during the thermal exchange process. At some airports, this may be one of the highest uses of water along with restrooms and irrigation.

Cooling towers are designed to balance indoor cooling requirements with energy usage and, of course, the seasonal variations in climate. Airport cooling towers are selected by the design engineer to meet the airport's regional climate, site-specific requirements, and project budgets. Typically, water usage and conservation are not design constraints. As a result, water use efficiency is an issue that the airport operation staff or contractors must address.

The standard recommendation for increasing water efficiency in cooling towers is to reduce the make-up water required by increasing the cycles of concentration within the cooling tower itself. The typical range of cycles of concentration is from 4 to 12. (Cycles of concentration are calculated as the ratio of the concentration of dissolved solids in the blowdown water compared to the make-up water.)

Increasing the cycles of concentration in a cooling tower can be limited by physical constraints such as the quality of the potable water that is used as make-up, regulatory constraints such as effluent permit limits for blowdown (i.e., the concentrated water released from the cooling tower basin), and operational limits such as corrosion of and scale buildup on the equipment.

The quality of the potable water can provide an upper limit to the cycles of concentration as highly mineralized water tends to precipitate and coat the media in the cooling tower as it is recirculated through the system prior to being removed via blowdown. For example, at airports that have potable water with high mineral content, the cycles of concentration may be limited to 2 to 3 cycles. On the other hand, airports with relatively mineral-free supply water can operate at 10 cycles of concentration.

Additives are often injected into the cooling tower make-up water to prevent precipitation of minerals and corrosion of the equipment; however, these additives have limited capacity and, in some cases, side stream or pre-treatment of the potable water may be necessary to increase the cycles of concentration to minimize make-up water flow (thereby conserving water) without damaging the cooling tower equipment. There are many resources, including the four tools discussed in the following paragraphs, to aid airport facilities staff with maintaining and increasing water efficiency in facility cooling towers. However, balancing water chemistry in the cooling tower make-up water with operational constraints is a complex problem that requires professional expertise and services that are best provided by consulting chemists, engineers, or representative experts from cooling tower manufacturers.

Cycles of Concentration Estimator and Water Efficiency Calculator

The Cycles of Concentration Estimator uses the quality level of an airport's potable water supply to estimate the recommended maximum cycles of concentration—a key indicator of cooling tower water efficiency—when using chemicals to treat the water. It also helps identify appropriate non-chemical water treatment options to increase the potential cycles of concentration. The range of cycles of concentration values, as predicted by the Cycles of Concentration Estimator, define the operational limits for minimizing make-up water requirements. Knowing this range defines the types of improvements, e.g., side stream treatment or chemistry adjustments, that can be recommended. The Water Efficiency Calculator can then be used to predict the cost and water savings of alternative improvements to reduce water use at the cooling tower.

COOL TUNES: Run an Efficient Cooling Tower (Version 2.0) Water Smart Technology Program

The first section of this manual is a primer on cooling tower mechanics and the types of towers from which to choose. The second section provides direction on the types of monitoring that help to improve system efficiency. The third section lists maintenance and capital upgrades that lead to increases in water and energy efficiency. The final section is a series of checklists that will prompt building operators to schedule daily, weekly, monthly, quarterly/semi-annual, or annual maintenance inspections. The information provided in this guidance explains how to balance water recirculation with corrosion control to reduce water use in the cooling tower. It includes practical recommendations on operational or design improvements that can reduce water use and monitoring and maintenance of the cooling tower to ensure that the water efficiency is maximized.

Cooling Towers: Understanding Key Components of Cooling Towers and How to Improve Water Efficiency

This fact sheet explains how cooling towers use water, how to balance system operational constraints, targets for water reduction, and potential treatment options to improve water efficiency in cooling towers.

Increasing Cooling Tower Efficiency

In a California Institute of Technology water efficiency project, on average, 83 percent of water loss each month was shown to be due to evaporation and the rest due to blowdown. The project aimed to improve overall water efficiency of cooling towers by examining two applicable systems that can recover vapor and reduce blowdown. This study paper can be used to show decision makers how to modify the use and maintenance of the cooling towers to help reduce the water use at their airport.

Construction Water Use

During construction, water may be consumed at various locations. For example, temporary connections to water hydrants may be installed to provide water for various operations (e.g., dust control or general use). At many facilities, a temporary water meter will be provided by the operator (either the municipality, utility, or airport) to the construction company to track such use. Airports should consider adopting such a temporary meter program to track this often undocumented water use and to encourage water conservation by construction contractors.

Similarly, at many airports, fire regulations require flushing of the sprinkler pipes during the build-out of new concession areas in a terminal concourse. This water use may be substantial depending on the length of un-valved run of sprinkler piping along the concourse. Since fire regulations are mandates, changing the code is not possible. Rather, increasing the number of valves within the piping system to shorten the runs and decrease the amount of water discharged during flushing is a typical long-term strategy.

Deicing and Anti-icing

Like requirements related to fire safety, the requirements for deicing and anti-icing at airports cannot be modified to meet water conservation goals. Practical measures to monitor the amount of water mixed into deicing fluids and to detect and control leaks in the water piping associated with the mixing system can be implemented.

It is a common perception that deicing aircraft uses large volumes of water; however, this may be unfounded. Type I deicing fluid, which is 80 percent glycol and 20 percent water, may be diluted when only defrosting. Type II, III, and IV anti-icing fluids are diluted with water (e.g., 70/30 or 50/50) to achieve the optimal freezing point relative to the outside air temperature and weather conditions.

Certain alternative deicing practices can result in a reduction in deicing fluid usage. According to recent industry literature, these practices include forced-air systems, infrared heating systems, adjustment of glycol content to ambient air temperature, and mechanical methods, among others [Airlines for America, Airports Council International–North America, Regional Airline Association, and American Association of Airport Executives (2015). *Airport Deicing Activities, Voluntary Pollution Reduction Program, Phase I Report.* Retrieved October 31, 2015. www.aci-na.org/sites/default/files/phase_1_report_3.30.15.pdf].

Deicing and anti-icing operations are complex and ultimately the responsibility of aircraft operators and/or their contracted service providers. Engage these stakeholders prior to any evaluation of new or alternative methods of aircraft deicing technologies.

Water Reuse

As part of a water efficiency program, airports could consider whether water can be reused or reclaimed to maximize the benefits and reduce cost and waste.

Although there are no federal regulations for reclaiming water or determining the reuse of water, the U.S. EPA has developed water reuse guidelines that describe the types of reuse applications and technical and legal issues in the United States. Chapter 3 of the guidelines provides specific information on various ways water can be reclaimed or reused.

Airports should contact their state programs or consult the state regulations on water use/reuse before making any decisions about, or making changes to, the discharge of water from their facility. In some cases, a state may require a facility to obtain a water quality/reclaimed water/water reuse permit. In *2012 Guidelines for Water Reuse*, Table 4-5 summarizes and Appendix C provides links (if available) to state regulations and/or guidance for water reuse.

Summary

This chapter discussed how to identify potential targets for water efficiency improvements within the airport setting. The starting point is a detailed and reasonably accurate accounting of where water is being used, how it is being used, and how much is being used. Some knowledge about technical levels of water use efficiency is required with respect to specific end uses of water in order to identify the potential for improvements in efficiency.

The End Use Water Audit Tool offers default levels of efficiency for most of the end uses it evaluates. The potential gain in savings from shifting to a more efficient use, plus the frequency of use, determines the volume of water savings that may be achievable. Other factors, such as purpose of use (e.g., kitchen faucets), may determine if a change in water use efficiency is practical. Finally, the cost of the upgrade should be weighed against the anticipated financial gain (i.e., volume saved times the cost of water) to determine if the upgrade might be economically justified. Chapter 4 of this report provides more discussion of this economic justification.

Other factors also come into play in determining which water end uses should be targeted for water efficiency improvements. Ownership, or responsibility for facility management, can be a factor. Similarly, an overall sustainability goal to be "green" may supersede the economic justification of an upgrade. These and other factors are discussed in Chapter 4 in which the screening of potential water efficiency targets for implementation is examined.

Challenges

Infrastructure and Asset Management

Rather than planning renovations to replace water infrastructure based on calculated remaining useful life, many airports replace water infrastructure only when the source of a leak is identified or during an unrelated structural renovation. Furthermore, some airports have had leaks go undetected. While most airports have either an informal or formal asset management tracking process, infrastructure records historically have not been maintained.

Solution: Tracking when a fixture was installed as well as the condition and remaining useful life will assist in establishing a replacement schedule and can help with spreading the cost of replacement over time.

The Path Forward

Water use varies widely across U.S. airports, from food service to irrigation to cooling to providing potable drinking water. Each end use can be made more water efficient, but airports need to consider where they can have the most cost-effective impact and how to balance the competing needs for safety, security, and level of service at their facilities.

Solution: Key airport personnel should create a tailored program that will succeed by involving stakeholders and securing buy-in, benchmarking their status quo water use, identifying measures to save water, evaluating those water conservation options, and effectively implementing those measures.

CHAPTER 4

Evaluating and Choosing Water Efficiency Measures and Strategies

Implement Water Efficiency Measures

This chapter discusses how to choose which water efficiency measures to implement and how to develop an implementation strategy. This chapter assumes a baseline water footprint has already been established, as described in Chapter 2, and the potential targets for water use efficiency improvements have been identified, as described in Chapter 3. The appendix includes an example of the calculations described in this chapter.

Before the screening process begins, decide on the program goals, and decide who to engage in the evaluation process. Program goals may include elements such as the following:

- Reducing water bills, water losses, or wastewater discharges
- Regulatory compliance
- Improving resource stewardship and management
- Improving community relations

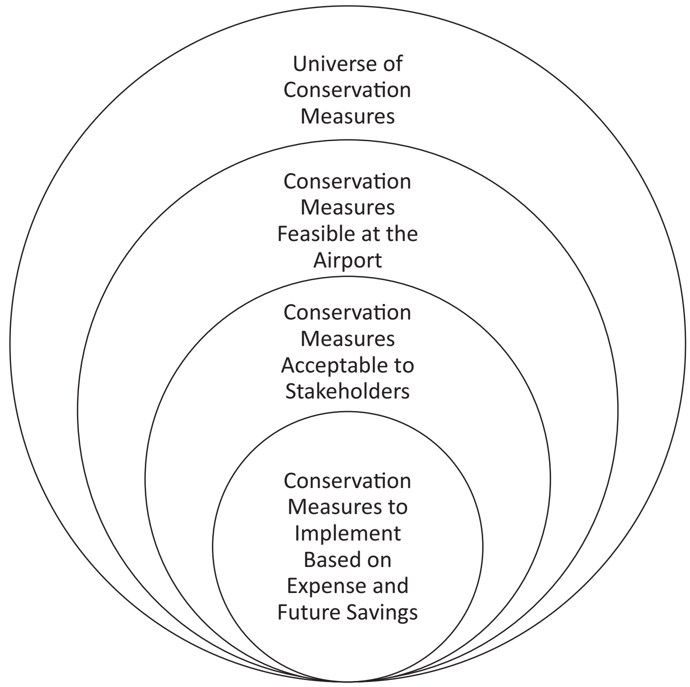
Including stakeholders in the process can be beneficial to ensure the program is able to proceed. See Chapters 5 and 6 for information on how and when to include stakeholders.

The screening process is illustrated in Exhibit 8. The first step is to determine which efficiency measures are technically feasible and likely to result in water savings. Chapter 3 discussed the process of identifying target areas and water uses within the airport for potential efficiency improvements. A detailed discussion with maintenance staff, management, contractors, and perhaps manufacturers may be needed to determine what technological changes or management changes will result in improved efficiency. A list of specific possible improvements for each identified target should be developed.

The next step is to choose conservation measures that can be implemented successfully. The program goals will help guide the screening process. Typical criteria are feasibility, applicability, ease of implementation, acceptability, effectiveness, and cost-effectiveness. Some measures may be technically feasible but cannot be used because of local constraints. Some may conflict with other stakeholder objectives. In some cases, the goals may give more weight to some criteria than to others. For example, if the goal is to reduce wastewater discharges in order to avoid excess fees and penalties, then the ease of implementation may not be as important a criterion as cost-effectiveness, as measured by the difference between the avoided fees and the cost of implementation. Similarly, if the goal is to improve community relations and make the airport a "green" focal point of the community, then management might be willing to accept more of the financial burden of the program and put less emphasis on having the water savings pay for themselves.

The final step in the evaluation of water efficiency programs is the evaluation of the economic feasibility of the alternative measures. The evaluation will need to identify the costs of the

Exhibit 8. The screening process.



alternative measures and when those costs are likely to be incurred. The benefit of the measures can be valued by the cost of the water saved, or the amount the airport would have spent on water under its baseline. These avoided costs are the benefit of the water efficiency program. In principle, a project is economically feasible if its benefits exceed its costs. The airport would then choose among feasible projects, picking the project or groups of projects with the largest net benefit. In practice, airports may need to consider projects whose benefits (at least in terms of the cost of the saved water) are less than its costs if it must meet local, state, or federal water efficiency targets. In that case, the analysis will want to identify the projects with the highest net benefit or the lowest cost per gallon saved.

Cost-benefit analysis provides the general framework for this comparison of costs and benefits. It can be used to provide several measures of the relative effectiveness of alternative water efficiency programs. The report will focus on four measures:

- Net present value: the difference between benefits and costs. Future costs and benefits are discounted to provide estimates of their present value. This provides the most general and complete measure of the value of the program.
- Benefit-cost ratios: the ratio of discounted benefits and costs. This provides a measure of the return on the investment, or "bang per buck," of the program: the dollar saved per dollar invested.
- Cost-effectiveness: the cost of the investment per gallon of water saved. This measure will help identify the least expensive approach to save a given quantity of water.
- Payback period: the amount of time (months or years) it will take to recoup the initial investment. A water efficiency program will likely require an up-front investment to install the water-saving devices, and it will produce water savings for several years. This measure estimates the amount of time it will take for value of the water savings to equal the initial investment.

The appendix provides an example of how to evaluate alternative programs. It also includes a simple example to demonstrate each step of the analysis. Off-the-shelf cost-benefit models are available; airports may have existing programs that can be adapted, as well. Spreadsheet programs can be used to conduct the analysis. In the appendix, how to use simple spreadsheets to calculate each measure will be explained.

Water and Energy Efficiency Program for Commercial, Industrial, and Institutional Customer Classes in Southern California includes a description of the cost-benefit analysis framework and how it can be used to evaluate water and energy efficiency programs. The description is in Volume 2 and includes a sample spreadsheet that implements the framework.

The FAA developed guidance to help airports prepare benefit-cost analyses as part of its Airport Improvement Program. The website provides guidance to airport sponsors on conducting project-specific benefit-cost analysis. The concepts and principles in the guidance can be applied to the analysis of a water efficiency program.

The Five Steps to a Cost-Benefit Analysis

The basic approach to a cost-benefit analysis is relatively simple. The costs and benefits of alternative programs are compared and the one with the highest net benefit is chosen. But the details can be challenging. The value of the costs and benefits of a program may not be readily available, and airports may need to estimate the program's impact. Assumptions about the timing of the program and future conditions are also needed. To keep track of the inputs and assumptions needed, it is useful to divide the analysis into five steps.

1. **Identify and measure the costs of the water efficiency program.** Costs can include one-time, up-front investments as well as recurring costs. Some costs, such as labor and energy costs, may vary with the scale of the project, while others may be fixed. For example, a project may require an up-front investment in capital equipment, followed by annual operations and maintenance (O&M) expenses.
2. **Identify and measure the benefits of the water efficiency program.** The primary benefit of the program will be the water savings. The quantity of water saved can be estimated with the End Use Water Audit Tool. The value of the water will depend on the cost of the water, including water rates (the price the airport pays for its water) and costs associated with its use within the airport. Other benefits may be included as well but may be harder to measure. These benefits may include the effect of the program on how the airport is perceived in the community and the effect of the water efficiency measures on the environment.
3. **Discount future costs and benefits.** The analysis must determine the timing of costs and benefits. Some costs will be incurred at the start of the program (like the purchase and installation of water-efficient fixtures or the development of training programs and outreach campaigns), while others will occur over time (like O&M costs or ongoing training). Many of the benefits will accrue over time, in some cases for years. To consistently compare costs and benefits, the analysis must account for what economists call the "time value of money." Because of people's time preferences (and because current funds can be invested and earn a return in the future), future costs and benefits have a lower value than current costs and benefits. The interest rate used to discount future costs and benefits is called the discount rate. In most cases, airports will use their cost of capital—the interest rate they would pay on a loan—to discount future costs and benefits.
4. **Calculate the impact of the water efficiency program on the bottom line.** The sums of discounted costs and benefits are compared. The four measures of the value of the program described previously—net present value, the benefit-cost ratio, the cost-effectiveness ratio, and the payback period—are calculated to identify programs with the highest value for the airport.

5. **Analyze the sensitivity of the results to the assumptions made by the analysis.** To estimate the impact of a water efficiency program on the airport's bottom line, the analysis may need to make several assumptions. Several critical assumptions include the cost of various elements of the program, the amount of water saved, and the discount rate. The final step of the analysis explores whether the design of the program would change under a different set of assumptions. The sensitivity analyses will help the airport choose programs that will be robust and deliver returns on its investments under a range of possible scenarios.

Accounting for Costs and Benefits

The first two steps of the cost-benefit analysis are critical to its success and will require the most time. A list of anticipated costs and benefits should be made for each potential efficiency measure. The list might include both quantitative values (e.g., dollar amounts) and qualitative scores (e.g., on a scale of one to five). A list of possible costs and benefits is provided in Exhibit 9. Stakeholders should be asked to review and discuss the costs and benefits of each potential measure to include their perspective and ensure all costs and benefits are included in the analysis.

The analysis should include the *incremental* costs and benefits. For example, if the cost of maintaining new water-efficient fixtures is the same as the cost of maintaining existing fixtures, the incremental O&M cost is zero. On the other hand, an outreach campaign may incur annual costs to update and revise the message over time.

The analysis also needs to account for changes in prices over time. It is usually easiest to conduct the cost-benefit analysis using *real* rather than *nominal* dollars. In other words, the analysis should remove the effect of inflation on prices so future costs and benefits are expressed in terms of current prices.

Inflation is not the only reason prices may change in the future. Relative (i.e., real) prices may change. For example, the rates an airport pays for water may be projected to grow faster than inflation. The analysis should capture these changes in relative prices by escalating (or de-escalating if prices are falling) prices of key inputs over time.

Exhibit 9. Possible program costs and benefits.

	Quantitative	Qualitative
Costs	• Implementation cost • Administrative cost • Education & media materials • Increase in operations or maintenance costs	• Disruption during construction • Increase in operational complexity • Increase in operations or maintenance training • Management by tenants or leaseholders
Benefits	• Volume of water saved • Reduced water bill • Reduced sewer bill • Reduced energy bill • Reduced operations or maintenance costs • Other avoided costs or fees • Incentives or cost-sharing received	• Visibility • Improved public relations • Improved environmental quality • Opportunity to use stormwater or non-potable water

Evaluating the Effect of Water Efficiency Programs on the Bottom Line

The present value of the program is the most robust estimate of the value of the program. The program with the highest net present value will always be the program that provides the highest value to the airport.

The benefit-cost ratio provides a quick comparison of the benefits relative to the costs. It also provides a general rate of return for the project, which enables comparisons of the return's alternative investments. The disadvantage of using a benefit-cost ratio is that it does not indicate the magnitude of the total value of the project. A project may have a very large benefit-cost ratio, but a small net present value compared to alternative projects.

The cost-effectiveness ratio (or unit cost) provides a measure of the costs associated with saving a specified amount of water. The cost-effectiveness ratio is the sum of discounted costs divided by the sum of the discounted water saved (as measured in gallons, cubic feet, acre feet, etc.) over time. Just as monetary values can be discounted, so can units of water. The volume of water saved is discounted to account for time preferences—airports would prefer to save water today than in the future, all else being equal. The cost-effectiveness ratio is a good measure to identify the lowest-cost option for reducing resource use. The alternative with the lowest cost per unit of water saved can be identified. The cost-effectiveness ratio does not allow comparison among the total resource savings for each of the alternatives, nor does it include the overall benefits associated with the projects. However, the unit cost of the water savings can be compared to the unit cost of current water supply to determine which measures are cost-effective relative to current water use.

Airports may use two measures of the payback period. The simple payback is commonly used because it describes actual cash flows—it is the amount of time needed to recoup the initial cash invested. While many analyses use simple payback, a discounted payback period more accurately reflects the value of future costs and benefits. The discounted payback period is the amount of time needed to recoup the initial investment after discounting future net benefits.

The equations used to calculate each measure of the value of water efficiency programs are shown in Exhibit 10.

Formulas and instruction on how to calculate a simple payback associated with retrofitting or replacing a piece of infrastructure are throughout the *WaterSense at Work*. For example, Section 5.5, Vehicle Washing, shows how to calculate the simple payback from the water savings associated with the vehicle wash system retrofit, using the equipment and installation cost of the retrofit water reclamation system, the calculated water savings, and the facility-specific cost of water and wastewater.

The quantitative metrics—net present value, cost-benefit ratios, cost-effectiveness, and payback period—can be used to rank the potential measures for comparison. In addition, qualitative scores of each potential measure can be compared. Note that the unit cost (e.g., dollar per gallon saved) of each measure can be compared with the cost of water from the utility to determine which measures have a unit cost that is less than simply paying for water. (Measures with a unit cost greater than the cost of utility water should not be implemented.)

At this point the stakeholders should review the rankings and scores of each measure relative to the previously identified goals. The optimal measures will achieve the defined goals, maximize water savings, and minimize costs.

The number of measures selected for implementation may depend upon available funding and resources. The ranking of measures can be used to develop a plan for phased implementation as resources are available. There may be trade-offs to consider. For example, a measure that

Exhibit 10. Measures of the value of water efficiency programs.

Equation	Measure of Value	Formula
1	Net present value	$\mathrm{NPV} = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t}$
2	Benefit-cost ratio	$\mathrm{B/C} = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}$
3	Cost-effectiveness ratio	$\mathrm{CE} = \frac{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{U_t}{(1+r)^t}}$
4	Simple payback period (costs and benefits vary by year): *n* that satisfies:	$C_I = \sum_{t=1}^{n} B_t - C_t$
5	Simple payback period (annual costs and benefits are constant after initial investment)	$\mathrm{SP} = \frac{C_t}{B - C}$
6	Discounted payback period: *n* that satisfies:	$C_I = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t}$

Where:

NPV	=	Net present value
B_t	=	Benefits in year *t*
C_t	=	Costs in year *t*
r	=	Annual discount rate
n	=	Number of years in the analysis
B/C	=	Benefit-cost ratio
CE	=	Cost-effectiveness ratio
U_t	=	Units of water in year *t*
C_I	=	Cost of initial investment
SP	=	Simple payback period

provides more visibility and improved public relations may be preferred over a measure with a lower unit cost. Such trade-offs should be discussed among the stakeholders, and decisions should be driven by achieving the agreed-upon goals.

Once the preferred measure, or group of measures, is identified, an implementation plan should be developed. The implementation plan may include the following:

- Who will be doing the installation (e.g., maintenance personnel or a contractor)
- An implementation schedule and strategy
- The resources (i.e., funding and staffing) required
- Development of educational and promotional materials
- Identification of metrics for monitoring and evaluating success

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RSMeans Online provides comprehensive, localized, and up-to-date construction costs. In the online system, the user is able to specify "Green Buildings" as a cost data center to identify infrastructure that promotes sustainable practices. On the second web page, the user can search for the type of infrastructure (e.g., cooling tower, faucet, etc.).

Challenge: Water Use Related to Safety

Airports use a significant volume of water for practices related to safety. For example, testing fire suppression systems is a critical practice that can consume thousands of gallons of water each day. Some airports must open the valves of their fire suppression system periodically, which results in the discharge of potable water. Options to decrease the amount of water used for these practices are limited, as airports must adhere to insurance and fire department requirements regarding the frequency of testing fire suppression systems. **Solution:** The End Use Water Audit Tool includes an end use category entitled "other" that allows airports to address these potential water uses in an airport's water use baseline.

CHAPTER 5

How to Design a Program

Not all water efficiency programs are the same, but the basic concepts of designing a water efficiency program are similar to those of other environmental or sustainability programs at airports. For any program to be successful, it must involve management, the employees, and all interested stakeholders early and often. A joint management/employee/stakeholder team should be formed to determine what water efficiency program will be useful to the airport. Stakeholders in the process may include representatives of the following:

- Airport management, finance, and maintenance
- Tenants and leaseholders
- Water utility representatives
- Members of the community such as business and civic organizations
- Perhaps state and federal agencies

Successful programs begin with a comprehensive plan that states the policies and goals of the water efficiency program.

Convene a Water Efficiency Management Team

In larger airports, the water efficiency management team should be headed by a leader with responsibility for the facility's operations. The first step of the leader is to assemble a team of interested parties from management, employees, and stakeholders and to identify the roles to be played by the team members. In smaller airports, one employee who has the full support of management should be assigned to develop and implement the plan. The water efficiency management team should then set the program goals. The goals should be based on the airport's water footprint baseline, the facility's needs and priorities, and the results of economic analyses. As with many other aspects of business management, ownership of the program by a member of the management team and routine management review of the results achieved are absolutely critical to successful implementation. A water efficiency program will generate cost savings but will require funding and a time commitment to make the program work.

Chapter IV of the *Facility Manager's Guide to Water Management* suggests that the water efficiency management team consist of the following:

- Representatives from airport management
- The chief operating engineer
- A representative from the maintenance department
- Representatives of tenants known to use significant volumes of water
- Qualified contractors who specialize in landscape or other water management fields
- A representative from the airport's water utility, if possible

Prepare an Action Plan

Using the goals developed by the water efficiency management team, the team should develop a flexible plan that can meet changes in demand, limitations on water availability (especially for airports facing drought conditions), and airport needs. An action plan does not need to be complex. In developing the plan, consider any major areas for improvement noted during the development of the water baseline footprint as well as any external challenges the airport may face (e.g., inconsistent regulations, environmental factors, complex tenant agreements, resource constraints) and strategies for overcoming these challenges. According to U.S. EPA's *WaterSense at Work*, the action plan should determine which projects and practices can be implemented at the facility to achieve established water management goals and the plan should consist of the following steps:

- Identifying projects and calculating cost and potential savings
- Identifying financing sources (including the airport's budget cycle)
- Calculating simple payback
- Prioritizing projects
- Documenting project priorities in a detailed action plan

The action plan should also include documentation of the program to ensure the program stays on track. The following documentation should be maintained to track the progress of the program:

- List of members of the water efficiency management team and team minutes
- List of actions taken to educate all employees and tenants about the importance of the program and steps taken to involve them in implementing the program
- Water efficiency program goals
- Estimated water savings and actual water savings for each item implemented and associated cost savings, if appropriate

Los Angeles World Airports developed a set of airport-specific performance standards for planning, design, and construction activities that integrate sustainable concepts and practices into projects at the four Los Angeles World Airports, which can be used as a resource by other airports. Part 3: Sustainable Planning and Design Guidelines provides a specific list of performance standards for designing a sustainability plan, including specific water efficiency and conservation sustainable planning and design guidelines.

Consider Financial Resources

In determining the full cost of water efficiency improvements, airports should estimate the project cost including labor and staff costs, materials, and overhead. Airports should also consider the budget cycle. Each airport's budgeting cycle can be different, and knowing the timing of budget requests is important when developing project concepts. As a first step, the water efficiency program should determine if the project can be funded through the facility's operating expenses or capital funding mechanisms. Some suggestions provided by U.S. EPA's *WaterSense at Work* for financial obstacles are as follows:

Keep in Mind

Costs drive business decisions, so cost savings are very important in the goal-setting process and in obtaining strong management commitment for implementing the specific program elements.

- For larger, more expensive pieces of equipment, consider leasing the equipment from a technology vendor. ENERGY STAR provides information on a variety of lease types for energy-using equipment, many of which might apply to water-using equipment, such as commercial dishwashers or cooling systems.
- Look for rebates and incentive programs offered by the local water utility to assist commercial and institutional building owners in making water efficiency upgrades. U.S. EPA's WaterSense Rebates Finder can help identify money-saving rebates available by area and determine if the rebates are available to commercial or industrial buildings. Rebate and incentive programs

include free product distribution, partial rebates on purchases of water- and energy-efficient products, financial incentives based on total gallons of water saved from implementing large-scale projects, and billing offsets based on submetered water use that can account for water that is not being sent to the sewer (e.g., metering cooling tower make-up water and blowdown water to account for evaporation).

No Opportunity Wasted

Santa Monica Municipal Airport (SMO) has adopted a city-wide goal to reduce water usage by 20 percent by 2016. In 2013, the City of Santa Monica Office of Sustainability and the Environment implemented a rebate program for water fixture retrofits. While the airport usually adheres to a water infrastructure replacement schedule based on age and need, SMO enrolled two buildings on its campus in the rebate program and installed water-efficient toilets and faucets. Santa Monica continues to offer water efficiency rebates for measures such as weather-based irrigation controllers and rain barrels and cisterns. **Lesson learned:** Keep an eye out for local resources.

- Look for state-specific financing programs. Many states have made water efficiency projects eligible for Property Assessed Clean Energy (PACE) financing programs that are carried out by local governments. The Database of State Incentives for Renewables & Efficiency® (DSIRE) is the most comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United States.

Unconventional Funding Opportunities

Used mostly for military and general aviation, the Victoria Regional Airport (VCT) in Victoria, Texas, identifies funding as a key restriction inhibiting the development of a formal water efficiency program. VCT instead considered unconventional ways to obtain funding to address ancillary issues that also affect costs associated with water usage. For example, rainwater had been infiltrating VCT's outdated sewer lines and caused their wastewater costs to increase. VCT applied for and was awarded a federal grant from the Coastal Impact Assistance Program of the U.S. Fish and Wildlife Service to improve sewer infrastructure. VCT was also able to upgrade infrastructure of their distribution system through a Texas Department of Transportation grant, which funds upgrades necessary to maintain sufficient water pressure for fire suppression. **Lesson learned:** Get creative in leveraging your resources.

Employee and Tenant Education and Participation

Employees and tenants can have a major effect on the success (or failure) of a water efficiency program. The importance of their awareness and cooperation to the program cannot be overstated. Therefore, they must be included in all parts of the program and be kept informed about changes. The following steps were adapted from the Texas Water Development Board, Water

Conservation Implementation Task Force's *Best Management Practices for Industrial Water Users* and can serve as guidelines for effectively enlisting employees' and tenants' support, keeping them informed about the program, and seeking their participation on an ongoing basis:

- Establish an employee water use education program. The education program should communicate information about
  - The importance of and need for maintaining a water efficiency program at the airport
  - The importance of each individual's contribution to the success of the program and the community
  - How specific water-saving measures by individuals can reduce overall consumption
  - How specific water-saving measures by employees working together as a team can result in major water use reductions
  - Any new procedures or equipment that should be implemented
- Use a wide variety of communication media to help keep the message current and to reinforce the importance of the airport's water efficiency efforts. Potential communication vehicles include
  - Airport newsletter
  - Memos
  - Paycheck stuffers
  - Posters and signs
  - Progress reports and "score cards"
  - Training on specific actions that can be taken to increase the airport's water efficiency (e.g., process for reporting a leak)
  - New and/or revised operating guides and manuals that describe changes made to implement water-saving measures
- Establish a schedule for regular communication with employees about the program. The initial excitement of a new program will begin to fade unless the importance of the program is regularly communicated. Ensure that employees are kept abreast of the specific water reduction measures as they are being implemented as well as the associated water, energy, and cost savings generated by those measures. Information about water and cost savings is especially useful to help tie water efficiency measures to business results.
- Establish incentive programs to encourage and reward participation. One example could be offering employees a percentage of the first year's direct savings resulting from water and energy conservation.
- Create a "Water Efficiency Ideas" box where employees can submit suggestions on how the organization can save water.
- Promote slogan and poster contests.
- Reward employees who spot leaks and other instances of water waste.

Recommendation

Communication activities should promote key components of the action plan to relevant stakeholders to gain support for specific projects.

Next Steps

Once the team has established its goals and action plan and has provided information to employees and tenants about the new program, the program is ready to be implemented. This implementation process will be discussed in Chapter 6.

Challenges

Lack of Consensus

The lack of federal guidelines or regulations on water efficiency and conservation has led to a maze of state, regional, and local planning, permitting, and regulatory efforts. This web of constraints has made it difficult for a consensus to emerge on the best practices for water efficiency, because the experiences of airports with successful water efficiency efforts vary so widely. **Solution:** Developing an airport-specific water efficiency management plan can avoid the trap of a one-size-fits-all approach.

Financial Obstacles

Financial obstacles were the most commonly reported limitation to the proposal, approval, and implementation of water efficiency measures. Airport personnel would agree to implement measures with quantifiable cost savings reflected over a short payback period. However, few municipalities or utilities offer incentive or rebate programs that would reduce the financial burden of water-efficient fixtures or appliances.

Hub airports rely heavily on passenger traffic from airlines for funding, and some airlines have struggled to respond and adapt to changes in the market (e.g., acquisitions and mergers, relocations). These unexpected and gradual declines in funding can severely limit the resources available to develop and maintain water efficiency programs.

Stakeholder Support

Environmental and economic priorities differ within decision-making boards. Airports must consider all of their stakeholders, including tenants, contractors, staff, and the community or municipality, when deciding to undertake a new initiative or program. Political imbalances can arise that may delay implementation. Stakeholders that are affected by leadership decisions about policies or procedures do not always have a voice in the decision-making process. A critical priority for all parties is to maintain the economic viability of a given sustainability measure, which may require a resource-intensive proposal of costs and benefits of implementing a new measure.

It is a challenge for some airports to understand the practices and decisions of their tenants. It also is difficult to manage airport staff to ensure compliance with changing airport policies and procedures. Issues have surfaced in which tenants made improvements to their space without notifying the airport staff tasked to ensure compliance with airport policies and procedures. There have also been cases in which airport staff have failed to report damaged or broken end use water fixtures. In general, airports have demonstrated a high level of commitment and effort to ensure compliance with best practices, but coordination with several types of tenants and employees hired directly or through third-party contractors remains a challenge. Balancing the needs for airport improvement continually poses a challenge in airports with so many different types of tenants and staff.

Management Issues

Because of their central role in communities, airports are often near the top of the priority list in terms of potable water recipients. This status, combined with other concurrent challenges—competing demands faced by airport leaders, an overwhelming array of water program options, and lack of water usage audit data—can create a lack of support for improving water efficiency. Where airport leadership has decided to improve management of the airport's water, the responsibility is often distributed across multiple staff members who may already be overburdened with prior commitments. Rarely is one designated person clearly in charge of improving water efficiency. Lack of staff capacity and management support is a significant issue.

Airports already manage a dizzying set of responsibilities, from passenger safety and national security to issues of local air and noise pollution. Water efficiency often takes a backseat to delivering these other critical functions. **Solution:** To make managing water efficiency more successful, the creation, implementation, and maintenance of a program must be more manageable for personnel without specialized training or expertise, and the program should use existing data and tools to the greatest degree possible.

CHAPTER 6

Implementing the Water Efficiency Program

Design a Successful Strategy

A carefully crafted and targeted implementation strategy can increase the success of the program and can help airports achieve their water efficiency management goals. Each airport will have a unique implementation strategy. Implementation strategies, much like the programs themselves, will vary based on the environmental conditions at each airport, the size of the airport, available resources, and the needs and preferences of stakeholders. Taking into consideration each airport's unique variables, each airport's team should modify and scale the approach discussed in this chapter to meet the airport's needs.

As with other sustainability planning efforts, a successful strategy includes the following:

- Engaging stakeholders to select, prioritize, and plan for short-term and long-term goals
- Ensuring adequate resources are available
- Making the implementation schedule, which is the lynchpin of the strategy

The implementation strategy should also identify connections between the airport's program and other local, regional, and national water efficiency management efforts which will yield greater stakeholder support.

Step 1. Assess Water Efficiency Priorities

When beginning to implement a water efficiency management program, review the water efficiency priorities outlined in the water efficiency action plan. In implementing the program, airports should also consider information about the airport's assets pertaining to water use, including age, condition, and remaining useful life, when prioritizing actions. By prioritizing actions in this way, the water efficiency program will allow airports to maximize water, energy, and financial savings while maintaining and improving the water operation at the airport's facilities.

During Step 1 of the implementation strategy, the team should again review the prioritized measures and strategies outlined in the action plan and make any changes based on the needs and/or priorities of the airport and its stakeholders. The finalized priorities should be revised in the action plan.

Keep in Mind

As part of the action plan, the facility manager should choose and prioritize water efficiency measures and strategies based on the evaluation of the airport's water footprint baseline, the facility's needs and priorities, and the results of economic analyses with support of the team.

Step 2. Determine Resource Adequacy

In order to achieve the goals of the action plan, airports need to ensure they have adequate resources (i.e., time, money, and personnel) available to complete projects and practices included in the action plan. The team should think creatively and consider other resources that may be available to assist in implementation, such as other employees, utility and government programs, interns, or engineering students.

Recommendation

Implementation can be done in phases, starting with the easiest and lowest-cost project, or in the order of priority (e.g., greatest water savings, oldest infrastructure).

By the time airports implement their programs, they will have already assessed their financial needs, established budgets, determined available resources, and begun to secure these resources. They will need to re-assess the available staffing resources, particularly as they develop an implementation schedule. The team should also review and note when anticipated funding will be available (e.g., grants and incentive programs) and how the funding schedule aligns with the time required to complete a water efficiency project. The funding timeline should be incorporated into the implementation schedule to synchronize the moving pieces.

WaterSense at Work suggests that facility managers assess large retrofit or replacement measures or high-priority jobs to determine the time and funding channel necessary to complete these projects. While many strategies can be implemented in a few hours, other strategies may require several months and the service of hired contractors. The document is intended for commercial facilities and much of the content is applicable to airports.

Step 3. Develop Implementation Schedule

Recommendation

Remember to include all necessary steps in the implementation schedule, including adopting necessary ordinances to meet city/state requirements. These ordinances may be required for new developments (e.g., retrofits and landscaping).

The third and final step in designing a successful implementation strategy is to establish an implementation schedule, with a specific timeline for meeting the airport's action plans.

Best Management Practices for Industrial Water Users suggests an implementation schedule for industrial users, which could be revised for airports. The following implementation schedule considerations were adapted from the different best management practices (BMPs):

1. The water audit, which will serve as the baseline for the program, should be updated as parts of the program are integrated into daily operations. The team should maintain the audit results to ensure they are readily accessible and use them to track and measure the success of the program.
2. Implementation of water efficiency measures and strategies should begin within the first normal budget cycle following the conclusion of the water audit. As some of the measures and strategies will take longer to implement, the schedule can be extended. Obvious water leaks and problems found during the course of the audit should be repaired as soon after discovery as possible. If leaks or problems are identified at the sample locations of the audits, then facility managers should look at similar facilities at the airport to determine if they also have leaks and other problems similar to those identified during the audit.
3. Additional best management practices should be initiated in the second year and continued until the action plan goals are reached.

M52 Water Conservation Programs—A Planning Manual provides information on establishing a water conservation program. Exhibit 11 shows an example of a schedule for the first year of an implementation plan, adapted from this manual. This implementation schedule includes only activities for two plan elements; however, the schedule should include all activities associated with the program and should show more than one year of implementation. The schedule may also show the funding schedule (also not shown in Exhibit 11).

Keep in Mind

The facility manager will want to identify and involve potential stakeholders in a water efficiency management program. The list of participants will differ from the airport's overall stakeholders.

Develop Employee Training

When included as part of the airport water efficiency education program, employee training will help to ensure effective implementation of the measures and strategies outlined in the action plan. Employee training programs will be largely dictated by the airport's employment structure.

Exhibit 11. Example of a schedule for the first year of implementation (adapted from M52 *Water Conservation Programs—A Planning Manual*).

Plan Element	Activity	Jan.	Feb.	Mar.	Apr.	May	Jun.	Dec.
Public Education	Design							
	Create Materials							
	Media Event							
	Terminal Lobbies							
Fixture Retrofit	Select Replacement Fixture							
	Secure Funding Source							
	Hire Contractor							
	Kick-off Event							
	Process Rebates							

The purpose of the training is to provide employees, with the support of the standard operating procedures, a unified and comprehensive understanding of the program. The training should focus specifically on employees' roles and responsibilities in the program, including best practices and the resources available to staff to help them to carry out the actions (for example, a hotline to report leaks or other wastes of water to facility managers and other maintenance personnel). Because many water efficiency measures only produce water and cost savings when used properly, it is important to teach employees how to use newly installed infrastructure (e.g., air conditioner cooling towers).

Worksheet II-7 in the *Facility Manager's Guide to Water Management* (see Exhibit 12) provides a simple and effective way to show maintenance personnel the water conservation practices

Exhibit 12. Part of Worksheet II-7, Institutional and Commercial Water Conservation Practices Checklist, which provides a list of typical commercial and industrial water uses (from *Facility Manager's Guide to Water Management*).

Worksheet II-7

INSTITUTIONAL AND COMMERCIAL WATER CONSERVATION PRACTICES CHECKLIST				
Water Conservation Practice	We are doing this	We should do this	We need to evaluate this measure	Not applicable
BUILDING OPERATIONS				
✓ Read water meters on a regular basis				
✓ Make water use figures known to employees				
✓ Shut off water to unused areas				
✓ Install pressure reducing valves if pressure is high				
✓ Regularly check building for leaks and water waste				
✓ To the extent possible, quantify water use by each operation				
✓ Where feasible, investigate recycling and re-using water				
✓ Install water fountains that are self-closing and use air-cooling for chilled water				
✓ Eliminate unnecessary wash-downs				
RESTROOMS				
✓ Repair leaks and plumbing problems				
✓ Use water conserving plumbing fixtures: • Install low-flow showers, faucets, toilets, and urinals • Install metering or spring-loaded faucets, or faucets with sensors				
✓ Adjust plumbing to use the minimum amount of water that is functional				

airports should follow and can help facility managers evaluate whether maintenance personnel understand the practices.

When developing the training, airports should consider involving their water utility (drinking water or wastewater). In addition to providing useful resources, involving the utilities is an effective way to build and strengthen community partnerships. It is important to involve airport personnel who are knowledgeable about the operations and goals of the airport and a third-party contractor familiar with the design and delivery of training to ensure effective training techniques are employed. Effective initial training can instill proper use of new equipment and implementation of water efficiency best practices, leading to greater water savings.

The short- and long-term impact of training should be evaluated. Evaluation of programs, including training, will be discussed later in this chapter.

If employees do not have time to participate in an in-person training, consider making web-based training available on an airport intranet site or YouTube. For example:

- The Environmental Defense Fund (EDF), AT&T, and the Global Environmental Management Institute (GEMI) developed a Cooling System Efficiency Guide and associated videos that can be used by airport staff to learn more about the fundamentals of how a cooling system works, and how it can be managed to minimize an airport's use of water, energy, and chemicals.

- The Port of Seattle developed a slide presentation that provides an overview of the Seattle-Tacoma International Airport's water efficiency activities, including background on the airport's water supply, water consumption, and water efficiency projects and messaging. Similar information can be used to explain to employees the importance of their involvement in saving water.

Continuing training efforts are needed to teach new airport staff about the program's operations and keep seasoned airport staff up to date on any changes to the operations.

Create Communication Strategies

Keep in Mind

Outreach is a process that involves communicating information to an audience and getting a response from that audience. How a facility manager chooses to communicate information depends on the audience, intended message, and budget. (Adapted from *Getting in Step: Engaging Stakeholders in Your Watershed.*)

After developing a strategy and providing training to employees on the steps the airport is taking to become more water efficient, the next stage is to decide on additional communication strategies that may be used during the program's implementation. Before moving forward on these efforts, confer with stakeholders to determine if there are any airport-specific protocols or resources that should be followed when developing messaging and outreach materials.

Some programs have found it useful to create a marketing and outreach committee from among members of the team. The committee can handle the communication efforts for the program. In addition, if the airport has any public relations personnel on staff, the facility manager should discuss with them communication about the program before proceeding.

Getting in Step: A Guide for Conducting Watershed Outreach Campaigns contains a section on using outreach to help change behavior, including Social Marketing 101, and building partnerships to achieve goals. Though this guide focuses mainly on communicating about watershed programs, it does contains information that airports may find helpful when communicating with stakeholders in the airport's water efficiency program.

Step 1. Develop a Mission Statement

A mission statement, while optional, can improve communication about the goals of the action plan. The mission statement—made up of vision, mission, and core values—can serve as a foundation for the program, allowing stakeholders to more easily discuss the program, its vision, and goals.

The development of the mission statement may include a subset of the team; typically, three to six people are a good size for a writing team. In selecting the writing team, consider using public relations personnel, or other available in-house staff who may have experience writing mission statements, as a resource during the process. The writing team should work together to draft the mission statement and should gather the feedback and consensus of the entire implementation team to revise and finalize it. Confirm with the airport decision makers if approval of the mission statement is needed.

To develop the mission statement, the team should first ensure that it fully understands the purpose of the program. It may help the team to brainstorm ideas as a group. During this process, questions may arise about the program and its purpose and goals. The writing team may make a list of these questions and bring them back to the whole implementation team to answer as a group. The writing team can then use the additional information from the implementation team to support the development of the mission statement. The writing team should consider the customers, services provided, and overall program goal.

Overall, the mission statement should be simple, capturing the essence of goals of the program and how the airport will achieve those goals. A mission statement is not set in stone and can be changed over time as the vision, mission, and values change.

For examples of mission statements for state and public water utility water conservation and water efficiency programs, see the Great Lakes/St. Lawrence River Water Conservation Model Policies & Measures document.

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Recommendation

Ensure that all outreach information is readily accessible and understandable to the general public.

Step 2. Brainstorm Communication Channels

When developing the communication plan for the program, the implementation team should consider all of the stakeholders identified. The team will need to think about the best communication channels to engage with the airport's stakeholders and elicit their input.

During the early stages of the program's implementation, ensure that employees, vendors, and third-party operations (e.g., airline tenants, hotels, car rental facilities) know about the program and why it is being implemented by the airport. Determine the best way to get in touch with airport employees and partners, recognizing that communication channels may vary among the different parties.

Overall, it is important to have multiple communication channels to maximize the potential for stakeholders (from employees to travelers to airport decision makers) to hear or read about the benefits of undertaking a water efficiency management program. Examples of useful means of communication may include promotional brochures available for distribution and posted on the airport's website, posters in the terminal lobbies, and posts on social media outlets.

Step 3. Develop a Communication Plan

Prior to conducting public outreach, airports should develop a communication plan. A communication plan can help to ensure outreach is conducted consistently and in the appropriate channels. Depending on the size of the airport and any pre-established communication channels, an extensive communication plan may not be necessary—in fact, these plans can be simple. A communication plan in its simplest form should include the list of communication projects and the timeline to update the products as the plan moves forward.

Communication plans may include the following steps:

1. Summarize the program's goals and objectives (established in the action plan)
2. Identify target audiences relevant to goals and objectives
3. Develop the message, based on the program's goals, objectives, and audience(s)
4. Package and distribute the message in formats appropriate to the audience(s)
5. Evaluate the outreach efforts and adjust as necessary. A discussion of outreach evaluation efforts is included in Chapter 7

Water and Energy Efficiency Program for Commercial, Industrial, and Institutional Customer Classes in Southern California, Volume 4: Water and Energy Efficiency Marketing and Outreach Practices Review shows how communication plans can be used to explain the following:

- How to maintain and extend the use of multiple communication channels—training, public events, emails, telephone calls, and other marketing and outreach activities—to encourage customers to engage in water efficiency activities
- The extent to which water efficiency marketing and outreach efforts should be coordinated across the airport's service areas to maximize traveler participation
- Any special circumstances that may affect a traveler's or staff member's response to adopting water efficiency options, for example, customer needs, plant-level conditions, operating constraints
- Whether there is value in creating a centralized website for the program to communicate information about the goals and vision of the program, as well as updates and outcomes

When developing the communication plan, consider the available funding resources for outreach efforts. These funds should be outlined in the program's budget. *Survival Guide: Public Communications for Water Professionals* provides suggestions to ensure the cost efficiency of the communications effort. For every activity or tool the airport plans to use, it should:

- Chart the cost of staffing and materials (graphic design, printing, mailing, etc.)
- Estimate who will be reached and how important they are to the program
- Determine the cost for each activity or tool on a per-person basis to determine if the activity or tool is cost-effective. The cost of the effort should include staff time (hours multiplied by wage), materials (e.g., brochures, presentation slides), services (e.g., printing and designing), and operating costs (e.g., computers, phones). See Exhibit 13 for an example.

Step 4. Brand the Program

Branding the program can help to make the water efficiency management program initiative consistent and memorable. *Getting in Step: A Guide for Conducting Watershed Outreach Campaigns* contains a section on branding a program that includes this advice:

> "A brand is a trademark, name, phrase, logo, or design given to a product or an organization. A brand can also be a behavior your group is focused on addressing. Brands are used to create a consistent, memorable identity for your product or project. Brand identity is what you want people to think or feel when they see or hear your brand. When developing a brand, you are hoping to build a positive, action-motivating brand image. For example, the U.S. EPA's WaterSense label is a brand for a water efficiency program."

Exhibit 13. Cost efficiency determination table (adapted from *Survival Guide: Public Communications for Water Professionals*).

Activity or Tool	Total Cost	Audience Reached	Cost Per Person
Water Efficiency Signage	$3,000	56,000	$0.053
Vendor Billing Insert	$250	50	$5.000
News Article	$60	60,000	$0.001

Step 5. Craft the Messaging

Developing a clear, simple, but robust message that appeals to the broad range of stakeholders and can be used when updating the websites, press releases, brochures, and other promotional material can help make the water efficiency management program consistent and memorable. Messages need to have a hook that is personal to the audience, resonating with their interests and values. They can also be light hearted and humorous in an attempt to draw an emotional reaction from the audience. Finally, messages should clearly identify the actions the audience should take (if appropriate).

Keep in Mind

Reach × Frequency = Results

Therefore, repeat your message and repeat it often. (Adapted from *Getting in Step: Engaging Stakeholders in Your Watershed.*)

The messages must resonate with the audience. The following are questions to keep in mind when developing messages for the target audience(s):

- What is the demographic makeup of the audience?
- How does the audience receive its information?
- What is the knowledge base of the audience regarding the issues involved?
- What are the perceptions and attitudes of the audience on those issues?

For more information on how to craft an effective message, see Part 2, Step 3: Create a Message in *Getting in Step: A Guide for Conducting Watershed Outreach Campaigns.*

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In addition to messaging, take time to develop charts, graphs, infographics, and other images to communicate more easily with a wider audience. Stick to a particular theme or style, which will spur greater employee attention. Ideally, the airport should seek graphic design expertise when designing graphics. When developing materials, or re-using materials from other airports or facilities, consider the airport's location. Tying the messaging to the local issues and values will be more compelling for travelers and will draw their attention.

For a list of free online photo galleries, which can be used in designing graphics and other materials, see page 83 of *Getting in Step: A Guide for Conducting Watershed Outreach Campaigns.*

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The presentation Sustainable Water Management, Northwest Perspective, Seattle-Tacoma International Airport also includes some images of the messaging efforts at the airport.

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Step 6. Package and Distribute

Now that the audience and message have been established, it is time to determine the best outreach "package," whether it be a poster, brochure, video advertisement, etc.

When discussing various outreach method options, consider the following questions:

- Is the package appropriate for the target audience?
- Is it user-friendly?
- Does it clearly communicate the message?
- How will the target audience access and use the information?
- Is it something they will see once and discard, or refer to often?
- Can it be produced in-house with existing resources?
- How much will it cost, and who will pay for it?
- Are there existing formats or templates that can be tapped into?

It is not necessary to "reinvent the wheel." Airports can get started with the communication examples and templates provided in the toolbox. But it is important for each airport to revise the materials to fit the vision and goals of its program.

The communication should express support for the program; urge employees to participate in the program; and explain the changes to be made, the difference employees will make, and why water-efficient practices are important. The following is a list of basic means of communication that airports may use to reach their audience:

Recommendation

In outreach products, include ideas for home water conservation so staff and customers can lower their personal expenses. Water utilities may have materials to support this effort.

- Social media post
- Logos with a slogan
- Water conservation display highlighting different aspects of water use affected by the program (e.g., landscaping, high-efficiency plumbing products)
- Emails/letters to internal staff
- If the airport has an employee newsletter, a water column highlighting the progress of the program and water savings (following the program's implementation)
- Press releases
- Website updates
- Brochures, pamphlets, and flyers promoting water efficiency initiatives (may be placed on employee bulletin boards)
- Signage, including infographics
- Water efficiency report (may be a portion of an airport's existing sustainability report; following the program's implementation)
- Signage near end use water fixtures (e.g., faucets, drinking fountains, toilets), both during projects as well as following the completion of the projects so customers are aware of the airport's water-savings initiatives. Signage may include instructions on how to use high-efficiency toilets and urinals, automatic faucets, etc.
- Water-saving contests, including applicable promotional material (e.g., a contest that challenges staff and customers to save a certain amount of water)

WaterMAPP includes resources that communicate water efficiency:

- The EDF-GEMI Water Scorecard can be used to create visibility for water performance at facilities. The Water Scorecard offers an overview of the scorecard concept, calculations used by AT&T in developing their first scorecard, and detailed information about how to develop a scorecard.
- Easy-to-understand general infographics (which can serve as examples) to help airports initiate the water conversation, drive awareness, and encourage participation and support by employees.

Best Management Practices for Industrial Water Users consolidates BMPs that were developed for conservation planning, program development, implementation, and evaluation, based on feedback provided by water users that have had these experiences. The manual includes educational BMPs for employees and management that are structured for delivering a conservation measure or series of measures that is useful, proven, cost-effective, and generally accepted among conservation experts.

Next Steps

After establishing an implementation strategy, including communication activities and employee training, the next step is to create a process for measuring and evaluating progress based on the established goals. This process will be discussed in Chapter 7, which will also discuss best practices for communicating the program's progress to both internal and external audiences.

CHAPTER 7

Maintaining, Evaluating, and Revising the Water Efficiency Program

The water efficiency management team should periodically conduct a formal review of water end use data and the action plan and determine if the program is achieving the established goals. This review will allow the airport to evaluate progress, set new goals, and continually improve. The water efficiency management team can also use this time to demonstrate and promote the success of the program, which can provide long-term support for the program and future projects and initiatives. *WaterSense at Work* guidance recommends the formal review include the following:

- A review of water bills and meter and submeter readings to verify that the expected water savings are achieved
- A review of the action plan, at least on an annual basis, and revision of water management goals as they are achieved
- A detailed reassessment of the program every 4 years

Successful maintenance of a water efficiency management program begins with its planning and runs through its implementation. *A Water Conservation Guide for Commercial, Institutional and Industrial Users* provides a list of eight keys to a successful water management program:

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1. Water management plans must be part of an integrated approach that examines how changes in water use will affect all other areas of operation.
2. Water conservation involves two distinct areas: technical and human. The technical side includes collecting data from water audits and installing water-efficient fixtures and procedures. The human side involves changing behaviors and expectations about water usage and "the way things should be done." Both areas must be addressed for a water conservation program to succeed.
3. A water conservation plan depends upon accurate data. Before water-saving measures are implemented, a thorough water audit should be conducted to determine where water is being used. Then, water use can be monitored to track conservation progress.
4. A successful water conservation plan follows a logical sequence of events. Implementation should be conducted in phases, starting with the most obvious and lowest-cost options.
5. An effective plan examines not just how much water is being used, but how it is used and by whom. When analyzing a water audit, ask the next question: "Can this process be done as well or better using less water?"
6. The quality of water needed should be matched with the application. Many commercial, institutional, and industrial applications do not require the use of potable water. Whenever possible, substitute recycled water used in one process for use in another. (For example, spent rinse water can often be reused in a cooling tower.)
7. The true cost of water must be considered when conducting a cost analysis. The true cost of water is the amount on the water bill *plus* the expense to heat, cool, treat, pump, and dispose of/discharge the water.

8. Life-cycle costing is the key to evaluating water conservation options. Do not just calculate the initial investment. Many conservation retrofits that appear to be prohibitively expensive are actually very cost-effective when amortized over the life of the equipment.

Challenge: Strategies and Goals

It is impossible to create one water efficiency management program that will work for every airport because each airport has different motivations. **Solution:** Determine the motivation behind the need for water efficiency. Motivation is critical because it influences water efficiency goals and the strategies chosen to achieve those goals. For example: Some airports face long-term drought conditions and need to craft a program that can achieve immediate and lasting results. Other airports need a program that can be responsive when needed due to acute water shortages that are relatively temporary and short-lived in nature. Some airports are seeking permanent efficiency improvements; others want to maximize monetary savings; and others are looking to drive success in their overall sustainability plans.

APPENDIX

An Example Cost-Benefit Analysis of Water Efficiency Measures

A critical component of an airport's development of a water efficiency program is an evaluation of the program's economic feasibility. As explained in Chapter 4, cost-benefit analyses can help airports compare alternative water efficiency measures and choose those that have the highest value for the airport. This appendix demonstrates how to use cost-benefit analyses to choose appropriate water efficiency measures. It also shows how information from the End Use Water Audit Tool can be incorporated into the analysis.

An example airport is used throughout the guidebook to illustrate features of the End Use Water Audit Tool. The description of the example airport is repeated here and used to illustrate the cost-benefit analysis.

As described in Chapter 4, cost-benefit analyses use several measures of the value of a program. Four important measures include:

- Net present value: the difference between benefits and costs. Future costs and benefits are discounted to provide estimates of their present value. This provides the most general and complete measure of the value of the program.
- Benefit-cost ratios: the ratio of discounted benefits and costs. This provides a measure of the return on the investment, or "bang-per-buck" of the program: the dollar saved per dollar invested.
- Cost-effectiveness: the cost of the investment per gallon of water saved. This measure will help identify the least expensive approach to save a given quantity of water.
- Payback period: the amount of time (months or years) it will take to recoup the initial investment. A water efficiency program will likely require an upfront investment to install the water-saving devices, and it will produce water savings for several years. This measure estimates the amount of time it will take for value of the water savings to equal the initial investment.

The example analysis relies primarily on net present value. It also discusses benefit-cost ratios, cost-effectiveness, and payback periods. Formulas for each are provided in Exhibit 10 in Part 1, Chapter 4.

Example Airport

The example airport has about 300 flights per day. It has **three terminals:** domestic, international, and executive.

- The domestic terminal is 1.5 million square feet and has approximately 40,000 passengers per day. There are two sets of restrooms (each set is one men's room and one women's room), two sit-down restaurants, and four coffee shops. The terminal has a cooling tower and has about 50,000 square feet of turf landscaping that is watered three times a week.

- The international terminal is 0.5 million square feet and averages approximately 10,000 passengers per day. It has two sets of restrooms, one sit-down restaurant, and two coffee shops. The terminal has a cooling tower and has about 10,000 square feet of turf landscaping that is watered three times a week.
- The executive terminal has a 12,500 square foot lounge area with restrooms and is used by 250 persons per day. There is about 3,000 square feet of turf landscaping that is watered three times a week.

Food service management for both the domestic and international terminals estimates sit-down meals are served to about one of every five passengers.

Cooling towers and **irrigation systems** are typically in operation 6 months out of the year. The cooling tower in the main terminal (domestic) has drift eliminators and is operated at 6 cycles of concentration. Other cooling towers throughout the airport have more standard induced draft systems and are operated at 4 cycles of concentration.

There are two **parking facilities** each with about 3,000 square feet of turf landscaping that is watered three times a week. No vehicle washing occurs at these facilities.

There is a **shuttle bus waiting area** with restrooms that can also be accessed by parking patrons. It can be assumed that about 10 percent of airport passengers use these restrooms. All shuttle vehicles are washed off site.

There is a centralized **rental car facility** with public restrooms that rents 500 cars per day and has 1,000 square feet of turf landscaping that is watered three times a week. Each returned vehicle is washed. There are five separate employee break rooms with restrooms. There are a total of 75 employees.

There are two **airline maintenance facilities (hangars).** Each has about 30 employees and restrooms and break rooms. There is a cargo shipping facility with about 50 employees that has restrooms and a break room. There are five small corporate/private hangars associated with the executive terminal; each has a single restroom.

There is a 35,000 square foot **flight kitchen** with about 50 employees that prepare about 2,000 meals per day. There is a cooling tower, restrooms, break room, and the commercial kitchen area.

The **aircraft rescue & firefighting facility** is staffed 24 hours per day, 7 days per week with 10 personnel per shift. There is a kitchen area and restrooms. There are four firefighting training exercises per year that use about 30,000 gallons of water per event.

The airport authority has an **office** with 100 employees that has restrooms and a break room. The FAA also has an office building and control tower with 30 employees, restrooms, and break rooms.

The airport does not have a centralized heating and cooling facility.

Nearly all restroom fixtures in public areas and offices have 1.6-gallon-per-flush toilets, 1.0-gallon-per-flush urinals, and 1 gallon-per-minute faucets. Restroom fixtures in nearly all hangars and maintenance areas have 3.5-gallon-per-flush toilets, 2.0-gallon-per-flush urinals, and 2-gallon-per-minute faucets.

Exhibit A1 summarizes the water footprint of the example airport and the potential water savings by the type of facility. (A discussion of developing the water footprint is provided

Exhibit A1. Baseline water footprint and potential savings by facility group for the example airport.

Facility Group	Estimated GPD	Total Use (%)	Optimal GPD	Savings GPD	Total Savings (%)	Water Use Ratio
Terminals	284,004	89.9	190,633	93,372	32.9	1.49
Office Buildings	1,100	0.3	662	438	39.8	1.66
Rental Car Center	10,271	3.3	7,198	3,073	29.9	1.43
Ground Transportation	4,965	1.6	2,998	1,967	39.6	1.66
Parking	1,018	0.3	375	643	63.2	2.72
Fire and Police Stations	1,003	0.3	415	588	58.6	2.42
Hotels	0	0.0	0	0	0.0	–
Central Heating/Cooling Plant	0	0.0	0	0	0.0	–
Maintenance & Services	3,022	1.0	805	2,217	73.4	3.76
Airlines/Cargo Hangars	10,559	3.3	5,289	5,270	49.9	2.00
TOTAL	315,941	100.0	208,373	107,567	34.0	1.52

in Part 1, Chapter 2, and an example is provided in Part 2, Tool 1.) Exhibit A2 summarizes water use and potential savings by water use area, while Exhibit A3 breaks water use down by end uses.

Most of the water is used in the airport terminals. A large share of water use is associated with restrooms, food service, maintenance, and landscaping. Most of the maintenance water use is for cooling towers. (As noted in Tool 1, a large volume of water is designated as "other" water use. "Other" uses include miscellaneous categories for water uses that are not accounted for by the pre-defined list of end uses. It also may include water that falls under multiple end uses; an individual fixture may have multiple uses, for example. Information also may be limited regarding interior water use in some facilities. The airport can affect "other" water use by changing some operations and procedures. But it will need to learn more about the "other" use.)

Exhibit A2. Baseline water footprint and potential savings by water use area for the example airport.

Water Use Areas	GPD	Total Use (%)	Optimal GPD	Savings GPD	Savings (%)	Water Use Ratio
Restrooms	88,787	28.1	51,826	36,961	41.6	1.71
Food service	16,525	5.2	6,356	10,169	61.5	2.60
Break rooms	197	0.1	49	148	75.0	4.00
Guestrooms	0	0.0	0	0	0.0	–
Flight kitchens	3,560	1.1	1,340	2,220	62.4	2.66
Aircraft	1,670	0.5	418	1,253	75.0	4.00
Landscaping	13,896	4.4	287	13,609	97.9	48.36
Maintenance	127,581	40.4	105,615	21,967	17.2	1.21
Other	63,725	20.2	42,483	21,242	33.3	1.50
TOTAL	315,941	100.0	208,373	107,567	34.0	1.52

Exhibit A3. Baseline water footprint and potential savings by water end use for the example airport.

Use	GPD	Total Use (%)	Optimal GPD	Savings GPD	Savings (%)	Water Use Ratio
Toilets	57,702	18.3	44,571	13,131	22.8	1.29
Urinals	21,521	6.8	2,612	18,909	87.9	8.24
Faucets	9,762	3.1	4,692	5,070	51.9	2.08
Kitchen faucets	12,000	3.8	6,000	6,000	50.0	2.00
Pre-rinse spray valves	400	0.1	256	144	36.0	1.56
Dishwashers	2,060	0.7	600	1,460	70.9	3.43
Ice machines	5,625	1.8	840	4,785	85.1	6.70
Showers	0	0.0	0	0	0.0	–
Swimming pool	0	0.0	0	0	0.0	–
Laundry	0	0.0	0	0	0.0	–
Boiler	0	0.0	0	0	0.0	–
Cooling	117,734	37.3	98,280	19,454	16.5	1.20
Outdoor irrigation	13,896	4.4	287	13,609	97.9	48.36
Vehicle washing	9,240	2.9	6,930	2,310	25.0	1.33
Pavement cleaning	592	0.2	395	197	33.3	1.50
Training	15	0.0	10	5	33.3	1.50
Snow removal	0	0.0	0	0	0.0	–
Fleet vehicle washing	0	0.0	0	0	0.0	–
Runway rubber removal	0	0.0	0	0	0.0	–
Aircraft cleaning	0	0.0	0	0	0.0	–
Onboard aircraft water	0	0.0	0	0	0.0	–
Deicing	1,670	0.5	418	1,253	75.0	4.00
Other	63,725	20.2	42,483	21,242	33.3	1.50
TOTAL	315,941	100.0	208,373	107,567	34.0	1.52

The End Use Water Audit Tool analysis shows that the airport can save a significant amount of water by upgrading the fixtures in its restrooms. While the fixtures are relatively efficient, restrooms use almost 89,000 gallons of water per day so even small improvements can save substantial amounts of water.

The airport can also save water by improving cooling tower efficiency and by modifying landscaping and irrigation practices, which are relatively inefficient. (The irrigation water use ratio is 3.75 times the efficient level.) While the analysis shows that commercial dishwashers and ice machines are using water inefficiently, these fixtures are under the domain of the concessionaire contractor and not under the direct control of the airport management. (The airport can pass this information to its concessionaire contractor and encourage them to consider upgrading their equipment.)

Based on this analysis, the airport is considering three projects:

- Replacing restroom fixtures with high-efficiency fixtures
- Replacing standard spray sprinklers with more efficient rotors, or modifying the landscape material
- Revising the operations of cooling towers

Cost-Benefit Analysis of Restroom Retrofit

The airport is exploring replacing toilets, urinals, and faucets in the domestic and international terminals. (A fixed base operator manages the executive terminal and is responsible for its water use.) An inventory of the restroom fixtures shows the following:

- No low-efficiency toilets (3.5 gallons per flush)
- 72 moderate-efficiency toilets (average of 1.6 gallons per flush)
- No high-efficiency toilets (average of 1.28 gallons per flush)
- No low-efficiency urinals (2 gallons per flush)
- 36 moderate-efficiency urinals (average of 1 gallon per flush)
- No high-efficiency urinals (average of 0.25 gallons per flush)
- No low-efficiency faucets (2 gallons per minute)
- 72 moderate-efficiency faucets (average of 1 gallon per minute)
- No high-efficiency faucets (average of 0.5 gallons per minute)

The project would replace the moderate-efficiency fixtures with high-efficiency fixtures. This would require purchasing and installing 72 toilets, 36 urinals, and 72 faucets. The airport contacts local vendors and determines the cost of purchasing the new fixtures. The number of fixtures and their costs are shown in the second and third columns of Exhibit A4. The initial investment will include the cost of the labor to install the fixtures. The estimated time needed to install each fixture is in the fourth column of Exhibit A4. The fully loaded labor cost of the airport's maintenance staff that will install the fixtures is an average of $50 per hour. The total cost of purchasing and installing the fixtures is $48,600.

The airport assumes there are no incremental operations and maintenance costs associated with the new fixtures. However, it will provide training for its staff on leak detection and other measures to ensure the new fixtures are working properly. It assumes 10 staff members will receive 8 hours of training per year, on average. At an average hourly rate of $50, the training costs $4,000 per year.

The End Use Water Audit Tool shows that replacing the restroom fixtures only in the domestic and international terminals would save about 23,500 gallons of water per day or 8.6 million gallons per year. The airport pays $3.50 per hundred cubic feet for water, plus $1.50 per hundred cubic feet of water to cover sewer charges. With 748 gallons per hundred cubic feet, the cost per gallon is approximately $6.68 per 1,000 gallons ($5.00 divided by 0.748 thousand gallons per hundred cubic feet). Thus, the value of the water saved is about $57,400 per year.

Exhibit A5 shows the annual costs and benefits of installing the new fixtures. The airport assumes the fixtures last 20 years and are installed in 2016. The first column shows the year of the analysis. The second column shows annual costs (i.e., the initial investment of $48,600 plus the annual training costs of $4,000 per year). The next column shows the volume of water saved each year, in thousands of gallons. The fourth column shows the benefits, or the dollar value of

Exhibit A4. Cost of new restroom fixtures.

Fixture	Number of Fixtures	Cost per Fixture	Installation Hours per Fixture	Hourly Rate (fully loaded)	Total Cost
Faucets	72	$200	1	$50	18,000
Toilets	72	$200	2	$50	21,600
Urinals	36	$200	1	$50	9,000
Total	**180**	**$36,000**	**252**	**$12,600**	**$48,600**

Exhibit A5. Annual costs and benefits of replacing restroom fixtures in example airport terminals.

	Annual Costs & Benefits						Discounted (Present) Costs & Benefits				
Year	Costs	Water Saved (1000 gal)	Benefit	Net Benefit	Cumula-tive Net Benefit	Dis-count Factor	Dis-counted Cost	Water Saved (1000 gal)	Discount-ed Benefit	Net Present Benefit	Cumula-tive Net Present Benefit
2016	–$48,600	0	$0	–$48,600	–$48,600	1.000	–$48,600	0	$0	–$48,600	–$48,600
2017	–$4,000	8,593	$57,401	$53,401	$4,801	0.952	–$3,810	8,184	$54,668	$50,858	$2,258
2018	–$4,000	8,593	$57,401	$53,401	$58,202	0.907	–$3,628	7,794	$52,065	$48,436	$50,695
2019	–$4,000	8,593	$57,401	$53,401	$111,604	0.864	–$3,455	7,423	$49,585	$46,130	$96,825
2020	–$4,000	8,593	$57,401	$53,401	$165,005	0.823	–$3,291	7,069	$47,224	$43,933	$140,758
2021	–$4,000	8,593	$57,401	$53,401	$218,406	0.784	–$3,134	6,733	$44,975	$41,841	$182,599
2022	–$4,000	8,593	$57,401	$53,401	$271,807	0.746	–$2,985	6,412	$42,834	$39,849	$222,448
2023	–$4,000	8,593	$57,401	$53,401	$325,209	0.711	–$2,843	6,107	$40,794	$37,951	$260,400
2024	–$4,000	8,593	$57,401	$53,401	$378,610	0.677	–$2,707	5,816	$38,851	$36,144	$296,544
2025	–$4,000	8,593	$57,401	$53,401	$432,011	0.645	–$2,578	5,539	$37,001	$34,423	$330,966
2026	–$4,000	8,593	$57,401	$53,401	$485,412	0.614	–$2,456	5,275	$35,239	$32,784	$363,750
2027	–$4,000	8,593	$57,401	$53,401	$538,814	0.585	–$2,339	5,024	$33,561	$31,223	$394,973
2028	–$4,000	8,593	$57,401	$53,401	$592,215	0.557	–$2,227	4,785	$31,963	$29,736	$424,709
2029	–$4,000	8,593	$57,401	$53,401	$645,616	0.530	–$2,121	4,557	$30,441	$28,320	$453,028
2030	–$4,000	8,593	$57,401	$53,401	$699,017	0.505	–$2,020	4,340	$28,992	$26,971	$480,000
2031	–$4,000	8,593	$57,401	$53,401	$752,419	0.481	–$1,924	4,133	$27,611	$25,687	$505,687
2032	–$4,000	8,593	$57,401	$53,401	$805,820	0.458	–$1,832	3,937	$26,296	$24,464	$530,150
2033	–$4,000	8,593	$57,401	$53,401	$859,221	0.436	–$1,745	3,749	$25,044	$23,299	$553,449
2034	–$4,000	8,593	$57,401	$53,401	$912,622	0.416	–$1,662	3,571	$23,851	$22,189	$575,638
2035	–$4,000	8,593	$57,401	$53,401	$966,024	0.396	–$1,583	3,401	$22,716	$21,133	$596,771
Total	**–$124,600**	**163,267**	**$1,090,624**	**$966,024**			**–$96,941**	**103,849**	**$693,712**	**$596,771**	

the water savings. The next column shows the net benefit each year (i.e., the difference between costs and benefits). The next column shows the cumulative net benefit (i.e., the sum across years of the annual net benefits).

For example, in 2017 the cumulative net benefit is the net benefit in 2016 (i.e., the cost of –$48,600), plus the net benefit that accrues in 2017 ($53,401), for a cumulative total of $4,801. In 2018 it is the net benefit in 2017 of $4,801 plus the net benefit of $53,401 accruing in 2018, for a total of $58,202.

To calculate the simple payback period, calculate the cumulative net benefit and determine the year in which it becomes positive. Therefore, the sixth column of the table can be used to calculate simple payback. The net cost of the new fixtures in the first year is $48,600. In year 2, the net cost is only $4,000 and yet the project generates $57,401 worth of water savings. Thus, the net value after the second year is positive and the project pays for itself by the second year.

To calculate the present value of the project, the analysis must discount future costs and benefits. The analysis assumes the cost of capital for the airport is 5 percent, which is used to calculate present value. The seventh column of Exhibit A5 shows the annual discount factor for a 5 percent discount rate. The next column shows the present value of each year's cost (i.e., the annual cost multiplied by the discount factor). The ninth and tenth columns show the present value of the quantity of water saved and the corresponding dollar value, respectively. The final two columns show the annual net present value of the project and the cumulative net present value. The last column shows that, even on a discounted basis, the project pays for itself within the second year.

The net present value of the project is the sum of column 11, about $596,700. (It is also given by adding together the sum of the discounted costs in column 8 and discounted benefits in column 10.) The benefit-cost ratio is the sum of the discounted benefits in column 10 ($693,712) divided by the absolute value of the sum of the discounted costs in column 8 ($96,941) or 7.16.

The unit cost per thousand gallons, or the cost-effectiveness ratio, is the absolute value of the sum of the discounted costs in column 8 ($96,941) divided by the sum of the discounted water saved in column 9 (103,849,000 gallons) or $0.93 per thousand gallons of water.

This project shows excellent potential to both save water and save money, even in the near term.

Cost-Benefit Analysis of Cooling Tower Modifications

As noted in the description, the cooling tower in the domestic terminal has drift eliminators and is operated at 6 cycles of concentration while other cooling towers throughout the airport have more standard induced draft systems and are operated at 4 cycles of concentration. Other facilities at the airport with cooling towers include the international terminal, the executive terminal, and the flight kitchen. The cooling towers are operated about 6 months of the year.

The End Use Water Audit Tool estimates the volume of make-up water for cooling towers using a standard algorithm and basic assumptions such that an estimate of make-up water can be derived from simply knowing the square footage of the area that is cooled. The two factors most likely to be modified are the drift rate and the cycles of concentration. (Note that the estimate of make-up water by the End Use Water Audit Tool includes estimates of both the draw-down replacement water and the evaporative loss.)

The drift (or windage) loss is the amount of water that is lost to the atmosphere due to evaporation. Drift is measured as a percentage of the total water flow and varies according to the design of the cooling tower. The following are typical metrics for drift rate (W):

- W = 0.3 to 1.0 percent of flow for a natural draft cooling tower
- W = 0.1 to 0.3 percent of flow for an induced draft cooling tower
- W = about 0.005 percent of flow if the cooling tower has windage drift eliminators

The cycles of concentration compare the level of dissolved minerals in the blowdown with the level in the cooling tower make-up water. The difference in the level of dissolved solids results from evaporative losses in the cooling tower. To prevent the build-up of minerals within the cooling system, water is drawn off (i.e., "blowdown") and replaced with fresh source water to reduce the levels of minerals in the water. The lower the number of cycles of concentration, the more frequently water must be drawn off and replaced, thus increasing water use.

Source water that is hard (i.e., high in mineral content), such as well water, limits the number of concentration cycles, whereas soft water, such as rainwater, allows cooling towers to operate at a higher number of cycles of concentration. Installing a water softener in advance of the cooling tower will improve the number of cycles of concentration at which the cooling system can be operated without the risk of mineral build-up and will improve the water use efficiency of the system.

Exhibit A6 shows information related to the four cooling towers in the example airport. As noted, the cooling tower for the domestic terminal has drift eliminators (and therefore operates

Exhibit A6. Cooling tower parameters at the example airport.

Facility	Sq. Ft. Cooled	Flow Rate (gpm)	Drift Rate	Delta T (°F)	Cycles of Concentration
Domestic Terminal	1,500,000	9,000	0.01%	10	6
International Terminal	500,000	3,000	0.10%	10	4
Executive Terminal	12,500	75	0.10%	10	4
Flight Kitchen	35,000	210	0.10%	10	6

Exhibit A7. Cooling tower savings at the example airport.

Facility	Current GPD	Optimal GPD	Savings GPD
Domestic	77,760	72,000	5,760
International	28,800	24,000	4,800
Executive	720	600	120
Flight Kitchen	1,815	1,680	135
Total	**109,095**	**98,280**	**10,815**

with a lower drift rate) and operates at a higher number of cycles per concentration. Exhibit A7 shows the estimated potential water savings from operating all the cooling towers at 10 cycles of concentration.

The airport received a contractor bid of $200,000 for the installation of water softeners at each of the four cooling towers. In addition, the airport would have to pay an estimated $8,000 per year in operation and maintenance for this equipment. This equipment would allow the cooling towers to operate at 10 cycles of concentration. Using the same cost of water and discount rate as in the restroom retrofit project, the calculated benefits and costs are shown in Exhibit A8.

In this example, the net present value of the project is only about $22,000 and the payback period is 17 years. The benefit-cost ratio is only slightly greater than 1.0 and the unit cost of the water saved is $6.22, which is almost the current cost of water. This project should be re-evaluated. A second bid from the contractor should be provided for providing water softeners for just the domestic and international terminals.

Exhibit A8. Annual costs and benefits of cooling water softeners at the example airport.

	Annual Costs & Benefits						Discounted (Present) Costs & Benefits				
Year	Costs	Water Saved (1,000 gal)	Benefits	Net Benefit	Cumulative Net Benefit	Discount Factor	Discounted Costs	Water Saved (1,000 gal)	Discounted Benefits	Net Present Benefit	Cumulative Net Present Benefit
2016	−$200,000	0	$0	−$200,000	−$200,000	1.000	−$200,000	0	$0	−$200,000	−$200,000
2017	−$8,000	3,947	$26,368	$18,368	−$181,632	0.952	−$7,619	3,759	$25,112	$17,493	−$182,507
2018	−$8,000	3,947	$26,368	$18,368	−$163,264	0.907	−$7,256	3,580	$23,916	$16,660	−$165,847
2019	−$8,000	3,947	$26,368	$18,368	−$144,896	0.864	−$6,911	3,410	$22,778	$15,867	−$149,980
2020	−$8,000	3,947	$26,368	$18,368	−$126,528	0.823	−$6,582	3,247	$21,693	$15,111	−$134,868
2021	−$8,000	3,947	$26,368	$18,368	−$108,160	0.784	−$6,268	3,093	$20,660	$14,392	−$120,477
2022	−$8,000	3,947	$26,368	$18,368	−$89,793	0.746	−$5,970	2,946	$19,676	$13,706	−$106,770
2023	−$8,000	3,947	$26,368	$18,368	−$71,425	0.711	−$5,685	2,805	$18,739	$13,054	−$93,716
2024	−$8,000	3,947	$26,368	$18,368	−$53,057	0.677	−$5,415	2,672	$17,847	$12,432	−$81,284
2025	−$8,000	3,947	$26,368	$18,368	−$34,689	0.645	−$5,157	2,544	$16,997	$11,840	−$69,444
2026	−$8,000	3,947	$26,368	$18,368	−$16,321	0.614	−$4,911	2,423	$16,188	$11,276	−$58,168
2027	−$8,000	3,947	$26,368	$18,368	$2,047	0.585	−$4,677	2,308	$15,417	$10,739	−$47,428
2028	−$8,000	3,947	$26,368	$18,368	$20,415	0.557	−$4,455	2,198	$14,683	$10,228	−$37,201
2029	−$8,000	3,947	$26,368	$18,368	$38,783	0.530	−$4,243	2,093	$13,983	$9,741	−$27,460
2030	−$8,000	3,947	$26,368	$18,368	$57,151	0.505	−$4,041	1,994	$13,318	$9,277	−$18,183
2031	−$8,000	3,947	$26,368	$18,368	$75,519	0.481	−$3,848	1,899	$12,683	$8,835	−$9,347
2032	−$8,000	3,947	$26,368	$18,368	$93,887	0.458	−$3,665	1,808	$12,079	$8,415	−$933
2033	−$8,000	3,947	$26,368	$18,368	$112,255	0.436	−$3,490	1,722	$11,504	$8,014	$7,081
2034	−$8,000	3,947	$26,368	$18,368	$130,622	0.416	−$3,324	1,640	$10,956	$7,632	$14,713
2035	−$8,000	3,947	$26,368	$18,368	$148,990	0.396	−$3,166	1,562	$10,435	$7,269	$21,982
Total	−$352,000	74,999	$500,990	$148,990			−$296,683	47,704	$318,665	$21,982	

Exhibit A9. Gallons per day per square foot.*

Landscaping	Irrigation Type		
	Spray	Rotor	Drip
Turf	0.15	0.13	N/A
Flowers	0.12	0.10	0.07
Shrubs	0.07	0.06	0.04
Groundcover	0.06	0.05	0.04
Drought-tolerant	0.00	0.00	0.00

*Assumes weekly requirement divided by 7.

Cost-Benefit Analysis of Landscape Modifications

As indicated in the description of the example airport, there are a number of facilities with irrigated landscape. As discussed in the Tool 1 illustration of the End Use Water Audit Tool using this example airport, those facilities at which irrigation water use is separately metered indicate a very poor level of irrigation efficiency. It is recommended that the airport review the type of landscape material and the efficiency of the irrigation technology. The current landscaping consists of turf grass with pop-up spray irrigation heads.

Turf grass requires about one inch of water per week. Flowers, shrubs, and groundcover require less than one inch. Drought-tolerant indigenous plants require hardly any watering at all. Spray irrigation heads lose water to drift and evaporation resulting in only about 60 percent efficiency. This means that additional water must be applied to make up for the efficiency loss. Rotor irrigation heads are about 70 percent efficient; especially those that disperse large water droplets that are less susceptible to drift. Drip irrigation, which can be installed with flowers, scrubs and groundcover, is close to 100 percent efficient. All irrigation systems need constant maintenance and repair to avoid leaks and wasteful spraying (e.g., watering impervious surfaces). These factors of vegetation requirements and irrigation efficiency, plus the conversion of inches to gallons (1 inch of water over 1 square foot = 0.6233 gallons) results in the application rates shown in Exhibit A9. The recommended weekly water requirement is divided by 7 days to derive a daily watering requirement per square foot.

Exhibit A10 identifies water use parameters used in conjunction with irrigation water use estimates in the example airport analysis with the End Use Water Audit Tool. Details of these parameters are discussed in Part 2, Tool 1. In particular, note that the intensity values are changed

Exhibit A10. Irrigation water use parameters in analysis of irrigation at the example airport.

Facility	Irrigated Sq. Ft.	Efficiency Levels (GPD / sq. ft.)			Calibrated Intensity Value	Volume (GPD)
		0.15	0.07	0.04		
Domestic Terminal	50,000	100%	0%	0%	2.67	10,012
International Terminal	10,000	100%	0%	0%	2.67	2,002
Executive Terminal	3,000	100%	0%	0%	1.00	225
Rental Car Center	1,000	100%	0%	0%	4.00	300
East Parking	3,000	100%	0%	0%	1.00	225
West Parking	3,000	100%	0%	0%	1.00	225

for some of the facilities to better reflect actual (metered) irrigation water use. Any irrigation intensity value greater than 1.0 reflects inefficient water use due to leaking systems, or water from this meter being used for purposes other than irrigation.

The first effort to improve landscape water use efficiency would be to assign a staff person to inspect, repair, and monitor the irrigation systems. This would be a half-time position during the irrigation season, or 0.25 full-time employee (FTE) on an annual basis, with $10,000 annual operating budget. The impact of this effort can be measured in the End Use Water Audit Tool by reducing the irrigation intensities that are greater than 1.0 to a level of 1.0 thus reflecting the proper application rate for turf grass by spray heads.

Results of this first effort provide an estimated savings of 7,739 gallons per day, or 2,824,735 gallons per year, savings. However, the economic value of these savings at $6.68 per 1,000 gallons ($18,869 per year) is less than the annual cost of the effort ($36,000), as shown in Exhibit A11. In order for this effort to break even, the labor should be limited to a 0.125 FTE and annual expenses kept below $5,800.

The second effort would be to modify the landscape material and/or the irrigation system. A landscape contractor has submitted a bid to replace all turf landscape with shrubs and ground cover and install drip irrigation at $1 per square foot for an initial cost of $70,000 plus an annual maintenance fee of $20,000. This would shift all landscaped areas from an irrigation application rate of 0.15 inches per day to 0.04 inches per day.

This second proposal would reduce irrigation water use to 1,400 gallons per day. The benefit-cost analysis is shown in Exhibit A12. The project would pay for itself after about 5 years. The present net worth is about $58,000 with a benefit-cost ratio of 1.19. The unit cost of the water saved is $5.63 per 1,000 gallons.

Exhibit A11. Annual costs and benefits of better management of irrigation at the example airport.

	Annual Costs & Benefits						Discounted (Present) Costs & Benefits				
Year	Costs	Water Saved (1,000 gal)	Benefit	Net Benefit	Cumulative Net Benefit	Discount Factor	Discounted Costs	Water Saved (1,000 gal)	Discounted Benefits	Net Present Benefit	Cumulative Net Present Benefit
2016	−$36,000	2,825	$18,869	−$17,131	−$17,131	1.000	−$36,000	2,825	$18,869	−$17,131	−$17,131
2017	−$36,000	2,825	$18,869	−$17,131	−$34,262	0.952	−$34,286	2,690	$17,971	−$16,315	−$33,446
2018	−$36,000	2,825	$18,869	−$17,131	−$51,392	0.907	−$32,653	2,562	$17,115	−$15,538	−$48,984
2019	−$36,000	2,825	$18,869	−$17,131	−$68,523	0.864	−$31,098	2,440	$16,300	−$14,798	−$63,782
2020	−$36,000	2,825	$18,869	−$17,131	−$85,654	0.823	−$29,617	2,324	$15,524	−$14,094	−$77,876
2021	−$36,000	2,825	$18,869	−$17,131	−$102,785	0.784	−$28,207	2,213	$14,785	−$13,422	−$91,298
2022	−$36,000	2,825	$18,869	−$17,131	−$119,915	0.746	−$26,864	2,108	$14,081	−$12,783	−$104,081
2023	−$36,000	2,825	$18,869	−$17,131	−$137,046	0.711	−$25,585	2,007	$13,410	−$12,175	−$116,256
2024	−$36,000	2,825	$18,869	−$17,131	−$154,177	0.677	−$24,366	1,912	$12,771	−$11,595	−$127,851
2025	−$36,000	2,825	$18,869	−$17,131	−$171,308	0.645	−$23,206	1,821	$12,163	−$11,043	−$138,893
2026	−$36,000	2,825	$18,869	−$17,131	−$188,438	0.614	−$22,101	1,734	$11,584	−$10,517	−$149,410
2027	−$36,000	2,825	$18,869	−$17,131	−$205,569	0.585	−$21,048	1,652	$11,032	−$10,016	−$159,426
2028	−$36,000	2,825	$18,869	−$17,131	−$222,700	0.557	−$20,046	1,573	$10,507	−$9,539	−$168,965
2029	−$36,000	2,825	$18,869	−$17,131	−$239,831	0.530	−$19,092	1,498	$10,007	−$9,085	−$178,050
2030	−$36,000	2,825	$18,869	−$17,131	−$256,962	0.505	−$18,182	1,427	$9,530	−$8,652	−$186,702
2031	−$36,000	2,825	$18,869	−$17,131	−$274,092	0.481	−$17,317	1,359	$9,076	−$8,240	−$194,942
2032	−$36,000	2,825	$18,869	−$17,131	−$291,223	0.458	−$16,492	1,294	$8,644	−$7,848	−$202,790
2033	−$36,000	2,825	$18,869	−$17,131	−$308,354	0.436	−$15,707	1,232	$8,233	−$7,474	−$210,264
2034	−$36,000	2,825	$18,869	−$17,131	−$325,485	0.416	−$14,959	1,174	$7,841	−$7,118	−$217,382
2035	−$36,000	2,825	$18,869	−$17,131	−$342,615	0.396	−$14,246	1,118	$7,467	−$6,779	−$224,162
Total	−$720,000	56,495	$377,385	−$342,615			−$471,072	36,963	$246,910	−$224,162	

Exhibit A12. Annual costs and benefits of replacement of landscaping at the example airport.

Year	Annual Costs & Benefits					Dis-count Factor	Discounted (Present) Costs & Benefits				
	Costs	Water Saved (1,000 gal)	Benefits	Net Benefit	Cumula-tive Net Benefit		Dis-counted Costs	Water Saved (1,000 gal)	Discount-ed Benefits	Net Present Benefit	Cumulative Net Present Benefit
2016	–$70,000	4,230	$28,256	–$41,744	–$41,744	1.000	–$70,000	4,230	$28,256	–$41,744	–$41,744
2017	–$20,000	4,230	$28,256	$8,256	–$33,487	0.952	–$19,048	4,029	$26,911	$7,863	–$33,881
2018	–$20,000	4,230	$28,256	$8,256	–$25,231	0.907	–$18,141	3,837	$25,629	$7,489	–$26,392
2019	–$20,000	4,230	$28,256	$8,256	–$16,975	0.864	–$17,277	3,654	$24,409	$7,132	–$19,260
2020	–$20,000	4,230	$28,256	$8,256	–$8,719	0.823	–$16,454	3,480	$23,247	$6,792	–$12,467
2021	–$20,000	4,230	$28,256	$8,256	–$462	0.784	–$15,671	3,314	$22,140	$6,469	–$5,998
2022	–$20,000	4,230	$28,256	$8,256	$7,794	0.746	–$14,924	3,156	$21,085	$6,161	$163
2023	–$20,000	4,230	$28,256	$8,256	$16,050	0.711	–$14,214	3,006	$20,081	$5,868	$6,030
2024	–$20,000	4,230	$28,256	$8,256	$24,307	0.677	–$13,537	2,863	$19,125	$5,588	$11,619
2025	–$20,000	4,230	$28,256	$8,256	$32,563	0.645	–$12,892	2,727	$18,214	$5,322	$16,941
2026	–$20,000	4,230	$28,256	$8,256	$40,819	0.614	–$12,278	2,597	$17,347	$5,069	$22,009
2027	–$20,000	4,230	$28,256	$8,256	$49,076	0.585	–$11,694	2,473	$16,521	$4,827	$26,837
2028	–$20,000	4,230	$28,256	$8,256	$57,332	0.557	–$11,137	2,355	$15,734	$4,597	$31,434
2029	–$20,000	4,230	$28,256	$8,256	$65,588	0.530	–$10,606	2,243	$14,985	$4,378	$35,812
2030	–$20,000	4,230	$28,256	$8,256	$73,844	0.505	–$10,101	2,136	$14,271	$4,170	$39,982
2031	–$20,000	4,230	$28,256	$8,256	$82,101	0.481	–$9,620	2,035	$13,592	$3,971	$43,954
2032	–$20,000	4,230	$28,256	$8,256	$90,357	0.458	–$9,162	1,938	$12,945	$3,782	$47,736
2033	–$20,000	4,230	$28,256	$8,256	$98,613	0.436	–$8,726	1,846	$12,328	$3,602	$51,338
2034	–$20,000	4,230	$28,256	$8,256	$106,870	0.416	–$8,310	1,758	$11,741	$3,431	$54,769
2035	–$20,000	4,230	$28,256	$8,256	$115,126	0.396	–$7,915	1,674	$11,182	$3,267	$58,036
Total	–$450,000	84,600	$565,126	$115,126			–$311,706	55,351	$369,743	$58,036	

The second proposal to replace all landscaping and have a contractor provide annual maintenance is more cost effective than maintaining the current landscaping and improving the irrigation efficiency with airport staff.

Summary of Cost-Benefit Analysis

Exhibit A13 shows the bottom line of the analyses of upgrading fixtures, cooling towers, and landscape irrigation.

The replacement of restroom fixtures in the terminals has the highest net present value and the lowest cost per gallon of water saved. It also has the highest benefit-cost ratio, and the shortest payback period. It should be pursued. If the airport has the resources, the other measures are worthwhile as well and can further reduce water use and costs incurred by the airport. The landscaping project has a higher net present value and benefit-cost ratio, and a shorter payback period and lower unit cost, than the cooling tower project. Therefore, if resources are available, the landscaping project should be considered before the cooling tower project.

Exhibit A13. Comparison of costs and benefits of water efficiency projects for example airport.

Water Efficiency Project	Discounted Volume of Water Saved (1,000 gal)	Present Value of Cost	Present Value of Benefit	Net Present Value	Benefit-Cost Ratio	Unit Cost per 1,000 gal	Discounted Payback Period (years)
Restroom fixtures	103,849	($96,941)	$693,712	$596,771	7.16	$0.93	2
Cooling towers	47,704	($296,683)	$318,665	$21,982	1.07	$6.22	17
Landscaping	55,351	($311,706)	$369,743	$58,036	1.19	$5.63	6

PART 2

Water Efficiency Management Toolbox

TOOL 1

End Use Water Audit Tool—User's Guide

Type of Tool: Spreadsheet tool

Author: The Cadmus Group, Inc. and CDM-Smith

The Purpose of the End Use Water Audit Tool

The water footprint of an airport provides three primary types of information: *how much* water is being used, *where* water is being used, and *how* the water is being used. The water footprint of current water usage is the basis from which current water use efficiency can be evaluated and the baseline from which future water use can be monitored. The End Use Water Audit Tool is designed to assist airport managers in developing the water footprint of their airport. This spreadsheet-based tool was developed in Microsoft® Excel™ to provide transparency for understanding and manipulation by the user. In addition, it is self-contained to eliminate future management and hosting challenges.

The End Use Water Audit Tool was developed with both small and large airports in mind. Thus, the airport manager should be able to use it as generally, or as detailed, as is necessary to get a clear picture of how much water is being used, where it is being used, and how it is being used.

Initially the airport manager should collect and organize information about the airport and its water use in an organized manner before using the tool itself. This first step alone can be informative and can provide insights into airport water use. Then the tool takes you deeper into the understanding of how water is used by associating water use with specific end uses in specific buildings (facilities). Finally, the tool offers an understanding of how current water use technology and practices compare with the best available technology (and practices), and provides a look at where and how water savings can be achieved by shifting to more efficient water use throughout the airport.

Getting Started

As discussed in Chapter 2 of the guidebook, the first step in the process of developing the airport water use footprint is to collect as much water use information as is available. This may include pulling water bills, identifying meter locations and the facilities served by each meter, and determining whether a specific meter has a primary designated use such as irrigation, a cooling tower, or a car wash facility.

It is helpful to have a map of the airport campus that shows all the facilities. If one is not available, a printout from Google® Earth or Google® Maps will work. In some airports, airport cost centers can be used to collect and organize water use information. Financial staff can usually provide a list of meters and historical water use. A year or more of billing records will provide a reasonable estimate of the average water use of each meter. Maintenance staff can be helpful in locating the meters and possibly identifying which facilities are served by each meter.

The metered water use information can be organized by the associated buildings and designated uses. The End Use Water Audit Tool contains a water use data template that can be printed out and used to organize the water use information. The number of rows in the template can be expanded to accommodate the number of facilities at a given airport. Similarly, more columns can be added if additional designated metered water uses are known. In addition, it may help to review the listing of typical airport activities in Exhibit 14 in order to identify which of the End Use Water Audit Tool facility groups is best aligned with the airport facilities that are to be evaluated.

One important step is to determine which facilities on the airport campus to include in the analysis. Many airports have facilities that are privately owned, are under land-leases, or in which the operation and maintenance of the facility is contracted out. Access to water use information for these facilities may not be available, but including these facilities would be useful in estimating the overall airport water use footprint.

Each type of facility has its unique list of water uses. Thus, each facility type requires information that is associated with its list of water uses. The list of "associated units" may include flights per day, passengers per day, meals served, employees, building square footage, cooled area square footage, landscape area square footage, daily car rentals, and other similar data. Exhibit 15 provides a list of the data potentially associated with each facility type. To collect this information, it may be necessary to talk with staff throughout the airport. Some information simply may not be available; in which case, the analysis will need to rely on reasonable estimates. Later in the calibration process, these estimates can be revised, if necessary.

The Layout of the Tool

Worksheet Tabs of the End Use Water Audit Tool

- Introduction
- Airport Activities
- Start Data Entry
- Data Entry
- Detailed Fixture Data
- Irrigation
- Cooling Data
- Intensity of Use Assumptions
- Level of Efficiency Assumptions
- Calibrate & Verify
- Water Use Calcs
- End Uses
- Summary Tables
- Summary Graphics
- Scratch sheets/data collection templates
- Climate Zones (hidden)
- Airport Mapping (hidden)
- Airport Statistics (hidden)
- Lists and List A (hidden)

The End Use Water Audit Tool contains a number of visible worksheets (or "tabs") and some hidden tabs. The hidden tabs contain lists and tables that are used in various lookup functions throughout the file and do not need to be accessed by the user. Similarly, there are hidden columns in most of the tabs that contain repetitive information that is used in the data lookup functions throughout the file. These columns are hidden to improve the look of the file layout. Information contained in these hidden columns will update automatically as changes are made in data inputs. A brief description of each tab and its organization is provided in the next section.

The Start Data Entry tab asks for the types of buildings to be included in the analysis and the number of buildings in each type. An example is provided in the Data Entry section. (If you have organized data according to your own customized version of the Water Use Data Template, then the data you need is in one place for data entry.) All remaining data entry requirements for the tool are combined in the Data Entry tab. Information entered in the Data Entry tab is automatically written to the various other tabs in which the information is used. The only information that is hidden are columns and tables used to organize and find information as it is passed from one tab to the next.

The following is a brief description of each tab in the End Use Water Audit Tool spreadsheet file:

- **Introduction:** This tab provides a brief overview of the tool and its structure.
- **Airport Activities:** A list of airport activities aligned with Facility Groups within the tool (see Exhibit 15).
- **Start Data Entry:** This is the initial data entry interface for the user for identifying which types of buildings are included in the analysis and how many buildings in each building type.

Exhibit 14. Assignment of activities to facility groups based upon end uses and associated metrics.

Airport Activities	Facility Group	Area	End Use	Associated with
Terminal FBO lobby Terminal restaurants Terminal concessions Terminal offices and breakrooms (airlines and airport)	Terminals	Restrooms	Toilets	Passengers per day
			Urinals	Passengers per day
			Faucets	Passengers per day
		Food Service	Kitchen faucets	Meals served
			Pre-rinse spray valves	Meals served
			Dishwashers	Meals served
			Ice machines	Meals served
		Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Boiler	Number of boilers
			Cooling	Cooling area sq. ft.
			Pavement cleaning	Passengers per day
Office Operations center FAA center FAA tower Classroom Conference center	Office Buildings	Restrooms	Toilets	Employees
			Urinals	Employees
			Faucets	Employees
		Break rooms	Faucets	Employees
		Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Boiler	Number of boilers
			Cooling	Cooling area sq. ft.
Car rental facility Quick-turn-around facility	Rental Car Center	Restrooms	Toilets	Employees
			Urinals	Employees
			Faucets	Employees
		Break rooms	Faucets	Employees
		Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Boiler	Number of boilers
			Cooling	Cooling area sq. ft.
			Vehicle washing	Rentals per day
			Pavement cleaning	Rentals per day
Passenger transfer area Taxi driver facility Cell lot—waiting area Vehicle maintenance facility	Ground Transportation	Restrooms	Toilets	Passengers per day
			Urinals	Passengers per day
			Faucets	Passengers per day
		Break rooms	Faucets	Employees
		Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Boiler	Number of boilers
			Cooling	Cooling area sq. ft.
			Vehicle washing	Passengers per day
			Pavement cleaning	Passengers per day
Parking facility	Parking	Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Vehicle washing	Vehicles per day
			Pavement cleaning	Vehicles per day
Aircraft rescue & firefighting Police station K-9 facility	Fire and Police Stations	Restrooms	Toilets	Employees
			Urinals	Employees
			Faucets	Employees
		Break rooms	Faucets	Employees
		Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Vehicle washing	Employees
			Training	Training events
Central heating/cooling facility	Central Heating/Cooling Plant	Maintenance	Boiler	Number of boilers
			Cooling	Cooling area sq. ft.
Maintenance facility Fleet shop Deicing pad	Maintenance & Services	Restrooms	Toilets	Employees
			Urinals	Employees
			Faucets	Employees

(continued on next page)

Exhibit 14. (Continued).

Airport Activities	Facility Group	Area	End Use	Associated with
Fueling facility	Maintenance & Services	Break rooms	Faucets	Employees
Line services	(continued)	Aircraft	Deicing	Flights per day
		Maintenance	Pavement cleaning	Flights per day
			Snow removal	Flights per day
			Fleet vehicle washing	Flights per day
			Runway rubber removal	Flights per day
Airline hangar	Airlines/Cargo Hangars	Restrooms	Toilets	Employees
Aircraft maintenance			Urinals	Employees
FBO hangar			Faucets	Employees
Corporate hangar		Break rooms	Faucets	Employees
Cargo facility		Flight kitchens	Kitchen faucets	Meals served
Flight kitchen			Dishwashers	Meals served
Air National Guard			Ice machines	Meals served
Maintenance, repair & overhaul		Aircraft	Aircraft cleaning	Flights per day
Customs quarantine facility			Onboard aircraft water	Flights per day
			Deicing	Flights per day
		Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Boiler	Number of boilers
			Cooling	Cooling area sq. ft.
			Vehicle washing	Flights per day
			Pavement cleaning	Flights per day
Hotel	Hotels	Guestrooms	Toilets	Occupied rooms per day
Flight school dormitory			Showers	Occupied rooms per day
			Faucets	Occupied rooms per day
		Food service	Kitchen faucets	Meals served
			Pre-rinse spray valves	Meals served
			Dishwashers	Meals served
			Ice machines	Occupied rooms per day
		Landscaping	Outdoor irrigation	Landscape sq. ft.
		Maintenance	Boiler	Number of boilers
			Cooling	Cooling area sq. ft.
			Swimming pool	Pool sq. ft.
			Laundry	Occupied rooms per day

FBO = fixed base operator

Exhibit 15. Associated units by facility type.

Facility Type	Passengers per Day	Employees	Meals Served per Day	Sq. Ft. Irrigated	Sq. Ft. Cooled	Flights per Day	Miscellaneous
Terminals	✓	✓	✓	✓	✓		
Office Buildings		✓		✓	✓		
Rental Car Center		✓		✓	✓		Rentals per day
Bus & Shuttle Facilities	✓	✓		✓	✓		
Parking Facilities		✓		✓	✓		Vehicles per day
Fire and Police Stations		✓		✓			Training events
Heating/Cooling Plant					✓		
Airport Maintenance		✓		✓		✓	
Airline/Cargo Facilities		✓		✓	✓	✓	
Flight Kitchens		✓	✓	✓	✓		
Hotels		✓	✓	✓	✓		Occupied rooms per day

- **Data Entry:** This is the primary data entry interface for the user. Information entered here is then transposed to the appropriate tabs for use in the model calculations.
- **Calibrate & Verify:** This tab is used to compare known water use with the water use estimated by the tool. This comparison determines the magnitude and location of adjustments to model inputs that may be needed to match the estimated water usage with known water usage. The known values are read from the Data Entry tab while the estimated values are read from the Summary Tables tab.
- **Summary Tables:** This tab presents the estimates of water use in a variety of perspectives. The summary data is calculated from the End Uses tab. The Summary Table is the only place where the water use ratio is calculated and reported.
- **Summary Graphics:** This tab has basic graphs derived from the Summary Table tab. These graphics can be used directly or can be the starting point for the development of additional, custom graphics.
- **Airport Mapping:** This tab records the local facility names assigned to the generic facility names from the Data Entry tab. These local names are then used throughout the model.
- **Airport Statistics:** This tab records the number of units for facilities from the Data Entry tab and is read by the End Uses tab.
- **End Uses:** This tab is the final calculation before the Summary Tables. This is where the estimated gallons per day per unit from the Water Use Calcs tab is multiplied by the number of units from the hidden Airport Statistics tab to derive the gallons-per-day values. It is a good location for reviewing specific computations by facility and end use.
- **Intensity of Use Assumptions:** This tab contains the default values for the intensity of use factors by end use. These values may be modified and are typically adjusted during the calibration process. This data is read into the Water Use Calcs tab.
- **Level of Efficiency Assumptions:** This tab contains the three default levels of water use for the levels of efficiency for each fixture type or end use. These may be modified as needed, but any changes may affect multiple facility types. This data is read into the Water Use Calcs tab.
- **Water Use Calcs:** This tab combines the level of intensity values, distribution factors, and the intensity factors to derive the estimates of the gallons per day per unit, which is then read into the End Uses tab.
- **Detailed Fixture Data:** This tab records the distribution of fixtures from the Data Entry tab and allows the user to substitute an efficiency distribution for a specific facility and end use. The substituted efficiency distribution must then be copied manually into the Data Entry tab.
- **Cooling Data:** This tab estimates the volume of water for cooling purposes based on the square footage of the cooled area and other parameters. The square footage is read from the Airport Statistics tab and results are read into the Water Use Calcs tab.
- **Irrigation:** This tab provides information on landscape irrigation requirements and includes the Irrigation Efficiency Calculator. The calculator should be used to generate localized irrigation efficiency factors for an airport based on its location, type of turf, and type of landscaping. This calculator uses tables contained in the hidden Climate Zones tab and writes three efficiency values to the Level of Efficiency tab for landscaping.
- **Lists** (hidden): This tab contains numerous tables and lists that are used by Excel to allow information to pass dynamically between functions of the model.

Data Entry

Basic Data Required

An illustration of the Start Data Entry tab is shown in Exhibit 16. The data in the illustration is from the example airport described in Part 1, Introduction. This example airport is used throughout this user's guide to illustrate the use of the tool. Notice in this example there are a

Exhibit 16. The Start Data Entry tab.

Select "yes" if you have this type of building and want to include them in the analysis.		If Yes, Select # of Buildings from Dropdown List
Terminals	yes	3
Office Buildings	yes	3
Rental Car Center	yes	1
Ground Transportation	yes	1
Parking Buildings	yes	2
Fire and Police Stations	yes	1
Hotels	no	
Central Heating/Cooling Plant	no	0
Maintenance & Services	yes	1
Airlines/Cargo Hangars	yes	5
	Total cannot exceed 32:	**17**

total of 17 different facilities to be evaluated, which corresponds to the example airport data shown in Exhibit 5.

The Start Data Entry tab has two drop-down boxes for each facility type. The first box is a yes/no indicator to identify the types of facilities at the airport. The second drop-down box is for entering the number of each respective facility to be included in the analysis.

After the initial setup of the number of buildings by facility type in the Start Data Entry tab, the data entry for the End Use Water Audit Tool is consolidated into the Data Entry tab of the spreadsheet.

The first information asked for on the Data Entry tab is the average annual water use for the entire airport, if known, as shown in Exhibit 17. If unknown, the tool will still work. The average annual volume of water should be entered as gallons per day (GPD), which is the annual total water use in gallons divided by 365.

Below this is a list of the facility types and number of each type that was entered on the Start Data Entry tab. Each entry has a generic facility name (e.g., Terminal A). As shown in Exhibit 18, users enter the local name of the facility along with the corresponding annual average water use next to each entry.

Notice in this example, as shown in Exhibit 18, that there are a total of 17 individual facilities with a total metered water use of 316,100 gallons per day. This total matches the total meter usage in the description of the airport provided in Part 1, Introduction.

Exhibit 17. Data Entry tab—total airport annual average water use.

Enter Annual Average GPD for Airport, if known	316,100	GPD

Exhibit 18. Data Entry tab—name and annual water use of each facility.

FACILITY	**Facility Type** (Copied from entry on Start Data Entry tab)	**Individual Facility** (Copied from entry on Start Data Entry tab)	**Enter Local Name** of Facility	Enter Annual Average GPD for Facility, if known
1	Terminals	Terminal A	Domestic	210,000
2	Terminals	Terminal B	International	73,000
3	Terminals	Terminal C	Executive	1,200
4	Office Buildings	Office Building A	Airport	800
5	Office Buildings	Office Building B	FAA	200
6	Office Buildings	Office Building C	Tower	100
7	Rental Car Center	Rental Car Center A	RCC	10,300
8	Ground Transportation	Ground Transportation A	Shuttle	5,000
9	Parking	Parking A	East	500
10	Parking	Parking B	West	500
11	Fire and Police Stations	Fire and Police Stations	ARFF	1,000
12	Maintenance & Services	Maintenance & Services	Airside Services	3,000
13	Airlines/Cargo Hangars	Tenant A	Eastern	2,000
14	Airlines/Cargo Hangars	Tenant B	Western	1,000
15	Airlines/Cargo Hangars	Tenant C	Corporate	500
16	Airlines/Cargo Hangars	Tenant D	Cargo	1,000
17	Airlines/Cargo Hangars	Tenant E	Flight Kitchen	6,000
18				
				316,100

Next, scroll down further in the Data Entry tab. Notice that, beginning in row 53, there is a matrix for each individual facility every 20 rows (see rows 73, 93, 113, 133, etc.). Columns A through H (including some hidden columns) on the first row of each facility matrix repeat the information entered above for each facility.

Before continuing, it is a good idea to save what has been done so far. Save the file with the current date imbedded in the file name to keep track of the work. Also, saving the file frequently throughout the data entry process will protect what has been input.

As shown in Exhibit 19, beginning in column I of each facility matrix is a list of end uses unique to that facility type. If you scroll down to a matrix for a different facility type, you will see a different list of end uses. Column L of each matrix identifies the associated units of measure for each end use. Note that multiple end uses may share the same associated unit. Enter the number of units in column M for each type of associated unit. If multiple end uses share the same associated unit, you only need to enter the number of units once. For example, water use for fixtures in restrooms (toilets, urinals, and faucets) in terminals is associated with the number of passengers per day. This value should only be entered once for each individual facility and will be used with each of these individual end uses.

Notice that some end uses, such as boilers and "other," have an "undefined unit." Enter a value of "1" for these types of end uses. Including a value placeholder of "1," "activates" the computation of the water use estimate for this end use for this facility. Later when you review the initial estimates and calibrate the model you may come back and change this undefined unit to some value other than one.

As shown in Exhibit 19, each facility has three end use entries for "other." These entries may be used in three ways: (1) to define unique site-specific end uses that do not fit into the pre-defined

Exhibit 19. Data Entry tab—number of units by facility and water use by end use.

Local Name of Facility	**Annual Average GPD**, copied from above	**Individual End Uses for facility type**	**Associated Units**	**Enter Number of Units** (only enter a value once if it is used multiple times)
Domestic	210000	Restrooms-Toilets	Passengers per day	40,000
		Restrooms-Urinals	Passengers per day	
		Restrooms-Faucets	Passengers per day	
		Food Service-Kitchen faucets	Meals Served	8,000
		Food Service-Pre-rinse spray valves	Meals Served	
		Food Service-Dishwashers	Meals Served	
		Food Service-Ice machines	Meals Served	
		Landscaping-Outdoor irrigation	Landscape sq. ft.	50,000
		Maintenance-Boiler	Number of Boilers	
		Maintenance-Cooling	Cooling Area sq. ft.	1,500,000
		Maintenance-Pavement cleaning	Passengers per day	
		Other-Other 1	Other 1 Undefined Unit	1
		Other-Other 2	Other 2 Undefined Unit	
		Other-Other 3	Other 3 Undefined Unit	

list of general end uses, (2) to capture unidentified or unaccounted for water use, and (3) to fine-tune the estimated water use.

"Other" is a miscellaneous category for each individual facility and may represent water uses that do not fit in the pre-defined list of end uses in the model. The end uses may be specific to a particular airport and are not commonly used throughout the country. The "other" category also may include water that is not otherwise accounted for. It may include water used in construction, for hosing-down tarmac, or other miscellaneous uses that are not part of the daily routine. During the calibration step, the "other" end use can be used to fine-tune the resulting estimated water use for the facility to account for these miscellaneous water uses and match a metered quantity of water use, if it is known.

Efficiency of Existing Water Use

The next step in data entry is to enter information on the distribution of fixtures for each end use according to three separate levels of efficiency. The default values for the levels of efficiency are set in the Level of Efficiency Assumptions tab of the spreadsheet, as shown in Exhibit 20. These default values are read into the Data Entry tab for the listed end uses of each individual facility. The three levels of efficiency are defined as Least Efficient, Standard Efficiency, and Best Available Efficiency. Note that making a change to the efficiency settings for an end use in the Level of Efficiency Assumptions tab will affect *all* facilities that have that same end use listed (i.e., it may have a global impact throughout the End Use Water Audit Tool). These three levels of efficiency are displayed in columns N–P for each facility matrix in the Data Entry tab and a description, or definition, of the efficiency value is listed in column Q. (Hint: depending upon

Exhibit 20. Data Entry tab—default efficiency values by end use.

			Efficiency Values for End Use			
			E3	E2	E1	
Local Name of Facility	**Annual Average GPD**, copied from above	**Individual End Uses for facility type**	**Least Efficient**	**Standard Efficiency**	**Best Available Efficiency**	**Description**
Domestic	210000	Restrooms-Toilets	3.5	1.6	1.28	gallons per flush
		Restrooms-Urinals	2	1	0.125	gallons per flush
		Restrooms-Faucets	2	1	0.5	gallon per minute
		Food Service-Kitchen faucets	2	1	0.5	gallon per minute
		Food Service-Pre-rinse spray valves	3	2	1.28	gallon per minute
		Food Service-Dishwashers	4.5	2.5	1.0	gallons per rack
		Food Service-Ice machines	1.5	0.25	0.12	gallons per lb ice
		Landscaping-Outdoor irrigation	28.6	14.0	0.6	gallons per sq. ft.
		Maintenance-Boiler	100	75	50	gallons per day
		Maintenance-Cooling				
		Maintenance-Pavement cleaning	10	7.5	5	gallons per day per unit
		Other-Other 1	10	7.5	5	gallons per day per unit
		Other-Other 2	10	7.5	5	gallons per day per unit
		Other-Other 3	10	7.5	5	gallons per day per unit

the width of your monitor, you may want to narrow the width of columns L–M, or hide the columns, to see the end uses and efficiency levels at the same time.)

The next step is to scroll right to columns R–T and enter the representative distribution of each end use within the individual facility as shown in Exhibit 21. Note that the values entered into columns R–T must sum to 100 percent. The values are entered as a decimal value, so the three values should total to 1.0 in column U. To facilitate the data entry, and to make sure that the three values always total to 1.0, the user can enter decimal values in columns S and T (highlighted in green) and the least efficiency percentage (column R) will be calculated as the remaining percentage.

As a default, all the percentages have been set to 100 percent *standard* efficiency. This setting can also be used if no information is available for a particular end use in a given facility. As with the number of units, these percentages can be estimated initially and later revised during the calibration process if you are not sure of the distribution.

Keep in mind that the distribution of efficiency levels for each end use in each facility is a *representative* percentage. This means that you do not have to inspect each and every toilet in the building. For example, the building maintenance staff may be able tell you when a percentage of fixtures have been replaced and the efficiency level of the new fixtures. Similarly, you might inspect a sample of fixtures until you get a reasonable indication of the fixture efficiency levels. For example, if you inspect five ice machines in food preparation areas and one out of the five is air-cooled but the others are water-cooled, you might assume that 0.2 are best available efficiency and 0.8 are standard efficiency. However, if one out of five is leaking badly then the distribution might be 0.2 best efficiency, 0.6 standard efficiency, which leaves 0.2 least efficient.

Exhibit 21. Data Entry—distribution of fixtures by efficiency level.

Local Name of Facility	Annual Average GPD, copied from above	Individual End Uses for facility type	Efficiency Values for End Use E3 Least Efficient	E2 Standard Efficiency	E1 Best Available Efficiency	Enter representative percentages for facility and end use: Percent Least Efficient	Percent Standard Efficiency	Percent Best Available Efficiency	Percent-ages should always total to 1.0
Domestic	210000	Restrooms-Toilets	3.5	1.6	1.28	-	1.00	-	1.00
		Restrooms-Urinals	2	1	0.125	-	1.00	-	1.00
		Restrooms-Faucets	2	1	0.5	-	1.00	-	1.00
		Food Service-Kitchen faucets	2	1	0.5	-	1.00	-	1.00
		Food Service-Pre-rinse spray valves	3	2	1.28	-	1.00	-	1.00
		Food Service-Dishwashers	4.5	2.5	1.0	0.50	0.50	-	1.00
		Food Service-Ice machines	1.50	0.25	0.12	0.50	0.50	-	1.00
		Landscaping-Outdoor irrigation	28.6	14.0	0.6	1.00	-	-	1.00
		Maintenance-Boiler	100	75	50	-	1.00	-	1.00
		Maintenance-Cooling				-	1.00	-	1.00
		Maintenance-Pavement cleaning	10	7.5	5	-	1.00	-	1.00
		Other-Other 1	10	7.5	5	-	1.00	-	1.00
		Other-Other 2	10	7.5	5	-	1.00	-	1.00
		Other-Other 3	10	7.5	5	-	1.00	-	1.00
						-	1.00	-	1.00
						-	1.00	-	1.00
						-	1.00	-	1.00
						-	1.00	-	1.00

Percentages will always total to 1.

Exhibit 22. Data Entry tab—seasonal use.

If applicable, **enter % of year** in use for seasonal uses (e.g., 0.5 = 6 months, 0.25 = 3 months, 0.083 = 1 month)

Seasonal Use	% of Year
Outdoor irrigation	1.0
Boiler	0.5
Cooling	0.5
	0.5

In the example airport data shown in Exhibit 21, it is assumed that about half of kitchen area dishwashers and ice machines are standard efficiency while half are of lesser efficiency. Similarly, it is assumed that the irrigation of turf grass is least efficient.

Note in this example that reasonable information is available for most end uses. Faucets in the food service are intended to fill containers quickly and thus installation of flow restrictors or aerators is not appropriate. Therefore the percentage remains at the default level. On the other hand, some end uses (like "other") remain at the default value due to a lack of information.

The final step on the Data Entry tab is to scroll right to columns W and X to a list of possible seasonal water uses, which depend on the type of facility shown in Exhibit 22. As a default, the percentage of seasonal use is set to 0.5 which indicates that the particular end use is active for 6 months out of the year at that facility. This setting can be changed to reflect the seasonal use of the listed end uses. If the end use is active all year long, then enter a value of 1.0. Note in the discussion of irrigation efficiency parameters, that the default water use factor is an annual average; therefore, the corresponding seasonal percentage is 1, since the seasonality is already incorporated in the water use factor. (In this example, the Default for Tool option is selected for the climate zone in the Irrigation Efficiency Calculator, as described in the irrigation discussion.)

The End Use Water Audit Tool contains a series of scratch sheets that can be used to gather data on water use at the airport. It is not necessary to collect end use fixture data on all fixtures for this tool to work. Scratch sheets are provided to guide in the collection of additional data if desired. These sheets are not linked to the tool; they are designed to be printed so that the information can be collected during a walk-around at the airport.

Once you have completed the data entry in each matrix for each individual facility on the Data Entry tab, you are ready to enter data for irrigation and cooling towers. Be sure to save your work.

Special Irrigation Requirement Calculator

Water requirements for landscaping vary by climate and soil zones, and by the type of landscape material. The efficiency of delivering the recommended volume of water varies by irrigation delivery system. The Irrigation tab includes a calculator to determine water volume for low-, medium-, and high-efficiency landscape irrigation. The landscape irrigation calculator estimates the irrigation requirement for turf grass, high-volume landscape, moderate-volume landscape, and low-volume landscape in gallons per square foot per year. The irrigation requirement (IR) is the amount of supplemental water needed beyond rainfall to maintain healthy turf or landscape.

The IR is an annualized value for each location based upon the seasonal weather patterns of the location and is expressed in gallons per square foot of landscape per year. Airports can override these estimates based on judgment of their needs or with information from their landscape maintenance staff.

The tool includes three ways to calculate the volume of water used in irrigation:

- The default values in the tool are based on national averages. Irrigation requirements are calculated for typical rainfall levels and evapotranspiration rates. Additional information about irrigation requirements is not required of the airports.
- Airports can improve the estimate of the irrigation requirements by using factors that reflect their climate zone. Airports can identify their climate zone using the map in the Irrigation tab of the tool (the map is included as Exhibit 45 in Tool 33 as well.) Their climate zone can be selected from a drop-down menu in the Irrigation tab. The irrigation requirements are then calculated using the average rainfall and evapotranspiration rates for the selected climate zone.
- Airports can follow the process developed by the U.S. Department of Energy's Federal Energy Management Program to estimate landscape water use. The process is from the report *Guidelines for Estimating Unmetered Landscaping Water Use;* the seven steps of the process are summarized below. By following these steps, the airport can determine which location's rainfall and evapotranspiration is most like their own. They can choose from among 36 locations, using the drop-down menu in the Irrigation tab.

The following seven steps are used to estimate the irrigation requirement. The initial five steps can be skipped if airports are willing to use national or regional averages.

1. Use the EPA website (www3.epa.gov/watersense/new_homes/wb_data_finder.html) to enter your zip code to determine your peak evapotranspiration and peak rainfall.
   - Evapotranspiration (ETo) is expressed in inches per month.
   - Peak ETo is the highest monthly value in the location.
   - Peak rainfall (in inches per month) is the average monthly rainfall in that peak month.
2. Use the map in the Irrigation tab (Exhibit 45) to determine the airport's climate zone.
3. Find one of the 36 locations on Exhibit 23 that best matches your ETo and rainfall and is in your climate zone.
4. Identify your turf grass and landscape type.
   a. Turf is classified as either cool season or warm season grasses. Use Exhibit 24 to identify which type of turf grass is used at the airport. Ground maintenance staff can be consulted as well. If you have a mix of turf grasses, you should enter the percentage of each type (cool or warm) in cells F45 and G45.
   b. The water use requirements for landscape areas (trees, shrubs, flowerbeds, groundcover, etc.) vary by plant species, the density of planting, and the microclimate of the landscape.
      i. Determine if the airport's landscaping has low, moderate, or high water requirements. This requirement depends upon the plant types and landscaping materials. Ground maintenance staff can be consulted. Airports can also contact the local cooperative extension office for assistance.
      ii. Determine the planting density using the following descriptions:
         1. Low density: immature and sparsely planted landscape.
         2. Average density: full coverage but predominantly one vegetation type.
         3. High density: landscape with a mixture of plant types with full coverage such as trees, flowers, and shrubs.
      iii. Determine the predominant microclimate for your landscape:
         1. Protected: areas shaded from sunlight and protected from wind and heat gain, such as landscape on the north side of a building or with a protective wind barrier.

Exhibit 23. City locations by climate zone.

Climate Zone	City	State	Zip Code	Peak ETo (in./mo)	Peak Rainfall (in./mo)
Alpine	Bozeman	MT	59715	7.37	1.44
	Laramie	WY	82051	7.44	1.33
	Santa Fe	NM	87501	7.75	1.16
Desert	Bakersfield	CA	93301	10.39	0.00
	Las Vegas	NV	89044	13.03	0.03
	Phoenix	AZ	85003	13.40	0.02
	Reno	NV	89501	8.92	0.13
Humid Continental - Cool Summer	Bangor	ME	04401	4.80	3.03
	Milwaukee	WI	53202	6.08	3.11
	Minneapolis	MN	55401	6.85	3.41
Humid Continental - Warm Summer	Boston	MA	02108	6.18	2.66
	Cincinnati	OH	45202	6.23	3.34
	Kansas City	MO	64101	7.43	3.47
	Omaha	NE	68102	7.15	3.14
	Philadelphia	PA	19102	6.25	3.43
Humid Southern	Atlanta	GA	30303	6.48	3.29
	Houston	TX	77002	6.91	3.24
	Memphis	TN	38103	7.38	3.17
	New Orleans	LA	70116	6.13	4.08
	San Antonio	TX	78205	8.42	0.87
	Raleigh	NC	27601	6.03	3.53
	Washington	DC	20004	6.46	2.99
Marine - West Coast	Olympia	WA	98501	5.14	0.70
	Portland	OR	97086	6.20	0.58
	Seattle	WA	98101	5.44	0.65
Mediterranean	Los Angeles	CA	90001	6.59	0.00
	Sacramento	CA	95814	9.47	0.00
	San Francisco	CA	94102	5.24	0.04
Semi-arid	Amarillo	TX	79107	9.64	2.33
	Boise	ID	83601	7.76	0.45
	Denver	CO	80002	8.25	1.78
	Rapid City	SD	57701	7.86	2.01
	Salt Lake City	UT	84101	10.13	0.57
Subarctic	Anchorage	AK	99501	4.09	1.03
Tropical	Honolulu	HI	96853	7.44	5.87
	Miami	FL	33010	6.65	2.16

Source: U.S. Department of Energy, Federal Energy Management Program (2010). *Guidelines for Estimating Unmetered Landscaping Water Use*, p. 6. energy.gov/sites/prod/files/2013/10/f3/est_unmetered_landscape_wtr.pdf.

Exhibit 24. Turf grass seasons.

Turf Grass Type	Season Type
Annual bluegrass	cool
Annual ryegrass	cool
Bermuda grass	warm
Buffalo grass	warm
Colonial bentgrass	cool
Creeping bentgrass	cool
Hard fescue	cool
Highland bentgrass	cool
Kentucky bluegrass	cool
Kikuyugrass	warm
Meadow fescue	cool
Perennial ryegrass	cool
Red fescue	cool
Rough-stalked	cool
Seashore paspalum	warm
St. Augustine grass	warm
Tall fescue	cool
Zoysia grass	warm

Source: U.S. Department of Energy, Federal Energy Management Program (2010). *Guidelines for Estimating Unmetered Landscaping Water Use*, p. 7. energy.gov/sites/prod/files/2013/10/f3/est_unmetered_landscape_wtr.pdf.

2. Open: areas that are in an open flat field, such as a park or field.
3. Intense exposure: areas exposed to high heat gain or windy conditions, such as a southern exposure or near highly reflective surface like a street median.

5. Select the city identified in Step 3 in the drop-down menu in the Irrigation tab. This selection will enter the landscape irrigation requirements for landscape in each cell in the table below the drop-down menu (Exhibit 25).
6. This table is used to calculate the irrigation requirement for high, moderate, and low IR landscape. Two approaches can be used. First, the tool calculates the weighted average of the low density/protected area, average density/open area, and high density/intense exposure requirements for the high, moderate, and low IR landscape. The average is weighted by the proportion of landscaping in the three types—low density/protected areas, average density/open areas, high density/intense exposure. Airports can enter estimates of the percentage of total of landscaping that falls in each column in cells F52, G52, and H52 of the Irrigation tab. These percentages should sum to 100 percent. (If the airport does not have this information, the calculation assumes the landscape is equally distributed among the three types.)

Exhibit 25. IR comparisons table.

	Low density/ Protected areas	Average density/ Open areas	High density/ Intense exposure
High IR Landscape			
Moderate IR Landscape			
Low IR landscape			

The second approach is more subjective. Rather than use the average calculated by the tool, airports can review the table and choose volumes that best reflect their requirements. For example, the combinations in the table (low density and protected areas, average density and open areas, high density and intense exposure) may not be a perfect match for the airport. Airports should select two scenarios that closely represent their landscape type and choose a factor that is within the range of the two scenarios. To do so, the airports can overwrite the formula for the averages in cells E73 to E76.

The tool will also determine the irrigation requirement for turf grass based on the climate zone. The airport must determine whether it uses cool or warm season turf types, or a mix. Airports can enter the percentage of their total turf that is cool or warm season turf types in cells F45 and G45. (These percentages should sum to 100 percent.)

7. This information is used to calculate the average water efficiency for three efficiency levels: low, medium, and high. The IR calculated for turf grass and high, moderate, and low IR landscape are entered in cells E73, E74, E75, and E76 in the Irrigation tab (Exhibit 26). If airports choose not to use the averages calculated by the model, they can enter their own estimates. The tool then calculates the amount of water required based on the efficiency of the irrigation system.

   Irrigation systems each have different efficiencies in the delivery of water to the plant material. That is, some delivery systems lose more water than others to evaporation, runoff, and leaks. For example, sprinkler systems tend to have lower efficiency ranging from 50 to 70 percent, while micro (drip) irrigation tends to have efficiency rating between 70 and 90 percent. Consistent with Tool 33, the three levels of efficiency used in the Efficiency Calculator are defined as follows:

   - 50% Efficiency: sprinkler type systems that are aging with poor maintenance and lack proper scheduling
   - 65% Efficiency: sprinkler type systems that have regular maintenance and proper scheduling
   - 85% Efficiency: micro irrigation systems that have regular maintenance and proper scheduling

   The lowest level of efficiency is equal to the maximum water use in the table. The medium level of efficiency is equal to the average water use in the table. The most efficient level of water use is equal to the minimum water use in the table. These efficiency levels reflect the climate zone, the type of turf grass and landscape material, microclimates and planting density, and the irrigation system efficiency. The efficiencies are used in the Level of Efficiency Assumptions tab.

The intensity of use parameter converts the irrigation requirement into an average daily volume of water per square foot to be used to calculate water use. The efficiency metric in the Irrigation tab is annual average gallons per square foot. The intensity of use factor is 1/365, which converts the volume to an average daily rate, in gallons per square foot. The factors are in the Intensity of Use Assumptions tab. While the model allows the intensity of use parameter to vary

Exhibit 26. Irrigation system efficiency table.

	Enter IR (gal/sf/year)	Irrigation System Efficiency		
		Low 50%	Medium 65%	High 85%
Turf grass				
High IR Landscape				
Moderate IR Landscape				
Low IR landscape				

by facility type, the default values are the same for each type. These should be changed only with great caution.

Updating Fixture Values in the End Use Tool

This section describes how the user can enter detailed fixture data if available and how the end use parameters of the End Use Water Audit Tool can be updated or modified. It is important to know where the default values are contained within the tool, and the implications of changing default values within the tool. It is strongly advised that a copy of the original file be made and renamed before making any such modifications, so as to preserve the original file with the default values.

Entering Detailed Fixture Data

Users with additional detailed data on the number and type of fixtures in each facility of their airport can enter this information in the Detailed Fixture Data worksheet. The worksheet derives the percentage distribution of fixtures by efficiency level based on the data entered. The user would collect and record the detailed fixture count in the field, using a printout of the Fixture Data Template or similar field record.

Note that the detailed data can be comprehensive (i.e., collected from each fixture at the facility); however, only a representative sample reflecting the actual conditions is necessary. For example, if the terminal has 30 bathrooms, it is not necessary that the characteristics including the efficiency of all the fixtures from each of the 30 bathrooms be recorded. Rather only the characteristics of a sample of bathrooms, which represents the characteristics of all the terminal bathrooms, is necessary.

Once the data is collected, it is entered in column Q of this worksheet by facility and end use. The numeric quantities entered in column Q are automatically aggregated by efficiency level in column M with the corresponding percentage distribution calculated and shown in column N. The user then would copy the percentage values from column N in this worksheet to the corresponding locations in the Data Entry tab. The values calculated in column N can then be compared with the percentage values shown in column O, to ensure that the manual copying step was completed correctly.

Modifying Pre-defined Efficiency Levels

Users of the tool who have additional detailed information on the efficiency levels of end uses (e.g., fixtures or other water-using appliances) may modify the pre-defined efficiency levels in the Level of Efficiency Assumptions tab or at the Water Use Calcs tab. These modifications should be made with **caution** and only if more precise information, such as site-specific information or updated data on equipment, is available.

These pre-defined values are derived from engineering or manufacturer guidelines. A few of the less common (i.e., hard to quantify) end uses have efficiency levels based on a relative scale designed to reflect increasing levels of efficiency (e.g., 10, 7.5, and 5) even though the actual water volume per use is unknown.

The pre-defined level of efficiency values can be adjusted either globally or by facility:

- Globally: In the Level of Efficiency Assumptions tab, for each area, the values in the shaded cells (column J) can be replaced with the new assumed values; or,

- By Facility: In the Water Use Calcs tab, for each individual facility, the values in the shaded cells (column M) can be replaced with the new values.

As noted previously, these changes are not recommended, especially at the facility level (in the Water Use Calcs tab). They require detailed research and diligent data entry. These modifications may result in inconsistent results, so data entry should be checked and verified.

Modifying Pre-defined Intensity of Use Levels

Like the assumptions on efficiency levels, pre-defined intensity of use levels can be modified; however, such changes should be made with **caution**. The Intensity of Use Assumptions tab includes pre-defined intensity of use default values in order to allow the generation of an initial estimate of water use. Intensity of use is a reflection of behavioral patterns. The default value reflects expected behavior in the frequency of use for a given end use at most airport facilities but may not be representative of behaviors at a given location. As a result, the pre-defined value can be replaced with a site-specific intensity of use value based on more representative behavioral data or can be adjusted during calibration, if necessary.

The pre-defined intensity of use values can be adjusted:

- Globally: In the Intensity of Use Assumptions tab, for each area, the values in the shaded cells (column J) can be replaced with the new assumed values; or,
- By Facility: In the Water Use Calcs tab, for each individual facility, the values in the shaded cells (column M) can be replaced with the new values.

As noted previously, these changes are not recommended, especially at the facility level (in the Water Use Calcs tab), as they require detailed research and diligent data entry. These modifications may result in inconsistent results, so data entry should be checked and verified.

Updating Cooling Tower Values in the End Use Water Audit Tool

This section describes how water use for cooling is estimated in the End Use Water Audit Tool and how the parameters can be updated or modified. Water use for cooling towers in this worksheet is estimated using engineering factors and is different from the methodology used for the remainder of the Tool. The user enters the number of square feet of cooling area (units) in the Data Entry tab. This information is used in the Cooling Data tab with a number of default values to derive an estimate of cooling make-up water. The estimate is then read into the Water Use Calcs tab where it is multiplied by the Seasonal Percent use value from the Data Entry tab.

The following assumptions are used in the Cooling Data tab in order to estimate the volume of make-up water for cooling purposes:

- Five hundred tons of cooling capacity are needed per square foot of cooled area.
- Three gallons per minute are required per ton.
- The flow rate in gallons per minute is estimated based on these factors and the cooling area for the facility.
- A drift rate of 0.1 percent of flow is assumed. This may vary with the design of the cooling tower. A drift rate of 0.3 to 1.0 percent of flow is typical for a natural drift cooling tower, 0.1 to 0.3 percent for an induced draft cooling tower, and about 0.01 percent if the cooling tower has windage drift eliminators.
- A volume of water in gallons per day is estimated for drift loss based on the flow rate and the drift rate.

- A 10 degree Fahrenheit change in temperature ("delta T") is assumed.
- A volume of water loss in gallons per day is estimated for evaporation based on the flow rate and the "delta T."
- A default value of 4 cycles of concentrate is assumed, with 10 cycles of concentrate assumed for the Optimal scenario.
- A volume of water loss for blowdown is calculated based upon the estimated drift loss, estimated evaporative loss, and the number of cycles per concentrate.
- Total make-up water is the sum of the drift loss, evaporation loss, and blowdown volumes.

These calculations are performed in the Cooling Data tab for each facility with cooling area square feet entered in the Data Entry tab. The parameters can be overwritten for any individual facility. Alternatively, these parameters can be globally changed for all facilities by changing the default values at the very top of the Cooling Data tab.

Once you have completed the data entry for detailed fixtures (if necessary) and for irrigation, and checked the cooling tower calculations (if necessary), you have completed the data entry phase and are ready to look at the initial water use estimates. Be sure to save your work.

Review Initial Results

After completing the data entry step you will have generated an estimate of water use among the airport facilities. The distribution of efficiency levels for each end use was multiplied by the corresponding efficiency level values to derive a weighted-average volume of water used per "use event." This value was then multiplied by the corresponding intensity of use value from the Intensity of Use Assumptions tab. The intensity of use value can be thought of as a behavioral metric: it tries to represent the number of times the end use is used per day. For example, in a terminal restroom, where the associated unit is the number of passengers per day, each passenger may be assumed to use the restroom fixtures once. In an office or maintenance facility where the associated unit for restrooms is employees, each employee may be assumed to use the restroom fixtures four times in an 8-hour day.

The weighted-average volume per use is multiplied by the intensity of use to estimate the water use per day per unit. This calculation can be viewed in the Water Use Calcs tab (Exhibit 27). The water use per day per unit is then multiplied by the number of associated units to derive the estimated water use for each end use and each facility. This calculation can be viewed in the End Uses tab (Exhibit 28).

In addition to the estimate of water use based upon the efficiency level distribution that you provided, the model executes a second calculation of water use assuming that all fixtures (100 percent) use the best available efficiency level. This calculation is labeled in the various tabs as the Optimal Use. These calculations are also in the Water Use Calcs tab and the End Uses tab. The difference between the estimated water use and the optimal water use is shown in the Summary Tables tab. Exhibit 29 is an example of the summary provided. The difference between these two calculations is reported as potential water savings. The ratio of these two calculations (i.e., estimated use divided by optimal use) is reported as the Water Use Ratio in the various tables of the Summary Tables tab.

The Summary Tables tab, the End Uses tab, and the Calibrate & Verify tab show the distribution of total water use. The Calibrate & Verify tab shows the percentage of total airport use as estimated for facility groups and for individual facilities. In the Summary Tables tab, the total airport use is distributed among facility groups, individual facilities, water use areas, water use areas within facility groups, by individual end uses aggregated across the entire airport, and by individual end uses within facility groups.

Exhibit 27. Water Use Calcs tab—computation of gallons per day per unit for each end use and facility.

					Read from Efficiency		Read from Fixture Data	Read from Intensity	365 DAYS		Read from Data Entry
Facility Group	**Individual Facility**	**Areas**	**Use**	**Associated unit**	**Levels of Efficiency**		**% of Fixtures at Efficiency Level**	**Intensity of Use**	**Water Use GPD per unit**	**Optimal GPD per unit**	**% of Year**
Terminals	Domestic	Restrooms	Toilets	Passengers	E3	3.5	0.000	0.625	1.000	0.800	1
			Toilets		E2	1.6	1.000				
			Toilets		E1	1.28	0.000				
			Urinals	Passengers	E3	2	0.000	0.375	0.375	0.047	1
			Urinals		E2	1	1.000				
			Urinals		E1	0.125	0.000				
			Faucets	Passengers	E3	2	0.000	0.167	0.167	0.083	1
			Faucets		E2	1	1.000				
			Faucets		E1	0.5	0.000				
		Food Service	Kitchen faucets	Meals Served	E3	2	0.000	1.000	1.000	0.500	1
			Kitchen faucets		E2	1	1.000				
			Kitchen faucets		E1	0.5	0.000				
			Pre-rinse spray valves	Meals Served	E3	3	0.000	0.020	0.040	0.026	1
			Pre-rinse spray valves		E2	2	1.000				
			Pre-rinse spray valves		E1	1.28	0.000				
			Dishwashers	Meals Served	E3	4.5	0.500	0.050	0.175	0.050	1
			Dishwashers		E2	2.5	0.500				
			Dishwashers		E1	1	0.000				
			Ice machines	Meals Served	E3	1.5	0.500	0.500	0.438	0.060	1
			Ice machines		E2	0.25	0.500				
			Ice machines		E1	0.12	0.000				

Exhibit 28. End Uses tab—computation of gallons per day by end use for each facility.

			Values derived from Data Entry	Values derived from Water Use Calcs	Estimated Volume				
Individual Facilities	**Areas**	**Use**	**Units**	**Water Use GPD per unit**	**Volume (est. GPD)**	**% Facility Water Use**	**Area subtotal GPD**	**Area % of Facility**	**Facility total GPD**
Domestic	Restrooms	Toilets	40,000	1.000	40,000.0	24.2%	61,667	37.3%	165,512
		Urinals	40,000	0.375	15,000.0	9.1%			
		Faucets	40,000	0.167	6,666.7	4.0%			
	Food Service	Kitchen faucets	8,000	1.000	8,000.0	4.8%	13,220	8.0%	
		Pre-rinse spray valves	8,000	0.040	320.0	0.2%			
		Dishwashers	8,000	0.175	1,400.0	0.8%			
		Ice machines	8,000	0.438	3,500.0	2.1%			
	Landscaping	Outdoor irrigation	50,000	0.078	3,917.8	2.4%	3,918	2.4%	
	Maintenance	Boiler	-	37.500	-	0.0%	86,700	52.4%	
		Cooling		86400	86,400.0	52.2%			
		Pavement cleaning	40,000	0.008	300.0	0.2%			
	Other	Other 1	1	7.500	7.5	0.005%	8	0.005%	
		Other 2	-	7.500	-	0.000%			
		Other 3	-	7.500	-	0.000%			

Exhibit 29. Summary Tables tab—summary of estimated and optimal water use by facility group.

Summary Table 1. Water Use by Facility Group						
Facility Group	Estimated GPD	% Total Use	Optimal GPD	Savings GPD	% Savings	Water Use Ratio
Terminals	215,250	79.7%	150,067	65,182	30.3%	1.43
Office Buildings	868	0.3%	510	358	41.3%	1.70
Rental Car Center	30,836	11.4%	15,294	15,542	50.4%	2.02
Ground Transportation	7,793	2.9%	4,711	3,082	39.6%	1.65
Parking	485	0.2%	20	465	95.9%	24.60
Fire and Police Stations	449	0.2%	147	302	67.2%	3.05
Hotels	-	0.0%	-	-	0.0%	-
Central Heating/Cooling Plant	-	0.0%	-	-	0.0%	-
Maintenance & Services	5,944	2.2%	3,310	2,635	44.3%	1.80
Airlines/Cargo Hangars	8,434	3.1%	3,692	4,743	56.2%	2.28
TOTAL	270,060	100%	177,750	92,309	34.2%	1.52

Water Use Ratio is: **1.52** **for this airport**
(Ratio of Estimated to Optimal)

Calibrate and Verify

On the Calibrate & Verify tab, the metered water use by facility from the Data Entry tab appears in the table in columns C–I (see Exhibit 30). The same table format is repeated in columns K–Q but with the estimated water use derived from the model calculations (see Exhibit 31). Scrolling further to the right is a table in the same format that shows the difference between your entered (metered) water use values and the estimated water use values (see Exhibit 32).

Notice in the example airport that the metered use is 316,100 GPD (see total in Exhibit 30), while the initial tool estimate is 270,060 GPD (see total in Exhibit 31), which is an *under*estimation of 46,040 GPD, or about 14 percent (see Exhibit 32). The right-most column (the last column in Exhibit 32) shows the percentage difference by facility. Facility estimates that are over the actual use are highlighted in red while those that are underestimates are highlighted in yellow. The next step will be to make adjustments to the model inputs to minimize these differences and accurately reflect water use at your airport.

Is It Reasonable or Is Something Off? Revisiting Assumptions and Calibrating the Results

The differences between the metered water use entered and the model's estimates are shown in the right-most table of the Calibrate & Verify tab (see Exhibit 32). These differences provide an indication of which facilities' assumptions and estimates need adjusting. Of course **this assumes that the metered data entered in the Data Entry tab for each facility is accurate and provides a complete picture of water use at the airport**. The process of checking the estimate of the water use baseline and comparing it to metered data, if available, comprises four steps:

- Step 1: Review for Reasonableness
- Step 2: Review Data Entry
- Step 3: Confirm Tool Assumptions
- Step 4: Final Calibration

Step 1: Review for Reasonableness: The first step in this process is identifying which estimates are reasonable and which may require adjustment. If there is a facility for which a water use value was

If Estimate is Higher than Actual:

1. Any misclassified uses?
2. Overestimated number of users?
3. Any leaks or unauthorized uses?
4. More efficient than assumed?
5. Meter data correct?

If Estimate is Lower than Actual:

1. Any missing water use activity?
2. Not as efficient as assumed?
3. Underestimated number of users?
4. Meter data correct?

Exhibit 30. Calibrate & Verify tab—actual water use from data entry (columns C–I).

Table 4. Actual Water Usage (from Data Entry)

Facility Group	Facility GPD	%Total Use	Individual Facilities	GPD	%Total Use
Terminals	284,200	89.9%	Domestic	210,000	66.4%
			International	73,000	23.1%
			Executive	1,200	0.4%
				-	0.0%
				-	0.0%
Office Buildings	1,100	0.3%	Airport	800	0.3%
			FAA	200	0.1%
			Tower	100	0.0%
				-	0.0%
				-	0.0%
Rental Car Center	10,300	3.3%	RCC	10,300	3.3%
				-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
Ground Transportation	5,000	1.6%	Shuttle	5,000	1.6%
				-	0.0%
Parking	1,000	0.3%	East	500	0.2%
			West	500	0.2%
				-	0.0%
				-	0.0%
				-	0.0%
Fire and Police Stations	1,000	0.3%	ARFF	1,000	0.3%
Hotels	-	0.0%		-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
Central Heating/Cooling Plant	-	0.0%		-	0.0%
Maintenance & Services	3,000	0.9%	Airside Services	3,000	0.9%
Airlines/Cargo Hangars	10,500	3.3%	Eastern	2,000	0.6%
			Western	1,000	0.3%
			Corporate	500	0.2%
			Cargo	1,000	0.3%
			Flight Kitchen	6,000	1.9%
TOTAL	**316,100**	**100%**		**316,100**	**100%**

TOTAL AIRPORT from Data Entry	316,100

not entered (if, for example, the facility is one of several facilities served by a single meter, but metered data are not available for the facility by itself), then the estimate shown in the Calibrate & Verify tab may be the best reasonable estimate of its use. Consider the following questions to determine whether the estimates are reasonable. (The water use estimates for a specific facility can be reviewed in detail in the End Use tab as well as the water estimates shown in the Calibrate & Verify tab.)

- Does the overall estimate for each facility seem reasonable relative to other facilities and what is known about the airport and the facility?
- Does the distribution of water use among end uses within each facility seem reasonable relative to the distribution of water use among end uses in other facilities?

Exhibit 31. Calibrate & Verify tab—estimated water use (columns K–Q).

Table 5. Estimated Water Use by Individual Facility					
Facility Group	**Facility GPD**	**%Total Use**	**Individual Facilities**	**GPD**	**%Total Use**
Terminals	215,250	79.7%	Domestic	165,512	61.3%
			International	48,388	17.9%
			Executive	1,350	0.5%
				-	0.0%
				-	0.0%
Office Buildings	868	0.3%	Airport	658	0.2%
			FAA	170	0.1%
			Tower	40	0.0%
				-	0.0%
				-	0.0%
Rental Car Center	30,836	11.4%	RCC	30,836	11.4%
				-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
Ground Transportation	7,793	2.9%	Shuttle	7,793	2.9%
				-	0.0%
Parking	485	0.2%	East	243	0.1%
			West	243	0.1%
				-	0.0%
				-	0.0%
				-	0.0%
Fire and Police Stations	449	0.2%	ARFF	449	0.2%
Hotels	-	0.0%		-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
Central Heating/Cooling Plant	-	0.0%		-	0.0%
Maintenance & Services	5,944	2.2%	Airside Services	5,944	2.2%
Airlines/Cargo Hangars	8,434	3.1%	Eastern	410	0.2%
			Western	410	0.2%
			Corporate	142	0.1%
			Cargo	678	0.3%
			Flight Kitchen	6,794	2.5%
TOTAL	**270,060**	**100%**		**270,060**	**100%**

- Are there specific end uses within specific facilities that seem out of place, overestimated, or underestimated?
- Look for the largest water-using end use in each facility; does this use seem reasonable?

Step 2: Review Data Entry: After the particular facilities or end uses that need adjustment have been identified, the next step is to determine what to change or correct. Begin by checking any assumptions made about the number of units by end use in the Data Entry tab. (The number of units by end use can be viewed in the End Uses tab and changed in the Data Entry tab.) If any of these values are "soft" numbers that were estimated, evaluate whether they can be changed by a reasonable amount. Similarly, double check to determine if numbers were entered correctly. Data that drive the largest water use at airports should be checked first.

Exhibit 32. Calibrate & Verify tab—differences between actual and estimated water use (columns S–Y).

Table 6. Differences between Estimated and Actual
If the difference is positive, then the Estimated value is higher than Actual.

Facility Group	Facility GPD	%Diff	Individual Facilities	GPD	%Diff
Terminals	(68,950)	-24.3%	Domestic	(44,488)	-21.2%
			International	(24,612)	-33.7%
			Executive	150	12.5%
				-	-
				-	-
Office Buildings	(233)	-21.1%	Airport	(143)	-17.8%
			FAA	(30)	-15.0%
			Tower	(60)	-60.0%
				-	-
				-	-
Rental Car Center	20,536	199.4%	RCC	20,536	199.4%
				-	-
				-	-
				-	-
				-	-
Ground Transportation	2,793	55.9%	Shuttle	2,793	55.9%
				-	-
Parking	(515)	-51.5%	East	(257)	-51.5%
			West	(257)	-51.5%
				-	-
				-	-
				-	-
Fire and Police Stations	(551)	-55.1%	ARFF	(551)	-55.1%
Hotels	-	-		-	-
				-	-
				-	-
				-	-
				-	-
Central Heating/Cooling Plant	-	-		-	-
Maintenance & Services	2,944	98.1%	Airside Services	2,944	98.1%
Airlines/Cargo Hangars	(2,066)	-19.7%	Eastern	(1,590)	-79.5%
			Western	(590)	-59.0%
			Corporate	(358)	-71.7%
			Cargo	(322)	-32.2%
			Flight Kitchen	794	13.2%
TOTAL	**(46,040)**	**-14.57%**		**(46,040)**	**-14.6%**

This data may include the units of passengers per day and the number of employees (which affects restroom water use estimates), the area of irrigation (which affects irrigation water use estimates), and the total area of terminals (which affects cooling/heating water use estimates).

Second, check any assumptions made about the distribution of efficiency levels on the Data Entry tab. A small shift in the distribution can result in a significant shift in the resulting estimate if there are a high number of users. For example, in some cases the user may have assumed that 50 percent of the toilets in terminal restrooms were high efficiency and 50 percent were medium efficiency. Detailed inspections of the fixtures and purchase records may reveal that 25 percent of these toilets are high efficiency and 75 percent are medium efficiency, which would increase baseline water use.

The End Uses tab shows the calculated gallons per day per unit value for each end use in each facility. If the gallons per day per unit value seems reasonable, you may need to adjust the number of units to bring the end result into line. If the gallons per day per unit seems questionable then go to the Water Use Calcs tab and review the distribution of fixtures by efficiency level (which comes from the Data Entry tab), the levels of efficiency, and the intensity of use for the end use and facility in question.

Step 3: Confirm Tool Assumptions: The assumptions included throughout the tool are based on literature research and experience at many airports, so any adjustments to these values should be completed with caution. The tool has been designed so that knowledgeable users can adjust both the level of efficiency assumptions and the intensity of use assumptions. These assumptions should be checked and adjusted, if necessary, after all other assumptions, noted above, have been confirmed and adjusted. Changes should be based on additional research and detailed information about the facility.

As part of the calibration process, you will likely need to review the level of efficiency and the intensity of use assumptions. The level of efficiency values for a given end use can be changed in the Level of Efficiency Assumptions tab. Notice that this can affect the calculated water use estimate for *all* facilities with this particular end use. In some cases it is an "across the board" adjustment.

The intensity of use value in the **Water Use Calcs tab** comes from the **Intensity of Use Assumptions tab**. Because the intensity of use is the behavioral metric in the equation, there can be a great deal of variation in reasonable values of this parameter. For example, not all employees use the restroom four times in an 8-hour day. This is an average value that may not reflect all employees' behavior at all locations. This means that the intensity of use value is a "soft" number that can be adjusted for a given location within some reasonable range. Note that changing an intensity value on the Intensity of Use Assumptions tab will generally affect the same end use in other facilities. The exceptions are restrooms, outdoor irrigation, and car wash facilities. The intensity value for restrooms is separated between computations based upon passengers (i.e., terminals) and those based upon employees (i.e., all non-terminal facilities). The intensity value for outdoor irrigation is individualized by facility group. Similarly, the intensity value for vehicle washing is separated between rental car centers, bus and shuttle facilities, parking facilities, and fire and police facilities, each with a different associated unit. The effect of adjustments to the intensity values can be seen in the Water Use Calcs tab. Also be sure to look at the effect across facilities.

For the example airport, the following adjustments were made after some additional research into operations throughout the airport:

- Zeroed out intensity value for Ground Transportation vehicle wash as it is not applicable at this location.
- Lowered the estimated number of shuttle passengers per day from 5,000 to 3,200, based on information from the shuttle service.
- Estimated a number of cars (12,500) parked at each parking facility per day. Zeroed out intensity value for Parking Vehicle Wash as it is not applicable.
- For the domestic terminal, multiplied irrigation intensity value by 2.67 to match data from landscape staff. (Note that this changes the irrigation intensity for *all* terminal group facilities.)
- For the international terminal, no data on cooling or irrigation water use, so made the same irrigation changes as was made for the domestic terminal.
- For the executive terminal, reduce estimated number of passengers per day from 250 to 150, based on information from the terminal. (Note that change in irrigation intensity for the domestic terminal impacted the executive terminal irrigation water estimate; therefore, divide irrigated square feet by 2.67 to compensate.)
- Irrigation water use at the Rental Car Center is separately metered. Needed to increase Rental Car Center irrigation intensity by 4.0 to match metered irrigation use.

- For the Rental Car Center car washing, changed the distribution of efficiency to 100 percent standard (40 gallons per wash) and reduced the number of rentals per day to 230 units.
- Water use for Maintenance & Service is only associated with the "deicing" meter; changed distribution of efficiency for deicing to lowest efficiency, which brought deicing water use in line with the metered data. Zeroed out intensity for snow removal, fleet vehicle washing and runway rubber removal. Suspect that water from the "deicing" meter is being used for multiple purposes.
- For the FAA tower, increased the number of employees per day (24 hours) from 5 to 10.
- For the fire station (ARFF), increased the number of employees per day from 30 to 50.
- For the airline, corporate and cargo facilities, assumed that 50 percent of metered use was for employees (restrooms and break rooms); therefore, changed number of Eastern employees to 75, Western employees to 37, and Corporate hangar employees to 19. (Employee water use in Cargo facility is more than half of metered use.)
- Flight kitchen estimated water use is higher than metered, changed cooling tower cycles of concentrate from 4 to 6, changed distribution of efficiency for Dishwashers and Ice Machines to 30 percent low efficiency and 70 percent standard efficiency.

Step 4: Final Calibration: With these adjustments, the tool provides a fairly good estimate of water use by facility and by end uses within each facility. The assumptions about fixtures, passengers, intensity of use, etc. have been confirmed, yet the water use estimate may still be different from the metered use. This is where the "other" water use category can be used to account for the difference. During data entry, a value of 1.0 was entered for the number of units for "other" for each facility. This value is an arbitrary place holder with no real defined meaning. It can be changed to increase or decrease the estimate of "other" water use for a given facility and produce an estimate that "balances" the facility total water use with the metered use. (See the effect in the End Uses tab.) This procedure can be repeated for each facility. In the example, the number of "other" units is used to calibrate the total facility water use estimates by changing the number of "other" units in the Data Entry tab. The resulting calibrated number of "other" units for the example airport is shown in Exhibit 33. The tool's calibrated estimate of water use is shown in Exhibit 34.

The "difference" table to the right in the Calibrate & Verify tab (Table 6) confirms that the calibration of the model for the example airport is within 1 percent of total metered use. Water

Exhibit 33. Calibrated units for "other" end use.

Individual Facilities	Units
Domestic	5,000.0
International	3,100.0
Executive	1.0
Airport Offices	20.0
FAA Office	4.9
FAA Tower	4.7
Rental Car Center	1.0
Shuttle Stop	1.0
East Parking	24.0
West Parking	24.0
ARFF	37.0
Gate Crews	1.0
Eastern Airlines	133.0
Western Airlines	67.0
Corporate Hangars	33.0
Cargo	44.0
Flight Kitchens	1.0

Exhibit 34. Estimated water use after adjustments and calibration.

Table 5. Estimated Water Use by Individual Facility

Facility Group	Facility GPD	%Total Use	Individual Facilities	GPD	%Total Use
Terminals	284,004	89.9%	Domestic	209,812	66.4%
			International	72,992	23.1%
			Executive	1,201	0.4%
				-	0.0%
				-	0.0%
Office Buildings	1,100	0.3%	Airport	800	0.3%
			FAA	199	0.1%
			Tower	100	0.0%
				-	0.0%
				-	0.0%
Rental Car Center	10,271	3.3%	RCC	10,271	3.3%
				-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
Ground Transportation	4,965	1.6%	Shuttle	4,965	1.6%
				-	0.0%
Parking	1,018	0.3%	East	509	0.2%
			West	509	0.2%
				-	0.0%
				-	0.0%
				-	0.0%
Fire and Police Stations	1,003	0.3%	ARFF	1,003	0.3%
Hotels	-	0.0%		-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
				-	0.0%
Central Heating/Cooling Plant	-	0.0%		-	0.0%
Maintenance & Services	3,022	1.0%	Airside Services	3,022	1.0%
Airlines/Cargo Hangars	10,559	3.3%	Eastern	2,004	0.6%
			Western	999	0.3%
			Corporate	502	0.2%
			Cargo	1,001	0.3%
			Flight Kitchen	6,053	1.9%
TOTAL	**315,941**	**100%**		**315,941**	**100%**

use at each facility is either within 1 percent or 25 gallons per day of metered use. The difference between the calibrated estimates and the metered use is shown in Exhibit 35.

Summary Tables and Graphics

The Summary Tables tab contains six summary tables that present the water use estimates from a variety of perspectives and levels of detail. Three of these tables for the example airport are shown in Exhibits 36, 37, and 38. These tables are formatted for copying and pasting into a text document. Some of the tables include hidden columns used for reading values from other tabs. These hidden columns may appear when a table is copied into a document, in which case the column can be deleted from the document table.

Each table contains an estimated water use ratio. The ratio is calculated for the entire airport, groups of facilities, individual facilities, and types of uses. It is the ratio of the estimated use to the optimal use. It shows how much estimated water use exceeds optimal water use. A water use

Exhibit 35. Differences after adjustments and calibration.

Table 6. Differences between Estimated and Actual
If the difference is positive, then the Estimated value is higher than Actual.

Facility Group	Facility GPD	%Diff	Individual Facilities	GPD	%Diff
Terminals	(196)	-0.1%	Domestic	(188)	-0.1%
			International	(8)	0.0%
			Executive	1	0.1%
				-	-
				-	-
Office Buildings	(1)	0.0%	Airport	-	0.0%
			FAA	(1)	-0.4%
			Tower	0	0.3%
				-	-
				-	-
Rental Car Center	(29)	-0.3%	RCC	(29)	-0.3%
				-	-
				-	-
				-	-
				-	-
Ground Transportation	(35)	-0.7%	Shuttle	(35)	-0.7%
				-	-
Parking	18	1.8%	East	9	1.8%
			West	9	1.8%
				-	-
				-	-
				-	-
Fire and Police Stations	3	0.3%	ARFF	3	0.3%
Hotels	-	-		-	-
				-	-
				-	-
				-	-
				-	-
Central Heating/Cooling Plant	-	-		-	-
Maintenance & Services	22	0.7%	Airside Services	22	0.7%
Airlines/Cargo Hangars	59	0.6%	Eastern	4	0.2%
			Western	(1)	-0.1%
			Corporate	2	0.5%
			Cargo	1	0.1%
			Flight Kitchen	53	0.9%
TOTAL	**(159)**	**-0.05%**		**(159)**	**-0.1%**

Exhibit 36. End Use Water Audit Tool summary table of water use by facility group.

Summary Table 1. Water Use by Facility Group						
Facility Group	**Estimated GPD**	**% Total Use**	**Optimal GPD**	**Savings GPD**	**% Savings**	**Water Use Ratio**
Terminals	284,004	89.9%	190,633	93,372	32.9%	1.49
Office Buildings	1,100	0.3%	662	438	39.8%	1.66
Rental Car Center	10,271	3.3%	7,198	3,073	29.9%	1.43
Ground Transportation	4,965	1.6%	2,998	1,967	39.6%	1.66
Parking	1,018	0.3%	375	643	63.2%	2.72
Fire and Police Stations	1,003	0.3%	415	588	58.6%	2.42
Hotels	-	0.0%	-	-	0.0%	-
Central Heating/Cooling Plant	-	0.0%	-	-	0.0%	-
Maintenance & Services	3,022	1.0%	805	2,217	73.4%	3.76
Airlines/Cargo Hangars	10,559	3.3%	5,289	5,270	49.9%	2.00
TOTAL	315,941	100%	208,373	107,567	34.0%	1.52

Water Use Ratio is:	**1.52**	**for this airport**
(Ratio of Estimated to Optimal)		

Exhibit 37. End Use Water Audit Tool summary table of water use by water use area.

Summary Table 3. Water Use by Water Use Area						
Water Use Areas	**GPD**	**% Total Use**	**Optimal GPD**	**Savings GPD**	**% Savings**	**Water Use Ratio**
Restrooms	88,787	28.1%	51,826	36,961	41.6%	1.71
Food Service	16,525	5.2%	6,356	10,169	61.5%	2.60
Break rooms	197	0.1%	49	148	75.0%	4.00
Guestrooms	-	0.0%	-	-	0.0%	-
Flight kitchens	3,560	1.1%	1,340	2,220	62.4%	2.66
Aircraft	1,670	0.5%	418	1,253	75.0%	4.00
Landscaping	13,896	4.4%	287	13,609	97.9%	48.36
Maintenance	127,581	40.4%	105,615	21,967	17.2%	1.21
Other	63,725	20.2%	42,483	21,242	33.3%	1.50
TOTAL	315,941	100%	208,373	107,567	34.0%	1.52

ratio close to 1.0 indicates better water use efficiency than a ratio that is higher than 1.0. A ratio of 1.5 means water use is 1.5 times the optimal level. These ratios can be recorded and tracked over time as a metric of water use efficiency.

The Summary Graphics tab has a sampling of graphics that can be created from the data in the Summary Tables tab. More graphs and charts can be created using the Microsoft Excel features. Exhibits 36, 37, and 38 are sample summary tables from the tool. Exhibits 39, 40, and 41 are sample graphs.

Saving Files for Later

The estimation of the water footprint of the airport with the End Use Tool is a "snapshot" in time. This time period is associated with the time period from which the model inputs were derived. You should save the End Use Tool file with a date stamp (e.g., 053015) representing the date in which the analysis was performed.

Once a water footprint of the airport has been created with the End Use Tool, you can come back at a later date, make a copy of the original file, change the file name, and update the model

Exhibit 38. End Use Water Audit Tool summary table of water use by end use.

Summary Table 5. Water Use by End Use						
Use	GPD	% Total Use	Optimal GPD	Savings GPD	% Savings	Water Use Ratio
Toilets	57,702	18.3%	44,571	13,131	22.8%	1.29
Urinals	21,521	6.8%	2,612	18,909	87.9%	8.24
Faucets	9,762	3.1%	4,692	5,070	51.9%	2.08
Kitchen faucets	12,000	3.8%	6,000	6,000	50.0%	2.00
Pre-rinse spray valves	400	0.1%	256	144	36.0%	1.56
Dishwashers	2,060	0.7%	600	1,460	70.9%	3.43
Ice machines	5,625	1.8%	840	4,785	85.1%	6.70
Showers	-	0.0%	-	-	0.0%	-
Swimming pool	-	0.0%	-	-	0.0%	-
Laundry	-	0.0%	-	-	0.0%	-
Boiler	-	0.0%	-	-	0.0%	-
Cooling	117,734	37.3%	98,280	19,454	16.5%	1.20
Outdoor irrigation	13,896	4.4%	287	13,609	97.9%	48.36
Vehicle washing	9,240	2.9%	6,930	2,310	25.0%	1.33
Pavement cleaning	592	0.2%	395	197	33.3%	1.50
Training	15	0.0%	10	5	33.3%	1.50
Snow removal	-	0.0%	-	-	0.0%	-
Fleet vehicle washing	-	0.0%	-	-	0.0%	-
Runway rubber removal	-	0.0%	-	-	0.0%	-
Aircraft cleaning	-	0.0%	-	-	0.0%	-
Onboard aircraft water	-	0.0%	-	-	0.0%	-
Deicing	1,670	0.5%	418	1,253	75.0%	4.00
Other	63,725	20.2%	42,483	21,242	33.3%	1.50
TOTAL	315,941	100%	208,373	107,567	34.0%	1.52

Exhibit 39. End Use Water Audit Tool summary graph of water use by facility group.

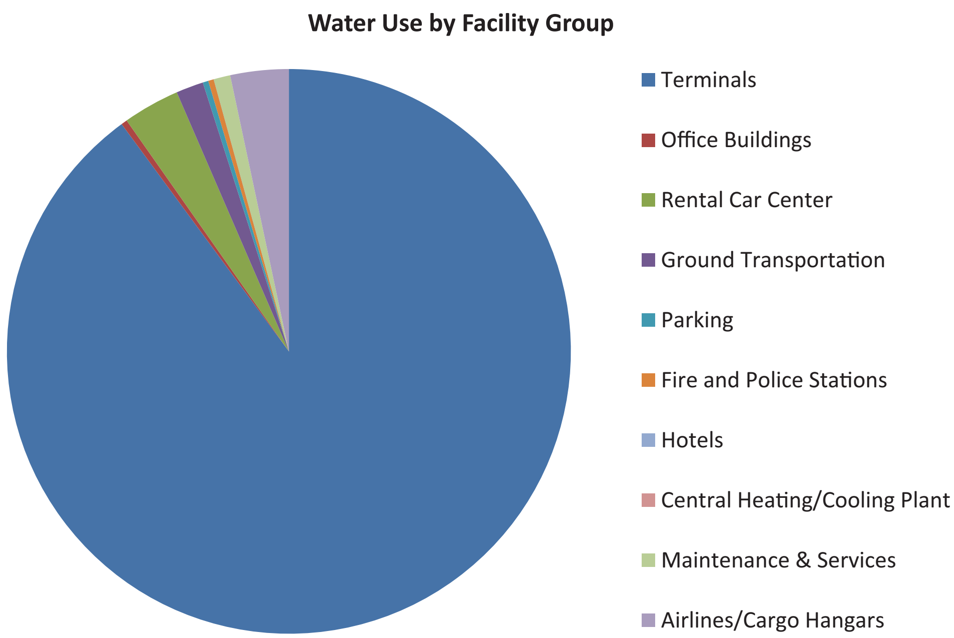

Exhibit 40. End Use Water Audit Tool summary graph of water use by area.

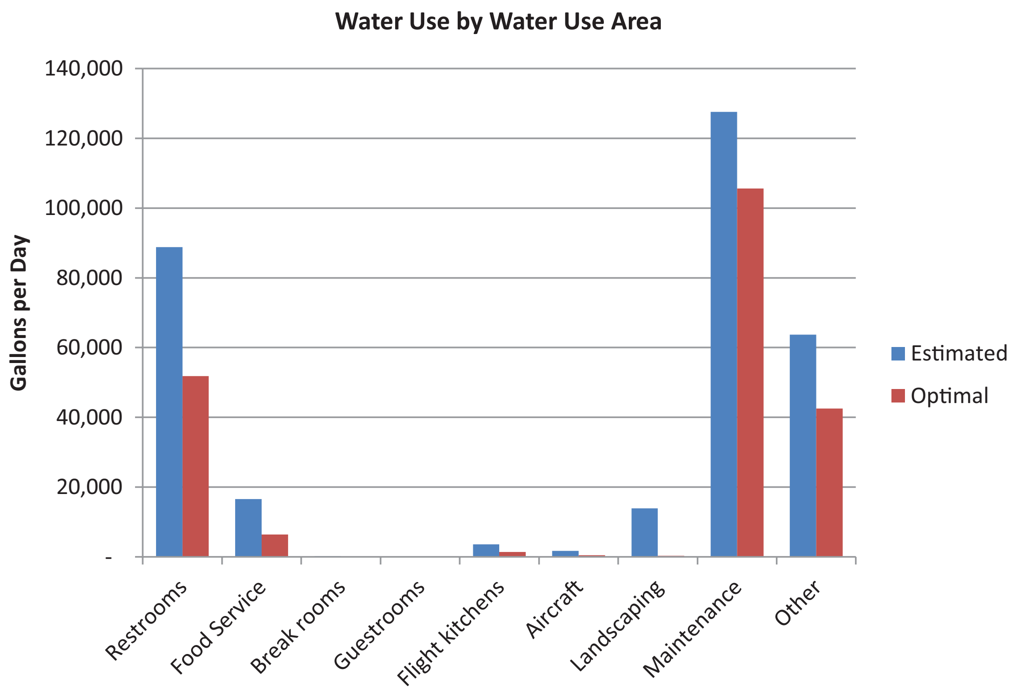

Exhibit 41. End Use Water Audit Tool summary graph of water use by end use.

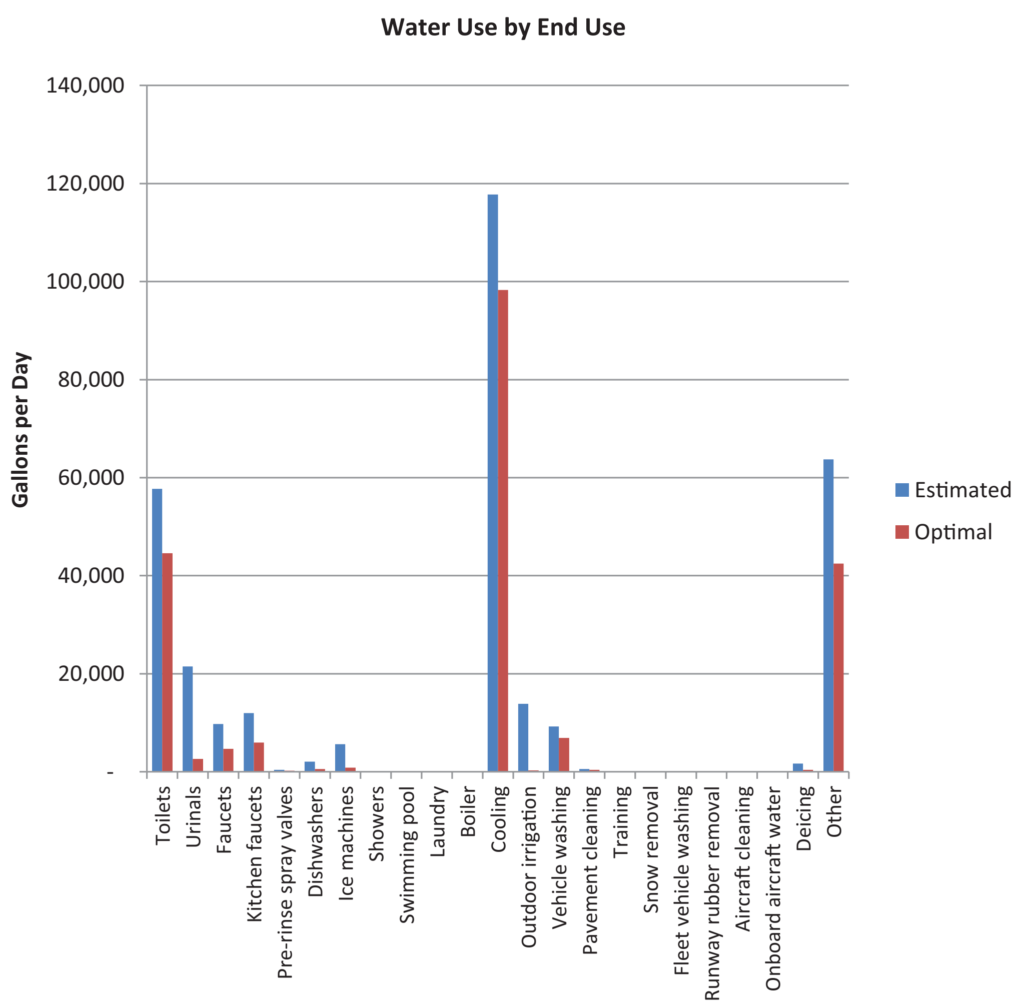

Exhibit 42. Example analysis of the sensitivity of water use estimates to the number of passengers.

Facility	Passengers per Day	GPD	Total Airport Use (%)
Domestic	60,000	240,795	69
	40,000	209,812	66
	20,000	178,828	63

inputs that reflect the current conditions. In this way, a series of water footprints can be created over time that will allow you to track changes in water use among airport facilities.

You also can explore the effect of key assumptions on the tool's estimate of the baseline and potential water savings. You can evaluate the sensitivity of the tool's estimates to its assumptions by varying the estimated number of passengers, water flow rates, intensity of use, and others. The following are three examples; other sensitivity analyses are possible as well.

- The tool's estimate of water used in terminal restrooms and food service areas is based on the estimated number of passengers expected per day. The example airport assumed that approximately 40,000 passengers used the domestic terminal each day. You can evaluate the effect this assumption has on the share of potential savings attributed to terminals by changing the value entered in column M of the Data Entry tab. Enter 20,000 passengers in cell M54 and check the results in Summary Table 2 of the Summary Tables tab to see the change in the percentage of savings by facility. (The results in Summary Table 2 can be saved in a separate file.) Then return to the Data Entry tab and change cell M54 to enter 60,000. Return to Summary Table 2 to see the effect on the percentage savings of water by facility. The results for these three scenarios for the example airport are shown in Exhibit 42.
- The intensity of use assumptions affect water use estimates throughout an airport. The baseline analysis may assume passengers use the bathroom once per day. You can explore the effect of this assumption on the water use ratios in Summary Table 2 by changing the values in the Intensity of Use tab. The default assumptions assume that each female passenger and one-quarter of male passengers use a toilet each day and that three-quarters of male passengers use a urinal. The average intensity of use for toilets is 0.625 flush per day per passenger, assuming one-half of the passengers are women and one-half are men. The intensity of use for urinals is 0.375 flush per day. If only half of the passengers use the bathrooms once a day, the intensity of use factor for toilets falls to 0.3125 flush per day. Enter this value in cell J12 of the Intensity of Use tab. The intensity of use factor for urinals falls to 0.1875. Enter this value in cell J15. On the other hand, if passengers tend to use the bathroom twice per day, the intensity of use factor for toilets increases to 1.25 flushes per day and the factor for urinals increases to 0.75 flush per day. Enter these changes in cells J12 and J15, respectively, to evaluate their effect on the water use ratios in Summary Table 2. Exhibit 43 summarizes the result of this analysis for the example airport.

Exhibit 43. Example analysis of the sensitivity of water use estimates to the intensity of use assumptions.

Facility	Restroom Uses per Passenger	GPD	Total Airport Use (%)
Domestic	2	264,812	68
	1	209,812	66
	0.5	182,312	65

Exhibit 44. Example analysis of the sensitivity of water use estimates to the cooling tower assumptions.

Square Feet per Ton	Facility	GPD	Total Airport Use (%)	Total Airport Maintenance GPD	Total Airport Use (%)
600	Domestic	195,412	65.9	107,959	36.4
550		201,957	66.2	116,878	38.3
500		209,812	66.4	127,581	40.4
450		219,412	66.7	140,663	42.8
400		231,412	67.0	157,015	45.5

- You can explore the implications of your assumptions about cooling towers by changing the inputs on the Cooling Data tab. The default value for cooling capacity is 500 square feet per ton, stored in cell F8 of the Cooling Data tab. You can change this to 400, 450, 550, or 600 and see the effect it has on the water use ratio for cooling on Summary Table 3 of the Summary Tables tab. You also can explore the effect of the assumptions about drift rate, the flow rate per ton, and the delta T. Exhibit 44 shows the results of the analysis for the Example Airport.

Rather than save a version of the tool for each scenario, you can save the tables of interest from the Summary Tables tab. You can then compare multiple scenarios and determine whether you need to revise the tool's default values.

On the other hand, you may want to compare sets of assumptions. For example, after you establish your baseline, you may want to consider an alternative baseline that uses different assumptions about the number of passengers, the intensity of use of water, cooling capacity, etc. You can save a version of the file under a new name and make the changes to these values. You can then compare the summary tables to your original baseline.

TOOL 2

WaterSense Commercial Buildings Website

Type of Tool: Website, fact sheets, guidance document

Author: U.S. Environmental Protection Agency, WaterSense Program

Website: www.epa.gov/watersense/commercial/index.html

U.S. EPA's WaterSense Commercial Buildings site contains information that can be useful to airports as they build a water efficiency program. According to the WaterSense website, facilities such as schools, hotels, retail stores, office buildings, and hospitals account for up to 17 percent of publicly supplied water use and 18 percent of energy use in the United States.

The WaterSense site identifies different industrial or commercial buildings, many of which can be found on airport properties. For each building type, the site provides information on the average percentage of water used at the various end uses, a downloadable fact sheet (that can be provided to tenants or water users on airport property to encourage them to reduce their water consumption or to decision makers as they work to decide what steps to take in reducing water consumption at your airport), and a to-do list for each type of building so water users can build their own water efficiency practice.

The different building types are as follows:

- Office Buildings [www.epa.gov/watersense/commercial/types.html (Tab: Office Building)]: In addition to providing guidance to any office buildings on an airport, this site can provide information to control water usage in terminals. On this site, there is a case study from Plano, Texas, where an office building reduced its water use by 40 percent by upgrading its irrigation systems and changing its maintenance practices. A very transferable concept to an airport irrigation system.
- Hotels [www.epa.gov/watersense/commercial/types.html (Tab: Hotels)]: In addition to the hotel-specific information on reducing water usage at individual hotels, this site provides case studies for hotels and other commercial and institutional building types that have taken action to reduce their water use. These case studies can be found at: www3.epa.gov/watersense/commercial/casestudies.html.
- Restaurants [www.epa.gov/watersense/commercial/types.html (Tab: Restaurants)]: Information on this site can be provided not only to full-serve restaurants on the airport property but also to quick-service restaurants that use water. A case study is provided that shows how three restaurants are saving water and energy by implementing various best management practices.

Each one of these websites has a to-do list for the different building types that can be quickly turned into a handout and even laminated so each person on the staff that uses the water can be made aware of the airport and the business interest in reducing water usage and the steps that each employee can undertake to help reduce the water use.

WaterSense's *WaterSense at Work* is a comprehensive best management guide for commercial and industrial facilities (www.epa.gov/watersense/commercial/docs/watersense_at_work/). The sections that are most relevant to airport facility managers are as follows:

- Getting Started provides a process to effective water management planning. It follows the same framework used in the ENERGY STAR® Guidelines for Energy Management.
- Section 3: Sanitary Fixtures and Equipment provides information on some sanitary fixtures and equipment, including toilets, urinals, faucets, showerheads, and laundry equipment.
- Section 5: Outdoor Water Use provides guidance on reducing outdoor water use for typical commercial buildings. Outdoor water use can account for between 5 and 30 percent of a facility's total water use and improved practices and more efficient equipment can help reduce water use and provide significant water savings. This section provides an overview of and guidance for reducing water used in
  - Landscaping
  - Irrigation
  - Vehicle washing
- Section 6: Mechanical Systems provides an overview of and guidance for effectively reducing the water use of
  - Single-pass cooling
  - Cooling towers
  - Chilled water systems
  - Boiler and steam systems

Throughout *WaterSense at Work*, there are formulas and instruction on how to calculate a simple payback associated with retrofitting or replacement of a piece of infrastructure.

For example, Section 5.5, Vehicle Washing, shows how to calculate the simple payback from the water savings associated with the vehicle wash system retrofit, using the equipment and installation cost of the retrofit water reclamation system, the calculated water savings, and the facility-specific cost of water and wastewater.

TOOL 3

Best Management Practices for Industrial Water Users

Type of Tool: Website, guidance manual

Author: Texas Water Development Board, Water Conservation Implementation Task Force

Website: www.twdb.texas.gov/conservation/BMPs/Ind/index.asp

Experience in water conservation program implementation over the decades has resulted in a body of knowledge in Texas. This guide provides best management practices (BMPs) for municipal, industrial, and agricultural water user groups. It also provides guidance on cost-effectiveness considerations for each of the specific BMPs. Each BMP is organized to be of assistance in conservation planning, program development, implementation, and evaluation. The BMPs were developed based on feedback provided by water users that have had these experiences. Each BMP is structured for delivering a conservation measure or series of measures that is useful, proven, cost-effective, and generally accepted among conservation experts.

These conservation BMPs are designed to fit into Texas's water resource planning process as one alternative to meet future water needs. Some of the information will not be relevant to airports outside of Texas but the BMPs are organized in a concise easy-to-use manner.

The following BMPs are available:

- Conservation analysis and planning
  - Cost-effectiveness for industrial water users—The industrial water user should determine if implementation of each identified BMP measure to achieve water savings would be cost-effective.
  - Industrial site-specific conservation—This BMP applies to any industrial water user with facility- or product-specific water-using processes.
  - Industrial water audit—This BMP is intended for industrial water users and should be thought of as the initial BMP for industrial water users to increase water efficiency at their facility.
- Educational practices
  - Management and employee programs—This BMP is intended as a supplemental BMP for the other industrial BMPs and could apply to all industrial water users.
- System operations
  - Boiler and steam systems—This BMP is intended for any water user that employs boilers and steam generators for heating or process steam.
  - Industrial alternative sources and reuse of process water—This BMP is intended for industrial water users that have the opportunity to reuse process water or other sources of nonpotable water such as treated effluent, rainwater collected on site, condensate, graywater, stormwater, sump pump discharge, or saline sources as a substitute for potable or raw water.

- Industrial submetering—This BMP is intended for industrial water users that do not already have submeters on all significant water uses.
- Industrial water waste reduction—This BMP is intended for industrial water users that could increase water use efficiency at facilities by prohibiting specific wasteful activities such as wasteful irrigation practices and scheduling, single-pass cooling, non-recycling decorative fountains, discharge of process water and use of inefficient water softeners.
- Refrigeration—This BMP is intended for any water user which utilizes water as a primary refrigerant fluid to remove heat. (Note: When this site was accessed on May 12, 2015, the link to this BMP was misdirected. The BMP was accessible under the Rinsing/Cleaning BMP link.)
- Rinsing/Cleaning—This BMP is intended for industrial water users that use rinsing or cleaning in processing, production, or finishing operations. (Note: When site was accessed May 12, 2015, the link to this BMP was misdirected and the BMP was not accessible. An older version of the BMP could be accessed at www.savetexaswater.org/about/doc/WCITFBMP Guide.pdf)
- Water treatment—This BMP is intended for those industrial water users that use water treatment systems in processing, production, or finishing operations.

• Cooling systems management
  - Cooling systems (other than cooling towers)—This BMP is intended for industrial water users that use circulated water to convey heat generated from industrial equipment and mechanical devices such as heat exchangers, condensers, process machinery, tools, air conditioning systems, appliances, vacuum pumps, welding machines, icemakers, and air compressors.
  - Cooling towers—This BMP is intended for any water user which employs cooling towers to remove heat by the evaporation of water.
  - Once-through cooling—This BMP is intended for those industrial water users that circulate water from a lake or bay to remove heat generated from industrial equipment and mechanical devices such as heat exchangers, condensers, or process equipment.

• Landscaping
  - Industrial landscape—This BMP is intended for industrial water users that irrigate landscape areas or use a significant amount of water in outdoor irrigation.

Note: The Texas Water Development Board is currently developing best management practices for commercial and institutional water users. It is anticipated that those BMPs will be located at www.twdb.texas.gov/conservation/BMPs/CI/index.asp#

TOOL 4

Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities

Type of Tool: Guidance manual

Author: North Carolina Department of Environmental and Natural Resources

Website: savewaternc.org/Documents/water-efficiency-business.pdf

This detailed manual provides information to industrial, commercial, and institutional water users in North Carolina on how to improve water efficiency. Even though this manual is developed specifically for water users in North Carolina, the information is relevant to water users outside of North Carolina. The manual provides guidance on identifying technologies and behaviors necessary to achieve more efficient water use, and it provides a practical stepwise framework to guide users through this process. Specifically, the manual provides steps for conducting a successful water efficiency program, from establishing goals to tracking and publicizing results. It also provides a methodology and tools for preparing an audit, conducting an audit, and documenting findings.

Specific information in the guidance that may be useful to airport facility managers is as follows:

- Defining the differences between water efficiency and water conservation (p. 7)
- Explaining the different methods for making a change—changing behavior vs. changing equipment (p. 11)
- Employee incentives (p. 20)
- Making a toilet replacement project successful (p. 33)

TOOL 5

Facility Manager's Guide to Water Management

Type of Tool: Guidance manual

Author: Arizona Municipal Water Users Association, Regional Water Conservation Committee

Website: www.amwua.org/resource_documents/facility_managers_guide.pdf

This document provides a step-by-step process for developing a water management plan. It is geared toward a facility manager and includes worksheets, sample water reduction calculations, and water management options for various water uses or processes, such as landscaping, cooling and heating, kitchen, and laundry. The document also includes sections on establishing a water efficiency management team and encouraging employee participation.

Worksheet II-7—Institutional and Commercial Water Conservation Practices Checklist—provides a list of typical commercial and industrial water uses. It is a good start of typical water uses and could be used as a basis to develop a checklist that pertains to individual airports.

TOOL 6

Water Efficiency and Self-Conducted Water Audits at Commercial and Institutional Facilities: A Guide for Facility Managers (Second Edition)

Type of Tool: Guidance manual

Author: South Florida Water Management District, Water Supply Development Section

Website: www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/water_efficiency_improvement_self_assess_guide.pdf

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

Although it is applicable to users in all areas, the guidebook does contain references to external resources and information specific to Florida. Florida-specific references and information are set apart from the main text in orange boxes to avoid confusion. For example, while the principles of water-efficient landscaping are the same everywhere (plants should be selected according to the local climate and site-specific conditions), the guidebook identifies organizations and provides web links to organizations which focus on plants adapted to Florida's climate. Users from areas outside of Florida should be able to find equivalent resources for their areas fairly easily.

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

The appendices contain information that could be useful to airport facility managers:

- Appendix A. How to Read Your Water Meter
- Appendix B. Best Management Practices for Commercial and Institutional Buildings
- Appendix C. Worksheets. These worksheets can be used to conduct an audit of a facility to record basic information for entry later into the End Use Water Audit Tool.
  - Basic Facility Header Sheet
  - Worksheet 1. Meters and Submeters
  - Worksheet 2. Facility Leak Detection

– Worksheet 3. Examining Utility Bills & Estimating Daily Facility Water Use
– Worksheet 4. Faucets
– Worksheet 5. Showerheads
– Worksheet 6. Toilets
– Worksheet 7. Urinals
– Worksheet 8. Appliances
– Worksheet 9. Commercial-Grade Kitchen Appliances
– Worksheet 10. Commercial-Grade Kitchen Fixtures
– Worksheet 11. Cooling Tower Water Use—Basic Audit
– Worksheet 12. Irrigation Schedule and Controller—Basic Audit
– Worksheet 13. Rain and Soil Moisture Sensor Survey
– Worksheet 14. Cooling Tower Water Use—Advanced Audit
– Worksheet 15. Facility Water Balance

TOOL 7

EDF-GEMI WaterMAPP

Type of Tool: Website

Author: Global Environmental Management Initiative

Website: www.gemi.org/EDFGEMIwaterMAPP/

The Environmental Defense Fund–Global Environmental Management Initiative (EDF-GEMI) WaterMAPP is a set of tools and resources to help organizations build a program to reduce water and energy use in buildings.

The EDF-GEMI Water Management Application (WaterMAPP) is a downloadable Microsoft Excel-based, multi-tabbed spreadsheet with three complementary components:

- The EDF-GEMI Water Scorecard helps assess water efficiency and can be used to create visibility for water performance at facilities. It offers an overview of the scorecard concept, calculations used by AT&T in developing their first scorecard, and detailed information about how to develop a scorecard.
- The Water Efficiency Calculator estimates water and financial savings from cooling tower or free-air cooling improvements.
- Cycles of Concentration Estimator takes information about water quality and estimates the recommended maximum cycles of concentration—a key indicator of cooling tower water efficiency—when using chemicals to treat the water. It also helps identify appropriate non-chemical water treatment options to increase the potential cycles of concentration.

Also included on the website, under Additional Resources, is the Cooling System Efficiency Guide that EDF developed, along with a series of videos that can be used to learn the fundamentals of how a cooling system works as well as how a facility can manage its cooling system to minimize the use of water, energy, and chemicals.

TOOL 8

Water and Energy Efficiency Program for Commercial, Industrial, and Institutional Customer Classes in Southern California

Type of Tool: Guidance manual

Author: U.S. Department of the Interior, Bureau of Reclamation

Website: www.usbr.gov/lc/socal/planning.html (hyperlink to specific study located in Planning Studies text box)

This study identifies potential Southern California commercial, industrial, and institutional customer classes for participation in water and energy efficiency programs, summarizes savings potentials for these commercial, industrial, and institutional customer classes, develops audit guidelines and tools to identify water and energy efficiency improvements, and recommends opportunities for enhancing practices at commercial, industrial, and institutional customer sites. It also identifies marketing and outreach practices that are best suited for promoting water and energy efficiency in Southern California and develops a method for evaluating the costs and benefits associated with water and energy efficiency improvements.

Table 3.3 in Volume 1: Executive Summary provides a summary of proposed incentive goals and recommended actions for overcoming barriers to integrated water and energy efficiency programs. The recommended incentives are structured to facilitate and fund implementation of integrated water and energy efficiency programs. They will encourage commercial, industrial, and institutional customers to participate in integrated programs by building their knowledge, providing additional financial and administrative incentives, and recognizing them for their accomplishments.

Chapter 5 and Appendix C in Volume 2 characterize water savings potential for commercial, industrial, and institutional sites by the end use. Chapter 6 of Volume 2 provides a useful framework for cost-benefit analysis of water efficiency investments (though it is very much a "textbook" approach). Volume 3 includes a very detailed and practical description of the audit process and includes field audit forms in the appendices. Volume 4 discusses currently implemented practices to promote water and energy efficiency as well as practices viewed as key activities for advancing the Water and Energy Efficiency Program. Finally, Volume 5 provides a good description of barriers to implementing water efficiency programs at commercial, industrial, and institutional sites based on interviews with commercial, industrial, and institutional customers.

TOOL 9

Federal Water Efficiency Best Management Practices

Type of Tool: Website

Author: U.S. Department of Energy, Federal Energy Management Program

Website: energy.gov/eere/femp/federal-water-efficiency-best-management-practices

The Federal Energy Management Program worked with the U.S. EPA to develop water efficiency best management practices to help federal agencies increase water efficiency. Each best management practice provides operation and maintenance improvements and retrofit and replacement options. A range of practices is available for a variety of end uses, including the following:

- Water management planning
- Information and education programs
- Distribution system audits, leak detection, and repair
- Water-efficient landscaping
- Water-efficient irrigation
- Toilets and urinals
- Faucets and showerheads
- Steam boiler systems
- Single-pass cooling equipment
- Cooling tower management
- Commercial kitchen equipment
- Laboratory and medical equipment
- Other water-intensive processes
- Alternative water sources

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TOOL 10

Water Efficiency Opportunities: Airports—Best Practice Guide

Type of Tool: Guidance manual

Author: Michael H. Smith

Website: s3.amazonaws.com/zanran_storage/www.environment.gov.au/ContentPages/2220252223.pdf

This Australian document discusses best practices for sustainable water management at airports. It provides information about promoting good water management among the many stakeholders at an airport, conducting water audits and developing baseline estimates, identifying areas of water use, analyzing water saving options, conducting a cost-benefit analysis, and setting targets. The document includes many case study examples from other airports.

Step 5, Analyze Water Saving Options for Reducing Water Withdrawal and Water Consumption, provides recommendations on ways airports can reduce their water use. The areas of water reduction opportunities discussed are as follows:

- Stopping water leaks
- Retrofitting water efficiency amenities
- Saving water in cooling towers
- Water efficiency for tenants
- Water-efficient green landscapes
- Aircraft wash recycling
- Alternative water sourcing option—rainwater harvesting and storage
- Enhanced rainwater harvesting for airports using roof drainage systems
- Other alternative water sourcing, reuse, and recycling options

TOOL 11

Guidebook for Incorporating Sustainability into Traditional Airport Projects

Type of Tool: Guidance manual

Author: Landrum & Brown, Inc.

Website: www.trb.org/main/blurbs/168044.aspx

This guidebook describes sustainability and its potential benefits and identifies different applications of sustainable initiatives in traditional airport construction and everyday maintenance projects. It provides case study examples of practices in administrative aspects, site management, and water efficiency. The guidebook is a good resource on developing and implementing a sustainability program.

Appendix B: Sustainable Initiatives for Incorporation into Traditional Airport Projects provides guidance on how to incorporate detailed sustainable strategies into traditional airport projects in the following areas:

- Administrative procedures
- Social responsibility
- The planning process
- Sustainable site management
- Site selection and management
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Construction practices
- Encouraging tenants and concessionaires to operate sustainably

TOOL 12

Sustainable Airport Planning, Design, and Construction Guidelines for Implementation on All Airport Projects

Type of Tool: Guidance manual

Author: Los Angeles World Airports

Website: www.lawa.org/uploadedFiles/LAWA/pdf/Sustainable%20Airport%20PDC%20Guidelines%20Jan08.pdf

Intended as a resource to be used by other airports, these guidelines provide a set of airport-specific performance standards for planning, design, and construction activities that integrate sustainable concepts and practices into projects at the four Los Angeles World Airports. The performance standards contain actions and targets, metrics, documentation, and technical approaches as well as a rating system to measure and document the level of success in achieving those requirements.

Part 3: Sustainable Planning and Design Guidelines provides a specific list of performance standards for designing a sustainability plan. Specific water efficiency and conservation sustainable planning and design guidelines can be found at:

- PD8-WE-1: Water Management Plan
- PD8-WE-2: Water Use Efficiency
- PD8-WE-3: Water Reuse & Reclamation

TOOL 13

AWWA Water Loss Control Committee Free Water Audit Software

Type of Tool: Spreadsheet tool

Author: American Water Works Association

Website: www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx

The AWWA Free Water Audit Software© is a spreadsheet-based water audit tool designed to help quantify and track water losses associated with water distribution systems and identify areas for improved efficiency and cost recovery. It includes 10 worksheets in a spreadsheet file. The first worksheet provides instructions on the use of the software. The majority of data is entered on the second worksheet, the Reporting Worksheet, which prompts the user to enter standard water supply information such as the volume of water supplied, customer consumption, distribution system attributes, and quantities of losses. The program can be used to estimate water loss metrics of the distribution system based upon miles of pipe, number of connections, operating pressure, and other inputs. This software can be used to estimate and monitor water loss between master meters and metered uses at airports. Airports with master water meters should be able to track the difference in water volume between the water flowing into the airport campus distribution system from the master meters and the volume of water recorded at individual meters throughout the campus. Much like the water distribution system of a water utility, this difference can be attributed to faulty meters, line breaks and leaking connections.

TOOL 14

Alliance for Water Efficiency Resource Library

Type of Tool: Website

Author: Alliance for Water Efficiency

Website: www.allianceforwaterefficiency.org/resource-library/default.aspx

The website for the Alliance for Water Efficiency Resource Library has substantial information and strives to provide the best online resources on water conservation and efficiency.

The following are some of its key resources:

- Water Saving Tips: Commercial, Industrial, and Institutional Water Use: www.allianceforwater efficiency.org/CII-tips.aspx
- Introduction to Cooling Towers: www.allianceforwaterefficiency.org/cooling_tower_intro.aspx
- Landscape, Irrigation, and Outdoor Water Use: www.allianceforwaterefficiency.org/Landscape_and_Irrigation_Library_Content_Listing.aspx

TOOL 15

WaterSense Smart Outdoor Practices

Type of Tool: Website

Author: U.S. Environmental Protection Agency, WaterSense Program

Website: epa.gov/watersense/outdoor/

This website provides information on creating a water-smart landscape that is beautiful, healthy, and easy to maintain. The main focus of the website is for residential landscaping, but the same basic principles apply to larger operations. The site offers information on the following:

- Designing a water-smart landscape that is both beautiful and efficient
- Knowing when and how much to water allow to keep a healthy landscape
- Using a WaterSense-labeled controller for an in-ground irrigation system
- How an irrigation professional certified by a WaterSense-labeled program can install, maintain, or audit an irrigation system to ensure it is operating efficiently while using less water

TOOL 16

COOL TUNES: Run an Efficient Cooling Tower (Version 1.0) Water Smart Technology Program

Type of Tool: Guidance manual

Author: Seattle Public Utilities, Resources Venture, and Saving Water Partnership

Website: www.savingwater.org/cs/groups/public/@spu/@swp/documents/webcontent/04_009226.pdf

Increased cooling tower efficiency reduces use of water, energy, and water treatment chemicals and extends the life of the equipment. The purpose of this manual is to help operate cooling towers efficiently and reduce operating costs.

The first section of this manual is a primer on cooling tower mechanics and the types of towers to choose from. With a focus on water conservation, the first half of the manual describes the ways that water is lost from a cooling tower and the need to balance continuous water recirculation with the associated increased risks of corrosion, scaling, and biological growth. The second section of the manual provides direction on the types of monitoring that help to improve system efficiency. This includes monitoring water use and quality. The third section lists maintenance and capital upgrades that lead to increases in water and energy efficiency. The final section is a series of checklists that will prompt building operators to schedule daily, weekly, monthly, quarterly/semi-annual, or annual maintenance inspections.

TOOL 17

Cooling Towers: Understanding Key Components of Cooling Towers and How to Improve Water Efficiency

Type of Tool: Fact sheet

Author: U.S. Department of Energy, Federal Energy Management Program

Website: energy.gov/sites/prod/files/2013/10/f3/waterfs_coolingtowers.pdf

By Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance, federal agencies are required to reduce water use intensity (water use per square foot of building space) for agency potable water consumption as well as reduce water use for industrial, landscaping, and agricultural applications. Cooling towers can be a significant source of water use for both of these categories of water use at federal facilities. The information in this fact sheet can be used to provide basic information to decision makers on changes to cooling towers use and maintenance.

TOOL 18

Increasing Cooling Tower Water Efficiency

Type of Tool: Study report

Author: Chang Sub Kim

Mentor: Melany Hunt

Co-Mentors: Jim Cowell, John Onderdonk, Matthew Berbee

Website: www.sustainability.caltech.edu/documents/33-chang_sub_final_paper.pdf

Abstract: In 2008, the California Institute of Technology used 764,064,005 liters of water. Cooling towers at the central and satellite plants consumed 319,951,956 liters of water through evaporation and blowdown, contributing to over 40 percent of overall water usage on campus. In this water efficiency project, the amount of water loss due to evaporation and blowdown each month was studied and demonstrated that, on average, 83 percent of water loss is due to evaporation and the rest due to blowdown. This project aimed to improve overall water efficiency of cooling towers by examining two applicable systems that can recover vapor and reduce blowdown. An ozone treatment reduces the use of chemicals and thus decreases the blowdown rate. A vapor recovery system consisting of a circular fiber filter on top of cooling towers absorbs and condenses water vapor coming out of the cooling towers. A feasibility experiment showed that approximately 10 percent of evaporated water could be recovered using this method.

This study paper can be used to show decision makers how to modify the use and maintenance of the cooling towers to help reduce the water use at their airports.

TOOL 19

WaterSense Rebates Finder

Type of Tool: Website

Author: U.S. Environmental Protection Agency, WaterSense Program

Website: www.epa.gov/watersense/rebate_finder_saving_money_water.html

Many WaterSense partners offer rebates for WaterSense-labeled products. This site lets users search for money-saving rebates available by area and check to see if the rebates are available to commercial or industrial buildings. Users can search for "All rebates" in Rebates Type and "All" in State/Province, then click on the "Building Type" header in the subsequent table and the table will be resorted based on that information, grouping the unspecified building types and the commercial and institutional building types together for easier reference.

Note:

- WaterSense offers rebate information but **does not** provide any rebates for products. Please contact the airport's local water provider directly for more information about a rebate or rebate program.
- Some links on this page will direct users to non-EPA websites. Please read the EPA Disclaimer.
- Adobe® Acrobat® Reader is needed to view some of the files on this page.

TOOL 20

Database of State Incentives for Renewables and Efficiency

Type of Tool: Database

Author: U.S. Department of Energy, NC Clean Energy Technology Center, Interstate Renewable Energy Council

Website: www.dsireusa.org/

The Database of State Incentives for Renewables and Efficiency (DSIRE®) is the most comprehensive source of information on incentives and policies that support renewables and energy efficiency in the United States. Established in 1995, DSIRE is operated by the NC Clean Energy Technology Center at North Carolina State University and is funded by the U.S. Department of Energy. The incentives and policies focus mainly on energy efficiency and renewable energy; however, some water efficiency programs incentives are listed in some states.

On the home page, click on the airport's state to access a list of policy and incentive programs. Click on the name to see additional information on the program. To filter for programs in which commercial and industrial buildings are eligible, click on the Apply Filter button and select Eligible Sector/Non-Residential/Business and then Commercial or Industrial, as desired. To remove a filter, click on the "X" in the box at the top of the page with the filter type to be removed.

TOOL 21

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

Type of Tool: Report

Author: Federal Aviation Administration, Office of Airport Planning and Programming, National Planning and Environmental Division

Website: www.faa.gov/airports/environmental/sustainability/media/SustainableMasterPlanPilotProgramLessonsLearned.pdf

This report is the 2012 update on the Sustainable Master Plan Pilot Program, which was developed by the FAA. Initiated in 2010, the Sustainable Master Plan Pilot Program's goal is to help 12 airports achieve their planning and operational objectives while reducing environmental impacts, achieving environmental benefits, and improving relationships with local communities. This goal is pursued through preparation of comprehensive, long-range plans that incorporate sustainability.

Introduction provides a basic understanding of current issues surrounding water use. The report then discusses detailed findings regarding critical issues, benchmarking and evaluation, and reduction of water consumption. The report also highlights the financial payoff of water conservation and includes case studies of organizations that have implemented water conservation programs.

Type of Tool: Presentation

Website: www.airportsgoinggreen.org/Presentations/2010-Presentations/Patrick%20Magnotta.pdf

A slide presentation that provides information from November 2010 on the FAA's Sustainable Master Plan Pilot Program.

TOOL 22

Getting in Step: A Guide for Conducting Watershed Outreach Campaigns

Type of Tool: Guidance manual

Author: U.S. Environmental Protection Agency, Office of Water, Nonpoint Source Control Branch

Website: cfpub.epa.gov/npstbx/files/getnstepguide.pdf

The purpose of this guide is to provide the tools needed to develop and implement an effective outreach campaign as part of a state or local water quality improvement effort. While this guide focuses on watershed management plans, it provides helpful information about communicating with affected parties, creating messages that resonate with them, finding appropriate ways to communicate, and prompting changes in behavior.

Sections that can be useful to communicating with affected parties are as follows:

- Part 1: Getting Started
  - Using outreach to help get the job done
  - Using outreach to help change behavior
  - Building partnerships to achieve goals
- Part 2
  - Step 2, Identify and Analyze the Target Audiences: What information do I need about the target audience?
  - Step 3, Create the Message: Branding your program
  - Step 4, Package the Message: Free online photo galleries

TOOL 23

Getting in Step: Engaging Stakeholders in Your Watershed

Type of Tool: Guidance manual

Author: U.S. Environmental Protection Agency, Office of Water, Nonpoint Source Control Branch

Website: cfpub.epa.gov/npstbx/files/stakeholderguide.pdf

The purpose of this guide is to provide the tools needed to effectively engage stakeholders to restore and maintain healthy environmental conditions through community support and cooperative action. This guide is intended primarily for federal, state, tribal, and local agency personnel involved in watershed management activities. The guide can also help private organizations interested in recruiting stakeholders and involving stakeholders in local or regional watershed efforts. While this guide focuses on watershed protection, it contains useful information on involving stakeholders in an environmental process.

Sections that can be useful to coordinating with stakeholders are as follows:

- Introduction
  - Why involve stakeholders?
- Section 1: Stakeholders and Watershed Management
  - Involving stakeholders throughout the watershed planning process
- Section 2: Getting Started
  - Develop a framework for stakeholder involvement
- Section 3: Outreach and Communication Tools
  - Changes in outreach over time
  - Steps for conducting effective outreach
- Section 4: Building Your Stakeholder Group
- Section 5: Keeping the Ball Rolling
  - Top 12 tips to move the process forward
  - Making decisions by consensus
  - Resolving conflict

TOOL 24

M52 Water Conservation Programs—A Planning Manual (First Edition)

Type of Tool: Planning manual

Author: American Water Works Association

Website: www.awwa.org/store/productdetail.aspx?ProductId=39312078 (Purchase cost of $126 for non-members)

The manual provides information on how to develop, implement, and measure the success of a utility conservation program. This manual is intended for use by water utilities that are contemplating the development of a conservation program. Also, water suppliers that already have a conservation program can use this information for improvement and gain the benefits of a more comprehensive approach. Though this manual is intended for water utilities developing a conservation program, it contains information facility managers may find valuable as they begin to develop a water efficiency program at their airport.

TOOL 25

Water Resources in the Phoenix Metro Area

Type of Tool: Presentation

Author: Cynthia Parker, City of Phoenix — Aviation Department

Website: airportsgoinggreen.com/Presentations/2013-Presentations/Cynthia_Parker.pdf

This presentation made by the sustainability coordinator of the Phoenix Sky Harbor International Airport at the Sixth Annual Airports Going Green Conference (November 12–24, 2013) describes the results and lessons learned from the May 2013 water audit performed at the Phoenix airport. Trends in monthly water use, percentage of water use at each airport facility, water usage rates per area for the terminals and rental car center for 2 years, as well as candidate submetering locations for the airport cooling system are described.

TOOL 26

Sustainable Water Management, Northwest Perspective, Seattle-Tacoma International Airport

Type of Tool: Presentation

Author: Bob Duffner, Port of Seattle

Website: airportsgoinggreen.com/Presentations/2013-Presentations/Bob_Duffner.pdf

This presentation made at the Sixth Annual Airports Going Green Conference (November 12–24, 2013) provides a brief description of water resources in the Pacific Northwest, potential climate change impacts, and conservation goals (i.e., endangered species such as salmon). The presentation describes trends in water consumption per passenger and the implemented conservation measures from 2006 through 2012 at Seattle-Tacoma airport and shows the results of the pilot program on sustainable restrooms including metering and user survey results as well as outreach and messaging efforts. The information is presented at a high level but includes some images of the messaging efforts at the airport.

TOOL 27

Great Lakes/St. Lawrence River Water Conservation Model Policies & Measures

Type of Tool: Model program summary

Author: Alliance for the Great Lakes

Website: www.greatlakes.org/Document.Doc?id=939

These models, endorsed by environmental groups across the Great Lakes and St. Lawrence River basin, were developed to influence state, provincial, and utility water conservation policies and measures; to be used in the periodic evaluation of state and provincial programs for effectiveness and improvement; and to be used to evaluate water conservation programs of applicants under the Great Lakes/St. Lawrence River Basin Water Resources Compact and Agreement provisions.

The Great Lakes/St. Lawrence River Basin Water Resources Compact and Agreement have two primary purposes: to prevent the diversion of Great Lakes/St. Lawrence waters outside of the basin and to efficiently manage the withdrawal and use of water within the basin. The Compact and Agreement, recognizing that efficient and responsible water use is a cornerstone of sound water management policy, require water conservation as a critical element of state and provincial water management programs.

The document contains two program models and objectives for a regional water conservation and efficiency program:

- Great Lakes/St. Lawrence River State/Provincial Water Conservation and Efficiency Program Model
- Great Lakes/St. Lawrence River Public Water Utility Water Conservation and Efficiency Program Model
- Great Lakes/St. Lawrence River Regional Water Conservation and Efficiency Objectives

TOOL 28

Survival Guide: Public Communications for Water Professionals

Type of Tool: Guidance document

Author: Water Environment Federation

Website: stage.wef.org/communications/

This guidance provides the basics of public communication. It is designed to help water professionals learn to communicate effectively with their community and customers, because when the public understands the effort being made to protect the public health and the environment, it is more likely they will support the work.

This guidance can provide insight to airport facility managers, because, as in the water and wastewater industries, airport resources may be limited and being stretched to meet growing demands of regulations, security, and the public.

TOOL 29

A Water Conservation Guide for Commercial, Institutional, and Industrial Users

Type of Tool: Guidance document

Author: New Mexico Office of the State Engineer

Website: www.ose.state.nm.us/WUC/PDF/cii-users-guide.pdf

This manual was developed to help commercial, institutional, and industrial water users conserve water in New Mexico. It includes useful data that can be used by decision makers to develop comprehensive water conservation plans, including the following:

- The elements required to implement a water conservation program
- Areas where major water savings are most likely to be realized
- Water conservation guidelines for specific water uses
- Case studies of businesses and institutions that have successfully enacted water conservation programs

TOOL 30

2012 Guidelines for Water Reuse

Type of Tool: Guidance document

Author: U.S. Environmental Protection Agency, Water Sustainability

Website: nepis.epa.gov/Adobe/PDF/P100FS7K.pdf

The U.S. EPA has developed water reuse guidelines that describe the types of reuse applications, technical and legal issues in the United States, public involvement, and water reuse in other countries. The document summarizes existing state regulations, types of reuse applications, and funding for reuse systems, as well as over 100 new case studies.

Chapter 3 of the document provides information about various ways water can be reclaimed or reused. Section 3.2 discusses agricultural reuse including the standards and water quality needed to reuse water on agricultural land; practices discussed in this section may be adaptable to reuse for airport landscaping. Section 3.5.1 discusses the use of reclaimed water in cooling towers.

Table 4-5 in this guidance document, on page 4–18, provides a summary of state and U.S. territory regulations and/or guidance for water reuse. Airports should contact their state programs or consult the state regulations on water use/reuse before making any decisions about, or making changes to, the discharge of water from their facility. In some cases, a state may require a facility to obtain a water quality/reclaimed water/water reuse permit.

Appendix C provides a list of links to state regulations/guidelines on water reuse.

TOOL 31

RSMeans Construction Cost Indices

Type of Tool: Website

Author: RSMeans

Website: www.rsmeansonline.com/Home/Index/

RSMeans is a supplier of construction cost information. This information helps owners, developers, architects, engineers, contractors and others to determine the cost of both new building construction and renovation projects. RSMeans collects data from all facets of the industry and organizes it in a format that is accessible. RSMeans Online provides comprehensive, localized, and up-to-date construction costs. A 30-day trial subscription is available on RSMeans Online. In the online system, the user is able to specify “Green Buildings” as a cost data center to identify infrastructure that promotes sustainable practices. On the second web page, the user can search for the type of infrastructure (e.g., cooling tower, faucet, etc.).

TOOL 32

Guidelines for Estimating Unmetered Landscaping Water Use

Type of Tool: Guidance manual

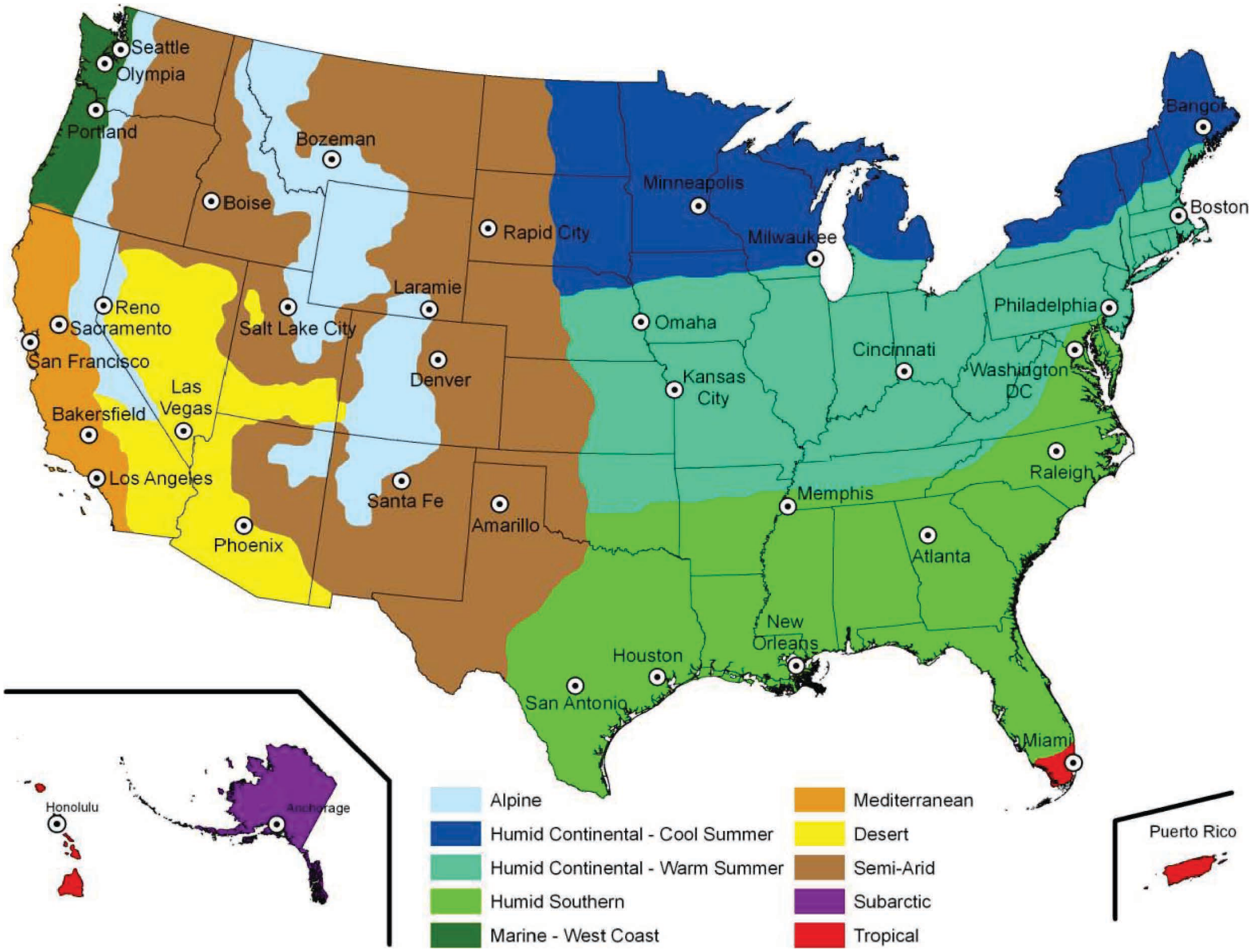
Author: U.S. Department of Energy, Federal Energy Management Program

Website: energy.gov/sites/prod/files/2013/10/f3/est_unmetered_landscape_wtr.pdf

Federal agencies are required to develop a baseline for industrial, landscaping, and agricultural water use in fiscal year 2010. Measuring actual water use through flow meters is the best method to develop this baseline, however there are sites that do not meter all applications. This document is intended to help federal agencies in developing a baseline of unmetered sources of landscaping water use utilizing engineering estimates. The document lays out step-by-step instructions to estimate landscaping water using two alternative approaches: evapotranspiration method and irrigation audit method.

The End Use Water Audit Tool (Tool 1) uses information from this document, including the map of climate zones (Exhibit 45), in the Special Irrigation Requirement Calculator. Airports can use this map to determine the general climate zone for their location.

Exhibit 45. Climate zones of the United States and Puerto Rico.



TOOL 33

National Integrated Drought Information System

Type of Tool: Website and guidance manuals

Author: National Oceanic and Atmospheric Administration

Website: https://www.drought.gov/drought/

The National Integrated Drought Information System (NIDIS) grew out of a number of activities, which culminated in the NIDIS Act being signed into law in 2006. NIDIS operates the U.S. Drought Portal, which provides information on drought planning, current drought monitoring information, and drought forecasting.

In 2013, a partnership between the American Planning Association, the National Drought Mitigation Center at the University of Nebraska-Lincoln, and the NIDIS developed “Planning and Drought,” a document that offers a comprehensive guide for citizens, planners, and communities. The document explores what drought is, how to track it, its impacts, and how planners and communities can prepare to mitigate its effects. It contains eight case studies illustrating the range of drought’s consequences and how different organizations prepared for and responded to them. The document is available electronically at www.drought.gov/media/pgfiles/PAS574.pdf.

TOOL 34

Benefit-Cost Analysis for the Airport Improvement Program Airports

Type of Tool: Guidance

Author: Federal Aviation Administration; Steve Landau and Glen Weisbrod

Website: www.faa.gov/airports/aip/bc_analysis/
www.trb.org/main/blurbs/161751.aspx

Under the Airport Improvement Program, the FAA provides grants for the planning and development of public-use airports that are included in the National Plan of Integrated Airport Systems. On this site is the FAA Airport Benefit-Cost Analysis Guidance, which was developed to help identify proposed projects with a net benefit. It provides guidance to airport sponsors on conducting project-specific benefit-cost analysis (BCA). Though this guidance was developed to conduct a BCA for capacity-related airport projects, the principles can be applied to the BCA of a water efficiency program.

Also on this site is a link to *ACRP Synthesis of Airport Practice 13: Effective Practices for Preparing Airport Improvement Program Benefit-Cost Analysis.* This report discusses benefit assessment techniques used by airports and highlights best practices that airports can implement when assessing the benefit and cost. It also identifies where there may be confusion in the FAA guidance.

Abbreviations and acronyms used without definitions in TRB publications:

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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