PUBLIC WORKS TECHNICAL BULLETIN 200-1-105
30 SEPTEMBER 2011

WATER-EFFICIENT INSTALLATIONS

Public Works Technical Bulletins are published by the U.S. Army Corps of Engineers, Washington, DC. They are intended to provide information on specific topics in areas of Facilities Engineering and Public Works. They are not intended to establish new Department of Army policy.

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
441 G Street NW
Washington, DC 20314-1000

CECW-CE

Public Works Technical Bulletin 30 September 2011

No. 200-1-105

FACILITIES ENGINEERING
ENVIRONMENTAL

WATER-EFFICIENT INSTALLATIONS

1. Purpose.

a. This PWTB describes methods and technology to support water conservation and water efficiency, gives a brief review of regulatory and other drivers, and describes lessons learned from installations. This guidance will enable installations to determine the potential for water conservation at their facilities as part of a sustainable water program and identify a variety of opportunities that can be taken.

b. All PWTBs are available electronically in Adobe® Acrobat® portable document format) through the World Wide Web at the National Institute of Building Sciences' Whole Building Design Guide Web page, which is accessible through this Universal Resource Locator:

http://www.wbdg.org/ccb/browse_cat.php?o=31&c=215

2. Applicability. This PWTB applies to engineering activities of the Directorate of Public Works (DPW) at all U.S. Army facilities. It also has some applicability to Civil Works Natural Resources as it relates to recreation areas (e.g., water-efficient landscaping and irrigation, toilet and urinals).

3. References.

a. Executive Order (EO) 13423, "Strengthening Federal Environmental, Energy, and Transportation Management," 26 January 2007.

b. EO 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” 8 October 2009.

c. International Plumbing Code, International Code Council (ICC), Falls Church, VA.

d. Federal Energy Management Program (FEMP), Best Management Practices (BMPs): http://www1.eere.energy.gov/femp/program/waterefficiency_bmp.html

e. U.S. Green Buildings Council (USGBC), Leadership in Energy and Environmental Design (LEED) Program.

f. Safe Drinking Water Act of 1974 as amended 19 June 1986 (Public Law 99–339).

g. Army Regulation (AR) 200-1, “Environmental Protection and Enhancement,” 13 December 2007

h. AR 420-1, “Army Facilities Management,” 12 February 2008.

i. Energy Independence and Security Act (EISA), Public Law 110–140, 19 December 2007.

j. ANSI/ASHRAE/USGBC/IES Standard 189.1-2009, “Standard for the Design of High-Performance Green Buildings Except Low-rise Residential Buildings,” ASHRAE, Atlanta GA.

4. Discussion.

a. In October 2009, EO 13514 “Federal Leadership in Environmental, Energy, and Economic Performance” superseded EO 13423. This new order set goals for federal agencies to:

i. Reduce potable water consumption intensity by 2% annually through FY 20, or 26% by the end of FY 20, relative to a baseline of the agency’s water consumption in FY07, by implementing water management strategies including water-efficient and low-flow fixtures and efficient cooling towers.

ii. Reduce agency industrial, landscaping, and agricultural water consumption by 2% annually or 20% by the end of FY20, relative to a baseline of the agency’s industrial, landscaping, and agricultural water consumption in FY10.

EO 13514 strengthens the requirement for potable water consumption standards and creates a new requirement for nonpotable water. Specifically, three key elements of compliance were identified and presented: water-use baseline development, reduction of water-use intensity, and reporting. Appendix A goes into further depth on these requirements. This PWTB supports this and other executive orders, policies, regulations and requirements by providing guidance and options for installations to efficiently use their available potable water while reducing consumption. Opportunities (techniques and technology)are also described for reducing amounts of nonpotable water consumption.

b. AR 200-1 sets forth policy, procedures, and responsibilities for the conservation, management, and restoration of land and natural resources consistent with the military mission and in accordance with national laws and policies. Chapter 4-2 of AR 200-1 requires compliance with applicable federal, state, and local laws and regulations regarding water resources management. The objective is to ensure the availability, conservation, and protection of water resources. It encompasses water supply and pollution abatement at fixed and field facilities. Other requirements are to participate with regional authorities in the development and implementation of water resource initiatives and to encourage the beneficial reuse of wastewater and sludge. Plans/programs are required to safeguard drinking water quality and quantity, both at the source and in the distribution system, which includes water conservation measures.

c. AR 420-1 addresses the management of Army facilities. Chapter 22 addresses the Army Energy and Water Management Program and prescribes policies, procedures, and responsibilities for the Army Energy and Water Management Program (AEWMP). The overall objective of the AEWMP is to ensure the availability, quality, and security of energy and water for the Army without degrading the environment, mission readiness, or the well-being of Soldiers. Section 22-4 provides implementing guidance infusing energy and water efficiencies into the development of Army operations, processes, procedures, acquisition strategies, and other mission-related functions. Section 22-9 requires energy and water savings technologies to be used and procured, and Section 22-12 requires increased water efficiency, conservation awareness, leak surveys, water audits, and plans for implementation of BMPs. It includes a requirement to use reclaimed or recycled water for landscape irrigation.

d. In addition to regulatory requirements, costs for water and sewage continue to rapidly escalate. Drought has also had a major impact nationally, affecting numerous installations and not just those in the arid and sub-arid regions of the country.

Water scarcity is expected to worsen in coming years globally, with relative importance varying from location to location. Potential mission shifting between Base Realignment and Closure (BRAC) or increased population growth may be difficult due to water restrictions or an unavailable water supply. Improved efficiency in existing water consumption uses will enable installations to achieve sustainability, be good neighbors in water-short areas, reduce environmental impact, reduce costs, and accomplish their mission.

e. Water efficiency is essential. Benefits of water efficiency include energy savings, local control of the water supply, and reliability of that supply. It is vital to support installations as they pursue their missions and maintain a desirable quality of life. Some installations, however, are becoming “water-limited” and pushing against restrictions on consumption. Drivers encouraging water efficiency and conservation include individual installation sustainability plans, Army Environmental Policy, the Army Energy Campaign Plan, LEED requirements for Silver certification in all new construction, EISA, and various iterations of Executive Orders that require percentage reductions in water use.

f. Water efficiency and conservation are one option available for the Army to become more sustainable; however, the responsibility for implementing water conservation management at installations often falls to energy conservation program managers who do not come from a strong water-related background. Other installations may have different personnel or branches (e.g., environmental or energy) in charge of water conservation. Moreover, the ability to implement a well-thought out, effective water conservation program requires multidisciplinary activity including the installation’s Directorate of Public Works (DPW), Public Affairs Office (PAO), and appropriate tenant representatives, along with contractors who consume water such as the Residential Communities Initiative (RCI), Army and Air Force Exchange Service, contracted utilities, etc.

g. Guidance is needed to enable installation personnel and Corps District planners to evaluate the water-use efficiency potential at their installations and to learn from experiences at other installations as well as in the federal and public sectors. LEED, the ICC National Green Building Standard, and American Society of Heating, Refrigerating and Air-Conditioning Engineers’ (ASHRAE’s) Standard for High Performance Green Buildings all recognize the efficient use of water as a means to meet prescribed building water-use reduction.

h. Information presented in this PWTB relates to water efficiency and should be paired with PWTB 200-1-104, “Implementing Water Conservation Programs on Army Installations.” This PWTB will also expand on FEMP BMPs (described later). In the areas of fixtures, for example, descriptions of devices and appropriate websites are presented. In the area of water-efficient irrigation and landscaping, identification of technologies and supportive websites are identified along with regionalized native species or appropriate plant listings. Water conservation options for commercial kitchens (e.g., dining halls, hospital kitchens) describe technology (including websites) and third-party assessments. The Laboratory and Medical Equipment category discusses hospital and clinic water conservation options and so on.

i. Sometimes installations are unable to pay up front for implementation of cost-saving water efficiency measures, and the use of energy savings performance contracts is a potential option; however, there are a number of concerns and opportunities that require review by an individual knowledgeable about water in order to protect the government’s interests and receive a mutually beneficial result. This PWTB should help interested installation parties receive fair value.

j. The FEMP BMP listing served as the initial starting point in describing water-efficiency practices. They are listed here and discussed in more detail in Appendix A:

(1) Water Management Planning (A-8)
(2) Information and Education Programs (A-13)
(3) Distribution System Audits, Leak Detection, and Repair (A-15)
(4) Water-Efficient Landscaping (A-19)
(5) Water-Efficient Irrigation (A-23)
(6) Toilets and Urinals (A-31)
(7) Faucets and Showerheads (A-36)
(8) Boiler/Steam Systems (A-40)
(9) Single-Pass Cooling Equipment (A-43)
(10) Cooling Tower Management (A-45)
(11) Commercial Kitchen Management (A-51)
(12) Laboratory and Medical Equipment (A-57)
(13) Other Water-Intensive Processes (A-62)
(14) Alternate Water Sources (A-67)

Information in Appendix A is designed to aid managers in implementing water efficiency at their military installations or U.S. Army Corps of Engineers (USACE) facilities.

k. Appendix B lists references used in this PWTB.

l. Appendix C contains a list of abbreviations/acronyms used in this PWTB.

5. Points of Contact.

a. Headquarters, U.S. Army Corps of Engineers (HQUSACE) is the proponent for this document. The point of contact (POC) at HQUSACE is Mr. Malcolm E. McLeod, CEMP-CEP, 202-761-5696, or e-mail: Malcolm.E.Mcleod@usace.army.mil.

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APPENDIX A

WATER EFFICIENCY FOR ARMY INSTALLATIONS

Introduction

Background

The Army spends more than $62 million annually in operating costs for water resources at its activities, with additional millions for sewage treatment and energy for hot water and distribution. Conserving water resources, even by a small amount, will help the Army protect its military activities and Soldiers against being vulnerable to availability of this critical resource. The Army Energy Security Implementation Strategy (2009) calls for a culture of accountability to be created for water conservation and for effectively including goals to reduce water consumption. A 2010 Army Audit Agency report found water-use intensity had increased by 1.8% rather than decreased by the mandated 2% reduction goal established by federal laws and guidelines, which indicates that there is still a strong urgency to implement water efficiency at Army installations.

As climate change becomes the number-one environmental issue around the world, a related topic is expected water shortages and the options available to cope with them. Water scarcity is not just a problem in arid areas, it happens in every climate around the globe. Droughts and low water supply in the United States are not limited to the arid and semi-arid West, where obvious water shortages currently exist; they occur throughout the Nation. When we have enough water, it is not a concern. But when there is a drought or when communities begin rationing water consumption, concern sets in, which turns to panic when reservoir levels fall to new lows.

Water costs are rapidly rising, supplies are becoming increasingly short, restrictions exist on consumption and disposal, and federal and Army mandates have been initiated to reduce annual consumption. Military installations have a strong interest in using resources such as water efficiently and are pursuing sustainable installation goals. In general, installations are charged with being stewards of the environment and efficiently using valuable natural resources such as water (AR 200-1; AR 420-1). When installations become “water-limited,” the condition may limit mission changes and execution. Installations must be able to stand alone and execute their missions without being constrained by the competing needs and interests of surrounding communities.

Water scarcity is expected to worsen in coming years nationally and globally. Installations are expanding and realigning with Base Realignment and Closure (BRAC) and Global War on Terror (GWOT) responsibilities and requirements, placing ever more demands on available water supplies, especially in some semi-arid and drought-stricken regions. Using available water to the best effect is essential in addressing water scarcity and ensuring environmental security.

The question arises: What can be done to increase the available water supply? The first step is to efficiently use whatever water is currently available to its fullest potential. This includes water conservation, water reuse, use of reclaimed water, and capture of stormwater and rainwater where feasible and legal. These are all elements of water efficiency.

Motivation for efficient use of water includes energy savings, local control of the water supply, and reliability of supply. Other drivers encouraging water efficiency include individual installation sustainability plans, Army Environmental Policy, the Army Energy Campaign Plan, and Leadership in Energy and Environmental Design (LEED) requirements for Silver in all new construction. Recent Executive Orders (EOs) require and direct federal agencies to reduce potable and nonpotable water-use intensity by 20%.

A number of federal, Department of Defense (DoD), and Army drivers encourage water conservation, efficiency, and reuse. These include the various iterations of Energy Policy Acts that require reductions in water-use intensity across the Army and federal agencies. Other drivers are: Sustainability Plans of Individual Military Installations; the Strategic Plan for Army Sustainability; Army Environmental Policy; Army Strategy for the Environment; Army Energy and Water Campaign Plan for Installations; Best Management Practices (BMPs) for water conservation promulgated by the Federal Energy Management Program (FEMP); the federal Green Building Initiative; requirements for Army projects for new construction to comply with Low Impact Development (LID) guidelines; and a requirement that any new construction projects must achieve LEED-NC (New Construction) rating of Silver. Most recently, EO 13514 requires a 2% annual reduction in potable water use on Army installations for a total of 26% by 2020. Additionally, reductions are mandated in irrigation, agricultural, and industrial consumption. These are only a few of the many requirements that stress water efficiency on a federal level. Additional drivers issued by numerous states also promote, require, and encourage water reuse.

Army Guidance

Army programs and policies, federal energy guidelines, and Executive Orders that encourage installations to pursue water reuse and conservation include: Installation sustainability plans; the DoD Strategic Sustainability Performance Plan; the Army Strategy for the Environment; the Army Energy and Water Campaign Plan for Installations; water conservation goals; the Clean Water Act; the Energy Policy Act; LEED requirements that all new construction achieve at least a “Silver” rating (see Table A-1); and EOs 13423 and 13514.

AR 420-1, “Army Facilities Management,” provides policies and procedures for the Army’s Energy and Water Management Program, including water supply and wastewater policy. The regulation provides guidance to ensure the availability, quality, and security of water without impairing the Army’s environmental, training, mission readiness, and combat capabilities. The Office of the Assistant Chief of Staff for Installation Management has overall responsibility for managing and overseeing the Army’s Energy and Water Management Program.

Table A-1. LEED opportunities.

Points related to water efficiency are available in LEED with the potential to garner up to seven LEED points as follows in the new construction category: – 1 point for installing above-code measures that result in 20% water savings. – 1 point for installing above-code measures that result in 30% water savings (typically waterless urinals or other unusual measures). – 1 point (innovation credit) for installing above-code measures that result in 40% water savings (Rainwater harvesting system or other water reuse). – Up to 2 points for stormwater reduction (stormwater management practices). – Up to 2 points for water-efficient irrigation. – 1 point for reducing the project’s sewage generation from use of potable water by 50% or more.

Potable water will be supplied in accordance with the Safe Drinking Water Act of 1974, as amended in 19 June 1986 (PL 99–339) and in October 1988 by the Lead Contamination Control Act (PL 100–572) and all applicable state and local regulations. Sanitary control and surveillance of potable water supplies on Army installations will be in accordance with AR 40-5, “Preventive Medicine” and Technical Bulletin (Medical) 576, “Sanitary Control and Surveillance of Water Supplies at Fixed Installations” or applicable state and local regulations. Treatment of wastewater and nonpoint source (NPS) pollution control and abatement will comply with the applicable parts of the Clean Water Act (CWA), as amended (33 USC 1251, et seq.), per AR 200–1. Measures for NPS pollution control will be included in all Army construction, installation operations, and land management plans and activities. This allows the incorporation and adaptation of concepts such as integrated water management, low impact development, total water management, and similar possibilities.

Water supply and wastewater services are also, per AR-420-1, to be provided at the lowest life-cycle cost consistent with installation and mission requirements, efficiency of operation, reliability of service, and environmental considerations. The costs for these services are to be held to a minimum through comprehensive water resource planning, management, and an effective water conservation program.

AR 420-1 also indicates that operation, maintenance, and repair of water supply systems and wastewater systems will be in accordance with Unified Facilities Criteria (UFC) 3–230–02, “Operation and Maintenance Water Supply System” and UFC 3–240–02N, “Operation and Maintenance: Wastewater Treatment Systems Augmenting Handbook.”

Additionally, design criteria and standards for water supply systems and for wastewater collection, treatment, and disposal systems will be in accordance with Technical Instruction 800–01. Alteration and construction projects are to be submitted for review by state regulatory authorities where required by law.

Federal Guidance

EO 13423, “Strengthening Federal Environmental, Energy and Transportation Management” set goals in 2007 for agencies to implement practices to reduce potable water consumption intensity, relative to a Fiscal Year (FY)07 baseline of an agency’s consumption. Reduction goals are 2% annually (a total of 16%) through the end of FY15. Federal guidance was then developed by the Department of Energy (DOE 2007) to assist in interpretation of EO 13423.

EO 13423 also directed federal sites to conduct water audits of at least 10% of facility square footage annually and to conduct said audits at least every 10 years. Federal agencies are also encouraged to purchase water-efficient products and services, including WaterSense-labeled products.

Note: The U.S. DOE established FEMP Water Efficiency BMPs in response to requirements set forth in EO 13123, “Greening the Government Through Efficient Energy Management,” which required federal agencies to reduce water use through cost-effective water-efficiency improvements. The requirements under EO 13423 superseded the requirements in EO 13123, namely to develop Water Management Plans and implement FEMP BMPs. However, agencies were still encouraged to use the existing tools, which have since been updated, in achieving the goals of EO 13423.

As pointed out in the earlier discussion section, EO 13514 “Federal Leadership in Environmental, Energy, and Economic Performance” superseded EO 13423 in October 2009. This new order set goals for agencies to:

- Reduce potable water consumption intensity by 2% annually through FY 20, or 26% by the end of FY 20, relative to a baseline of the agency’s water consumption in FY07, by implementing water management strategies including water-efficient and low-flow fixtures and efficient cooling towers.

- Reduce agency industrial, landscaping, and agricultural water consumption by 2% annually or 20% by the end of FY20, relative to a baseline of the agency’s industrial, landscaping, and agricultural water consumption in FY10.

EO 13514 strengthens the requirement for potable water consumption standards and creates a new requirement for nonpotable water, which can be difficult to measure due to the Army’s lack of a strong water metering program. Specifically, three key elements of compliance were identified and presented: water-use baseline development, reduction of water-use intensity, and reporting.

- Water-use intensity baseline development - Agencies must develop a water-use intensity baseline (defined as gallons per gross square foot of facility space) for water used in FY07.

- Reduction of water-use intensity - Agencies must identify and implement life-cycle cost-effective water savings measures to achieve, at minimum, 2% annual reduction or 16% overall reduction of water-use intensity (gallons per total gross square footage of facility space) in agency facilities by the end of FY15.

- Reporting - Agencies are required to report up the chain their annual water use and facility gross square feet.

The Energy Independence and Security Act of 2007 requires comprehensive energy and water evaluations/audits and the implementation of energy and water efficiency measures. It also requires putting in place operation and maintenance plans and measuring and verifying energy and water savings.

Current Status of Army Installation Water Use

Army installations exist throughout the United States and the world, in every climate zone and geographic area. Installations vary widely in age and in size from small Reserve facilities to many installations that occupy more than 100,000 acres with populations exceeding 50,000 residents and staff. Buildings on installations are usually under central control, and the master-planning division of the installation maintains a schedule to phase in new construction and demolish old buildings. Although the military tries to maintain and upgrade utility systems on a regular basis, the reality is that many utility collection and distribution systems are more than 50 years old. (Due to their visibility, treatment plants receive slightly more attention.) Moreover, military installations have hundreds of historic buildings and substantial stocks of World War II vintage facilities.

Directorates of Public Works (DPWs) or similar entities have traditionally been responsible for keeping installations functional and operational; and for controlling all real estate within installation boundaries. However, some installations have privatized utilities, including water and wastewater. Also, with the advent of the RCI, private companies sometimes provide family housing, including utility services, on a long-term property lease, which takes direct control away from the installation.

Usually, the largest water consumption activity on most installations is irrigation of large expanses of parade grounds, parks and recreation areas, athletic fields, golf courses, cemeteries, and landscaped grounds. In addition to family housing, institutional, industrial, and barracks buildings also use water, primarily for domestic wastewater. Some of the biggest water consumers are hospitals, laboratories of various sorts, and dining facilities. Central Vehicle Wash Facilities, which are used for washing tracked and wheeled vehicles, are unique facilities with unique recycling developed to accomplish the task.

Water supply is finite. It is essential to squeeze maximum use out of the existing supply while supplementing that supply through beneficial reuse in nonpotable applications in addition to being water efficient. Chapters 1 through 14 provide BMPs for water-use efficiency.

Chapter 1 - Water Management Planning

A water management plan is the start of a water management program and should be included along with other installation plans. Water management plans provide information about how an installation uses water from production or purchase to ultimate disposal or reuse. Knowing where water is used enables Army installations to better understand their systems and make appropriate water management decisions.

Overview

Installation water management plans should include the following:

- Water-use Policy Statement and Goals
- Utility Information
- Water-use Information
- Metering or Measurement Plan
- Emergency Response Information
- Comprehensive Planning
- Opportunity Assessment
- Coordination with Installation Environmental Management Systems

Water-use Policy Statement and Goals

Senior installation management should support water efficiency in a material way. This can be done in two ways:

1. By providing a written policy statement that ties water efficiency into the long-term operating objective of the installation.

2. By making the necessary staff and financial resources available to track water use, maintain equipment, and implement cost-effective water-use reduction projects.

The installation should translate its water efficiency policy into specific water-use reduction targets in coordination with its headquarters organization. Each federal agency, starting with fiscal year FY08, was directed to reduce water consumption intensity, relative to a FY07 baseline, 2% annually (a total of 16%) through the end of FY15 through life-cycle cost-effective measures. The numeric target is to be achieved at the agency level, indicating that all installations have to contribute their share through reductions at the local level.

Utility Information

The purpose of this chapter is to identify the cost of water and sewer service on a unit basis, verify that the installation is paying the right amount, and identify any services that the supporting water utility or installation, if water operations are conducted by the installation, might provide to help manage water more efficiently. Appropriate information should include the following:

- Contact information for all water and wastewater utilities
- Current rate schedule and alternative schedules appropriate for the installation to ensure that the best or most appropriate rate is being paid.
- Copies of water/sewer bills for the past 2 years, which helps identify inaccuracies and ensure the appropriate rate structure is applied.
- Information on financial or technical assistance available from supporting utilities (of which an installation may be a customer) to help with installation water planning and implementing water efficiency programs. Energy utilities may be a source of assistance.
- Contact information for the federal agency or office that pays water/sewer bills.
- Production information if the installation produces its water and/or treats its own wastewater.

Water-use Information

The most important step in creating a water management plan is establishing a water balance for the installation, which includes identifying and quantifying, to the extent possible, current water use. Most federal installations have metered data for total water use and may have limited-to-zero sub-metering data on individual activities or buildings. However, a walk-through audit of the installation, coupled with a basic understanding of how water is being used and some engineering judgment, enables an assessor to create a relatively complete account of how water is being used and the approximate quantities used for each purpose. This basic understanding is critical to identifying potential water saving opportunities.

The following six steps outline one way to assess water-use trends at an installation:

1. Plot water-use data from the utility water bills for the previous 2 years. Is water consumption decreasing, increasing, or steady? Do you know why? Is there a seasonal pattern to water use as is often the case when irrigation or cooling water demands increase during summer months?

2. Create an inventory of all water-using activities. Other BMPs provide a good checklist to start. Individuals with direct knowledge of high water-consuming activities such as cooling water, irrigation systems, and industrial processes may need to be contacted to generate a complete inventory.

   This step should include a walk-through audit of all installation activities and buildings to identify all significant water-using processes and associated operating characteristics. Pay particular attention to drain lines plumbed to floor drains in building mechanical spaces and rooms and utility chases. Trace these back to the originating equipment to ensure they are included in the inventory.

3. For all water-using activities on the inventory, obtain any sub-metering data that may be available. Any such data helps quantify that particular use. Make a quick estimate of continuous uses such as once-through cooling using a bucket and stopwatch technique. This method uses a bucket of known volume and a stopwatch to time how long it takes to fill. A gallons-per-minute calculation can then be determined.

4. Evaluate any seasonal patterns and compare them to the inventory of users. Are any uses seasonal in nature such as cooling tower use or irrigation? The seasonal pattern of water flow (peak use) can help quantify these uses.

5. Use supplemental data to create engineering estimates of use. For example: estimate sanitary water use based on the number of occupants and daily use per occupant; cooling tower use based on cooling capacity and load factor; irrigation water use based on irrigated area and inches of water applied (discuss with agronomist, irrigation POC, or other appropriate individual); and operating equipment water use based on water use per cycle and frequency of cycles.

6. After this process, evaluate the results. Does the inventory and associated water-use account for most of the metered water use? If not, have you missed something or might there be a

leak? After going through this process, you should know the primary water-using activities, which will help prioritize water saving opportunities.

If metered total water-use information does not exist for the installation, examine the component water uses in the estimating method and the relative contribution of each component. This helps prioritize saving opportunities. It should be noted that local or supporting utilities to an installation may have assessment staff that can help with assessment activities. Other sources of assistance may include local and state agencies, ERDC-CERL, Installation Management Command (IMCOM), Center for Health Promotion and Preventive Medicine, and others. Contact this PWTB's technical POC for information.

Metering or Measurement Plan

Once the assessment has been conducted, evaluate the biggest water-using activities and the quality of data available for that use. Consider installing sub-meters on water-intensive processes, such as cooling towers and irrigation systems. Processes can be more carefully controlled when accurate, quantitative information is available. Another option is to use portable flow meters to gain information over a specific time period such as a weekly basis.

The plan should assign responsibility to track water use on an ongoing basis. Continue to plot total water use as new water bills become available. Also, plot any available sub-metered data. Evaluate trends and investigate and resolve any unexpected deviations in water use. Track water-use reductions and publicize success.

Emergency Response Information

Develop water emergency and/or drought contingency plans that describe how the installation will meet minimum water needs in an emergency or reduce water consumption in a drought or other water shortage. This should be done in partnership with local water suppliers and other regional entities if interconnections are available.

Comprehensive Planning

Inform staff, contractors, and the public of the priority the installation places on water and energy efficiency. Ensure water supply, wastewater, stormwater issues, and water efficiency is taken into account when making equipment purchases and during the earliest stages of planning and design for renovation and new construction.

Opportunity Assessment

The water balance described above provides an inventory of water uses and the relative magnitude of each use. For each of these, consider other water-efficient BMPs. Include recommended practices in the installation’s operation and maintenance documentation. Develop a comprehensive list of potential capital improvement projects that reduce water use, noting the cost, potential water savings, and payback of each. This list should provide prioritization to include these projects in the capital planning and budgeting process.

Coordination with Installation Environmental Management Systems (EMS)

EO 13423 established EMS as the primary management approach for addressing environmental aspects; establishing objectives and targets to ensure implementation; and collecting, analyzing, and reporting information to measure performance. Water management planning and implementation should not be separate and distinct from an EMS. Both are part of the same whole and should be consistent. The “Plan, Do, Check, Act” model approach established under an installation EMS should be followed.

Chapter 2 - Information and Education Programs

Education is essential if water efficiency technologies and methods are to be successful. It is not enough to install a retrofit or water saving technology in a facility or building. New operation procedures, retrofits, and replacements are most effective when employees, contractors, and the public know what the new technology or methods are and how to use them properly.

An additional benefit to water efficiency is positive public opinion. If your installation is doing its part to save community and regional resources, let them know. Informing the public about your installation's commitment to reduce waste is good news. The news media is often interested in installations that take a proactive stand on water efficiency. Options include both internal and external information and education.

Internal Information and Education Options

The following options are available to help federal agencies conduct internal communication and education programs:

- Establish a user-friendly hotline or other communication system internal stakeholders can use to report water leaks or other wastes of water. Repair reported leaks promptly to encourage continued participation.

- Keep employees informed about the installation's commitment to water efficiency, ongoing improvement programs, and any program success. Start a water conservation column in the local newsletter or paper featuring how much water has been saved through the water management program.

- Share information with employees on how water is used within the installation and how much water is used for different activities. This communicates to employees how their actions can reduce water use.

- Place signs and placards near new equipment, making it easy to understand the new technology and how to use it properly.

- Start a suggestion and incentive system to recognize and encourage water savings at the installation. Consider distributing efficiency devices. Communicate progress towards achieving water-use reduction goals.

- Conduct regular training workshops for implementing water efficiency BMPs. Include maintenance personnel to keep them up to date on operational changes and maintenance procedures.

- Integrate water management into the installation EMS. Consider water use as an environmental aspect of the EMS. Use existing EMS teams and procedures as appropriate for training, monitoring, and communication.

External Information and Education Options

The following options are available to conduct external communication and education programs:

- Work with local utilities to develop comprehensive programs and to share successes with similar facilities.

- Invite members of the local news media to tour your installation and see first-hand the efficiency program and achieved success.

- Create displays presenting installation water savings for posting in lobbies, school environmental fairs, or other public reception areas (Figure A-1).

- Develop websites, brochures, and other materials for distribution to employees and the public describing your program, goals, and successes.

Figure A-1. Fort Huachuca water education program (Scholze 2010).

Chapter 3 - Distribution System Audits, Leak Detection, and Repair

A distribution system audit, leak detection, and repair program will help Army installations reduce water losses and make better use of limited water resources (Figure A-2).

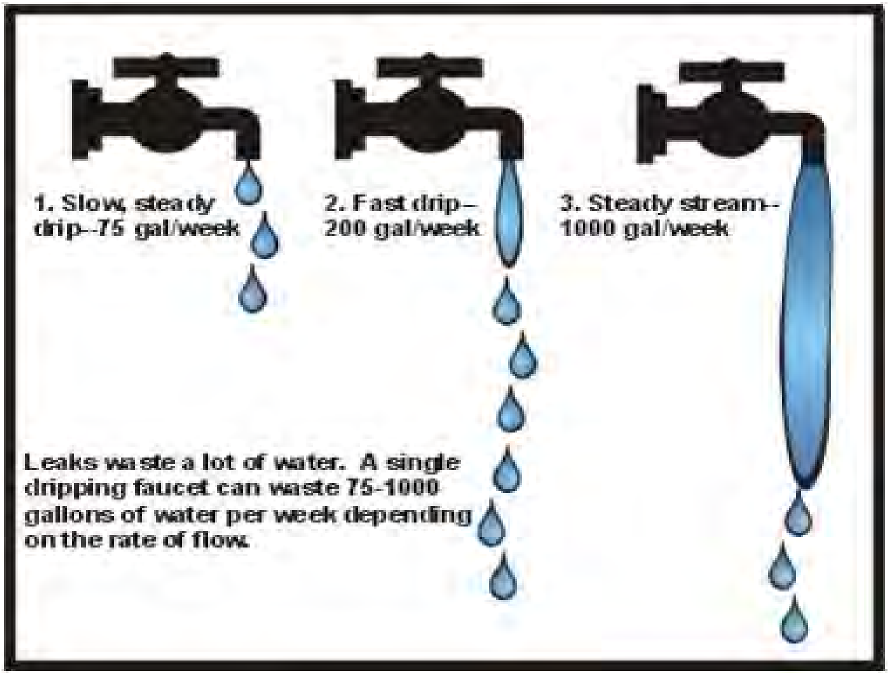

Figure A-2. Typical water losses over time can waste large quantities of water (Scholze 2011).

Overview

The average circa-1940s military installation loses more than 10% of its total water production and purchase to system leaks or poor metering practices (e.g., meter under registration and meter reading errors due to malfunction, poor installation, or wear). Regular surveys of distribution systems should always be conducted prior to obtaining additional water supplies (Figure A-3 and Figure A-4). Surveys for leaks can generate substantial benefits including:

- Reduced water losses: Reducing water losses stretches existing supplies to meet increasing demand. This could defer construction of new water facilities such as wells, reservoirs, or treatment plants.

- Reduced operating costs: repairing leaks saves money by reducing power costs to deliver water and chemical costs to treat water.

- Increased knowledge of the distribution system: Becoming more familiar with the system, including knowing the location of mains and valves, enables personnel to respond faster to emergencies such as main breaks.

- Reduced property damage: Repairing system leaks prevents damage to property and safeguards public health and safety.

- Improved justification for water management: Conducting routine water audits and verifying production and end point meters results in better accounting and helps validate the need to reduce water losses.

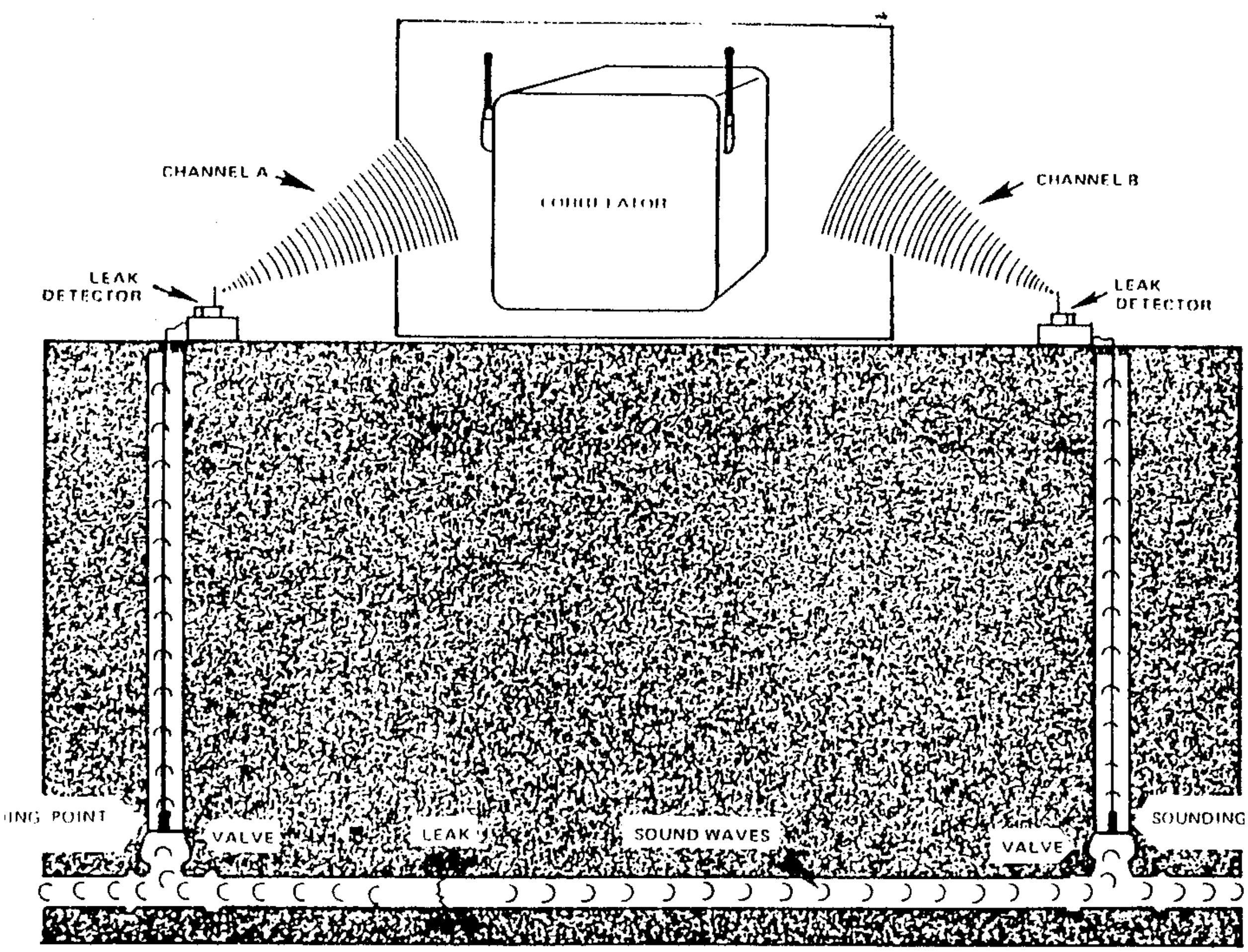

Figure A-3. Leak detection can be accomplished acoustically when a correlator receives sound waves indicating location of a leak in pipe (Scholze 2011b).

Figure A-4. A more advanced leak detection system uses software to analyze information downloaded from data loggers located on pipes within a water distribution system (Scholze 2011b).

Operations and Maintenance

To maintain water efficiency in operations and maintenance, installations should complete a pre-screening system audit, which helps determine the need for a full-scale system audit. The following two methods can be used for pre-screening and are recommended to be completed every 2 years.

Method 1:

1. Determine authorized users.

2. Determine other verifiable water system uses.

3. Determine total water supply into the system.

4. Divide authorized users plus other verifiable uses by total supply into the system.

If the quantity derived from the above calculation is less than 0.9, a full-scale system audit is needed.

Method 2:

Obtain and monitor minimum system flow after a system audit has been conducted. This is typically the flow rate at 0300 or 0400 hours.

A significant increase to the minimum system flow can be assumed to be leak related and indicates that a full-scale leak detection survey is necessary.

When indicated, facilities and installations should complete full-scale water audits using the latest edition of the American Water Works Association Water Audit Software.

Retrofit and Replacement Options

The following retrofit and replacement options help installations maintain water efficiency across systems:

Repair leaks or replace pipes when leaks are found. These repair and replacements are done to repair or avoid main breaks; replace corroded pipe; alleviate water quality problems; increase available fire-hydrant flow; and improve overall area delivery for the distribution system.

For specifics, consult with experts in the field. The first resource should be local or headquarters engineers (DPW, USACE, ERDC-CERL, IMCOM), but do not overlook input from experienced contractors or other government agencies.

Chapter 4 – Water-Efficient Landscaping

Overview

Traditional landscaping requires supplemental water to thrive in most locations. Irrigation must be added to make up the difference between landscape water requirements and the natural precipitation in many areas. Depending upon the climate, water applied outdoors may be a substantial portion of total water use. If any irrigated landscape exists on an installation, exterior water use is an important part of any overall water efficiency program. These principles apply to traditional landscapes as well as cemeteries, golf courses, parade grounds, athletic fields, or other nontraditional landscapes (Figure A-5).

Figure A-5. A typical parade ground is one example of a landscape that requires water to thrive in most locations (Scholze 2011a).

There are two facets of outdoor water-use efficiency:

1. Designing a landscape that requires minimal supplemental water.

2. Designing, installing, and maintaining an irrigation system that applies the appropriate amount of supplemental water in an efficient manner. See Chapter 4 BMP on Water-Efficient Irrigation.

Water-efficient landscapes that use native and other “climate-appropriate” materials can reduce irrigation water use by more than 50%, stand up better to drought, reduce drought loss or damage, and require less time and money to maintain.

Operation and Maintenance

To maintain water efficiency in operations and maintenance, installations should:

- Periodically review all landscape service and maintenance agreements to incorporate a high priority for water, chemical, and energy efficiency.
- Consider hiring landscape contractors that focus on water-efficient or climate-appropriate landscaping. Recommend existing contractors attend courses or seminars to learn these techniques.
- Encourage landscape contractors to report and/or fix problems. Many landscape contractors not only install and maintain plants in a landscape, but also install and maintain the irrigation system. These contractors can identify and report leaks or other inefficiencies in the landscape.
- Add mulch to plant beds. Mulch decreases water lost from soil through evaporation and helps reduce weed growth.
- Maintain a sufficient quantity of good topsoil, 4–6 in., to capture stormwater as it falls and to release moisture back to plants over time. The result reduces irrigation requirements.
- Recirculate water in decorative fountains, ponds, and waterfalls. Shut off these features when possible to reduce evaporation losses. Check water recirculation systems annually for leaks and other damage. Consider using nonpotable water in these systems.
- Alternate turf mowing height between low and high levels. This encourages roots to grow deeply and allows plants to go longer between watering sessions.
- Keep irrigated landscape weed free so valuable water is consumed only by decorative landscape.
- Stop using water to clean sidewalks, driveways, parking lots, tennis courts, pool decks, and other hardscapes.

Retrofit Options

The following retrofit options help the Army maintain water efficiency across installations and facilities/activities:

- Select drought-tolerant or climate-appropriate turf, trees, shrubs, and ground cover when replanting landscaped areas.

- Consider reducing the area of turf in the landscape. Most turf requires substantially more water than planted beds, especially if the plants are climate-appropriate and covered with mulch.

- Eliminate “strip grass” to the greatest extent possible. Small strips of grass, common in parking islands and between sidewalks and the roadway, are hard to maintain and difficult to water efficiently. Use bushes, mulch, or permeable hardscape instead.

- Implement low-impact development techniques, such as making parking lot islands depressions instead of raised curb areas to capture and retain moisture.

Replacement Options

The following replacement options can help maintain water efficiency:

- Replace or install the entire landscape with climate-appropriate, water-efficient plant material. It is possible to design a landscape that does not require the use of supplemental water. Think native species and xeriscape.

- Design the landscape so plants with similar water needs are grouped together (hydrozoning). This allows for more efficient irrigation.

- Ensure the landscape is properly designed from the start. Hire a licensed architect or a qualified site planner/designer if none is on staff. Designing with water efficiency in mind limits the clearing of native vegetation, which increases recharge and limits surface runoff, thereby limiting the size of potential stormwater pond(s).

- Ensure soil does not need improvement before installing a landscape. Depending on type, soil may need to be amended to ensure water is delivered to the plant efficiently (i.e., good absorption and water holding capacity).

- Use turf only where it is needed, avoiding long narrow areas that cannot be irrigated effectively.
- Ensure trees are planted at the appropriate depth.
- When designing new landscape, avoid the use of ornamental water features.

Chapter 5 – Water-Efficient Irrigation

Water efficiency must be considered from the initial irrigation system design phase through installation to ensure optimal performance. Consistent mismanagement and maintenance is also essential. Failure to do so can result in losing more than 50% of irrigation water due to evaporation, wind, poor management, and/or improper system design, installation, or maintenance.

With the irrigation system hardware operating efficiently, it is important to consider the irrigation schedule, which dictates the amount and timing of the water applied. Water changes with the seasons as should the irrigation schedule. Many landscapes are watered at the same level all year, adding unnecessary water for months at a time. Over-watering can cause more damage to plant materials than under-watering and can damage streets, curbs, other paving, and building foundations.

Overview

Whether installing a new irrigation system or retrofitting an old one, there are many options to improve water efficiency. Most importantly, the person(s) responsible for the irrigation system should have proper training in system installation, maintenance, and management.

An important efficiency concept associated with irrigation systems is distribution uniformity, or how evenly water is applied over the landscape. Extra water is often applied because the system is not distributing water in a uniform manner. When water is not applied evenly, the landscape is watered to keep the driest spot green, grossly over-irrigating other areas.

Operation and Maintenance

To maintain water efficiency in operations and maintenance, installations should:

- Recommend existing contractors become familiar with water-efficient irrigation practices through partnerships, classes, seminars, and/or published guidance documents. They can be referred to:
  - The U.S. Environmental Protection Agency (EPA) WaterSense program to learn about becoming a WaterSense irrigation partner.

  - Locally offered courses or seminars on water-efficient irrigation practices (check with local water utilities or community colleges for availability).

  - BMPs and guidance documents. Many local cooperative extensions and irrigation trade associations provide BMP and guidance documents online or hard copy.

- When hiring a vendor, inquire about the water efficiency knowledge of their personnel. Request a demonstration of practices that promote efficient irrigation. WaterSense can help locate irrigation professionals in a given area that have demonstrated knowledge in water-efficient irrigation.

- Periodically review all irrigation service agreements/ contracts to incorporate a high priority for water efficiency. Consider the following options:

  - Incorporate a water budget, which can be used as a performance standard for water consumption. A vendor calculates your water needs and uses that information to plan an irrigation schedule to meet those needs.

  - Require a full audit of the irrigation system every 3 years by a qualified auditor. This process is an in-depth assessment of the irrigation system and its performance to verify proper scheduling and to expose growing deficiencies from changes, growth of landscape, or an aging system (Figure A-6). It is also an opportunity to employ new technologies.

Figure A-6. An irrigation audit with cups to measure water distribution (http://www.keywordpicture.com/keyword/irrigation%20audit/).

- Request vendors include immediate reporting and repair of problems in their maintenance programs and also require regular, periodic maintenance routines as part of the overall irrigation maintenance program.

- Install an irrigation meter to measure the amount of water applied to the landscape. Some water utilities offer an interruptible rate for the service or will provide a credit to the sewer charges. Installation maintenance or the contractor responsible for maintenance should keep a record of all irrigation water use as part of its maintenance program.

- Verify that the irrigation schedule is appropriate for climate, soil conditions, plant materials, grading, and season.

  – Change the schedule based upon changing weather conditions and as part of regular, periodic maintenance. Require the maintenance vendor and/or auditor to deliver options for automating schedule changes based on changing weather conditions.

  – Certain soil types or steep slopes may increase the chance of surface runoff. Irrigation events may need to be broken up into multiple applications depending on landscape conditions. This methodology is commonly known as “cycle and soak.” Ask the maintenance vendor to assemble and implement such schedule parameters as necessary. If currently installed irrigation controllers(s) is/are not capable of such programming, replace with current technology.

  – Generally, it is better to water deeply and less frequently than to water lightly and often. A deep, less frequent schedule encourages deep roots resulting in healthy plants. Ask the vendor to produce and implement a program that takes into account the optimal water window and other scheduling requirements that relate to the actual landscape being maintained.

- In addition to a full system audit every few years, periodically monitor for effectiveness throughout the year. Ask the vendor to produce and implement a program that makes sure certain sprinkler components are placed and adjusted so that they will water the cultivated plants and not the pavement. Verify that irrigation system pressure is within manufacturer specifications. To help ensure consistent uniformity, require that replacement equipment is compatible with existing equipment.

- Always attach shut-off nozzles to handheld hoses.

Retrofit Options

The following retrofit options can help the Army maintain water efficiency across installations:

- Replace existing irrigation system controllers with a more advanced control system that waters plants only when needed (Figure A-7). There are many available technologies that use weather or soil moisture information to schedule irrigation according to plant needs. Below are a few options to discuss with the service provider, auditor, or consultant/designer:

  – Weather-based irrigation controls are an irrigation controller or device that can be added to an existing controller. They use real-time or historical weather information along with landscape parameters entered by the vendor to schedule or allow for irrigation when plants need water.

  – Soil-moisture-based irrigation controls are inserted into the soil to measure moisture. They can be connected to an existing controller or add-on device, enabling irrigation when the plants need water.

- Complete central control systems utilize demand-based controls and enable a water manager to centrally operate and manage multiple irrigation systems at multiple locations using various locations using various means of communication.

Figure A-7. A typical, newer style of irrigation control system that will conserve water (Scholze 2011a).

- Consider retrofitting a portion of the trees, shrubs, or plant beds with low-flow, low-volume irrigation, also called micro-irrigation or drip irrigation. Many plant beds do not require the spray heads traditionally used to water turf areas. Drip irrigation can be more efficient due to slow and direct water application to plant root zones, minimizing evaporation and runoff.

- Increase the efficiency of the system’s sprinkler heads. Sprinklers with a fine mist are susceptible to water waste from wind drift. Also, some sprinklers don’t apply water evenly over the landscape. Existing sprinkler heads can often be exchanged with more efficient heads designed to minimize water lost to wind and distribute water in a more uniform manner.

- Install rain-sensing technology on the system to prevent irrigation from taking place during periods of sufficient moisture. Many cities, and some states, require rain-sensing technology by law. Check with supporting cities or states on relevant mandates.

- Install wind-sensing technology to interrupt irrigation cycles in the presence of significant wind.

- Install freeze-sensing technology to prevent irrigation during freeze conditions.

Replacement Options

The following replacement options can help maintain water efficiency across an installation:

- When installing a new system, hire an irrigation design company that has experience in designing water-efficient systems. Also ensure that the installation and maintenance vendor has a background in water efficiency.

- Upon completion of new irrigation systems, audit the irrigation system using a qualified irrigation auditor to determine if baseline efficiencies are compatible with design intent and to make minor adjustment recommendations as needed.

- Recommend that your system be designed, installed, and maintained according to irrigation BMPs published by local cooperative extensions and irrigation or landscape trade associations. Visit the Irrigation Association website for information related to the most widely known irrigation BMPs.

- Design the system for maximum water application uniformity (distribution uniformity). Discuss the following with the designer:

  - No direct distribution of water over impermeable surfaces or non-target areas.

  - Maximize sprinkler distribution uniformity by following manufacturer recommendations for head spacing. Consider necessary spacing reductions to compensate for prevailing winds.

  - Create irrigation hydrozones by grouping turf and plants with similar water needs. Also consider varying soil conditions, sun/shade/wind exposure, slope, and other site specifics that may impact watering needs.

- Consider installing the following components for optimal water efficiency:

  - Drip/micro-irrigation for all areas suitable for such technology (Figure A-8 and Figure A-9).

  - Check valves in all sprinklers to retain water in lateral pipes between cycles.

Figure A-8. Drip irrigation system in use (Scholze 2011a).

Figure A-9. Components of a drip irrigation system, which can be easily installed. (http://watercentral.wordpress.com/).

- Demand-based irrigation controls such as weather- or sensor-based controls.

- Rain, freeze, and wind sensors to interrupt irrigation during unfavorable weather conditions.

- Flow rate monitoring equipment that can interrupt irrigation if excess flow is detected (i.e., caused by broken pipes, fittings, nozzles, emitter, sprinklers, etc.).

- Use alternative sources of water where environmentally appropriate and local regulations allow, such as reclaimed or nonpotable water.

Chapter 6 - Toilets and Urinals

The United States uses 4.8 billion gallons of water every day to flush waste. Toilets and urinals account for nearly one-third of building water consumption, making the savings potential in this area significant.

Overview

Unless the buildings on your installation are relatively new or have been recently refurbished, there is a good chance that toilets and urinals are consuming too much water. Current Federal law requires residential toilets (flush tank type) manufactured and sold in the United States after 1 January 1994 to use no more than 1.6 gallons per flush (gpf). Similarly, commercial toilets (flushometer valve type) manufactured and sold after 1 January 1997 must use no more than 1.6 gpf (Figure A-10, left). The toilets in this group are called low-flow toilets. Urinals must use no more than 1.0 gpf.

The U.S. EPA WaterSense program released specifications for tank-type toilets and flushing urinals. Tank-type toilets cannot exceed an effective flush rate of 1.28 gpf and flushing urinals are specified to not exceed 0.5 gpf. These units are called High Efficiency Toilets (HETs).

Niagara Corporation recently began selling its Stealth™ toilets for residential use, proving that even lower water-consuming toilets can be manufactured. The Stealth toilet uses 0.8 gal per flush (Figure A-10, right and Figure A-11).

Figure A-10. Typical high-efficiency flushometer toilet used in institutional settings (left) and the Stealth toilet (right). (http://www.ecohomemagazine.com/Images/tmp13D7.tmp_tcm14-406661.jpg).

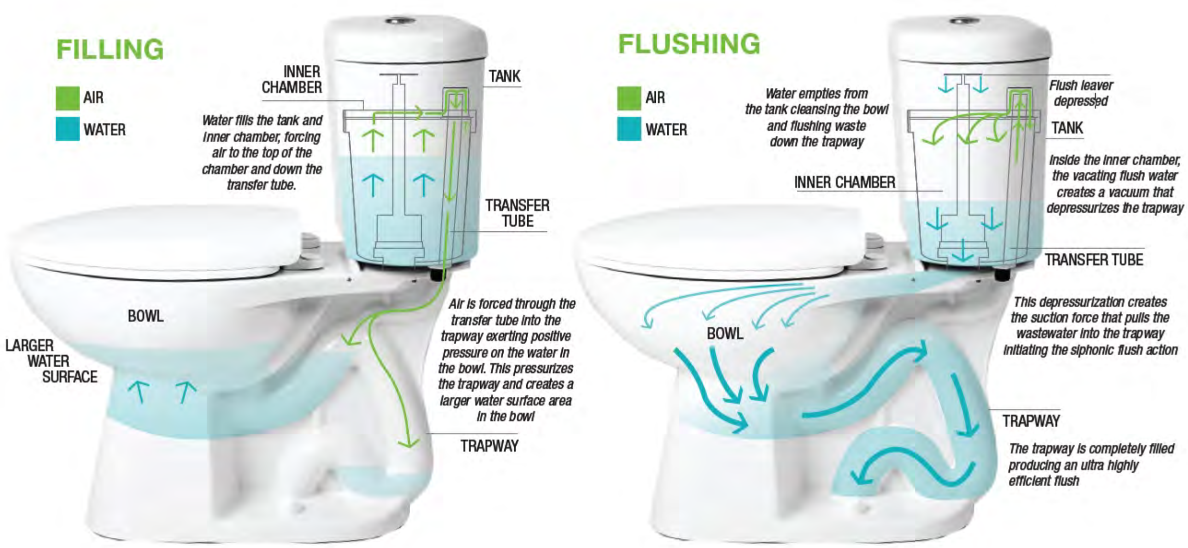

Figure A-11. Explanation of how a Stealth toilet functions. (http://static2.vipasuite.com/resources/dyn/files/414318z86b0462f/_fn/Stealth+Flushing+Technology.JPG).

Operation and Maintenance

To maintain water efficiency in operations and maintenance, installations should check individual buildings and facilities as follows:

- Check for leaks every 6 months.
- Establish a user-friendly method to report leaks and fix them immediately.
- Encourage cleaning or custodial crews to report problems.
- Periodically replace flush valves and fill valves in tank-type toilets.
- When performing maintenance, replace worn parts and adjust mechanisms to ensure that the water consumed per flush meets manufacturer equipment specifications.
- If nonwater urinals are used, clean and replace the seal cartridges or materials in accordance with manufacturer recommendations.
- Correctly adjust and maintain automatic sensors to ensure proper operation.

Retrofit Options

Although some options are not appropriate for use in military facilities, the following retrofit options can help maintain water efficiency:

- Retrofits for tank-type toilets, such as displacement dams or bags, may hamper overall operation of the toilet and increase maintenance costs as they often have a short life span and require frequent replacement or adjustment. Therefore, they are not appropriate for military facilities.
- For flushometer valve-type toilets, infrared or ultrasonic sensors can be retrofit to automatically activate flushing, making their operation fully “hands free” and sanitary. However, these devices need to be set properly and regularly maintained to avoid multiple flushing. While providing sanitary advantages, it should not be considered as a water-saving device.

- For some commercial flushometer valve toilets (diaphragm type only), the existing flush valve can be retrofit with a dual-flush valve capable of delivering a reduced flush or a full flush depending upon the demand (i.e., liquid waste only or solid and liquid waste). Note that this type of retrofit may require user education to be fully successful. In addition, the existing bowl must be compatible with the reduced flush volume.

- Early closure or valve insert or replacement devices can reduce flush volumes by 0.6 to 2 gpf. However, they often require frequent replacement or adjustment, may lead to clogging and other flush performance problems, and may void warranties on the fixture itself. Therefore, they are not appropriate for installation facilities.

- Consider using nonpotable water for toilet and urinal flushing. Package graywater treatment systems are now available that provide water filtered and treated sufficiently for these uses. If using nonpotable water for toilet and urinal flushing, monitor flapper valves and seals to determine their useful life span.

Replacement Options

- The following replacement options can help the Army maintain water efficiency across installation facilities:

- Replace 3.5–5 gpf toilets with flushometer valves and bowls specifically designed to use 1.6 gpf or less. Consider installing HET that use no more than 1.28 gpf. For maximum water savings and performance, purchase the valve and bowl in hydraulically matched combinations that are compatible in terms of their designed flushing capacity. To ensure proper flushing, avoid replacing only the flushometer valve or tank with a more efficient 1.6 gpf or less model if the bowl is designed to handle 3.5 gpf or more. Site-specific evaluation of existing waste lines, water pressure, distance, usage, settling, and types of users (e.g., employees, residents, public, high visitor populations, criminals, etc.) is necessary to determine the appropriate models for a specific site. Where appropriate, recycle used parts such as tank trim and metal flush valves (only the interior mechanism needs to be replaced) to minimize landfill impacts.

- If replacing tank-type toilets (gravity or pressure assist), select toilets with the WaterSense label. These HETs save 20%

over conventional low-flow toilets and have been independently tested and certified for performance. For a listing, visit the WaterSense website.

- Replace urinals with high-efficiency models designed to use 0.5 gpf or less (Figure A-12). Urinals meeting this standard have been available for more than 15 years. If replacing with flushing urinals, consider installing WaterSense-labeled urinals, which are designated to use not more than 0.5 gpf. Some high-efficiency flushing urinals on the market use as little as 1 pint per flush.

- If considering a nonwater urinal, weigh all of the pros and cons available, including life-cycle costs, long-term maintenance, and replacement parts needed over the product's lifetime.

- In remote areas, consider alternatives such as composting or incinerating toilets.

Figure A-12. Each waterless urinal can save tens of thousands of gallons of water per year (Scholze 2011a).

Resources

USEPA WaterSense Program http://www.epa.gov/WaterSense/

Alliance for Water Efficiency Toilet Fixture Introduction: Overview on high-efficiency toilets. http://www.allianceforwaterefficiency.org/toilet_fixtures.aspx?terms=toilets

Alliance for Water Efficiency Urinal Fixture Introduction: Overview on high-efficiency urinals. http://www.allianceforwaterefficiency.org/Urinal_Fixtures_Introduction.aspx?terms=urinals

Chapter 7 - Faucets and Showerheads

Federal guidelines mandate that all lavatory and kitchen faucets and faucet aerators manufactured and sold in the United States after 1 January 1994 must use no more than 2.2 gallons per minute (gpm). In addition, metering faucets (those that, when activated, dispense water of a predetermined volume or for a predetermined period of time) must discharge no more than 0.25 gallons per cycle. Federal guidelines also mandate that all showerheads manufactured and sold in the United States after 1 January 1994, must use no more than 2.5 gpm.

Overview

Advances in technology and differentiation between faucets intended for public versus private use provide water and energy savings potential. The USEPA’s WaterSense program released a specification for residential bathroom lavatory faucets and faucet accessories (aerators or laminar devices) requiring a maximum flow rate of 1.5 gpm or less, a 32% decrease in flow over federal guidelines. Only lavatory faucets intended for private use (i.e., residential housing, barracks, and other dwelling units like hotel guest rooms and hospital rooms) are eligible for the WaterSense label (Figure A-13).

Figure A-13. The WaterSense label means the fixtures meets efficiency requirements per EPA consensus standard.

To address lavatory faucets intended for public use, the American Society of Mechanical Engineers A112.18.1/ Canadian Standards Association B125.1 Plumbing Supply Fittings specifies that public lavatory faucets (all faucets other than those defined as private above), other than metering, must have a maximum flow rate of 0.5 gpm (Figure A-14).

Figure A-14. A typical low-flow faucet will save both water and energy costs.

The WaterSense program released a specification for showerheads requiring a maximum flow rate of no more than 2.0 gpm (Figure A-15). Replacement of older faucets and showerheads offers a significant opportunity to save both water and energy costs (hot water) along with reductions in sewer flow.

Figure A-15. Low-flow shower heads will produce the same shower experience as showerheads using much more water.

Operation and Maintenance

To maintain water efficiency in operations and maintenance, installations should:

- Establish a user-friendly method to report leaks and fix them immediately.
- Encourage cleaning or custodial crews to report problems.
- Test system pressure to make sure it is between 20 and 80 psi. If the pressure is too low, high-efficiency devices will not

work properly. If it is too high, they will consume more than their rated amount of water.

- Install expansion tanks and pressure-reducing valves and reduce water heater settings where appropriate to prevent temperature and pressure relief valves from discharging water.

- Correctly adjust and maintain automatic sensors to ensure proper operation.

- Encourage users to take shorter showers. Place clocks or timers in or near showers to allow users to track their timing better.

- Post energy/water awareness information to encourage efficiency from users.

Retrofit and Replacement Options

The following retrofit and replacement options can help installations maintain water efficiency across their buildings and activities:

- Avoid retrofitting existing inefficient showerheads with flow control inserts or flow control valves (designed to restrict flow or temporarily shut off flow of water, respectively). Flow control inserts and flow control valves may increase risks of thermal shock and scalding and may not provide adequate flow in facilities with low water pressure.

- When installing new showerheads, choose models with a WaterSense label, which have flow rates of no more than 2.0 gpm. Verify that the hot and cold water plumbing lines are routed through an auto-compensating mixing valve (either thermostatic or pressure balancing) designed for the flow rate of the showerhead. This valve protects against significant fluctuations in water pressure and temperature if designed for the flow rate of the showerhead and can reduce risks of thermal shock and scalding. Check with a local plumber and, if necessary, install an auto-compensating mixing valve designed for the flow rate of the showerhead you plan to install.

- For kitchen faucet retrofits, install aerators or laminar flow devices that achieve a flow rate of 2.2 gpm.

- For lavatory faucet retrofits in public restrooms, install faucets or faucet aerators or laminar flow devices that achieve the 0.5 gpm flow rate requirement. For lavatory faucet retrofits in private restrooms (residential housing, barracks, hotel guest rooms, and hospital rooms), install WaterSense-labeled high-efficiency lavatory faucets or faucet aerators or laminar flow devices.

- Install temporary shut-off or foot-operated valves with kitchen faucets. These valves cut off the water flow during intermittent activities like scrubbing or dishwashing. The water can be reactivated at the previous temperature without the need to remix the hot and cold water.

Resources

EPA WaterSense Program http://www.epa.gov/WaterSense/

Alliance for Water Efficiency: Information on faucet and showerhead efficiency http://www.allianceforwaterefficiency.org/

Chapter 8 - Boiler/Steam Systems

Boilers and steam generators are commonly used in large heating systems, institutional kitchens, or facilities where large amounts of process steam are used. This equipment consumes varying amounts of water depending on system use, the amount of steam used, and the amount of condensate returned.

Operation and Maintenance Options

To maintain water efficiency in operations and maintenance, the following should be done:

- Develop and implement a routine inspection and maintenance program to check steam traps and steam lines for leaks. Repair leaks as soon as possible.

- Develop and implement a boiler tuning program to be completed a minimum of once per operating year.

- Provide proper insulation on piping and the central storage tank.

- Blowdown (the periodic or continuous removal of water from a boiler to remove accumulated dissolved solids and/or sludge) is a common mechanism to reduce contaminant build-up. Insufficient blowdown may lead to deposits or carryover. Excessive blowdown wastes water, energy, and chemicals.

- Obtain the services of a water treatment specialist to prevent system scale and corrosion and to optimize cycles of concentration. Treatment programs should include periodic checks of boiler water chemistry.

- Develop and implement routine inspection and maintenance programs on condensate pumps.

- Regularly clean and inspect boiler water and fire tubes. Reducing scale buildup improves heat transfer and the system energy efficiency.

- Employ an expansion tank to temper boiler blowdown drainage rather than cold water mixing.

- Install meters on boiler system make-up lines.

- Install meters on make-up lines to recirculating closed water loop heating systems so that leaks can be detected.

Retrofit Options

The following retrofit options can help water efficiency:

- Install and maintain a condensate return system. Water supply, chemical use, and operating costs for this equipment can be reduced by up to 70% by recycling condensate for reuse. A condensate return system also lowers energy costs as the condensate water is already hot and needs less heating to produce steam than water from other make-up sources.

- Install an automatic blowdown system based on boiler water quality to better manage the treatment of boiler make-up water.

- Add an automatic chemical feed system controlled by make-up water flow.

- To optimize cycles of concentration and reduce the frequency of blowdown, an inert ion such as silica or chloride can be measured in the boiler and the concentration compared to the amount in the boiler feedwater. For example, a boiler with a silica concentration of 100 parts per million (ppm) and a feedwater silica concentration of 10 ppm is considered to be carrying 10 cycles of concentration. Monitoring the ion continuously can allow better control and adjustment of the chemical feed rate to optimize the number of blowdown cycles.

- In large-scale boilers, blowdown heat exchangers are a useful technology allowing the heat contained in boiler blowdown to be transferred to boiler feedwater. This also allows for the production of low-pressure steam, which can be returned to the steam system or used in the de-aeration of boiler feed water.

Replacement Options

The following replacement options may help water efficiency at installations:

Replacement options vary depending on the size of the facility and existing equipment. Consider performing an energy audit to reduce heating loads and ensure that the system is sized appropriately. Reducing the size of the boiler system can reduce water requirements.

Always purchase the most life-cycle cost-effective boiler available for new installations or major renovations.

Consider installing a small summer boiler, distributed system, or heat-capture system for reheat or dehumidification requirements instead of running a large boiler at part load. Also consider alternative technologies such as heat pumps.

Consult with experts in the field. The first resource is the local DPW or IMCOM engineers. Other resources include ERDC-CERL engineers and other government agencies.

Chapter 9 - Single-Pass Cooling Equipment

Single-pass or once-through cooling systems provide an opportunity for significant water savings. In these systems, water is circulated once through a piece of equipment and is then disposed down the drain. Types of equipment that typically use single-pass cooling include computerized axial tomography (CAT) scanners, degreasers, hydraulic equipment, condensers, air compressors, welding machines, vacuum pumps, ice machines, x-ray equipment, and air conditioners.

To remove the same heat load, single-pass systems use 40 times more water than a cooling tower operated at five cycles of concentration. To maximize water savings, single-pass cooling equipment should be either modified to recirculate water or, if possible, should be eliminated altogether.

Operation and Maintenance

To maintain water efficiency in operations and maintenance, installations should:

- Provide proper insulation on piping, chiller, or storage tanks.
- Inventory cooling equipment and identify all single-pass cooling systems.
- Check entering and leaving water temperatures and flow rates to ensure they are within the manufacturer’s recommendations. For maximum water savings, water flow rates should be near the minimum allowed by the manufacturer.
- Keep coil loops clean to maximize heat exchange with the refrigerated enclosure.
- Check operation of water control valve. Water control valves adjust the flow rate of water based on demand. Regular valve maintenance ensures water is used as efficiently as possible.

Retrofit Options

The following retrofit option can help installations maintain water efficiency:

- To maximize water savings, eliminate single-pass cooling by modifying equipment to operate on a closed loop that recirculates water instead of discharging it.

- If modification of equipment to a closed-loop system is not feasible, add an automatic control to shut off the entire system during unoccupied night or weekend hours. This option should be considered only when shutdown has no adverse impact on indoor air quality.

- Installation of a chiller or cooling tower is also an economical alternative. Excess cooling capacity may already exist within the building that can be utilized.

- Find another use for the single-pass effluent in boiler make-up supply or landscape irrigation and implement. Some equipment effluent may be contaminated, such as degreasers and hydraulic equipment. This effluent must not be used in boilers.

Replacement Options

The following replacement options can help maintain water efficiency:

- Replace water-cooled equipment with air-cooled equipment or best available energy/water-efficient technology.

- Replace the once-through cooling systems with a multi-pass cooling tower or closed-loop system.

- Consult with experts in the field such as local or headquarters engineers or similar experienced personnel, IMCOM, USACE, etc.

Chapter 10 - Cooling Tower Management

Cooling towers regulate temperature by dissipating heat from recirculating water used to cool chillers, air-conditioning equipment, or other process equipment. Heat is rejected from the tower primarily through evaporation. Therefore, by design, cooling towers consume significant amounts of water.

Figure A-16 illustrates water flow across a typical cooling tower. A brief primer on cooling towers and water efficiency is available from FEMP (US Department of Energy 2011).

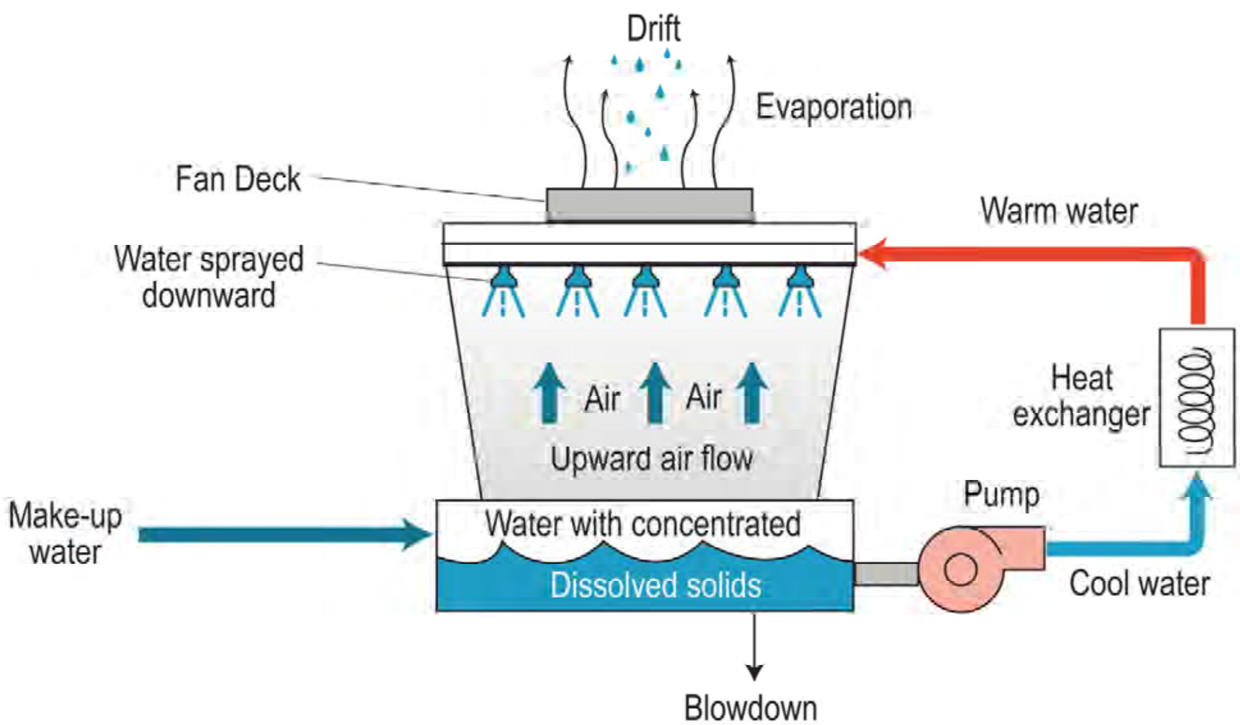

Figure A-16. Water flow across a cooling tower (US Dept of Energy 2011).

Overview

The thermal efficiency and longevity of the cooling tower and equipment used to cool it depend on the proper management of water recirculated through the tower. Water leaves a cooling tower system in any one of four ways:

- Evaporation: This is the primary function of the tower and is the method that transfers heat from the cooling tower system to the environment. The quantity of evaporation is not a subject for water efficiency efforts (although improving the energy efficiency of the systems you are cooling will reduce the evaporative load on the tower).

- Drift: A small quantity of water may be carried from the tower as mist or small droplets. Drift loss is small compared to evaporation and blowdown, and is controlled with baffles and drift eliminators.

- Blowdown or bleed-off: When water evaporates from the tower, dissolved solids are left behind. As more water evaporates, the concentration of dissolved solids increases. If the concentration gets too high, the solids can cause scale to form within the system or the dissolved solids can lead top corrosion problems. The concentration of dissolved solids is controlled by blowdown. Careful monitoring and control of the quantity of blowdown provides the most significant opportunity to conserve water in cooling tower operations.

- Basin leaks or overflows: Properly operated towers should not have leaks or overflows.

The sum of water that is lost from the tower must be replaced by make-up water:

$$\text{Make-up} = \text{Evaporation Blowdown} + \text{Drift}$$

A key parameter used to evaluate cooling tower operation is “cycles of concentration” (sometimes referred to as cycles or concentration ratio). This is calculated as the ratio of the concentration of dissolved solids (or conductivity) in the blowdown water compared to the make-up water. Since dissolved solids enter the system in the make-up water and exit the system in the blowdown water, the cycles of concentration are also approximately equal to the ratio of volume of make-up to blowdown water.

From a water efficiency standpoint, you want to maximize cycles of concentration, which will minimize blowdown water quantity and reduce make-up water demand. However, this can be done only within the constraints of the make-up water and cooling tower chemistry. Dissolved solids increase as cycles of concentration increase, which can cause scale and corrosion problems unless carefully controlled.

In addition to carefully controlling blowdown, other water efficiency opportunities arise from using alternate sources of make-up water. Water from other equipment within a facility can sometimes be recycled and reused for cooling tower make-up with little or no pre-treatment, including the following:

- Air handler condensate (water that collects when warm, moist air passes over the cooling coils in air handler units). This reuse is particularly appropriate because the condensate has a low mineral content and is typically generated in greatest quantities when cooling tower loads are the highest.

- Water used in a once-through cooling system.

- Pretreated effluent from other processes, provided that any chemicals used are compatible with the cooling tower system.

- High-quality municipal wastewater effluent or recycled water (where available).

Operation and Maintenance

To maintain water efficiency in operations and maintenance, installations should:

- Calculate and understand your “cycles of concentration.” Check the ratio of conductivity of blowdown and make-up water. Work with a cooling tower water treatment specialist to maximize the cycles of concentration. Many systems operate at two to four cycles of concentration, while six cycles or more may be possible. Increasing cycles from three to six reduces cooling tower make-up water by 20% and cooling tower blowdown by 50%.

- The actual number of cycles that can be carried depends on make-up water quality and the cooling tower water treatment regimen. Depending on the make-up water, treatment programs may include corrosion and scaling inhibitors along with biological fouling inhibitors.

- Install a conductivity controller to automatically control blowdown. Working with the water treatment specialist, determine the maximum cycles of concentration that can be safely achieved and the resulting conductivity. A conductivity controller can continuously measure the conductivity of the cooling tower water and discharge water only when the conductivity set point is exceeded.

- Install flow meters on make-up and blowdown lines. Check the ratio of make-up flow to blowdown flow. Then check the ratio of conductivity of blowdown water and the make-up water. This ratio should match your target cycles of concentration. If both ratios are not about the same, check the tower for leaks or other unauthorized draw-off. If you are not maintaining target cycles of concentration, check system components including conductivity controller, make-up water fill valve, and blowdown valve.

- Read conductivity and flow meters regularly to quickly identify problems. Keep a log of make-up and blowdown quantities, conductivity, and cycles of concentration. Monitor trends to spot deterioration in performance.

- Consider using acid treatment such as sulfuric, hydrochloric, or ascorbic acid where appropriate. When added to recirculating water, acid can improve the efficiency of a cooling system by controlling the scale buildup potential from mineral deposits. Acid treatment lowers the pH of the water and is effective in converting a portion of the alkalinity, a primary constituent of scale formation, into more readily soluble forms. Acid overdoses can severely damage a cooling system. The use of a timer of continuous pH monitoring via instrumentation should be employed. Additionally, it is important to add acid at a point where the flow of water promotes rapid mixing and distribution. A corrosion inhibitor may have to be added when lowering pH.

- Select your water treatment vendor with care. Tell vendors that water efficiency is a high priority and ask them to estimate the quantities and costs of treatment chemicals, volumes of blowdown water, and the expected cycles of concentration ratio. Keep in mind that some vendors may be reluctant to improve water efficiency because it means the installation will purchase fewer chemicals. In some cases, savings on chemicals can outweigh the savings on water costs. Vendors should be selected on “cost to treat 1,000 gallons make-up water” and highest “recommended system water cycle of concentration.”

- Consider measuring the amount of water lost to evaporation. Some water utilities provide a credit to the sewer charges for evaporative losses, measured as the difference between metered make-up water minus metered blowdown water.

- Consider a comprehensive air handler coil maintenance program. As coils become dirty or fouled, there is increased load on the chilled water system to maintain conditioned air set point temperatures. Increased load on the chilled water system not only has an associated increase in electrical consumption, it also increases the load on the evaporative cooling process, which uses more water.

Retrofit Options

The following retrofit options can help installations maintain water efficiency:

- Install a sidestream filtration system composed of a rapid sand filter or high-efficiency cartridge filter to cleanse the water. These systems draw water from the sump, filter out sediments, and return the filtered water to the tower. This enables the system to operate more efficiently with less water and chemicals. Sidestream filtration is particularly helpful if the system is subject to dusty atmospheric conditions. Sidestream filtration can turn a troublesome system into a more trouble-free system.

- Install a make-up water softening system when hardness (calcium and magnesium) is the limiting factor on cycles of concentration. Water softening removes hardness using an ion exchange resin and can allow operation at higher cycles of concentration.

- Install covers to block sunlight penetration. Reducing the amount of sunlight on tower surfaces can significantly reduce biological growth such as algae.

- Consider alternative water treatment options (e.g., ozonation or ionization) to reduce water and chemical usage. Be careful to consider the life-cycle cost impact of such systems.

- Install automated chemical feed systems on large cooling tower systems (over 100 tons). The automated feed system should control blowdown/bleed-off by conductivity and then add chemicals based on make-up water flow. These systems minimize water and chemical use while optimizing control against scale, corrosion, and biological growth.

Replacement Options

The following replacement options can help installations maintain and improve water efficiency:

Get expert advice to help determine if a cooling tower replacement is appropriate. New cooling tower designs and improved materials can significantly reduce water and energy requirements for cooling. However, since replacing a cooling tower involves significant capital costs, you should investigate every retrofit, operations, and maintenance option available and compare costs and benefits to a new tower.

For specifics on this technology, consult with experts in the field. The first resource should be engineers at either the local DPW or IMCOM headquarters. ERDC-CERL also has a number of experts on this subject.

Chapter 11 - Commercial Kitchen Management

Commercial kitchen management represents a large sector of water users in the nonresidential sector. Water efficiency for commercial kitchen equipment is especially important because high volume applications typically use mostly hot water. Making sure commercial kitchen equipment uses water efficiently affords both significant water and energy savings.

Types of water-using commercial kitchen equipment include pre-rinse spray valves, wash tanks and sinks, commercial dishwashers, food steamers, steam kettles, commercial ice makers, and combination ovens (combination oven/steamer).

Operation and Maintenance

To maintain water efficiency in operations and maintenance, installations should:

- Educate staff about the benefits of water efficiency and the importance of hand scraping before loading dishwashers.
- Encourage a user-friendly method to report leaks and fix them immediately. Encourage cleaning or custodial crews to report problems.
- Only run dishwashers if they are full. Fill each rack to maximum capacity.
- Immediately replace any damaged dishwasher racks.
- Check equipment water temperatures and flow rates to ensure each is within manufacturer recommendations. For maximum water savings, water flow rate should be near the minimum recommended by the manufacturer.
- Test system pressure to make sure it is between 20 and 80 psi. High-efficiency devices will not work properly if pressure is too low. If pressure is too high, they will consume more than their rated amount of water.
- For dishwashers, observe final rinse pressure to ensure it is within manufacturer recommendations, typically 20 plus/minus 5 psi. If the pressure is too low, the dishes may not be rinsed and sanitized properly. If it is too high, they will require more than their rated amount of water.

- Ensure all equipment is installed and operated in accordance with manufacturer instructions.

- Use the combi-mode of combination ovens sparingly and appropriately as this mode consumes water and significantly increases energy usage. Combi-mode should be minimized and convection mode maximized. By moderating use at the beginning of the cook cycle, the benefit of the combi-mode can be achieved without using the mode for the entire cooking event. When adjusting the use of the combi-mode, consider the impact on cook times and product yield.

- For steam cooking, use batch production as opposed to staged loading of food pans (i.e., do not continuously open the door to load and unload food pans). This uses a lot of energy and wastes water. If possible, fill the steamers to capacity instead of cooking one pan in a five pan steamer.

- Some pre-rinse spray valves may be easily taken apart to perform routine cleaning or to clean when performance is noticeably impacted. However, because pre-rinse spray valves are relatively inexpensive, it may be more viable to replace plugged or poorly performing valves with new efficient models. If cleaning or maintenance is necessary, avoid drilling out holes to remove scale and buildup. Drilling may damage protective coatings or plating.

- Garbage disposals can waste significant amounts of water. Eliminate or minimize the use of garbage disposals by using strainers or traps that employ a mesh screen to collect food waste.

- For kitchens that house a scullery waste collection process, equipment is available to extract the solid waste portion and recycle the water flow (Figure A-17).

Figure A-17. Somat Pulper (left) and Hydra-extractor (right) are methods of conserving water in scullery operations (Scholze 2010).

Retrofit Options

The following retrofit options can help installations maintain water efficiency:

- Install dishwashers with rack sensors to allow water flow only when dishes are present.

- Check if ice machines operate with single-pass cooling. To maximize water savings, eliminate single-pass cooling by modifying equipment (if possible) to operate on a closed loop that recirculates the water instead of discharging it. Otherwise, replace the ice-making head with an air-cooled unit.

- Install flow restrictors in existing pre-rinse spray valves to reduce the flow rate to 1.25 gpm or less (the federal standard). Flow restrictors may not provide adequate performance in most situations. Purchasing new, more efficient and inexpensive pre-rinse spray valves may provide a better alternative for saving water (Figure A-18).

Figure A-18.High-efficiency pre-rinse spray valve (Scholze 2010).

Replacement Options

The following replacement options help installations maintain water efficiency:

- For commercial dishwashers, check volume of service and size the dishwasher accordingly. Be sure to consider the energy tradeoff associated with increased tank heat that may be required for larger machines.

- Purchase high-efficiency commercial dishwashers with the ENERGY STAR label. If possible, install low-temperature machines that rely on chemical sanitizing over high water temperature. If purchasing a low-temperature chemical sanitizing machine, carefully consider the cost of chemicals and verify water use with the distributor or manufacturer to ensure that the machine uses less water than an equivalent high-temperature machine.

- Replace water-cooled commercial ice makers with high-efficiency air cooled commercial ice makers with the ENERGY STAR label.

- For low to medium volume steam cooking needs, purchase high-efficiency steam cookers with the ENERGY STAR label or purchase boilerless (without connections) commercial steam cookers (Figure A-19). Specifically look for steamers with improved insulation, standby mode, and closed-system design to ensure steamers are used most efficiently. Select a steamer based on projected use (i.e., balance production demand with steamer production capacity).

Figure A-19. Boilerless steamer (Scholze 2010).

- Purchase high-efficiency pre-rinse spray valves. The Energy Policy Act of 2005 requires that pre-rinse spray valves manufactured after January 2006 have a maximum flow rate of 1.6 gpm. Moreover, in 2007 FEMP released a purchasing specification for pre-rinse spray valves, which requires federal agencies to purchase pre-rinse spray valves that have flow rates of 1.25 gpm or less and that meet ASTM F2323-03, Standard test Method for Performance of Pre-Rinse Spray Valves. For ease of maintenance and to increase operational life, purchase pre-rinse spray valves that can be easily taken apart and cleaned.

- Consider steaming needs when purchasing steam kettles. Direct steam kettles may be appropriate for bulk cooking (more than 50 servings at a time), but may require more maintenance as they are supplied with steam from an external boiler and may need to be “blown down” daily to eliminate condensate buildup in the steam supply line. For smaller steaming needs, purchase self-contained steam kettles. Self-contained kettles may require regular monitoring of water levels and maintenance of control components.

Table A-2 shows conservation and cost-savings results based on spray valve water savings of 1 gpm, water cost of $2.00 per unit (748 gallons), sewer cost of $3.00 per unit (748 gallons), and gas cost of $1.00 per therm (source: Fishnick.com).

Table A-2. Cost savings comparison of replacing one 3-gpm pre-rinse valve with low-flow unit.

Hours of Spray Valve Usage	Water Savings (gallons/day)	Wastewater Savings (gallons/day)	Gas Savings (therms/day)	Annual Savings ($)
1 hr/day	60	60	0.5	$300 - $350
2 hrs/day	120	120	1.0	$600 - $700
3 hrs/day	180	180	1.5	$900 - $1050

Resources

The following resources provide guidance on water BMPs:

Food Service Technology Center – Low-flow, pre-rinse spray valve overview, including water and annual dollar savings opportunities. The site also has descriptions of other water-conserving equipment. http://www.fishnick.com

ENERGY STAR Commercial Food Service Equipment – Overview of performance requirements for ENERGY STAR-labeled commercial food service equipment. http://energystar.gov

FEMP Purchasing Specifications for Energy Efficient Products – Purchase specifications and performance requirements for FEMP-designated product categories. http://www1.eere.energy.gov/femp/technologies/eep_purchasingspecs.html

Chapter 12 - Laboratory and Medical Equipment

Equipment used in hospitals and laboratories can use significant amounts of water, but also offer the opportunity for substantial water savings by making a few small changes to how and when the water is used by the equipment.

Overview

Focusing on reducing water use from equipment such as water treatment systems, sterilization/disinfection systems, photographic and x-ray equipment, vacuum systems, glassware washers, and vivarium equipment such as automatic animal watering systems and cage and rack washers can go a long way towards helping installations achieve water efficiency goals.

The EPA and the DOE teamed under a program called Laboratories for the 21st Century (Labs 21) to provide architects, engineers, and facility managers with information on technologies and practices used to create and maintain sustainable, high-efficiency laboratories.

Operation and Maintenance

The following operations and maintenance options help installations maintain water efficiency:

- Establish a user-friendly method to report leaks and fix them immediately.
- Encourage cleaning or custodial crews to report problems.
- When performing maintenance, replace worn parts and adjust mechanisms to ensure water consumption continues to meet manufacturer guidance.
- Shut-off units that are not in use or install an automatic shut-off feature if it does not interfere with the unit’s normal operation.
- Check solenoids or automatic shut-off valves regularly to ensure that they are working properly. Verify that water is not flowing when equipment is in standby mode.

- Install a pressure-reducing device on equipment that does not require high pressure. Lowering the pressure can reduce water use.

- Set equipment to the minimum flow rates acceptable or recommended by the manufacturer and post signs near equipment to increase employee awareness and discourage tampering with equipment flow rate.

- Run glassware washers only when full. Use newer, cleaner rinsing detergents, and reduce the number of rinse cycles whenever possible.

Retrofit and Replacement Options

The following retrofit and replacement options can help installations maintain water efficiencies:

Water Purification Systems

– Evaluate laboratory requirements for high-quality water, including the total volume and the rate at which it will be needed, so that the system can be properly designed and sized.

– Choose systems with a high recovery rate (the ratio of filtered purified water to the volume of feed water). Some proprietary systems claim recovery rates up to 95%. Conventional reverse osmosis systems claim recovery rates between 50 and 75%.

– Consider reusing concentrate produced by reverse osmosis treatment systems for nonpotable applications such as bathroom commodes. Water quality should be monitored to avoid fouling other systems.

– Determine the quality of water required in each application. Use the lowest appropriate level of quality to guide the system design. For example, reverse osmosis units should be used only in processes that require very pure water.

– Evaluate water supply quality for a period of time before the water purification system is designed. This evaluation allows designers to accurately characterize water supply quality and helps determine the best method for attaining the required quality level.

Disinfect/Sterilization Systems

- Replace older inefficient equipment with equipment designed to recirculate water or that allows the flow to be turned off when the unit is not in use, or both.

- If purchasing new equipment is not feasible, consider purchasing a water efficiency retrofit kit. Many are now available for older units. These kits reduce water use by controlling the flow of tempering water or by replacing the venture mechanism for drawing of a vacuum. Tempering kits sense the discharge water temperature and allow tempering water to flow only as needed.

- Install a small expansion tank instead of using water to cool steam for discharge to the sewer. Check with the manufacturer to make sure this will not interfere with the unit’s normal operation.

- Use high-quality steam for improved efficiency.

- Use uncontaminated, noncontact steam condensate and cooling water as make-up for nonpotable uses, such as in cooling towers and boilers.

Photographic and X-ray Equipment

- Replace older equipment with digital x-ray and photography equipment and computerized printing. If transitioning to digital equipment is not feasible, look for models with a squeegee that removes excess chemicals from the film. The squeegee can reduce chemical carryover and the amount of water needed for the wash cycle.

- If the purchase of new equipment is not feasible, adjust the film processor flow to the minimum acceptable rate. Install a control valve and flow meter in the supply line to monitor flow rate if necessary.

- Recycle rinse bath effluent as make-up for the developer/fixer solution.

Vacuum Systems

- Install a laboratory vacuum system or use small electric vacuum pumps instead of employing faucet-based aspirators to create a siphon vacuum source.

Glassware Washers

- Replace older inefficient glassware washers with new dishwashers that use less water. Choose models that allow the operator to select the number of rinse cycles or that can reuse final rinse water as wash water for the following load.

- Install a water recycling system for glassware washer wastewater.

Vivarium Equipment

- Replace older inefficient cage and rack washers with more efficient models. Look for models that recycle water through four cleaning stages using a counter-current rinsing process. In counter-current rinsing, the cleanest water is used only for the final rinsing stage. Water for early rinsing tasks (when the quality of rinse water is not as important) is water that previously was used in the later stages of rinsing operations.

- Retrofit existing cage and rack washers to make use of counter-current flow system to reuse the final rinse water from one cage-washing cycle in earlier rinses in the next washing cycle.

- Use tunnel washers for small cage cleaning operations.

- Sterilize and recirculate water used in automatic animal watering systems instead of discharging water to the drain. Consider using water that cannot be recycled for drinking water due to purity concerns in other nonpotable applications such as cooling water make-up or for cleaning cage racks and washing down animal rooms.

Resources

The following resources have additional information on water best management practices for laboratories and medical systems:

Water Efficiency Guide for Laboratories: Guide to water efficiency as part of a larger series of best practices for laboratories. http://www.labs21century.gov/pdf/bp_water_508.pdf

Portland Veterans Affairs Medical Center Case Study: Overview detaining how a large medical facility generated a 9.2% reduction in annual water use (1.6 million gallons a year) and $19,000 in annual cost savings. http://www1.eere.energy.gov/femp/program/waterefficiency_portland.html

Chapter 13 - Other Water-Intensive Processes

Many water-using processes beyond the previously covered BMPs are found at Army installations, including vehicle wash systems, maintenance services, cleaning/laundry services, single-pass air conditioners, water softening systems, and others. All water intensive processes should be identified and analyzed for potential efficiency improvements.

Overview

Laundry facilities are often found on installations. The laundry facility may be a self-serve laundry where residents and personnel wash their own clothing, a commercial-type laundry service where residents drop off laundry to be washed or dry cleaned, or an industrial laundry facility where large volumes of linens and uniforms are cleaned. Large amounts of water are regularly used in industrial laundries, making them highly suitable for a water efficiency program.

Evaporative coolers, also known as swamp coolers and desert coolers, work on the same principle as cooling towers. Air is cooled and humidified as it passes through porous pads that are kept moist by water dripped on their upper edges. Un-evaporated water trickles down through pads and collects in a pan for either discharge or recirculation. Since cooling relies on evaporation, these coolers work best in arid climates.

When water evaporates, it leaves behind scale and mineral deposits on the pads, reducing the volume of air flowing through the pads and compromising cooler performance. Bleed-off water serves to dilute the mineral concentration of pan water and reduces scale and dirt build-up on the pads. There are two types of bleed-off systems: once-through and recirculating. The once-through (pumpless) type is simpler and less expensive than the recirculating (pump) type, but consumes more water and requires constant drainage.

In many areas of the country, additional water softening should not be necessary for most operations. When water softeners are required, look for systems that generate a minimal amount of water brine per gallon of water softened.

The military maintains facilities for washing and rinsing aircraft and vehicles. These washrack facilities are excellent candidates for water efficiency. The five typical washrack groups are based on the type of wastewater emitted:

- Aircraft rinsing
- Aircraft washrack platform
- Automotive vehicle washrack
- Tracked vehicle washrack
- Automotive vehicle maintenance

The amount of water used per item washed varies from approximately 100 to 3,000 gallons. Newer, commercially available washrack equipment usually includes some retrofit and recycling options that significantly reduces the amount of water used per item washed.

New system designs and improved materials can significantly reduce water and energy requirements. However, since this may involve significant capital costs, first investigate retrofit or operations and maintenance options.

Expert assistance is available within the Army community from the supporting DPW, IMCOM, and Headquarters elements. USACE CERL has resident expertise in various washrack systems. CERL was responsible for development of the Central Vehicle Wash Facility (CVWF) which can recycle hundreds of millions of gallons of water annually on an installation.


Figure A-20. A Central Vehicle Wash Facility saves water by sending wash water through a sand filter to a holding pond, from which it is reused (ERDC-CERL).

To maintain water efficiency in operations and maintenance, installations should:

- If practical, consider metering or otherwise measuring the amount of water used in water intensive processes not previously discussed.
- As with all water-using equipment, locate and repair leaks in plumbing connections.
- If applicable, ensure procedures are in place to turn off the water supply when equipment is not in operation. Some equipment allows water to constantly run even when the equipment is turned off.
- If applicable, check flow rates to ensure they are within manufacturer recommendations. For maximum water savings, the flow rate should be near the minimum allowed by the manufacturer.
- To reduce water used by evaporative coolers, keep a tight rein on bleed-off water amounts. For most small coolers, bleed-off volumes should be less than a few gallons per hour for each 1,000 cubic feet per minute of air flow. Also replace worn or torn pads and inspect the recirculation pump and reservoir level controls periodically during warm months when the system is running.
- For water softeners, set the controls to start softening and regeneration processes only when needed. Softeners with timers should be avoided.
- For existing washing machines, encourage users to wash only full loads. If the water level is able to be set by the user, encourage using only as much water as needed for that load. Also consider separating laundry by the number of cycles needed.
- Large commercial laundry equipment should be easily programmable to use no more water than required for the degree of soiling of the items being washed.
- For washrack cleaning facilities that use detergents, use high quality detergents to shorten the length of time required to clean each vehicle or aircraft.

Retrofit and Replacement Options

The following retrofit and replacement options can help installations maintain water efficiency:

- If applicable, replace water-cooled equipment with air-cooled equipment or the best available technology for achieving energy and water efficiency.

- Avoid single-pass (pumpless) coolers. Recirculation saves water and increases thermal efficiency.

- New water softener models may come with water-efficient regeneration cycles.

- For existing washrack cleaning facilities, several low-cost measures can save significant amounts of water. Timers and automatic spray heads are useful in aircraft rinsing facilities but not for washrack units, since each vehicle or aircraft must be washed until sufficiently clean. Automatic shutoff nozzles are designed for facilities with manual rinsing. Since water is usually left on the entire time a vehicle or aircraft is washed and rinsed, the automatic shutoff spray nozzle can save tens to hundreds of gallons per run. Low-flow and high-pressure hot water units can reduce the amount of water and solvents used by facilities for cleaning engine components. Pre-wash areas are recommended for tracked vehicle washracks with recycling systems to eliminate a majority of the coarse dirt so that it will not enter into and clog up the treatment system. Where feasible, include water reuse equipment on vehicle washing equipment. Also consider using self-closing valves on chamois wringers.

- For washrack cleaning facilities, choose new rollover and conveyor equipment that uses less than 35 gallons per vehicle for automobiles and light trucks and less than 75 gallons per vehicle for bus and large truck washes.

- A costly but effective way to reduce water usage at wash and rinse facilities is to implement a wastewater recycling system. Where possible, reuse reverse osmosis or nanofiltration reject water for vehicle washing in rollover and conveyor type systems.

- Replace old commercial clothes washers (vertical axis) with high-efficiency washers (horizontal axis) that use significantly less energy, water, and detergent. Look for

ENERGY STAR-labeled washers with a water factor of 8.5 gallons of water used per cubic foot or less. Most full-sized ENERGY-STAR-labeled washers use 18-25 gallons of water per load compared to the 40 gallons used by standard machines. These efficient machines have the potential to reduce combined utility costs by as much as 50%.

- For large industrial or commercial-type laundries, consider replacing old washers with tunnel washers or ozone laundry laundering. Tunnel washers, also known as continuous batch washers, are heavy-duty, multi-tank systems for use in large industrial laundries. They are capable of handling up to 2,000 pounds of laundry per hour. Tunnel washers use counter current wash methods to maximize water efficiency. These are costly to install, but are capable of saving up to 70% of the volume of water used with a washer-extractor and require less operating and maintenance labor. Tunnel washers typically use 2 gallons of water or less per pound of laundry.

- Technologies for reducing water use in laundry operations include ozone laundering. Ozone laundering is suited for light-to-moderately soiled laundry and uses no detergent, uses only cold water, and recycles water. Ozone-generating equipment is attached to the washer as a closed-loop system.

Resources

The following resources provide some additional guidance on water BMPs:

Water Conservation Guide for Commercial, Institutional, and Industrial Users: Overview of water conservation strategies and benefits (1999) presented by the New Mexico Office of the State Engineer. http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf

Chapter 14 - Alternate Water Sources

In fact, the vast majority of potable water consumed on installations goes for nonpotable uses that may be well served by secondary water sources, by captured rainwater (the primary feasible, cost-effective, source for additional water), or efficiently reused/recycled water. (Of course, state water laws and regulations may impact what can actually be achieved at specific installations.)

Strong programs in water management and water efficiency at individual installations may be augmented by approaches already in use within other sectors. Many regions find alternative sources of water by purifying impaired waters, by increasing water reuse and recycling, and by desalination of brackish groundwater and seawater. Surface water may be supplemented with reclaimed water, aquifer storage and recovery, stormwater reuse, rainwater harvesting, aquifer recharge, and off-line reservoir storage. Available water sources may be expanded by using such currently unharvested or unused water as irrigation tailwaters—water produced from energy production, brackish water, and air-conditioning condensate.

Many installations have water uses that can be met with nonpotable water from alternate water sources. Potentially available alternative water sources include municipal-supplied reclaimed water, treated graywater from on-site sources, and stormwater.

Overview

On-site alternative water sources are most economical if included in the original design. Common uses for these sources include landscape irrigation, ornamental pond and fountain filling, cooling tower make-up, and toilet and urinal flushing.

Municipal-Supplied Reclaimed Water

Municipal supplied reclaimed water has been treated and recycled for nonpotable use. This water may be available at a significantly lower rate than potable water; however, use of reclaimed water may be restricted by local codes and guidelines.

Traditionally, centralized sewage treatment facilities have been the primary source of water disposal for installations. However, heightened concerns about water supply availability have encouraged facility managers to consider recycling of wastewater or graywater.

Treated Graywater

Graywater is generated by bathroom sinks, showers, and clothes washing machines. These water sources can contain pathogens.

In a typical graywater recycling system, water that would normally be discharged to the sanitary sewer system is collected, treated to remove suspended solids and contaminants, and reused. On-site wastewater recycling applications are currently found in states with persistent drought conditions. However, all arid, semi-arid, and coastal areas that have experienced water shortages, as well as major urban areas where sewage treatment plants are overloaded and expansion is constrained, are potential candidates for on-site recycling. The recycled water is typically used as flush water for toilets and urinals, landscape irrigation, supply water for ornamental ponds, and make-up water for cooling towers.

At its most basic, graywater treatment consists of removing suspended solids from the water. Filtering with no additional treatment may be applicable for rinse water from laundries or car washes and air handler condensate. At its most sophisticated, graywater treatment also uses activated carbon, and ultraviolet light or ozone disinfection to destroy pathogens. The basic graywater system includes storage tanks, color-coded piping, filters, pumps, valves, and controls.

Rainwater

Rainwater harvesting (RWH) is increasing in many parts of the United States as well as around the world. Rainfall patterns in an area contribute to applicability. RWH is most applicable where other sources of water are either not available or are too expensive. Rainwater collected from roof surfaces is stored in cisterns or other tanks and either pumped back into buildings for indoor use or used for irrigation. In some remote areas, the stored water is filtered, treated, and used for all indoor purposes. Where municipal water systems are available, supplementally harvested rainwater is used primarily for landscape irrigation, thus reducing overall demand for municipal water. Indoor uses include toilet flushing and hot water supply in some applications.

Another reason to integrate RWH into a new building's design is increasing interest in green building. RWH is a relatively easy and excellent way to demonstrate environmental stewardship to local communities and facility stakeholders. And, depending on the design, RWH can help a project garner up to seven points (Table A-1) toward the U.S. Green Buildings Council's LEED rating, making it easier to achieve Silver, Gold, or Platinum levels.

Rainwater harvesting captures, diverts, and stores rainwater for later use. Captured rainwater is often used in landscaping because the water is free of salts and other harmful minerals and does not have to be treated. It is also useful in attracting and providing water for wildlife. Rainwater harvesting can also help prevent flooding and erosion, turning stormwater problems into water supply assets by slowing runoff and allowing it to soak into the ground. Reducing runoff also helps reduce contamination of surface water with sediments, fertilizers, and pesticides in rainfall runoff.

Rainwater can be collected in cisterns and used with little or no treatment for a variety of nonpotable purposes. The major components of a rainwater harvesting system include:

- Catchment area/roof or surface upon which the rain falls
- Gutters and downspouts to carry the water to storage
- Leaf screens to remove debris
- Cisterns/storage tanks to store the harvested rainwater
- Conveyances to deliver the stored water either by pump or gravity
- Water treatment system to settle, filter, and disinfect the water, if required.

These features make RWH an acceptable option for Army installations to increase available water supply. RWH has been used both to provide potable water and water for uses requiring lesser quality water such as toilet flushing or irrigation. RWH is also widely practiced for supplying water to wildlife and as a source for domestic animals.

Stormwater

Like rainwater, stormwater can be harvested and reused for washdown, cooling tower make-up or process water, dust suppression, and vehicle washing. Stormwater harvesting differs from rainwater harvesting as the runoff is collected from drains or creeks, rather than roofs. The characteristics of stormwater harvesting and reuse schemes vary considerably between projects, but most schemes include collection, storage, treatment, and distribution.

Stormwater is generally collected from a drain, creek, or ponds and then stored temporarily in dams or tanks to balance supply and demand. Storage can be on-line (constructed on the creek or drain) or off-line (constructed some distance from the creek or drain). Captured water is typically treated to reduce pathogens and pollution levels through the use of constructed wetlands, sand filters, and disinfection techniques including chlorine, ultraviolet radiation, and membrane filtration. The degree of treatment required depends on the proposed use and the level of public exposure.

Successful stormwater harvesting and reuse plans need specialist input from a number of areas, including stormwater management, water supply management, environmental management, and public health. The potential limitations and disadvantages to stormwater harvesting and reuse include variable rainfall patterns, environmental impacts of storage methods, potential health risks, and high relative unit costs of treated stormwater. Stormwater harvesting and reuse is an emerging practice that may be useful in specific situations.

Municipally Supplied Reclaimed Water

To develop an efficient and successful reclaimed water project, you must have a reliable source of wastewater of adequate quantity and quality to meet nonpotable water needs. These projects are economically more viable when:

- The cost of water is high.
- There is a lack of high-quality freshwater supply.
- Reuse is the most cost-effective way to dispose of wastewater effluent.
- Local policies encourage the use of reclaimed water or water efficiency.

Operation and Maintenance Options

To maintain water efficiency in operations and maintenance, installations should:

- Identify potential nonpotable water use while reviewing current water-use practices. The use of nonpotable water is generally most cost-effective when included in the design of new facilities.
- Consult with experts in the field such as ERDC-CERL or IMCOM headquarters.
- Facilities using alternative on-site water sources must comply with all applicable backflow prevention requirements

Municipally supplied reclaimed water pipes must be color coded with purple according to standards set by the American Waterworks Association (AWWA) to minimize cross-connection problems.

Signs should be used liberally to indicate that reclaimed water is nonpotable. Place them in public places such as in front of a fountain and on valves, meters, and fixtures.

Keep the pressure of reclaimed water 10 psi lower than potable water mains to prevent backflow and siphonage in case of accidental cross-connection.

Run reclaimed water mains at least 12 in. lower in elevation than potable water mains and horizontally at least 5 ft away.

Review the quality of reclaimed water to ensure there will be no harmful effects (e.g., salt buildup) from long-term use.

Graywater Recycling Systems

See the following PWTBs for information on graywater recycling systems.

PWTB 200-1-75, “Rainwater Harvesting for Army Installations”
http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_75.pdf

PWTB 200-1-101, “Graywater Applications for Army Installations”
http://www.wbdg.org/ccb/ARMYCOE/PWTB/pwtb_200_1_101.pdf

Chapter 15 – Army Experience with Water Efficiency Practices

Due to space limitations, not all of the above BMPs can be addressed; however, a few examples of water efficiency practices are discussed below.

Distribution System Audits, Leak Detection, and Repair

This practice usually has immediate or near immediate payback. Many older systems have not had a regular program of acoustic leak detection. Often, dozens of leaks are discovered and some installations have demonstrated savings of tens of millions of gallons after repairs.

Water-Efficient Landscaping and Irrigation

Landscaping and irrigation have been addressed through a variety of measures. The principles of xeriscape have been applied in many locations. Other actions include changing turf types and reducing turf areas, performing landscape audits, using automatic controllers with rain and moisture sensors, limiting irrigation, improving soil ability to retain water, controlling water that falls on the site, using mulch, following principles of LEED and LID, and reusing wastewater and take advantage of harvested stormwater. LID is a component of the Army’s sustainability program and is mentioned here because it supplies a mechanism for using water on-site for beneficial uses as well as offering opportunities to recharge aquifers. The LID approach to stormwater management follows basic natural principles: manage rainfall as near the source as possible using micro-scale controls. LID’s goal is to mimic a site’s predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. LID addresses stormwater through small, cost-effective features at lot or local level. Components include open space, rooftops, streetscapes, parking lots, sidewalks, and medians and can save money over conventional approaches by reducing infrastructure and site preparation work (up to 25% or 30%) through reductions in clearing, grading, pipes, ponds, inlets, curbs, and paving, and through potential space recovery for other beneficial uses. Examples of LID being demonstrated and incorporated at Army installations include: bioretention or rain gardens, constructed wetlands, water quality swales, vegetated roof systems, and porous pavement with subsurface infiltration beds.

Toilets and Urinals

Toilets and urinals have historically accounted for nearly one-third of building water consumption. Use of 1.6 gpf toilets is mandatory in new construction and refurbishment. HETs provide another 20 plus percent water savings. Dual-flush toilets are also being used. Similarly, 1.0 gpf urinals have been mandatory and current requirements promote waterless urinals in many buildings. Waterless urinals have been widely demonstrated throughout the Army with positive results and heavily encouraged in Army new construction to meet LEED goals.

Single-Pass Cooling Equipment

Single-pass or once-through cooling systems provide an opportunity for significant water savings. Types of equipment that may use single-pass cooling are CAT scanners, degreasers, hydraulic equipment, condensers, air compressors, ice machines, x-ray equipment, and air conditioning. Practices to achieve better efficiency include improved operation and maintenance, automatic shutoff controls during unoccupied hours, modification to a closed-loop system, reuse of effluent for another purpose such as boiler make-up or irrigation or replacement with air-cooled equipment.

Commercial Kitchen Equipment

Installations have large troop dining facilities, large hospitals with dining facilities, and tenant restaurants located on-site. Numerous opportunities exist and are being used to reduce water: Energy Star versions of appliances such as ice machines, dishwashers, steamers. Other water-efficient options include: high-efficiency pre-rinse spray valves; on-and-off valves on ice cream dipper wells; low-flow nozzles for sinks; pressure-controlled foot pedals for hand sinks; innovative garbage disposal systems, and many more.

Other Water Sources and Uses

Examples of additional existing, on-site water sources, and uses for reclaimed water include:

- Air-conditioning condensate and runoff harvested from parking lots, roofs, or other areas can be used beneficially for irrigation, toilet flushing, and boiler make-up water.

- Reclaimed water can be used for irrigation and cooling tower make-up at multiple installations.

- Industrial operations (central energy facilities, wet scrubbers, and boiler make-up) are all targets for reclaimed-water use that would otherwise use potable water.
- Central vehicle wash facilities use a wastewater recycle concept that adequately treats water for reuse, saving hundreds of millions of gallons per year at installations.
- Vehicle washing, including car/bus washes, is a large consumer of recycled water.

Other actual or potential applications for water reuse at military installations include: man-made wetlands, groundwater recharge, stream augmentation, aquifer storage and recovery, and saltwater intrusion barriers along coasts.

Categories of Water Reuse by the Army

The following is a general listing of water reuse categories currently in practice by the US Army.

Irrigation

Typical applications include: athletic fields, parks, school yards, highway medians, golf courses, cemeteries, and parade grounds, building landscapes, crops, or vegetable gardens.

Industrial Recycling and Reuse

Applications include: cooling water, boiler feed, process water, and construction.

Groundwater Recharge

Opportunities include: groundwater recharge, saltwater intrusion control, and subsidence control.

Recreational/Environmental

Options include use in lakes and ponds, marsh enhancement, streamflow augmentation, and fisheries.

Nonpotable Installation Uses

These reuse possibilities include fire protection, air conditioning, toilet flushing, and water features.

Fort Huachuca's Experience

Fort Huachuca, Arizona, has been the role model for water efficiency programs in the Army for many years. The Upper San Pedro Basin (USPB) is located in the headwaters of the San Pedro River, one of the last free-flowing rivers in the southwest. The river basin is habitat for several threatened or endangered species, contains a section designated by Congress as the first riparian national conservation area, and is home for some 78,000 human residents and Fort Huachuca.

The residents of the USPB, including Fort Huachuca, are entirely dependent on groundwater to meet all their water needs. This groundwater demand competes with ecosystem needs for water as year-round flow along sections of the San Pedro River is supported by groundwater discharge from the regional aquifer. This competition for limited groundwater resources has been identified as a principal threat to the San Pedro River and is why Congress passed legislation requiring that steps be taken to address groundwater overdraft in the USPB.

Fort Huachuca has made tremendous progress in its efforts to mitigate its impacts on the regional groundwater system that, in part, supports the San Pedro River. These efforts include water conservation initiatives and education, aggressive leak detection and repair, reuse and recharge of treated effluent, and, in partnership with The Nature Conservancy, retirement of agricultural pumping through purchase of conservation easements. The net effect of these efforts has been to reduce the Fort's net groundwater consumption by approximately 2,272 acre-feet per year (71%) since 1989.

In addition, a regional consortium of federal, state, and local agencies and nongovernmental organizations known as the Upper San Pedro Partnership (USPP) has helped implement various projects and fund research that furthers our understanding of the regional hydrologic cycle. To date, the USPP and its member agencies have implemented water conservation and recharge projects totaling 4,000 acre-feet/year. Although these projects have not entirely mitigated the groundwater overdraft, they have at least kept it in check in the face of sun-induced population growth.

Further progress must be made to address the regional groundwater deficit in order to protect the San Pedro River and ensure the viability of Fort Huachuca. Implementation of regional water projects (e.g., spatially distributed treated effluent and stormwater recharge facilities; local site-specific projects incorporating advances in water conservation technology) and augmentation of groundwater resources with alternative water sources such as harvested rain water will be required.

The comprehensive water efficiency program at Fort Huachuca has many elements. Rainwater capture for infiltration and aquifer replenishment (Figure ____ and ____); xeriscaping using native vegetation avoids the need for irrigation (Figure _____); replacement of natural turn with artificial turf conserves irrigation water (Figure ______) and the installation is an Army leader in installation of waterless urinals (Figure____).

Figure A-21. Capture of rainwater for infiltration purposes at Fort Huachuca (Courtesy of Tom Runyon, Fort Huachuca).

Figure A-22. Retention and infiltration to an aquifer at Fort Huachuca (Courtesy of Tom Runyon, Fort Huachuca).

Figure A-23. Xeriscaping example at Fort Huachuca, using native vegetation (Scholze 2010).

Figure A-24. Artificial turf athletic field at Fort Huachuca (Scholze 2010).

Figure A-25. Waterless urinals installed at Fort Huachuca (Scholze 2010).

Chapter 16 – Summary

Water efficiency is a necessity for mission performance. In addition to a wide array of water efficiency techniques and technology, there exists a need for more complete utilization of water. Activities such as water reuse and reclamation, use of brackish water and other saline sources in inland areas through membrane processes, capture of stormwater and rainwater for beneficial use on site or on a regional basis, use of greywater on site, and capture and use of produced waters are all potential options. Indirect potable reuse through activities such as riverbank filtration and aquifer recharge can also be expanded.

Achieving maximum efficiency from an available water supply and using water that would normally be discarded will enable installations to meet their long-term sustainability goals and show immediate reductions in water consumption.

APPENDIX B

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APPENDIX C

ACRONYMS AND ABBREVIATIONS

Term	Spellout
AEWMP	Army Energy and Water Management Program
ANSI	American National Standards Institute
AWWA	American Waterworks Association
AR	Army Regulation
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BMP	best management practice
CAT	computerized axial tomography
CECW	Directorate of Civil Works, U.S. Army Corps of Engineers
CEMP-CE	Directorate of Military Programs, U.S. Army Corps of Engineers
CERL	Construction Engineering Research Laboratory
CFR	Code of Federal Regulations
CVWF	Central Vehicle Wash Facility
CWA	Clean Water Act
DOE	Department of Energy
DPW	Directorate of Public Works
EISA	Energy Independence and Security Act
EO	Executive Order
EPA	Environmental Protection Agency; also USEPA
ERDC	Engineer Research and Development Center
gpf	gallons per flush
gpm	gallons per minute
HET	high-efficiency toilet
HQUSACE	Headquarters, U.S. Army Corps of Engineers
ICC	International Code Council
IES	Illuminating Engineering Society
IMCOM	Installation Management Command
LEED	Leadership in Energy and Environmental Design
LID	low-impact development
NPS	nonpoint source
POC	point of contact
PWTB	Public Works Technical Bulletin
RCI	Residential Communities Initiative
RWH	rain-water harvesting
UFC	Unified Facilities Criteria
URL	universal resource locator
USACE	United States Army Corps of Engineers
USGBC	United States Green Building Council
USPB	Upper San Pedro Basin
USPP	Upper San Pedro Partnership
WBDG	Whole Building Design Guide