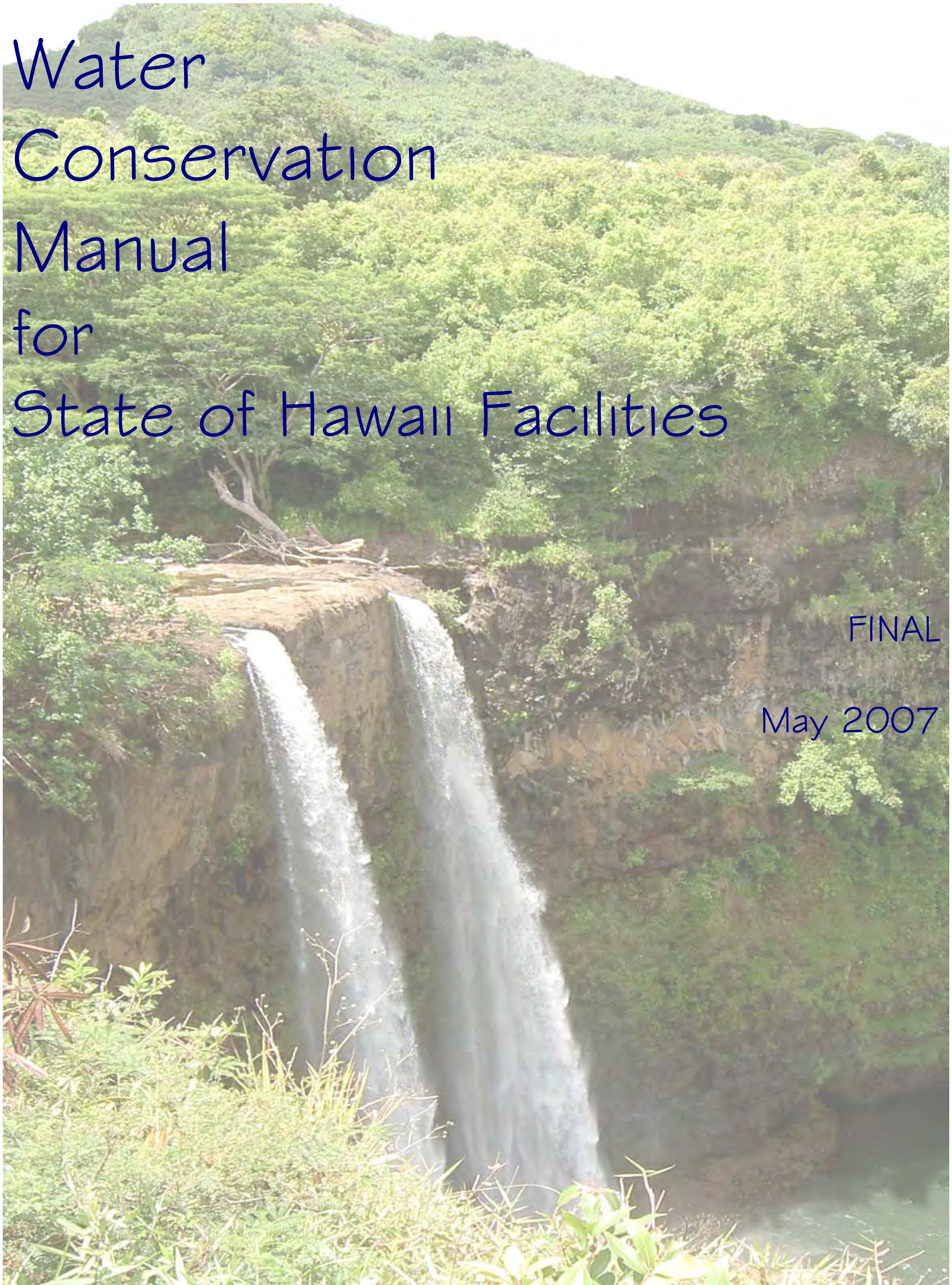
Water Conservation Manual for State of Hawaii Facilities



FINAL

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Table of Contents

LIST OF APPENDICES

List of Figures

List of Tables

List of Acronyms

Acronym	Definition
AWWA	American Water Works Association
BTU	British Thermal Units
CWRM	Commission on Water Resource Management
DLNR	State of Hawaii, Department of Land and Natural Resources
DOE	Department of Energy
DOH	State of Hawaii, Department of Health
EPA	U.S. Environmental Protection Agency
ET	evapotranspiration
FEMP	Federal Energy Management Program
gpd	gallons per day
gpf	gallons per flush
gpm	gallons per minute
HBWS	Honolulu Board of Water Supply
LEED	Leadership in Energy and Environmental Design
SRF	State Revolving Fund
TDS	total dissolved solids
UAW	unaccounted-for water
U.S.	United States
USGBC	United States Green Building Council
ULF	ultra low flush
WWRD	Wastewater Reclamation Division

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PREAMBLE Governor's Administrative Directive No. 06-01: Energy and Resource Efficiency and Renewable Energy and Resource Development

On January 20, 2006, Governor Linda Lingle issued Administrative Directive No. 06-01 requiring all State agencies and programs to increase their commitment towards implementing innovative and resource efficient operations and management. Examples of better management practices that were cited in this directive included: reduced energy and water use; reuse and recycle options; improved construction and demolition waste management; environmentally preferable purchasing; efficient use of transportation fuels, especially greater use of alternative fuels; as well as, increased incorporation of sustainable building practices. For State facilities, a requirement was set to design and construct new buildings and augment existing buildings to meet and receive certification for the United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) standards. Furthermore, State agencies are specifically directed to implement water and energy efficiency practices in operations to reduce waste and increase conservation (1). A copy of Administrative Directive No. 06-01 is included in **Appendix A**, while Chapter 1 of this manual provides more details about the aforementioned LEED program.

This manual can help State agencies comply with Administrative Directive No. 06-01 by providing detailed information on how to implement a number of water efficient practices at State buildings and facilities that will result in waste reduction and increased levels of conservation. The conversion of State buildings and facilities to water-efficient status will assist State agencies in their efforts to obtain LEED certification, as required by the Governor's directive.

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CHAPTER 1 Leadership in Energy and Environmental Design

Section 1.1 What is LEED?

The LEED Green Building Rating System is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings. LEED gives building owners and operators the tools they need to have an immediate and measurable impact on their buildings' performance. LEED promotes a whole-building approach to sustainability by recognizing performance in five key areas of human and environmental health: sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality. With regards to water efficiency, the specific goals of the LEED program are 1) to reduce the quantity of water needed for a building and 2) reduce municipal water supply and treatment burden. This manual will help State agencies meet these specific water efficiency goals of the LEED program.

LEED provides a roadmap for measuring and documenting success for every building type and phase of a building lifecycle. Specific LEED programs include:

- New Commercial Construction and Major Renovation projects,
- Existing Building Operations and Maintenance,
- Commercial Interior projects,
- Core and Shell Development projects,
- Homes,
- Neighborhood Development, and
- Guidelines for Multiple Buildings and On-Campus Building projects.

USGBC is also developing LEED for Schools, LEED Retail for New Construction, LEED Retail for Commercial Interiors, and LEED for Healthcare.

Hawaii currently does not have a USGBC Chapter. On the other hand, it does have a USGBC organizing group that was formed for the benefit of all Hawaiian Islands. Information about Hawaii's USGBC Organizing Group may be obtained from the following website: http://usgbc.org/chapters/organizing/hawaii.asp.

Section 1.2 How is LEED Developed?

The LEED Rating System was created to transform the built environment to sustainability by providing the building industry with consistent, credible standards for what constitutes a green building. The rating system is developed and continuously refined via an open, consensus-based process that has made LEED the green building standard of choice for federal agencies and State and local governments nationwide.

Section 1.3 What is LEED Certification?

The first step to LEED certification is to register your project. To earn certification, a building project must meet certain prerequisites and performance benchmarks ("credits") within each category. Projects are awarded Certified, Silver, Gold, or Platinum certification depending on the number of credits they achieve. This comprehensive approach is the reason LEED-certified buildings have reduced operating costs, result in healthier and more productive occupants, and conserve our natural resources. (2)

In Hawaii, there are a number of LEED-certified projects including buildings owned by the University of Hawaii at Manoa (see the case study in **Appendix B** to learn about the University's Hawaii Institute of Marine Biology), Punahou School, Hawaii Baptist Academy, and the Dowling Company. Several other companies throughout Hawaii are currently in the process of obtaining LEED certification.

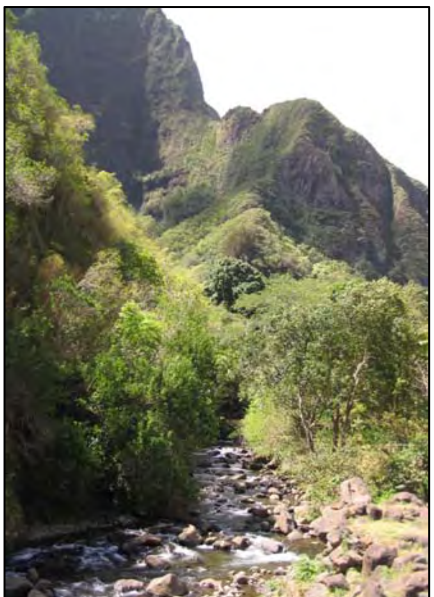
For more information about the LEED program, visit the internet site presented in **Figure 1-1**.

Figure 1-1. Leadership in Energy and Environmental Design Program Internet Site
United States Green Building Council http://www.usgbc.org

CHAPTER 2 Reasons for Water Conservation

Hawaii, like the rest of the world, may face future shortages of clean, fresh water. The problem is not the supply of water; Earth has virtually the same amount today as it did when dinosaurs roamed the planet. Ninety-seven percent of that supply is in the form of salt water. Only 3 percent is fresh water, and two-thirds of that is ice. The problem is simply people – our increasing numbers and our inefficient use of one of our most precious and limited resources.

According to *The State of Hawaii Data Book 2005*, Hawaii's total resident population is expected to increase to over 1.6 million people by the year 2030. This represents an increase of over 0.5 million people from the 2005 census. Hawaii's projected population increase will no doubt place a burden on our available fresh water supplies. (3)



Maui's Iao Stream

Without a doubt, fresh water is our most precious natural resource. Our natural supply of fresh water makes Hawaii the special place that it is. Nevertheless, in some areas we are pushing the limits of our available supply due to increases in population and urban development. To ensure that we have enough fresh water now and in the future, we must make the most efficient use of our existing fresh water supplies.

In some areas of the State, our ground water aquifers are being pumped at or close to their sustainable yields. As defined in the State Water Code, Chapter 174C, Hawaii Revised Statutes, sustainable yield is the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the Commission. On Oahu, it is estimated that within 20 to 30 years all available ground water supplies may be committed (4). Other aquifers in the State, such as Maui's Iao aquifer, have been over pumped and are showing signs of degradation. To ensure the long-term sustainability of these aquifers, we must carefully monitor their use and, in some cases, reduce pumping by developing alternative sources of fresh water. **Table 2-1** below presents the volume of fresh water utilized throughout the State for the year 2000, as presented in *The State of Hawaii Data Book 2005*. The graphs depicted in **Figures 2-1 through 2-4** accompany the data presented in **Table 2-1**. (5)

Table 2-1. Fresh Water Use in the State of Hawaii for 2000, by Type and County

Use	State Total (mgd)	Hawaii (mgd)	Honolulu (mgd)	Kalawao (mgd)	Kauai (mgd)	Maui (mgd)
Total	628.43	53.41	216.91	0.09	45.20	312.82
Ground Water	428.00	44.55	208.84	0.09	25.83	148.69
Public Supply *	242.83	31.16	164.81	0.09	14.94	31.83
Industrial	14.50	0.04	12.93	-	0.27	1.26
Thermoelectric	-	-	-	-	-	-
Irrigation	170.67	13.35	31.10	-	10.62	115.60
Surface Water	200.43	8.86	8.07	-	19.37	164.13
Public Supply *	7.60	2.50	-	-	-	5.10
Industrial	-	-	-	-	-	-
Thermoelectric	-	-	-	-	-	-
Irrigation	192.83	6.36	8.07	-	19.37	159.03

*Includes water withdrawn by public and private water systems for use by cities and military bases. Water withdrawn by these facilities may be delivered to users for domestic, commercial, industrial, and thermoelectric purposes or may be used for water and wastewater treatment, pools, parks and city buildings.

Acronyms: mgd – million gallons per day

Source: U.S. Geological Survey, Water Resources, records.

Figure 2-1. Fresh Water Use (Ground Water vs. Surface Water) in the State of Hawaii for 2000

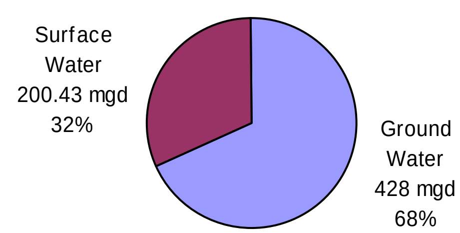


Figure 2-2. Ground Water Use in the State of Hawaii for 2000

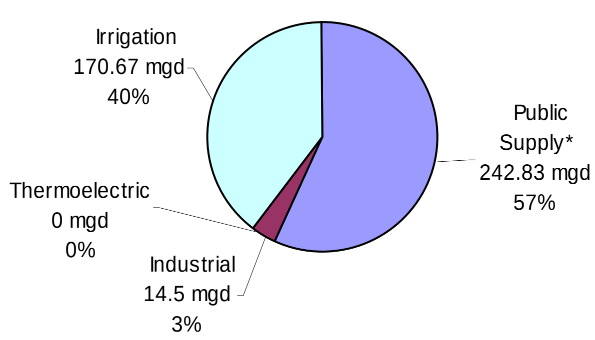


Figure 2-3. Surface Water Use in the State of Hawaii for 2000

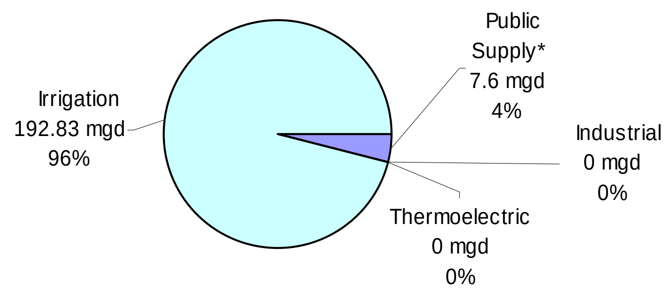
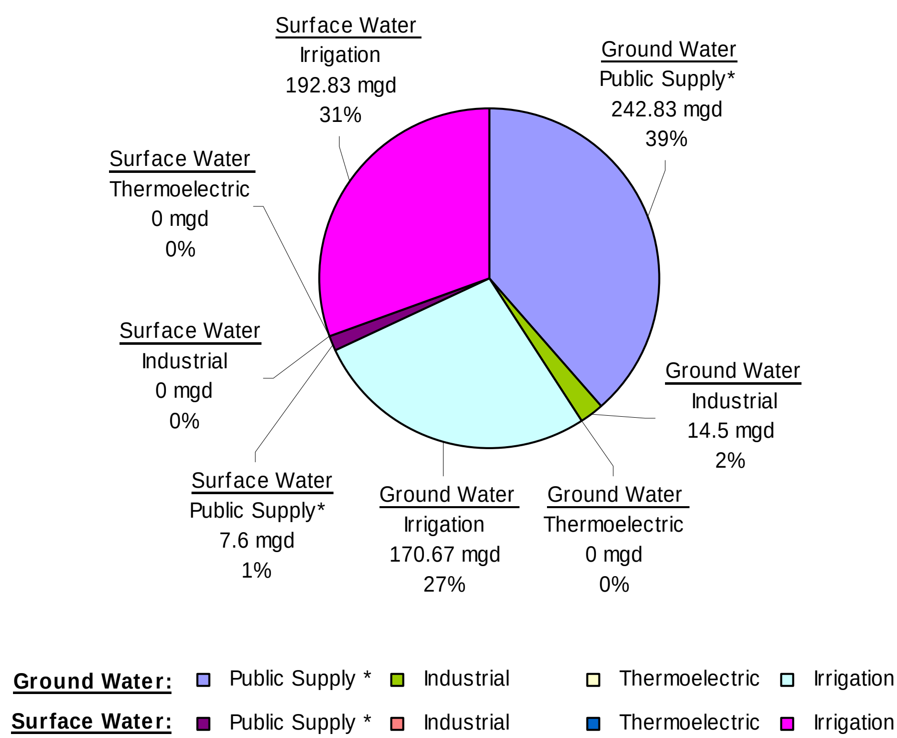


Figure 2-4. Fresh Water Use (Detailed Breakdown) in the State of Hawaii for 2000



Compounding the challenge of ground water depletion is the fact that Hawaii is often subjected to drought conditions that result in severe water use restrictions. In 2003, the Governor of Hawaii issued a proclamation of statewide drought in Hawaii. The potential of prolonged statewide drought conditions coupled with diminishing ground water supplies requires that water conservation programs be integrated into Hawaii's water resource management efforts.

There are numerous State departments and agencies within Hawaii's government, with hundreds of buildings and facilities are under the State's jurisdiction. As a result, the State is a large user of our water resources. Given the nature of the various State departments and agencies, the variety of State buildings/facilities is vast. See **Figure 2-5** below for examples of some of the types of buildings and facilities under the jurisdiction of the State's various agencies. Accordingly, the quantity of water use at each State building/facility and for each State department or agency can vary greatly.

Figure 2-5. Examples of Types of Buildings/Facilities under the State of Hawaii's Jurisdiction
• Office Buildings/Facilities • Libraries • Schools • Universities • Affordable Housing Complexes • Boating Facilities (e.g., Small Boat Harbor, Boat Ramp/Pier/Anchorage Facility) • Maintenance Yards • Nurseries • Parks • Transportation Corridor Landscaping • Aquaculture Facilities • Wildlife Propagation Facilities

In addition to assessing the total water consumption by division, estimated monthly costs for the purchase of such water was determined for the various State of Hawaii, Department of Land and Natural Resources (DLNR) divisions. Based on the water use for the 82 facilities, an average cost of over $60,700 per month was paid by the DLNR.

Within the State of Hawaii, there are several State and county agencies that have implemented various water conservation programs. Examples of water management practices and water conservation measures that have been implemented at some existing State buildings/facilities are provided in **Figure 2-6** below. Private businesses and organizations have also adopted water conservation initiatives within their operations. Even so, despite these efforts, the State of Hawaii lacks an overall statewide water conservation program to provide guidance to agencies and businesses lacking any conservation programs and to coordinate the various on-going water conservation efforts across the State. (6)

Figure 2-6. Example Water Conservation Measures at Existing State of Hawaii Buildings/Facilities
• Existing low volume/retrofits: toilets, urinals, showers, faucets, float-controlled valves. • Leak detection and repair. • Retrofit kits. • Main line metering shut off. • Informational signs (e.g., for boaters to limit their washing time). • Irrigation management & irrigating only in early morning. • Understanding the water bill.

In 2005, the DLNR, through the Commission on Water Resource Management (CWRM), developed a *Prototype Water Conservation Plan for the Department of Land and Natural Resources (DLNR)* (referred to herein as the DLNR Prototype Water Conservation Plan). The intention of the CWRM is for this prototype water conservation plan to serve as a model for a larger, more extensive statewide water conservation plan.

In order to compile the necessary detailed building/facility information as part of the preparation process for the DLNR Prototype Water Conservation Plan, a survey form was sent to all DLNR divisions. **Appendix C** of this manual includes the survey form from the DLNR prototype plan.

In addition, **Appendix D** of this manual provides a summary of the five DLNR buildings/facilities and suggested water conservation measures that were discussed in the prototype water conservation plan. State agencies can use these prototype examples as a guide to determine projected water savings and the payback analysis for their respective buildings and facilities.

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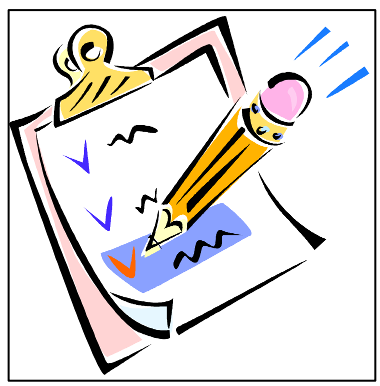
CHAPTER 3 How to Conduct a Successful Water Conservation Program

There are many facets to implementing a successful water conservation program. This chapter will outline the key steps that must be taken to set the foundation for a water conservation program that, if implemented, will result in significant water savings for years to come at State buildings and facilities.

Section 3.1 Action Items for Management

The first and most important thing that managers of State buildings and facilities should do prior to initiating water conservation programs is to make a full commitment to the concept of saving water. Support by upper management is essential to the success of any water conservation program. This commitment must be both ideological and financial. All employees must be aware and clearly understand upper management's commitment to the water conservation ethic at their respective facilities. As stated in the preamble of this manual, the Governor's Administrative Directive No. 06-01 provides the impetus for all managers of State facilities and buildings to make a full commitment to the development of successful water conservation programs.



After upper management has committed to supporting water conservation, the following steps towards the development of a comprehensive water conservation plan should be undertaken:

1. Establish the major goals and priorities of the water conservation program. These broad-based goals will set the tone for the specific water conservation measures that will later be identified and enacted.
2. Appoint a Water Conservation Manager who is empowered to design and implement a comprehensive water management plan.
3. Issue an organization-wide directive announcing the appointment of the Water Conservation Manager. A strong message of support for the facility's comprehensive water conservation program should be included in this announcement.
4. Provide funding for the program. Initial funding will be needed to launch the program, and continued funding will be required to implement water-saving infrastructure and process changes. Since the Governor's Administrative Directive No. 06-01 *requires* that all State agencies and programs implement resource efficient operations and management, funding for implementing water conservation measures should be routinely included during the budgetary planning process. External funding may also be available to supplement State budgeting for a water conservation program. Possible funding sources could include:

a. Federal Grants: Internet websites that may be helpful in identifying federal grants are http://www.grants.gov and http://www.federalgrantswire.com.
b. State Revolving Fund: The State of Hawaii, Department of Health (DOH) administers the U.S. Environmental Protection Agency's (EPA) State Revolving Fund (SRF) program. The SRF program provides money for drinking and clean water programs through low interest loans. Water conservation programs implemented by State agencies could be viewed as "source protection", thus making such programs eligible for SRF funding.
c. Partnership Agreements: The State has previously partnered with municipal water and/or wastewater agencies and electrical utility companies in water conservation programs (see the case studies on Maui County's water conservation programs in **Appendix B** for examples of such partnerships). Similar partnership programs may be available in the future.

It is recommended that the State's appointed Water Conservation Program Coordinator be responsible for researching potential outside funding assistance and partnerships.

5. Emphasize the importance of water conservation to all employees.
6. Recognize and publicize achievements in water conservation, both large and small. Ongoing communication will reinforce management's continued support for the water conservation program.

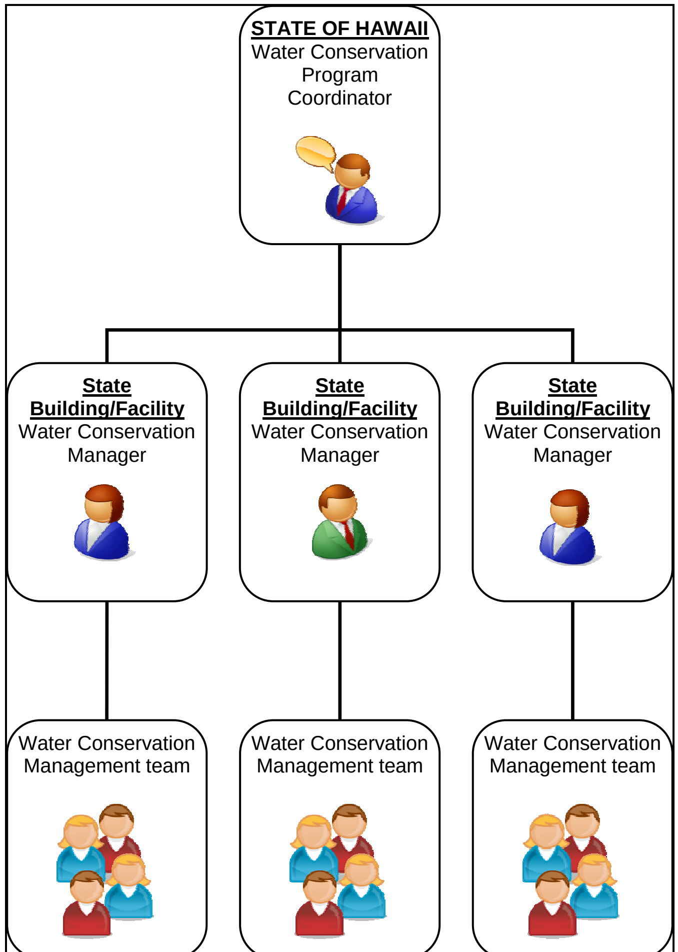
Section 3.2 The Water Conservation Manager's Responsibilities

This section will discuss the responsibilities of the Water Conservation Manager of each respective State building and facility. It is, nevertheless, recommended that the State appoint an overall Water Conservation Program Coordinator who can work directly with each building/facility Water Conservation Manager to ensure that a consistent approach is being taken towards implementing water conservation efforts throughout the entire State organization.

The Water Conservation Manager is responsible for designing a workable program that will allow his or her respective building or facility to meet the commitment made by upper management to reduce water use throughout the State. *It should be noted that Water Conservation Managers could potentially oversee the water conservation programs for more than one building/facility, if determined feasible and practical.* It is imperative that the Water Conservation Manager be provided with the appropriate resources to achieve the State's goal of reducing water use. The Water Conservation Manager may also establish a Water Conservation Management team to oversee the development and implementation of a water conservation program for his or her respective facility. The team should include personnel from the facility management, financial, operations, and maintenance departments of each State building/facility.

The Water Conservation Manager of each State building or facility should undertake the following actions:

1. Research institutional and regulatory issues or policies that may impact water use decisions. The State's appointed Water Conservation Program Coordinator could perform this step.
2. Review and evaluate the State's existing or previous water conservation programs to determine their overall effectiveness. Areas that were successful and areas that were unsuccessful should be noted. The State's appointed Water Conservation Program Coordinator could also perform this step.
3. Prepare a budget for the water conservation program and acquire the necessary funding. Seek outside funding, if needed.
4. Schedule onsite water audits of all water-using equipment and processes. Supervise the auditing process both initially and during follow-up and routine inspections. See **Section 3.4** below for additional information on how to conduct a water audit.



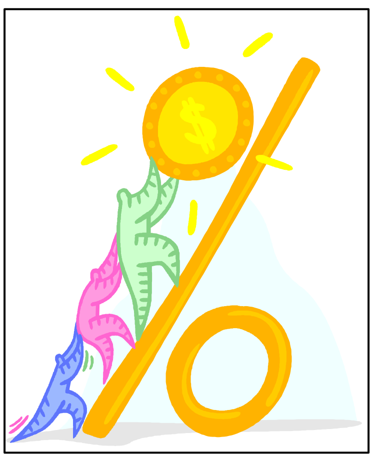
Water Conservation Program Organizational Chart

5. Create the water conservation action plan. The plan should include the goals of the program, as well as the details for implementing specific water conservation measures.
6. Establish a method that will allow the water conservation plan to be documented and evaluated.
7. Create an employee communications program that will inform employees about the State's program and its goals. Employees should be encouraged to become actively involved in their respective building or facility's water conservation program.
8. Initiate the water conservation program by installing water conservation equipment/devices and implementing other water conservation measures.
9. Evaluate how the water conservation program is performing on a regular basis. Modify the components of the program, as necessary, to improve water reduction efficiency.
10. Report the progress of the program to upper management (i.e., the Water Conservation Program Coordinator). Adjust the plan as required to save even more water.

The American Water Works Association (AWWA) and the United States (U.S.) Bureau of Reclamation, as well as other agencies, provide formal training in water conservation program management. **Figure 3-1** lists a few of these agencies with their corresponding internet site addresses. Resources such as these allow Water Conservation Program Coordinators and Managers to keep up to date with conservation programs, services, and technological developments. (7)

Figure 3-1. Water Efficiency Internet Sites
American Water Works Association http://www.awwa.org **United States Bureau of Reclamation** http://www.usbr.gov **Waterwiser – Water Efficiency Resources** http://www.waterwiser.org **Division of Pollution Prevention and Environmental Assistance** http://www.p2pays.org

Section 3.3 Setting Goals for Water Conservation



Prior to implementing a water conservation program, the Water Conservation Manager should set specific water reduction goals that are both measurable and realistically obtainable. The water reduction goals should be stated as gallons saved and/or percentage of water saved during a specific time frame. Additionally, the area of the building or facility where the water reduction will take place and the method by which the savings will be accomplished should be stated. Each specific water conservation action should be supported with a cost/benefit analysis.

An example of a specific goal would be to reduce indoor water use at a State affordable housing complex by 25% by December 31. This goal could be realized by retrofitting all apartments within the complex with low-flow showerheads, faucet aerators, and water-saving toilet flappers. Water consumption data obtained before and after the retrofit will be evaluated to determine if the goal is met. The cost to retrofit the complex will be $3,000 and will result in an annual water savings of 200,000 gallons. The payback period resulting from the water savings will be 2 years.

Generally, water conservation may be achieved by addressing three main areas:

1. Finding and repairing leaks (i.e., leaky pipes and faucets).
2. Reducing water use by:
    a. Installing low-flow fixtures.

   b. Eliminating once-through cooling.
   c. Changing people's water wasting habits.
3. Water reuse:
   a. Using water that is currently being discarded, such as using rinse water or air conditioner condensate for irrigation.
   b. Using recycled water from the local wastewater reclamation facility for irrigation and other allowable purposes, if it is available. For an example of this, **Appendix B** provides a case study on the Kihei Public Library's use of R-1 recycled water.

While it is important that water reduction goals be set early, the Water Conservation Manager must ensure that health and environmental requirements are met when designing a building or facility water conservation program. Examples of such requirements would be local building and fire codes, State water reuse regulations, or federal sanitation regulations put forth by the U.S. Department of Agriculture and Food and Drug Administration.

A few suggestions the Water Conservation Manager should consider during the water conservation program's goal setting process include, but are not limited to, the following:

- Inform the local water and wastewater agencies of the State's plan to make its buildings and facilities more water efficient. These agencies may have their own concerns (e.g., meeting summer's higher water demand) that will be consistent with the State's desire to reduce water consumption.
- Encourage the local water and wastewater agencies to establish rebate or incentive programs. Programs such as these may help offset the costs of converting a building/facility to more water efficient status.
- Anticipate increased water and wastewater service costs when considering options. Check with the water and wastewater service provider to see when rate increases are expected to occur.
- Anticipate future increases or decreases in the number of employees or visitors (e.g., to a State park) that will influence water use.
- Use total cost accounting methods to perform an economic comparison of water-efficient techniques. Consider water and wastewater costs, on-site pretreatment costs, marginal cost for capacity expansion, and energy savings (especially heat).
- Program goals should not only address the technical-side of water efficiency, but should also consider the human-side, such as changing behaviors and attitudes, towards water use.
- Perform the simple tasks first to gain acceptance and positive feedback for the program.

The Water Conservation Management team may maximize water reduction by striving to meet multiple water reduction goals during the same time period. However, it is not feasible to attempt to make all areas within a building or facility water efficient at the same time. The focus should be on those areas with the most water use, the highest water and sewage costs, and the greatest incidence of leaks and repairs. This approach will allow the water conservation program to obtain the goals set by the Water Conservation Management team in a relatively short period of time.

Section 3.4 Conduct a Water Audit

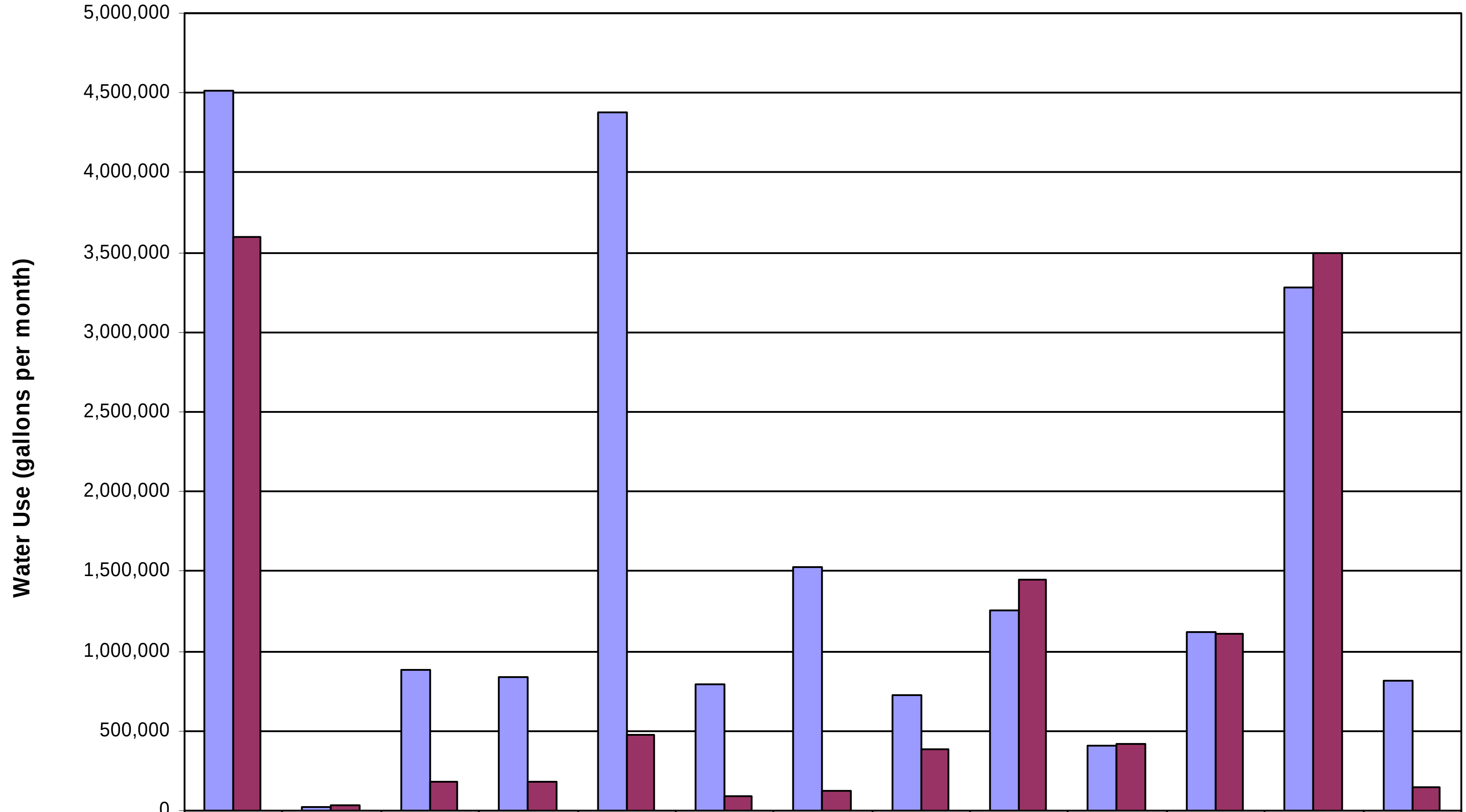
A water audit is defined as the process by which all uses of water on a site are characterized as flow rate, flow direction, temperature, and quality requirement. Conducting a water audit is an essential component of a water conservation program because it can demonstrate the potential for various water conservation opportunities and benefits. Water audits will reveal that significant financial savings can be obtained with relatively small investments that have short payback periods. Also, the water audits will demonstrate that long-term financial savings will result from improving the water efficiency at a building or facility.

A water audit essentially is an accounting procedure that quantifies the amount of water entering a building or facility's water distribution system, as well as the amount of water leaving the system. A water audit's main purpose is to accurately determine the amount of unaccounted-for water (UAW) in a water distribution system. Unaccounted-for water use may originate from leaks, inoperative system controls, and water used from non-metered sources (e.g., private wells). By performing a water audit, the Water Conservation Manager will be able to focus his or her water conservation efforts in areas that need the most attention. Water audits typically provide such information as:

- An inventory of water using equipment and fixtures;
- A basic analysis of water consumption patterns;
- Estimates of potential cost savings, the cost of implementation, and the payback period; and
- The recommended measures to achieve these savings. (8)

As previously mentioned, a survey form was sent to all DLNR divisions as part of the preparation process for the DLNR Prototype Water Conservation Plan (see **Appendix C** for a copy of the survey form—it is recommended that all State agencies utilize this survey form as a tool to help determine the water efficiency status of their respective buildings/facilities). In addition to utilizing the completed survey forms, water billing records were initially compiled in order to gain some insight into actual water use for the DLNR prototype plan. **Figure 3-2** summarizes and presents the comparison of water demand (in gallons per month) from the water billing records versus the reported survey results for thirteen of DLNR's buildings/facilities. As shown in the table, there was some disparity between the water supply billing records and the water demand reported in the surveys. Therefore, as demonstrated by the DLNR Prototype Water Conservation Plan, water audits can also show that the volume of water that a building or facility's staff assumes is being used may be quite different than the actual volume of water actually being used. (9)

Figure 3-2. Water Use Comparison (Assumed vs. Actual) at Some State of Hawaii Buildings/Facilities



	Facility 1	Facility 2	Facility 3	Facility 4	Facility 5	Facility 6	Facility 7	Facility 8	Facility 9	Facility 10	Facility 11	Facility 12	Facility 13
Actual Water Use	4,514,000	26,000	885,000	834,000	4,377,000	787,000	1,531,000	724,000	1,257,000	406,000	1,124,000	3,284,000	815,000
Assumed Water Use	3,600,000	39,000	180,000	180,000	480,000	90,000	120,000	381,000	1,445,970	420,000	1,110,000	3,495,000	150,000

Facilities

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An important task of the water audit is to construct a water balance diagram or summary chart. This diagram or chart will identify all water uses from their source through the on-site process, machines, buildings, and landscape irrigation to evaporation and wastewater discharge. To account for all uses in the water balance, the total inflow should equal the total outflow plus irrigation, evaporation, and other water losses. **Figure 3-3** depicts a simplified water balance diagram for a typical office building, while **Table 3-1** presents a summary chart of a sample water balance through a typical office building. The table below is shown solely as an example of a water balance for an office building. The data is based on a 1991 non-residential water conservation audit program conducted in Denver, Colorado. (10)

Figure 3-3. Simplified Water Balance at a Typical Office Building

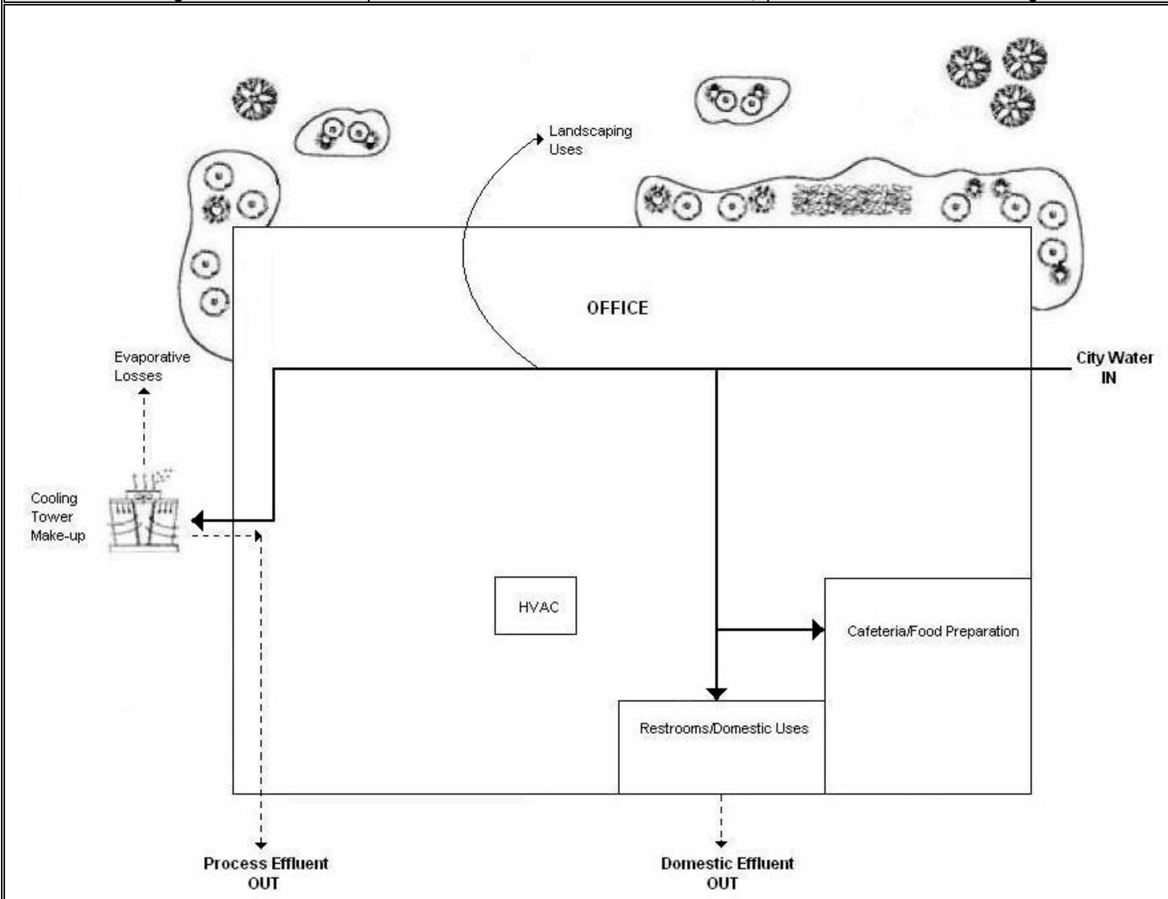


Table 3-1. Sample Water Balance Summary

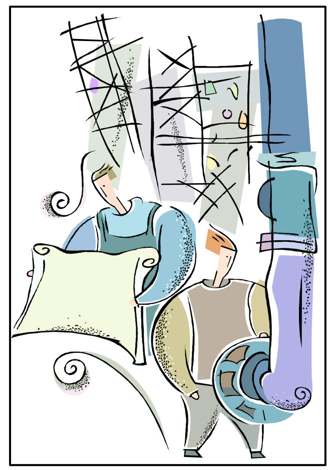
Source of Water Use	Gallons per year	Percent of total
Cooling tower make-up	3,830,400	28.0
Domestic use: faucets, toilets, & showers	5,472,000	40.0
Landscaping	3,009,600	22.0
Kitchen	136,800	1.0
Leaks (detected)	136,800	1.0
SUBTOTAL	12,585,600	92.0
TOTAL WATER PURCHASED	13,680,000	100.0
UNACCOUNTED FOR	1,094,400	8.0

Water Conservation Managers may use the following step-by-step procedure as a guide to conduct their respective water audits.

STEP 1: Collect and Prepare Information

Prior to conducting the actual water audit, collect pertinent information from utility records, such as water bills. Identify personnel who are involved with daily operations who can assist with the gathering of the required information. Collect information including:

- Building and location information, including as-built drawings that show floor plans and plumbing schematic drawings.
- Location maps that identify each water meter that registers incoming water, as well as any sub meters that measure water for specific processes or individual buildings or facilities.
- Utility records, such as water and sewer bills, for the last two years.
- Information pertaining to any expected water and sewer fee increases for the next two years.
- Records that show all other water use for the last two years including water use from sub meters, water wells, and water tank deliveries.
- Plumbing fixture inventories.
- A list of all water using equipment with the manufacturers' listed flow rates.
- The operating schedules that show the total number of employees and number of employees per shift.
- Information obtained from any previous water audits.



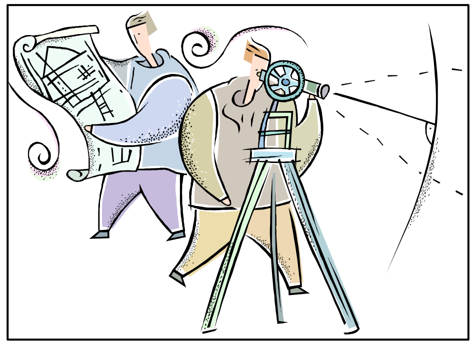
Please note that while gathering and analyzing the above listed information, abnormal rainfall conditions (i.e., dry, wet) should also be accounted for.

The records collected may be used to determine the volume of water required to provide services at State buildings or facilities. Results should be graphed to display monthly water use. For establishments such as cafeterias, hospitals, schools, and parks, obtain records for meals served, rooms occupied, number of visitors, etc. Monthly water use data can then be used to determine the volume of water used per employee, patient, student, or visitor.

STEP 2: Conduct Facility Survey

Step 2 of the water audit process is to conduct a physical survey of the building or facility. While conducting the physical survey, opportunities for water conservation should be noted. The Water Conservation Manager should:

- Walk through the building or facility with operations and maintenance personnel to gain a thorough understanding how water is actually utilized.
- Identify and then create a list of all equipment that uses water including all plumbing fixtures (e.g., faucets, toilets, and showerheads), boilers, cooling towers, rinse tanks, and other water-using process equipment.



- Check the list of water-using equipment against those listed in the building or facility's equipment inventory to see if the inventory is accurate.
- Compare floor plans and plumbing schematic drawings with the observed actual conditions within the building or facility. Any inaccuracies should be noted so that an accurate record of equipment can be created.
- Make notes of equipment or plumbing fixtures that use water for more than one operation.
- Record hours of operation for each piece of water-using equipment. Verify schedules of use with those operating personnel that are familiar with the building or facility's use and equipment.
- Verify and, if needed, calibrate all existing water meters to ensure accuracy. (For water purchased from a municipal or private water purveyor, check with the purveyor to see if the source meter has been verified at least on an annual basis).
- Measure the volume of water used by each water-using fixture or equipment. In many cases, permanent meters will not have been installed. In these cases, a temporary strap-on flow meter commonly referred to as a "poly-sonic" meter that uses ultrasonic waves to measure water flow can be used. A bucket and stopwatch may also be used in some cases to measure water flow in gallons per minute (gpm).
- Compare the water use measurements with the manufacturer's listed/recommended flow rates. Note all discrepancies.
- Solicit water saving ideas and suggestions from employees who are familiar with each water use process.
- Measure exterior water use (e.g., water used for irrigation). Obtain irrigation system drawings and an inventory of all irrigation sprinkler heads and related delivery equipment to determine the flow rate from each head and each exterior area that is being irrigated.
- Perform water quality analyses on previously used water. There may be cases where water may be used for multiple purposes. As it discharges from one water use application, it may be rerouted to another process for use as long as it is of sufficient quality. (e.g., using spent rinse water for other rinse applications or in cooling towers.). Typical water quality parameters to test for include pH, total dissolved solids (TDS), conductivity, waste strength, temperature, and chemical make-up.
- Compare the volume of water used within the building or facility's confines with the total volume of water purchased from the water purveyor, as well as the water obtained from water wells or other sources. There may be UAW that needs to be investigated by the Water Conservation Manager and his/her team.

Appendix E contains a Water Audit Worksheet that may be used while conducting the water audits at State buildings and facilities.

STEP 3: Prepare an Audit Report

Once all of the water use data has been recorded and the Water Conservation Management team has physically surveyed the building or facility, the Audit Report can be prepared. This report is the foundation of the water conservation program. The Audit Report should contain the following information:

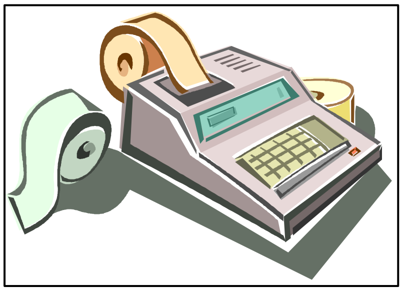
- Building/facility diagrams, blueprints, and water flow charts that have been updated based on the physical survey.
- An updated list of all water-using equipment. The list should contain the manufacturers' recommended flow rates and the actual flow rates that were recorded during the water audit, as well as the age (i.e., date of manufacture and/or installation) of the fixtures, if available.
- An operation schedule for all areas of the building/facility. The schedule should include the number of shifts, the number of employees per shift, the number of people utilizing the facility (e.g., students at a school, patients at a hospital, etc.).
- A monthly landscape irrigation schedule that will demonstrate seasonal variation in watering rates.
- Water use figures for the total building/facility, as well as water use figures for each individual area of the building/facility.
- A water flow chart that displays the movement of water once it enters the building/facility until it is actually discharged.
- Other water use observations that were noticed during the physical survey of the building/facility.
- The total cost of water used by the entire building/facility. (See details in "Step 4: Determine True and Total Cost of Water" below.).
- A description of measures that will be taken to investigate if/why there are major discrepancies between the building/facility's total water use figures and the sum of each water use area (e.g., investigate underground leaks in water distribution system within the building/facility).

STEP 4: Determine True and Total Cost of Water

The true and total cost of water will most likely be more than the building/facility's actual water use fees. In addition to the cost of water purchased from the water utility, several other factors may increase the true cost of water. Such factors include:

- Heating;
- Cooling;
- Energy costs of pumping water from a well or to other locations;
- Pre-treating including purifying, filtering, and softening;
- Chemical treatment, including treating boiler feed and cooling tower water;
- Predisposal treatment;

- Disposal of hazardous liquid substances;
- Sewer discharge; and
- Related labor for any of the above factors.



The costs associated with the above listed additional water use factors must be added to the water use fees for the building/facility. By using the above information, the true and total annual cost of water and water processing for a building or facility may be determined. This cost represents the current baseline for water. Calculate the cost for each unit (e.g., per 1000 gallons) of water utilized by dividing the total cost by the quantity of water used.

Section 3.5 Prepare a Plan of Action and Implementation

After it has been determined how much water is being used and how much it costs, a plan of action and implementation may be prepared to improve the water efficiency at a building or facility. The potential water conservation initiatives that will be considered as part of the plan should be evaluated using the following measures:

- Potential annual water savings,
- Potential annual savings from reduced water processing and discharge,
- Annual implementation costs,
- Ongoing operational costs,
- Time required for implementation, and
- Payback period.

The Action and Implementation plan should prioritize early on each potential water savings opportunity as follows:

A. Priority I: Water conservation opportunities that are both cost-effective and practical. Opportunities in this category should be acted upon as soon as possible.
B. Priority II: Potentially viable initiatives that may need further data collection through a pilot or testing program.
C. Priority III: Not recommended at this time; however, it could be enacted in the future depending on cost/benefit ratio change or extreme water shortage.

The Action and Implementation Plan should include the following items:

- A statement of the State of Hawaii's commitment to water conservation and efficiency.
- The State, department, or building/facility's water conservation goals, as well as the time frame for implementing the goals.

- A listing of all proposed water conservation initiatives that will be taken with the respective implementation dates. The initiatives should be prioritized as indicated by the priority and implementation costs.
- Recommendations of additional or future actions for consideration, including the addition of new water saving fixtures/equipment or process changes.
- A listing of the funding sources for water saving initiatives that will require capital expenditures. Indicate whether water or energy utility company rebates/loans or grants are being utilized.
- Identification of the need for any engineering changes in the building or facility.
- Identification of the department, section, or employee responsible for implementing each initiative. Continuously monitor the effectiveness and performance of each initiative.
- A review and evaluation process. Follow-up water audits should be scheduled for high water use areas. Reports should be prepared and submitted to upper management on a regular basis as deemed appropriate by the Water Conservation Manager. The plan should be revised, as necessary.

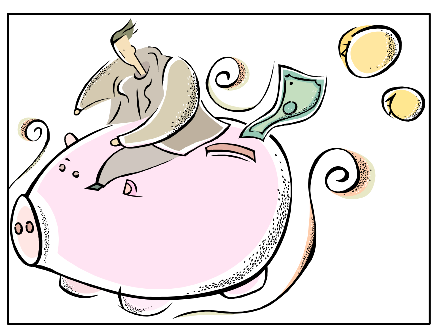
The majority of water conservation opportunities will fall into four main areas for State buildings/facilities. These are: 1) domestic plumbing fixtures, 2) landscape irrigation, 3) cooling and heating, and 4) processing. The Action and Implementation Plan should review all fixtures and water using equipment in these four areas. Chapters 5 through 8 of this manual provide detailed discussions on how to conserve water in each of these main areas.

Other factors that should be considered when deciding which water conservation measures to enact are:

- <u>Publicity</u>: Water conservation initiatives that are easily noticed by employees and the general public will portray a positive image of the State and its commitment to water conservation.
- <u>Ease of Implementation</u>: By quickly taking action on those water conservation opportunities that are the easiest to implement, the State will bring credibility to its commitment to water efficiency.
- <u>Employee Morale</u>: Acting upon water saving suggestions by employees will improve morale and encourage more employee participation in the program.

Section 3.6 Begin with Certain Savings

To start saving water at State buildings and facilities, target the most obvious areas that will result in immediate reductions in water use. These target areas are the easiest to address and include:



- <u>Leaks</u>: The water audit should have documented leaks originating from faucets, toilets, and other plumbing fixtures, pipes, fittings, hoses, etc.

Perform the easiest repairs first and then target the hard to find leaks (e.g., underground) next. An easy way to find out if water is leaking is to shut off all water use in an area and check the water meter to see if it is registering flow. After all leaks have been repaired, set a routine schedule for leak detection and repair. Areas that should be checked are:
  - Restrooms and shower facilities: For tank-type toilets, check for flapper leaks by adding food coloring or dye tablets to the tank – if a leak is present, color will show up in the bowl after a few minutes.
  - Kitchens: Check plumbing fixtures at sinks and food preparation areas, dishwashers, and related piping.
  - Janitorial areas: Check floor sinks, fixtures, and piping.
  - Landscape irrigation: Look for noticeable leaks in piping.
  - Water fountains.
  - Process plumbing and overflow valves.
  - All other water lines and water delivery systems and fittings.
- Cold water: Many building and facility managers are now limiting restrooms to cold water only. A significant volume of water is wasted when employees allow lavatory faucets to run while waiting for hot water. Use of cold water in restrooms will also result in energy savings.
- Landscape irrigation system: The conversion or replacement of older irrigation systems to more water conservative designs is a long-term solution to more efficient water use. On the other hand, there are a number of actions that can be taken in lieu of conversion or replacement improvements; such as,:
  - Check and adjust sprinkler heads as required to ensure that only the vegetation is being watered and not roads and walkways.
  - Irrigate during evening or early morning hours to reduce evaporative losses.
  - Install moisture sensors that will shut off the irrigation system if it is raining.
  - Manually shut down the irrigation system if there are no moisture sensors installed and rainfall is expected.
  - Decrease watering times during the cooler, wetter months.
- Operations: Simply changing water use schedules or adjusting equipment can result in significant water savings. Suggested operational adjustments include:
  - Check to see that all water using equipment is performing per the manufacturer's specifications.
  - Eliminate unneeded restrooms and other water using equipment. Close off main water inlet valves to avoid potential of future leaks from plumbing fixtures, pipes, etc.
  - Maintain close communication with employees and other water users about water conservation efforts. Implement employee suggestions whenever appropriate.
  - Replace water use when other alternatives exist (e.g., sweeping a sidewalk instead of hosing it down).
  - Reduce vehicle-washing frequencies.
  - Install timers on equipment to automatically shut off water flow at specified times.

Section 3.7 Focus on Areas of Major Water Savings

The next phase in reducing water use at State buildings and facilities is to seek out areas that will result in major water savings. These areas may take longer and cost more to convert to water efficient status, yet the long-term water savings justify the time and money spent. Action items in this phase could include replacing outdated equipment, modifying existing equipment, establishing more efficient operational procedures, and exploring new procedures that will use significantly less water without negatively impacting production and/or service quality or quantity. (11)

The following suggestions can lead to long-term water savings at most State buildings and facilities:

- Additional metering: Install meters or sub meters to accurately determine water use at specific areas. Metering can detect abnormal use and can alert operations personnel of a leak in the water distribution system. Installing an "irrigation" meter may result in lower water related sewer charges since most municipalities base sewage fees on the volume of water used. Check with the local water purveyor for details about installing an "irrigation" meter.
- Additional controls: Install solenoid valves that work with timers or power switches to shut off water flow to equipment when appropriate. Limit or float switches installed on tanks can eliminate overfilling.
- Reduce water flow: After additional meters or sub meters are installed, reduce flow to water using equipment that is in excess of the respective equipment's manufacturer's specifications. Flow restrictors may be used on certain plumbing fixtures and other water using equipment.
- Reduce water pressure: The water pressure from the local water purveyor may be in excess of what is required to make most plumbing fixtures and other water using equipment perform adequately. Excessive water pressure can result in significant increases in water consumption and cause leaks in the water distribution system. Check and adjust water pressure as required. In some cases, pressure-reducing valves may need to be installed.
- Internal reuse and recycle: There may be cases where water can be used more than once within State buildings and facilities. As long as the water quality is not degraded by one process, it may be safely used by another process. Examples are:
    - Spent rinse water may be used for additional rinsing or in cooling tower applications.
    - Water used for heat transfer, such as heating and cooling, can be stored in holding tanks and used for other purposes (e.g., irrigation).
- Non-potable water use: If available, switch to R-1 recycled water for non-potable uses, such as landscape irrigation and cooling tower applications. R-1 recycled water is the highest quality recognized by the DOH and can be used for a variety purposes with minimal restrictions. To learn how the Kihei Public Library converted its irrigation system to R-1 recycled water and saves approximately 2.2 million gallons of potable water each year, refer to **Appendix B**. Rainwater may also be collected and used for landscape irrigation.

Section 3.8 Employee Education and Participation

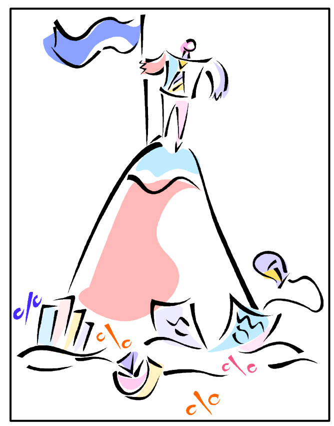
The importance of employee education and participation in the State's water conservation program should not be underestimated. Employee involvement is critical for the program to succeed. To achieve employee education and participation, the upper management of each State building and facility should consider implementing the following steps:

- Introduce the State's water conservation program by sending a formal letter from the Governor to each employee. The State's designated Water Conservation Program Coordinator should be identified and the employees should be encouraged to fully support and participate in the program.
- Initiate a water education program for employees. Staff meetings or training seminars could be utilized to:
    - Provide background information about Hawaii's current and future water supply challenges.
    - Introduce the respective building or facility's designated Water Conservation Manager. Provide background information about the Governor's Administrative Directive No. 06-01 and the State's quest to earn LEED certification at its buildings and facilities.
    - State the water conservation goals of the respective building or facility.
    - Emphasize that the employees' cooperation and participation is essential for the program to succeed.
    - Describe how the employees can contribute to the program (e.g., use less water, report leaks, etc.).
    - Encourage employees to make water saving suggestions.
    - Describe new water saving procedures that are being implemented and new water saving fixtures or equipment that are being installed.
- Supplement the education program through regular communication and updates about the water conservation program. Newsletters, memos, posters, e-mail, paycheck stuffers, progress reports, and updated water saving procedures could be used to keep employees informed. Posters, stickers, signs, etc. should be posted where employees congregate, such as in cafeterias, locker rooms, and restrooms.
- Provide regular updates on the progress of the program. Charts, graphs, and other visual aides should be utilized to show results. Remember to congratulate employees for their participation and support of the water conservation program.
- Get employees involved by:
    - Creating a water conservation idea box. Respond to each idea submitted.
    - Publicly acknowledging employees for their water saving suggestions and for reporting leaks and other water wasteful situations.
    - Implementing the employees' suggestions that are practical and cost-effective. Acknowledge and reward employees as deemed appropriate.
    - Developing a slogan contest. Reward employee(s) as deemed appropriate.
    - Encouraging employees to save water at home as well as in the work place by:

- Providing water saving devices for home use either for free or on a cost basis.
- Sponsoring demonstrations that will educate employees how to irrigate landscapes efficiently, use water saving plants, install low-flow plumbing fixtures and devices, and, in general, improve their water use behaviors.
- Providing home water conservation booklets or brochures.

Section 3.9 Publicize Success

Once the water conservation program has been established and savings in water, energy, and money are being realized, it is time to publicize the success of the program. Conservation of resources is good news and by implementing water conservation at its buildings and facilities, the State can set an example for the community on how to contribute to sustainable resource management. The positive publicity is good for community relations and will help the program gain forward momentum.



Avenues that can be used to gain the public's attention about and in support of the water conservation program include:

- News releases to local media, including newspapers and television stations.
- Provide tours to the media and other interested parties showing water efficient modifications.
- Letters to public officials.
- Posters/displays showing results of program. Posters/displays could be displayed in public reception areas of State buildings and facilities that serve the public or the visitor industry.
- Brochures.
- Technical presentations about the program at local and national water industry conferences, seminars, and workshops.
- Talk radio.
- Trade publications.
- Participation in local water advisory committees. Share information about the State's water conservation program with members.
- Participation in water fairs sponsored by local schools.
- Sponsor water conservation demonstrations, such as water efficient (i.e., xeriscape) landscaping.

State officials should be proud of their water conservation program and should not be shy about sharing information about the program's positive benefits. The public and news media need to know that the State is acting in an environmentally and socially responsible manner. The key point to emphasize when publicizing success is that as a result of saving water today, the State of Hawaii is benefiting the community by making more water available now and for future generations.

Essential Components of a Water Conservation Program

1. Identification of Current Water Use at the Facility:

- Facility water system inventory – understanding the current water system layout;
- Gather historical water consumption data (i.e., water billings, water metering records);
- List of all water uses including domestic, irrigation, maintenance, etc.;
- Water quantities used on average by each water use type. This may require the installation of sub-metering systems to determine specific water usage by category (e.g., domestic use, irrigation, maintenance operations); and
- Identify significant water uses.

2. Identification of Existing Conservation Measures:

- List all existing water conservation measures;
- Assess existing water conservation measures and any previous attempts to implement water conservation measures and gain understanding of relative success or failure; and
- Identify areas without water conservation measures.

3. Identification of applicable/practical water conservation measures:

- List potential water conservation measures to be considered; and
- Discuss potential water conservation measures with facility staff.

4. Potential Water Conservation Measures Cost Benefit Analysis and Environmental Assessment:

- Develop projected water conservation plan implementation costs;
- Develop estimated projected water savings based on water conservation measures selected;
- Evaluate water conservation plan feasibility through cost benefit analysis;
- Environmental Assessment–identifying resources and any possible negative impacts; and
- Develop final recommended water conservation plan based on cost benefit and environmental analysis.

5. Conservation Plan Implementation Schedule:

- Develop timetable of interim and long-term conservation measures for agency implementation.

6. Development of initial steps to be taken by facility:

- Possible installation of sub-metering systems to monitor water usage;
- Identify implementation costs, including labor;
- Identify activities for monitoring performance and results;
- Educate facility staff on water conservation measures;
- Post signs to educate water users on water conservation; and
- Post signs identifying contacts if facility is in need of repair.

Source: State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management. (2005), *Prototype Water Conservation Plan for the Department of Land and Natural Resources (DLNR)*, pgs. 9-8 and 9-9.

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CHAPTER 4 Water Conservation Guidelines for Indoor/Domestic Use

Surveys conducted as part of the DLNR Prototype Water Conservation Plan revealed that water required for indoor and domestic purposes can range from over fifty percent of the total water used at certain commercial establishments, such as an office building, to under three percent for a typical State park (12). Within State buildings and facilities there certainly are several easy and cost-effective measures that can be taken to reduce water use. These measures can be implemented by replacing or retrofitting water using equipment (e.g., replacing an old toilet with a water conserving model), improving operational practices (e.g., conducting routine inspections for leaks), or behavioral modifications (e.g., educating employees to use less water or simply report leaks).

Many of the plumbing fixtures in use today, such as toilets, urinals, showerheads, and faucets, were installed years ago when there were no federal or local regulations governing flow rate standards. These fixtures waste tremendous amounts of water and energy every day and could be replaced or retrofitted (if not already done so) to improve the water efficiency of State buildings and facilities.

The Energy Policy Act of 1992 was established to extend fresh water supplies and to standardize the plumbing fixture industry. It set national water efficiency flow rate standards for newly installed indoor plumbing fixtures. The flow rate standards mandated by the Energy Policy Act are compared to flow rates for conventional plumbing fixtures in **Table 4-1**.

Table 4-1. Federal Flow Rate Standards vs. Conventional Standards for New Fixtures in Commercial Buildings & Facilities

Plumbing Fixture	Federal Standards	Conventional Models
Toilets	1.6 gpf	3.5 to 7 gpf
Urinals	1.0 gpf	2 to 3 gpf
Showerheads	2.5 gpf	5 to 7 gpf
Lavatory Faucets	2.5 gpm	3 to 5 gpm
Kitchen Faucets	2.5 gpm	3 to 5 gpm
Faucet Aerators	2.5 gpm	n/a
Metering Faucets	0.25 gallons per one time use	n/a
Acronyms: gpf – gallons per flush; gpm – gallons per minute		

This legislation will result in nationwide water savings of approximately 6.5 billion gallons per day (gpd) by the year 2025, as estimated by the AWWA. (13)

There are potentially many high water use plumbing fixtures within the State's buildings and facilities that were installed prior to the enactment of the Energy Policy Act. These fixtures could be replaced or retrofitted to meet the federal standards. Options for replacing or retrofitting the various plumbing fixtures listed in **Table 4-1** are discussed later in this chapter.

This chapter will provide detailed information pertaining to water conservation opportunities for the following indoor areas:

- Restrooms and shower facilities;
- Kitchens, cafeterias, and staff rooms;
- Laundries; and
- Cleaning and maintenance.

Section 4.1 Restroom and Shower Facilities

Section 4.1.1 Toilets

It is estimated that Americans flush approximately 4.8 billion gpd of water down the toilet. By improving the water efficiency of toilets alone, the State will conserve a significant volume of water. There are a variety of different toilets in use today including gravity flush, flush valve, pressurized tank system, composting, and incinerating models. State buildings and facilities most commonly utilize the gravity flush and flush valve types. Thus, the focus of this section will be on maintaining, retrofitting, or replacing these types of toilets.

<u>Gravity Flush Toilets</u>
Gravity flush toilets are the most common type of toilets in use today. They function by allowing water in an attached tank to flow down through a flapper valve on the bottom of the tank. The suction action created by this downward flow drains the toilet bowl contents into the building's sewage collection system. Options for improving the water efficiency of gravity flush toilets are discussed below.

- <u>Maintenance</u>: The most common maintenance problem that results in excessive water use from a gravity flush toilet is a leaky flapper valve. Ball cocks also may be a leak source. Leaks can be detected simply by listening for running water, observing ripples or small waves in the toilet bowl, or by adding food coloring or a leak detection tablet to the toilet tank (the color will appear in the bowl after a few minutes if water is leaking through the flapper valve). To avoid this condition from occurring, gravity flush toilets should be routinely checked for leaks on a regular basis. Flapper valves and ball cocks should also be periodically replaced. Tank levels can also be lowered so that the toilet uses less water; however, maintenance personnel should verify that the toilets still flush adequately after actually lowering the water level.

- <u>Retrofit Options</u>: Gravity flush toilet retrofit options are a relatively inexpensive way to save water. Options include displacement devices, toilet dams, bowl diversion devices, dual flush kits, and early closing devices. The recommended option is the early closing device, which is an adjustable flapper valve that closes earlier than a standard flapper valve. The advantage of early closing devices over the other options listed above is that water is saved at the bottom of the tank, resulting in a more complete flush because a higher level of water is maintained in the tank. These adjustable flappers, which can be easily adjusted to ensure that flushing is not hindered, can save up to 2 gallons per flush (gpf) and can be obtained for under $5.00 each. The County of Maui's Wastewater Reclamation Division (WWRD) has successfully utilized these devices in its multifamily residential water conservation program (see the case study in **Appendix B** to learn more about this program). While early closing devices are the recommended option, Water Conservation Managers are encouraged to experiment with the other devices mentioned above. Water conservation companies will often supply free samples of their products to prospective customers. Early closing devices as well as other toilet retrofit devices can be obtained from various water conservation companies (see **Figure 4-1** for details). *NOTE: Never place a brick in the toilet tank to displace water. The brick will eventually break apart into small pieces that will damage flow valves and prevent proper closure of the flapper valve.*

Gravity Flush Toilet Flow Schematic

Figure 4-1. Where to Obtain Low Flow Fixtures & Devices

- Plumbing Supply Stores
- Home Improvement Stores
- Niagara Conservation, 1-800-831-8383 or http://www.niagaraconservation.com
- New Resources Group, 1-203-366-1000 or http://www.nrgideas.com

Important Disclaimer: *The State of Hawaii does not endorse the companies listed above; this list is presented for general assistance purposes only. Any products, manufacturers, or resellers mentioned in this manual are provided for demonstration purposes and the State in no way endorses any of them.*

- Replacement Options: As shown in **Table 4-1**, conventional toilets can use anywhere from 3.5 to 7 gpf. Water conserving models, often referred to as ultra low flush (ULF) toilets, use only 1.6 gpf. Replacing an older, conventional toilet with a new 1.6-gpf model will result in the most water savings and the payback period for most 1.6-gpf models will be less than four years. The Water Conservation Manager should strongly consider replacing older toilets with ULF toilets if his or her respective building/facility has any of the following:
  - High water and sewer bills,
  - Old toilets that use 5 to 7 gpf, or
  - High number of uses per toilet.

ULF toilets generally function well, but it is recommended that Water Conservation Managers research which brands flush the best. An excellent website that lists the performance testing results of several brands and models of ULF toilets is http://www.cuwcc.org/uploads/product/MaP_7th_Edition_06-07-07.pdf. Also, checking with the Honolulu Board of Water Supply (HBWS) or with other cities that have established toilet replacement programs is a good idea. The County of Maui's WWRD coordinated a toilet replacement in Kaunakakai, Molokai during the mid 1990's. A total of 365 ULF toilets were installed in single and multifamily homes. No complaints were filed regarding the flushing capability of these toilets. **Appendix B** contains a detailed case study concerning this program.

There are also "flapper less" ULF toilets on the market now that can be obtained from one of the companies (Niagara Conservation) listed in **Figure 4-1** *(Please note the Important Disclaimer stated in this figure.)*. These toilets have a refillable trough at the top of the tank that empties during the flushing process. The advantage of this type of toilet is that there are no flappers. Flappers are a common source of leaks in most toilets and have to be replaced every few years.

Flush Valve Toilets

Flush valve (flushometer) toilets are commonly used in commercial and industrial settings, especially in high use areas. This type of toilet uses water line pressure to flush wastes and consists of a valve and toilet bowl fixture. Options for improving the water efficiency of flush valve toilets are discussed below.

Typical Flush Valve Toilet

- Maintenance: A common problem with both flush valve toilets and flush valve urinals is that the flush times become extended because the valve components get worn or clogged with contaminants in the water supply. A regular valve cleaning and inspection program will help resolve this problem. Worn valve diaphragms should be replaced. Flush valves should also be adjusted to use as little water as possible. Also, signs should be posted in restrooms to remind people not to flush trash down the toilet. Flushing trash not only wastes water, but also can clog the sewer piping system.

- Retrofit Options: Flush valve (flushometer) toilet retrofit options include insert or valve replacement devices, sensors, and dual flush adapters. Flush valves can be retrofitted with inserts that reduce water consumption by 0.5 to 1.0 gpf. Check with the manufacturer on the availability of these inserts. Another option is to replace 5.0-gpf flush valves with 3.5-gpf flush valves. *NOTE: Do not install a 1.6-gpf flush valve on a 5.0- or 3.5-gpf toilet bowl fixture, as the toilet will not flush well!* Installing infrared or ultrasonic sensors will eliminate unnecessary double flushing. Dual flush valves are also available from the toilet manufacturer for installation. Activating the handle in the upward position for liquid wastes uses 30% less water than the downward flush used for solid wastes. Signs should be posted in the restrooms to educate people about this water saving feature.

- Replacement Options: Maximum water savings can be obtained by replacing older, inefficient flush valve toilets with ULF 1.6-gpf models. *Remember to replace both the valve and the toilet bowl fixture, as a 1.6-gpf valve will only work with a 1.6 gpf-designed toilet bowl.* See the Replacement Options bullet of the Gravity Flush Toilets section above for more information on ULF replacement options.

Other Types of Toilets: There are other types of toilets that can be used in specific circumstances. For example, pressurized tank toilets utilize compressed air to assist the flushing process. These types of toilets are effective in situations where flushing is problematic, such as when the existing sewer lines consist of old cast iron piping. Pressurized tank toilets are very expensive and should only be considered when toilet flushing cannot be accomplished with gravity or flush valve toilets. Other types of toilets include composting and incinerating toilets. Both can be used where water is scarce and sewers or septic systems are not available.

Pressurized Tank

Example of a Composting Toilet

Incinerating Toilet

Section 4.1.2 Urinals

As in the case of toilets, there are several types of urinals. Siphon jet urinals are designed for high use applications. An elevated tank provides the flushing action to remove items, such as cigarette butts and gum wrappers. This type of urinal requires little maintenance and is more sanitary than other types of urinals, but water runs continuously resulting in excessive water waste. Washout or wash down urinals utilize a flush valve to flush the urinal after each use. Flushing is activated manually or automatically with a sensor. There are also waterless urinals available. These urinals use no water and have no handles, sensors, or moving parts. See below under Replacement Options for more information about this type of urinal. Options for improving the water efficiency of urinals are discussed below.

Siphon Jet Urinal

- Maintenance: Siphon jet urinals should be routinely checked for leaks, at least every six months. Wash down urinals should be checked for extended flush times and the flush valve should be cleaned periodically. The flush valves can be adjusted to use a minimal volume of water. The floating chemical seal required by waterless urinals in order to eliminate odors must be replaced throughout the year depending on the frequency of urinal use. In addition, occasionally flushing waterless urinals with hot water helps to keep the urinal passageways clear.

Wash Down Urinal

- Retrofit Options: Siphon jet urinals can have timers installed to shut them off when the building/facility is not occupied. Some washout and wash down urinals can be retrofitted by replacing a part in the flush valve with an insert that will result in less water used per flush. *Make sure that the retrofit does not interfere with adequate removal of liquid wastes.* Check with the manufacturer on the availability of these inserts. Installing infrared or ultrasonic sensors can also save water by eliminating double flushing.

Waterless Urinal

- Replacement Options: Replacing high use conventional urinals that use 2 to 3 gpf with a high efficiency urinal that uses only 1.0 gpf or a waterless urinal will save the most water. Waterless urinals use a biodegradable liquid to keep urine odors and sewer gases from escaping into the restroom. Replacing a 2.0-gpf urinal with a waterless variety in a typical office building can save up to 44,000 gallons of water per year (assuming the urinal is used 200 times a day for 220 days a year) (14). Waterless urinals have been successfully utilized at the Haleakala National Park Visitor Center on Maui (see the case study in **Appendix B** for more information regarding this program). For more information about waterless urinals, visit the useful internet sites listed in **Figure 4-2**.

Figure 4-2. Waterless Urinal Internet Sites

Waterless Co.
http://www.waterless.com

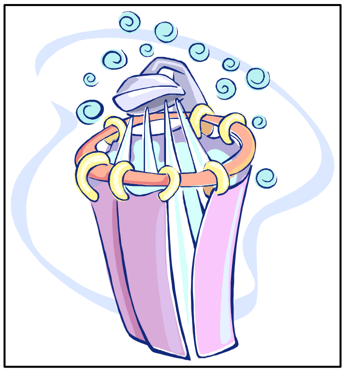
Sloan Valve Company
http://www.sloanvalve.com

Important Disclaimer: *The State of Hawaii does not endorse the companies listed above; this list is presented for general assistance purposes only. Any products, manufacturers, or resellers mentioned in this manual are provided for demonstration purposes and the State in no way endorses any of them.*

Section 4.1.3 Showerheads

Showerhead replacement is another easy and cost-effective measure that can be taken to save water. Older showerheads use anywhere from 3 to 7 gpm, where as newer showerheads by standard can use no more than 2.5 gpm. These new water efficient showerheads perform quite well and come in many styles. They will not only save water, but also will reduce the energy requirements for hot water heating. New water efficient showerheads are available from the various companies listed previously in **Figure 4-1**.

Another option is to install flow restrictors in order to decrease flow to older, conventional showerheads. Still, given that new high efficiency showerheads are relatively inexpensive to purchase and install, showerhead replacement (described above) is the recommended option to make shower facilities more water efficient.



Signs could also be posted to encourage users to take shorter showers. The signs should request cooperation in the State's water conservation efforts and convey the message that fresh water is our most precious natural resource. Example language on these signs could be:

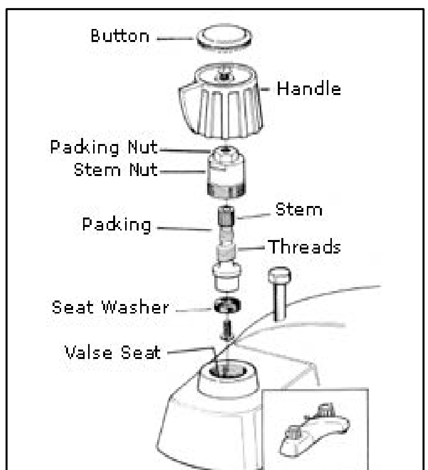
"For water conservation purposes,
Please limit showers to no longer than 5 minutes.
Mahalo!"

For parks and other outdoor showers, consider using tamper proof brass showerheads. It is not uncommon for beach and park users to remove showerheads so that a higher volume of water is provided. Tamper poof showerheads are outfitted with a setscrew that makes it difficult to remove, and can be obtained at a reasonable cost from the water conservation companies listed in **Figure 4-1**.

Section 4.1.4 Faucets

Faucets represent yet another area that can be easily targeted for water conservation measures. Conventional, older faucets use 3 to 5 gpm while federal guidelines require that all new kitchen and lavatory faucets, as well as faucet aerators, use no more than 2.5 gpm. A leaky faucet can waste up to 36 gpd. Over the course of a year, this leak rate will result in over 13,000 gallons of wasted water. Maintenance, retrofit, and replacement options for faucets are discussed below.

- Maintenance: Leaks from faucets are undoubtedly one of the easiest and most economical repairs to accomplish that will aid the State in its water conservation efforts. Typically, all that is required to fix a leaky faucet is to replace a worn o-ring or seat gasket in the faucet valve stem assembly. Worn valve stems may also be the source of these leaks. Repairs such as any of these take minutes to perform. If unsure of exactly what repair parts are required, you can take the worn parts to a local home improvement store or plumbing supply outlet. As stated above, one leaky faucet can waste over 13,000 gallons per year so it makes good sense not to ignore these simple repairs.



Typical Faucet Assembly

- Retrofit Options: Faucet aerators are a great way to reduce flow rates in conventional faucets. Aerators screw onto the faucet head and add air to the water flow, thus reducing the flow rate. For restroom applications, aerators are available at ratings of 0.5, 0.75, and 1.0 gpm. The 0.5 gpm aerator provides adequate flow for hand-wetting purposes in a restroom. Aerators are inexpensive and can be installed in minutes. Some older faucets cannot be retrofitted with aerators because their design does not allow such a device to be screwed onto the faucet. In these cases, a good option is the installation of a flow regulator before the faucet(s). Flow regulators can be installed in the hot and cold water feed lines to the faucet(s). Common flow rates for flow regulators are 0.5, 0.75, 1.0 and 1.5 gpm.

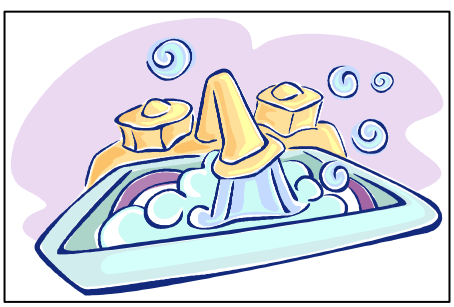
- Replacement Options: All new faucets that are purchased use 2.5 gpm or less to meet federal standards. When installing a new faucet, additional features that may be compared and opted for include:
    - Automatic shutoff: Once the handle is released, the valve shuts off.
    - Metered shutoff: Once the handle is depressed, the faucet delivers water for a preset time.
    - Infrared and ultrasonic sensors: An "electric eye" senses when a person approaches the sink area. A metered volume of water is discharged when the faucet is in use. Many State facilities, such as airports, utilize this control system. This is the most expensive option with the longest payback period.


New Faucet with Electric Eye Sensor

Section 4.2 Kitchens, Cafeterias and Staff Rooms

Kitchens, cafeterias, and staff rooms typically have a number of high water use plumbing fixtures and appliances that can be targeted for water efficiency upgrades. The following sections provide several water conserving measures that can be implemented by means of the various plumbing fixtures and appliances found in the kitchens, cafeterias, and staff rooms of State buildings and facilities.

Section 4.2.1 Kitchen Faucets

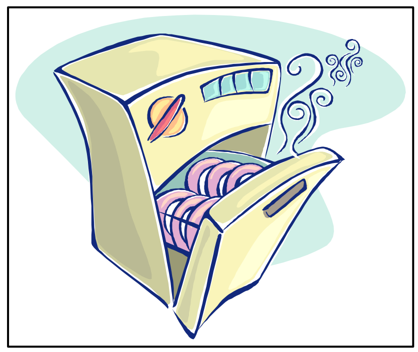


By federal standards, new kitchen faucets must use 2.5 gpm or less while conventional kitchen faucets use 3 to 5 gpm. Conventional faucets can either be replaced with new faucets or retrofitted with aerators as described above in **Section 4.1.4 Faucets**. *It is important to note that water audits of commercial facilities have shown that 60% of identified water savings come from simply installing faucet aerators on all kitchen sink outlets.* When retrofitting a conventional kitchen faucet, consider using a dual setting touch flow kitchen aerator with a swivel. This swivel allows effective area cleaning and includes an aerated jet/wide spray option. The touch flow allows the user to shut off the water when performing a task that does not require it, and then turn the water back on at the exact same flow rate and temperature. This and other types of kitchen aerators can be obtained from the water conservation companies previously listed in **Figure 4-1**.

Leaks from kitchen faucets should also be repaired as described in **Section 4.1.4** above. Additionally, signs should be posted reminding employees to report leaks immediately to management and to shut off faucets when not in use. *Remember that a leaky faucet can waste up to 13,000 gallons of water per year!*

Section 4.2.2 Dishwashers

Dishwashers of all types have wash, rinse, and sanitizing cycles that use water. Most dishwashers use between 2.0 and 7.0 gpm during these cycles. There are four types of dishwashers.



1. Under-counter: The under-counter machines are the smallest of all commercial dishwashers and are best suited for small establishments serving up to 60 people. Typical establishments that use this type of machine are nursing homes, small food service establishments, and office buildings. These machines are similar to residential dishwashers since the door opens downward with the racks rolling out on the lowered door. The under-counter machines use the most water per rack of all commercial dishwashers; thus, it is important to wash only full loads.
2. Door-type: Door-type machines are the most common commercial dishwasher and can serve 50 – 200 people. These machines are used in such facilities as schools, hospitals, restaurants, and churches. The machines are box shaped and have doors that slide vertically for loading and unloading. Some door-type machines can now recycle rinse water so that it can be used in the wash cycle.
3. C-line or Rack Conveyor: The C-line or rack conveyor dishwashers use conveyor belts to move the rack-loaded dishes through a large tank with separate wash and rinse compartments. These machines can serve 200 or more people and are typically used in hotels, large restaurants, schools, universities, and hospitals. Timers control the conveyor speeds, and final rinse water is normally recycled.
4. Flight-type: The flight-type is similar to the C-line or rack conveyor machine, but dishes are loaded directly onto the conveyor belt. These machines are only used in the largest institutional, commercial, and industrial facilities where high volume washing is required.

State buildings and facilities may have some or all of these types of dishwashers in service. Maintenance, retrofit, and replacement options for dishwashers are discussed below. (15)

- Maintenance:
  - Check and repair leaks in hoses, spray rinse fixtures, etc.
  - For rack-type dishwashers, wash only full loads.
  - Use the minimum flow rates suggested by the manufacturer.
  - For conveyor-type dishwashers, reduce flow rates for the pre-wash spray, if present, to minimum acceptable levels.
  - For conveyor-type dishwashers, make sure that the flow of water stops when no dishes are present.

- Retrofit Options:
  - Install pressure or flow regulators to limit the water flow to the manufacturers suggested levels.
  - For conveyor-type dishwashers, install an "electric eye" (i.e., infrared and ultrasonic sensors) to automatically shut off the water flow when dishes are not present in the machine.
  - For conveyor-type dishwashers, limit or eliminate scrapping troughs that are used to convey food waste in a water stream to the garbage disposal. A conveyor system that uses no water can be used instead of a scrapping trough.
  - Design and construct an internal recycle/reuse system that will allow the final rinse water to be used in the pre-wash cycle, scrapping troughs, or garbage disposals.

- Replacement Options: The EPA has expanded its Energy Star program to include dishwashers. This program is a voluntary partnership between government, businesses, and purchasers designed to encourage the design, manufacture, purchase, and use of efficient products. Machines that earn the Energy Star rating are both energy and water efficient (16). It is recommended that all new dishwashers purchased by the State be classified as Energy Star products. Some other options to consider when purchasing a new dishwasher include:
  - Install low temperature machines that rely on chemical sanitizing instead of high water temperature machines.
  - Check the volume of service and estimate facility needs. A better option may be to purchase a larger machine that has a lower water flow rate per rack.

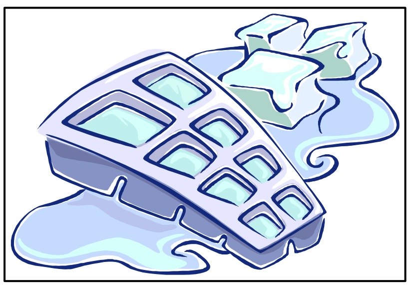
Section 4.2.3 Garbage Disposals

Garbage disposals are high maintenance items that use between 5 to 8 gpm and more if scrapping troughs are connected to them. Since food waste does not need to be discharged to a sewage collection system, many commercial and institutional facilities have eliminated garbage disposals. Instead, they utilize garbage strainers, which use only about 2 gpm. Food waste is collected in the strainer basket as a recirculating stream of water passes through. This stream washes out the soluble material and smaller particles to the sewer system, and the remaining food waste is then disposed of in the garbage.

If it is not practical to replace an existing garbage disposal at a State building or facility with a garbage strainer, the garbage disposal can be made more water efficient by implementing any or all of the ideas listed below.

- Install a solenoid valve, which shuts off the water once the disposal motor turns off, to control water flow to the unit. Routinely check to make sure that the solenoid valve is working properly. Remember that most garbage disposals have two water supply lines: one to the grinding chamber and one to the bowl.
- Set the water flow rate to the disposal unit to the minimum acceptable rate as specified by the manufacturer.
- Install flow regulators in order to reduce excessive flow caused by high water pressure.
- If the unit operates automatically for a preset duration each time the disposal turns on, reduce the preset duration to the minimum necessary to allow the unit to function adequately.
- Reuse water by utilizing dishwasher or other similar types of wastewater in the garbage disposal.

Section 4.2.4 Ice Machines



Ice machines are appliances that should be considered for inclusion in a building or facility's water conservation program because they can use significant volumes of water. Water is used for both ice making and cooling the machine. Some of the larger water-cooled machines can use up to 1,000 gallons of water per day for cooling purposes. The volume of water required for the ice making process varies depending on the manufacturer and the type of machine. In general, machines that make ice cubes use more water than those that make ice flakes. Ice cube machines can use anywhere from 20 to 90 gallons of water per 100 pounds of ice. Ice flake machines, on the other hand, use considerably less water: 15 to 20 gallons per 100 pounds of ice.

Some options that could be used to save water during the cooling and ice-making process of ice machines are listed below.

- Eliminate once-through (i.e., single-pass) cooling by tapping into another chilled water system, if available.
- If it is impractical to eliminate once-through cooling, consider reusing the cooling water for another purpose (e.g., landscape irrigation or use in garbage disposals). *Do not waste this perfectly good water!*
- Replace water-cooled ice machines with air-cooled machines. The life expectancy of ice machines is usually about five years, so replacement is a viable option. Air-cooled machines use slightly more electricity and produce less ice than water-cooled units, but they use considerably less water.
- Water softening could be used to reduce the bleed-off process for ice cube machines.
- Adjust ice machines to dispense only the amount of ice needed.
- Use ice flake machines instead of ice cube machines, if possible.

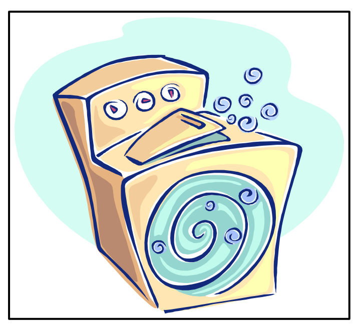
Section 4.2.5 Other Ways to Save Water in Kitchens, Cafeterias and Staff Rooms

There are several other ways to save water in kitchens, cafeterias, and staff rooms. Many of these require behavioral modifications of employees. *The importance of educating employees about water conservation and including them in the program cannot be overemphasized.* Other water saving measures could include:

- Pre-soak utensils and dishes before washing them.
- Turn off continuous water flow to the drainage trays of beverage islands; instead, clean the trays as necessary.
- Install hot water on-demand systems as opposed to letting water faucets run for long periods of time before hot water becomes available. In order to avoid high electricity expenses, choose a system that does not require a recirculating pump.
- Use water from the steam table to wash down the cooking area rather than using fresh water.
- Reduce the water flow rate to dipper wells or troughs for ice cream and butter scoops.
- Eliminate the practice of using running water for thawing frozen foods; plan ahead and thaw frozen foods in the refrigerator. If water thawing is unavoidable, use a low flow stream.
- Turn off food preparation faucets when not in use. Moreover, foot trigger activated faucets could be installed to reduce water use at kitchen and cafeteria sinks.

Section 4.3 Laundry Facilities

Laundries typically use high volumes of water; especially those that are located in hospitals, convalescent homes, and other medical care facilities. Most of the laundries at facilities such as these utilize commercial type washing machines called washer-extractors. These machines range in capacity from 25 to 400 pounds per load and use 2.5 to 3.5 gallons of water per pound of laundry. Fresh water is added for each wash and rinse cycle since there is no internal water recycling.



Options that may be considered to reduce water consumption for larger laundries include the following:

- Wash only full loads; this is the simplest and most cost-effective procedure. Post signs in the laundry facility reminding employees to only wash full loads.
- Research laundry methods that will reduce the number of wash and rinse steps. For example, consult the vendor who supplies the facility's laundry chemicals. The vendor may suggest changing laundry chemicals that will allow fewer wash and rinse cycles.

- Install a computerized rinse water reclamation system. These systems store rinse water to be used for future wash cycles and can save 25% of the water used at large laundry facilities.
- Computerized rinse and wash water reclamation systems are also available, which can save up to 50% of the water normally required. The wash water is treated to make it usable for future wash cycles.
- Replace conventional washer-extractors with continuous batch-type washers. These washers use only 1.0 to 2.0 gallons of water per pound of laundry and can save up to 60% of the water normally used. This option should only be considered when it is time to purchase a new washing system, as capital costs for replacement will be high.

Smaller laundry facilities will utilize residential type top-loading washing machines. These machines use 40 gallons per load. When it is time to purchase new washers for small laundry facilities, consider purchasing a horizontal-axis washing machine. This type of machine, which is loaded from the front rather than the top, uses only 20 to 25 gallons of water per load. Horizontal-axis washing machines also use about 50% of the energy required by conventional top-loading machines. There are other advantages with horizontal-axis washers over conventional washers; for instance, less detergent is required, and the drying time is reduced because more water is extracted from the clothes during the washer's spin cycle.

Section 4.4 Cleaning and Maintenance

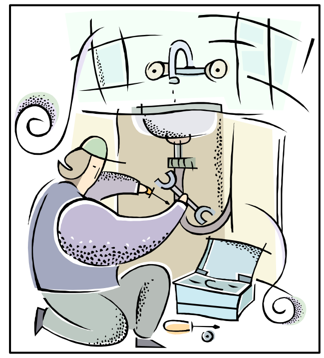
Water conservation opportunities are available in the cleaning and maintenance of State buildings and facilities; however, most of these opportunities will include changes in the procedures typically utilized by employees. Thus, the education component of the water conservation program is critical. Employees must not only be educated on how to save water by changing habits and procedures, but they must believe that their participation is crucial for the program to succeed. If the input of employees is actively solicited and their practical suggestions implemented, then the building or facility's water conservation program will most likely succeed. Please refer to **Chapter 3, Section 3.8** for more information about employee education and participation.

Listed below are some ideas on how to reduce water consumption as required for cleaning and maintenance activities.

- Utilize dry clean-up procedures when possible. For instance,:
  - Sweep floors and sidewalks with a broom as a replacement for hosing them down with water.
  - Vacuum dry materials instead of using water to wash them away.
  - Clean carpets with dry powders as opposed to using wet carpet cleaning methods, such as steam.
  - Use dry absorbents to soak up oil and other liquid wastes on floors at base yards, garages, etc. rather than trying to clean up with water.

  - Place floor mats down to reduce the tracking of dirt and waste material throughout the building or facility.
  - Find and eliminate those sources of maintenance-related spills and leaks that are the primary reason that water wash downs are routinely required.

- When water is required, try implementing procedures or equipment modifications such as the following:
  - Fix leaks that are reported by employees immediately to show that management is serious about saving water.
  - Spot mop, if necessary.
  - Turn off water when not in use.
  - Shut off water to areas or equipment that is not currently in use.
  - Instead of using a standard garden hose nozzle to wash down an area, consider using a high efficient nozzle with an automatic shut-off. These water efficient nozzles are available from the water conservation companies listed in **Figure 4-1**.



  - Use a pressure washer to clean areas quickly with less water.
  - Install pressure regulators and flow restrictors in water lines that supply hoses.
  - Install spring-loaded valves or timers on all manually operated hoses.
  - Install hot water on-demand systems near sinks and other places where hot water is needed in order to avoid having employees run water for long periods of time while waiting for it to get hot.

CHAPTER 5 Water Conservation Guidelines for Landscaping

The irrigation of landscaping consumes vast quantities of water at commercial, governmental, and residential properties in Hawaii. Traditional landscapes in Hawaii typically have lush tropical plants that have high water demands. Supplemental irrigation is normally required in order to maintain these landscapes, especially on the drier, leeward sides of the islands in the Hawaiian chain. The Water Conservation Managers of State buildings and facilities can utilize a variety of measures to render their respective landscapes more water efficient. These measures are discussed in the following sections of this chapter.

Section 5.1 Xeriscaping

Example of Xeriscaping

Xeriscaping is one of the popular tools in water management. The term "xeriscape" was developed in the American southwest and can be defined as "water efficient landscaping appropriate to the natural environment". The goal of a xeriscape is to minimize water waste by utilizing landscaping techniques and plants that are both water efficient and visually attractive. Outdoor water use in a xeriscape can save anywhere from 30 to 80 percent in water consumption. This means comparable savings in water and sewer charges, as well. (17)

There are seven principles of xeriscaping listed on the HBWS's website (http://www.hbws.org/cssweb/). These seven principles are presented below.

Section 5.1.1 Seven Principles of Xeriscaping

1. *A good xeriscape garden starts with good planning and design.*
   Planning allows you to install your landscape in phases, which minimizes initial expenses.

2. *Limit and separate turf areas.*
   Grassed areas frequently require the greatest amount of watering. Turf is best separated from planting of trees, shrubs, ground covers, and flowering plants so that it may be irrigated separately. Replace turf with other, less water-demanding materials such as ground covers, low water-demanding plants, or mulches.

3. *A well-planned sprinkler system can save water.*
   For efficient water use, group garden plants according to similar water needs. Turf areas are best watered with sprinklers. Trees, shrubs, garden flowers, and ground covers can be watered efficiently with low volume drip, spray, or bubbler emitters. Moisture sensors—devices that shut down the irrigation system when the ground is wet or on a rainy day—also help reduce water waste.

4. *Soil improvement allows for better absorption of water and improved water-holding capacity.*
   Coupled with grading, soils and soil amendments that have organic matter—which provide beneficial nutrients to plants—will encourage whatever you plant to take root and flourish. Remember that grading and soil improvements should be done prior to the installation of irrigation systems.

5. *Mulched planting beds are an ideal replacement for turf areas.*
   Mulches cover and cool soil, minimize evaporation, reduce weed growth, and slow erosion. Mulches also create landscape interest. Organic mulches are typically bark chips, wood grindings, or bagasse. Inorganic mulches include rock and various gravel products. Place mulch directly on the soil or on breathable fabric. Avoid using sheet plastic in planted areas.

6. *"Less-thirsty" plants improve your garden in more ways than one.*
   There are many attractive less-thirsty garden species available for use in the tropical xeriscape, including numerous popular flowering trees, shrubs and vines, and turf grasses, which require less watering than others. Ideally, native plants that thrive on natural rainfall do best in a xeriscape. There are many native Hawaiian plants that are less thirsty.

7. *Regular maintenance preserves the intended beauty of your landscape and saves water.*
   Because of their design, xeriscapes can help reduce maintenance costs. Pruning, weeding, proper fertilization, pest control, and irrigation system adjustments further water savings. Always water according to plant needs.

Xeriscaping also encourages the "zoning of landscapes", which means clustering your turf, ground cover, shrubs, plants, and trees according to their water need and according to how natural weather conditions affect each area of the landscape. Moisture, sun, shade, air movement, and heat affect these "microclimates". For example, light reflected from structures facing the area of most sun creates high temperatures and increases the loss of water from nearby plantings. Shade trees and ground covers strategically planted in these exposures reduce temperatures in the warm, dry season; yet, they allow sunlight to enter during the months of high rainfall. Similarly, water-loving plants can be grown in the microclimate zone of the landscape where irrigation and other water run-off are captured in drainage swales—again reducing the need for heavy watering. All of these microclimates utilize the seven principles of xeriscaping outlined above.

Water Conservation Managers can learn more about xeriscaping by visiting the HBWS's Halawa Xeriscape Garden in Halawa Valley, located just outside Honolulu. Free tours are offered by appointment, while self-guided tours and visits to the garden are also available on Saturdays from 10:00 am to 2:00 pm. There are also classes on xeriscaping offered by the Friends of Halawa Xeriscape Garden on Saturdays on a year round basis. For more information, contact the HBWS at (808) 748-5041.

The HBWS also offers several resources that provide information about plants that can and should be used for xeriscaping in Hawaii. For example, the HBWS website (http://www.hbws.org/cssweb/) presents:

- Detailed information on what and how to plant in your area of the island of Oahu. This user-friendly website presents a list of zones that are general guidelines to help you select the right type of Hawaiian plant to use in the landscape on Oahu.
- General information about the selecting, planting, and caring of native plants for landscapes and a list of resources related to native Hawaiian plants (see **Figure 5-1** below for a list).
- A thorough registry of nurseries on the island of Oahu that grow less thirsty plants.

Figure 5-1. Native Hawaiian Plant Resources

Places to See Native Plants on Oahu

Foster Botanical Garden	50 North Vineyard Blvd Honolulu, HI 96817	(808) 522-7066
Halawa Xeriscape Garden	99-1258 Iwaena St Aiea HI 96701	(808) 748-5041
Pearl City Urban Garden Center	962 Second St Pearl City, HI 96782	(808) 453-6050
Liliuokalani Botanical Garden	North Kuakini St Honolulu, HI 96817	(808) 522-7060
Koko Crater Botanical Garden	Inside Koko Crater	(808) 522-7060
Hoomaluhia Botanical Garden	45-680 Luluku Rd Kaneohe, HI 96744	(808) 233-7323
Leeward Community College	96-045 Ala Ike Pearl City, HI 96782	(808) 455-0290 Contact: Frani Okamoto (808)455-0285 Contact: Priscilla Millen
Waimea Valley Audubon Center	59-864 Kamehameha Hwy Haleiwa, HI 96712	(808) 638-9199

Resources/References

Department of Health Office of Environmental Quality Control, *How To Plant A Native Hawaiian Garden*, An On-Line Handbook. http://www.hawaii.gov/health/oeqc/garden/index.html

University of Hawai'i at Manoa College of Tropical Agriculture and Human Resources Hawaiian Native Plant Propagation Database. http://pdcs.ctahr.hawaii.edu:591/hawnprop/

University of Hawai'i Botany Department: Native Hawaiian Plant Website. http://www.botany.hawaii.edu/faculty/carr/natives.htm

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Culliney, John L., and Bruce P. Koebele. 1999. *A Native Hawaiian Garden: How To Grow And Care For Island Plants*. Honolulu: University of Hawai'i Press.

Lilleeng-Rosenberger, Kerin E. 2005. *Growing Hawaii's Native Plants: A Simple Step-By-Step Approach for Every Species.* Honolulu: Mutual Publishing.

Section 5.2 Efficient Operation & Design Considerations for Landscapes

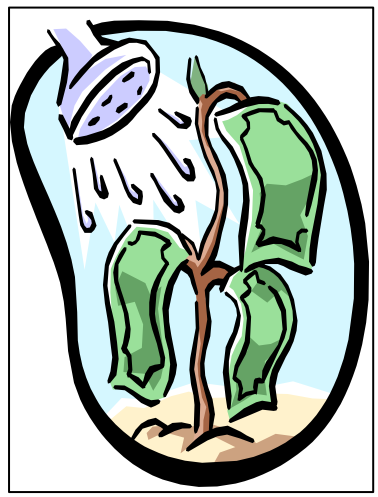
The two basic principles that should be followed when irrigating any type of landscaping are:

1. Use the most efficient methods possible to apply water.
2. Only apply water where and when it is required.

This section will cover a number of water efficient operation and design options for irrigating landscapes. Some of these options involve very simple procedures while others require equipment modifications or replacement. Where budgets allow, it is recommended that landscape architects be consulted so that maximum water efficiency can be incorporated into the management of landscaping at State buildings and facilities.

Section 5.2.1 Choose the Optimum Time to Water

Use these tips to maximize water savings:



- Schedule normal irrigation events to take place during the early morning or late evening hours. This technique will maximize absorption, minimize evaporation, and reduce watering demand by up to 30 percent.
- Avoid watering during windy conditions. High winds can move water away from the area(s) it is intended for as well as increase evaporation rates.
- Irrigate only when plant groups are showing signs of drought stress. This technique allows the plants to develop strong root systems.
- Do not irrigate when it is raining. Often times, automatic irrigation systems turn on regardless if it is raining or not. Consider installing rain sensors on the irrigation systems that will prevent unnecessary watering from occurring.

Section 5.2.2 Apply the Appropriate Amount of Water

Applying the appropriate amount of water will not only result in water savings, but will provide healthier conditions for landscaping. Listed below are tips to help determine how much water should be applied to landscaping.

- Use evapotranspiration (ET) data to determine a plant's water requirements. See **Figure 5-2** below for more information on ET.

Figure 5-2. What is Evapotranspiration?

Evapotranspiration (ET) refers to the combined process of evaporation from the soil and water transpiration through plant surfaces. ET is measured in inches of water per day (or week, month, year), and it changes with the weather (i.e., the hotter and drier the weather, the higher the ET). Many weather stations and municipalities now provide daily, weekly, and monthly ET figures. Use your local ET figures to help determine when and how much water must be added to your landscape.

Note that ET, for various types of landscape plants, is normally related to a reference ET (ET_R) for a cool season grass by a coefficient (K_L).

Thus, $ET = K_L \times ET_R$.

To determine the amount of irrigation water (IR) required, take the ET and subtract the amount of effective rainfall (Re). Then divide that amount by your irrigation system's efficiency :

$IR = ET - Re \div Ef$

Sprinkler systems should generally be designed to achieve 70% (i.e., .70) efficiency, and drip systems should achieve 85–90% efficiency.

Field tests conducted by Yaron M. Sternberg (1967. Analysis of Sprinkler Irrigation Losses. In "Journal of the Irrigation and Drainage Division," 93 [IR4], p. 111-124. American Society of Civil Engineers, New York, New York.) suggest that evaporation and drift losses may range from 17–22% of sprinkler discharge in the daytime and 11–16% at night.

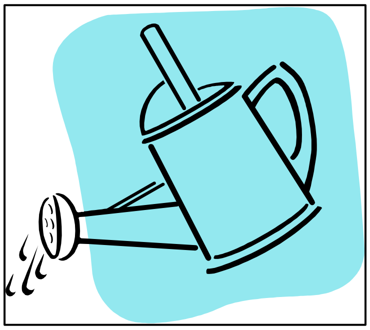
Source: New Mexico Office of the State Engineer. (1999), *A Water Conservation Guide for Commercial, Institutional and Industrial Users,* http://www.seo.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf, pg. 56.

- Water deeply once or twice per week instead of lightly every day. Watering deeply will allow plants to develop strong, deep root systems that will enable them to become drought tolerant because they will be able to draw moisture from a larger volume of soil.
- Never apply water faster than the soil can take in or more than the soil can hold. This technique will prevent runoff and deep percolation below the root zone. See **Table 5-1** for the maximum sprinkler run times for various soil types.
- Evaluate the particular water needs and conditions of specific sites by conducting a landscape irrigation audit (see **Section 5.2.6** below).
- Use moisture sensors to measure the amount of moisture at the plant's root zone. Over watering can be eliminated by using moisture sensors. Moisture sensors can be obtained from the water conservation companies listed previously in **Figure 4-1**.
- Stop using water to clean hardscapes such as sidewalks, driveways, parking lots, pool decks, etc. For every square foot of hardscape, a generally accepted fact is that 25 gallons of water per year will runoff.

Table 5-1. Maximum Sprinkler Run Time

Maximum Sprinkler Run Time (Minutes Per Application)		
Soil Type	Sprinkler Type	
	Spray	Rotor
Sand	15 to 20	45 to 60
Loam	10 to 15	30 to 45
Clay	7 to 10	20 to 30

Section 5.2.3 Where to Water



Minimize water waste by following these general guidelines on where to water:

- Water plants at their roots, not on their leaves or trunks.
- Ensure that automatic irrigation systems, such as drip and sprinklers, are adjusted to reach plant roots.
- Adjust sprinkler heads so that they do not overspray onto sidewalks and pavement.

Section 5.2.4 Irrigation System Maintenance

The importance of maintaining the components of an irrigation system cannot be overstated. Listed below are a number of suggested maintenance tasks that will improve the water efficiency of irrigation systems.

- When replacing broken or worn sprinkler heads, made sure that the same type of heads are installed.
- Make sure that sprinkler heads are aligned with the grade of the landscape.
- Regulate pressure to meet system demands.
- Routinely check for leaky valves.
- Routinely check sprinklers for clogged nozzles.
- Routinely check drip systems for plugged emitters.
- Adjust sprinkler spray patterns to avoid overspray onto sidewalks and pavement.
- Adjust the run times of sprinklers to match seasonal water requirements (e.g., less water should be used during the cool winter months).
- To avoid runoff, take soil samples to detect compaction or thatch build up.

Section 5.2.5 Landscape Design and Operational Modifications

The following landscape design and operational modifications can lead to additional water savings.

- Replace sections of high water use turf grass with low water use trees, shrubs, perennials, and ground covers.
- Consider installing a fertigation system. Fertigation, simply defined, is a practice that delivers water-soluble minerals through an irrigation system at the precise rate and time that they are needed. Landscaping health is optimized while less fertilizer (20% to 50% reduction) is being used. Additionally, because well-nourished plants better absorb water, less frequent watering is required. (18)
- Install separate valves for turf grass and for other types of plants (trees, shrubs, groundcovers, etc.) to ensure that each type of plant material receives only the amount of water it needs.

- Adjust mowers to cut turf grass at higher levels. Never cut more than 1/3 of the grass blade. Longer leaf surfaces promote deeper root growth and shade the root zone, which make the turf grass more water efficient.
- Avoid planting turf grass in areas less than 10 feet wide. Small turf areas are difficult to water efficiently using sprinklers. For small and uneven areas, use low water use plants and drip irrigation systems.
- Install an irrigation system timer to schedule both watering times and durations. The timer should have a manual override feature that will allow the maintenance staff to cancel irrigation events in the occurrence of rain.
- Retrofit sprinkler systems by replacing all old sprinkler heads with new water efficient models.
- Choose the right sprinkler for the job:
    - Fixed spray sprinklers produce a tight, constant fan of water that is suitable for small landscaped areas.
    - Pop-up sprinklers retract when not in use so that they will not be damaged by lawn mowers or pedestrian traffic.
    - Stream rotors utilize multiple rotating streams of water and are used for medium sized landscaped areas.
    - Impact rotors are used to irrigate large turf grass areas, such as golf courses and athletic fields.
- When using drip irrigation systems, install a pressure regulator and set the regulator to deliver no more than 20 pounds per square inch. This is the optimum pressure for drip systems. Pressure regulators ensure even distribution of water throughout the irrigation zone.

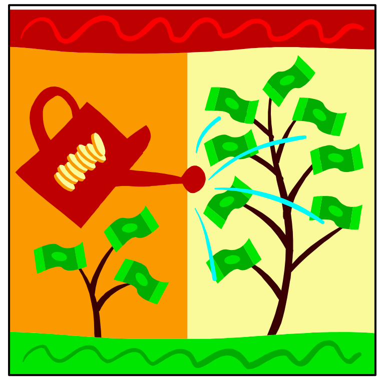
Stream Rotor

Pop-up Sprinkler

Fixed Spray Sprinkler

Impact Rotor

Section 5.2.6 Landscape Irrigation System Audit



Because landscape irrigation is a major water use category for many State buildings and facilities, exterior water use management should be an important component of each facility's overall water conservation program. Separate landscape irrigation system audits can be conducted to improve the water efficiency at many of these facilities. Landscape irrigation audits provide valuable information, such as:

- An assessment of current water use practices (i.e., how much water enters the irrigation system and where it is actually used).
- The identification of water waste and inefficiencies that can be immediately corrected (e.g., broken pipes, broken or malfunctioning sprinkler heads, over spray areas, etc.).
- Areas of the landscape that require redesign or retrofitting.
- Areas of the landscape where water use appears to be both efficient and effective.

Prior to beginning an irrigation audit, use the pre-audit checklist presented in **Figure 5-3** to gather valuable information that will streamline the audit process.

Figure 5-3. Landscape Irrigation System Pre-Audit Checklist
□ Consult with facility personnel who are familiar with the landscape irrigation system. □ Obtain the irrigation system plans and maintenance records as well as the landscape planting plans. □ Obtain the water use records (i.e., utility bills, meter readings) for landscape watering for the past 12 – 24 months. If there is no separate irrigation meter, estimate that 50% of the facility's water use is utilized for landscape irrigation. Consider installing a separate irrigation meter, as it will allow for better monitoring of the irrigation system in the future. □ Obtain a current watering schedule that is listed on a zone-by-zone basis.

Irrigation audits consist of three main activities:

- Site inspection,
- Performance testing, and
- Irrigation scheduling.

Each activity in itself can result in significant water and cost savings. Together, these activities provide landscape maintenance personnel with a customized irrigation program based on specific conditions and irrigation system performance. Additionally, a landscape audit report should be prepared after the audit is completed. (19)

<u>Site Inspection</u>: As time goes by, even the most efficiently designed irrigation system will develop problems. Minor operational and performance problems can continue for months and even years without regular maintenance; thereby, resulting in excessive water use, decreased efficiency, and poor landscape appearance. The following tasks should be included during the site inspection:

- Compare the irrigation system plans and blueprints to the actual water-using equipment in each irrigation zone. Update the plans as necessary to show the actual equipment.
- Turn on each irrigation zone individually. Identify and inspect all water delivery devices (e.g., sprinkler heads, bubbler, and drip emitters).
- Note the location of all faucets, shut off-on valves, flush valves, solenoids, booster pumps, timers, and other irrigation system components.
- Record the landscape area served by each irrigation system zone. Plant and soil types, terrain information, and other relevant data should be noted.
- Record the problem areas where water is being wasted. Also, record the areas where too little water is being applied.

<u>Performance Testing</u>: Testing the performance of an irrigation system and comparing it with the design criteria will determine if the system is performing satisfactorily. The following techniques can be used to test the performance of an irrigation system:

- Test the water pressure at several key points in each irrigation zone. Too much pressure will result in over watering, while too little pressure will result in dead or stressed plants.
- Conduct a "catch can" test on sprinkler heads to ensure that they are delivering consistent volumes of water over the entire area. A catch can test is the most accurate determination of precipitation rate for scheduling irrigation events. Catch can tests measure the amount of water that actually hits the ground at various points within the landscape, and also serves to measure application uniformity. Since irrigation systems commonly use different types and brands of sprinklers, it is important to conduct catch can tests for each individual zone or "station" of an irrigation system. Conduct catch can tests as follows:
    - Turn on the irrigation system, one zone at a time, to locate and mark sprinkler heads.
    - Starting with zone 1, layout catch devices only on the part of the landscape covered by zone 1. Catch devices should be placed in a grid-like pattern throughout the zone to achieve an accurate representation of sprinkler performance. *NOTE: Try not to place catch devices too close to sprinkler heads to avoid altering spray patterns.*
    - Turn on zone 1, allowing water to fill the catch devices. Keep track of the number of minutes that the zone is allowed to operate.
    - After a measurable amount of water has fallen, measure the depth of water (in inches) contained in each catch can using a ruler. *It is recommended that the ruler measure in "tenths" of inches.* Record these values on a data sheet. Also record how long (in minutes) the zone was operated.
    - Repeat these steps for each remaining zone of the irrigation system. The precipitation rate can then be calculated as shown in **Figure 5-4**.
- Operate each irrigation zone for its currently prescribed watering period. Select random areas to spot-check the irrigation depth to determine if the plants are receiving the proper water for their root zones. Typical water depths (also referred to

herein as targeted irrigation depths), or the desirable wetted depths of the soil, are as follows:

- 8-10 inches for turf grass and lawns,
- 2 feet for groundcovers, and
- 6-8 feet for trees (once a month). (20)

Figure 5-4. Irrigation System Precipitation Rate Calculation
Precipitation Rate = (Average Catch Can Depth ÷ Test Run Time) x 60 <u>Units</u> Precipitation Rate = inches per hour Average Catch Can Depth = inches Test Run Time = minutes

Appendix E contains an Irrigation Audit Datasheet, which may be helpful to use while conducting the performance testing activities as part of the landscape irrigation system audits at State buildings and facilities.

<u>Irrigation Scheduling</u>: As explained in Chapter 1 of this manual, Hawaii is facing a critical shortage of fresh water in some areas of the State. Because landscapes may potentially use large volumes of water, we must use good judgment when scheduling irrigation events.

Typically, when and how long landscapes are irrigated has been based on assumptions and generalizations with regards to sprinkler system performance and plant water requirements. A landscape irrigation audit can replace these assumptions and generalizations by allowing the customization of irrigation schedules based upon "catch can" results, site-specific soil conditions, and plant water requirements. Instead of randomly selecting an irrigation schedule, run times for individual irrigation zones can be adjusted based on the respective measured precipitation rates determined during the performance testing activities described above. Additionally, the depth of the plant's root zone and the soil type should be used to determine when to irrigate. These two parameters reveal the volume of water that is available for plant use. For example, a six-inch column of clay soil will hold more water than will a six-inch column of sandy soil. Therefore, the clay soil will require a fewer number of irrigations per week than the sand soil although the volume of water the plant needs will remain the same. Root depth also influences irrigation frequency. Deeper-rooted plants will require fewer irrigation events than will shallow rooted plants.

To determine how long to irrigate, the volume of water that should be applied during each irrigation event must be calculated. Be aware that plant water requirements can vary significantly in urban landscapes due to the variety of plant species, maintenance practices, microclimates, seasonal climatic changes, and rainfall patterns. After determining how much water (in inches) is required, a simple calculation can be used to figure out the respective zone run times. The equation in **Figure 5-5** can be used to determine zone run times. *NOTE: In order to determine the "targeted irrigation depth" component of the equation, use the target irrigation depths for the various types of plants listed immediately prior to* ***Figure 5-4*** *above. Also, the "zone precipitation rate" component of the equation is calculated using the technique explained and presented under the* <u>Performance Testing</u> *section above.*

Figure 5-5. Irrigation System Zone Run Time Calculation

Zone Run Time per Irrigation = (Targeted Irrigation Depth ÷ Zone Precipitation Rate) x 60

Units
Zone Run Time per Irrigation = minutes
Targeted Irrigation Depth = inches
Zone Precipitation Rate = inches per hour

NOTES: To determine the "targeted irrigation depth" component of the equation, use the target irrigation depths for the various types of plants listed immediately prior to Figure 5-4 above.
The "zone precipitation rate" component of the equation is calculated using the technique explained and presented under the Performance Testing section above.

Landscape Audit Report: A complete audit report should be prepared after the existing irrigation system and landscape have been evaluated and documented. The following information should be included in the report:

- A list of repairs that can be completed, which will result in immediate water savings.
- An updated drawing of all the components of the irrigation system and corresponding plant materials.
- Short-term retrofit options that will improve the water efficiency of the irrigation system (e.g., replace older sprinkler heads with newer, more efficient models).
- Long-term recommendations for landscape water conservation (e.g., implementing periodic precipitation rate tests as described above, reducing turf grass area, xeriscaping, etc.).
- The physical location of sub-meters should be highlighted on the landscaping site plan. Landscape personnel should be aware of the locations of sub-meters so that they may use these sub-meters to determine exactly how much water is being used when irrigating the landscaping.

Do not hesitate to request outside help! The Irrigation Association (http://www.irrigation.org) has prepared a manual entitled "Certified Landscape Irrigation Auditor" dated 2004 that may be consulted for more information about conducting such audits. Landscape architects and/or irrigation supply companies may also be contacted for additional ideas about landscape water efficiency.

Section 5.2.7 Irrigation with Recycled Water and Other Non-Potable Water Sources

This section will primarily discuss the use of recycled water (sometimes referred to recycled wastewater) for purposes of landscape irrigation, which has been an accepted practice in Hawaii and the U.S. mainland for many years. The uses of other non-potable water sources for irrigation, including graywater, stormwater, and captured rainwater, will also be briefly discussed.

Section 5.2.7.1 Recycled Water

Remember that the environment through a process known as the water cycle recycles all of our water naturally. Similarly, humans have established methods to recycle water that has been previously utilized by and for mankind. This practice of utilizing already-used water again is commonly referred to as *water reuse*, and this type of water is commonly referred to as *recycled water*. This section will discuss the use of recycled water for irrigation purposes.

Water reuse has been successfully practiced in Hawaii for decades, and each of the populated islands of the Hawaiian chain has ongoing water reuse activity. In fact, a *2004 Hawai'i Water Reuse Survey and Report* was prepared for the CWRM to inventory all water reuse in Hawaii on a statewide basis. Most of the water reuse takes place at golf courses, but there are an increasing number of commercial properties (e.g., parks, schools, condominiums, etc.) that currently are or will be in the near future using recycled water for irrigation purposes. (21)

Turf Irrigation with R-1 Recycled Water

In its *Guidelines for the Treatment and Use of Recycled Water*, dated May 15, 2002, the DOH has established three classes of recycled water: R-1, R-2, and R-3 (22). R-1 is of the highest quality. It is tertiary treated water that has undergone traditional secondary treatment and then been filtered and disinfected. It can be used via spray irrigation with minimal restrictions. R-1 water is virtually pathogen free and can be used to irrigate crops that are eaten raw, such as lettuce. Many of the vegetables imported to Hawaii from the U.S. mainland are grown with R-1 quality recycled water. R-2 water is secondary treated wastewater that has been disinfected. It has some limitations when used via spray irrigation. R-2 water, historically used at golf courses, can only be spray irrigated during evening hours and there must be a 500-foot buffer zone between its use and adjacent properties. R-3 water is un-disinfected secondary treated water and its use is severely limited. Only R-1 water should be considered for the purpose of landscape irrigation at State buildings and facilities.

Currently, there are only two R-1 water distribution systems that have the capability of delivering recycled water to areas where State buildings or facilities are located. These areas are south Maui and southwest Oahu. In south Maui, the County of Maui's WWRD has developed a distribution system that serves numerous commercial and public properties with R-1 recycled water from the Kihei Wastewater Reclamation Facility. One such facility is the Kihei Public Library where R-1 water has been used for landscape irrigation since 1996 (see **Appendix B** for the case study about this program). The Kihei Elementary School and the Lokelani Intermediate School have also utilized R-1 from this system for landscape irrigation since 1999. In southwest Oahu, the HBWS provides R-1 recycled water to a number of golf courses from its Honouliuli Water Recycling Facility. R-1 water is also provided to the Ewa Elementary School for landscape irrigation. The HBWS is expanding its distribution to system to make R-1 water available to other commercial properties in the future—some of which will be State buildings and facilities.

Irrigation systems that utilize recycled water as well as other types of non-potable water are required to be identified as such. Pipes, sprinkler heads, and other components of the delivery system are typically colored purple and labeled with terminology to inform people that the water is not suitable for drinking. Facilities that convert their existing irrigation systems from the use of potable water to recycled water are not required to replace the underground irrigation piping; however, all connections to the potable water supply must be severed. A cross connection test by the recycled water purveyor must be performed and verified by the DOH. Signs must also be posted throughout the buildings/facilities that inform people that recycled water is being used for irrigation and is not suitable for drinking.

Typical Recycled Water Notification Sign

The main challenges associated with recycled water use are 1) overcoming the perspective that recycled water is unsafe and 2) potentially higher TDS (primarily salts) content. Regarding the first challenge, recycled water has a long history of success in Hawaii and in the U.S. mainland. As mentioned above, R-1 water is of very high quality and actually meets many drinking water standards. R-1 water quality must meet strict DOH standards and the recycled water purveyor cannot distribute it unless it meets those standards. Best management practices such as irrigation during evening hours and avoiding over spray conditions further ensure safety when using recycled water for irrigation purposes. The County of Maui's WWRD and the HBWS have both developed informative public education programs to gain public acceptance of their water reuse programs. It is recommended that managers and employees of State buildings and facilities that are or will be using recycled water for landscape irrigation take advantage of these programs. In regards to the second challenge, recycled water does have a higher salt content than potable water. These salts may build up in the soil and eventually cause problems with some landscape plants. To prevent salt build up from occurring, landscape managers may 1) occasionally over irrigate to flush accumulated salts down past the root zone and 2) add gypsum, which conditions the soil and prevents the salts from damaging the plants.

Section 5.2.7.2 Graywater

Graywater is regulated by the DOH through Chapter 62 of Title 11 of the Hawaii Administrative Rules, entitled "Wastewater Systems". Graywater is defined as wastewater from a dwelling or other establishment produced by bathing, washdown, and minor laundry and minor culinary operations, and specifically excludes toilet waste. The design flow of non-residential graywater systems is determined on a case-by-case basis by the DOH. In general, graywater will require treatment to remove sediment, lint, and other debris that could clog the components of irrigation systems. The treatment may include sedimentation tanks, filters, and possibly disinfection. Graywater is not just soapy water; *E. coli* is frequently present in graywater and can cause illness to humans if they are allowed to come into contact with it (23). Thus, the DOH recommends that graywater be applied via subsurface irrigation systems. In these cases, the DOH may waive the disinfection requirement.

Section 5.2.7.3 Stormwater

Stormwater harvesting and reuse is a practice that has gained considerable attention in recent years. Stormwater is now recognized as a valuable resource rather than a nuisance to be disposed of quickly, especially in large urban centers. Harvesting and reusing stormwater offer both a potential alternative water supply for non-drinking uses and a means to further reduce pollution in our waterways. (24)

Stormwater harvesting and reuse can be defined as the collection, treatment, storage, and use of stormwater run-off from urban areas. It differs from rainwater harvesting (discussed in **Section 5.2.7.4** below) in that the runoff is collected from drains or streams, rather than roofs. The characteristics of stormwater harvesting and reuse schemes vary considerably between projects, but most schemes would have the following elements in common:

- Collection: Stormwater is collected from a drain, stream, or pond.
- Storage: Stormwater is temporarily held in dams or tanks to balance the supply and demand. Storage can be on-line (i.e., constructed on the creek or drain) or off-line (i.e., constructed some distance from the stream or drain).
- Treatment: Captured stormwater is treated to reduce pathogen and pollution levels or to meet any additional requirements of end users; hence, the risks to public health and the environment are reduced.
- Distribution: The treated stormwater is distributed to the area of use.

Until comprehensive stormwater harvesting and reuse systems are constructed in Hawaii, it is probably not practical for State buildings and facilities to plan on utilizing stormwater for irrigation in the near future. However, the Water Conservation Managers of State buildings and facilities should be aware of the potential for stormwater harvesting and reuse in Hawaii in the not to distant future.

Section 5.2.7.4 Rainwater Catchment

Rainwater catchment offers a relatively easy way to supplement the landscape irrigation requirements at State buildings and facilities. Harvesting rainwater, in one form or another, has been in practice for thousands of years. Rainwater catchment is the term used to describe any system that acts as a kind of sky net to capture and impound rainfall. Catchment systems are essentially storage tanks that capture rainwater after if falls on a surface, such as a roof. The water is typically funneled to a tank called a cistern.

Rainwater harvesting is, in most places, a less expensive form of water supply. This is mainly because the system is so simple. Costs associated with installing the system include mostly capital expenditures, such as gutter systems, piping systems, pumps, and storage tanks.

Rainwater is fairly clean except for some dissolved gases it may pick up while traveling through the atmosphere. Rainwater may be collected from any type of roof except those with lead-based paint. Courtyards and ground areas may also be used to collect rainwater.

Storage of collected rainwater is important due to the sporadic nature of rain. Storage facilities may either be below ground or above ground, but should be completely covered in order to prevent debris from blowing into the tank, algae from growing, and evaporation. (25)

Section 5.2.8 Training Landscape Maintenance Personnel

Typical Hawaiian Resort "Thirsty" Landscaping

The proper operation and maintenance of a facility's landscape irrigation system is essential for it to be water efficient. Landscape maintenance personnel must be trained in the various operational and maintenance procedures, but also must be convinced that water conservation is important and can be used as a tool to increase their effectiveness as State employees.

Before implementing any water conservation measures, take the time to educate the landscape maintenance personnel about the State's water conservation directive. The employees must be made aware of the merits of the program and that their participation in the program is essential for it to succeed. Landscape irrigation water conservation measures that may be implemented should be explained to the employees. These measures could include the landscape irrigation audit, the creation of xeriscape gardens, upgrading irrigation systems with more water efficient equipment, or revised maintenance schedules.

The training program should include the following key elements:

- Irrigation Scheduling: Include an overview of the water requirements of different plant species, signs of plant stress due to over watering and under watering, use of soil probes and soil cores to check soil moisture, best time of day to irrigate, and ET rates.
- Irrigation System Operation: Include a basic overview of the irrigation system and its components, water application techniques of the components, use of automatic controllers to turn water on and off, manual override of controllers and the landscape's watering zones.
- Irrigation System Maintenance: Address how to spot problems with irrigation equipment and make the necessary repairs or replacements. Include a basic checklist for a regular walk-through inspection.
- Landscape Maintenance: Deal with the practices that reduce the need for irrigation water. These practices include:
    - Proper height for turf mowing.

  - Proper frequency of turf aeration and dethatching to increase water retention.
  - Proper fertilization schedules to maintain plant health and drought tolerance.
  - Soil preparation and mulching practices to increase water retention.
- Additional Training and Certification: Ideally, the facility's landscape maintenance manager should be trained in exterior water use management and be a certified Landscape Irrigation Auditor. The Irrigation Association certifies landscape Irrigation Auditors. For more information about the organization and its certification classes, contact The Irrigation Association at 6540 Arlington Boulevard, Falls Church, VA 22042-6638, phone: 1-703-536-7080; website: http://www.irrigation.org. (26)

CHAPTER 6 Water Conservation Guidelines for Cooling and Heating

Cooling and heating processes represent another area where tremendous water conservation opportunities exist. Equipment such as cooling towers, chillers, small evaporative coolers, boilers, and steam generators not only consume a lot of water, but the water that is consumed is often utilized inefficiently. Optimizing the operations of cooling and heating equipment at State buildings and facilities should be given a high priority in the State's overall water conservation program. The efficient operation of cooling and heating systems will save water as well as reduce energy and chemical costs.

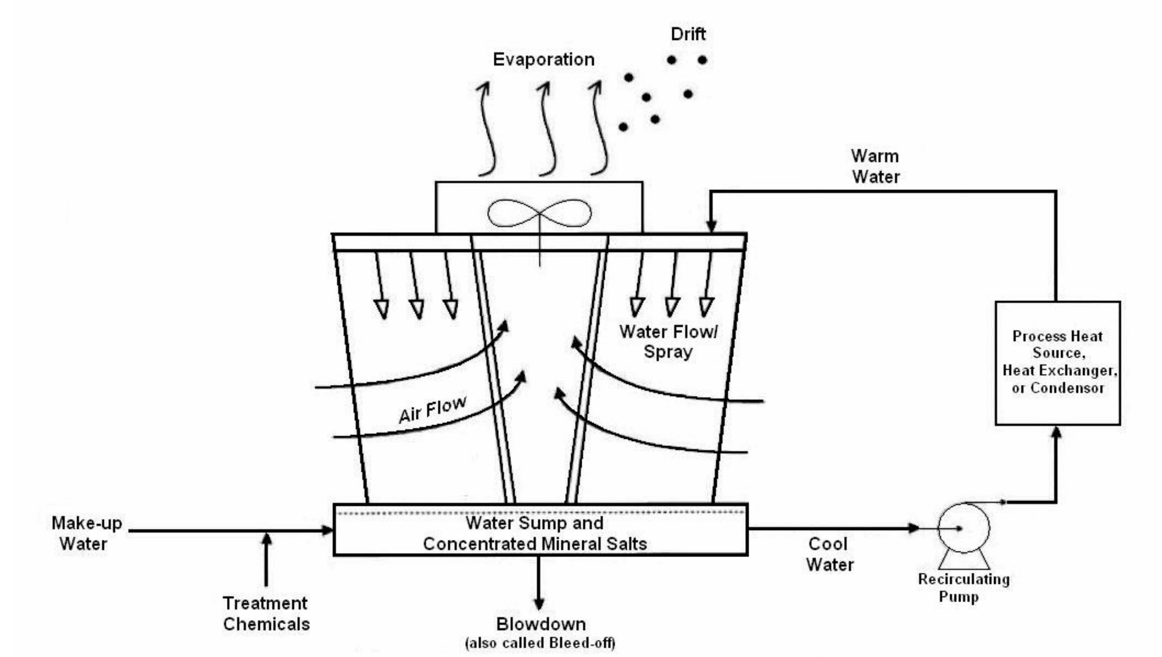
While this chapter primarily discusses water conservation opportunities for conventional cooling systems, a new technology has recently begun to be implemented in Hawaii. This new technology utilizes cold sea water from the deep ocean as a coolant for air conditioning systems. This technology shows great promise and is now being used at the University of Hawaii's John A. Burns School of Medicine facility on Oahu and the Natural Energy Laboratory of Hawaii on Hawaii's Big Island. Please refer to the case study in **Appendix B** for more information about this innovative new cooling process.

Section 6.1 Cooling Towers

Cooling Tower

Cooling towers typically represent the largest user of water at hospitals and office buildings. Large volumes of water are utilized by cooling towers because they are designed to remove heat through evaporation. A cooling tower cools a continuous circulating stream of warm water from a heat source (such as an air conditioner) by exposing the warm water droplets to air flow. In most cooling towers, the warm water is pumped to the top of the tower where it is either sprayed or dripped through internal fill materials called wet decking. The wet decking creates a large surface area so that a uniform thin layer of water is established throughout the tower. Air is blown over the wet decking and results in evaporation, which enables heat to be dissipated. The remaining cooled water then flows to an air conditioning unit or other equipment and heat exchange occurs. The equipment is cooled and the circulating water is heated. The warmed water is then returned to the cooling tower and the cycle renews itself. **Figure 6-1** below provides a schematic illustration of this cooling tower process.

Figure 6-1. Schematic of a Typical Cooling Tower



Although cooling towers continuously reuse water, they regularly lose water through these three processes: 1) evaporation, 2) blowdown, and 3) drift losses. Therefore, water must be added to the cooling system to replace the water lost through evaporation, blowdown, and drift losses—this is called make-up water. Descriptions of these processes and their relationship to the water balance are provided below.

Evaporation: Cooling towers take advantage of the transfer of sensible heat when water evaporates. The word "sensible" indicates that a temperature change can be sensed; thus, a heat transfer has taken place. When some of the circulating stream of water evaporates, the remaining water is cooled. In cooling towers, this loss of heat by evaporation is approximately 1,000 British Thermal Units (BTU) per pound of water. The rate of evaporation from a cooling tower is about 1% of the rate of recirculation of water flow for every 10 degrees Fahrenheit in temperature drop that the cooling tower achieves. The decrease in water temperature will vary with the ambient dew point temperature. The lower the dew point, the greater the temperature difference between the water flowing in and out of the cooling tower. Another approach for estimating the rate at which water is lost through evaporation from a cooling tower—known as the evaporation rate—is using the following equation:

Evaporation Rate = 3 gpm per 100 "tons" of cooling load placed in the tower.

The term "ton", when used to describe cooling tower capacity, is equal to 12,000 BTU per hour of heat removed by the tower. When the dew point temperature is low, the tower air induction fans can be slowed by using a motor speed control or merely cycled on and off. Thus, saving both energy and water evaporation losses. (27)

Blowdown: Blowdown, also referred to as bleed-off, is a procedure utilized to remove excess suspended and dissolved solids in the water that is circulated through a cooling tower. Suspended and dissolved solids accumulate in a cooling tower because the water that evaporates is very pure; the concentration of suspended and dissolved solids in the cooling tower's remaining water increase over time as a result of evaporation. Consequently, the suspended and dissolved solids must be removed or reduced to prevent scaling, corrosion, and other problems that will damage the cooling system. Periodic blowdown is the discharge of a portion of the circulating water to remove these solids from the system. Valves that are actuated by timers or conductivity meters can control blowdown manually or automatically.

Drift Losses: Drift losses occur when mist is carried out of the tower by air drafts. A typical range for drift rate is 0.05% to 0.2% of the total circulation rate. Baffles or drift eliminators can be installed to save water, reduce the loss of water treatment chemicals, and to improve operating efficiency of the cooling tower. Since the mist consists of water droplets that contain dissolved solids, drift is considered a small part of blowdown/bleed-off.

Make-Up Water: Water that is lost from a cooling tower through evaporation, blowdown, and drift losses is replenished with make-up water. The amount of make-up water added directly affects the quality of water in the cooling system. The concentration ratio is the relationship between the blowdown water quality and the make-up water quality. This ratio is shown in **Figure 6-2**.

Figure 6-2. Cooling Tower Concentration Ratio Calculation

$$\text{Concentration Ratio} = \frac{\text{concentration of TDS of blowdown}}{\text{concentration of TDS of make-up water}}$$

OR

$$\frac{\mu\text{mhos of blowdown}}{\mu\text{mhos of make-up water}}$$

OR

$$\frac{\text{volume of make-up water}}{\text{volume of blowdown}}$$

Acronyms
TDS = total dissolved solids
µmhos = specific conductance

Water Balance: Based on the relationships between the evaporation, blowdown, drift losses, and make-up water processes described and presented above, the water balance on a cooling tower can be expressed as shown in **Figure 6-3**.

Figure 6-3. Cooling Tower Water Balance Equation

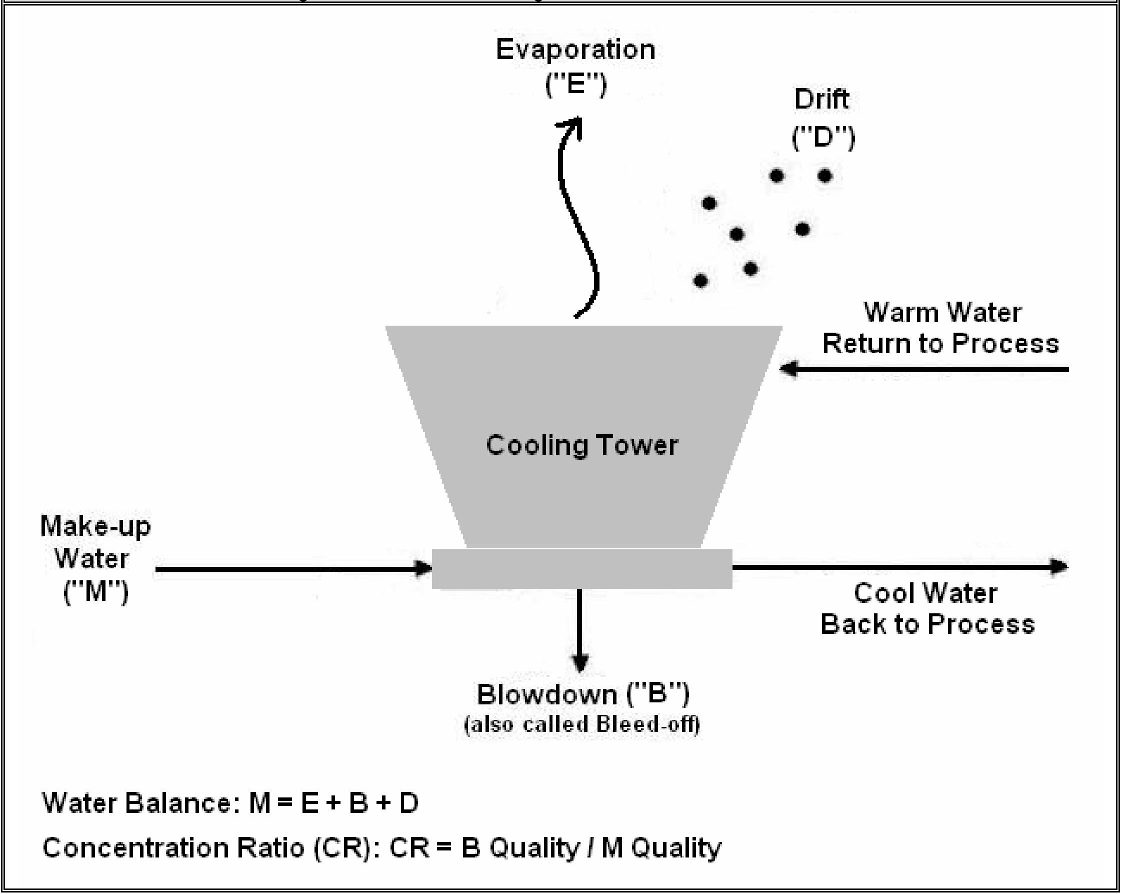
Make-up Water = Evaporation + Blowdown + Drift

OR

$$M = E + B + D$$

Accordingly, a simple water balance on a cooling tower system can be determined if any three of the four parameters are known. **Figure 6-4** depicts a typical water balance for a cooling tower.

Figure 6-4. Cooling Tower Water Balance



Section 6.1.1 Efficient Operation Considerations for Cooling Towers

Conserving water in a cooling tower is predominantly a function of water quality. With respect to cooling tower operations, water savings can be accomplished by maintaining a high quality of water in the system. Sustaining high quality water will, thereby, reduce the volume of water that must be removed from the system through blowdown. In summary, as evidenced by the discussions presented in the previous section, water consumption of cooling towers can be reduced significantly by minimizing blowdown. Below are a number of measures that can help reduce blowdown.

- <u>Eliminate the "batch method" of controlling blowdown</u>. Typically, batch method blowdown is automatically activated by measured conductivity readings. This method may result in wide fluctuations of conductivity, which actually wastes water. Instead, attempt to operate the blowdown on a more continuous basis by reducing the range of the conductivity levels on the actuating meters or by setting the blowdown timer (if present) to a shorter duration.

- Install flow and conductivity meters on the make-up and blowdown water lines. Flow and conductivity meters allow the operator of the cooling system to closely monitor how much water is being used and to make sure that the system is operating within desired conductivity ranges. The flow meters should have total water use as well as gpm readouts.
- Maintain a daily logbook. Read all meters on a regular basis and keep records of make-up and blowdown consumption as well as TDS concentration, evaporation, cooling load, and concentration ratio.
- Shut off the cooling tower when it is not being used. Installing an automatic control that shuts the system off at night or on weekends will save water and energy.
- Use sulfuric acid to adjust pH. Sulfuric acid can be added to cooling tower water in order to control scale build up. When properly applied, sulfuric acid will lower the pH and convert the calcium bicarbonate scale to calcium sulfate, which is more soluble. Water consumption can be reduced by 25%. Workers must be trained in the proper application and safe handling of sulfuric acid to avoid contact with skin and eyes. Always add sulfuric acid to points of the system that are well mixed and avoid overdosing, which will damage the cooling system. Be aware that a corrosion inhibitor may need to be added due to the lower pH.
- Set up performance-based specifications for chemical vendors. Request proposals from vendors that are based on performance specifications. Require the vendors to commit to a predetermined minimum level of water efficiency. Have them provide projected annual water and chemical consumption costs.
- Request assistance from the chemical vendor. Make sure the chemical vendor understands that water conservation is a priority at all State buildings and facilities. Ask the vendor to discuss alternatives that will result in a reduction of the amount of water bled off from cooling towers. Work with the vendor to increase the cooling tower's cycles of concentration, thereby, decreasing the amount of water bleed-off. Ask the chemical vendor to explain the purpose of each chemical that is purchased. The vendor should provide a written report for each service call. Be sure that the vendor explains the meaning of each analysis performed and the test results.
- Install side-stream filtration. Directing cooling tower water though an additional filter will improve water quality, especially in locations where airborne contaminants such as dust are present. Filters also help in systems that are supplied with cloudy water or that have narrow passages that are prone to clogging. The filters, which can be the rapid sand filter type or high efficiency cartridges, improve cooling tower efficiency and reduce maintenance requirements.
- Use ozone to treat cooling tower water. Ozone acts as a biocide by killing viruses and bacteria, and it is also reported to control scale by forming mineral oxides that will precipitate out to the water in the form of sludge. The sludge will collect on the cooling tower basin or in a separate tank. Ozone can improve water quality without the need for additional chemicals. Ozone must be generated on-site because its effective life is only one hour. An ozone treatment system consists of an air compressor, an ozone generator, a diffuser or contactor, and a control system. Ozone is also quite corrosive, so be sure that the cooling tower components are compatible with ozone.

- Investigate the use of magnets and electrostatic field generators to treat cooling tower water. Some vendors sell water treating magnets and electrostatic field generators that alter the surface charge of suspended particles in cooling tower water. The particles disrupt and break loose deposits on surfaces in the cooling tower. Suppliers of these systems claim they remove scale without the use of conventional water treatment chemicals. *Investigate these systems thoroughly before purchasing them!*

Even after doing everything possible to conserve water by improving water quality in a cooling tower, water savings can still be realized through water reuse. Some buildings and facilities may have an opportunity to 1) reuse water from another process for cooling tower water and/or 2) find uses for blowdown water. Measures that include the reuse of water as related to cooling towers are listed below.

- Use alternative sources of make-up water. Where possible, consider reusing water from other processes within a building or facility, such as reverse osmosis reject water, used water from a once-through cooling process, or other clean wastewater streams. High quality tertiary treated municipal wastewater (i.e., R-1 recycled water) may also be used provided that the tower is operated at somewhat conservative concentration ratios. When using R-1 recycled water, phosphate scale may be problematic if water softening pretreatment is not performed.
- Reuse blowdown water. Blowdown water, while high in TDS, may be able to be used for other lower-grade non-potable uses such as washing floors or sidewalks. In order to reuse blowdown water for higher grade uses, such as landscape irrigation, washing vehicles, or flushing toilets, it must be treated to remove dissolved solids. Improved treatment technologies, such as membrane filtration, are now cost effectively making the reuse of cooling tower blowdown water economically attractive. (28)

Table 6-1 lists the advantages and disadvantages of some of the water conservation options listed above (29).

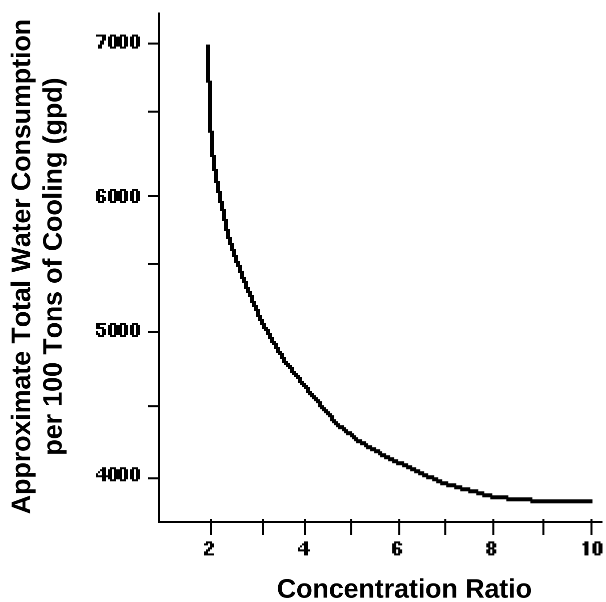
Table 6-1. Advantages & Disadvantages of Cooling Tower Conservation Options

Option	Advantages	Disadvantages
Operational Improvements	Low capital cost Low operation cost Low maintenance requirements	Limited cycles of concentration
Sulfuric Acid Treatment	Low capital cost Low operation cost High cycles of concentration possible	Possible safety hazard Possible damage to system if overdosed
Side-stream Filtration	Reduced possibility of fouling Higher operating efficiency Reduced maintenance Reduced blowdown	Moderately high initial capital cost Limited effectiveness for solids removal Additional energy costs for pumping
Ozone System	High cycles of concentration possible Eliminates or reduces chemical treatment	High capital investment Complex system Additional energy costs Possible safety hazard
Magnet System	Reduced scale Eliminates or reduces chemical treatment	Newer technology Controversial performance claims
Reuse of Water within Facility	Reduces overall facility water consumption	Possible requirements for pretreatment (additional energy & chemical costs) Increased potential for fouling in poor quality water used

Section 6.1.2 Determining Water Consumption Conservation for Cooling Towers

Increasing the concentration ratio of a State building/facility's cooling tower will result in less water consumed by the cooling tower and will enhance the State's overall water conservation program. This is plainly demonstrated by the graph in **Figure 6-5** below, which shows the relationship between the concentration ratio and the amount of water consumed by a cooling tower (30). This pertains directly to **Section 6.1.1** above in that increasing a cooling tower's concentration ratio (i.e., increasing the cycles of concentration) will thereby decrease the amount of blowdown.

Figure 6-5. Cooling Tower Concentration Ratio vs. Water Consumption



In order to determine the percentage of cooling tower water consumption that can be conserved by increasing a cooling tower's concentration ratio (i.e., increasing the cycles of concentration), a simple calculation can be used. **Figure 6-6** presents this calculation. Applying this calculation, **Table 6-2** below was created with the intention of allowing users to easily estimate the percentage of potential water savings.

Figure 6-6. Cooling Tower Water Consumption Conservation Calculation

$$\text{Percent of Water Consumption Conserved} = \frac{CR_f - CR_i}{CR_i\,(CR_f - 1)} \times 100\%$$

Units

CR_i = initial concentration ratio before increasing cycles

CR_f = new concentration ratios after increasing cycles

Table 6-2. Cooling Tower Water Consumption Conservation– How Much Water Can be Saved?

Initial Concentration Ratio (CR_i)	New Concentration Ratio (CR_f)										
	2	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1.5	33%	44%	50%	53%	56%	58%	60%	61%	62%	63%	64%
2	-	17%	25%	30%	33%	38%	40%	42%	43%	44%	45%
2.5	-	-	10%	16%	20%	25%	28%	30%	31%	33%	34%
3	-	-	-	7%	11%	17%	20%	22%	24%	25%	26%
3.5	-	-	-	-	5%	11%	14%	17%	18%	20%	21%
4	-	-	-	-	-	6%	10%	13%	14%	16%	17%
5	-	-	-	-	-	-	4%	7%	9%	10%	11%
6	-	-	-	-	-	-	-	3%	5%	6%	7%

Section 6.2 Single-Pass Cooling Systems

Single-pass (also referred to as once-through) cooling systems are inefficient because water is passed through a piece of equipment for cooling purposes, and then it is disposed of down the drain. In many instances, perfectly clean water is only used once and then discharged to the sewer system. Equipment that typically utilizes single-pass cooling includes: CAT scanners, degreasers, rectifiers, hydraulic presses, x-ray processors, condensers, air conditioners, air compressors, welding machines, ice machines, vacuum pumps, and viscosity baths. Some areas of the U.S. now prohibit single-pass cooling.

Cost-effective options to eliminate or make better use of the water used during single-pass cooling include the following:

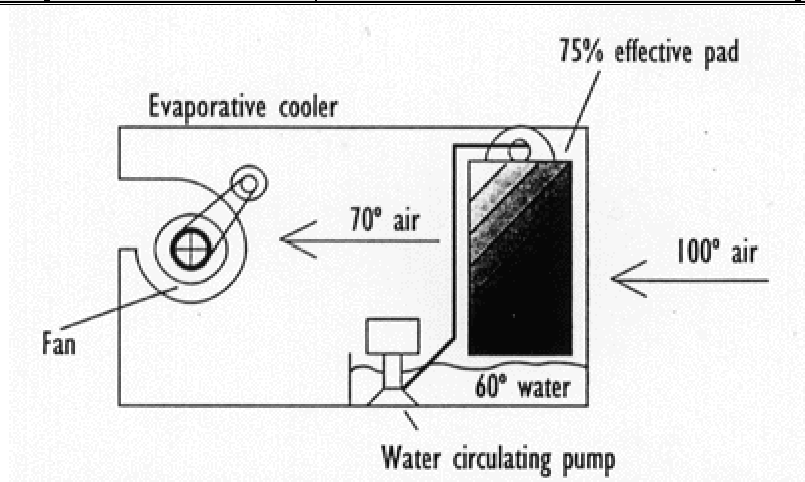
- Connect the equipment to an existing recirculating cooling system such as a cooling tower or chiller if excess capacity exists. Even the installation of a new recirculating cooling system is an economical alternative.
- Consider replacing water-cooled equipment with air-cooled equipment. For example, when it is time to replace the building's ice machine, replace an old water-cooled model with an air-cooled model.
- Reuse the single-pass cooling water for some other water requirement such as cooling tower make-up water, rinsing, washing, or landscaping.

Section 6.3 Small Evaporative Cooling Systems

Evaporative coolers tend to work best in arid climates. Although this type of cooling system is not commonly found in Hawaii, there may be current or proposed use of these systems at some State buildings/facilities.

Evaporative coolers (often referred to as swamp coolers) are often used instead of air conditioners because they are relatively quiet, simple appliances that use less than a quarter as much electricity as an air conditioner. They also do not require ozone-depleting refrigerants. Evaporative coolers consist of a large fan and water-wetted pads. Fresh outside air is cooled by about 20 degrees as it is drawn through the wet pads and blown into the building. The cooler slightly increases the humidity of the entering air. **Figure 6-7** shows a basic schematic drawing of a small evaporative cooler.

Figure 6-7. Small Evaporative Cooler Schematic Drawing



Evaporative coolers work on the same principle as cooling towers. Air is cooled and humidified as it passes through the wet porous pads that are kept moist by water dripped on their upper edges. Unevaporated water trickles down through the pads and collects in a pan or sump for discharge or recirculation. Cooling relies on evaporation; thus, evaporative coolers work best in dry climates.

Scale and mineral deposits are left behind on the pads as the water evaporates. These deposits will reduce the air volume flowing through the pads and, thereby, reduce the efficiency of the cooler. In areas where the water is hard and/or the air is dusty, the pads can become clogged very quickly.

As with cooling towers, blowdown water improves the quality of the evaporative cooler's water. The mineral concentration of the water is diluted, and scale and dirt build-up on the pads is reduced. Two types of blowdown are typically utilized: the single-pass type and the recirculating type. The single-pass type is simpler and less expensive than the recirculating type, but it consumes more water and requires constant drainage.

Suggestions to reduce water consumption by small evaporative coolers include:

- Avoid using single-pass coolers. The recirculating type saves water and increases thermal efficiency. If singe-pass coolers are used, reuse the spent water for irrigation, toilet flushing, or other non-potable uses.
- Initiate a regular pad inspection program. Replace worn or torn pads as necessary.
- Reduce the volume of blowdown water. Blowdown volume should be less than a few gallons per hour for each 1,000 cubic feet per minute of airflow. Lower blowdown rates not only save water but increase thermal efficiency.
- Inspect the recirculating pump and reservoir level controls on a regular basis when the system is running.

Section 6.4 Boiler and Steam Systems

Boiler and steam generators are typically used in large heating systems, institutional kitchens, or in facilities where large amounts of process steam are used. The volume of water consumed by this equipment varies depending on the size of the system, the amount of steam used, and the amount of condensate return.

Fire Tube Boiler

There are many different designs for boiler/steam generators. The most common is the fire tube boiler, also referred to as the shell and tube design, in which a gas or oil fired heater directs heat to the tubes and water in the shell to generate steam. The boiler water must be treated with chemicals to prevent corrosion and scale formation in the steam distribution system. Commonly, after the steam is used (e.g., for heating, cooking, etc.), the condensate is returned to the boiler. This practice helps reduce the need for boiler make-up feed water. Water is typically added to a boiler system to make up for the water lost as steam and to periodically blowdown the boiler to remove scale deposits. If a condensate return system is not in place, all of the water utilized to generate steam is lost and make-up water must be added.

The U.S. Department of Energy (DOE), as part of its Federal Energy Management Program (FEMP), has compiled a list of operation and maintenance, retrofit, and replacement options for boiler/steam generators that will help conserve both energy and water. These options are described below. (31)

- <u>Operation and Maintenance Options:</u>
    - Develop and implement a routine inspection and maintenance program on steam traps and steam lines.
    - Maintain proper water treatment to prevent system corrosion and optimize cycles of concentration.
    - Develop and implement a routine inspection and maintenance program on condensate pumps.
    - Use periodic quality assurance of boiler water treatment.
    - Regularly clean and inspect boiler water and fire tubes. Reducing scale buildup will reduce the amount of blowdown necessary as well as improve the energy efficiency of the system.

- <u>Retrofit Options:</u>
    - Install and maintain a condensate return system. By recycling condensate for reuse, water supply, chemical use, and operating costs for this equipment can be reduced by up to 70 per cent. A condensate return system also helps lower 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.
  - Install an automatic control to turn off the unit when it is not in use during nights and/or weekends.

- Replacement Options:
  - Replacement options vary depending on the size of the facility and existing equipment. Consider performing an energy audit to reduce heating load 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.
  - For specifics on this technology, consult with experts in the field such as experienced contractors or other Governmental agencies (DOE, FEMP, etc.).

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CHAPTER 7 Water Conservation Guidelines for Medical Facilities

Medical facilities, such as hospitals and nursing homes, have a variety of water uses with corresponding water conservation opportunities. Most of these water use activities (e.g., food preparation, restrooms, landscaping, cooling and heating, etc.) and their respective water conservation guidelines are discussed in the previous chapters of this manual. However, medical facilities do have some unique processes that require water. These processes along with their suggested water conservation guidelines are discussed below.

Section 7.1 Sterilizers and Autoclaves

Sterilizers and autoclaves can use as much water as cooling towers and heating systems in many hospitals. Some of the older models continuously use water. Because hospitals or other medical care facilities may have several of these units, significant volumes of water can be used.

Sterilizers require water to produce steam, to cool the steam before discharging it to the sewer system, and to create a vacuum in the unit to facilitate the drying of the various surgical instruments, trays, and tools being sterilized. Autoclaves use a chemical called ethylene oxide rather than steam to sterilize surgical implements. However, water is used in autoclaves to remove the spent ethylene oxide as well as create a vacuum to assist with drying of the surgical implements.

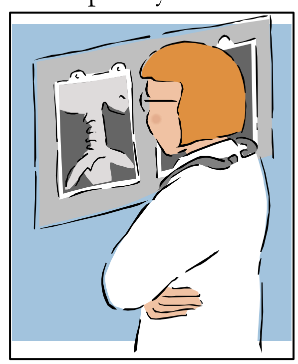
Measures that can be utilized to reduce water consumption when using sterilizers and autoclaves include the following:

- Check that the flow rates through the sterilizers and/or autoclaves do not exceed the manufacturer's recommendations. Reduce flow rates to the minimum acceptable levels.
- Install solenoid-operated valves that will shut off the flow to the units when they are not in operation.
- When purchasing new sterilizers or autoclaves, select units that are designed to recirculate water and that shut off the flow of water when the units are not in use.
- Rather than using water to cool the sterilizer steam before discharging it to the sewer system, install a small expansion tank that will reduce the steam temperature to acceptable levels for sewer discharge. *Verify with the manufacturer of the unit that this modification will not adversely affect the performance of the sterilizer.*

- Reuse the cooling water and steam condensate as make-up water in cooling towers or boilers.
- Load sterilizers and autoclaves with full loads of surgical implements as much as possible.
- Consider using high quality demineralized water to maximize the efficiency of sterilizers.
- Shut off all units that are not in use.
- Consider purchasing a water conservation retrofit kit—many are now available for older units. They reduce water use by either controlling the flow of tempering water or replacing the venture mechanism for drawing a vacuum. Tempering kits sense the discharge water temperature and allow tempering water to flow only as needed. This can save about 2,900 gpd when equipment is in idle mode. Venturi kits replace the venture with a vacuum pump, saving approximately 90 gallons per cycle.

Section 7.2 X-Ray Equipment and Photo Processing

Many medical facilities are now using digital x-ray equipment, which completely eliminates the need for water-cooling systems used for film development. However, there are still a significant number of medical facilities that use the traditional x-ray machines. These machines use a series of tanks and dryers to develop, stop, fix, harden, wash, bleach, and dry the film. Water is used primarily in the rinse or wash cycle at a rate of 2.0 gpm, although rates of 3.0 – 4.0 gpm are more typical. Newer machines are more water efficient.



In order to use less water in photographic and x-ray processing,:

- Install a packaged retrofit system. X-ray film processors in hospitals use an average of 1.04 million gallons of water per year. Package systems are now available for those units, which can reduce water use to only 32,585 gallons per year. (32)
- Adjust the film processor flow to the minimum acceptable rate. This may require installing a control valve and a flow meter in the supply line. Post a listing of minimum acceptable flow rates near the processors.
- Recycle rinse bath effluent as make-up water for the developer/fixer solution. A silver recovery unit can also be helpful in recovering metal for later use.
- Install a pressure-reducing device on equipment that does not require high pressure.
- Check the processor regularly to ensure that it is working properly if it has a solenoid or an automatic shut-off valve for times when the unit is not in use. A malfunctioning valve can let water flow when the system is in standby mode.
- Replace older equipment with newer, more efficient models. Look for models with a squeegee that removes excess chemicals from the film. This can reduce chemical carryover by 95% and reduce the amount of water needed in the wash cycle. (33)

Section 7.3 Other Medical Facility Processes

There are several other types of equipment that use water at medical facilities. The ways to save water when using such equipment are discussed below.

- Vacuum systems: Discontinue the practice of running a stream of water through an aspirator to create a vacuum. Instead, install a centralized vacuum system or small, electric vacuum pumps to create the pressure differentials necessary for vacuum applications.
- Vacuum and air pumps: Medical vacuum pumps are used to remove bodily fluids, and medical air pumps supply purified air for breathing. Since older models are cooled and lubricated with water, replacing them with new oil-cooled versions can reap substantial water savings. Kaseman Hospital in Albuquerque, New Mexico replaced two medical pumps in 1998 and saved the hospital 2.6 million gallons of water annually (34).
- Single-pass cooling laboratory instruments: If possible, replace single-pass cooling for laboratory instruments by connecting them to the facility's recirculating cooling system.

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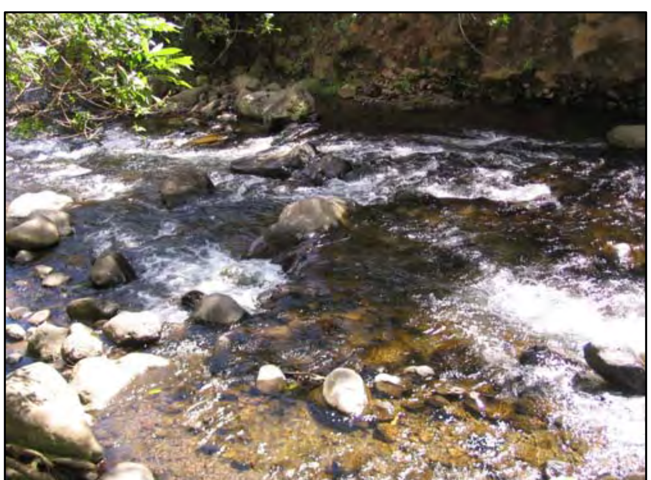
CHAPTER 8 Conclusion

This manual can be used as a tool by State of Hawaii Water Conservation Managers to improve the water efficiency at their respective buildings and facilities, thus, enabling State agencies to comply with the Governor's Administrative Directive No. 06-01. This manual can be utilized in different ways—because of the tremendous diversity of State buildings and facilities, it can be used as part of an overall State comprehensive water conservation plan and/or on a smaller scale, such as for the retrofitting of a building's restrooms in order to make them more water efficient. This manual can also be employed at many different times, such as:

- Immediately to learn what measures can be implemented to reduce water use and save money in operations.
- During the budget planning process to determine what programs, equipment, and employee participation will be required to improve water efficiency.
- Prior to purchasing any new water-using plumbing fixtures; cooling, heating, and landscaping equipment; and service contracts.
- Prior to requesting support and commitment from upper management and key operations and maintenance personnel. *NOTE: It is recommended that they also read this manual!*
- Prior to constructing or upgrading buildings or facilities.
- During unpredicted water shortages, droughts, or voluntary/mandatory water restrictions.

Finally, the water conservation measures detailed in this manual, if implemented, will allow State buildings and facilities to serve as models for the public and private sector of Hawaii to emulate. Serving as a role model for water efficiency will go a long way in helping the State contribute to sustainable water resource management in Hawaii. Fresh water is our most precious natural resource, and we must all work cooperatively to ensure its availability for future generations.



Our Most Precious Natural Resource – Hawaii's Fresh Water

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CHAPTER 9 Acknowledgements

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Appendix A

Administrative Directive No. 06-01

EXECUTIVE CHAMBERS

HONOLULU

LINDA LINGLE
GOVERNOR

January 20, 2006

ADMINISTRATIVE DIRECTIVE NO. 06-01

TO: ALL DEPARTMENT HEADS AND AGENCY HEADS

FROM: LINDA LINGLE, GOVERNOR

SUBJECT: ENERGY AND RESOURCE EFFICIENCY AND RENEWABLE ENERGY AND RESOURCE DEVELOPMENT

As an island state that is over 90 percent dependent on imported fossil fuel, Hawaii is especially vulnerable to volatile energy prices. The growing energy demand of State operations increase costs and poses potential electricity delivery problems. As such, agencies need to assess their practices and programs to reduce energy use and curtail the rise in State expenditures for fuel and utilities.

State agencies and programs are directed to increase their leadership commitment to implement innovative and resource-efficient operations and management. Better management practices can include reduced energy and water use; reduce, reuse, and recycle options; improved construction and demolition waste management; environmentally preferable purchasing; efficient use of transportation fuels, especially greater use of alternative fuels; as well as increased incorporation of sustainable building practices.

We have many excellent, ongoing programs, which have challenged us to do more with less. There are, however, additional challenges which bring new opportunities. These opportunities may not be easy to implement but over time will serve the State's best interest.

The initial costs may be higher, but incorporating lifecycle analysis result in long term savings. For example, Energy Star equipment and products are identified as those which produce fewer emissions and save energy, and we should opt for these types of appliances when purchasing replacements of existing State assets.

As a state blessed with abundant renewable resources, it is in our best interest to develop renewable energy projects which increase our use of renewable resources. State agencies can contribute to expediting our progress toward the use of clean, renewable, and indigenous energy resources.

Therefore, all departments and programs are directed to implement, to the extent possible, the following goals during budget planning and program implementation.

Buildings and Facilities

For items 1 through 6, the following shall apply to facilities using any portion of State funds and/or located on State owned lands.

1. Design and construct buildings to meet and receive certification for U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) standards. As appropriate for the type of construction, the buildings should meet LEED Silver certification for new commercial construction and major renovation, LEED for existing building operations, and LEED for commercial interiors.

2. Incorporate energy efficiency measures to prevent heat gain in residential facilities of one to three stories by providing R-19 or equivalent insulation on roofs, R-11 or equivalent in walls, and high-performance windows to minimize heat gain and, if air conditioned, to minimize cool air loss. Where possible, orient buildings to maximize natural ventilation and day lighting without heat gain, and optimize building roof exposure for solar water heating.

3. Install solar water heating systems where it is cost-effective, based on a comparative analysis to determine the cost-benefit of using a conventional water heating system or a solar water heating system. The analysis shall be based on the projected life cycle costs to purchase and operate the water heating system. If the life cycle analysis is positive, the facility shall incorporate solar water heating. If water heating entirely by solar is not cost-effective, the analysis shall evaluate the life cycle, cost-benefit of solar water heating for preheating water. If a multistory building is centrally air conditioned, heat recovery or ice/thermal storage systems may be employed as the primary water heating or cooling system.

   Single-family residential clients of the Department of Hawaiian Home Lands are exempted from this Executive Order so that they may continue to qualify for utility rebates for solar water heating.

4. Implement water and energy efficiency practices in operations to reduce waste and increase conservation.

5. Incorporate principles of waste minimization and pollution prevention: reduce, reuse, and recycle as a standard operating practice, including programs for construction and demolition waste management and office paper and packaging recycling programs.

6. Use life cycle cost-benefit analysis to purchase energy efficient equipment such as Energy Star products and use utility rebates, where available, to reduce the purchase and installation costs. Energy Star products meet strict efficiency guidelines set by the U.S. Environmental Protection Agency and the U.S. Department of Energy.

7. Procure environmentally preferable products, including but not limited to, recycled and recycled-content, bio-based, and other resource-efficient products and materials.

Transportation Fuel

1. Comply with Title 10, Code of Federal Regulations, Part 490, Subpart C, "Mandatory State Fleet Program," if applicable.

2. Comply with all applicable State laws regarding vehicle purchases.

3. Once federal and State vehicle purchase mandates have been satisfied, purchase the most fuel-efficient vehicles that meet the needs of their programs. Life cycle cost-benefit analysis of vehicle purchases should include projected fuel costs.

4. Purchase alternative fuels and ethanol blended gasoline when available.

5. Evaluate a purchase preference for biodiesel blends, as applicable to agencies with diesel fuel purchases.

6. Promote efficient operation of vehicles.

7. Use the most appropriate (minimum) octane fuel. Vehicles should use 87-octane fuel unless the owner's manual for the vehicle states otherwise, or the engine experiences knocking or pinging.

Renewable Energy and Resource Development

All affected agencies and programs are directed to review internal policies, rules, and practices regarding permitting requirements affecting renewable energy development. To the extent possible, permitting policies and practices should be streamlined to expedite implementation of renewable energy projects.

It is requested that agencies prepare by January 12, 2007, a report to my office identifying the specific steps they have taken to expedite the approval of renewable energy projects.

Appendix B

Water Conservation Case Studies

University of Hawaii – Hawaii Institute of Marine Biology

Located on Coconut Island in Kaneohe Bay, Oahu the University of Hawaii (UH) Hawaii Institute of Marine Biology (HIMB) is a world-renowned research institute for zoology and oceanography. This 28.8 acre site, with 6 acres enclosed in lagoons, is surrounded by 64 acres of coral reef designated by the State of Hawaii as the Hawaii Marine Laboratory Refuge. Both the new Pauley Marine Laboratory and Coconut Island itself serve as HIMB research facilities, for faculty and students who come from all over the world. Its unique location provides both unparalleled research opportunities as well as a model environment in which the principles of sustainability can be tested and demonstrated.

The UH Sea Grant Program held its first Laboratories for the 21st Century (Labs21) Design Workshop at the HIMB on Coconut Island in November 2001. Co-sponsored by the U.S. Environmental Protection Agency, the U.S. Department of Energy, and the International Institute for Sustainable Laboratories, Labs21 is a voluntary partnership program dedicated to improving the environmental performance of U.S. laboratories. The Labs21 Partnership Program began with 15 private and public sector laboratories that joined the program as Pilot Partners in 2002. The Labs21 Partnership Program has now expanded beyond the Pilot phase, and the goal of the program is to encourage the development of sustainable, high performance, and low-energy laboratories nationwide.

Since then, the UH Sea Grant Program has moved steadily forward in advancing energy efficiency in its laboratory and campus buildings. While increasing its world-class ocean science research, educational, and outreach programs, the UH Sea Grant Program has also expanded its mission to include improved building design and operational performance. The program has initiated and supported an extensive energy benchmarking study on the UH at Manoa campus. It has undertaken an innovative solar energy and water catchment study for the same campus and is about to establish building performance standards for the design of new and the renovation of existing buildings for all of the university campuses. These projects support reduced energy demand, renewable energy applications, and resource conservation throughout the university system. The Sea Grant Program and its newly formed Center for Smart Building and Community Design have also focused much effort towards improving their marine-based laboratories.

In 2002 the UH joined The Labs21 Partnership Program as a Pilot Partner and in 2003 the UH proposed to establish a Labs21 Center of Excellence for Marine-Based Laboratories at the university. One year later the "Labs21 Center of Excellence" designation was granted to the UH to promote the design and operation of high performance marine education and research labs. Labs21 Centers of Excellence are independent sites run by organizations that share the goals and objectives of the Labs21 program. The Centers help implement and promote the goals of Labs21 by conducting research, demonstration projects, and educational initiatives to foster a new generation of laboratories. Each Center is well-positioned to serve as a nationally-recognized technical resource in its given area of expertise, facilitating world-class knowledge, information, and solutions for advanced, sustainable laboratories.

In June of 2004, funding was allocated by the State legislature for the design of a new, state-of-the-art, marine science laboratory on Coconut Island. The laboratory was intended to embody the principles of the Labs21 program and become the physical model for marine research laboratories and provide a focal point to the UH's Labs21 program.

In 2006, it was announced that the Pauley Marine Laboratory at the HIMB will serve as the pilot project for promoting sustainability on the UH at Manoa campus. As the interim Chancellor Denise Konan stated at a press conference held at the HIMB, "We've identified this building as being one of the most inefficient in our campus system in terms of its energy use." Specifically, the Pauley Marine Laboratory building alone uses 100 kilowatts of energy per square foot per year, which is approximately four times more energy than even the biggest building on the UH at Manoa campus. The laboratory building burns an average of $300,000 each year in electricity. The entire Coconut Island, which consists of approximately 29 acres of land and about six acres of enclosed lagoons that are used for keeping organisms in captivity for study, uses about $450,000 dollars annually. Dr. Steve Pauley, part of the Pauley family that donated Coconut Island to the UH, stated that "We've always wanted to make Coconut Island a model of sustainability." He also revealed that it has taken them 10 years to address the energy problem.

Therefore, the UH is retrofitting the HIMB to become a model in sustainability for the rest of the university, the City and County of Honolulu, and the State of Hawaii. Goals include achieving a Leadership in Energy and Environmental Design gold rating, reducing energy consumption in other existing and planned buildings by between 25 to 50 percent, and reducing dependence on outside sources of water by 80 percent. Jo-Ann Leong, director of HIMB, has stated that "On Coconut Island, we work in a conservation zone, and we are very restricted in our resource use by our zoning," and has committed to the facility reducing energy usage by 40 to 50 percent. Gordon Grau, a zoology professor, researcher at HIMB, and director of the UH Sea Grant Program, has said that they could even reduce energy usage by up to two-thirds. "We are going to be using state-of-the-art, cutting-edge techniques," Grau has said, in reference to the multiple ways the Pauley Marine Laboratory will be modified to be sustainable.

The methods they plan to implement are not entirely new and have been used by others in the past. Ground source heat pumping is one method in which buildings use ground water, surface water, and the Earth to dissipate heat. This has proven to reduce energy usage for cooling in other commercial buildings by 50 percent. Other methods include resealing the building to prevent heat from escaping and reinstalling more energy-efficient fume hoods.

Resources:

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Kihei Public Library – Irrigation System Conversion to R-1 Recycled Water

The Kihei Public Library is located in southwest Maui, a very arid area that receives only an estimated 15 inches of rainfall per year. The library was constructed in 1995. However, Chapter 20.30 of the Maui County Code was adopted in 1996, which essentially requires all commercial properties that are within 100 feet of a County of Maui owned R-1 recycled water distribution system to utilize recycled water for irrigation purposes. This facility was consequently required to utilize R-1 recycled water.

State of Hawaii, Department of Health (DOH) regulations require that irrigation systems which utilize R-1 water be identified with purple pipes; however, since the library's irrigation system had originally been designed to use potable water and was already in place, the DOH waived this requirement. To ensure that the irrigation system was not connected to the building's potable water system, cross connection tests were performed. Signs indicating that R-1 recycled water is used for irrigation purposes were also posted on the exterior of the building and throughout the landscaped areas.

Since converting its irrigation system over to recycled water, no significant problems with the Kihei Public Library's landscaping have occurred. In fact, due to the nitrogen and phosphorus present in the recycled water, the landscaping has thrived. Recycled water has proven to be a reliable and drought-proof source of high quality irrigation water.

The greatest benefit of course has been potable water savings. The library has used an average of 6,000 gallons per day of recycled water since 1996. This figure translates into a potable water savings of 2,190,000 gallons per year. Since the recycled water is purchased from the County of Maui at less than half the cost of potable water, considerable monetary savings have been realized as well.

Resource:

County of Maui, Wastewater Reclamation Division. Files.

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Kaunakakai Residential Plumbing Retrofit Program

The Kaunakakai Residential Plumbing Retrofit Program was a successful water conservation program jointly funded and implemented in 1995-96 by the County of Maui's Department of Water Supply and the Department of Public Works-Wastewater Reclamation Division (WWRD). The goals of the program were to:

- Save potable water to defer development of new fresh water sources.
- Reduce wastewater flow to the County of Maui's Kaunakakai Wastewater Reclamation Facility (WWRF) for the purpose of deferring a costly facility expansion.
- Provide residents with quality ultra-low flush toilets (ULF) that performed well.
- Allow residents to save money on their water and sewer bills.

The program allowed Kaunakakai residents to have their old toilets replaced with new ULF toilets by a licensed plumber and at no cost. Kitchen and bathroom faucet aerators were also installed as part of the program. In order to be eligible for the program, applicants' residences had to already be hooked up to the County's sewer system. Prior to the commencement of the program, research was conducted to determine the best functioning and most cost effective ULF toilet on the market. Based on this research, the Toto CST703 1.6 gpf toilet was selected. The old toilets were crushed and used as an additive for asphalt road mix. Overall, the results of the program were very positive and are listed below.

- Approximately 43% of Kaunakakai residences were retrofitted at a cost of $95,410.
- A total of 387 ULF toilets, 251 kitchen faucet aerators, and 317 bathroom aerators were installed.
- Single family residences realized an average 22% reduction in water use. The one multifamily residential complex that participated in the program realized a 32% reduction.
- Over 11 million gallons of potable water per year are now being saved on Molokai because of this program.
- Wastewater flow to the Kaunakakai WWRF was reduced by 31,000 gallons per day at a cost of $3.08 per gallon. Expansion of the facility would have cost an estimated $10.00 per gallon. To date (11 years later), wastewater flows have remained low; thus, the need to expand the wastewater facility has been delayed.
- No complaints were filed pertaining to the flushing capability of the Toto ULF toilets.

The program was an overall success and a win-win situation for both the participating residents and the County of Maui's Department of Water Supply and the Department of

Public Works-WWRD. Residents are saving money on their water and sewer bills, and both potable water resources and wastewater treatment capacity were cost effectively saved.

Resource:

Parabicoli, Steve and Takakura, Jacky. *Maui County's Attempt to Slow the Flow*. May 14, 2003, AWWA-Hawaii Section 29th Annual Conference.

County of Maui Wastewater Reclamation Division – Multifamily Affordable Housing Plumbing Retrofit Program

Encouraged by the success of the Kaunakakai Residential Plumbing Retrofit Program in 1995-96 (see **Page B-7** of this **Appendix B** for detailed information about this program), the County of Maui's Wastewater Reclamation Division continued its water conservation efforts by retrofitting several State and County multifamily affordable housing complexes in 1996, 1997, and 1998. The goals of the program were to save water and defer expansions of the County of Maui wastewater treatment plants by reducing wastewater generation.

The complexes were provided with low flow showerheads (2.5 gallons per minute) and early closing toilet flappers. The flappers were utilized for this program because they were much less expensive than replacing the entire toilet with an ultra low flush model (as was the case with the Kaunakakai Residential Plumbing Retrofit Program described on **Page B-7** of this **Appendix B**). The flappers, called the "Frugal Flush Retroflapper", are high quality 5-year flappers that have an adjustable setting that determines the rate of closing. Depending on which setting is selected, water savings can range from 0.25 to 2.0 gallons per flush (gpf). The flappers can only be used in toilets that consume 3.5 gpf or more and must be adjusted properly to ensure that the toilet not only reduces water consumption, but it is also allowed to flush completely. Both the showerheads and the flappers were obtained from the water conservation companies listed in **Figure 4-1** of this manual. The maintenance staffs of the various housing complexes installed the devices.

The water billing records for the participating affordable housing complexes were recorded for the one-year period before the devices were installed and for a one-year period after the devices were installed in order to gauge the effectiveness of the program. Based on this accounting method, the reduction in water consumption for the various affordable housing complexes ranged from 22% to 32%.

One disadvantage of this program is that the water saving toilet flappers are only guaranteed for five years and must eventually be replaced. While the managers of the various affordable housing complexes were encouraged to replace them with the same or a similar early-closing device, it is uncertain whether they have done so. It is likely that inexpensive conventional flappers have since been installed, thus, negating the earlier water savings that were realized after the original retrofits took place.

Nevertheless, this program did demonstrate that significant water savings can be realized by retrofitting conventional plumbing fixtures with inexpensive low flow devices.

Resource:

County of Maui, Wastewater Reclamation Division. Files.

Haleakala National Park Visitor Center – Integrated Approach to Sustainable Water Resource Management

Located on the island of Maui, the Haleakala National Park Visitor Center is situated on the summit of Mount Haleakala at an elevation of 10,000 feet above mean sea level. It is estimated that 1.3 million people visit the summit of Mount Haleakala per year. With no municipal water distribution system available, potable water has historically been hauled to the Haleakala National Park Visitor Center in tanker trucks as a supply for drinking, lavatory faucets, cleaning purposes, and sanitary toilet and urinal flushing. In order to reduce and eventually eliminate the cost associated with the hauling of water for sanitary flushing purposes and to improve restroom services for the millions of visitors, an innovative water conservation program has been implemented at Haleakala National Park.

The first water conservation initiative involved the replacement of conventional urinals with new waterless urinals. The waterless urinals work with no water or flush valves. Odors are eliminated by a floating chemical seal that prevents sewer gases from escaping. The chemical seal, known as "Blue-Seal", must be replaced 2 to 4 times per year depending on the frequency of urinal use. The chemical layer, which consists of 3 ounces of Blue-Seal, typically lasts for approximately 1,500 sanitary uses. Occasional flushing with hot water also helps to keep the urinal passageways clear. It is estimated that each waterless urinal saves over 45,000 gallons of water per year.

The second water conservation initiative was the construction of a closed-loop water recycling system. Wastewater from sinks and toilets at the Haleakala National Park Visitor Center is treated to meet State of Hawaii, Department of Health R-1 recycled water standards and blended with captured rain water. The R-1 recycled water blend is then used for toilet flushing in the restrooms at the visitor center. The wastewater is continuously treated and reused again for sanitary flushing purposes. This initiative won the Hawaii Chapter of the American Institute of Architects' 2004 Sustainability Design Award and the Hawaii Chapter of the American Council of Certified Engineers 2004 Grand Conception Award.

Resources:

Kafka, Peter; Maintenance Mechanic Supervisor. Haleakala National Park.

Department of Land and Natural Resources, Commission on Water Resource Management. (2005), *2004 Hawai`i Water Reuse Survey and Report.*

Waterless Co. Website, http://www.waterless.com

Deep Sea Water Cooling Systems

In general, sea water cooling systems use deep cold sea water as a coolant for air conditioning systems. Deep sea water cooling systems utilize only the cold nature of the water, and not the actual ocean water itself.

It should be noted that the conditions for utilizing cold deep sea water as a coolant for air conditioning systems are particularly favorable for coastal developments with a large air conditioning demand and reasonable access to deep cold sea water (i.e., areas where both the sea floor and the water temperatures plummet not too far offshore). Notable areas in the State of Hawaii include southern Kauai, several areas of Oahu, and the southern 60 percent or more of the Big Island. Three facilities/projects located within these notable areas in the State of Hawaii and which utilize this new deep sea water cooling system technology are described below: the University of Hawaii (UH) John A. Burns School of Medicine facility, the Natural Energy Laboratory of Hawaii, and the Honolulu Seawater Air Conditioning, LLC (HSWAC) downtown project.

University of Hawaii John A. Burns School of Medicine Facility

The UH John A. Burns School of Medicine facility is located in Kakaako, near the island of Oahu's coastline. During the planning/design phase of the medical school facility and prior to its construction, a plan and new technology was proposed to use cold sea water as a coolant for an air conditioning system. The plan, to drill a 3,000-foot-deep well straight down and pump the sea water as the source of a proposed "district cooling" project for the UH's medical school, was given preliminary approval in 2003 by the Honolulu Board of Water Supply (HBWS).

At a meeting held in 2005 at Maui Community College, the UH Board of Regents approved agreements with the HBWS in order to provide the chilled sea water for air conditioning purposes to the School of Medicine's new Kakaako facilities. As part of the construction of the new medical school facilities, the HBWS funded the installation of the deep sea water well cooling system. Through the approved agreements, the HBWS would provide the UH medical school with this chilled water service by leasing the central utility plant equipment from the UH.

The accepted benefits of utilizing this cooling method included the following: 1) the sea water "district cooling" system would use less electricity and reduce energy costs when compared to a conventional air conditioning system and 2) the sea water "district cooling" system would conserve fresh water. Use of this new technology was estimated to cut the building's cooling costs by as much as 85%. Overall, the School of Medicine was projected to save approximately $100,000 per year through its arrangement with the HBWS. The system was expected to pump approximately 10 million gallons of salt water a day, and an estimated 14 million gallons of fresh water and 800,000 kilowatt-hours annually were anticipated to be conserved.

Conventional air conditioning for the medical school facility would have required a plant with the capacity of 4,000 tons of refrigeration. Such a system would result in the evaporation of 30 million gallons of potable water a year into the air. If used at the UH medical school, a conventional system would use a large compressor and cooling tower that would consume 2.25 to 6.75 million kilowatt hours of electricity and 30 to 40 million gallons of fresh water per year. Instead, the HBWS reasoned that utilizing the cold deep sea water to provide the cooling effect would be a desirable solution.

A key factor in deciding the project's success was determining the water temperature at the 3,000-foot depth. In April 2004, the HWBS was to drill a test well at the medical school site in order to gather temperature data. The HBWS stated that the water needed to be in the low 40 degrees Fahrenheit (ºF) in order to properly chill the water to be used in the cooling system, but could be in the low 50ºF and still be effective by simply cooling the water a little. Additionally, it was recognized that the total project cost would vary depending on what was discovered about the deep sea water temperatures. The cost would include development of a deep sea water well on the medical school site and construction of a cooling plant.

Below is a simplified step-by-step outline of how the UH's medical school "district cooling" system works:

- A 3,000-foot-deep well was drilled.
- Cold sea water is pumped through the well to a station on the UH property.
- The cold sea water passes through a heat exchanger that chills stored fresh water.
- The chilled fresh water is then circulated into the medical school facility's air conditioning system.
- The fresh water recycles back to a storage area.
- The seawater is warmed after cooling the fresh water and then discharged to a drainage canal west of the property.

Natural Energy Laboratory of Hawaii

The technology proposed by the HBWS and utilized at the UH John A. Burns School of Medicine facility is a unique twist on existing systems used in dozens of U.S. cities and at the Natural Energy Laboratory of Hawaii on Hawaii's Big Island. Although similar technology, these other systems use pipelines that are miles long to reach cold lake and ocean water.

The Natural Energy Laboratory of Hawaii Authority (NELHA) is a state agency that operates a unique and innovative ocean science and technology park located at Keahole Point in Kailua-Kona. The Natural Energy Laboratory of Hawaii constructed a pipeline to provide 27,000 gallons per minute of cold sea water for its aquaculture enterprises and air conditioning. Cold deep sea water is delivered onshore at a chilly 43°F from a 2,000-foot depth. The cold sea water is brought to shore through a 6,284-foot-long, 40-inch-diameter pipeline made of high density polyethylene.

A small deep sea water air conditioning system provides cooling for NELHA's water quality laboratory, tenant laboratory space, and public meeting rooms—a volume totaling 67,200 cubic feet. The low cost cooling for air conditioning and industrial cooling is extremely cost effective using cold deep sea water to replace traditional coolants. NELHA has been saving up to $4,000 per month in electricity costs since it switched its 3 buildings to deep sea water-based cooling, using a renewable—and local—resource, and saving potable water. Additionally, the system requires much less maintenance than compressor systems.

Honolulu Seawater Air Conditioning, LLC Downtown Project

A company on the island of Oahu recently began to examine whether cold deep water below the ocean's surface could be harnessed to meet the islands' year-round air conditioning needs. The HSWAC is currently developing a 25,000-ton sea water air conditioning "district cooling" system for downtown Honolulu. The system is designed to serve buildings in Honolulu's downtown core. As with the UH John A. Burns School of Medicine and NELHA facilities, the HSWAC downtown project technology would involve cold deep sea water of the Pacific Ocean pumped up to a cooling station through a closed system. The cold sea water would cool down the fresh water in an adjacent system, with the cooling station ensuring that the sea water and fresh water never mix. The HSWAC downtown project would include a system of underground pipes leading from the on-shore cooling station. Buildings would then be able to tap into the system, and the cold fresh water would then be used by buildings to bring down the temperatures of their interiors. The warmed sea water, however, would be retuned to the ocean.

Bills are being considered by Hawaii's Legislature to help move the project along, including providing the company with special purpose revenue bonds. Initial construction activities are targeted for end of 2007, and commercial operation is targeted for mid-2009. HSWAC also plans to develop a similar sea water air conditioning system for Waikiki and possibly for other areas in Hawaii.

Sea water air conditioning systems provide numerous environmental, economic development, and customer benefits. Specific to water conservation, development of such a system in Hawaii would eliminate the need for cooling towers and, as a result, reduce potable water use, toxic chemical use, and the production of sewage. HSWAC notes that the 25,000-ton HSWAC downtown project would save up to 300 million gallons of potable water per year, reduce sewage generation by up to 90 million gallons per year, and eliminate the need for cooling water treatment chemicals.

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"UH Board of Regents approves agreements with Board of Water Supply for Kakaako deep-well cooling project: Agreement will reduce potable water usage, energy usage and cost at new medical school." Posted: March 18, 2005. http://jabsom.hawaii.edu/JABSOM/about/news.php?articleid=76.

Appendix C

DLNR Prototype Water Conservation Plan: Survey Form

WATER CONSERVATION PLAN - SURVEY FORM

Commission on Water Resource Management
Department of Land and Natural Resources

The Commission on Water Resource Management is developing a water conservation plan for the Department of Land and Natural Resources through a grant received from the U.S. Bureau of Reclamation. This project is part of a phased approach to the development of a comprehensive water conservation plan for all state agencies to address potable and non-potable water demands through conservation practices and enhanced water use efficiency. Upon acceptance of the plan by the Bureau of Reclamation, it is expected that Hawaii will become eligible for future federal funding to implement the plan provisions. This phase of the water conservation plan development will focus on larger water-using facilities. In order to obtain the additional information necessary to determine each facility's water conservation potential, this survey form was developed. Please complete this survey to the best of your ability.

If you have any questions please call Lance Manabe at (808) 944-1821.

Please return this survey form to: Fukunaga and Associates, Inc.
1388 Kapiolani Boulevard, 2nd Floor
Honolulu, Hawaii 96814
Attn: Lance Manabe

DLNR Division-Office: ______ Island: ______

Water Use Facility Name: ______

Facility Address: ______

Tax Map Key(s): ______

Facility Contact Name: ______

Phone Number: ______ Fax Number: ______

Is Facility Shared with Other Departments/Agencies? ______ (Yes or No)

If Yes, List Departments / Agencies who share the facility: ______

Number of DLNR Staff at Facility (Per Day): ______

Number of Other Users of Facility (Per Day): ______ If not applicable, N/A.

Water Usage Information Please describe each type of water usage at your facility. (For example: General office, landscape irrigation, public comfort station, equipment washdown, etc.)

Example:

General Description of Water Use: **Landscape Irrigation**

Quality of Water Used: **Potable** (i.e. Potable, Non-Potable, Recycled or Other)

Source of Water Used: **State-owned Well** (i.e. County Water System, State Water System, Private Water System or Other))

Quantity of Water Used: **1,500** gallons per day Quantity: $\boxed{\text{Estimated}}$ or Metered (circle one)

General Description of Water Use:

Quality of Water Used: (i.e. Potable, Non-Potable, Recycled or Other)

Source of Water Used: (i.e. County Water System, State Water System, Private Water System or Other))

Quantity of Water Used: gallons per day Quantity: Estimated or Metered (circle one)

General Description of Water Use:

Quality of Water Used: (i.e. Potable, Non-Potable, Recycled or Other)

Source of Water Used: (i.e. County Water System, State Water System, Private Water System or Other))

Quantity of Water Used: gallons per day Quantity: Estimated or Metered (circle one)

General Description of Water Use:

Quality of Water Used: (i.e. Potable, Non-Potable, Recycled or Other)

Source of Water Used: (i.e. County Water System, State Water System, Private Water System or Other))

Quantity of Water Used: gallons per day Quantity: Estimated or Metered (circle one)

General Description of Water Use:

Quality of Water Used: (i.e. Potable, Non-Potable, Recycled or Other)

Source of Water Used: (i.e. County Water System, State Water System, Private Water System or Other))

Quantity of Water Used: gallons per day Quantity: Estimated or Metered (circle one)

Water System Information

Are there any water system problems at your facility? [ ] (Yes or No)

If Yes, describe your water system problems in the space provided below:

(i.e. Low water pressure, excessive water pressure, water quality, etc.)

Landscaping and Irrigation System Information

Do you have landscaped areas? [ ] (Yes or No) Total landscaping area: [ ] Acres

If Yes, Describe the existing landscaping. (i.e. grass, planting areas, trees, brush, etc.)

Describe your existing irrigation system: (i.e. sprinklers, drip irrigation, hand water, etc.)

Describe your current irrigation schedule:

Current Water Conservation Measures (if applicable)

Low Volume(Flush) Toilets: ____ (Yes or No) Toilet Leak Check/Repair: ____ (Yes or No)

Toilet Retrofit Device(s): ____ (Yes or No)

Types of Toilet Retrofit Device(s): (i.e. Displacement devices, toilet dams, early closure devices, efficiency adjustments for flush valves, etc.)

Low Volume(Flush) Urinals: ____ (Yes or No) Urinal Leak Check/ Repair: ____ (Yes or No)

Low-Volume(Flow) Showerheads: ____ (Yes or No)

Showerhead Retrofit Device(s): ____ (Yes or No)

Types of Showerhead Retrofit Device(s): (i.e. Timed shut-off valves, flow restrictors, etc.)

Low-Volume(Flow) Faucets: ____ (Yes or No) Faucet Leak Check/ Repair: ____ (Yes or No)

Faucet Retrofit Devices: ____ (Yes or No)

Types of Faucet Retrofit Device(s): (i.e. Aerators, metered valve, self-closing, sensor-activated, etc.

List Other Water Conservation Meaures you are currently using or are planning to implement:
(For examples see next page)

Other Water Conservation Measures List

Information and Education

- Understanding water bill
- Information available
- Informative water bill
- Water bill inserts
- Public education program
- Workshops
- Advisory committee

Costing and Pricing

- Cost of service accounting
- User charges
- Metered rates
- Cost analysis
- Non-promotional rates
- Advanced pricing methods

Water Use Audits

- Audits of large volume users
- Large landscape audits
- Selective end use audits

Pressure Management

- System-wide pressure regulation
- Selective use of pressure reducing valves

Replacement and Promotions

- Rebates and incentives (commercial)
- Promotion of new technologies

Water Conservation Program

- Shortage allocation policies
- Operation & maintenance program
- Monitoring program
- Water conservation coordiantor
- Drought/shortage contingency plan
- Plumbing regulations

Water Accounting and Loss Control

- Account for water
- Repair known leaks
- Analyze non-account water
- Water system audit
- Leak detection and repair strategy
- Automated sensors/telemetry
- Loss prevention

Universal Metering

- Source water metering
- Service connection metering and reading
- Meter public use water
- Fixed interval metering reading
- Meter accuracy analysis
- Test, calibrate repair and replace meters

Retrofits

- Retrofit kits available
- Distribution of retrofit kits
- Targeted programs

Reuse and Recycling

- Industrial applications
- Large volume irrigation applications

Water use Regulation

- Water use standards and regulations

Landscape Efficiency

- Promotion of landscape efficiency
- Landscape planning and renovation
- Selective irrigation submetering
- Irrigation management

Appendix D

DLNR Prototype Water Conservation Plan: Summary of 5 DLNR Building/Facility Prototype Examples

Prototype Facility 1: Kalanimoku State Office Building

Background

The Kalanimoku State Office Building is located on the island of Oahu, at 1151 Punchbowl Street. It is a five-story structure, surrounded by approximately 5.3 acres of landscaped areas. The Kalanimoku Building serves several State agencies/departments, as well as the United States Department of Agriculture's (USDA) Forest Services. The building houses a total of approximately 875 staff from the various agencies/departments. Typical of most office buildings, the majority of water use within the Kalanimoku Building comes from domestic uses (e.g., toilets, urinals, sinks, drinking fountains, etc.) and the surrounding landscaped areas are irrigated by an existing automatic spray system.

During preparation of the Department of Land and Natural Resources (DLNR) Prototype Water Conservation Plan, a count of the total plumbing fixtures for the Kalanimoku Building was conducted based on available construction plans and site inspections. See **Table D-1** for the count summary. Also, it was determined that the landscaped area surrounding the Kalanimoku Building has a sprinkler irrigation system with 515 total fixtures. The sprinkler irrigation system was first installed in 1974 during the construction of the building, and various "piecemeal" replacement and repairs have been performed over the years to maintain it.

Table D-1. Kalanimoku Building – Count of Plumbing Fixtures

Fixture Type	Number of Fixtures	Fixture Units per Fixture	Fixture Count	Percentage of Total Fixtures
Water Closet (Toilet)	79	5	395	59%
Urinal	17	5	85	13%
Lavatory	55	2	110	16%
Basin / Sink	9	4	36	5%
Drinking Fountain	21	2	42	6%
		TOTAL FIXTURE UNITS	**668**	**100%**

Recommended Water Conservation Measures

Domestic use (drinking fountains, restroom facilities and custodial facilities) and irrigation use (landscaped areas surrounding the building and the existing irrigation system) are the two primary water uses in the Kalanimoku Building.

Domestic Use

The water conservation measures recommended for the Kalanimoku Building included low-consumption flushometer-valve toilets, low-consumption urinals, and low-volume faucets (see **Table D-2**). Drinking fountains and basins/sinks were not considered for water conservation measures because these fixture types made up a small percentage of the total water usage fixtures in the building. Additionally, existing drinking fountains are relatively water efficient due to automatic shut-off mechanisms and basins/sinks for custodial services are limited to janitorial staff that can be educated on water conservation measures.

Irrigation Use

The water conservation measures suggested for the building's irrigation use included metering water use for irrigation and replacement of the existing irrigation system with a new and more water-efficient irrigation system (see **Table D-2**). Other water conservation measures for the landscaped areas included selection of native and low-water use plants, monitoring and optimizing the irrigation schedule, soil improvements, and application of mulches to retain soil moisture.

At the time the DLNR Prototype Water Conservation Plan was being prepared, the Department of Accounting and General Services (the agency responsible for the Kalanimoku Building's operation and maintenance) was in the process of undertaking a project to replace the existing irrigation system at the building. A primary reason for replacing the existing irrigation system is due to the age of the current system (i.e., the system has served out its expected design life of 30 years) and changes to the landscaped area surrounding the Kalanimoku Building over the years. From discussions with the project's landscape architect, the new irrigation system to be installed will be more efficient and save approximately 15% on irrigation water consumption because it will include components such as:

- High efficiency sprinkler heads (91% vs. 75% for old system);
- Rain sensors shut-off sprinkler system (set at ¼" rainfall);
- Pressure regulators keeping water pressures within 10% of optimum operating pressures;
- Sprinkler system designed for existing facilities (e.g., old system covered sidewalk areas which were constructed later); and
- New solid-state controllers, which are more accurate than old dial type timers.

An additional water conservation measure that could be applied is the sub-metering of irrigation water use separately from the domestic water consumption for in the Kalanimoku Building. While this measure does not have direct water usage savings, it would enable the staff to monitor water usage and properly apply water conservation measures to the facility.

This conservation measure is vital for the facility to develop and monitor the water conservation program.

Table D-2. Kalanimoku Building – Water Conservation Measures and Devices

Fixture Type	Existing Water Usage	Water Conservation Measure	Conservation Water Usage	Water Savings Percentage (%)
Water Closet (Toilet)	3.5gpf	Low-Consumption Flushometer-Valve Toilets	1.6 gpf	54%
Urinal	3.5 gpf	Low-Consumption Urinals	1 gpf	71%
Lavatory	5 gpm	Low-Volume Faucets (Metering)	0.5 gpm	90%
Existing Irrigation System/ Existing Landscaping	18,000 gpd	New Irrigation System	15,300 gpd	15%
Acronyms: gpf – gallons per flush; gpm – gallons per minute, gpd – gallons per day				

The overall projected water conservation savings for the Kalanimoku Building are summarized in **Table D-3**.

Table D-3. Kalanimoku Building – Projected Water Conservation Savings

Fixture Type	Total Estimated Water Usage (gpd)	Water Savings Percentage (%)	Total Estimated Water Saved (gpd)
Water Closet (Toilet)	11,800	54%	6,400
Urinal	2,500	71%	1,800
Lavatory	3,300	90%	2,970
Basin/Sink	1,100	n/a	-
Drinking Fountain	1,300	n/a	-
Existing Irrigation System/ Existing Landscaping	18,000	15%	2,700
TOTALS	**38,000**	**-**	**13,870**
Acronyms: gpd – gallons per day			

Additional

Other water conservation measures that could be applied at the Kalanimoku State Office Building, which do not have direct water usage savings, include the following:

- Education of custodial staff on water conservation measures;
- Training of maintenance staff on upkeep of low-flow fixtures;
- Installation of signs that encourage water conservation in comfort stations or work areas where water is used; and
- Installation of signs with information on who to call should a comfort station/restroom need repair.

Cost-Benefit Analysis of the Recommended Water Conservation Measures

Domestic Use

The implementation cost (including materials and labor) for the proposed water conservation measures at the Kalanimoku Building is presented in **Table D-4**.

Table D-4. Kalanimoku Building – Projected Cost of Implementing the Domestic Use Water Conservation Measures

Fixture Type	Number of Fixtures	Cost per Fixture*	Estimated Total Fixture Cost
Low-Consumption Flushometer-Valve Toilets	79	$ 610	$ 48,200
Low-Consumption Urinals	17	$ 630	$ 10,700
Low-Volume Faucets (Metering)	55	$ 550	$ 30,300
		TOTAL COST	**$ 89,200**
*Planning cost based on the Honolulu Board of Water Supply conversion of water fixtures for the City and County of Honolulu's municipal facilities to water conserving fixtures, implementation 2001-2003 (includes 20% contingency).			

The water saved for the Kalanimoku Building was estimated at 11,170 gallons per day (gpd) for domestic use. This translates to $22.10 per day ($1.98/1,000 gallons – Honolulu Board of Water Supply [HBWS] water rate) or an estimated $8,100 per year savings. With an initial implementation cost of $89,200, the payback period would be approximately 11 years.

Irrigation Use

The construction cost estimate for the replacement of the irrigation system surrounding the Kalanimoku Building is $210,000. The water savings from the new irrigation system was estimated at 2,700 gpd for irrigation use. This translates to $5.35 per day ($1.98/1,000 gallons – HBWS water rate) or an estimated $2,000 per year savings. The water use cost savings from the new irrigation system can be seen as an added benefit of replacing the old system, which has reached the end of its useful life.

The construction cost estimate for installation of one water sub-meter and box to monitor irrigation water consumption would be approximately $2,500.

Projected Water Savings

The total projected water savings for the Kalanimoku State Office Building is 11,170 gpd for domestic use and 2,700 gpd for irrigation (based on 15% water savings from a new irrigation system), resulting in a total water savings of 13,870 gpd. This could save the State $27.46 per day ($1.98/1,000 gallons – HBWS water rate), which translates to approximately $840.00 per month or about $10,100.00 per year.

Source: State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management. (2005), *Prototype Water Conservation Plan for the Department of Land and Natural Resources (DLNR)*, pgs. 8-6 to 8-17.

Prototype Facility 2: Kakaako Waterfront Park

Background

The Kakaako Waterfront Park is located on the island of Oahu at 709 Kelikoi Street in the Kakaako district, extending along the shoreline west of Kewalo Basin. Covering approximately 35 acres, the park and is a well-used recreational area that includes such features as shoreline fishing, access to ocean activities, a waterfront promenade, picnic areas, an amphitheater, comfort stations (restroom facilities), and outdoor showers. Two comfort stations, three drinking fountains, and the outdoor showers are located along the promenade. A third comfort station is located north of the park entrance. The Kakaako Waterfront Park's landscaped area (i.e., grass, ground cover, shrubs, and trees) covers approximately 15 acres. Irrigation usage at the Kakaako Waterfront Park accounts for approximately 97% of the park's total water consumption.

During preparation of the DLNR Prototype Water Conservation Plan, a count of the total plumbing fixtures for the Kakaako Waterfront Park was conducted based on available construction plans and site inspections. See **Table D-5** for the count summary. Unfortunately, while the park contains an extensive landscape irrigation system to take care of the 15 acres of various trees, shrubs, ground covers, and grass areas in the park, information on the total fixture count for the irrigation system was unavailable. The irrigation system uses above ground sprinklers made up of Rainbird and Toro sprinkler system components. Various modifications, repairs and adjustments have been made over the years to maintain the existing irrigation system.

Table D-5. Kakaako Waterfront Park – Count of Plumbing Fixtures

Fixture Type	Number of Fixtures	Fixture Units per Fixture	Fixture Count	Percentage of Total Fixtures
Water Closet (Toilet)	17	5	85	46%
Urinal	5	5	25	13%
Lavatory	12	2	24	13%
Shower	6	4	24	13%
Drinking Fountain	4	2	8	4%
Hose Bib (Spigot)	4	5	20	11%
TOTAL FIXTURE UNITS			**186**	**100%**

Recommended Water Conservation Measures

Domestic use (drinking fountains, showers and comfort station facilities) and irrigation use (landscaped areas surrounding/throughout the park and an existing irrigation system) are the two primary water uses in the Kakaako Waterfront Park.

Domestic Use

The water conservation measures recommended for the Kakaako Waterfront Park included low-consumption flushometer-valve toilets, low-consumption urinals, low-volume faucets, and low-flow showerheads (see **Table D-6**). These low-volume fixtures would require the least amount of modification to the existing facilities and are the most practical conservation measures. While there are several other water saving devices available, such as composting and incinerating toilets and urinals, these were considered impractical for this application.

Irrigation Use

Although the current irrigation practices efficiently and adequately irrigate the existing landscape, the deficiencies of the existing system require frequent timer and controller adjustments to be made and supplemented by manual adjustments. Therefore, measures directed toward conservation of irrigation water usage could reduce water consumption at the park. The water conservation measures suggested for the park's irrigation use included replacement of the irrigation system or components of the system, such as installation of efficient low-trajectory sprinkler heads, better distribution of sprinkler heads, solid state replacement timers, and rain and moisture sensors to reduce water usage (see **Table D-6**). A new irrigation system will be more efficient and save approximately 15% on irrigation water consumption. Another alternative would be to retrofit the existing irrigation system at the park; however, the actual water savings and implementation would require a more in-depth study of the current irrigation system and possible retrofit components.

While it was noted that another water conservation measure for the landscaped areas of the park would include replacement of the existing plantings with low-water use plants, the Hawaii Community Development Authority (the agency with jurisdiction over the park, although it is considered a DLNR State Park facility) would like to maintain the local/native plants for the Kakaako Waterfront Park to keep a Hawaiian sense of place.

Table D-6. Kakaako Waterfront Park – Water Conservation Measures and Devices

Fixture Type	Existing Water Usage	Water Conservation Measure	Conservation Water Usage	Water Savings Percentage (%)
Water Closet (Toilet)	3.5gpf	Low-Consumption Flushometer-Valve Toilets	1.6 gpf	54%
Urinal	3.5 gpf	Low-Consumption Urinals	1 gpf	71%
Lavatory	5 gpm	Low-Volume Faucets (Metering)	0.5 gpm	90%
Shower	3.4 gpm	Low-Flow Showerheads	2.5 gpm	26%
Existing Irrigation System/ Existing Landscaping	93,740 gpd	New Irrigation System	79,680 gpd	15%
Acronyms: gpf – gallons per flush; gpm – gallons per minute, gpd – gallons per day				

The overall projected water conservation savings for the Kakaako Waterfront Park are summarized in **Table D-7**.

Table D-7. Kakaako Waterfront Park – Projected Water Conservation Savings

Fixture Type	Total Estimated Water Usage (gpd)	Water Savings Percentage (%)	Total Estimated Water Saved (gpd)
Water Closet (Toilet)	1,214	54%	656
Urinal	344	71%	244
Lavatory	343	90%	310
Shower	343	26%	90
Drinking Fountain	106	n/a	-
Hose Bib (Spigot)	290	n/a	-
Existing Irrigation System/ Existing Landscaping	93,740	15%	14,060
TOTALS	**96,380**	**-**	**15,360**
Acronyms: gpd – gallons per day			

Additional

Other water conservation measures that could be applied at the Kakaako Waterfront Park include the following:

- Education of custodial staff on water conservation measures;
- Training of maintenance staff on upkeep of low-flow fixtures;
- Installation of signs that encourage water conservation in comfort stations or work areas where water is used; and
- Installation of signs with information on who to call should a comfort station/restroom facility need repair.

Cost-Benefit Analysis of the Recommended Water Conservation Measures

Domestic Use

The implementation cost (including materials and labor) for the proposed water conservation measures at the Kakaako Waterfront Park is presented in **Table D-8**.

Table D-8. Kakaako Waterfront Park – Projected Cost of Implementing the Domestic Use Water Conservation Measures

Fixture Type	Number of Fixtures	Cost per Fixture*	Estimated Total Fixture Cost
Low-Consumption Flushometer-Valve Toilets	17	$ 610	$ 10,400
Low-Consumption Urinals	5	$ 630	$ 3,200
Low-Volume Faucets (Metering)	12	$ 550	$ 6,600
Low-Flow Showerheads	6	$ 650	$ 3,900
		TOTAL COST	**$ 24,100**
*Planning cost based on the Honolulu Board of Water Supply conversion of water fixtures for the City and County of Honolulu's municipal facilities to water conserving fixtures, implementation 2001-2003 (includes 20% contingency).			

The water saved for the Kakaako Waterfront Park was estimated at 1,300 gpd for domestic water use alone. This would save the State $2.57 per day ($1.98/1,000 gallons – HBWS water rate), which translates to approximately $77 per month (30 days) or $940 per year. With an initial implementation cost of $24,100, the payback period would be approximately 26 years.

Irrigation Use

Based on discussions with various landscape contractors, the planning cost estimate for the replacement of the irrigation system at the Kakaako Waterfront Park is approximately $1.85 million. The water savings from the new irrigation system was estimated at 14,000 gpd for irrigation use. This translates to $27.72 per day ($1.98/1,000 gallons – HBWS water rate) or an estimated $10,120 per year savings.

Projected Water Savings

The total projected water savings for the Kakaako Waterfront Park is approximately 1,300 gpd for domestic use and 14,000 gpd for irrigation (based on 15% water savings from a new irrigation system), resulting in a total water savings of an estimated 15,300 gpd. This could save the State $30.29 per day ($1.98/1,000 gallons – HBWS water rate), which translates to approximately $909.00 per month (30 days) or $11,100 per year. Of the total projected water savings for the Kakaako Waterfront Park (or $11,100 per year), the water savings for domestic use alone is only approximately $940 per year. This is because of the relatively small percentage of domestic water requirements as compared to irrigation water requirements at the park.

With an initial implementation cost of $1.87 million (approximately $24,100 for domestic use conservation measures plus approximately $1.85 million for irrigation use conservation measures), the payback period would extend beyond the useful life of the park's proposed domestic and irrigation water system improvements. Therefore, replacement of the irrigation system only for water conservation purposes would be infeasible. However, should the irrigation system require major repair or replacement in the future, it would be prudent to implement water conservation measures at that time.

Source: State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management. (2005), *Prototype Water Conservation Plan for the Department of Land and Natural Resources (DLNR),* pgs. 8-18 to 8-28.

Prototype Facility 3: Ala Wai Small Boat Harbor

Background

The Ala Wai Small Boat Harbor (referred to commonly and herein as Ala Wai Harbor) is located between Waikiki and Ala Moana beaches, on the south coast of the island of Oahu. This harbor is designated strictly for "recreational boating activities" (i.e., for the use of watercraft for sports, hobbies, or pleasure), and does not allow moorage for commercial vessels and commercial vessel activities. Encompassing a total of 128 acres, the Ala Wai Harbor includes 699 berths with dock, 85 moorings, one ramp, 22 dry storage spaces, and a fuel dock facility. The harbor also includes a landscaped area less than 0.25 acres, consisting of a sprinkler irrigation system for coconut trees and grass areas. The small sprinkler irrigation systems and hand watering irrigate these landscaped areas. The harbor includes areas used by the Hawaii Yacht Club, the Waikiki Yacht Club, and the Royal Hawaiian Ocean Racing Club.

The Ala Wai Harbor's water system serves the harbor's main office facility, three restroom facilities (comfort stations), boat washdown area, outdoor showers for surfers/beach goers, a small irrigation system, and water connections for individual boat slips in the harbor. The fuel dock facility and the Hawaii Yacht Club are both users of the Ala Wai Harbor water system. The Waikiki Yacht Club leases its site from the Ala Wai Harbor, but is independent from the Ala Wai Harbor's water system with its own water service connection and water meter. The Race Headquarters for the Transpac Honolulu Committee uses an office facility at the harbor for coordination of the Trans-Pac Yacht races; however, there is no water service to the headquarters building. Various repairs have been made over the years to maintain the harbor water system; however, overall the Ala Wai Harbor's water system is antiquated.

During preparation of the DLNR Prototype Water Conservation Plan, a count of the total plumbing fixtures for the Ala Wai Harbor's three (3) comfort stations was conducted based on available construction plans, site inspections, and harbor staff interviews. Given that the fuel dock facility and the Hawaii Yacht Club lease property in the harbor area and utilize the Ala Wai Harbor's water system, a count of the total plumbing fixtures for these facilities was also performed. Finally, a plumbing fixture count was carried out for the rest of the harbor facilities, including the boat washdown facility, piers/docks, and beach shower facilities that are not currently metered. See **Table D-9** below for the plumbing fixture count summaries associated with the various abovementioned facilities.

The largest fixture unit count at the Ala Wai Harbor is from hose bib connections provided by the harbor to serve its users. Hose bib connections account for 88% of all the fixtures in the Ala Wai Harbor, providing water to harbor users such as resident and transient boaters, Hawaii Yacht Club, the fuel dock facility, and boat washdown area. Unfortunately, at the present time there is no way to monitor the water usage at the Ala Wai Harbor's piers/docks and washdown area.

Although the Ala Wai Harbor's landscaped area has a sprinkler irrigation system, no information was available on the irrigation system's fixture unit count.

Table D-9. Ala Wai Small Boat Harbor – Count of Plumbing Fixtures

Fixture Type	Harbor Facility	Number of Fixtures	Fixture Units per Fixture	Fixture Count	Percentage of Total Fixtures
Water Closet (Toilet)	Comfort Stations	27	5	135	4%
	Fuel Dock Facility	2		10	
	Hawaii Yacht Club	6		30	
	Other Facilities Not Metered	2		10	
Urinal	Comfort Stations	9	5	45	2%
	Fuel Dock Facility	1		5	
	Hawaii Yacht Club	3		15	
	Other Facilities Not Metered	1		5	
Lavatory	Comfort Stations	20	2	40	2%
	Fuel Dock Facility	2		4	
	Hawaii Yacht Club	9		18	
	Other Facilities Not Metered	2		4	
Shower	Comfort Stations	17	4	68	2%
	Fuel Dock Facility	2		8	
	Hawaii Yacht Club	0		0	
	Other Facilities Not Metered	4		16	
Basin / Sink	Comfort Stations	3	4	12	1%
	Fuel Dock Facility	1		4	
	Hawaii Yacht Club	5		20	
	Other Facilities Not Metered	1		4	
Hose Bib (Spigot)	Comfort Stations	6	5	30	88%
	Fuel Dock Facility	5		25	
	Hawaii Yacht Club	24		120	
	Other Facilities Not Metered	724		3620	
Drinking Fountain	Comfort Stations	1	2	2	0%
	Fuel Dock Facility	0		0	
	Hawaii Yacht Club	1		2	
	Other Facilities Not Metered	1		2	
Washing Machine	Comfort Stations	0	10	0	1%
	Fuel Dock Facility	5		50	
	Hawaii Yacht Club	0		0	
	Other Facilities Not Metered	0		0	
TOTAL FIXTURE UNITS				**4,304**	**100%**

Recommended Water Conservation Measures

Domestic use (drinking fountains, restroom facilities at comfort stations, water connections for harbor users, and shower facilities for beach goers), boat washdown (washdown facilities and various other harbor operation and maintenance activities), and irrigation use (< 0.25 acres of landscaped areas and the existing small sprinkler irrigation systems and hand watering) are the three primary water uses at the Ala Wai Harbor.

Domestic Use

The water conservation measures recommended for the Ala Wai Harbor included low-consumption flushometer-valve toilets, low-consumption urinals, low-volume faucets, and low-flow showerheads (see **Table D-10**). Drinking fountains and basins/sinks were not considered for such measures because these fixture types represent a small percentage of the total water usage fixtures at the harbor. Additionally, existing drinking fountains are relatively water efficient due to automatic shut-off mechanisms and basins/sinks for custodial services are limited to janitorial staff that can be educated on water conservation measures.

Boat Washdown

The water conservation measures implemented above will affect approximately 40% of the total water usage at the Ala Wai Harbor. The other 60% of total water usage at the harbor is attributed to the harbor users of the piers/docks and hose bib connections, which currently go unmonitored.

Therefore, an additional water conservation measure that should be applied is the installation of additional sub-metering of the boat washdown area, pier/dock fingers, and beach shower facilities for water usage at the piers/docks. While this measure does not have direct water usage savings, it would enable the harbor staff to monitor water usage and properly apply water conservation measures to the harbor facility.

Irrigation Use

No specific water conservation measures were suggested for the harbor's irrigation use as the total landscaped areas are limited in size and do not amount to significant water usage.

Table D-10. Ala Wai Small Boat Harbor – Water Conservation Measures and Devices

Fixture Type	Existing Water Usage	Water Conservation Measure	Conservation Water Usage	Water Savings Percentage (%)
Water Closet (Toilet)	3.5gpf	Low-Consumption Flushometer-Valve Toilets	1.6 gpf	54%
Urinal	3.5 gpf	Low-Consumption Urinals	1 gpf	71%
Lavatory	5 gpm	Low-Volume Faucets (Metering)	0.5 gpm	90%
Shower	3.4 gpm	Low-Flow Showerheads	2.5 gpm	26%
Acronyms: gpf – gallons per flush; gpm – gallons per minute, gpd – gallons per day				

The overall projected water conservation savings for the Ala Wai Harbor are summarized in **Table D-11**.

Table D-11. Ala Wai Small Boat Harbor – Projected Water Conservation Savings

Fixture Type	Total Estimated Water Usage (gpd)	Water Savings Percentage (%)	Total Estimated Water Saved (gpd)
Water Closet (Toilet)	3,600	54%	1,940
Urinal	1,400	71%	990
Lavatory	1,300	90%	1,170
Shower	1,700	26%	440
Basin/Sink	800	n/a	-
Hose Bib (Spigot)	26,400	n/a	-
Drinking Fountain	100	n/a	-
Washing Machine	1,700	n/a	-
TOTALS	**37,000**	**-**	**4,540**
Acronyms: gpd – gallons per day			

Additional

Other water conservation measures that could be applied at the Ala Wai Harbor, which do not have direct water usage savings, include the following:

- Education of custodial staff on water conservation measures;
- Training of maintenance staff on upkeep of low-flow fixtures;
- Education of harbor users with flyers or letters on water conservation measures which they can implement;
- Require automatic shut-off hose nozzles for all boat slip water connections;
- Installation of signs that encourage water conservation in comfort stations or work areas where water is used; and
- Installation of signs with information on who to call should a comfort station/restroom need repair.

Cost-Benefit Analysis of the Recommended Water Conservation Measures

Domestic Use

The implementation cost (including materials and labor) for the proposed water conservation measures at the Ala Wai Harbor is presented in **Table D-12**.

Table D-12. Ala Wai Small Boat Harbor – Projected Cost of Implementing the Domestic Use Water Conservation Measures

Fixture Type	Number of Fixtures	Cost per Fixture*	Estimated Total Fixture Cost
Low-Consumption Flushometer-Valve Toilets	37	$ 610	$ 22,570
Low-Consumption Urinals	14	$ 630	$ 8,820
Low-Volume Faucets (Metering)	33	$ 550	$ 18,150
Low-Flow Showerheads	23	$ 650	$ 14,950
		TOTAL COST	**$ 64,490**
*Planning cost based on the Honolulu Board of Water Supply conversion of water fixtures for the City and County of Honolulu's municipal facilities to water conserving fixtures, implementation 2001-2003 (includes 20% contingency).			

The water saved for the Ala Wai Harbor was estimated at 4,540 gpd for domestic use, mainly from comfort stations/restrooms. This translates to $8.99 per day ($1.98/1,000 gallons – HBWS water rate) or an estimated $3,300 per year savings. With an initial implementation cost approximately of $64,500, the payback period would be approximately 20 years.

Boat Washdown

The most beneficial conservation measure may be the implementation of water sub-metering (with the replacement of the existing water system; however, that would be a major capital improvement cost and would require further study of the harbor's water requirements and existing water system, and was therefore was not considered a recommended measure of the DLNR Prototype Water Conservation Plan.). Sub-meters to monitor water use at the docks/piers could be installed for six docks, several berths, and two showers. The construction cost estimate for installation of seven (7) water sub-meters and boxes to monitor water consumption would be approximately $17,500.

Irrigation Use

As previously mentioned, no specific water conservation measures were suggested for the harbor's irrigation use. Therefore, there is no projected water savings associated with the harbor's irrigation system.

Projected Water Savings

The total projected water savings for the Ala Wai Harbor is 4,540 gpd for domestic use. This could save the State $8.99 per day ($1.98/1,000 gallons – HBWS water rate), which translates to approximately $3,300.00 per year.

Source: State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management. (2005), *Prototype Water Conservation Plan for the Department of Land and Natural Resources (DLNR)*, pgs. 8-29 to 8-43.

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Prototype Facility 4: Honokohau Small Boat Harbor

Background

The Honokohau Small Boat Harbor (referred to commonly and herein as Honokohau Harbor) is located approximately three miles northwest of Kailua-Kona Wharf, on the west coast of the island of Hawaii. The harbor consists of a dredged channel that leads to two basins. Encompassing a total of 142.3 acres, the Honokohau Harbor includes 270 moorings (boat slips), four ramps (two 30-foot wide, two lane ramps), piers A – H, two T-piers, an outer basin, vessel washdown area, fuel facility, harbor office and two comfort stations. The Honokokau Harbor allows commercial operations of recreational tours or activities, as well as recreational boating activities (e.g., use of watercraft for sports, hobbies, or pleasure). The harbor also includes a landscaped area, consisting of a drip irrigation system for approximately 350 coconut trees and naupaka hedges, of approximately 5 acres.

The Honokohau Harbor's water system serves the harbor's main office facility, two comfort stations, vessel washdown area, irrigation system, and water connections for individual boat slips in the harbor. Although the harbor area also includes other buildings (a restaurant complex leased by Gentry, a boat storage facility, a fuel dock leased by Gordon Crabtree, a private sailing club [leased], and a canoe club [leased]) these are separately metered. These facilities have their own water service connections and water meters and are independent from the Honokohau Harbor's water system. Therefore, these facilities were not be addressed by the DLNR Prototype Water Conservation Plan study.

Various repairs have been made over the years to maintain the harbor water system; however, overall the Honokohau Harbor's water system is antiquated.

During preparation of the DLNR Prototype Water Conservation Plan, a count of the total plumbing fixtures for the Honokohau Harbor's two (2) comfort stations and harbor office was conducted based on available construction plans and harbor staff interviews. A plumbing fixture count was also performed for the boat washdown facility and boat slips. See **Table D-13** below for the plumbing fixture count summaries associated with the various abovementioned facilities.

The largest fixture unit count at the Honokohau Harbor is from hose bib connections provided by the harbor to serve its users. Hose bib connections account for 91% of all the fixtures in the Honokohau Harbor, providing water to harbor users such as transient boaters and boat washdown area. Unfortunately, at the present time there is no way to monitor the water usage at the Honokohau Harbor's boat slips and washdown area.

Although the Honokohau Harbor's landscaped area has a drip irrigation system, no information was available on the irrigation system's fixture unit count. The harbor's irrigation system accounts for about 12% of the total water usage at the harbor. According to the harbor staff, the existing irrigation system is drip and is relatively efficient.

Table D-13. Honokohau Small Boat Harbor – Count of Plumbing Fixtures

<table>
<tr><th>Fixture Type</th><th>Harbor Facility</th><th>Number of Fixtures</th><th>Fixture Units per Fixture</th><th>Fixture Count</th><th>Percentage of Total Fixtures</th></tr>
<tr><td rowspan="2">Water Closet (Toilet)</td><td>Comfort Stations & Harbor Office</td><td>16</td><td rowspan="2">5</td><td>80</td><td rowspan="2">5%</td></tr>
<tr><td>Boat Washdown & Boat Slips</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Urinal</td><td>Comfort Stations & Harbor Office</td><td>5</td><td rowspan="2">5</td><td>25</td><td rowspan="2">2%</td></tr>
<tr><td>Boat Washdown & Boat Slips</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Lavatory</td><td>Comfort Stations & Harbor Office</td><td>16</td><td rowspan="2">2</td><td>32</td><td rowspan="2">2%</td></tr>
<tr><td>Boat Washdown & Boat Slips</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Shower</td><td>Comfort Stations & Harbor Office</td><td>1</td><td rowspan="2">4</td><td>4</td><td rowspan="2">0%</td></tr>
<tr><td>Boat Washdown & Boat Slips</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Basin / Sink</td><td>Comfort Stations & Harbor Office</td><td>1</td><td rowspan="2">4</td><td>4</td><td rowspan="2">0%</td></tr>
<tr><td>Boat Washdown & Boat Slips</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Hose Bib (Spigot)</td><td>Comfort Stations & Harbor Office</td><td>12</td><td rowspan="2">5</td><td>60</td><td rowspan="2">91%</td></tr>
<tr><td>Boat Washdown & Boat Slips</td><td>280</td><td>1,400</td></tr>
<tr><td rowspan="2">Drinking Fountain</td><td>Comfort Stations & Harbor Office</td><td>3</td><td rowspan="2">2</td><td>6</td><td rowspan="2">0%</td></tr>
<tr><td>Boat Washdown & Boat Slips</td><td>0</td><td>0</td></tr>
<tr><td colspan="4">TOTAL FIXTURE UNITS</td><td>1,611</td><td>100%</td></tr>
</table>

Recommended Water Conservation Measures

Domestic use (drinking fountains, restroom facilities at comfort stations, water connections for harbor users, and shower facilities for beach goers), boat washdown (washdown facilities and various other harbor operation and maintenance activities), and irrigation use (landscaped areas and a drip irrigation system) are the three primary water uses at the Honokohau Harbor.

Domestic Use

The water conservation measures recommended for the Honokohau Harbor included low-consumption flushometer-valve toilets, low-consumption urinals, low-volume faucets, and low-flow showerheads (see **Table D-14**). Drinking fountains and basins/sinks were not considered for water conservation measures because these fixture types represent a small percentage of the total water usage fixtures at the harbor. Additionally, existing drinking fountains are relatively water efficient due to automatic shut-off mechanisms and basins/sinks for custodial services are limited to janitorial staff that can be educated on water conservation measures.

Boat Washdown & Irrigation Use

The water conservation measures implemented above will affect approximately 3% of the total water usage at the Honokohau Harbor. The other 97% of total water usage at the harbor is attributed to the harbor users of the boat slips, boat washdown areas using spigots, and landscape irrigation.

Therefore, an additional water conservation measure that should be applied is the sub-metering of the boat washdown area, pier/dock fingers, and irrigation system, along with installation of auto shut-off nozzles. While this measure does not have direct water usage savings, it would enable the harbor staff to monitor water usage and properly apply water conservation measures to the harbor facility.

Table D-14. Honokohau Small Boat Harbor – Water Conservation Measures and Devices

Fixture Type	Existing Water Usage	Water Conservation Measure	Conservation Water Usage	Water Savings Percentage (%)
Water Closet (Toilet)	3.5gpf	Low-Consumption Flushometer-Valve Toilets	1.6 gpf	54%
Urinal	3.5 gpf	Low-Consumption Urinals	1 gpf	71%
Lavatory	5 gpm	Low-Volume Faucets (Metering)	0.5 gpm	90%
Shower	3.4 gpm	Low-Flow Showerheads	2.5 gpm	26%
Acronyms: gpf – gallons per flush; gpm – gallons per minute, gpd – gallons per day				

The overall projected water conservation savings for the Honokohau Harbor are summarized in **Table D-15**.

Table D-15. Honokohau Small Boat Harbor – Projected Water Conservation Savings

Fixture Type	Total Estimated Water Usage (gpd)	Water Savings Percentage (%)	Total Estimated Water Saved (gpd)
Water Closet (Toilet)	5,100	54%	2,800
Urinal	1,600	71%	1,100
Lavatory	2,000	90%	1,800
Shower	300	26%	100
Basin/Sink	300	n/a	-
Hose Bib (Spigot)	92,800	n/a	-
Drinking Fountain	400	n/a	-
Existing Irrigation System/ Existing Landscaping	14,000	n/a	-
TOTALS	**116,500**	**-**	**5,800**
Acronyms: gpd – gallons per day			

Additional

Other water conservation measures that could be applied at the Honokohau Harbor, which do not have direct water usage savings, include the following:

- Education of custodial staff on water conservation measures;
- Training of maintenance staff on upkeep of low-flow fixtures;
- Education of harbor users with flyers or letters on water conservation measures which they can implement;
- Require automatic shut-off hose nozzles for all boat slip water connections;
- Installation of signs that encourage water conservation in comfort stations or work areas where water is used; and
- Installation of signs with information on who to call should a comfort station/restroom need repair.

Cost-Benefit Analysis of the Recommended Water Conservation Measures

Domestic Use

The implementation cost (including materials and labor) for the proposed water conservation measures at the Honokohau Harbor is presented in **Table D-16**.

Table D-16. Honokohau Small Boat Harbor– Projected Cost of Implementing the Domestic Use Water Conservation Measures

Fixture Type	Number of Fixtures	Cost per Fixture*	Estimated Total Fixture Cost
Low-Consumption Flushometer-Valve Toilets	16	$ 610	$ 9,760
Low-Consumption Urinals	5	$ 630	$ 3,150
Low-Volume Faucets (Metering)	16	$ 550	$ 8,800
Low-Flow Showerheads	1	$ 650	$ 650
		TOTAL COST	**$ 22,360**
*Planning cost based on the Honolulu Board of Water Supply conversion of water fixtures for the City and County of Honolulu's municipal facilities to water conserving fixtures, implementation 2001-2003 (includes 20% contingency).			

The water saved for the Honokohau Harbor was estimated at 5,800 gpd for domestic use, mainly from comfort stations/restrooms. This translates to $16.24 per day ($2.80/1,000 gallons – County of Hawaii's Department of Water Supply [DWS] water rate) or an estimated $5,900 per year savings. With an initial implementation cost of approximately $22,400, the payback period would be approximately 4 years.

Boat Washdown & Irrigation Use

The most beneficial conservation measure may be the implementation of water sub-metering (with the replacement of the existing water system; however, that would be a major capital improvement cost and would require further study of the harbor's water requirements and existing water system, and was therefore was not considered a recommended measure of the DLNR Prototype Water Conservation Plan.). Sub-meters to monitor water use at the boat slips could be installed for piers A – H and two T-piers. The construction cost estimate for installation of five (5) water sub-meters and boxes to monitor water consumption would be approximately $12,500.

As previously mentioned, the existing irrigation system is drip and is relatively efficient according to the harbor staff.

Projected Water Savings

The total projected water savings for the Honokohau Harbor is 5,800 gpd for domestic use. This could save the State $16.24 per day ($2.80/1,000 gallons – DWS water rate), which translates to approximately $5,900.00 per year.

Source: State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management. (2005), *Prototype Water Conservation Plan for the Department of Land and Natural Resources (DLNR),* pgs. 8-43 to 8-55.

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Prototype Facility 5: Division of Forestry and Wildlife Hilo Baseyard Complex

Background

The Division of Forestry and Wildlife (DOFAW) Hilo Baseyard Complex (referred to commonly and herein as Hilo Baseyard) is located on the east side of the island of Hawaii. The Hilo Baseyard consists of several government agency facilities that serve various functions including general office use, vehicle and equipment repair, and a nursery/arboretum. The facility is shared with other government agencies, including the USDA Forest Services and the DLNR State Parks Division.

The Hilo Baseyard's water system serves the DOFAW main office building, fire control storage building, fuel station facility, arboretum, nursery, and three residential houses on the property that serve as office/storage, residence for DOFAW interns, and residence for the baseyard's manager. Consisting of the nursery and arboretum with a sprinkler irrigation system, the baseyard's landscaped area covers approximately 1 acre. The irrigation system utilized at the baseyard is a manual irrigation system; therefore, baseyard staff controls the irrigation of the nursery/arboretum.

The DOFAW leases office and warehouse space to the USDA Forest Services. The DLNR State Parks Division rents space in a building on the property, but is independent from the Hilo Baseyard's water system with its own water service connection and water meter. According to the State Parks' staff, the facility's maintenance building is used to store park supplies and the only water service provided at this building is one hose bib.

During preparation of the DLNR Prototype Water Conservation Plan, a count of the total plumbing fixtures for the Hilo Baseyard DOFAW facilities was conducted based on available construction plans and staff interviews. A plumbing fixture count was also performed for the USDA Forest Services facilities. See **Table D-17** below for the plumbing fixture count summaries associated with the various abovementioned facilities.

Although the Hilo Baseyard's landscaped area has a sprinkler irrigation system, no information was available on the irrigation system's fixture unit count.

Table D-17. DOFAW Hilo Baseyard Complex – Count of Plumbing Fixtures

<table>
<tr><th>Fixture Type</th><th>Harbor Facility</th><th>Number of Fixtures</th><th>Fixture Units per Fixture</th><th>Fixture Count</th><th>Percentage of Total Fixtures</th></tr>
<tr><td rowspan="2">Water Closet (Toilet)</td><td>DOFAW Facilities</td><td>11</td><td rowspan="2">5</td><td>55</td><td rowspan="2">21%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>1</td><td>5</td></tr>
<tr><td rowspan="2">Urinal</td><td>DOFAW Facilities</td><td>2</td><td rowspan="2">5</td><td>10</td><td rowspan="2">5%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>1</td><td>5</td></tr>
<tr><td rowspan="2">Lavatory</td><td>DOFAW Facilities</td><td>11</td><td rowspan="2">2</td><td>22</td><td rowspan="2">9%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>1</td><td>2</td></tr>
<tr><td rowspan="2">Shower</td><td>DOFAW Facilities</td><td>8</td><td rowspan="2">4</td><td>32</td><td rowspan="2">11%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Basin / Sink</td><td>DOFAW Facilities</td><td>4</td><td rowspan="2">4</td><td>16</td><td rowspan="2">9%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>2</td><td>8</td></tr>
<tr><td rowspan="2">Hose Bib (Spigot)</td><td>DOFAW Facilities</td><td>19</td><td rowspan="2">5</td><td>95</td><td rowspan="2">39%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>3</td><td>15</td></tr>
<tr><td rowspan="2">Drinking Fountain</td><td>DOFAW Facilities</td><td>1</td><td rowspan="2">2</td><td>2</td><td rowspan="2">1%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>1</td><td>2</td></tr>
<tr><td rowspan="2">Washing Machine</td><td>DOFAW Facilities</td><td>1</td><td rowspan="2">10</td><td>10</td><td rowspan="2">4%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">Dishwasher</td><td>DOFAW Facilities</td><td>1</td><td rowspan="2">4</td><td>4</td><td rowspan="2">1%</td></tr>
<tr><td>USDA Forest Services Facilities</td><td>0</td><td>0</td></tr>
<tr><td colspan="4">TOTAL FIXTURE UNITS</td><td>283</td><td>100%</td></tr>
</table>

Recommended Water Conservation Measures

Domestic use (drinking fountains, showers, and restroom facilities), facility operation and maintenance (equipment washdown and various other facility activities), and irrigation use (landscaped areas and an existing sprinkler irrigation system) are the three primary water uses at the Ala Wai Harbor.

Domestic Use & Facility Operation and Maintenance

The DOFAW staff currently occupies a new office complex built in 1998. The new Hilo Baseyard office complex is equipped with water-conserving fixtures; therefore, water conservation retrofits for the office complex fixtures will not be necessary.

The water conservation measures recommended for the rest of the Hilo Baseyard included low-consumption flushometer-valve toilets, low-consumption urinals, low-volume faucets, and low-flow showerheads (see **Table D-18**).

Irrigation Use

The current irrigation system for the baseyard and nursery is manually operated and accounts for a small percentage of the total water use at the baseyard. According to baseyard staff, the irrigation system is minimally operated because of the ample rainfall that is typical of the Hilo area. Therefore, no specific water conservation measures were suggested for the baseyard's irrigation use. However, sub-metering of the irrigation system could account for the water usage of the nursery and arboretum.

Table D-18. DOFAW Hilo Baseyard Complex – Water Conservation Measures and Devices

Fixture Type	Existing Water Usage	Water Conservation Measure	Conservation Water Usage	Water Savings Percentage (%)
Water Closet (Toilet)	3.5gpf	Low-Consumption Flushometer-Valve Toilets	1.6 gpf	54%
Urinal	3.5 gpf	Low-Consumption Urinals	1 gpf	71%
Lavatory	5 gpm	Low-Volume Faucets (Metering)	0.5 gpm	90%
Shower	3.4 gpm	Low-Flow Showerheads	2.5 gpm	26%
Acronyms: gpf – gallons per flush; gpm – gallons per minute, gpd – gallons per day				

The overall projected water conservation savings for the Hilo Baseyard are summarized in **Table D-19**.

Table D-19. DOFAW Hilo Baseyard Complex – Projected Water Conservation Savings

Fixture Type	Total Estimated Water Usage (gpd)	Water Savings Percentage (%)	Total Estimated Water Saved (gpd)
Water Closet (Toilet)	700	54%	380
Urinal	170	71%	120
Lavatory	280	90%	250
Shower	370	26%	100
Basin/Sink	280	n/a	-
Hose Bib (Spigot)	1,280	n/a	-
Drinking Fountain	50	n/a	-
Washing Machine	120	n/a	-
Dishwasher	50	n/a	-
TOTALS	**3,300**	**-**	**850**
Acronyms: gpd – gallons per day			

Additional

Other water conservation measures that could be applied at the Hilo Baseyard, which do not have direct water usage savings, include the following:

- Education of employees on water conservation measures;
- Education of baseyard staff on water conservation measures that can be implemented (e.g. automatic shut-off hose nozzles);

- Installation of signs that encourage water conservation in restroom facilities or work areas where water is used; and
- Installation of signs with information on who to call should a restroom facility need repair.

Cost-Benefit Analysis of the Recommended Water Conservation Measures

Domestic Use & Facility Operation and Maintenance

The implementation cost (including materials and labor) for the proposed water conservation measures at the Hilo Baseyard is presented in **Table D-20**.

Table D-20. DOFAW Hilo Baseyard Complex – Projected Cost of Implementing the Domestic Use Water Conservation Measures

Fixture Type	Number of Fixtures	Cost per Fixture*	Estimated Total Fixture Cost
Low-Consumption Flushometer-Valve Toilets	12	$ 610	$ 7,320
Low-Consumption Urinals	3	$ 630	$ 1,890
Low-Volume Faucets (Metering)	12	$ 550	$ 6,600
Low-Flow Showerheads	12	$ 650	$ 7,800
		TOTAL COST	**$ 23,610**
*Planning cost based on the Honolulu Board of Water Supply conversion of water fixtures for the City and County of Honolulu's municipal facilities to water conserving fixtures, implementation 2001-2003 (includes 20% contingency).			

The water saved for the Hilo Baseyard was estimated at 850 gpd for domestic use, including restroom facilities and operations and maintenance facilities. This translates to $2.38 per day ($2.80/1,000 gallons – DWS water rate) or an estimated $900 per year savings. With an initial implementation cost of approximately $23,600, the payback period would be an estimated 26 years.

Irrigation Use

The construction cost estimate for installation of one water sub-meter and box to monitor irrigation water consumption would be approximately $2,500.

Projected Water Savings

The total projected water savings for the Hilo Baseyard is 850 gpd for domestic use. This could save the State $2.38 per day ($2.80/1,000 gallons – DWS water rate), which translates to approximately $900.00 per year.

Source: State of Hawaii, Department of Land and Natural Resources, Commission on Water Resource Management. (2005), *Prototype Water Conservation Plan for the Department of Land and Natural Resources (DLNR)*, pgs. 8-56 to 8-66.

Acronyms

Acronym	Definition
DOFAW	Division of Forestry and Wildlife
DLNR	Department of Land and Natural Resources
DWS	County of Hawaii's Department of Water Supply
gpd	gallons per day
HBWS	Honolulu Board of Water Supply
USDA	United States Department of Agriculture

Appendix E

Water Audit Forms

WATER AUDIT WORKSHEET

For: ______________________ Audit Study Period: ______________________

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Units*
Task 1—Measure Supply				
1	Uncorrected total water supply to the distribution system (total of master meters)	______	______	______
2A-C	Adjustments to total water supply			
2A	Source meter error (+ or –)	______	______	______
2B	Change in reservoir and tank storage (+ or –)	______	______	______
2C	Other contributions or losses (+ or –)	______	______	______
3	Total adjustments to total water supply (add lines 2A, 2B, and 2C)	______	______	______
4	Adjusted total water supply to the distribution system (add line 1 and line 3)	______	______	______
Task 2—Measure Metered Use				
5	Uncorrected total metered water use	______	______	______
6	Adjustments due to meter reading lag time (+ or –)	______	______	______
7	Metered deliveries (add lines 5 and 6)	______	______	______
8A-C	Total sales meter error and system-service meter errors (+ or –)			
8A	Residential meter error	______	______	______
8B	Large meter error	______	______	______
8C	Total (add line 8A and 8B)	______	______	______
9	Corrected total metered water deliveries (add lines 7 and 8C)	______	______	______
10	Corrected total unmetered water (subtract line 9 from line 4)	______	______	______
11A-M	Authorized unmetered water uses			
11A	Firefighting and firefighting training	______	______	______
11B	Main flushing	______	______	______

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Units*
11A-M	Authorized unmetered water uses (continued)			
11C	Storm drain flushing	______	______	______
11D	Sewer cleaning	______	______	______
11E	Street cleaning	______	______	______
11F	Schools	______	______	______
11G	Landscaping in large public areas:			
	Parks	______	______	______
	Golf courses	______	______	______
	Cemeteries	______	______	______
	Playgrounds	______	______	______
	Highway median strips	______	______	______
	Other landscaping	______	______	______
11H	Decorative water facilities	______	______	______
11I	Swimming pools	______	______	______
11J	Construction sites	______	______	______
11K	Water quality and other testing (pressure testing pipe, water quality, etc.)	______	______	______
11L	Process water at treatment plants	______	______	______
11M	Other unmetered uses	______	______	______
12	Total authorized unmetered water (add lines 11A through 11M)	______	______	______
13	Total water losses (subtract line 12 from line 10)	______	______	______
14A-H	Identified water losses			
14A	Accounting procedure errors	______	______	______
14B	Illegal connections	______	______	______
14C	Malfunctioning distribution system controls	______	______	______
14D	Reservoir seepage and leakage	______	______	______
14E	Evaporation	______	______	______

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

Form continues on next page.

Line	Item	Water Volume: Subtotal	Water Volume: Total Cumulative	Water Volume: Units*
14A-H	Identified water losses (continued)			
14F	Reservoir overflow	________	________	________
14G	Discovered leaks	________	________	________
14H	Theft	________	________	________
15	Total identified water losses (add lines 14A through 14H)	________	________	________
16	Potential water system leakage (subtract line 15 from line 13)	________	________	________
17	Recoverable leakage (multiply line 16 by 0.75)	________	________	________

Line	Item	Dollars per Unit of Volume
18A-B	Cost savings	
18A	Cost of water supply	________________
18B	Variable operation and maintenance costs	________________
19	Total costs per unit of recoverable leakage (add line 18A and line 18B)	________________

Line	Item	Dollars per Year
20	One-year benefit from recoverable leakage (multiply line 17 by line 19)	________________
21	Total benefits from recovered leakage (multiply line 20 by 2)	________________
22	Total costs of leak detection project	________________
23	Benefit to cost ratio (divide line 21 by line 22)	________________

Prepared by:

Name ____

Title ____ Date ______________

NOTE: 1 ac-ft = 43,560 ft^3 = 325,851 gal.

*Units of measure must be consistent throughout the worksheet. The particular unit used (that is, acre-feet, millions of gallons, cubic feet, cubic metres, or other unit) is left to the user.

IRRIGATION AUDIT DATASHEET

Auditor	Site Name	Date/Time
	Address	

SITE INSPECTION

Zone #	Broken Heads	Mis-aligned Head	Sunken head	High pressure	Low pressure	Mixed Head Type	Comments
1							
2							
3							
4							
5							
6							
7							
8							

CATCH CAN RESULTS

Zone #	1	2	3	4	5	6	7	8
Test Run Time (minutes)								
Catch Can Depth (inches)								
Precipitation Rate (in./hr) = Average Can Depth (inches) ÷ Test Run Time (minutes) x 60	Precipitation Rate (inches/hour)							

Root Zone Depth (inches)	Soil Type			Landscape Area (square feet)
	Clay	Loam	Sand	