# water efficiency MANUAL

*for Commercial, Industrial, and Institutional Facilities*


BY:

North Carolina Department of Environment and Natural Resources
North Carolina Division of Pollution Prevention and Environmental Assistance
North Carolina Division of Water Resources
Land-of-Sky Regional Council - WRATT Program

Editor’s note:

I’ve inserted full table pages in this version to supplement the charts that failed to transfer properly to PDF.  Each additional page will display immediately in front of the corresponding damaged page.

# water efficiency MANUAL

## *for Commercial, Industrial, and Institutional Facilities*

*A joint publication of the Division of Pollution Prevention and Environmental Assistance and Division of Water Resources of the North Carolina Department of Environment and Natural Resources, and Land-of-Sky Regional Council.*

*August 1998*



*State of North Carolina*

*James B. Hunt, Jr., Governor*
*Wayne McDevitt, Secretary of the Department of Environment and Natural Resources*
*Gary Hunt, Director of the Division of Pollution Prevention and Environmental Assistance*
*John Morris, Director of the Division of Water Resources*

*Printed under contract with the Land-of-Sky Regional Council, Asheville, North Carolina.*

*Printed on recycled paper.*

# When to Use This Guide

**Now,** to determine what you can do reduce water use, improve efficiency, and save money in your operations.

**As you plan and budget for next year,** to determine what programs, equipment, and employee participation will be necessary to use water more efficiently.

**Before you purchase** any new water-using domestic fixtures, cooling, heating, process, landscaping, and facility support equipment and service contracts.

**Before you seek buy-in and support** from your management, maintenance, and production personnel. They also should read this manual.

**Before any facility upgrading, new construction,** processing expansions, and new product manufacturing.

**During unforeseeable water shortages,** drought conditions, or voluntary/mandatory water conservation requirements.

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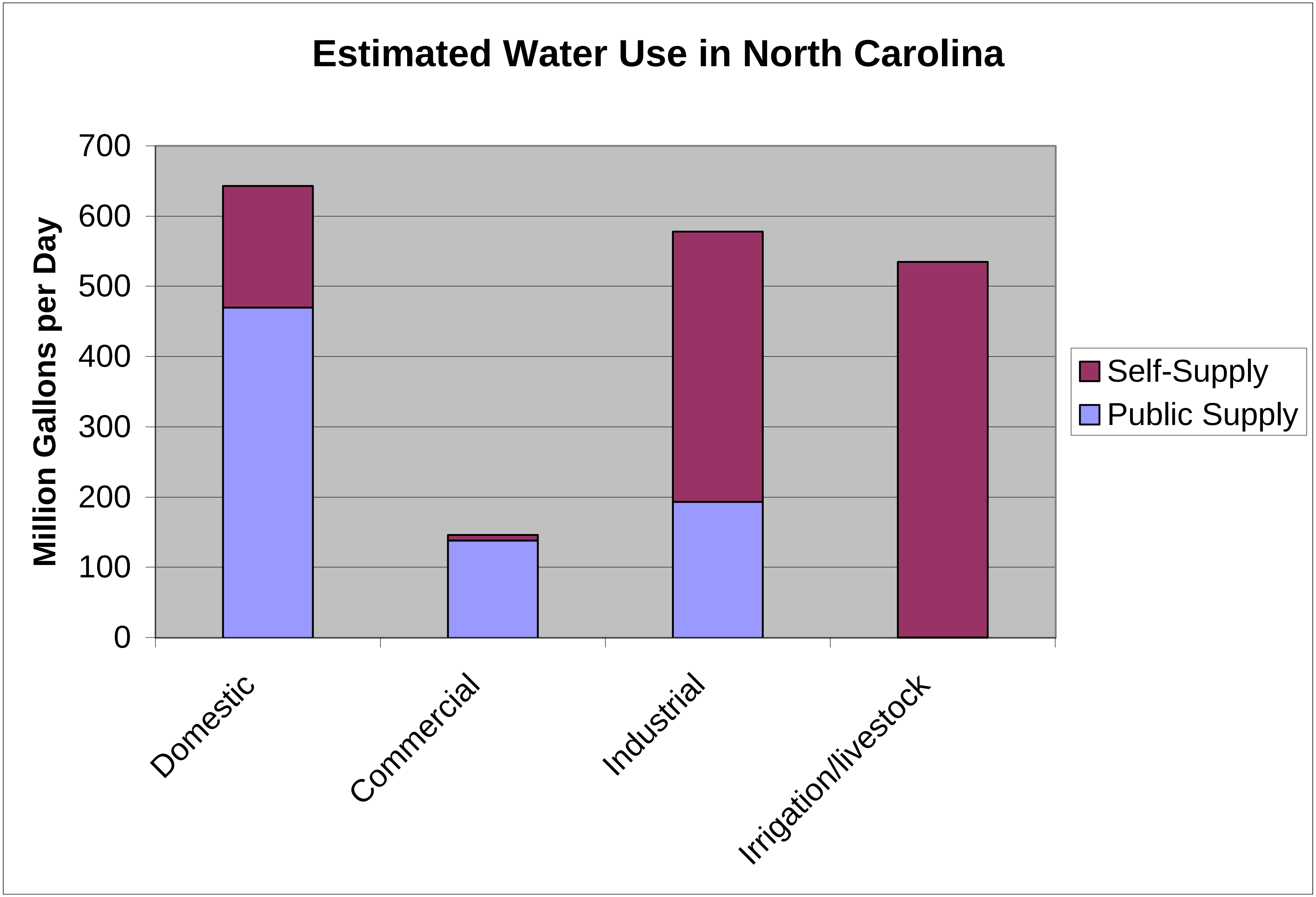
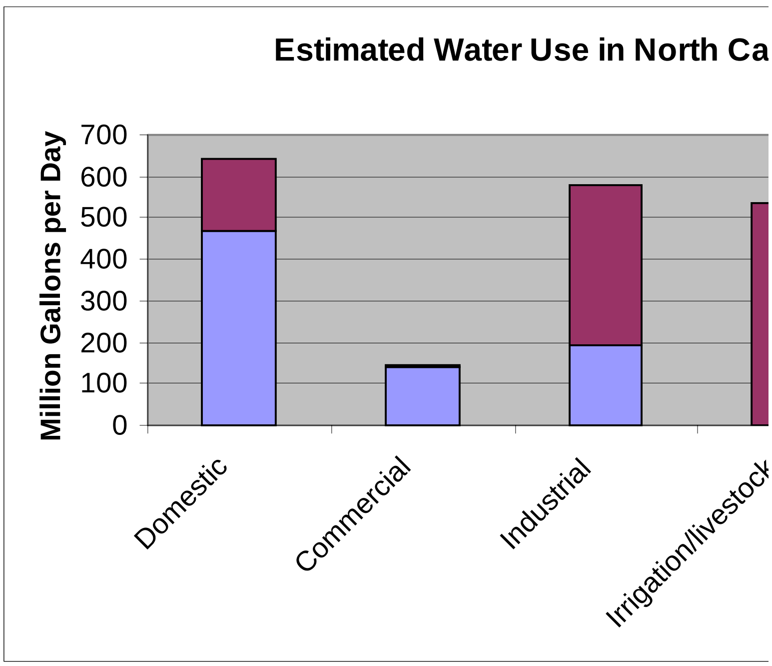

Estimated Water Use in North Carolina
Million Gallons per Day
700
600
500
400
300
200
100
0
Domestic
Commercial
Industrial
Irrigation/livestock
Self-Supply
Public Supply

# Reasons for Water Efficiency Efforts

FIGURE 1

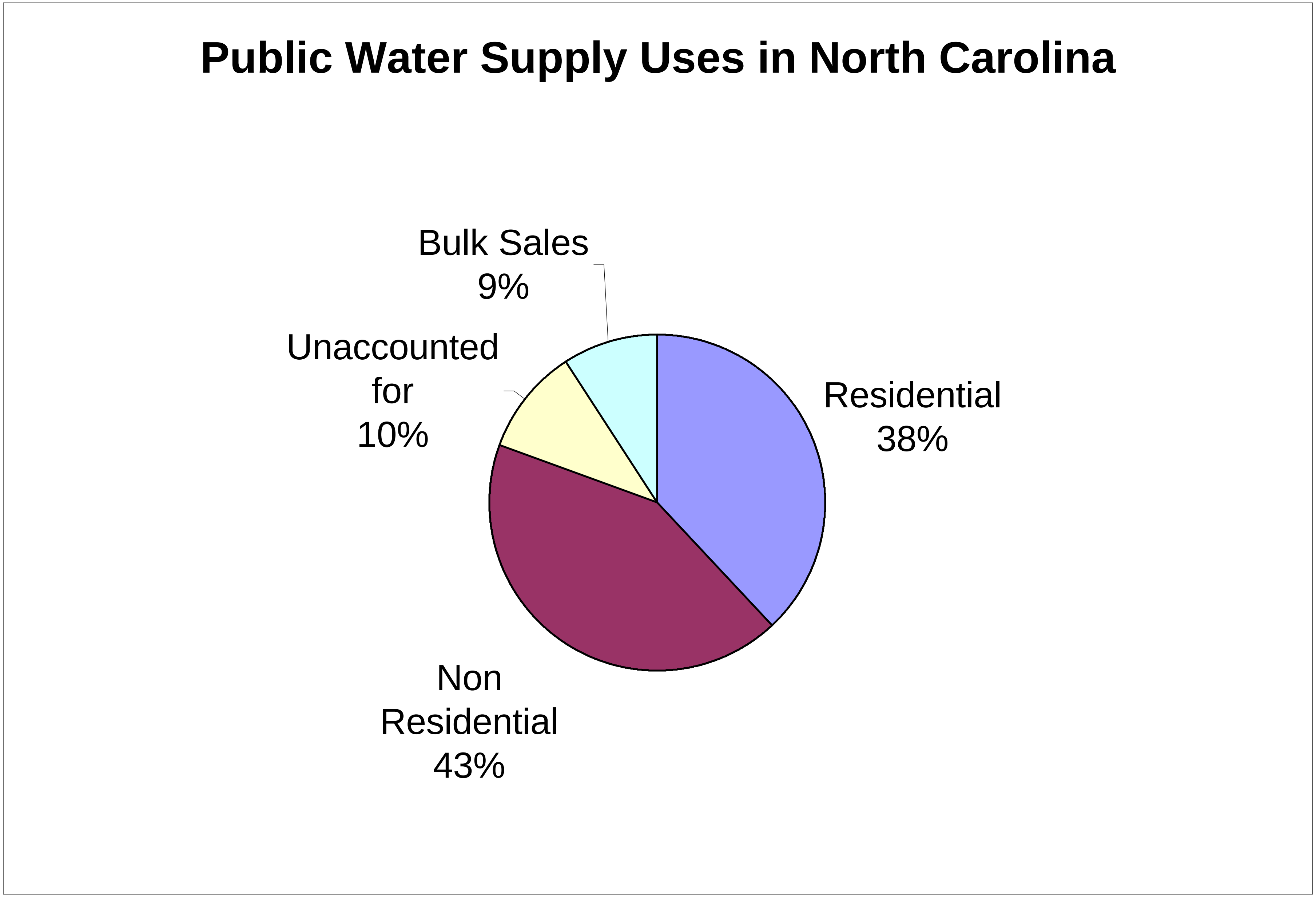



Source: United States Geological Survey, 1995.

## Water Issues in North Carolina

North Carolina is fortunate in having generally abundant water resources. These resources must meet ever increasing water supply demands as North Carolina continue to grow at impressive rates. From 1990 to 1997, statewide population increased by almost 800,000 to 7,428,194, an increase of 12 percent. Some areas of the state actually experienced population increases of 20 to 30 percent for that same period. In the future, maintaining adequate water supplies will require better planning by water systems and more efficient water use by all users.

Certain areas of the state are already facing water supply planning challenges, particularly the coastal plain. In the central coastal plain, ground water levels have dropped dramatically in response to increased pumping, possibly limiting the available ground water supply for future


Public Water Supply Uses in North Carolina
Bulk Sales 9%
Unaccounted for 10%
Residential 38%
Non Residential 43%

use. Elsewhere across the state, numerous water systems are experiencing demands that are approaching their available supply. Some situations are due to limited water resources; others are due to inadequate water treatment capacity to meet peak water needs. Regardless, their ability to produce additional potable water is constrained.

According to the University of North Carolina Water Resources Research Institute (WRRI), approximately 4 million North Carolinians rely on ground water for water supply, and about 3.2 million depend on surface water. Excluding water use by thermoelectric power plants, 1333 million gallons per day (mgd) of surface water and 535 mgd of ground water are withdrawn to meet water domestic, commercial, industrial, mining, irrigation, and livestock demands. Of this 1868 mgd total demand, approximately 769 mgd are delivered by public water supply systems. The remainder is self-supplied.

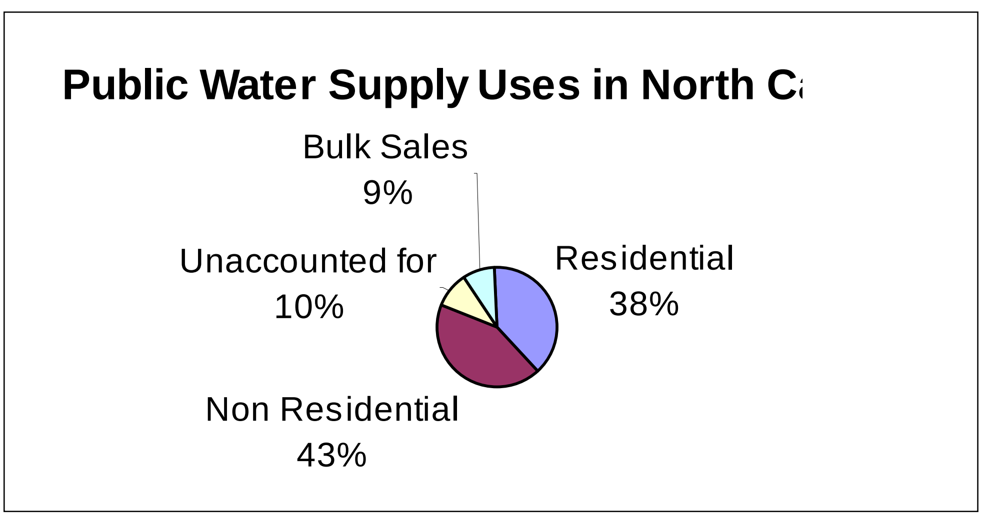
## Industrial, Commercial, and Institutional Water Use

Information in the 1992 Local Water Supply Plans indicated non-residential uses of water, consisting of commercial, industrial, and institutional sectors, that totaled 322 mgd. This represents about 43 percent of the average daily demand of the systems submitting plans. *(See Figure 2.)* Commercial, industrial, and institutional water demands can make up a larger percentage of total demand for some municipal water systems. These "non-residential" uses can have a significant

### Benefits of Water Efficiency Programs

- **Reduced Water Demand**
  Generally faster, cheaper, and easier than supply-side programs.
- **Water and Wastewater Treatment Saving**
  Reduces costs and defers plant expansion.
- **Less Environmental Impact**
  Due to less surface and subsurface withdrawals.
- **Sustained Water Quality**
  Reduces groundwater's contaminant intrusion and curtails demand for new supplies that are of lower quality.

FIGURE 2




Source: 1992 Public Water Supply Plans, North Carolina Division of Water Resources.

## efficiency vs. conservation

"Water efficiency" means using improved technologies and practices that deliver equal or better service with less water. For example, the use of low flow faucet aerators can be more powerful than no aerators for washing hands. "Water conservation" has been associated with curtailment of water use and doing "less" with less water, typically during a water shortage, such as a drought. For example, minimizing lawn watering and automobile washing in order to conserve water. Water conservation also includes day-to-day "demand management" to better manage how and when water is used, so it is common to hear the words "water conservation" used synonymously with "water efficiency."

effect on local water demands. In the 1992 local plans, non-residential demand accounted for over half of average daily demand for 87 systems, with 29 systems having non-residential demand at least 70 percent of average demand.

The commercial and industrial sectors also use a great deal of water that is self-supplied from surface and ground water sources. The USGS estimated these sectors used 377 mgd of self-supplied water in 1995 (excluding thermoelectric power uses). The commercial sector accounted for about 8 mgd of that total. The mining, irrigation, and livestock sectors of the economy also use self-supplied water. In 1995, mining used 16 mgd, irrigation used 239 mgd, and livestock used 297 mgd from ground and surface water sources.

## Local and State Responses to Water Supply Issues

As a result of increasing water supply demands, municipalities and water and sewer districts are implementing water efficiency programs. These programs range from including water efficiency tips in water bills to hiring staff to actively promote and implement water conservation/efficiency programs. A common target of such programs is reduction and management of peak water demands. These programs are intended to extend the life of existing raw water supplies, postpone investment in infrastructure expansions, and minimize the impacts of water shortages such as droughts. Benefits of water efficiency programs include reduced water demand, savings in water and wastewater treatment costs, reduced environmental effect, and protection of high quality water sources.

Water rate structures can greatly influence efficiency efforts. The feasibility of implementing efficiency options depends on the analysis of the expected payback period, a key component of which is the cost of water. Trends during the past 10 years show many municipalities are moving away from traditional "declining block" rate structures which charge less per unit as users consume more. Alternative rate structures, such as "uniform" and "increasing block" make efficiency measures more economically advantageous. Still, about half of large municipalities use declining block rates which offer little economic incentive for conservation.

In response to water supply issues that arose during serious droughts in the late 1980s, North Carolina now requires each local government water system to prepare a local water supply plan and to update that plan at least every five years. Local water supply plans include evaluations of current and future system demands, current and future water supplies, and an accounting of water use by sector for the reporting year. The preparation of these plans provides system managers and community officials the opportunity to evaluate the ability of their water system and supply sources to meet current and future demands.

When evaluating these water supply plans, the Division of Water Resources (DWR) is encouraging systems for which average daily demands exceed 80 percent of their available supply to develop a plan to manage and meet future demands. More than 500 systems submitted water supply plans for the calendar year 1992. For 1992, about 10 percent of these systems had demands that exceeded 80 percent of supply. However, more than 20 percent of these systems project demand exceeding 80 percent of supply by 2020.

In evaluating options for meeting future demand, DWR strongly encourages systems to incorporate ways to use available water supplies more efficiently.

## Coordinated Efficiency Efforts

Conservation/efficiency efforts need to be coordinated among the municipalities and districts that share river basins and aquifers. North Carolina has been taking steps to improve the accountability and coordination of water use in the state. In 1989, the General Assembly passed a bill that addresses local and state water supply planning. Several bills and rules related to water management have been and are being passed and adopted. They include the reuse of reclaimed wastewater, water supply watershed protection, the Water Use Act, the Coastal Area Management Act, and Basinwide Water Quality Planning.

## Water Efficiency Demand-Side Programs

Nationally, water efficiency programs for the commercial and industrial sectors have been established in several state and local water resources departments for many years. These programs have achieved billions of gallons of accumulative water savings and have proven to be cost effective to both public and private sectors. Programs include activities such as on-site audits, guidebooks, seminars, conservation planning, employee education, advisory committees, trade shows expositions, awards, financial incentives/assistance, ordinances, regulations, research studies, and industrial reuse programs. While these programs have been well developed in various locations in California, Phoenix, Tucson, Seattle, Boston, and New York City, only a few programs exist in North Carolina.

## Roles and Responsibilities in Water Efficiency

When public water supply systems are reaching capacity limits, both public and private sectors have important roles to play. Public water conservation programs must address leaks and "unaccounted for" water use, drought planning, water efficiency awareness and communications, and residential program coordination; enact appropriate billing structures; and serve as role models for water use efficiency in public facilities.

The private sector also should think about conserving water. When industrial and commercial facilities use water more efficiently, it saves money while helping the environment. Many facility managers may view water efficiency measures as actions necessary only in droughts, but there are many important reasons to continually use water efficiently. These driving factors include: preservation of quality water supplies, both surface and groundwater; cost savings in water, sewer, chemical treatment, and energy; production expansion without increased water use; and delaying the need for new water supplies.

# 2 Sound Principles of Water Management

*Optimizing facility water use means more than conducting an in-plant study and preparing a report. Water efficiency measures must be viewed holistically within a business' strategic planning. Firms that use water more efficiently now will have a competitive advantage over companies that choose to wait. A successful program must prioritize needs, set well-informed goals, establish current performance minimums, and carefully plan a course for action. Consider these principles when establishing water efficiency initiatives.*

## Categories of Water Efficiency Measures

- Reducing losses (e.g. fixing leaking hose nozzles)
- Reducing overall water use (e.g. shutting off process water when not in use)
- Employing water reuse practices (e.g. reusing washwater)

## changing behavior vs. equipment

Equipment changes may be viewed as a "permanent fix" to achieve water efficiency. Changing employee behaviors, such as an operating procedure, may be viewed as a quick and inexpensive way to achieve similar savings without up-front capital expense. In reality, both the technical and human side of water management issues must be addressed. Consistent training and awareness in combination with proper tools and equipment will achieve more permanent water savings.

## Prioritizing Needs and Setting Goals

Before considering any water efficiency measure, management must first ensure water use performance is consistent with:

- Public health sanitation requirements such as the United States Department of Agriculture (USDA), the Food and Drug Administration (FDA), and state and local health regulations.
- Environmental requirements such as water quality reuse rules and criteria.
- Other health and safety requirement, such as state and local building codes and fire safety codes.
- Customer quality expectations, such as product cleanliness specifications.

Closer examination of the above requirement may lead to more water-efficient ways to achieve and exceed health, safety, and customer quality requirements. With the above priority established, consider the following suggestions before embarking on program goal setting.

- Any program should include water supply and wastewater utilities in the process. Involving utilities can help align water use goals for both water users and suppliers. Utilities may have demand-side management concerns such as meeting summer's increased demands or meeting a peak hourly demand. These specific concerns can be factored into a facility water management program.
- Anticipate increased water and wastewater service costs when considering options. Ask utilities to provide any expected increases.
- Anticipate future increases in production or number of employees that will influence water consumption.
- Use total cost accounting methods to perform 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).
- Encourage water and wastewater utilities to provide rebates and

# Self-Assessment Checklist ✔

What efforts has your facility already made in water efficiency? Several questions for facility managers are listed below to help gauge a facility's present water efficiency performance.

## Top Management Commitment and Resources

- Is water efficiency included in the company's environmental policy statement?
- Are water efficiency responsibilities delegated?
- Are quantitative goals established and tracked?
- How are water efficiency goals communicated to employees?
- What incentives and feedback loops exist for employee participation, suggestions, and increased awareness?
- Has your facility taken advantage of available help and resources from your utilities, assistance programs, vendors, or consultants?

## Water Efficiency Survey

- Do you know the actual breakdown of your water uses: cooling and heating, domestic uses, process rinsing, cleaning activities, kitchens, laundries, landscaping, water treatment regeneration, evaporation, leaks, and others?
- Do you know your life cycle water costs for supply water, wastewater treatment, sewer/discharge, and heat and mechanic energy losses?
- Are you doing simple things such as leak inspections, eliminating unnecessary uses, and using timers? Are these practices institutionalized?

## Identifying Opportunities - Target Areas for Water Reduction

### DOMESTIC

- Are code conforming 1.6 gpf commodes, 0.5-1.0 gpm faucet aerators, and low flow 2.5 gpm showerheads in use?

### HEATING/COOLING

- Has once-through cooling water used in air conditioners, air compressors, vacuum pumps, etc., been eliminated with the use of chillers, cooling towers, or air cooled equipment?
- Has blow-down/bleed-off control on boilers and cooling towers been optimized?
- Is condensate being reused?

CHECKLIST IS CONTINUED ON NEXT PAGE

SELF-ASSESSMENT CHECKLIST CONTINUED FROM PREVIOUS PAGE

### PROCESS RINSING AND CLEANING

- Have you considered improved rinsing techniques such as counter current systems, sequential use from high quality to lower quality needs, conductivity flow controls, improved spray nozzles/ pressure rinsing, fog rinsing, or agitated rinsing?
- Is water cut off when not in use by flow timers, limit switches, or manually?
- Is the life of an aqueous bath being maximized via filtration and maintenance control?
- Are "dry clean-up" practices used instead of hosing down, and first pass pre-cleaning conducted with squeegees, brushes, or brooms?

### ON-SITE WATER REUSE

- Is water quality matched with water quantity?
- Have reuse applications been examined for process water, landscaping irrigation, ornamental ponds, flush water, and cooling towers?

### LANDSCAPING

- Are low-flow sprinklers, trickle/drip irrigation, optimized watering schedules and water placement, preventative maintenance, and xeriscaping techniques in place?

### KITCHENS

- Are "electric eye" sensors for conveyer dishwashers installed?
- Have new water and energy efficient dishwashers been examined?

## Water Efficiency Action Plan

- Have you performed a cost analysis on water efficiency opportunities?
- Do you have a prioritized implementation schedule?
- Are water users informed of the changes and communication channels open for feedback?

## Tracking and Communicating Results

- Do you post monthly water usage rates to employees and management?
- Are your water efficiency achievements being recognized in case study articles, media coverage, mentoring to other businesses, business environmental exchange programs, or in award programs?

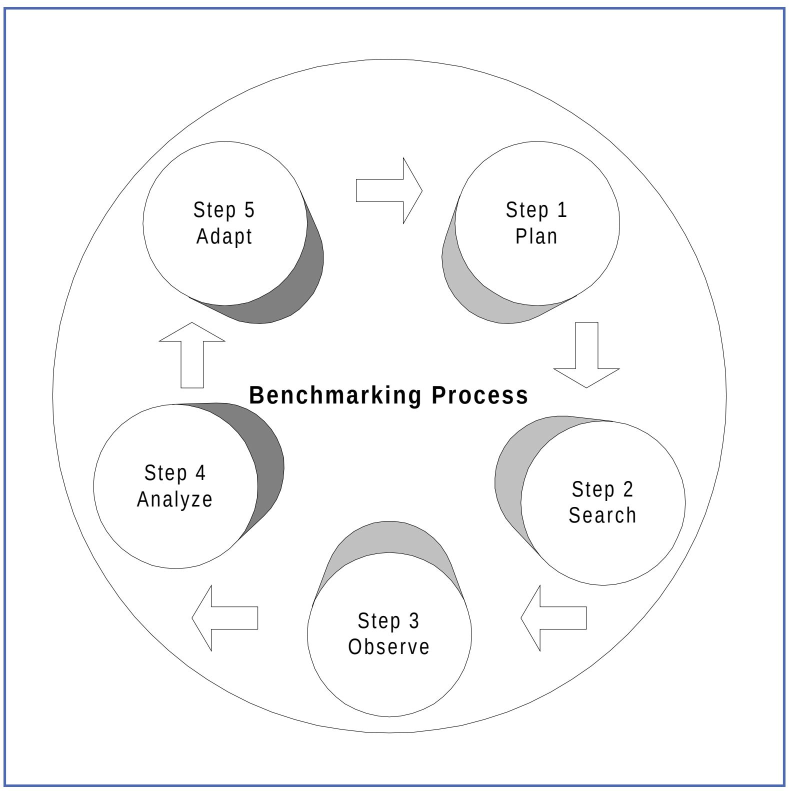
other financial incentives to offset the cost of implementing a water conservation measure. Use the efficiency/conservation plan as a bargaining point.

- Program goals should not only consider the technical side for water efficiency, but also should consider the human side, such as changing behaviors and attitudes toward water use.
- Do the simple tasks first to gain acceptance and positive feedback for the program.

Use internal and external benchmarking techniques to help optimize water consumption.

## Using TQM and Benchmarking Tools

Facility managers have a variety of Total Quality Management (TQM) tools to help plan, develop, and implement water efficiency measures. These tools include self assessments, statistical process control, ISO 9000 and 14000, process analysis, quality circle, and many others. Benchmarking, too, can be an important TQM tool to improve water use efficiency. Benchmarking is a process of comparing one's own operational performance to other organization's to become "best in class" and make continual improvements. Benchmarking is more than simply setting a performance reference or comparison, it is a way to facilitate learning for continual improvements. The key to the learning process is looking outside one's own business to other industry sectors that have discovered better ways of achieving improved performance. Benchmarking can be performance based, process based, or strategic based and can compare financial or operational performance measures, methods or practices, or strategic choices.




## Five Steps of a Benchmarking Process

### *Planning*

Managers must select a process to be benchmarked. A benchmarking team should be formed. The process of benchmarking must be thoroughly understood and documented. The performance measure for the process should be established (i.e. cost, time, and quality).

### *Search*

Information on the "best-in-class" performer must be determined. The information can be derived from the company's existing network, industry experts, industry and trade associations, publications, public information, and other award-winning companies. This information can be used to identify the best benchmarking partners with which to begin cooperative participation.

### Observation

The observation step is a study of the benchmarking partner's performance level, processes and practices that have achieved those levels, and other enabling factors.

### Analysis

In this phase, comparisons in performance levels among the facilities are determined. The root causes for the performance gaps are studied. To make accurate and appropriate comparisons, the comparison data must be sorted, controlled for quality, and normalized.

### Adaptation

This phase is putting what is learned throughout the benchmarking process into action. The findings of the benchmarking study must be communicated to gain acceptance, functional goals must be established, and a plan must be developed. Progress should be monitored and corrections in the process made accordingly.

The benchmarking process should be interactive. It should also recalibrate performance measures and improve the process itself.

## Common Water Efficiency Measures

As businesses managers seek to gauge their own performance in areas concerning water management, data from a

FIGURE 3

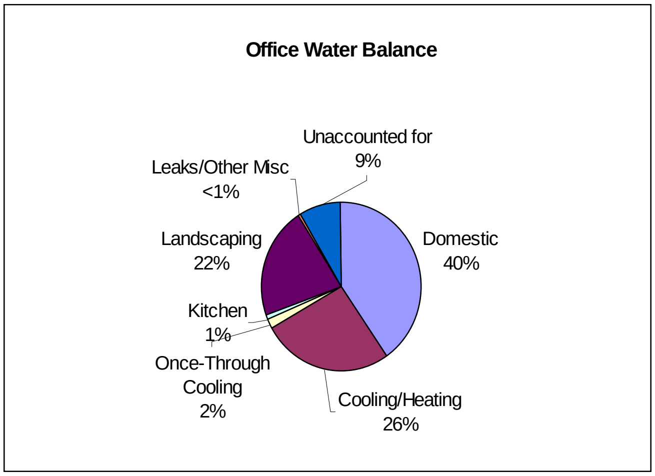
**Most Commonly Implemented Efficiency Measures by Business and Industry**

- Recycle Process Water
- Improved Maintenance to Replace Miscellaneous Equipment and Parts
- Use Domestic Water Efficiency Techniques - ultra low flush toilets, urinal, faucet aerators, low flow showerheads, etc.
- Change Operational Practices
- Adjust Cooling Tower Blowdown
- Reduce Landscaping Irrigation Time Schedules
- Adjust Equipment
- Repair Leaks
- Install Spray Nozzles
- Install and/or Replace Automatic Shut-Off Nozzles
- Reduce Dishwasher loads
- Turn Off Equipment when Not in Use

(Source: Metropolitan Water District of Southern California - Survey of 902 Commercial, Industrial, and Institutional Facilities, November 1997.)

number of water efficiency programs can be used to determine "best in class" techniques. Figure 3 shows the most common water efficiency measures used by a variety of commercial, institutional, and industrial facilities that participated in water use audit programs.

FIGURE 4




## Typical Water Balance Findings

Understanding water use at a facility is imperative to appropriately prioritize areas to focus time and resources. The following graphs (Figures 4 - 9) show examples of water use distribution (water balances) for common commercial, institutional, and industrial settings. Manufacturers sampled in Figure 5 include metal fabricators, rubber products, aeronautical, and cardboard products manufacturers. Data are based on a 1991 Non-residential Water Audit Program conducted in Denver, Colorado. Each facility should determine its own unique water balance to best target opportunities.

FIGURE 5

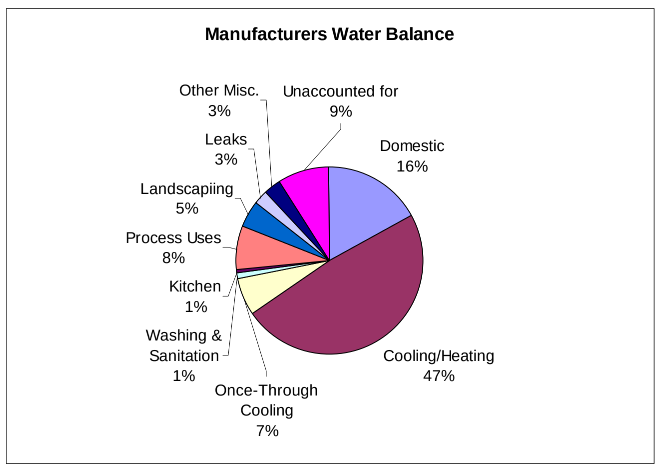



FIGURE 6

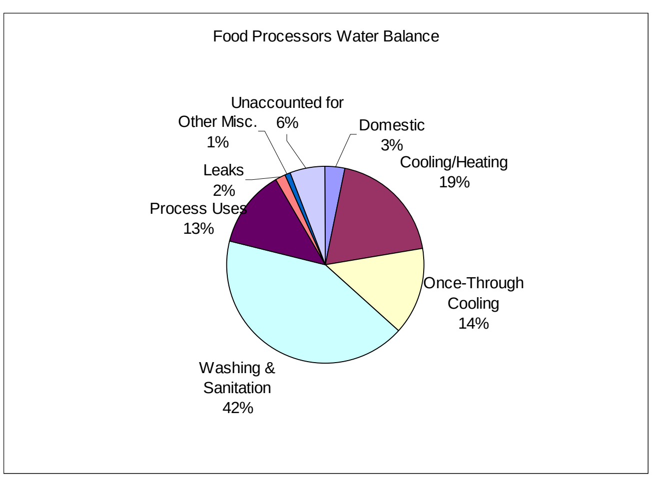


FIGURE 7

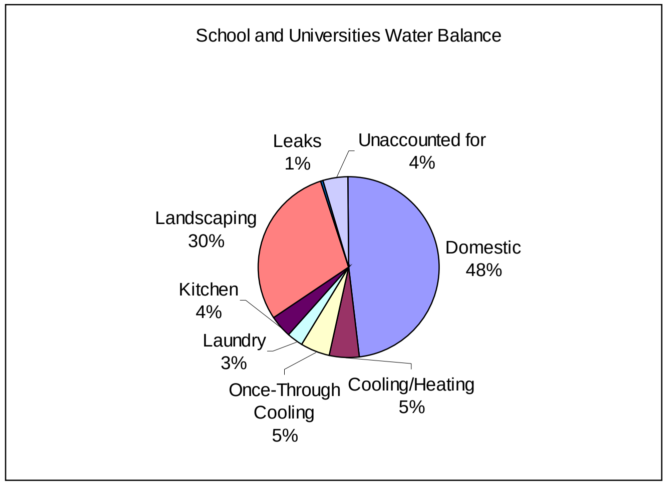



FIGURE 8

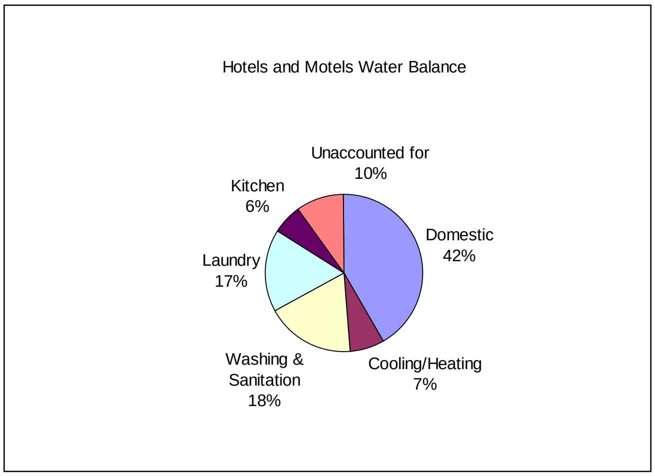
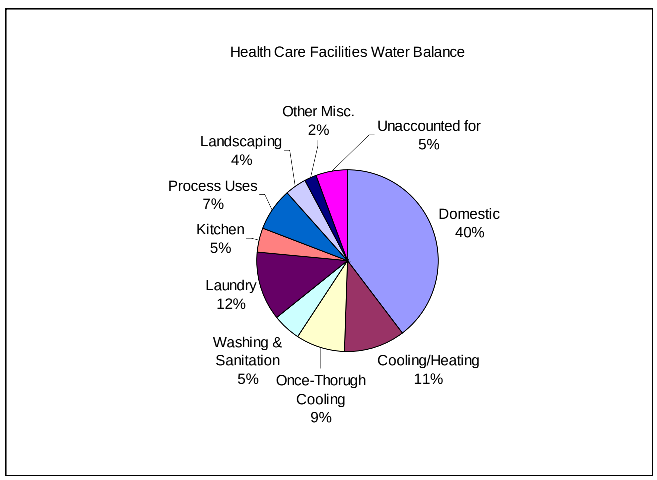
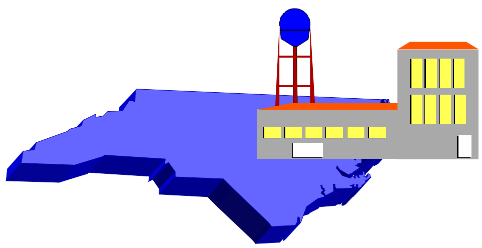



FIGURE 9




*The guidance presented in this chapter provides the framework to pursue water efficiency measures. Chapter 3 presents a six-step process to guide facility staff through the details of enacting a successful water efficiency program.*

# 3 Conducting a Successful Water Efficiency Program



A successful water efficiency program should begin with a well-thought plan. Crucial to the development and use of this plan are management's commitment; sufficient technical staff and financial resources; employee awareness and participation; and well-publicized results. Water efficiency measures may very likely be just one part of an integrated energy management, pollution prevention, or other cost-reduction program or environmental management system. Regardless the driving factors, a heightened awareness and road map to water efficiency opportunities and cost savings will help management make sound choices to optimize operational efficiency, improve economic competitiveness, and conserve quality water resources for the future.

## Steps for a successful water efficiency program

**Step 1** - Establish commitment and goals

**Step 2** - Line up support and resources

**Step 3** - Conduct a water audit

**Step 4** - Identify water management options

**Step 5** - Prepare a plan and implemention schedule

**Step 6** - Track results and publicize success

## Step 1

# Establish Commitment and Goals

At first, water efficiency goals may be qualitative and included in statements of commitment, environmental policies, budgetary planning, or other external awareness measures. Initial commitments should allocate staff and resources to assess the current water use baseline and explore water efficiency opportunities. With additional information, realistic goals of quantitative water efficiency can be established. For example, goals could include establishing a percent reduction goal in overall water consumption (such as a 10 percent overall reduction in water use next fiscal year) or establishing a gallon-per-year reduction goal in water consumption (such as reducing consumption by 20,000 gallons per year). Even better goal setting uses industry benchmarking information based on an operating index (such as gallons per pound of product manufactured or gallons consumed per client served). Remember, goal setting is an on-going process requiring periodic review and revisions for continual improvement.

## Step 2

# Line Up Support and Resources

### *Designate a Conservation Manager*

A conservation manager, coordinator, or team leader also may have responsibilities for energy management and or environmental management. The conservation manager should:

1. Review effectiveness of present water efficiency measures for further improvements.
2. Establish a budget, and procure funding.
3. Evaluate regulatory constraints and local water supply issues.
4. Seek outside funding, grants, and available technical assistance.
5. Coordinate a water efficiency audit.
6. Establish implementation criteria for designing water efficiency measures.
7. Develop a plan.
8. Encourage employee participation and create awareness.
9. Oversee implementation of efficiency measures and activities.
10. Periodically review program progress and make modifications for continuous improvement.

### *Achieve Employee Participation*

The importance of employee awareness and cooperation in the water conservation program cannot be over emphasized.

- Establish and promote the water efficiency/conservation program for employees. Provide background information about the water conservation policy and its implications for company operations.
- Initiate the employee awareness program with a letter directed to each employee from the head of the organization, such as the CEO, president, owner, mayor, city manager, governor, or chief administrator. The letter should describe the established conservation policy, identify the water efficiency coordinator, express full support for the plan, and invite

feedback.

- Emphasize the need for individual responsibility as part of a team effort to achieve efficiency and environmental goals.
- Establish a "water-saving idea box" and encourage employees at all levels to submit water-saving ideas. Respond to each suggestion offered.

### *Communicate Water Conservation Awareness*

- Incorporate water conservation policies and procedures into employee training programs.
- Use bulletins, e-mail, newsletters, paycheck stuffers, or other appropriate methods to transmit policies, programs, ideas, announcements, progress reports, and news of special achievements.
- Schedule staff meetings to communicate the organization's water-conservation plan and progress in water savings.
- Establish charts that graphically show the financial savings.
- Use audio-visual programs, outside speakers, and other means for employee meetings.
- Post water-conservation stickers, signs, and posters in bathrooms, kitchens, cafeterias, conference rooms, and other places where employees congregate.

world wide web

## Check out these water efficiency Internet sites

Waterwiser – Water Efficiency Resources
http://www.waterwiser.org

Water Librarian's home page
http://www.wco.com/~rteeter/waterlib.html

Division of Pollution Prevention and Environmental Assistance
http://www.p2pays.org

North Carolina Division of Water Resources
http://www.dwr.ehnr.state.nc.us/home.htm

North Carolina Division of Water Quality
http://h2o.ehnr.state.nc.us/

VendInfo - Pollution Prevention Vendors
http://es/epa.gov/vendors

### *Establish Employee Incentives*

- Recognize and reward those employees who submit water-saving ideas.
- Include water consumption measures in employees' job performance reviews.
- Motivate employees by rewarding them with a percentage of the first year's direct savings.
- Allocate water and sewer costs to each individual department to create responsibility for water efficiency.
- Organize and promote competition between shifts.

### *Use Outside Assistance*

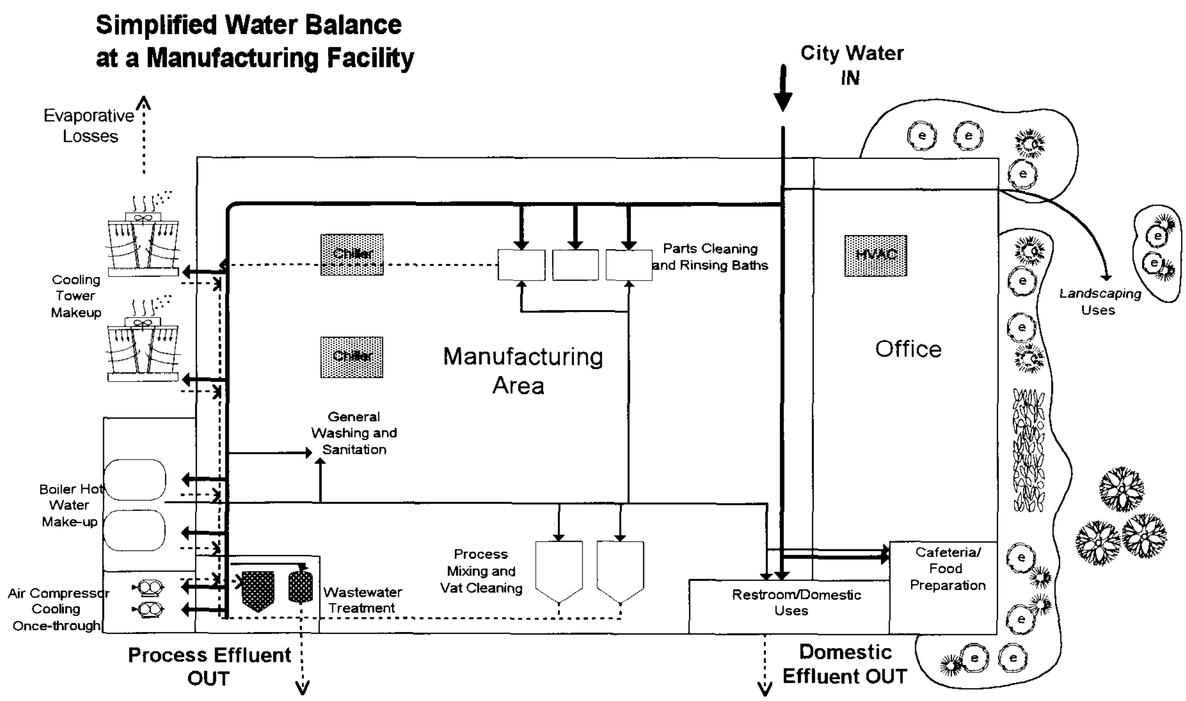
Outside organizations are available to assist with water conservation activities. Their assistance should be solicited wherever feasible as a resource for the promotion of water conservation. Some suggestions are listed below.

- Take advantage of free or low cost technical assistance organizations such as EPA's Water Alliances of Voluntary Efficiency (WAVE) Program, North Carolina Division of Pollution Prevention and Environmental Assistance, North Carolina State University's (NCSU) Industrial Extension Service, NCSU's Industrial Assessment Center, Waste Reduction and Technology Transfer program in western North Carolina, and energy utilities assistance programs (i.e., CP&L and Duke Power).
- Water and wastewater utilities are vitally interested in assisting customers to conserve water. They can provide information, contacts with other industries, and advice. Water suppliers may even assist customers with leak-detection programs or water audits of facilities. Some utilities nationwide offer rate reductions and financial incentives for water efficiency investments.
- Participate in any water conservation advisory group, or similar organization, generally sponsored by local water authorities. If such a group does not exist, help the utility establish one.
- Consider hiring private consultants to help develop water efficiency programs and conduct audits. Ensure professionals have adequate experience and proper certifications for their field (i.e., Certifications for landscaping include certified landscaping irrigation auditors, certified irrigation designers, and certified irrigation contractors.).
- Work with local wastewater utilities and wastewater discharge regulators. As conservation measures are put into effect in industrial processes, wastewater pollutant concentration may increase, although the same mass of these pollutants have stayed the same. These increased concentrations may alter a facility's ability to meet local, state, or federal effluent discharge limits. Request wastewater regulators to recognize conservation efforts by amending the wastewater discharge permits to address total mass of pollutants instead of concentration levels.

### *Help Take the Message Home*

Develop an employee education program that will encourage employees to save water at home, as well as in the workplace. Some suggestions are:

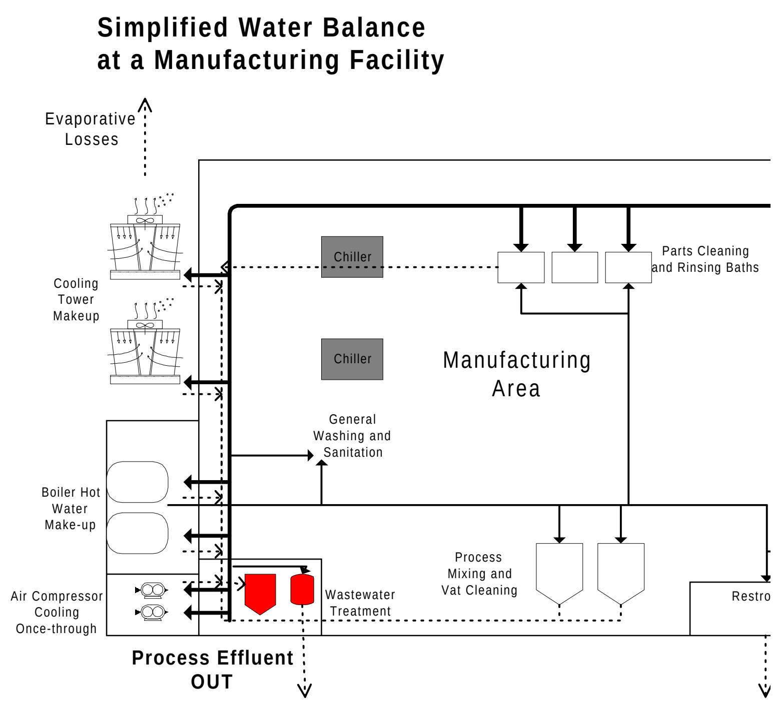
FIGURE 10




## Water Balance Summary

| Sources of Water Use | Gallons per year | Percent of total |
|---|---|---|
| Cooling: tower make-up and boiler make-up | 7,966,000 | 38.3 |
| Process use: parts and mixing vat cleaning | 3,848,000 | 18.5 |
| Domestic: faucets, toilets, and showers | 3,536,000 | 17 |
| Once-through cooling: air compressors, and pumps | 2,388,000 | 11 |
| Landscaping | 832,000 | 4 |
| General washing, sanitation, and maintenance | 561,600 | 2.7 |
| Leaks (detected) | 416,000 | 2 |
| Food preparation: dishwasher | 312,000 | 1.5 |
| SUBTOTAL | 19,859,000 | 95.5 |
| TOTAL WATER PURCHASED | 20,800,000 | 100.0 |
| UNACCOUNTED FOR | 941,000 | 4.5 |

FIGURE 10

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| UNACCOUNTED FOR | 941,000 | 4.5 |

- Offer home water-saving devices to employees free or at cost.
- Sponsor demonstrations that will educate employees how to water landscapes efficiently, plant seeds for water-thrifty plants, install low-flow plumbing fixtures, and improve water-use habits. Device manufacturers, local hardware stores, or your water utility may be happy to assist with such a program.
- Distribute home water conservation booklets.

## Step 3

## Conduct Water Audit to Assess Current Water Uses and Costs

To identify potential water efficiency opportunities, it is first necessary to gain a thorough understanding of the site's water uses through 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.

### *Water Balance*

An important task is to construct a water balance diagram or summary chart, which identifies all water uses from their source through the on-site processes, 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. *(See Figure 10.)*

### *Select a Water Audit Team*

Include the follow representatives:

- Water efficiency coordinator
- Personnel familiar with the operations
- Facility management/plant manager
- Maintenance
- Possible outside auditors

### *Collect Background Site Information and Records*

- Water bills (previous full year) – Note rate structures
- Water meter sizes and locations
- All sources of potable and non-potable water
- Process sub-metering data
- Wastewater treatment
- Sewer bill
- Production process sheet
- Plumbing diagram
- Irrigation drawing/plan and existing irrigation control program.
- Number of employees
- Number of shifts, work, and clean-up schedules
- Facility description – square footage, functions
- Products and services preformed at the site
- Production rates or client service rates
- List of known water consuming process and uses
- Prior water use or energy survey
- (Preventive) Maintenance schedules.

### *Walk-Through Survey*

The next step is to conduct a walk-through survey with the audit team. Use direct observation and measurements, and ask questions. Talk with equipment operators who may have important first-hand information. Use the following procedure to conduct the survey.

- Identify all water consuming equipment.
- Confirm plumbing diagrams.
- Quantify water flow rates and

usage.

- Determine water quality needs for each process.
- Review current water saving measures.
- Observe shift clean-ups (third shifts), and process change-overs.
- Also note all water losses, evaporative losses, and water incorporated in product; excessive water pressure; and leaks.
- Judge current water use efficiency and potential for each operation.

### *Determine the True Cost of Water Use*

The true cost of using water may include several factors other than the actual water utility fees. Examples of costs include water heating, chemical agents, electrical pumping, on-site pretreatment, and related labor. *(See Figure 11.)*

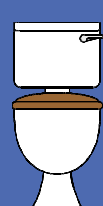
To calculate the dollar savings resulting from reduced water use, a value for each unit of water used must be derived.


## *Key areas to check during a walk-through survey*

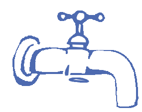
Process and Equipment Use
- Cleaning, washing, rinsing
- Metal finishing
- Painting
- Dyeing and finishing
- Photo processing
- Reuses
- Product fluming (water transport)
- Water use in products

Cooling and Heating
- Single-pass cooling
- Cooling tower/chillers
- Boiler, hot water, steam systems
- Air washers
- Boiler scrubber

Sanitary and Domestic
- Toilets
- Urinals
- Faucets
- Showers



Kitchen Food
- Cafeteria uses
- Dishwashers
- Ice machines
- Faucets



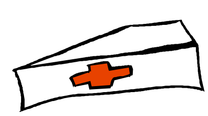
Other Facility Support
- Floor washing
- Air emission wet scubbers
- Building washing
- QA/QC testing
- Laboratories
- Wastewater treatment

Outdoor Uses
- Landscaping
- Irrigation
- Particulate emission control

Decorative fountains/ponds

Vehicle washing

Personnel
- Medical



One approach is to divide the total costs of water used per year by the total amount of water used. For facilities engaged in production of "widgets," the total cost of water used for a production run should be divided by the total number of widgets produced to get a "cost per widget" of water use.

In calculating the total cost of water use and the many components that go into the total cost, current prices of all these elements is a good starting point. However, a more meaningful comparison can be made using future rates and prices for these elements after the efficiency measures are put into effect. These major cost elements include:

1. Water purchased from utilities. Billing normally consists of a fixed service cost and water rate cost. The fixed charge should be excluded from the analysis.
2. Wastewater sewer rate and surcharges.
3. Total cost of on-site water softening or treatment before use.
4. Cost of energy for heating water.
5. Total cost of pretreating wastewater effluent, including labor, chemical, energy, and residual disposal.
6. Cost of maintenance personnel performing preventative or reactive maintenance on water using components.

FIGURE 11

**Example Total Water Costs in a Metal Finishing Operation (not heated)**

| Activity | Unit Cost ($/CCF) | Total Unit Cost ($/CCF) 1 CCF = 748 gallons |
|---|---|---|
| City water purchase | | $1.55 |
| Sewer rate | | $1.78 |
| Deionized using reverse osmosis | | |
| Equipment | $0.37 | |
| Energy | $0.97 | |
| Labor | $1.12 | |
| Total deionized water (flexible cost)* | $2.46 x 40% | |
| Deionized water (flexible cost)* | 40% x $2.46 | $0.98 |
| Wastewater treatment | | |
| Sludge disposal | $3.45 | |
| Treatment chemicals | $2.30 | |
| Energy | $0.22 | |
| Labor | $5.46 | |
| Total wastewater treatment | $11.43 | |
| WW treatment (flexible cost) | 40% x $11.43/CCF | $4.57 |
| Total cost of water | | $8.88/CCF |
| | | ($11.87/1,000 gallons) |

If a metal finisher consuming 35,000 gallons per day reduces use by 10%, estimated savings using water and sewer cost only = 250 days/yr x 0.01 x 35,000 gpd x (1.55/784 + 1.78/784) = $389/year

Estimated savings using total cost of water =
250 days/yr x 0.01 x 35,000 gpd x $11.87/1,000 gallons = $1,038/year

*Flexible cost savings of conserved water estimated to be 40 percent of total treatment cost.

7. If water demand is increasing, determine the marginal costs of increasing effluent treatment capacity.
8. Energy costs for pumping water from wells or pumping water within the facility itself.

When comparing efficiency options, first consider reducing consumption of the most expensive components of water use.

## Step 4

### Identify Water Management Opportunities in Plant and Equipment

There are at least six general approaches for identifying water-saving opportunities, as listed below. These approaches can be applied to water uses at any site.

#### *General Approaches for Water-Saving Opportunities*

- Identify unnecessary uses and fix leaks.
- Use minimum amounts of water to accomplish the task.
- Recirculate water within a process or group of processes.
- Reuse water sequentially.
- Treat and reclaim used water.
- Displace potable water supplies with water from non-potable sources were appropriate.
- Install meters at high-flow processes and equipment.

*This manual provides a detailed discussion about water reduction options in chapters 4 and 5.*

## Step 5

### Prepare a Plan and Implementation Schedule

Develop an action plan that outlines and lists all proposed water efficiency measures resulting from the facility audit. Include the following items in the plan:

1. State the company policy regarding conservation and water efficiency, reflecting the commitment of company management.
2. Quantify your goals. Establish the amount of water to be saved throughout the entire facility, as well as by each organizational unit. Also, set deadlines by which these savings are to be achieved.
3. Summarize all efficiency measures identified during the water audit and by employee suggestions.
4. Evaluate each of these measures. Be sure to include all costs and benefits including capital costs, operating costs, projected savings, and payback periods. Do not forget to include cost of energy consumption, treatment of water, chemical costs, creation of solid and toxic wastes, and wastewater discharge.
5. Prioritize the measures in the following order:

   - Those that are most cost-effective and should be put into effect as soon as possible.
   - Those measures that should be evaluated through a trial period to collect meaningful data.
   - Those measures that are not cost-effective, but could be implemented in times of drought or emergency situations.

6. Identify need for any engineering design changes.
7. Establish the schedule for implementing each specific measure.
8. Identify the employee responsible for implementing each measure; continuously monitor the effectiveness and performance of each measure.
9. Identify funding sources for specific measures that will require capital expenditure. Consider loans and rebates that may be available from energy and water utilities.
10. Review periodically, and revise plan appropriately.

## Step 6

## Track Results and Publicize Success

Publicize the success of your program. Positive publicity promotes good relations with employees, the community, other businesses, and organizations that support economic development. It also helps to stimulate similar water management efforts. Some publicity options include internal memos, company newsletters, brochures, trade publications, news releases to local media, letters to public officials, talk radio, and interviews with the media. Many water utilities will help publicize good results to encourage others to develop similar plans. A good water efficiency program is news because it means more water will be available to the community.

Businesses with successful water management programs deserve recognition by the public. Likewise, the public should be informed that businesses are socially and environmentally responsible partners in the community. These steps can help businesses make their publicity efforts more visible and successful:

1. Encourage company conservation team members to participate in:

   - Community conservation seminars to share program results, as well as obtaining useful information from other campanies' efforts.
   - Water conservation committees sponsored by local water utilities.

2. Present savings in relevant terms such as dollars, water savings per unit of product, earnings per share, or annual consumption per household.
3. Prepare, display, and promote the company's water conservation successes by means such as:

   - Display the company's water conservation results in public reception areas.
   - Place posters and other exhibits in public buildings and art fairs.
   - Post signs on water-thrifty landscapes to identify types of plants that require little water.
   - Once the plan has shown significant savings, develop a public relations program, including interviews with local radio and TV stations and newspapers, about the company's successes.

4. Sponsor water conservation projects such as a public xeriscape demonstration garden.
5. Sponsor water conservation contests in schools. For example, encourage students to create posters to be displayed in the community and at company work sites.

# 4 Water Management Options

**Sanitary/Domestic Uses**

**Cooling and Heating**

**Landscaping**

**Kitchen and Food Preparation**

**Cleaning, Rinsing, and In-process Reuse**

## Sanitary/Domestic Uses

Often overlooked are the water and cost savings achievable in the domestic water usage by commercial and industrial facilities. While water efficiency measures should begin with the highest water use operations such as cooling, cleaning, rinsing, heating, etc., many facilities miss the easy improvements that can be made in domestic water devices such as toilets, urinals, sink faucets, and showers. Domestic water use at industrial and commercial facilities may range from a few percent at a food processing industry to more than 50 percent in an office setting. Average daily domestic demands in commercial/industrial settings range between 20 and 35 gallons per day (gpd) per employee, and a savings of 25 to 30 percent in this domestic usage is readily achievable.

### Toilets

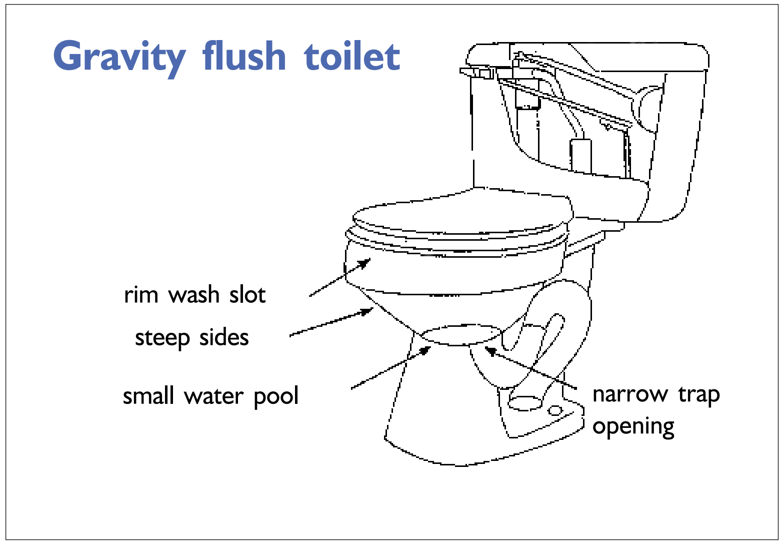
Americans consume almost 4.8 billion gallons of water daily by flushing toilets and urinals. In a business office setting, toilet water usage alone can account for approximately one-third of all water used.

A number of water efficiency options exist for toilets in most facilities constructed before 1994 that have not been renovated recently.

FIGURE 12

| Typical Water Consumption for Toilets | | |
|---|---|---|
| **Years Manufactured** | **Gravity Tank Style** | **Flush Valve Style** |
| Pre-1977 | 5.0-7.0 gpf | 4.5-5.0 gpf |
| 1977 to mid 1990s | 3.5 (some 5.0 gpf) | 3.5 gpf |
| Mid 1990s | 1.6 maximum | 1.6 maximum |

The three major types of toilets include gravity flush, flush valve, and pressurized tank type. Pre-1977 gravity toilets will consume five to seven gallons per flush (gpf). Pre-1977 flush valve toilets use 4.5 to 5.0 gallons per flush. Gravity and flush valve style toilets manufactured between 1977 and mid 1990s mostly use 3.5 gallons per flush, although some 5.0 gpf gravity flush toilets continued to be manufactured during that period. *(See Figure 12.)*




## The 1.6 Gallons Per Flush Toilet

In the 1990s, toilet manufacturers introduced ultra-low-flush toilets (ULF) that use 1.6 gallons per flush. Federal regulations require that all toilets manufactured after January 1, 1994, consume no more than 1.6 gpf. Some of the original ULF models were associated with performance problems, but more recent models have improved designs and performance.

FIGURE 13

### Maintenance Checklist for Gravity Flush and Flush Valve (flushometer) Toilets

Check for leaks every six months.

Encourage employees to report leaks promptly.

Adjust float valve to use as little water as possible without impeding waste removal or violating the manufacturer's recommendations.

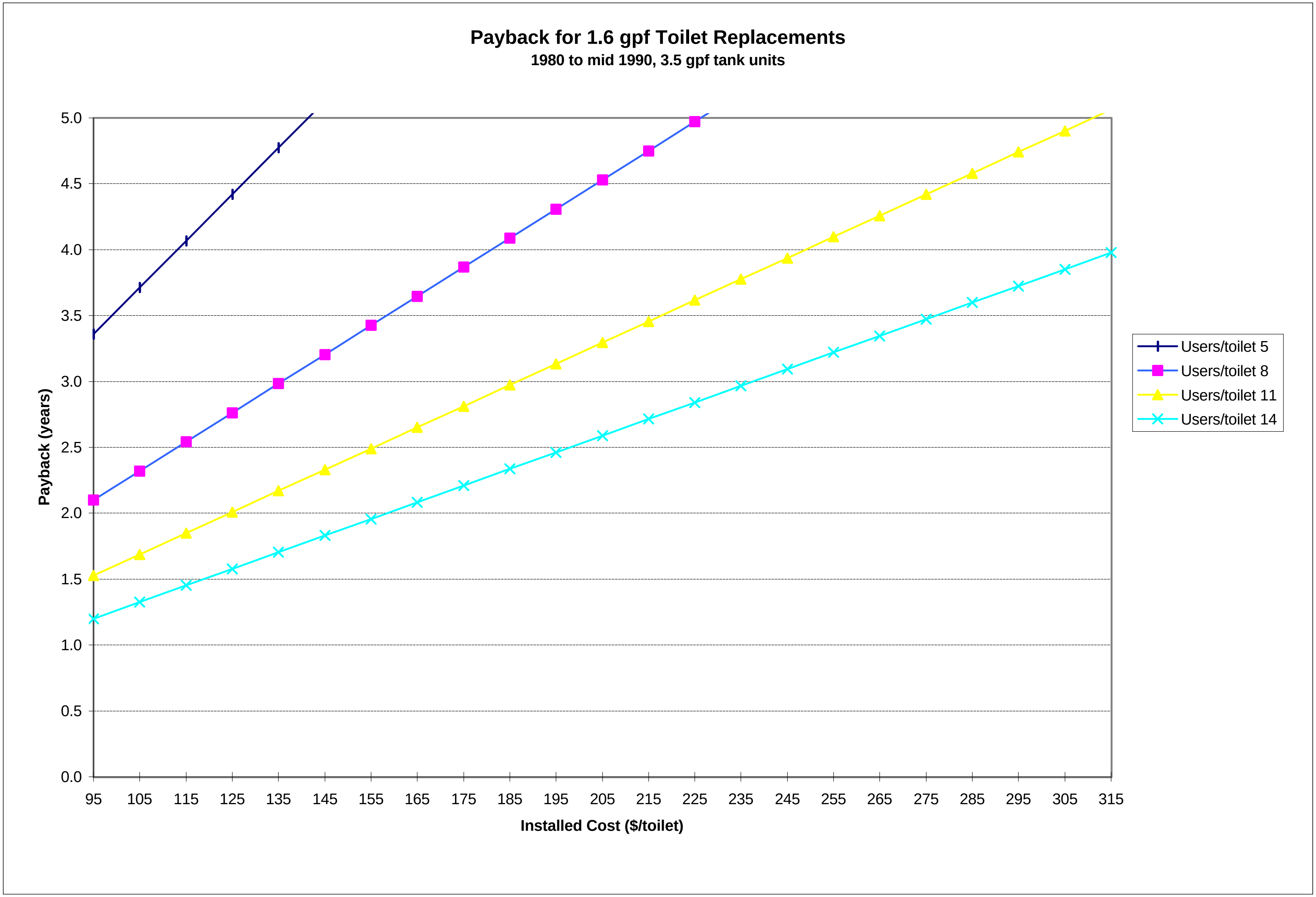
Periodically replace valves and ballcocks.

## Gravity Flush Toilets

Gravity flush toilets are the most common of all toilets. Gravity flush toilets most likely are found in medium- to light-use business applications.

Water efficiency options for gravity flush toilets include improved maintenance, retrofit, and replacement options.

*For a maintenance checklist, see Figure 13.*


Payback for 1.6 gpf Toilet Replacements
1980 to mid 1990, 3.5 gpf tank units
Payback (years)
Installed Cost ($/toilet)
Users/toilet 5
Users/toilet 8
Users/toilet 11
Users/toilet 14

## Retrofit

Retrofit options of gravity flush systems are most effective on units that consume more than 3.5 gpf (pre-1980s models). For toilets that consume 3.5 gpf or less, retrofit options may hamper toilet performance or increase maintenance cost. Most retrofit options are available for less than $20.

Displacement devices, including bags or bottles, can reduce water flow by approximately 0.75 gpf. They function by displacing flush water stored in the tank. The devices are inexpensive and easy to install, but do require regular maintenance. Bricks or other friable objects should never be used as displacement devices because granular contaminants can prevent proper closure of the flapper and damage flow valves.

Toilet dams are flexible inserts placed in a toilet tank to keep 0.5 to 1.0 gallon out of each flush cycle. Dams will last five to six years. A plumber should be consulted before installing such devices.

Early closure flapper valves replace the existing flush valve in the tank. These devices are adjustable to optimize performance and can save 0.5 to 2 gpf. Early closing flappers are inexpensive and

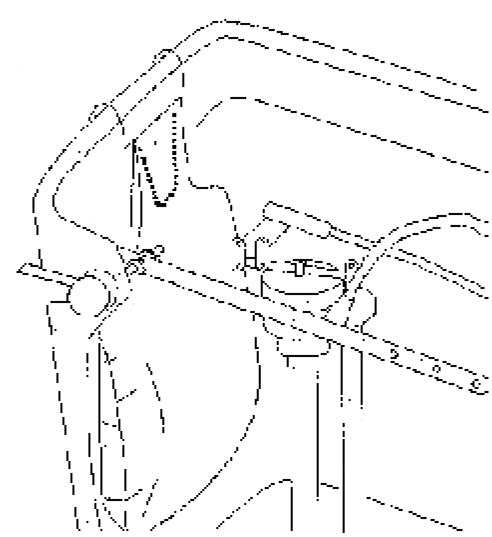
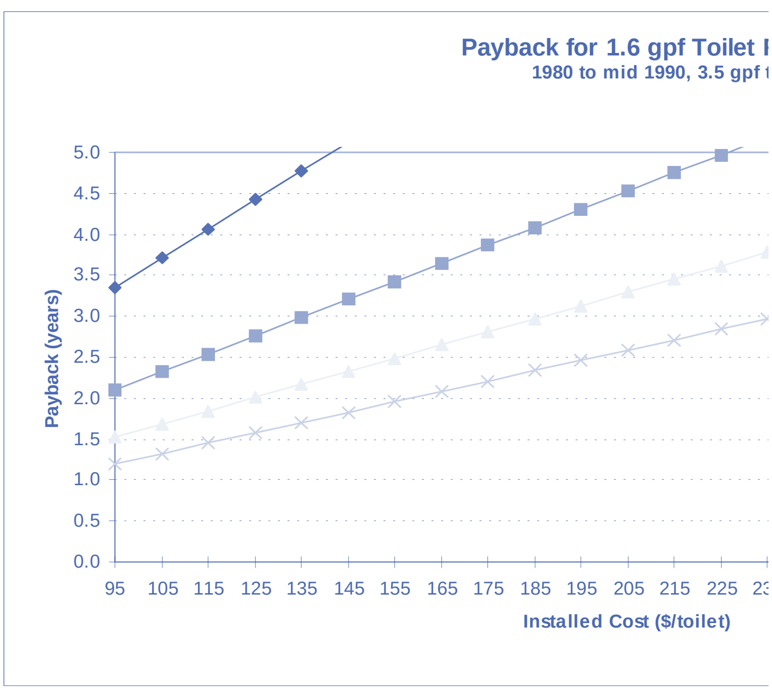

Toilet Displacement Bag

FIGURE 14



usually can be installed in 10-15 minutes, barring other problems with the toilet's mechanisms.

Dual flush adapters allow users to use a standard flush for solids removal or a modified smaller flush for liquid and paper. Dual flush adapters have been more popular in Europe than the United States. Dual flush adapters can save between 0.6 to 1.2 gpf. To use this retrofit option, facility managers should provide user instructions about the proper use of hese dual flush systems.

### *Replacements*

Replacing older commodes with 1.6 gpf models will provide the most water savings. Most 1.6-gpf replacements will offer a payback period of less than four years. Facilities may achieve quicker payback in these situations:

- Experience high water and/or sewer costs.
- Have a relatively high number of users per toilet.
- Currently use high water consuming (five to seven gpf) toilets.

## Energy Policy Act of 1992

The Energy Policy Act established water efficiency plumbing standards for certain plumbing devices. Prior to 1992, many states and municipalities concerned about water conservation were setting unique standards, which created difficulty for manufacturers and distributors trying to meet these numerous standards. The Energy Policy Act created a set of unified national standards.

Effective January 1, 1994, federal standards set for *maximum* water usage are:

| | |
|---|---|
| Toilets | 1.6 gpf |
| Urinals | 1.0 gpf |
| Showerheads | 2.5 gpm @ 80psi |
| Lavatory Faucets | 2.5 gpm @ 80 psi |
| Kitchen Faucets | 2.5 gpm @ 80 psi |

Commercial use of gravity tank type units manufactured between January 1, 1994, and January 1, 1997, could use 3.5 gpf.

The water efficiency standard was established to:

- Preserve and protect water supply source, both surface and groundwater.
- Ensure water availability for all beneficial uses.
- Reduce water and energy costs.
- Regulate and standardize plumbing fixture trade.
- Protect health and the environment.

The American Water Works Association estimates nationwide savings of 6.5 billion gallons per day will be achieved by the year 2025 through these standards.

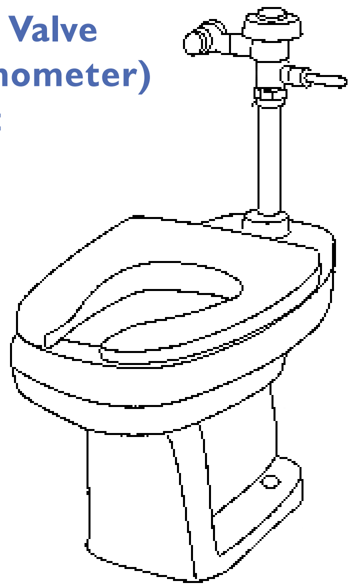



FIGURE 15

| Public Facilities | Estimated Water Savings (gpd per toilet) |
|---|---|
| Fire Stations | 28 |
| Police Stations | 20 |
| Libraries | 76 |
| Recreational Facilities | 117 |

Source: Public Facilities Toilet Retrofits, A&T Technical Services, Inc., 1994, based on study of 70 public facilities in San Diego, California.

FIGURE 16

| Commercial/ Business Sector | Estimated Water Savings (gpd per toilet) |
|---|---|
| Wholesale | 57 |
| Food Stores | 48 |
| Restaurants | 47 |
| Retail | 37 |
| Automotive | 36 |
| Multiple Use | 29 |
| Manufacturing | 23 |
| Health Care | 21 |
| Office | 20 |
| Hotel/Motel | 16 |

Source: The CII ULF Saving Study, 1997, California Urban Water Conservation Council. Survey of 452 organizations in California.

*See Figure 14 for typical simple payback periods for 1.6 gpf toilet retrofits.*

## Flush Valve (Flushometer) Toilets

Flush valve, or flushometer, toilets use water line pressure to flush waste into the sanitary sewer system. They consist of a valve and a toilet bowl fixture. Most commercial/industrial facilities use flush valve toilets, especially in higher-use areas.

*For maintenance checklist, see Figure 13.*

### *Retrofits*

Valve inserts are available and can reduce flush volumes by 0.5 to 1.0 gpf. Some of these devices consist of plastic orifices, perforated with holes in a wheel and spoke pattern. Others actually replace the existing valve mechanisms of a 5 gpf unit with a 3.5 gpf valve without changing the toilet bowl fixture. Do not retrofit ultra-low valves (1.6 gpf) without changing a fixture bowl.

### *Replacement*

Replacing inefficient units with an ultra low (1.6 gpf) flush valve mechanism and toilets will result in the maximum water savings. It is important to note that both the low flow valves and bowls should be replaced simultaneously. A 1.6-gpf valve must be used with an appropriately designed 1.6 gpf bowl, or the unit will not perform adequately.

## Pressurized tanks system toilets

The most modern and effectively designed toilet currently on the market is the pressurized tank toilet. These units perform very well at removing waste, but also are more costly. These toilets use

# Making a toilet replacement project successful

Below are factors to consider when installing new ULF fixtures:

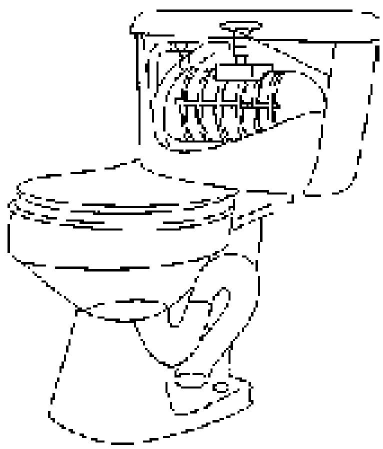
- Replace highest use toilets first – highest use toilets will provide quickest payback.
- Carefully choose toilet type depending on use level and the potential for misuse.
- Know your sewer infrastructure. Older cast iron types with a larger diameter (4" and 6") may have more problems transporting waste with 1.6 gallons. Substandard waste water pipe grading should be addressed before installing water efficient toilets. Make sure the building's water pressure is adequate if switching from a gravity type to flushometer or pressurized tank toilets. Usually, 25 to 35 psi or more at the toilet is required for pressure dependant systems.
- ULF toilets cannot be used as trash cans. If flushing trash is a problem at the facility, employee education with the new toilet installation is necessary.
- Ask for references from building manager, plumbers, or other users who have installed the manufactured products.
- Base decisions on the current models. Many design improvements continue to be made.
- Listen to noise levels of the model you are considering.
- A high cost does not automatically mean better performance.
- Ask about guarantees and returns especially for future leak problems.
- Choose a licensed plumber or contractor.
- Plan for the legal disposal of old toilets. Consult your local solid waste authority for recycling options or disposal requirements.

### *Use Satisfaction*

Some owners of early 1.6 ULF toilets reported dissatisfaction. Many improvements have been made in the 1.6 gpf toilet design to address these issues. It is important to remember that 1.6 gpf units are finely-tuned design systems that require proper use. The type of toilet should be chosen carefully for its level of use and application. Educating employees not to flush trash and of the importance of water efficiency will go a long way in improving user satisfaction. Actual customer satisfaction surveys conducted in Santa Rosa, California; Denver, Colorado; and New York City had a high customer satisfaction rate for customers installing ULF toilets. Less than 10 percent reported any dissatisfaction.

water line pressure to compress air in a special sealed tank in the toilet. When flushed, the compressed air greatly increases the flush water force.

**Pressurized Tank Toilet**



Figures 15 and 16 show examples of water savings from implemented ULF retrofit programs in both public and commercial settings.

## Other options: composting toilets

Where sewers or septic tanks are not available, composting and incinerating toilets are available. Before purchasing any of these toilets, make sure building inspection programs can approve such toilet systems.

## Urinals

The typical water consumption for urinal is two to three gpf. New federal standards require all urinals to use no more than 1.0 gpf. Urinals can have a flushometer valve or water tanks for both washdown and trough urinals. Waterless urinals exist that use a biodegradable liquid in place of water to provide flushing action. Waterless urinals are more popular in Europe.

### *Siphon jet urinals*

These common urinals are designed to accommodate relatively high level usage. The siphon jet urinal has an elevated tank to provide the flushing action to remove foreign matter such as cigarette butts and gum wrappers. While these types of toilets are more sanitary than washout toilets and require little maintenance, the great disadvantage is that water runs through these units constantly. Washout/washdown and blowout urinals all are used in different traffic demand settings. Water efficiency options vary with each unit.

### CASE STUDY

Urinal Timer Adjustment

The Asheville Civic Center has several large banks of urinals to handle restroom traffic during large events. Sensors had been installed to continuously flush all urinals when the restroom doors were open. This system lead to excess water use. After a water audit by the WRATT program, a two-minute delay timer was added to the sensor so the urinals could not flush more frequently than every two minutes. This simple change saved almost 90 percent of urinal water use and reduced water consumption by 600,000 gallons per year.

- Check for leaks every six months.
- Check flushometer valves for leaks. For tank-style urinals, check the rubber diaphragm for leaks or wear, and replace as needed.
- Use a timer. A timer can be installed to stop water flow when a facility is not occupied.
- Use electronic eye sensors to flush automatically.

### *Washout and washdown urinals*

*Replacement options*
Some models can be retrofitted to use less water per flush by replacing a part in the flush valve or float levels in tanks. Make sure any retrofit will continue to allow adequate removal of liquid waste. Again, bowls and flush valves need to be compatible in design use to function properly. Installing new models that use 1.0 gpf can achieve the maximum water savings for urinals.

*Special Note: Monitoring toilet usage patterns may indicate that replacing a toilet with a less water intensive urinal is possible.*

## Showerheads

Showerhead replacement or modification represents another water efficiency area that is very cost effective. Most conventional showerheads use three to seven gpm at 60 psi water pressure. New standards require showerheads to use no more than 2.5 gpm. These new water efficient showerheads come in many different models and features and typically perform very well. Water efficient showerheads also reduce energy consumption for hot water generation.

**Showerhead**

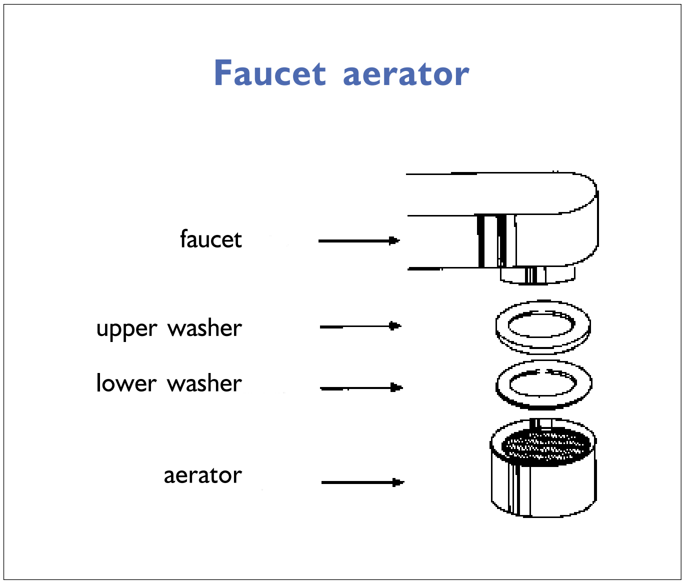
### *Behavioral modifications*

- Encourage users to take shorter showers. User awareness is important especially in institutional settings.
- Check regularly for leaks, and institute a program to have users or employees inform maintenance about leaks.

### *Plumbing modifications*

Install flow restrictors. These washer-like disks fit inside the showerhead and limit water flow. Flow restrictors are very inexpensive (less than $5) and easy to install. Newer designs are not noisy at higher pressures.

Temporary cut-off valves usually are attached to, or incorporated into, the showerheads to allow the user to temporarily cutoff water while soaping, shampooing, or shaving. The water can be reactivated at the previous temperature without no need to re-adjust hot and cold water valves. Facility managers employing cutoff valve showerheads should be




warned that water temperature may be hotter upon reactivation, which could cause unexpected burns.

### *Replacement options*

The best water efficiency option is to purchase new 2.5 gpm showerheads. The products vary in price, from $3 to $48. Good single-setting showerheads can be purchased for less than $10. The newer code compliant showerheads have a narrower spray area and a greater mix of air and water than conventional showerheads. Wide arrays of spray patterns are available, including adjustable massage action. Fixed and flexible position models also are available.

## Faucets

Conventional faucet flow rates can range from three to five gpm. A leaking faucet dripping one drip per second can waste 36 gallons of water a day. Federal guidelines mandate that all lavatory and kitchen faucet and replacement aerators manufactured after January 1, 1994, consume no more than 2.5 gpm at 80 psi.

### *Modification*

- Adjust flow valves to the faucet. Keep in mind this modification also can be easily changed by users.
- Check regularly for leaks.
- Use aerators for faucet flow controllers on existing faucets. Aerators screw onto the faucet head and add air to the water flow while reducing water flow. They are available at common ratings of 0.5, 0.75, and 1.0 gpm. Flow rates as low as 0.5 are adequate for hand wetting purposes in a bath room setting. Higher flow rate kitchen aerators deliver water at 2.0 to 2.5 gpm for more general washing purposes. Aerators cost $5 to $10 installed and typically yield a payback within a few months.
- Install flow regulators. Flow regulators can be installed in the hot and cold water feed lines to the faucet. Common flow rate designs include 0.5, 0.75, 1.0, and 1.5 gpm. Flow restrictors can be used where aerators cannot be used or where there is faucet abuse (aerator removal is problematic). Flow restrictors can be installed for less than $25 and also yield a paybackwithin months.

### *Replacement*

Any new faucet purchase must have a flow rate less than 2.5 gpm. Many types of faucet and water control systems are available for commercial faucets. These include:

- Automatic shutoff – once handle is released, valve shuts off.
- Metered shutoff – once new lever is depressed, the faucet delivers a water flow for a pre-set time

FIGURE 17

## Water Efficiency Summary: Domestic Applications[1,2,3]

| Fixture | Current Syle/ Flow Rates | Ages | Water Efficiency Options/ Water Saving Estimates | Installed Cost ($) | Typical Payback (years) | Comments |
|---|---|---|---|---|---|---|
| Toilets | Flushometer 3.5 gpf | 1977 to early 1990s | Install new 1.6 gpf ULF model. Saves 1.9 gpf. | $115-$300 | 1.5 – 6 | Must change both bowl and valve |
| | | | Consider valve inserts. Save 0.5 gpf | $10-$30 | 0.6 –2.5 | Usually not recommended by OEM |
| | Flushometer 4.5 gpf | Pre- 1980s | Install 3.5 gpf valve retrofit with no change to china bowl. Saves 1.0 gpf. | $25-$40 | 0.7 – 1.7 | Flushometer valves used in commercial high use areas. |
| | Tank-type gravity 1.6 gpf | 1992 and later | Best available option. | NA | NA | Ultra-low flush (<1.6 gpf) exist for special eviro-sensitive cases. |
| | Tank-type gravity - 3.5 gpf | 1977 to mid- 1990 | Install 1.6 gpf gravity toilet or other 1.6 gpf models. Saves 1.9 gpf. | $115-$300 | 1.5 - 6 | Displacement devices/dams not typically recommended for 3.5 gpf units. |
| | | | Consider early closing flapper. Saves from 0.5 to 1.0 gpf. | $20 | 0.7-1.5 | Adjustable for quality performance |
| | Tank-type - gravity 5-7 gpf | Pre-1980 devices | Install 1.6 gravity flush or other 1.6 gpf models. | $115-$300 | 0.7-4.5 | Consider pressurized tanks systems for high use areas. |
| | | | Consider dams, displacement devices, or early closure flapper. Saves 0.75-2 gpf. | $20 | 0.4-0.9 | Do not use bricks. |
| Urinals[4] | Flushometer 1.6 gpf | | Install repair valves to 1.0 or 0.5 gpf for non-pooling styles. Saves 0.6-1.1 gpf. | $20-$40 | 1.0 –3.5 | For non-pooling styles |
| | Flushometer 3.0 gpf | | Replace urinal fixture and retrofit valves to 1.0 gpf. Saves 2.0 gpf. | $100-$250 | 1.8 - 8.0 | |
| Showerhead[5] | 2.5 gpm | Post mid-1990s | Currently Best Option – lower flow showerhead available for special condition (down to 1.5 gpm). | NA | NA | Rated at 60 psi pressure. |
| | 3-5 gpm | Post 1980 | Install 2.5 gpm showerhead. | <$20 | 0.5-2.5 | Appropriate pressure needed |
| | 5-8 gpm | Pre-1980 devises | Install 2.5 gpm showerhead. | <$20 | 0.25-0.5 | Appropriate pressure needed. |
| Kitchen Faucets[6] | 3-7 gpm | Pre 1980 devises | Install aerators to reduce flow to 2.5 gpm. | $5-$10 | 0.4-3.5 | No less than 2.5 gpm for kitchen applications. |
| Lavatory Faucets[7] | 3 - 7 gpm | Pre 1980 devises | Install aerators to reduce flow to 1.0 gpm or as little as 0.5 gpm. | $5-$10 | 0.05-0.7 | 0.5 gpm aerators suitable for bathroom wetting services. |

[1]Based on an average water and sewer rate in North Carolina of $3.97 per 1,000 gallons.
[2]Payback estimated for one shift operations. Divide payback period by two and three for two and three shift operations, respectively.
[3]Cost estimates are based on approximate installation cost using internal maintenance. Actual cost and payback periods may vary. Options based on widely available equipment believed not to reduce service quality or reliability.
[4]Urinal savings based on two uses per day per male employee.
[5]Showerhead savings base on two eight-minute showers per work day.
[6]Kitchen faucet savings based on three minutes of use per day.
[7]Lavatory faucet use based on 10 seconds of use per restroom visit.

period (e.g. five to 20 seconds), then automatically shuts off.

## Infrared and Ultrasonic Sensors

"Electric eye" sensors are available for a number of plumbing applications including lavatory faucets, urinals, and toilets. These devices deliver a metered flow only when the fixture is in use. For faucets, both the flow rate and activation time can be adjusted. The "no-touch" activation also is helpful to prevent the spread of disease and useful for users with disabilities. Sensored faucets, too, need to be checked for leaks and clogged flow controllerss because of any water impurities. An infrared sensored faucet or urinal/toilet controls can be purchased for about $200.

## Water spigots

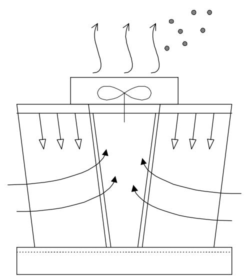
Self-closing commercial valves are available for water spigots, like those installed in public areas. Shut-off cycles from four to 25 seconds typically are available.

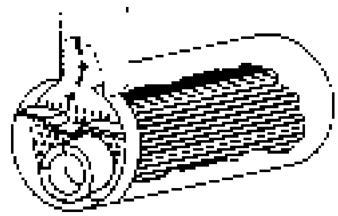
## Pressure Reducing Valves

Facilities should consider using a pressure-regulating valve when water line pressure is higher than 50 to 60 psi. Lowering excessively high-line pressure helps reduce the formation of leaks and will lower water flows from spigots, hoses, faucets, and water feed lines. A pressure reduction of 15 psi from 80 to 65 psi will reduce water flow by about 10 percent without sacraficing water service. A reduction from 80 to 50 psi will correspond to about a 25 percent water use reduction in light commercial settings.

# Cooling and Heating

**Cooling tower**





**Boiler**

## Background

The use of cooling towers represents the largest reuse of water in industrial and commercial applications. Cooling towers offer the means to remove heat from air conditioning systems and from a wide variety of industrial processes that generate excess heat. While all cooling towers continually reuse water, they still can consume 20 to 30 percent of a facility's total water use. Optimizing operation and maintenance of cooling tower systems can offer facility managers significant savings in water consumption.

## Cooling Tower Design

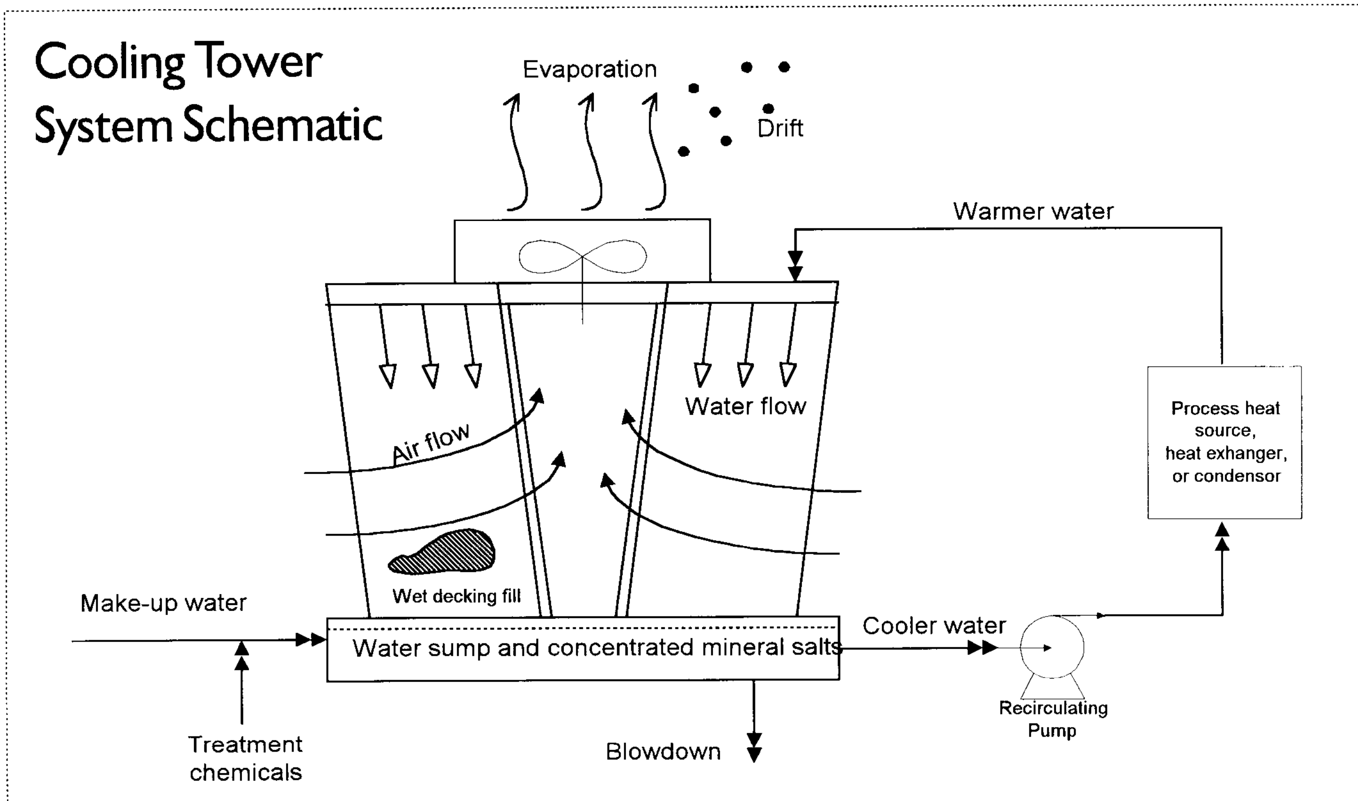
Warm water is recirculated continuously from a heat source, such as an air conditioning system or process equipment, to the cooling tower *(See Figure 18.)* In most cooling tower systems, warm water (or water to be cooled) is pumped to the top of the tower where it is sprayed or dripped through internal fill materials called wet decking. The wet decking creates a large surface area for a uniform thin film of water to be established throughout the tower. Air is blown through falling water over the wet decking to cause evaporation. Fans pull air through the tower in a counterflow, crossflow, or parallel flow to the falling water in the tower. Fore most efficient cooling, the air and water must mix as completely as possible.

## Evaporation

Cooling occurs in a tower by the mechanisms of evaporative cooling and the exchange of sensible heat. The loss of heat by evaporation (approximately 1,000 Btu per pound of water) lowers the remaining water temperature. The smaller amount of cooling also occurs when the remaining water transfers heat (sensible heat) to the air.

The rate of evaporation is about 1.2 percent of the rate of flow of the recirculating water passing through the tower for every 10 F decrease in water temperature achieved by the tower. The decrease in water temperature will vary with the ambient dew point temperature (DPT). The lower the dew point, the greater the temperature difference ($\Delta$T) between water flowing in and out of the tower. Another rule of thumb for estimating the

Figure 18




rate of evaporation from a cooling tower is as follows: evaporation equals three gallons per minute (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 British thermal units (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, saving both energy and water evaporation losses.

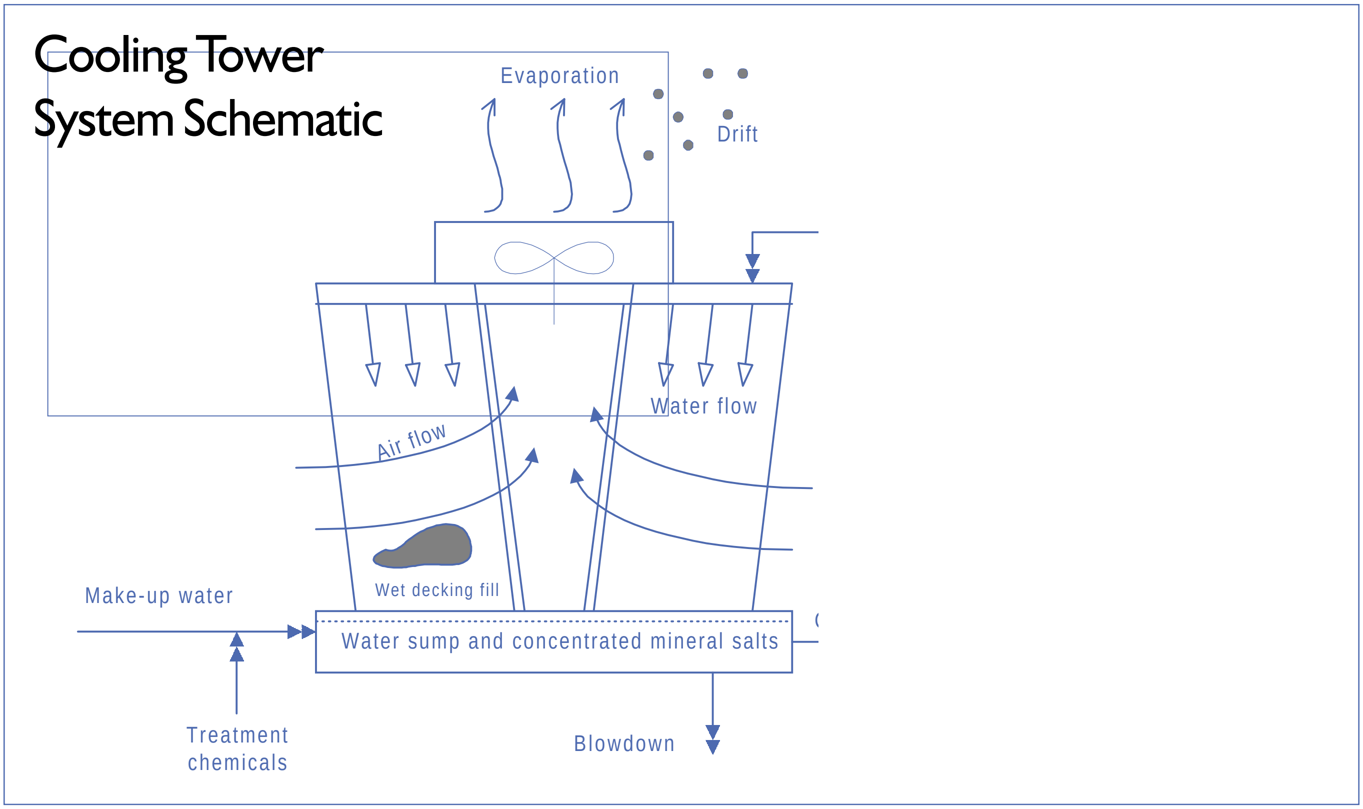
## Blowdown

Blowdown is a term for water that is removed from the recirculating cooling water to reduce contaminant buildup in the tower water. As evaporation occurs, water contaminants, such as dissolved solids, build up in the water. By removing blowdown and adding fresh makeup water, the dissolved solids level in the water can be maintained to reduce mineral scale build-up and other contaminants in the tower, cooling condensers, and process heat exchangers. Thermal efficiency, proper operation, and life of the cooling tower are related directly to the quality of the recirculating water in the tower.

Water quality in the tower is dependent on makeup water quality, water treatment, and blowdown rate. Optimization of blowdown, in conjunction with proper water treatment, represents the greatest opportunity for water efficiency improvement. Blowdown can be controlled manually or automatically by valves actuated by timers or conductivity meters.

## Drift losses

Drift is a loss of water from the cooling tower in the form of mist carried out of the tower by an air draft. A typical rate of

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## Drift losses

Drift is a loss of water from the cooling tower in the form of mist carried out of the tower by an air draft. A typical rate of drift is 0.05 to 0.2 percent of the total circulation rate. Reduction in drift through baffles or drift eliminators will conserve water, retain water treatment chemicals in the system, and improve operating efficiency.

## Make-up water

Makeup water is water added to the cooling towers to replace evaporative, blowdown, and drift losses. The amount of make-up water added directly affects the quality of water in the systems. The relationship between blowdown water quality and make-up water quality can be expressed as a "concentration ratio" or a "cycle of concentration." This ratio is shown in Figure 19.

The most efficient use occurs when the concentration ratio increases and blowdown decreases.

FIGURE 19

**CONCENTRATION RATIO**

$$\frac{\text{total dissolved solid (TDS) of make-up water}}{\text{TDS of blowdown}}$$

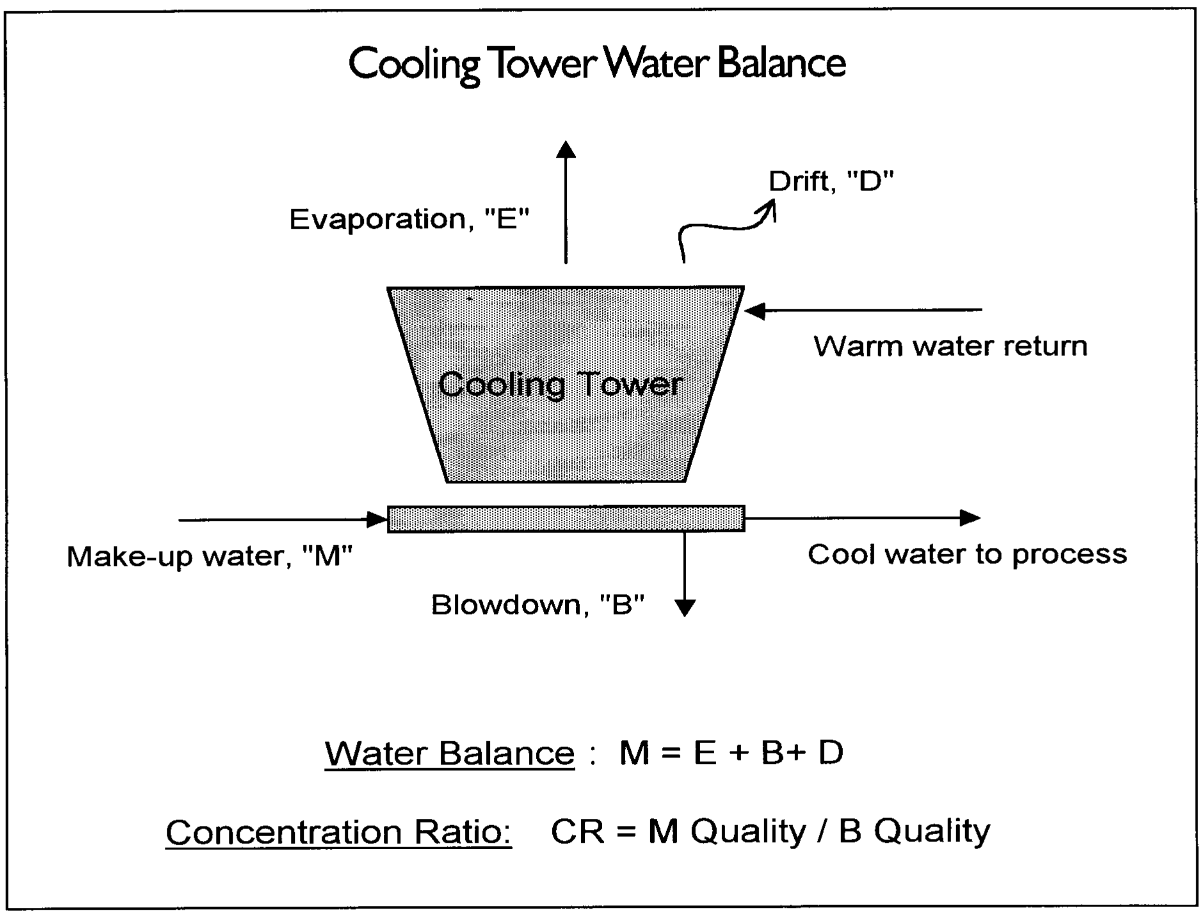
OR

$$\frac{\text{specific conductance } (\mu\text{mhos}) \text{ of make-up}}{\mu\text{mhos of blowdown}}$$

## Water balance

A simple water balance on a cooling tower system can be determined if three of the four following parameters are known: make-up, evaporation, drift, and blowdown. *(See figure 20 for a description of the cooling tower water balance.)*

FIGURE 20



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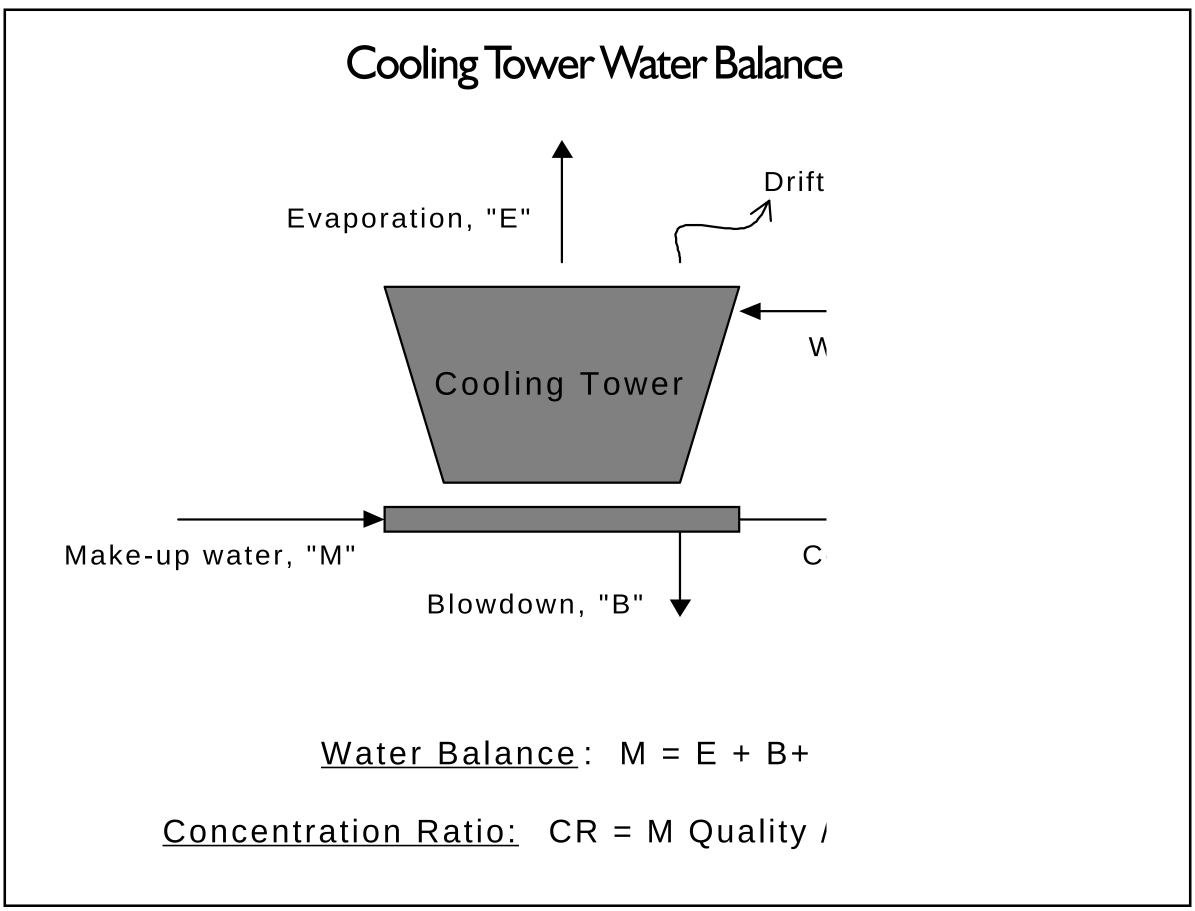


# WATER EFFICIENCY OPTIONS
*for cooling towers*

FIGURE 21

**Percent of Make-up Water 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% |

## Blowdown Optimization

Water consumption of cooling towers can be reduced significantly by minimizing blowdown in coordination with an integrated operation and maintenance program. Blowdown is minimized when the concentration ratio increases. Typical concentration ratios are 2-to-3, and generally can be increased up to six or more.

Some states have passed laws governing the quality level in a cooling tower as an attempt to promote efficient cooling tower water use. For example, the State of Arizona requires that the total dissolved solids (TDS) of blowdown water be 2,000 ppm or greater for a new large cooling facility whose total cooling capac-

$$V = M_i \times \frac{CR_i - CR_f}{(CR_i)(CR_f - 1)}$$

$V$ = volume of water conserved

$M_i$ = initial make-up water volume (before modification)

$CR_i$ = concentration ratio before increasing cycle

$CR_f$ = concentration ratio after increasing cycles ity is greater than 250 tons or three million Btu.

The volume of water saved by increasing the cycles of concentration can be determined by this equation:
For example, increasing concentration ratio from two to six will save 40 percent of the initial make-up water volume. Table 21 allows users to easily estimate potential water savings.

The maximum concentration ratio at which a cooling tower can still properly operate will depend on the feedwater quality, such as pH, TDS, alkalinity, conductivity, hardness, and microorganism levels. The use and sensitivity of a cooling system also will control how much blowdown can be reduced. Scale, corrosion, fouling, and microbial growth are four critical parameters that must be controlled in cooling towers. Minimum blowdown rates must be determined in tandem with the optimum water treatment program for the cooling tower.

## Controlling Blowdown

To better control the blowdown and concentration ratio, facilities can install submeters on the make-up water feed line

### Practical guidance for working with a service contractor

- Work closely with your chemical vendor or contracted service provider to reduce blowdown. Because reducing blowdown also reduces chemical purchasing requirements, facility personnel must keenly set up performance-based service contracts.

- Require vendors to commit to a predetermined minimum level of water efficiency. Have them provide an estimate of projected annual water and chemical consumption and costs.

- Tell your vendor that water efficiency is a priority, and ask about alternative treatment programs that will help reduce blowdown.

When purchasing chemicals for treating cooling tower water, have the chemical vendor explain the purpose and action of each chemical. Your vendor should provide a written report of each service call. Be sure the vendor explains the meaning of each analysis performed, as well as the test results.

and the blowdown line. Submetering allows operators to carefully control water use. In some areas, evaporative water loss, as determined by submetering and water balances, can be subtracted from local sewer charges. Submeters can be installed on most cooling towers for less than $1,000.

Blowdown can be conducted manually or automatically. Recirculating water systems are blown down when the conductivity of the water reaches a preset level. Typically, this is done in a batch process, blowing down sizable water volumes. A better approach is to use a conductivity controller to continuously bleed and refill water in the system. Continuous systems maintain water quality at a more consistent level without wide fluctuations in TDS.

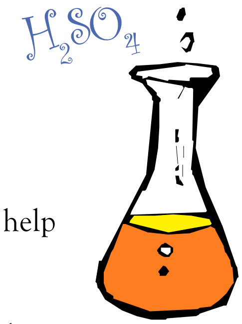
## Cooling Tower Water Treatment

Almost all well-managed cooling towers use a water treatment program. The goal of a water treatment program is to maintain a clean heat transfer surface while minimizing water consumption and meeting discharge limits. Critical water chemistry parameters that require review and control include pH, alkalinity, conductivity, hardness, microbial growth, biocides, and corrosion inhibitors.

Depending of the quality of the make-up water, treatment programs may include corrosion and scaling inhibitors, such as organophosphate types, along with biological fouling inhibitors. These chemicals normally are fed into the system by automatic feeders on timers or actuated by conductivity meters. Automatic chemical feeding tends to decrease chemical dosing requirements.

### *Sulfuric "Acid" Treatment*

Sulfuric acid can be used in a cooling tower water to help control scale buildup. When properly applied, sulfuric acid will lower the water's pH and help convert the calcium bicarbonate scale to a more soluble calcium sulfate form. In locations in Southern California and Phoenix, facilities are able to operate cooling towers at a concentration ratio of 5-to-6 using sulfuric acid treatment.




Important precautions need to be taken when using sulfuric acid treatment. Because sulfuric acid is an aggressive acid that will corrode metal, it must be carefully dosed into the system and must be used in conjunction with an appropriate corrosion inhibitor. Workers handling sulfuric acid must exercise caution to prevent contact with eyes or skin. All personnel should receive training on proper handling, management, and accident response for sulfuric acid used at the facility.

### *Side Stream Filtration*

In cooling towers that use makeup water with high suspended solids, or in cases where airborne contaminants such as dust can enter cooling tower water, side stream filtration can be used to reduce solids build-up in the system. Typically five to 20 percent of the circulating flow can be filtered using a rapid sand filter or a cartridge filter system.

Rapid sand filters can remove solids as small as 15 microns in diameter while cartridges are effective to remove solids to 10 microns or less. Neither of these filters are very effective at removing dissolved solids, but can remove mobile mineral scale precipitants and other solid contaminants in the water. The advantages of side stream filtration systems are a modest reduction in scale formation and fouling, which allows longer periods between major maintenance.

### Ozone

Ozone can be a very effective agent to treat nuisance organics in the cooling water. Ozone treatment also is reported to control the scale by forming mineral oxides that will precipitate out to the water in the form of sludge. This sludge

## CASE STUDY

Bayer Corp. in Clayton, North Carolina, substantially reduced city water consumption for cooling towers by reusing the "reject" stream from their reverse osmosis (RO) water treatment process. By reusing the RO "reject" water to replace cooling tower evaporative losses, Bayer is saving 10 million gallons of city water per year.

FIGURE 22

Summary of Cooling Tower Water Efficiency and Treatment Options

| Option | Advantages | Disadvantages |
|---|---|---|
| Operation improvements to control blowdown and chemical additions | Low capital costs<br>Low operating costs<br>Low maintenance requirements | None |
| Sulfuric acid treatment | Low capital cost<br>Low operating cost<br>Increased concentration ratio | Potential safety hazard<br>Potential for corrosion damage if overdosed |
| Side stream filtration | Low possibility of fouling<br>Improve operation efficiency | Moderately high capital cost<br>Limit effectiveness on dissolved solids<br>Additional maintenance |
| Ozonation | Increased concentration ratio<br>Reduced chemical requirements | High capital investment<br>Complex system<br>Possible health issue |
| Magnet System | Reduced scale<br>Reduced or eleminated chemical usage | Novel technology<br>Controversial performance claims |
| Reuse of water within the facility | Reduces overall facility water consumption | Increased fouling potential<br>Low concentration ratios required<br>Possible need for additional water pretreatment |

collects on the cooling tower basin or in a separate tank. Ozone treatment consists of an air compressor, an ozone generator, a diffuser or contactor, and a control system. The initial capital costs of such systems are high but have been shown to provide payback in 18 months.

### *Magnets*

Some vendors offer special water treating magnets that alter the surface charge of suspended particles in cooling tower water. The particles help disrupt and break loose deposits on surfaces in the cooling tower system. The particles settle in a low velocity area of the cooling tower — such as sumps where they can be mechanically removed. Suppliers of these magnetic treatment systems claim that magnets will remove scale without conventional chemicals. Also, a similar novel treatment technology, called an electrostatic field generator, can be investigated and validated.

CASE STUDY

**Eliminating Once-Through Cooling**

A small medical equipment manufacturer in Arden, North Carolina, was using a continuous tap water flow of 12 gpm to cool a 20-horsepower vacuum pump. After a water efficiency audit, the company installed a chiller water recirculating system. The company is now saving 6.6 million gallons of water per year, an estimated $30,500 annual savings in water and sewer costs.

### *Alternative Sources of Make-up Water*

Some facilities may have an opportunity to reuse water from another process for cooling make-up water. Water reuse from reverse osmosis reject water, wastewater from a once through cooling process, or from other clean wastewater streams in the plant are examples. In some cases, treated effluent can be used as cooling tower make-up if the concentration ratio is maintained conservatively low. Similarly, blowdown streams may be suitable for use as process water in some applications

It has been reported that municipal wastewater effluent from tertiary treatment may be suitably used as make-up water. In these reuse applications, reports of phosphate scale formation was problematic where water softening pretreatment was not also employed.

## Eliminate Once-Through Cooling

Many facilities use "once-through" water to cool small heat generating equipment. Once-through cooling is a very wasteful practice because water is used only one time before being sewered. Typical equipment that can be using once-through cooling includes: vacuum pumps, air compressors, condensers, hydraulic equipment, rectifiers, degreasers, X-ray processors, welders, and sometimes even air conditioners. Some areas of the country prohibit the use of once-through cooling practice. Option to eliminate once-through cooling are typically very cost effective. They include:

- Connect equipment to a recirculating cooling system. Installation of a chiller or cooling tower is usually an economical alternative.

Sometimes excess cooling capacity already exists within the plant that can be utilized.

- Consider replacing water-cooled equipment with air-cooled equipment. One example is switching from a water-cooled to an air-cooled ice making machine.
- Reuse the once-through cooling water for other facility water requirements such as cooling tower make-up, rinsing, washing, and landscaping.

# WATER EFFICIENCY IN LANDSCAPING

## Trends in Awareness

Irrigation and the care of landscapes is an important target for water efficiency. The demand for water in landscaping has caused many areas of the country to adopt measures to regulate the distribution of water supply. Some municipalities in North Carolina, such as Cary and Salisbury, have implemented landscaping ordinances, rate structures, and wastewater reuse systems to deal with water shortages and drought. As a growing trend nationwide, municipal conservation programs are heightening the awareness of design, installation, and maintenance standards for commercial landscapes.

Facility managers are becoming more aware of the need for water efficiency measures in their daily operations. The advancements of landscape design and maintenance technologies have made the upkeep of healthy, efficient landscapes simple and cost effective. With the assistance of extension agencies and consulting services, facility managers can develop optimum management methodologies to meet landscaping needs and water reduction goals.

## Xeriscaping for Water Efficiency

Xeriscaping is an approach that combines selecting, placing, and maintaining plants for optimum water management. The practice of xeriscaping began as a way to lessen the effects of water shortages, while maintaining the aesthetic and functional

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Facility managers are becoming more aware of the need for water efficiency measures in their daily operations. The advancements of landscape design and maintenance technologies have made the upkeep of healthy, efficient landscapes simple and cost effective. With the assistance of extension agencies and consulting services, facility managers can develop optimum management methodologies to meet landscaping needs and water reduction goals.

## Xeriscaping for Water Efficiency

Xeriscaping is an approach that combines selecting, placing, and maintaining plants for optimum water management. The practice of xeriscaping began as a way to lessen the effects of water shortages, while maintaining the aesthetic and functional qualities of a site. Xeriscape systems can reduce total water demand by as much as 50 percent or more. There are seven basic principles to xeriscaping:

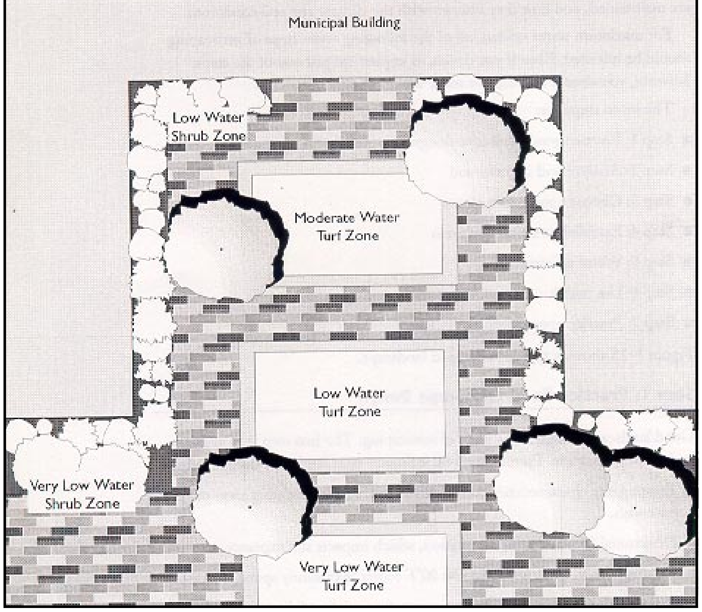
## 1 Planning and Design

A comprehensive design plan is the initial step to a water-efficient landscape. A well-thought and researched design will minimize cost and attain a proper strategy for plant and sprinkler placement. These factors should be considered:

- Site conditions such as drainage, soil type, sun exposure/shade, aesthetic preferences, existing plantings, slope/grade, and water availability are all crucial elements of an efficient plan.
- Intended use of the site must be carefully considered, including recreation, habitat, and traffic.
- Trees, shrubs, and grass all require different amounts of water. Plants should be placed in groups according to their respective water needs, called hydrozones. This way an irrigation system can be designed to properly match the needs of the plants, soils and weather conditions.
- A proper irrigation design should have a base schedule that includes sprinkler run times and weekly frequency for every month. This base schedule is used as a starting point for an irrigation manager.
- Incorporate high water demanding plants at the bottom of slopes.
- Incorporate the use of existing trees, plants, and wildlife areas to help add value to the site.
- Consider creating shade areas, which can be 20 degrees cooler than non-shaded areas.
- Minimize the use of impervious surfaces to reduce runoff and subsequent stormwater pollution.

FIGURE 23

Example of Xeriscaping at a Municipal Facility




- Consider using porous materials such as porous concrete or permeable paving methods.
- Consider grading and directing surface run-off and rainfall gutters to landscaped areas as opposed to drainageways that exit the property.

## 2 Soil Analysis and Improvement

- Soil testing will help determine soil quality and absorptive capacity. Choose plants based on these findings. Most soils require some adjustment of the pH (acidity or alkalinity). Contact your county cooperative extension offices for more information about how to conduct soil testing. The North Carolina Department of Agriculture (NCDA) provides free soil testing and improvement recommendations.
- Organic matter such as compost, mulch, or manure increases the

water holding capacity of soil and can help improve water distribution.

- When improving the soil of a given area, it is important to treat a large area around the planting to allow ample space for root systems.
- Do not allow heavy construction equipment to compact soil around existing trees or other sensitive natural areas.

## 3 Proper Plant Selection

- The selection of drought-tolerant, native species to a given area will greatly reduce maintenance costs and can improve the aesthetic presentation of a site.
- Consider plants' water demand, pest tolerance, soil nutrient, and drainage requirements.
- Native species are adapted to work together in similar soils and benefit each other's growth by forming symbiotic relationships.

## 4 Practical Turf Areas

- Turf grasses have the largest water consumption patterns of any plant group. Typically, turf in North Carolina requires between one and two inches of water per week.
- Plant grass only where it will provide optimal functional and aesthetic benefits.
- Avoid very small turf areas under 10 feet wide.
- Proper watering of turf (less frequent and deeper versus frequent and light watering) will promote deep root development, which will make the turf more drought tolerant.
- Where growing climates permit, consider warm season grasses such as bermuda and zoysia that require 50-75 percent less water than cool season tall fescues.
- Studies have shown that mowing turf at alternating heights can save up to 30 percent in watering requirements. Cutting grass short reduces water demand and cutting it higher leads to deeper root development and more drought tolerance.
- Whenever possible, plant alternative groundcovers that require less water, or consider the use of patios and decks, further reducing water demand.

## 5 Efficient Irrigation

- The proper design, installation, and maintenance of both the irrigation system and the landscape accomplish efficient irrigation. No amount of good maintenance can overcome the inefficiencies of poor design.
- Effective irrigation incorporates watering plants deeply, infrequently, and slowly. Saturating the soil deep enough to assist roots in growth is crucial; watering a higher number of times in a time period will restrict growth.

Extra irrigation will be required during establishment for most plantings.

- Automatic systems are a cost-effective way of ensuring that proper watering occurs, although it is important to adjust the system regularly for weather changes and plant growth.
- Trees, shrubs, and groundcovers are watered most effectively through drip emitter pipes and spray emitters that target the root zone of each plant.
- Uniformity of the water being applied by the irrigation system is the key ingredient in irrigation efficiency. Sprinkler uniformity is affected by the operating pressure, the nozzle used, and the sprinkler spacing.
- By observing the water consumption rates of plants throughout a growing season (called evapotranspiration, or ET rates), one can get an idea of the needs of the site as seasons change.
- Rain and moisture sensors add to the efficiency of a system, keeping in mind that maintenance always is necessary to ensure proper and dependable functions.
- Overspray that covers concrete or other impervious areas can negatively impact an area by contributing to runoff, pavement damage, and pollution of water resources adjacent to a site.
- The excessive or improper use of irrigation systems can severely hamper the nutritive ability of a site's soil content. Nutrients can leach out of the soil and move across a site to contaminate groundwater sources.

## 6 Use Mulches

Mulches are various organic materials, such as pine/oak bark, pine straw, aged wood chips, and compost mixtures that are placed around the root zone of a plant.

- The use of mulches around planting is highly effective in retaining soil moisture and reducing the need for watering and maintenance.
- Three to five inches of mulch reduces the level of evaporation from the soil, insulates root systems from heat, and limits the germination of weeds around beds and flora.
- Fine textured mulches help retain more moisture than coarse mulches.

## 7 Proper Maintenance

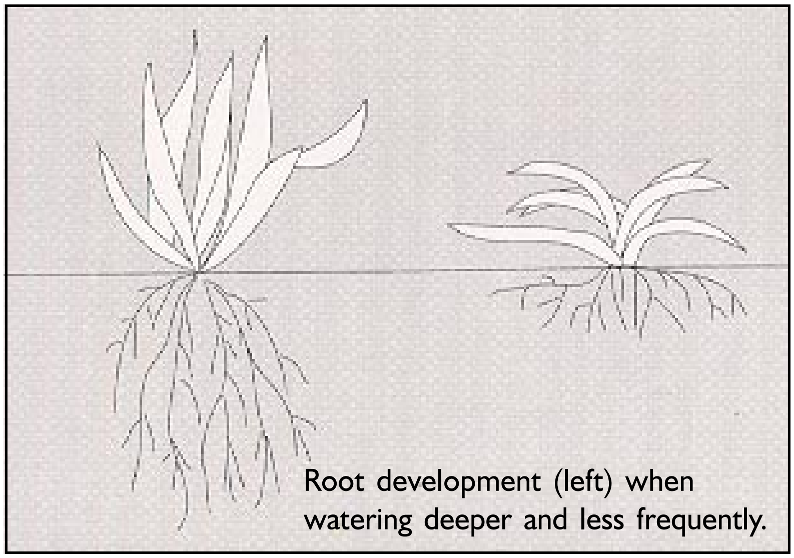
The most crucial element in sustaining water efficiency in any landscape site is ensuring that a regular maintenance

### CASE STUDY

The City of Santa Monica, California, was one of the first cities to require the use of xeriscaping for all landscapes installed in new commercial and industrial development.

Requirements included the use of low water plant materials, 20 percent maximum allowable turf area, low volume methods for irrigation (i.e. auto controllers, moisture sensors, and proper device placement, ongoing maintenance programs, and restricting the use of decorative water fountains and lakes).

FIGURE 24



Root development (left) when watering deeper and less frequently.

schedule is met. Attention to the landscape and irrigation system at regular time intervals will lower the cost of maintenance, and increase the effectiveness of water for landscaping.

- Mow grass at a proper height. Never mow grass to a height less than one-third its original height.
- Regular aeration of clay soils will improve water holding capabilities and prevent runoff.
- Use irrigation schedules that attain a deep and healthy root system.
- Keep nutrient levels balanced throughout the seasons.
- Inspect and adjust the sprinker emitters, filters, valves, and controllers for proper operation once a month.

## Benefits of Well-Planned Xeriscaping

Planning and development of functional landscapes should incorporate not only xeriscaping principles, but also use natural and native landscaping techniques to minimize the environmental effects from runoff, pesticides, fertilizer, water consumption, and other effects caused by maintenance practices. Ecologically balanced landscapes not only conserve resources and money but they physically improve property, reduce long term maintenance costs, and create land conscious landscapes. Benefits of ecologically-based, water-conserving landscapes include:

- Reduced off-site water consumption.
- Lower HVAC requirements.
- Provision for pedestrian movement and habitat needs.
- Maintained nutrients on site.
- Lower energy use and pollution
- Reduced water pumping and water treatment.
- Lessened runoff of stormwater and irrigation water.
- Lower maintenance and labor costs.
- Increased quality of landscape and surrounding habitat.

## Water Efficient Options for Existing Landscapes

A wide range of water efficiency options are available for existing landscapes. Facility managers should read the following list as well as review the previous explanation of the xeriscaping principle for performance improvements. Additionally, professional help can be obtained by contacting the Irrigation Association for a list of certified irrigation designers, certified landscape water auditors and certified irrigation contractors in North Carolina.

## When to Water

- Water in the early morning or late evening to maximize absorption and minimize evaporation. These techniques can save as much as 30 percent of your watering demand.
- Water when wind is less than 10 miles per hour.
- Water only when plant groups are showing signs of drought stress.
- If there has been significant rain to replace the water used (evapotranspiration, ET rate), do not water. A rain sensor attached to the irrigation timer will accomplish this automatically.

## Amount of Water Plants Require

- Use ET data to help determine a plant's water needs.
- Water deeply once or twice a week instead of lightly every day. *(See Figure 24.)*
- To prevent runoff or deep percolation below the roots, never apply water faster than the soil can take it in or more than the soil can hold. *(See Maximum Sprinkler Run Time figure.)*
- Assess the characteristics of a site through a water audit. Audits

### Average Weekly Run Times for North Carolina

**Minutes Per Week**

| | Water required (inches/week) | Cool season turf | | Warm season turf | | Shrubs | |
|---|---|---|---|---|---|---|---|
| | | Spray | Rotor | Spray | Rotor | Spray | Rotor |
| March | 0.77" | 42 | 141 | 36 | 123 | 28 | 94 |
| April | 1.19" | 65 | 219 | 56 | 189 | 43 | 146 |
| May | 1.47" | 80 | 270 | 69 | 234 | 53 | 180 |
| June | 1.61" | 88 | 296 | 76 | 256 | 59 | 197 |
| July | 1.66" | 91 | 305 | 78 | 264 | 60 | 203 |
| August | 1.57" | 86 | 288 | 74 | 250 | 57 | 192 |
| September | 1.12" | 61 | 206 | 53 | 178 | 41 | 137 |
| October | 0.74" | 40 | 136 | 35 | 118 | 27 | 91 |

**To Use:**

1. Identify the type of plant material the valve is watering.
2. Determine the type of sprinkler heads on that valve.
3. Locate the weekly runtime for the current month and divide the number of minutes by the number of days the valve will operate in one week.
4. Enter that daily run time on the controller.
5. Repeat for each valve on the controller.
6. Set the controller to come on the same number of days in a week as you divided by.

These average run times are meant as a starting point to build an irrigation schedule. Every landscape has different soil types, micro-climates, and plant types. Each system also will operate with different pressures, sprinkler spacings, and brands of sprinklerheads. All these differences will require that these times be adjusted to meet the specific conditions of every zone valve.

## 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 |

evaluate the specific water needs and conditions of an existing site.

- Consider that every square foot of watershed hardscape can shed more than 25 gallons of irrigation water every year.

## Where to Water

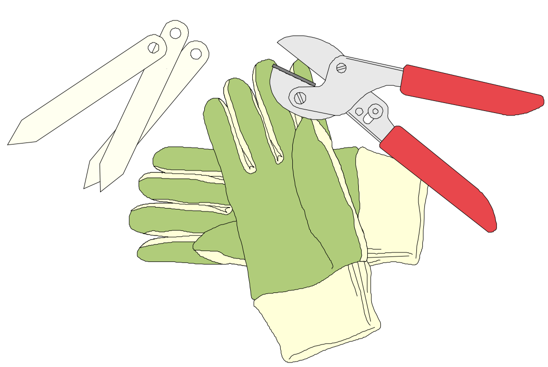
- Plants should be watered at their roots, not on their leaves or trunk.
- Make sure automatic irrigation systems such as drip and sprinklers are adjusted to reach plant roots.
- Select and maintain sprinkler heads to avoid watering sidewalks and pavement.

## System Maintenance Considerations

- Replace sprinklers with like sprinklers. Spray heads should not operate on the same value with rotors.
- Ensure spray heads are aligned with grade.
- Replace worn spray nozzles.
- Regulate pressure properly for system demands.
- Check for leaking valves.
- Inspect low-volume emitters for plugs.
- Inspect sprinklers for clogged nozzles.
- Adjust sprinklers to water plant material and not sidewalks or roads.
- Adjust the operating time (runtimes) of the sprinklers to match the seasonal or monthly requirements.
- Take soil samples to look for compaction or thatch buildup.

## Irrigation System Operations

- Consider adding a rain shutoff device, rainfall sensors, or a soil tensiometer to your automatic irrigation control system.
- Consider alternative sources for irrigation water, including the use of wells as opposed to city water, water reuse options from fountains, non-contact cooling water, or even treated graywater.
- Use electronic controllers with precise timing, multiple irrigation zones, multiple cycles, and attached rain shut-off devices.
- Incorporate separate irrigation



zones for all irrigated plant hydrozones, and use separate irrigation zones for turf areas.
- Use dedicated water meters for landscaping water use.
- Use drip or other low volume irrigation wherever possible.
- Have a catchment, or DU (distribution uniformity), test performed on-site to determine how evenly water is applied when sprinklers are in use.

## Water Efficient Technologies

### *Automatic Irrigation Timer*

A simple-to-operate automatic timer or controller can be installed on an existing manual irrigation system. The controller automatically will operate the sprinklers on the proper day of the week for the correct amount of run time. This will meet the plant's water needs as well as apply the water in off-peak night or early morning hours. More elaborate controllers offer extra flexibility to manage larger sites with many different hydrozones and site conditions. Any controller can use a rain soil moisture sensor to prevent the sprinklers from operating when natural precipitation has met the plant's water needs.

### *Centralized Irrigation Controllers*

To manage many irrigation controllers, spread out among many sites, a centralized control system will save labor costs as well as increase water efficiencies. A typical central irrigation control system utilizes a personal computer (PC) to create, adjust, and save irrigation schedules for multiple controllers at various locations. The PC then communicates to the controllers by radio, hardwire, telephone, or a combination of two or more methods. A PC central system can also monitor and react to different alarm situations like broken heads or pipes, valve malfunctions, or many other water saving sensors.

A central control system does not relieve the water manager from monitoring and adjusting the equipment. It allows them to quickly adjust multiple controllers to the monthly or daily changes in conditions that affect the water needs of the plants. This typically results in the prevention of over-watering.

### *PC Software*

There are software programs that have been developed to assist the designer and water manager in the analysis of the efficiency of an existing or newly designed irrigation system. Two of the primary programs were developed by the Center for Irrigation Technology at California State University, Fresno. The program used to generate graphic representations of sprinkler efficiencies is called *Hyper-SPACE™*. The software that analyzes the costs versus the benefits of improving irrigation efficiencies is *called SPACE Irrigation Survey™*. Many Certified Water Auditors and Certified Irrigation Designers use this software programs extensively.

### *Sensors*

There are two basic types of sensors used in water management.  The soil moisture sensor measures the moisture levels in the

CASE STUDY

Aurora, Colorado, eliminated more than one billion gallons of water needs by the construction of a wastewater reuse system that uses industrial wastewater for irrigation.

soil and the rain sensor measures the amount of effective rainfall. Both are designed to be added to any automatic irrigation controller. They both prevent the controller from activating the valves if there is either enough moisture of rainfall.

Soil moisture sensors detect moisture in a number of different ways. The specific soil conditions and landscape layout will determine which type is best suited for the application. When properly maintained, soil moisture sensors can reduce water use by as much as 40 percent.

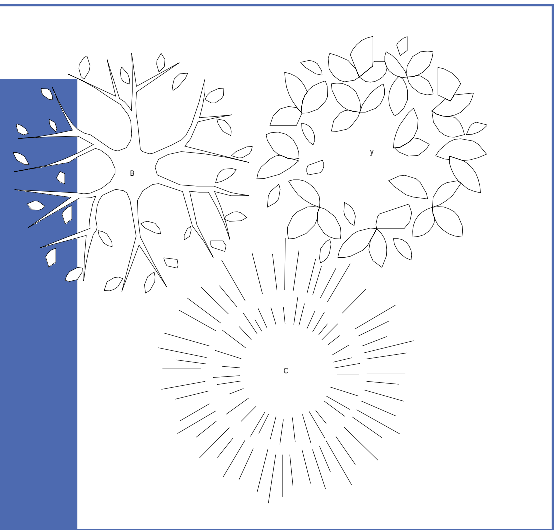
Rain sensors have the single largest impact on water savings in an automatic irrigation system of any equipment that can be added. Rainfall sensors measure the amount of rainfall and, at a preset level, stop the irrigation. When the conditions dry out, the rain sensor allows the controller to resume normal operation. They do not affect the programming of the controller.

## Water Efficient Plants

A major factor of water efficient landscapes is the selection of plants. Plants' watering needs are divided by hydrozones. The use of drought tolerant and native plants not only minimizes runoff concerns, but also can strategically make the most use of rainfall patterns. In addition to the lists of drought tolerant plants *(See next tow pages.)*, the North Carolina Cooperative Extension Services can provide further information and assistance for selecting water efficient plants.

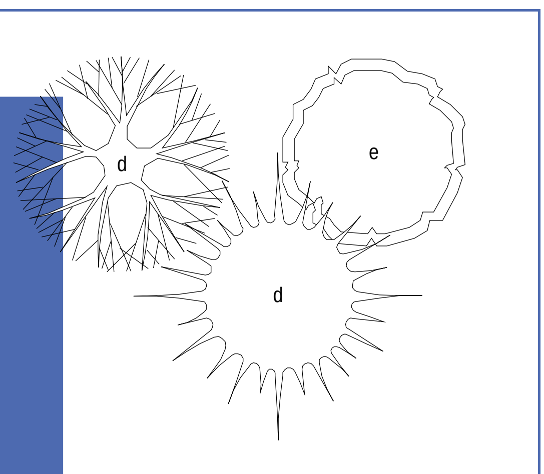
TREES

| Common Name | Botanical Name |
|---|---|
| Lacebark elm | Ulmus parvifolia |
| Japanese zelkova | Zelkova serrata |
| Tulip poplar | Liriodendron tulipfera |
| Sycamore | Platanus occidentalis |
| Laurel Oak | Quercus laurifolia |
| Live Oak | Quercus virginiana |
| Pin Oak | Quercus palustris |
| White Oak | Quercus alba |
| Crepe Myrtle | Lagerstroemia indica |
| Hollies | Ilex spp. |
| Chaste tree | Vitex agnus-castus |
| Sweet gum | Liquidambar styraciflua |

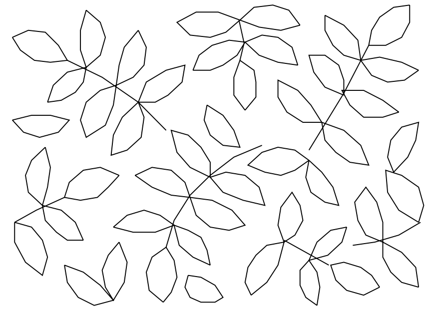


SHRUBS

| Common Name | Botanical Name |
|---|---|
| Chinese photinia | Photinia serrulata |
| Elaeagnus | Elaeagnus |
| Firethorn (pyracantha) | Pyracantha coccinea |
| Japanese privet | Ligustrum japonicum |
| Junipers | Juniperus spp. |
| Yaupon holly | Ilex vomitoria |
| Mahonia | Mahonia spp. |
| Nandina | Nandina domestica |
| Chinese holly | Ilex cornuta |
| Strawberry bush | Euonymus americana |
| Forsythia | Forsythia intermedia |
| Barberry | Berberis spp. |
| Quince | Chaenomeles japonica |
| Viburnum | Viburnum spp. |
| Euonymus | Euonymus spp. |
| Spirea | Spirea spp. |
| Glossy abelia | Abelia grandiflora |
| Jasmine | Jasminum spp. |

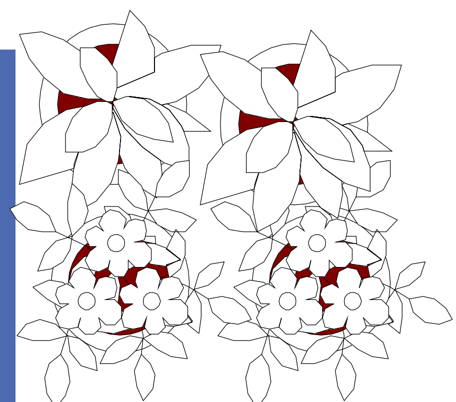


# GROUND COVERS/VINES



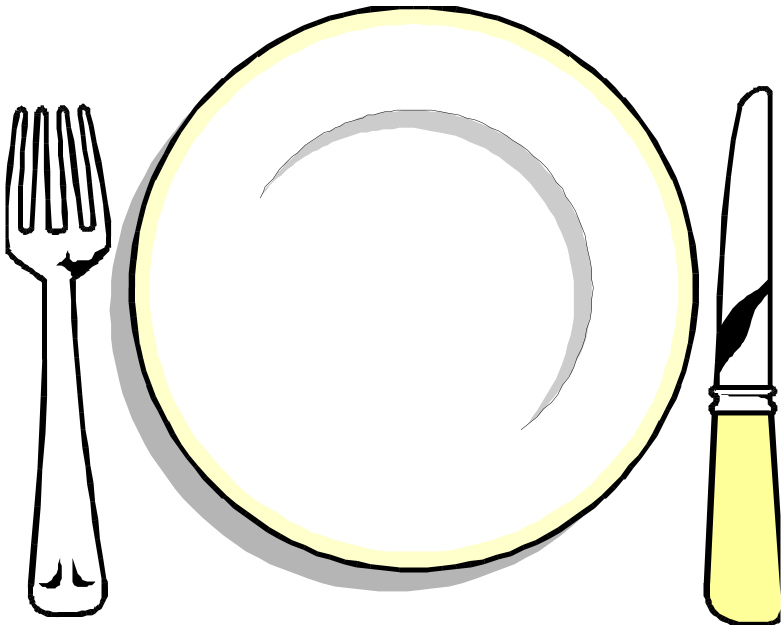
| Common Name | Botanical Name |
|---|---|
| Mondograss | Ohpiopogon japonicus |
| Liriope | Liriope spp. |
| Junipers | Juniperus spp. |
| Thrift | Phlox subulata |
| English Ivy | Hedera helix |
| Clematis | Clematis spp. |
| Trumpet Honey Suckle | Lonicera sempervirens |
| Wisteria | Westeria spp. |
| Wintercreeper | Euonymusfortunei |
| Periwinkle | Vinca spp. |

# ANNUALS & PERENNIALS



| Common Name | Botanical Name |
|---|---|
| Gazania | Gazania rigens |
| Annual Vinca | Catharathus roseus |
| Annual phlox | Phlox drummondii |
| Baby's breath | Gypsophila spp. |
| Black-eyed Susan | Rudbeckia spp. |
| Coreopsis | Coreopsis spp. |
| Cape marigold | Dimorphotheca sinuata |
| Cornflower | Centaurea cyanus |
| Cosmos | Cosmos spp. |
| Globe amaranth | Gomphrena globosa |
| Moss rose | Portulaca grandiflora |
| Straw flower | Helichrysum bacteatum |
| Verbena | Verbena spp. |
| Butterfly weed | Asclepias tuberosa |
| Gaillardia | Gaillardia x grandiflora |
| Goldenrod | Solidago hybrids |
| Liatris | Liatris spp. |
| Purple coneflower | Echineacea prurpurea |
| Sedum | Sedum spp. |
| Stokes' aster | Stokesia cyanea |

# KITCHEN & FOOD PREPARATION



Although commonly overlooked, there are many ways to reduce water usage in the kitchen. Traditionally, saving water has not been a major consideration of commercial food preparers. Many establishments cite the lack of money or employees as reasons for not using water conservation methods. Case histories have shown that water efficiency programs are cost-effective, and most initial costs are retrieved within a two-year period. Participation in water efficiency programs shows that there is a concern for efficient water. These programs are supported by local communities.

Inefficient uses of water in kitchen operations come mainly from two areas: equipment design and behavioral patterns. The main types of water-using equipment found in kitchens are dishwashers, faucets, ice-making machines, and garbage disposal use. Improved technology has eliminated many of the

## CASE STUDY

A study of 605 industrial water efficiency programs by the Metropolitan Water District of California estimated that facilities cut kitchen/cafeteria water use by 32 percent, yielding a saving of nearly 100,000 CCF of water per year.

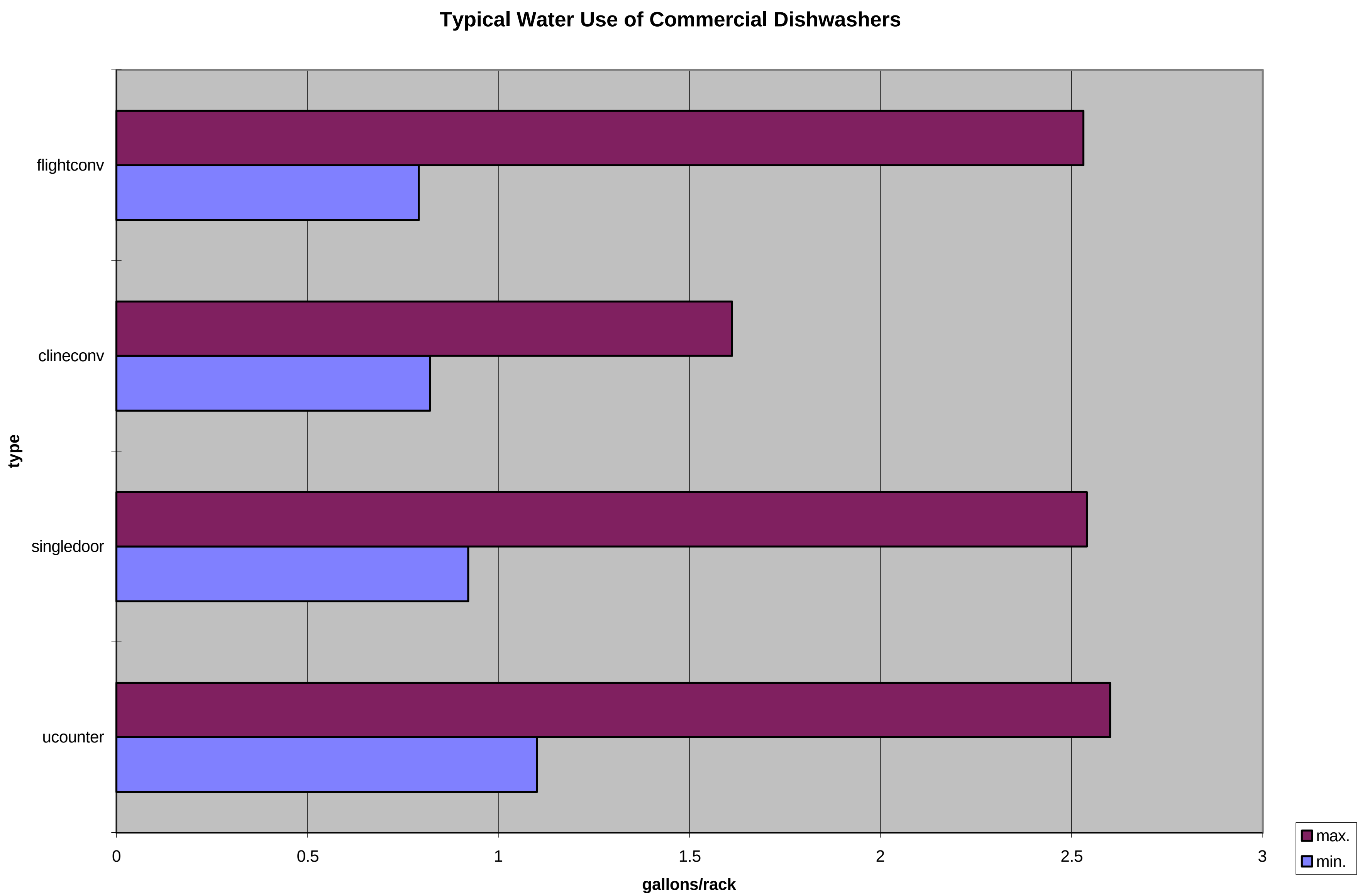
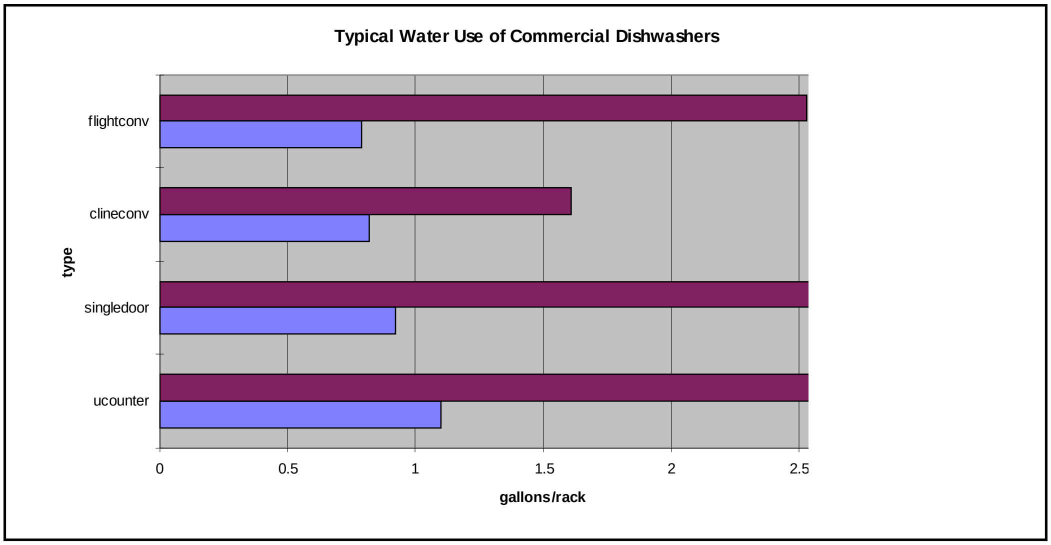

Typical Water Use of Commercial Dishwashers
type
flightconv
clineconv
singledoor
ucounter
0
0.5
1
1.5
2
2.5
3
gallons/rack
max.
min.

FIGURE 25




water issues associated with equipment, as more rigid standards have been created to curtail excessive water use. Water audits of commercial facilities have shown that 60 percent of identified water savings comes from simply installing faucet aerators in all kitchen sink outlets. An effective part of water savings in kitchens is attributed to behavioral patterns in facilities. Awareness programs, education, training, and job performance measures can influence proper behavioral patterns of staff.

## Dishwashers

All dishwashing machines employ wash, rinse, and sanitizing cycles. The sanitizing cycle typically is the chemical reduction of microorganisms to safe levels on any food utensil. The time taken for a dishwasher to complete a cycle is a combination of mechanical action, water temperature, and chemical action. Most dishwashers use between 2.0 and 7.0 gpm for a complete cycle of cleaning and sanitation. Hot water use varies with the pressure of supply lines, operation speed of the machine, and dish table layout.
All these variables are intrinsically linked and any adjustments affect each component. For example, rapid washing cycles necessitate stronger mechanical action and more concentrated detergents for cleaning.

## Types of Dishwashing Machines

There are four main types of dishwashing machines: undercounter, door, conveyor, and flight. A wide array of models and accessories are available for each category. Requirements for machine size can be calculated by estimating the amount of traffic that will be served in the food service area. Energy guidelines and water consumption levels for dishwashers are becoming stricter, and many manufacturers offer new water-saving models. Figure x illustrates typical water use ranges for each type of dishwasher normalized on a "per rack" basis. Most importantly, note the wide range of water use in each dishwashing category. *(See Figure 25.)* Using an appropriately sized, water efficient model will save a significant amount of water.

### *Undercounter*

Smallest of commercial dishwashers, undercounter dishwashers are best suited for small establishments of about 60 people. They commonly are used in nursing homes, churches, small food service areas, office buildings, and for glass washing in taverns and bars. The undercounter machines are similar to residential dishwashers in that the door opens downward with rack(s) rolling out onto the lowered door for access.

A revolving wash arm handles the wash and rinse cycles, with a small holding tank being automatically drained after each cycle. An automatic timer controls cycle length. Undercounter machines come in both hot water and chemical sanitizing models, with optional booster heaters for the latter. As can be seen in Figure 25, undercounter machines use the most water per rack of all commercial dishwashers. This illustrates the need to wash only full racks when the machine is in use.

### *Door-type*

Manufactured to service 50-200 people, door type machines are the most widely used of commercial dishwashing machines. Door machines are used in schools, hospitals, churches, restaurants, catering businesses, fast-food establishments, and as glass and utensil units in larger operations. These box-shaped machines have singular or multiple doors that slide vertically for loading and unloading. Door type machines are available in high temperature and chemical sanitizing models. These "dump and rinse" machines have a single tank for water and detergent, which are circulated in measured volumes and temperatures. Two revolving spray arms (one above and one below the dish rack) distribute wash solutions evenly over the dishes. Some door-type machines now have the ability to recycle rinse water to be used again in a wash cycle.

## Types of dishwashing machines

- undercounter
- door-type
- C-line conveyor, or rack
- flight type

### *C-line Conveyor, Rack*

C-line, or rack conveyor, machines use a motor-driven conveyor belt to move the rack-loaded dishes through a large tank with separate wash and rinse compartments. Most widely-used in hotels, large restaurants, hospitals, schools, and universities, these machines are well suited for service of 200 or more people, accommodating most heavy food service operations.

C-line machines come in varying sizes, with available additions such as pre-wash units, side-loading trays, condensers, and blower-dryers. A single tank holds the water and detergent at a regulated temperature. The wash solution is pumped through multiple spray arms (revolving or stationary) that run constantly once the machine is operational, regardless the presence of a dish rack. The rack is then sent through the rinse compartment, where it is sprayed with the 180 F water by spray nozzles above and below the rack. C-line machines with multiple tanks differ in that some use stationary versus rotating spray arms. The racks then are sent into a pump-driven rinse tank that rinses the dishes heavily. This process usually uses recycled water from the final rinse. All rack conveyor machines have a timer control for the speed of the conveyor to assure proper wash and rinse times.

Water efficient measures, such as the installation of an electric eye sensor (that keeps the conveyor from running when there are no dishes on the racks) have started to make rack conveyors more energy- and cost-effective. Some efficient conveyors can reduce final rinse consumption from 300 gph to 130 gph. The use of energy efficient boosters and low flow pumps can reduce energy and water consumption levels by 50 percent.

### *Flight type*

Similar in that they use a conveyor belt to move dishware, flight type machines do not have racks. Rather, dishes are loaded directly onto the belt. Flight type dishwashers provide high volume washing capability needed only in the largest institutional, commercial, and industrial facilities. Variations in possible machine additions include power scrapers, power wash, power rinse, final rinse, and blower-dryers.

Water efficient strategies for these machines include the recirculation of final rinse water, electric eye sensors, extra-wide conveyors, and low-energy built-in booster heaters. These additions have amounted to water savings as much as 47 percent, while maintaining loads of more than 14,000 dishes per hour.

## Water Efficient Practices for Dishwashers

The volume of consumption in dishwashers can be reduced by a variety of practices, all of which target awareness of equipment and operation needs.

### *Behavioral Modifications*

- Educate staff about the benefits of water efficiency and the importance of hand scraping before loading a dishwasher.
- Instruct staff to quickly report leaks and troubleshoot.
- Only run rack machines if they are full.
- Try to fill each rack to maximum capacity.

### *Mechanical Modifications*

- Recycle final rinse water for washing.
- Keep flow rates as close as possible to manufacturer specifications.
- Install “electric eye sensors” to allow water flow only when dishes are present.
- Install door switches for convenient on/off access.
- Check voltage of booster heater to make sure it fits the machine.
- Uses “steam doors” to prevent loss of water due to evaporation.
- Install low temperature machines that rely on chemical sanitizing over high water temperature.
- Check volume of service and estimate facility needs — a better option may be a larger machine that has a lower water flow rate per rack.

## Kitchen Faucets and Pre-rinse Sprayers

Faucets can waste large amounts of water, as they are the most heavily used water source in kitchens. Conventional faucets, with typical flow rates of 2.5 to 4.0 gpm, can waste as much as 40 gallons of water a day when not fully closed. Since 1994, water efficiency standards have been federally mandated, requiring that all post 1994 manufactured faucets consume a maximum of 2.5 gpm @ 80psi. But many facilities have older fixtures with rubber gaskets that wear and deform because of high amounts of hot water use. By simply installing a brass gasket and an automatic shut-off nozzle, a facility could save as much as 21,000 gallons of water per year. There have been many adjustments and technology advancements in faucet design as a variety of low-flow faucet types are manufactured. Foot-activated kitchen faucets will reduce water use while providing additional convenience. Faucets used in kitchens will be primarily the conventional type or pre-rinse pressure sprayers. There are a variety of modifications that can be employed for all types.

## CASE STUDY

By installing a foot-actuated faucet, one food service facility reduced its monthly water usage by 3,700 gallons. This translated to annual savings of nearly $700.

## Water Efficiency Options for Kitchen Faucets

- Adjust flow valve to reduce water flow.
- Check for leaks and worn gaskets.
- Install a flow restrictor to limit maximum flow rate to 2.5 gpm or less.
- Install a 2.5 gpm faucet aerator, maximizing flow efficiency by increasing airflow to the stream.
- Consider infrared or ultrasonic sensors that activate water flow only in the presence of hands or some other object.
- Install pedal operated faucet controllers to ensure valves are closed when not in use.
- Educate staff to look for leaks and broken faucets in their area.
- Do not leave faucets on to thaw vegetables and other frozen foods.
- Post water conservation literature and reminders to staff around work areas.

## Pre-rinse Sprayers

Pre-rinse sprayers are used for rinsing cooking utensils, pots, pans, soaking dishes, and cleaning. They are designed with automatic shut-off valves at the hose head to supply water only when needed. There are water efficient spray valves offered that supply from 1.6-2.65 gpm @ 80psi. These types of sprayers are designed to meet the demands of food service operations.

## Ice Making Machines

Ice machines have many commercial uses, from restaurants to lodges, and can use significant amounts of water depending on the type of machine and the desired type of ice. Ice machines are composed of the following components: a condensing unit used for cooling, an evaporator surface for ice formation, an ice harvester, an ice storage container, and, in some models, a dispenser. The type of condenser an ice machine uses will have the largest effect on water use. Two types of condensers are available: air-cooled and water-cooled. Water-cooled machines use 10 times as much water as air-cooled machines and water rarely is recirculated. *(See Figure 26.)* In comparing water- and air-cooled compressors, the compressor horsepower at design conditions is invariably higher with air-cooled machining. However, operating costs frequently compare favorably during a full year. The

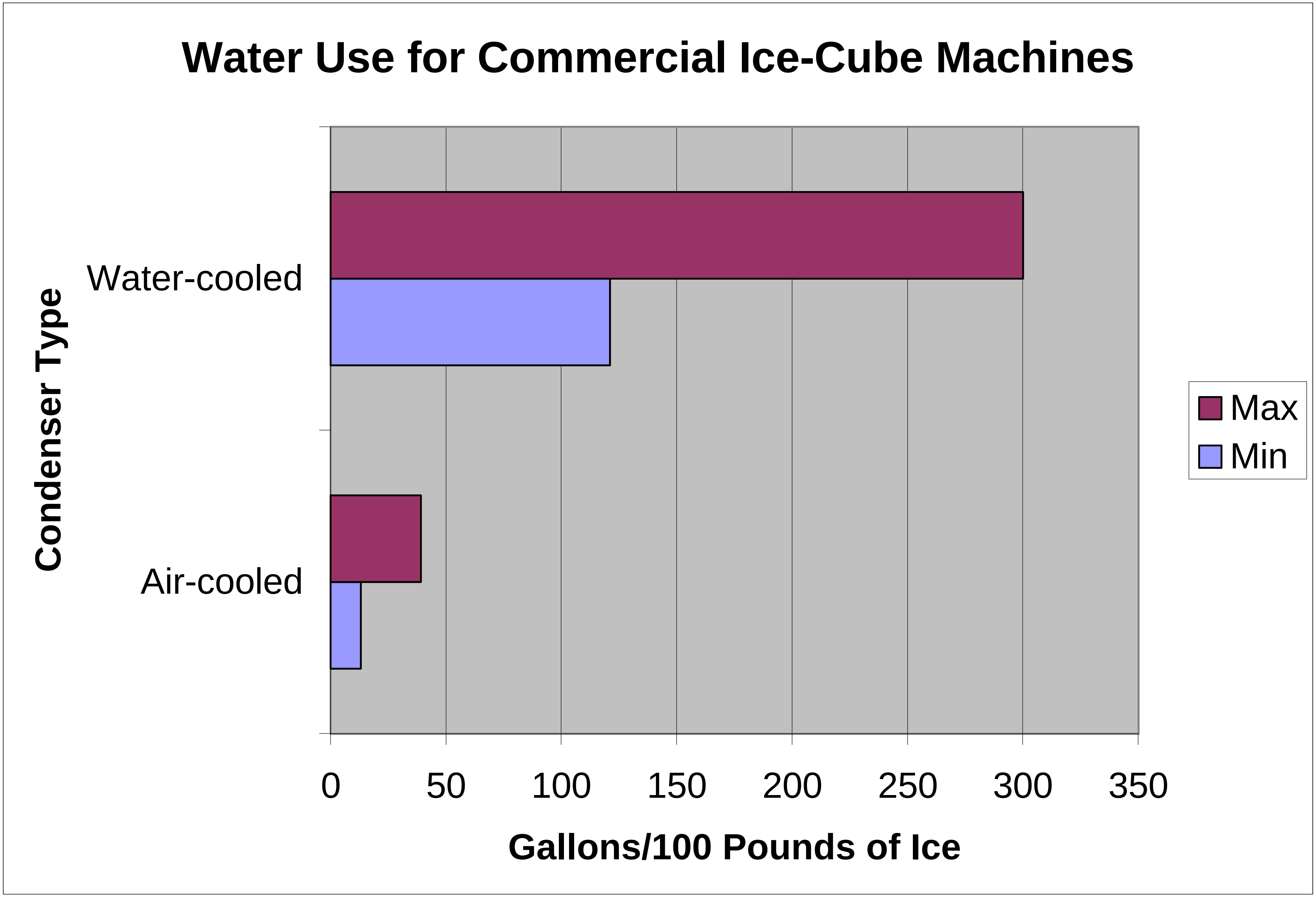
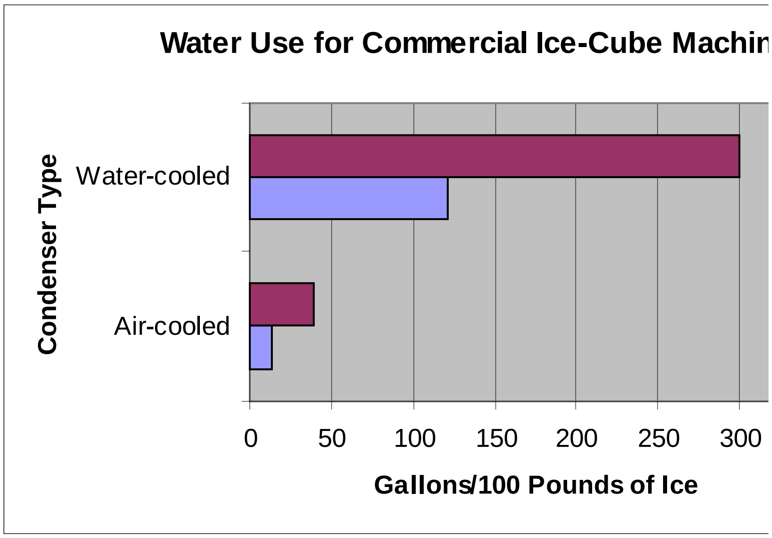

Water Use for Commercial Ice-Cube Machines
Water-cooled
Air-cooled
Condenser Type
Max
Min
0
50
100
150
200
250
300
350
Gallons/100 Pounds of Ice

FIGURE 26



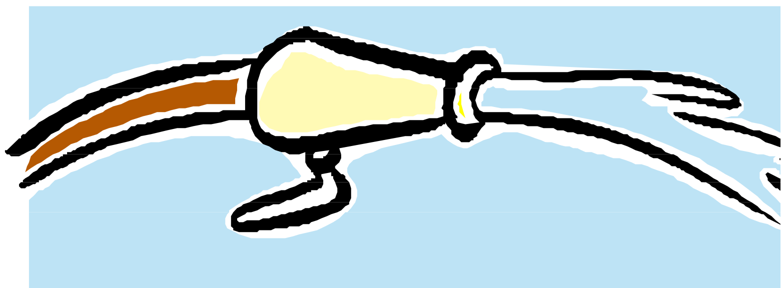

*Water-cooled machines use 10 times as much water as air-cooled machines and water rarely is recirculated.*

desired quality and visual clarity of ice also will influence water consumption. Ice quality, machine cleaning, and water efficiency all need to be balanced for optimum operation.

## Garbage Disposals

Studies show that garbage disposals can waste a significant amount of water. It is recommended that their use be minimized or eliminated from kitchen operations. Many facilities use strainers or traps that employ a mesh screen to collect food waste for proper waste treatment. Another option is to install strainers in sinks, leaving the food matter in the sink for disposal in trash receptacles or composting units.

# CLEANING AND RINSING APPLICATIONS



Most industrial and commercial businesses have a variety of cleaning and rinsing applications that can consume large volumes of water. Water efficiency techniques presented here address general water uses for process change-overs, equipment clean-out, parts rinsing, tanks rinsing, line flushing, floor cleaning, and other applications. Because this section is generic in nature, the water efficiency concepts presented will need to be individualized for specific business needs and any regulatory cleanliness standards. *(Also see sections on metal finishing, textiles, and food processing for more specific water efficiency applications.)*

## Education: First and Foremost

Employees must be aware of the need for water efficiency. Many cleaning processes can be made significantly more efficient by simple measures. If employees are actively solicited and involved in water reduction efforts, behavior, and equipment modifications will successfully reduce water consumption.

## Dry Cleanup

Dry clean-up means using brooms, brushes, vacuums, squeegees, scrapers, and other utensils to clean material *before* water is used. By collecting the majority of wastes, residues, or contaminants in a dry form, large volumes of water and wastewater can be eliminated. The bulk of solid materials can be more efficiently removed in dry form before water is introduced for secondary washing.

### *Examples of Dry Clean-up Practices*

- Sweeping floors instead of hosing with water.
- Vacuuming or sweeping dry material spills such as salt or dyes

CASE STUDY

Dry Cleanup

The Equity Group in Reidsville, North Carolina, instituted a comprehensive program to reduce water use and wastewater pollutant loading in their food processing operation. Employees were trained to remove all dry waste from floor and equipment for cleaning. Because of dry clean-up practices, much of the waste food residuals can have a secondary use, such as for animal food. Dry-cleanup, improved employee awareness, and other operation modifications saved 1.25 million gallons per month and reduced organic pollutant loading to wastewater by 50 percent.

instead of using water.
- Use squeegees and scrapers first to remove residual from machines such as ink sludge from machine troughs between color change-overs.
- Vacuuming or sweeping particulate emissions (dust) instead of hosing with water.

Use rubber squeegees to collect food processing residuals from the floor before hosing with water. Use "pigs" to purge residual from pipes before flushing with water.

### *Benefits of Dry Clean-up*

- Saves water and reduces wastewater.
- Reduces water, wastewater, and surcharge costs.
- Reduces pollutant loading entering wastewater system.
- Saves energy for processes that use hot water.
- Reduces hydraulic capacity demands on any wastewater treatment systems.
- Better enables the reuse, recycling, or composting, of "dry" collected materials.

## Eliminate/Reduce Floor Washing Where Feasible

- Many floor surfaces (i.e. warehouses, offices, automotive garages, non-critical processing areas, facility support operations, etc.) do not need to be washed with water.
- If necessary, use dry absorbents, and sweep or vacuum these areas.
- Find and eliminate the source of spills and leaks that may be the sole reason why water washdowns are needed.
- Spot mop if necessary.
- Use floor mats, "clean-zones," and

other means to reduce the tracking of waste and dirt residual throughout a facility.

## Use Efficient Spray Washing/Rinse

Many improvements can be made to the water delivery system for washing and rinsing. Proper selection, control, use, and maintenance are essential. Consider these suggestions:

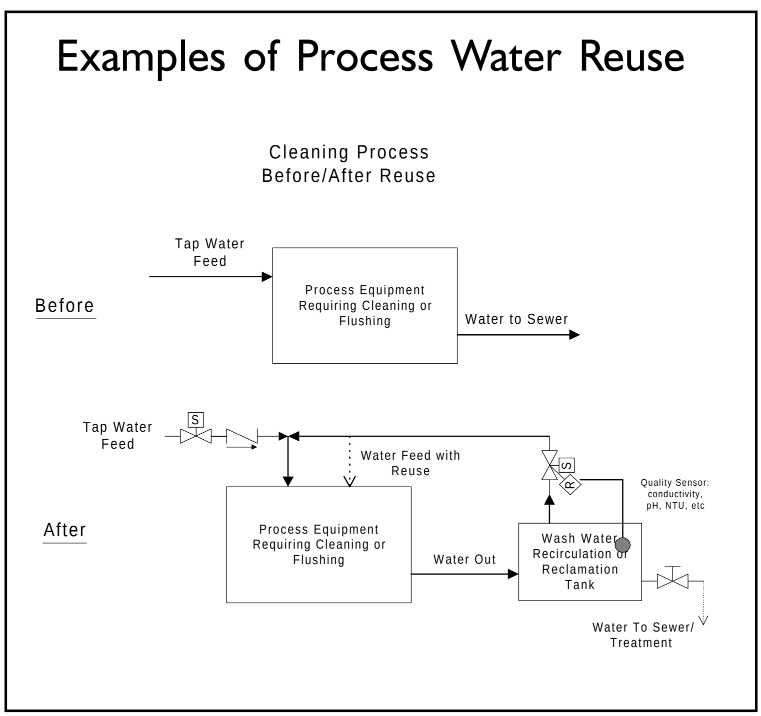
- Do not use a hose as a broom. This practice is a waste of valuable labor, water, and energy.
- Use efficient spray nozzles with automatic shut-offs on the end of hoses. Garden hose nozzles are not very efficient.
- Consider high-pressure washers to clean more quickly and efficiently.
- Consider pressurized air-assisted spray nozzles to provide more cleaning force with less water.
- Use low-flow "fogging" nozzles to rinse parts efficiently.
- Use flow restrictors in water lines that supply hoses and pressure washers.
- Use timers to shut off process water rinses when process is shut down.
- Turn off running water when not in use.
- Ensure stationary spray nozzles are aimed properly.
- Review nozzle spray patterns for optimum application. Fan, cone, hollow cone, air atomizing, fine spray, and fogging are a few examples of nozzle spray patterns.
- Replace worn spray nozzle heads, that lead to poor spray patterns and excessive water consumption.
- Use counter current washing techniques. *(See Chapter 5.)*
- Use conductivity controllers to regulate rinse water flow rates. *(See Chapter 5.)*
- Use spray washing/rinsing techniques for tank cleaning versus refilling/dropping tank washwater.

### CASE STUDY

**High Pressure Washers**

Sparta Foods, in St. Paul, Minnesota, replaced garden hoses with high-pressure washers to clean equipment that processes flour products. The new high-pressure washers cost $200 each. Equipment now is cleaned quicker and more efficiently using half the water. The washers save 217,000 gallons of water per year, and payback was less than three months.

FIGURE 27



## CASE STUDY

### Process Water Reuse

Jackson Paper in Sylva, North Carolina, manufactures corrugated cardboard medium from 100 percent recycled feedstock. An on-site wastewater facility allows 100,000 gallons of wastewater per day to be reused on-site. Treated mill water is reused for papermaking, boiler scrubber make-up water, and sludge press showers in the wastewater treatment area. No wastewater is discharged from the facility. The intensive water reuse modifications save an estimated $92,000 per year.

## CASE STUDY

### In-plant Water Reuse

Outboard Marine Corporation, in Andrews, North Carolina, manufactures gear assemblies for outboard motors. Annually, the company generated 85,000 gallons of wastewater from water soluble coolant, compressor blowdown, mop water, and parts cleaning. The facility installed a nanofiltration unit to treat the oily wastewater and reclaim water for reuse in coolant formulation and mop water. Now 56,000 gallons of water is reclaimed and $24,000 in wastewater disposal costs are saved each year.

## Cleaning Water Reuse

Tremendous opportunity exists to reuse cleaning and rinsing water in-process. Instead of using water only once, water can be pumped or drained to a recirculation tank for reuse. Depending on water quality requirements for the particular stage of reuse, water simply may be recirculated or require basic treatment such as solid settling, oil skimming, and/or filtration using cartridge, bag, disk, indexing fabric, or sand filtration. *(See Figure 27.)* Water quality control standards need to be carefully established for each point of reuse. For high water quality demands, more advanced water reclamation techniques exists, such as ultrafiltration, nanofiltration (or reverse osmosis), carbon filtration, and ion exchange.

In-process water reuse can allow the user to salvage a valuable product that presently is being discharged as wastewater, such as cleaning chemicals in washing solutions or valuable metals in rinsing solutions.

Also consider staged cleaning techniques where the first and second pass cleaning water is saved for reuse or product reclamation.

## Water Reuse Rules

With several areas in North Carolina approaching limits on the reasonable availability of high-quality fresh water as well as limits on the capacity of streams to assimilate the wastewater they receive, wastewater reuse rules have been revised to encourage the reuse of industrial, domestic, and municipal wastewater. On June 1, 1996, revised rules went into effect that regulate water reuse within North Carolina.

Industrial effluents can be directly reused without a non-discharge permit in these specific reuse situations:

- Industrial process water within the facility that originated the effluent.
- Cooling tower make-up water.
- Fire-fighting or extinguishing water.

Other uses of reclaimed industrial effluents are allowed but are contingent upon (1) a demonstration by the facility that the quality of the water is such that employee health and safety are protected and (2) a notification to employees that nonpotable reclaimed water is being used. Examples of such other uses include:

- Irrigation of property.
- Dust control.
- Decorative ponds.
- Vehicle washing
- Street cleaning.

All valves, piping, storage facilities, outlets, and other means of distribution of reclaimed water must be tagged or labeled to inform employees that the water is not intended for drinking. In addition, no cross-connection can occur between the reclaimed water and potable water systems. Where potable water is used to supplement the reclaimed water system, an air gap must separate the potable and reclaimed water. The supplemental system is subject to approval by the potable water supplier.

To provide a greater protection from pathogens, reuse limitations are more stringent for ***domestic and municipal effluents*** than for industrial effluents. The most likely reuse situations for domestic wastewater are to irrigate golf courses, parks, and other areas and as industrial process or cooling water.

Other reuse scenarios for either industrial or municipal wastewater may include urinal and toilet flushing and sprinkler systems or other fire protection in industrial, commercial or residential applications. The rules explicitly prohibit the use of reclaimed water for irrigation of direct food chain crops; make up for swimming pools, spas, and hot tubs; and raw potable water supply.

The specific rule language can be accessed and downloaded from the Division of Water Quality's web site. The rules are

## CASE STUDY

### Cleaning Solution Reuse

T.S. Designs, a screen printer in Burlington, North Carolina, would clean printing screens using strong oxidizing solution in manual wiping application. To reduce chemical consumption and save water, T.S. Designs installed a 43-gallon reclamation tank to continuously filter and circulate the aqueous cleaning solution past the printing screen suspended in a tank. A similar reuse system was used for a stain and haze removing wash step. The reuse process allows cleaning solution to be used continuously for one month. With the reuse system, less concentrated and safer solutions could be employed. The reuse system saves $5,200 per year in chemical, water, and sewer costs.

located in Subchapter 2H.0200 - Non-Discharge Rules. For questions about a wastewater reuse application or a copy of the regulation, contact Donald Safrit, P.E., Assistant Chief for Technical Support, Division of Water Quality, P.O. Box 29535, Raleigh, NC 27626-0535, (919) 733-5083, ext. 519.

## Other Improvements to the Cleaning Process

### *Teflon Surface Coatings*

Tanks, vats, pipeline, other equipment surfaces can be coated with a Teflon non-stick surface. This allows for easier cleaning during process line changeovers and clean-up.

### CASE STUDY

Integrated Water Conservation

Campbell Soup Company in Maxton, North Carolina, instituted a corporate wide integrated pollution prevention program. For water efficiency measures, Campbell soup used dry-cleanup procedures for floors and equipment, installed process water flow meters, and eliminated water transport (fluming) of scrap. A continuous maintenance/housekeeping schedule was implemented instead of the previous once-a-day practice. These water efficiency techniques have saved $125,000 annually in operating costs. The program also improved solids collection and recycling.

### *Cleaning Chemical Changes*

Changes in the type, temperature, and concentration for cleaning solutions can save water.

### *Operational Controls and Maintenance*

Overflow controls should be in place for filling tanks and vessels.

## Sub-Metering Water Use

Some businesses restrict water flow to an entire processing area and force water operators to find the optimum ratio level for individual activities. Sub-metering and monitoring allows excessive water consumption and leaks to be quickly detected and corrected.

## Vehicle Washwater Recycling

Many commercial water recycle systems are available for fleet maintenance and vehicle cleaning. With a recycle water permit from the proper authority, facilities can install a washwater recycle system for vehicle cleaning.

Washwater recycling systems provide several advantages over typical wastewater disposal:

1. These systems allow for simple cleanup of contaminants from spills or system failures by preventing entry to the sanitary sewer or septic system.
2. These systems reduce costs for water use and disposal.
3. Many of the systems are pre-engineered, have a proven track record, and can be submitted for permit issuance from previously approved plans and specifications.

Typical washwater recycling systems consist of a sedimentation basin for grit/sand removal, an oil/water separator, filtration, and a disinfection unit to prevent biological growth. Basin/sump compartments are used to settle grit, sand, and other solids and also used to skim any floating oils. Water then is filtered, typically using a multimedia filter that removes solids in the water larger than five to 20 microns in diameter. The filtered water is oxidized/sanitized to reduce organics and meet any health/safety standards for non-potable water reuse. Water then is stored and pumped back to the washing bay for reuse.

Although such systems can be nearly closed-loop, except for occasional solids removal and filter backwash wastewater, occasionally water must be changed due to buildup of dissolved solids (salts). Washing practices and discharges to the recycle system must be closely controlled, as they will not handle shock loads. Maintenance to the treatment/recycle equipment also is very important. Pre-engineered units for single wash bays cost approximately $20,000. The regional staff for the North Carolina Division of Water Quality can provide additional details about permits for a recycling system.

# 5 Industry Specific Processes

**Textiles**

**Food**

**Metal Finishing**

## TEXTILES*

FIGURE 28

**Water Use in Textile Processing**

| Processing Subcategory | Water Use Minimum, gal/lb of production | Water Use Median, gal/lb of production | Water Use Maximum, gal/lb of production |
|---|---|---|---|
| Wool | 13.3 | 34.1 | 78.9 |
| Woven | 0.6 | 13.6 | 60.9 |
| Knit | 2.4 | 10.0 | 45.2 |
| Carpet | 1.0 | 5.6 | 19.5 |
| Stock/Yarn | 0.4 | 12.0 | 66.9 |
| Nonwoven | 0.3 | 4.8 | 9.9 |
| Felted Fabrics | 4.0 | 25.5 | 111.8 |

* Excerpts from "Best Management Practices for Pollution Prevention in the Textile Industry," EPA, 1996.

## Water Consumption in Textiles

Water is used extensively throughout textile processing operations. Almost all dyes, specialty chemicals, and finishing chemicals are applied to textile substrates from water baths. In addition, most fabric preparation steps, including desizing, scouring, bleaching, and mercerizing, use aqueous systems.

The amount of water used varies widely in the industry, depending on the specific processes operated at the mill, the equipment used, and the prevailing management philosophy concerning water use. Reducing water consumption in textile processing is important for furthering pollution prevention efforts, in part because excess water use dilutes pollutants and adds to the effluent load.

Mills that currently use excessive quantities of water can achieve large gains from pollution prevention. A reduction in water use of 10 to 30 percent can be accomplished by taking fairly simple measures. A walk-through audit can uncover water waste in the form of:

- Hoses left running.
- Broken or missing valves.
- Excessive water use in washing operations.
- Leaks from pipes, joints, valves, and pumps.
- Cooling water or wash boxes left running when machinery is shut down.
- Defective toilets and water coolers.

In addition, many less obvious causes of water waste exist. These causes are presented below by subcategory, unit process, and machine type.

## Subcategory

Textile operations vary greatly in water consumption. Figure 28 summarizes the water consumption of various types of operations. Wool and felted fabrics processes are more water intensive than other processing subcategories such as wovens, knits, stock, and carpet.

Water use can vary widely between similar operations as well. For example, knit mills average 10 gallons of water per pound of production, yet water use ranges from a low of 2.5 gallons to a high of 45.2 gallons. These data serve as a good benchmark for determining whether water use in a particular mill is excessive.

## Unit Process

Water consumption varies greatly among unit processes, as indicated in Figure 29. Certain dyeing processes and print afterwashing are among the more intensive unit processes. Within the dye category, certain unit processes are particularly low in water consumption (e.g., pad-batch).

## Machine Type

Different types of processing machinery use different amounts of water, particularly in relation to the bath ratio in dyeing processes (the ratio of the mass of water in an exhaust dyebath to the mass of fabric). Washing fabric consumes greater quantities of water than dyeing. Water consumption of a batch processing machine depends on its bath ratio and also on mechanical factors such as agitation, mixing, bath and fabric turnover rate (called contact), turbulence and other mechanical considerations, as well as physical flow characteristics involved in washing operations. These factors all affect washing efficiency.

In general, heating, wash, and dyebaths

FIGURE 29

## Water Consumption by Unit Process

| Processing Subcategory | Water Consumption, gal/lb of production |
|---|---|
| Yarn & fabric forming | Nil |
| Slashing | 0.06 to 0.94 |
| Preparation | |
| Singeing | Nil |
| Desizing | 0.3 to 2.4 |
| Scouring | 2.3 to 5.1 |
| Continuous bleaching | 0.3 to 14.9 |
| Mercerizing | 0.12 |
| Dyeing | |
| Beam | 20 |
| Beck | 28 |
| Jet | 24 |
| Jig | 12 |
| Paddle | 35 |
| Skein | 30 |
| Stock | 20 |
| Pad-batch | 2 |
| Package | 22 |
| Continuous bleaching | 20 |
| Indigo Dyeing | 1 to 6 |
| Printing | 3 |
| Print afterwashing | 13.2 |
| Finishing | |
| Chemical | 0.6 |
| Mechanical | Nil |

constitutes the major portion of energy consumed in dyeing. Therefore, low bath-ratio dyeing equipment not only conserves water but also saves energy, in addition to reducing steam use and air pollution from boilers. Low-bath-ratio dyeing machines conserve chemicals as well as water and also achieve higher fixation efficiency. But the washing efficiency of some types of low-bath-ratio dyeing machines, such as jigs, is inherently poor; therefore, a correlation between bath ratio and total water use is not always exact.

FIGURE 30

**Water Consumption for a Typical Bleach Range**

| Stage | Water, gph | Percent, % |
|---|---|---|
| Saturators | 550 | 5 |
| Steamer and J Boxes | 150 | 1.4 |
| Washers | | |
| Desize | 3,700 | 33.5 |
| Scour | 3,100 | 28.1 |
| Bleach | 3,100 | 28.1 |
| Dry cans | 450 | 4.1 |
| Total | 11,050 | 100 |

## Process Water Conservation

### *Washing*

Washing and rinsing operations are two of the most common operations in textile manufacturing that have significant potential for pollution prevention. Many processes involve washing and rinsing stages, and optimizing wash processes can conserve significant amounts of water. In some cases, careful auditing and implementation of controls can achieve wastewater reductions of up to 70 percent. The washing and rinsing stages of preparation typically require more water than the other stages (e.g., bleaching, dyeing). Several typical washing and rinsing processes include:

- Drop and fill batch washing.
- Overflow batch washing.
- Continuous washing (countercurrent, horizontal, or inclined washers).

A report on water consumption for a typical continuous bleach range found that consumption was more than 11,000 gallons per hour, or 270,000 million gallons per day. *(See Figure 30.)* Washing stages accounted for 9,900 gallons per hour, or 90 percent of the total. The application of the following simple, low-technology methods of water conservation reduced water use:

- Properly regulating flows: 300 gallons per hour savings.
- Counterflowing bleach to scour: 3,000 gallons per hour savings.
- Counterflowing scour to desize: 3,000 gallons per hour savings.

The total water savings without process modification was 150,000 million gallons per day, or 55 percent of water use. A process modification such as a combined one-stage bleach and scour also would save 6,200 gallons of water per hour, or an additional 150,000 million gallons per day, along with energy savings.

FIGURE 31

**Water Use in Batch Washing**

| Process Description | Bath Ratio | Water Use, gal/lbs | % Change from Standard |
|---|---|---|---|
| 1 Standard - 3 step drop/fill | 1:8 | 1.62 | --- |
| 2 Reduced bath - seven step drop/fill | 1:5 | 1.26 | -22.2 |
| 3 Continuous overflow | 1:8 | 2.38 | 46.9 |
| 4 Continuous overflow - reduced bath | 1:5 | 1.49 | -8 |
| 5 Three-step drop/fill, reuse bath 2 | 1:8 | 1.19 | -26.5 |
| 6 Three-step, reuse baths 2 and 3 | 1:8 | 0.75 | -53.7 |

## Drop-Fill Versus Overflow Washing

In the drop/fill method of batch washing, spent wash water is drained and the machine is refilled with a fresh wash bath. The fabric or other substrate in the machine retains much of the previous bath, perhaps as much as 350 percent owg. This percentage can be reduced by mechanical means (e.g., extraction, blowdown). Comparison of several methods of washing after bleaching shows the benefits of countercurrent wash methods, see Figure 31. Methods five and six, which implement countercurrent washing, produce savings of 26 and 53 percent compared with the standard drop/fill method. These results are based on comparisons of washing processes that would produce the same degree of reduction of fabric impurities using computer models.

Countercurrent washing processes require the addition of holding tanks and pumps. The capital cost of setting up such a reuse system typically is less than $50,000 and generates estimated savings of $95,000 annually. In many cases, reducing wastewater also reduces the need for expensive waste treatment systems.

## Reusing Wash Water

Many strategies can be applied for reusing wash water. Three of the most common strategies are countercurrent washing, reducing carryover, and reusing wash water for cleaning purposes.

### *Countercurrent Washing*

The countercurrent washing method is relatively straightforward and inexpensive to use in multistage washing processes. Basically, the least contaminated water from the final wash is reused for the next-to-last wash and so on until the water reaches the first wash stage, after which it is discharged. This technique is useful for washing after continuous dyeing, printing, desizing, scouring, or bleaching.

An important variant of the countercurrent principle is "horizontal" or "inclined" washers. Horizontal or inclined washing is more efficient because of the inherent countercurrent nature of water flow within the process. The mechanical construction of an inclined or horizontal countercurrent washer has to be much better than a traditional vertical washer, however.

Sloppy roll settings, weak or undersized rolls, unevenness, bends, bows, biases, bearing play, or other misalignments within the machine are much more important in a horizontal or inclined washer because the weight of water pressing down on the fabric can cause it to sag, balloon, or stretch. If properly constructed and maintained, horizontal or inclined washers can produce high quality fabrics while saving money and water.

### *Reducing Carryover*

Because the purpose of washing is to reduce the amount of impurities in the substrate, as much water as possible must be removed between sequential washing steps in multistage washing operations. Water containing contaminants that is not removed is "carried over" into the next step, contributing to washing inefficiency.

Proper draining in batch drop/fill washing and proper extraction between steps in the continuous washing process are important. Often, 350 percent owg is carried over in typical drop/fill procedures. This amount can be reduced in some batch machines (e.g., yarn package dyeing, stock dyeing) by using compressed air or vacuum blowdown between washing steps.

In continuous washing operations, squeeze rolls or vacuum extractors typically extract water between steps. Equipment employing vacuum technology to reduce dragout and carryover of chemical solutions with cloth, stock, or yarn is used to increase washing efficiency in multistage washing operations.

In one case history, a processor installed vacuum slots after each wash box in an existing multistage continuous washing line and was able to reduce the number of boxes from eight to three. Wash boxes with built-in vacuum extractors are available for purchase, as well as washers for prints that combine successive spray and vacuum slots without any bath for the fabric to pass through. Because the fabric is never submerged, bleeding, marking off, and staining of grounds is minimized, and water use decreases.

Another washer configuration with internal recycling capabilities is the vertical counterflow washer, which sprays recirculated water onto the fabric and uses rollers to squeeze waste through the fabric into a sump, here it is filtered and recirculated. The filter is unique, consisting of continuous loops of polyester fabric that rotate continuously and are cleaned of filtrate at one end with a spray of clean water. This construction allows for maximum removal of suspended solids from water before discharge or reuse in another process. High-efficiency washing with low water use results. Energy use decreases greatly because less water must be heated.

### *Reuse for Cleaning Purposes*

In many types of operations, washwater can be reused for cleaning purposes. In printing, cleanup activities can be performed with used washwater, including:

- Backgray blanket washing.

- Screen and squeegee cleaning.
- Color shop cleanup.
- Equipment and facility cleaning.

A typical preparation department may also reuse wash water as follows:

- Reuse scour rinses for desizing.
- Reuse mercerizer washwater for scouring.
- Reuse bleach washwater for scouring.
- Reuse water-jet loom washwater for desizing.
- Recycle kier drains to saturator.

## Work Practices

Workers can greatly influence water use. Sloppy chemical handling and poor housekeeping can result in excessive cleanup. Poor scheduling and mix planning also can require excessive cleanup and lead to unnecessary cleaning of equipment like machines and mix tanks. Leaks and spills should be reported and repaired promptly. Equipment maintenance, especially maintenance of washing equipment, is essential. Inappropriate work practices waste significant amounts of water; and good procedures and training are important. When operations are controlled manually, an operations audit checklist is helpful for operator reference, training, and retraining.

In one case history, a knitting mill experienced excessive water use on beck dyeing machines. A study of operating practices revealed that each operator was filling the machines to a different level. Some operators filled the becks to a depth of 16 inches, others as much as 24 inches. Also, the amount of water used for washing varied. Some operators used an overflow procedure, and others used drop/fill or "half baths" (repeatedly draining half of the bath, then refilling it). Inspection of the written procedures showed that the fill step simply said "fill." The wash step simply said "wash." Without training and without a specific operating procedure, operators were left to determine water use on their own. This case may seem extreme, but even the best mills, which have well-documented production procedures, often do not have documented cleaning procedures. Cleaning operations that contribute large amounts of pollution to the total waste stream include machine cleaning, screen and squeegee cleaning, and drum washing.

## Engineering Controls

Every mill should have moveable water meters that can be installed on individual machines to document water use and evaluate improvements. In practice, mills rarely measure water use but rely on manufacturers' claims concerning equipment and water use. The manufacturers' estimates are useful starting points for evaluating water consumption, but the actual performance of equipment depends on the chemical system used and the substrate. Therefore, water use is situation-specific and should be measured on-site for accurate results. The water meters should be regularly maintained and calibrated.

Other important engineering controls, some of which have been discussed in other sections of this chapter, include:

- Flow control on washers.
- Flow control on cooling water (use minimum necessary).
- Countercurrent washing.
- High extraction to reduce dragout.
- Recycle and reuse.
- Detection and repair of leaks.
- Detection and repair of defective toilets and water coolers.

Machinery should be inspected and improved where possible to facilitate cleaning and to reduce susceptibility to fouling. Bath ratios sometimes can be reduced by using displacers that result in lower chemical requirements for pH control as well as lower water use.

## Process Changes

### *Pad-Batch Dyeing*

In pad-batch dyeing, prepared fabric is padded with a solution of fiber reactive dyestuff and alkali, then stored (or batched) on rolls or in boxes and covered with plastic film to prevent evaporation of water or absorption of carbon dioxide from the air. The fabric then is batched for two to 12 hours. Washing can be done on whatever equipment is available in the mill.

Pad-batch dyeing offers several significant advantages, primarily cost and waste reduction, simplicity, and speed. Production of between 75 and 150 yards per minute, depending on the construction and weight of the goods involved, is common. Also, pad-batch dyeing is flexible compared with a continuous range. Either wovens or knits can be dyed in many constructions. Frequent changes of shade present no problems because reactives remain water soluble, making cleanup easy. This method of dyeing is useful when versatility is required. Water use typically decreases from 17 gallons per pound to 1.5 gallons per pound, a reduction of more than 90 percent.

## Processing Bath Reuse

Water from many processes can be renovated for reuse by a variety of methods. Several research efforts are underway. In a few operations, up to 50 percent of the treated wastewater is recycled directly back from the effluent to the raw-water intake system with no adverse effects on production. In some cases, specific types of wastewater can be recycled within a process or department. Examples are dyebath reuse, bleach bath reuse, final rinse reuse as a loading bath for the next lot, washwater reuse, countercurrent washing, and reuse for other purposes.

## Bleach Bath Reuse

Cotton and cotton blend preparation (e.g., desizing, scouring, bleaching) are performed using continuous or batch processes and usually are the largest water consumers in a mill. Continuous processes are much easier to adapt to wastewater recycling/reuse because the wastestream is continuous, shows fairly constant characteristics, and usually is easy to segregate from other waste streams.
Waste-stream reuse in a typical bleach unit for polyester/cotton and 100 percent cotton fabrics would include:

- Recycling J-box and kier drain wastewater to saturators.
- Using countercurrent washing.
- Recycling continuous scour washwater to batch scouring.
- Recycling washerwater to backgray blanket washing.
- Recycling washerwater to screen and squeegee cleaning.
- Recycling washerwater to color shop cleanup.
- Recycling washerwater to equipment and facility cleaning.
- Reusing scour rinses for desizing.
- Reusing mercerizer washwater for scouring.

Preparation chemicals (including optical brighteners and tints), however, must be selected in such a way that reuse does not create quality problems such as spotting.

Batch scouring and bleaching are less easy to adapt to recycling of waste streams because streams occur intermittently, drains generally go into pits and are not easily segregated, and batch preparation steps frequently are combined. With appropriate holding tanks, however, bleach bath reuse can be practiced in a similar manner to dyebath reuse, and several pieces of equipment are now available that have the necessary holding tanks. The spent bleach bath contains all of the alkali and heat necessary for the next bleaching operation. Peroxide and chelates must be added to reconstitute the bath. Like dyebath reuse, the number of reuse cycles in bleach bath reuse is limited by impurity buildup. The main impurities are metals, such as iron, that can interfere with the bleaching reaction.

New types of rope bleaching units for knits featuring six to 12-stage jet transport systems have made continuous bleaching of most knit styles possible. These units were introduced in the late 1970s and typically produce 40 pounds per minute of knit fabric or more than one million pounds per month based on a three-shift, six-day operation. These machines have become very popular with large knit processors because of their flexibility and ability to conserve energy, water, and chemicals. They also have complete built-in countercurrent capabilities. These units are being promoted for use in afterwashing fiber reactive and other types of dyes (e.g., after pad-batch dyeing) in addition to use as continuous knit preparation ranges.

### Final Rinse Reuse as Loading Bath for Next Lot

One simple technique that saves water and, in some cases, BOD loading is to reuse the final bath from one dyeing cycle to load the next lot. This technique works well in situations where the same shade is being repeated or where the dyeing machine is fairly clean.

A good example of this technique is acid dyeing of nylon hosiery. The final bath usually contains an emulsified softener that exhausts onto the substrate, leaving the emulsifier in the bath. This technique can serve as the wetting agent for loading the next batch, thus saving the water, heat, and wetting agent and associated BOD.

# F O O D & B E V E R A G E

## *Water Conservation Techniques*

In the food and beverage industry, water plays a significant role in transporting, cleaning, processing, and formulating products as well as meeting many federal sanitary standards. Facilities implementing water conservation programs sometimes struggle to balance these needs with the many benefits of reducing water usage. The following section discusses the methods and techniques many facilities have used to implement a successful water conservation program while maintaining production requirements.

For general rinsing and cleaning operations, refer to Chapter 4 on cleaning, rinsing, and in-process water reuse. Several opportunities in the beverage industry include:

- Adjust pump cooling and flushing water to the minimum required.
- Investigate potentially reusable discharges including final rinses from tank cleaning, keg washes, fermenters; bottle and can soak and rinse water; cooler flushwater; filter backwash; and pasterizer and sterilizer water.
- Potential areas for reuse include first rinses in wash cycles; can shredder; bottle crusher; filter backflush; caustic dilution; boiler make-up; refrigeration equipment defrost; and floor and gutter wash.

Several opportunities in the food industry include:

- Recycle transport water where feasible.
- Use conveyor belts for product transport. Preference should be given to "rabbit-ear" or V-shaped roller supports because these are much easier to clean.
- Use pneumatic conveying systems where practical.
- Use flumes with parabolic cross-sections rather than flat bottom troughs.
- Consider these alternatives to water-intensive units: 1) rubber-disc units instead of raw product cleaning and peeling; 2) steam instead of water blanchers, 3) evaporative coolers instead of water cooled systems.
- Establish optimum depth of product on conveyors to maximize wash water efficiency.
- Divide spray wash units into two or more sections, and establish a counterflow reuse system.
- Control belt sprays with a timer to allow for intermittent application of chlorinated water.
- Figure 32 provides a listing of potential reuse areas for specified canning operations.

## CASE STUDY

### Case Study: Recycling Transport Water

Sparta Foods in Minnesota hired an intern to evaluate water usage in corn processing. For the transport water use (5,200 gallons per day) the intern investigated alternative dry methods: 1) screw conveyors were unacceptable because of degradation of corn, 2) belt conveyors on the vertical cook tanks where a potential solution but only reduced water by 10 percent making the intial investment is unjustifiable. The intern found that 20% of transport water could be recycled without effecting product quality (concerns included pH and cleanliness). Recycling 20 percent would reduce total plant water usage by 3.5 percent and save $1,570 annually.

FIGURE 32

## Potential Water Reuse for Selected Food Processing Operations

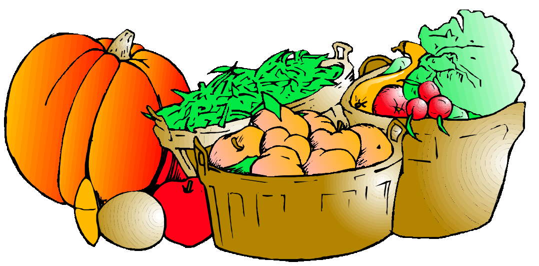
| Operation | Can reserved water be used? | Can effluent be used? | Source of make-up water |
|---|---|---|---|
| Acid dip for fruit | yes | no | can coolers |
| Washing of product | | | |
| First wash, followed by second wash | yes | yes[1] | can coolers |
| Final wash of product | no | yes[1] | can coolers |
| Flumes | | | |
| Fluming unwashed or unprepared product | yes | yes[1] | can coolers |
| Fluming partially prepared product | yes | yes[1] | |
| Fluming fully prepared product | no | yes | any wastewater |
| Fluming waste | yes | no | can coolers |
| Lye Peeling | yes | no | |
| Product holding vats (covered with water or brine) | no | no | |
| Blanchers, all types | | | |
| Original filling water | no | no | |
| Replacement of make-up water | no | no | |
| Salt brine quality graders with fresh water final wash | yes | this operation | |
| Washing Pans and Trays | | | |
| Tank washers, original water | no | no | |
| Spray or make-up water | no | no | |
| Lubrication of product inside machines | no | yes[1] | can coolers |
| Washing cans after closing | no | no | |
| Brine and syrup | yes | yes[1] | can coolers |
| Processing jars and underwater | no | | |
| Can coolers | yes | this operation | can coolers |
| Cooling canals | | | |
| original make-up | no | yes[2] | |
| make-up water | yes | yes[2] | |
| Continuous cookers (cans partially immersed) | | | |
| originial make-up | no | yes[2] | |
| make-up water | yes | yes[2] | |
| Spray coolers with cans not immersed | yes | yes | |
| Batch cooling in retorts | yes | yes[2] | |
| Clean-up purposes | | | |
| Preliminary wash | yes | yes[1] | can coolers |
| Final wash | no | no | |
| Box washers | yes | no | can coolers |

[1] - Use in preceding operation under precautions, [2] - Use in can coolers if quality is maintained.

# F O O D

## *Water and Wastewater Use in the Food Processing Industry**

*The following sections discuss major water using and waste generating processes in fruit, vegetable, dairy, meat, poultry, and oil processing. The information is provided to help food processing managers evaluate water use performance and consider additional water efficiency measures. In the absence of water use data, wastewater (hydraulic) loadings information is presented as a reference for water use.*



### Fruit and Vegetable Processing

The fruit and vegetable processing industries may be described as consisting of two segments: fresh pack and processing. The former collects crops and field packs them into lug boxes or bulk bins for shipment to a produce finishing plant. Crops are cooled to preserve integrity and fumigated or treated to control insect infestation or microbial disease development. The processing segment, or packers, includes all unit operations, extending the shelf life of food being processed and adding value through produce modification to satisfy market niches.

The fresh pack segment of the industry shares unit operations with the processing segment. These operations are the sorting/trimming, washing, grading, and packing lines. But after the packing lines, additional unit operations may add to the waste generating scheme for the processing segment alone. Additional operations may include combinations of peeling, stemming, snipping, pitting, trimming, chopping, and blanching. In some instances, the final product is dehydrated (e.g., chopped onions). In others, it is packaged and processed. Processing can include one treatment or a combination of several treatments (e.g., acidifying, brining, freezing, or cooking).

* Excerpts from "Waste Management and Utilization In Food Production and Process," CAST, October 1995.

Major water use and waste generation points associated with the fruit and vegetable industry include the washing steps for raw and processed produce, peeling and pitting practices, blanching, fluming the produce after blanching, sorting, and conveying the product within the plant. Reducing size, coring, slicing, dicing, pureeing, and juicing process steps, as well as filling and sanitizing activities after processing, also contribute to the wastestream.

### *Wastewater Characterization*

Major wastewater characteristics to be considered for the vegetable and fruit processing industry are the wide ranges of wastewater volume and the concentra-

FIGURE 34

**Representative Wastewater Loadings Per Ton of Product Associated with Typical Vegetable and Fruit Raw Products**

| Crop | Flow (1,000 gal/ton) minimum | Flow (1,000 gal/ton) mean | Flow (1,000 gal/ton) maximum |
|---|---|---|---|
| Vegetable products | | | |
| Asparagus | 1.9 | 8.5 | 29.0 |
| Bean, snap | 1.3 | 4.2 | 11.2 |
| Broccoli | 4.1 | 9.2 | 21.0 |
| Carrot | 1.2 | 3.3 | 7.1 |
| Cauliflower | 12.0 | 17.0 | 24.0 |
| Pea | 1.9 | 5.4 | 14.0 |
| Pickle | 1.4 | 3.5 | 11.0 |
| Potato, sweet | 0.4 | 2.2 | 9.7 |
| Potato, white | 1.9 | 3.6 | 6.6 |
| Spinach | 3.2 | 8.8 | 23.0 |
| Squash | 1.1 | 6.0 | 22.0 |
| Tomato, peeled | 1.3 | 2.2 | 3.7 |
| Tomato, product | 1.1 | 1.6 | 2.4 |
| | | | |
| Fruit Products | | | |
| Apple | 0.2 | 2.4 | 13.0 |
| Apricot | 2.5 | 5.6 | 14.0 |
| Berry | 1.8 | 3.5 | 9.1 |
| Cherry | 1.2 | 3.9 | 14.0 |
| Citrus | 0.3 | 3.0 | 9.3 |
| Peach | 1.4 | 3.0 | 6.3 |
| Pear | 1.6 | 3.6 | 7.7 |
| Pineapple | 2.6 | 2.7 | 3.8 |
| Pumpkin | 0.4 | 2.9 | 11.0 |

tions of organic materials. Wastewater characteristics can be influenced by a number of factors such as the commodity processed, the process unit operations used, the daily-production performance level, and the seasonal variation, e.g., growing condition and crop age at harvest. Figure 34 presents historical data collected from raw wastewater discharged from the vegetable and fruit processing industry.

### *Water Use and Wastewater Sources*

In the processing environment for vegetable and fruit material handling, heating, cooling, and packaging, there are six major contributing point sources for waste. These sources are the following operations: (1) raw produce washing, grading, and trimming, (2) washing after steam/lye peeling and/or size reducing, (3) blanching and fluming, (4) filling, (5) sanitation/plant cleanup, and (6) processed product cooling. Plant management practices greatly influence process operation efficiency relative to final product yield and waste quantity generated. *(Refer to Figure 34 for industrial variability.)*

### *Water Use and Waste Minimization*

Ideally, considerable waste reduction can be achieved if harvesting equipment permits additional stems, leaves, and culled materials to remain in the field during harvest. If crop washing, grading, and trimming can occur in the field, then additional soil and food residues will remain at the farm. Realistically, most such wastes are being handled at vegetable and fruit processing plant sites. Primary waste-management strategies used by this industry are water conservation and waste-solids separation.

Water use by the vegetable and fruit processing industry is essential to the washing, heating, and cooling of food products. But the industry has adopted a number of practices, showing heightened sensitivity to the need for water conservation:

1. Use of air flotation units to remove suspended debris from raw crop materials
2. Recovery and reuse of process water throughout the processing plant.
3. Decrease of water volume use in peeling and pitting operations, as well as decrease of raw product losses.
4. Separation of waste process streams at their sources, for potential by-product use.
5. Countercurrent reuse of wash and flume/cooling waters.
6. Separation of low and high strength wastestreams.
7. Installation of low-volume, high-pressure cleanup systems.
8. Conversion from water to steam blanching.
9. Use of air cooling after blanching.

## Fruit Processing (Canning, Freezing, Fermenting, etc.)

The initial preparation processes for canned, frozen, and fermented fruits are washing, sorting, trimming, peeling, pitting, cutting or slicing, inspecting, and grading. Unwanted and undesirable materials must be removed before the fruits undergo additional processing, but not all fruits are subject to each step. For example, cherries and plums may be canned whole and unpeeled whereas apples, peaches, and pears must be peeled and either cored or pitted before being canned. Peeling can be by hand or with machines, chemicals, or steam. After

FIGURE 35

**Wastewater Loadings Per ton of Product from Canned Fruits**

| Fruit | Flow (gallon/ton) |
|---|---|
| Apple | 500,000 |
| Apricot | 500,000 |
| Cherry | 200,000 |
| Citrus | 300,000 |
| Peach | 400,000 |
| Pear | 400,000 |
| Pineapple | 50,000 |
| Other fruit | 800,000 |

inspection and grading, the peeled fruits are conveyed mechanically or flumed to product handling equipment for processing.

The converted fruit handling processes are can filling, syrup adding, exhausting and sealing, thermoprocessing, can cooling, and storing. Processing equipment and plant floor usually are cleaned at the end of each shift and so constitute a final source of waste materials.

### *Water and Wastewater Management*

Several water conservation and waste prevention techniques are available by which to decrease water volume. These techniques include

- The use of high-pressure sprays for clean-up.
- The elimination of excessive overflow from washing and soaking tanks.
- The substitution of mechanical conveyors for flumes, the use of automatic shut-off valves on water hoses.
- The separation of can cooling water from composite wasteflow.
- The recirculation of can cooling water. When can cooling water is not recirculated, it may be reused in caustic soda (NaOH) or in water peeling baths, in removal of NaOH after peeling, in primary wash of the raw material, in canning belt lubrication, and in plant cleanup operations[1].

## Dairy Processing

The processing of dairy products often entails various unit operations. These generally include the receiving and the storing of raw materials, the processing of raw materials into finished products, the packing and the storing of finished goods, and a number of ancillary processes (e.g., heat transferring and cleaning) associated indirectly with processing and distributing.

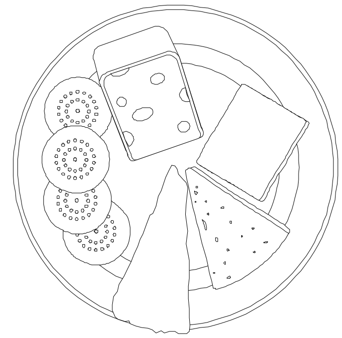
Equipment and facilities for receiving, transporting, and storing raw materials are much the same industrywide. Bulk carriers unload products in receiving areas by means of flexible lines or dump material into hoppers connected to fixed lines subsequently transferred by pump to storage. Storage facilities can be of the refrigerator, vertical, or silo type, with storage tanks containing either liquid or dry products and ranging in volume from a few thousand gallons to one million gallons or more.

Milk, a perishable product made up of fat, protein, carbohydrates, salts, and vitamins, is an ideal food for microorganisms as well as for humans. Thus, it needs to be protected from contamination, and much of the efforts of the dairy industry are directed to this end. Milk and its by-products are processed according to approved procedures, on machinery normally run no longer than about 20 hours per day. Much equipment is dismantled daily. Systems may be cleaned in place or after they are taken apart. Automated cleaning systems, now predominant in the industry, require less labor but more water and cleaning chemicals than hand washing dismantled equipment does.

### *Wastewater and Management*

Dairy processing wastewaters are generated during the pasteurization and the homogenization of fluid milk and the production of dairy products such as butter, ice cream, and cheese. The principal constituents of these wastewaters are whole and processed milk, whey from cheese production, and cleaning compounds.

Water use in the dairy products industry depends on plant complexity and water-management practices. Process wasteloads also differ considerably and are influenced greatly by the extent to which the plant controls raw material and product losses. Raw wastewater loading for the American dairy industry is summarized by commodity segment in Figure 36.



Milk product losses typically range from 0.5 percent in large, technologically advanced plants to greater than 2.5 percent in small, old plants. Given redoubled effort by management, water usage in most plants could be decreased to approximately 0.50 L/kg milk equivalent processed. Considerable improvements in water and waste management remain important and realistic industry goals.

FIGURE 36

**Summary of American Dairy and Milk Processing Plant Effluent Loadings**

| Products | Wastewater (kg ww/kg milk) range | Wastewater (kg ww/kg milk) average |
|---|---|---|
| Milk | 0.10-5.40 | 3.25 |
| Cheese | 1.63-5.70 | 3.14 |
| Ice cream | 0.80-5.60 | 2.80 |
| Condensed milk | 1.00-3.30 | 2.10 |
| Butter | | 0.80 |
| Powder | 1.50-5.90 | 3.70 |
| Cottage cheese | 0.80-12.40 | 6.00 |
| Cottage cheese and milk | 0.05-7.20 | 1.84 |
| Cottage cheese, ice cream, and milk | 1.40-3.90 | 2.52 |
| Mixed products | 0.80-4.60 | 2.34 |

### *Innovations*

In recent years, technological innovations with membrane systems have provided many new opportunities. For example, ultrafiltration now can be used instead of the biological separation of organic material from liquid substrate. And instead of using reverse-osmosis systems for tertiary waste treatment, some food plants use them to recycle internal liquid wastestreams. The outflow from reverse-osmosis treatment can be of better quality than the native water.

## Meat and Poultry Processing

The meat and poultry processing industries in the United States together make up a $75.6 billion per year industry. The U.S. Department of Commerce reported that the value of red meat shipments for 1988 totaled $46.8 billion. Most red meat processing plants are located in the Midwest; most poultry processing plants are in the Southeast and the Mid-Atlantic. Processing of prepared meats, including canned cooked products, luncheon meats, hot dogs, bacons, stews, and other ready-to-eat meat products, has expanded rapidly in recent years.

FIGURE 37

**Typical Water Consumption for Beef, Turkey, and Broiler Processing**

| Animal type | Water (gallon/animal) |
|---|---|
| Beef | 150 - 450 |
| Turkey | 11 - 23 |
| Broiler | 3.5 - 10 |

### *Waste and By-Products*

Most waste products are recovered somehow by the industry. Blood, feathers, and bone usually are processed into a meal product for animal feed. Similarly, meat scraps unsuitable for processing into food products are sold or given to rendering facilities for processing into animal and pet foods. The ultimate characteristics of solid materials and wastewaters generated by these source areas in a plant and unrecovered for another use differ greatly and are affected by:

1. animal size and type
2. processing level
3. conveyance means
4. processing water use
5. cleanup and housekeeping procedures

### *Water Usage*

Water use for broiler processing typically ranges from 3.5 to 10.0 gal./bird; for turkeys, 11 to 23 gal./bird. Flow rates of 350 gal./animal have been reported for beef slaughtering plants. In one beef slaughtering operation, water use dropped from 458 to 187 gal/head after water conservation measures were adopted. Similar water use numbers appear in the examples in Figure 37.

Water is used for chilling, scalding, can retorting, washing, cleaning, and waste conveying. For example, poultry processing uses approximately 3.5 to 7.0 gallons of water per bird of four-pound average weight. All broiler processing plants are required to have a scalder overflow rate of 0.25 gal./bird and a chiller overflow rate of 0.50 gal./bird. In many instances, this water is used in the plant for the transport of feathers and offal from the processing area. One researcher, studying a broiler processing plant, reported that processing accounted for 76 percent of the water use, with 13 percent used in cleanup and 12 percent used in downtime.

Beef processing water usage, primarily from carcass washing and process cleanup, has been reported in the range of 150 to 450 gallons per animal processed. As a general rule, meat processors use about one gallon of water per pound of processed hamburger meat.

### Use and Minimization of Wastes

The amount of wastewater generated by the industries can be decreased largely through changes in cleanup practices. Water use can be minimized by means of commercially available high-pressure, restricted flow hoses, which can be fit with automatic shutoffs to prevent water loss during inactivity. Many materials can be handled mechanically. For example, flour and other dry material can be vacuumed from the floor and augers and conveyors can be used to transport scrap meat and viscera.

Chiller and scalder water is reused in most poultry processing plants for flushing water to remove offal and feathers. Reconditioning of chiller overflow through the use of filtration and ultraviolet irradiation has been recommended. Limits to use include the potential of bacterial contamination by coliforms or by *Escherichia coli*. Recycling is limited by the characteristics of the wastestream and by the potential for contamination of food products.

## Grain Processing for Oils

The extracting, refining, and processing of edible oils produces a variety of waste products. This chapter, which focuses on conventional caustic refinements and on related downstream processes, briefly reviews major processes and facilities, especially as they relate to waste generation and control.

### Process Components and Major Wastewater Sources

Figure 38 lists primary processes and associated wastewater loadings from a well-run fat and oil processing facility. Separate totals are presented with and without salad dressing and mayonnaise because these processes often are absent in a facility. Certain oil processing and refining operations have no oil seed processing facilities, but instead bring in crude vegetable oil. To account for this practice, adjustments can be made to the figures in the table. Data presented in Figure 38 are based on these operating parameters:

1. Milling and extracting: 80,000 bushels per day.
2. Caustic refining with single-stage water wash:60,000 lb/hr, nondegummed soybean oil.
3. Semicontinual deodorizing with scrub cooler, barometric condenser with atmospheric cooling tower.
4. Acidulating of soapstock and washwater with 90 to 95 percent recovery efficiency.
5. Bottling line and/or other extensive liquid-oil packaging.
6. Margarine, mayonnaise, and salad dressing production and packaging.
7. Washing of tank cars for finished oil only (cars carrying crude oil excluded).

Obviously, operations of an atypical size or those omitting certain processes will have different waste loads. This applies especially to operations involved in acidulation or in mayonnaise and salad

FIGURE 38

## Fats and Oils Processes and Wastewater Loads from a Well-run Facility

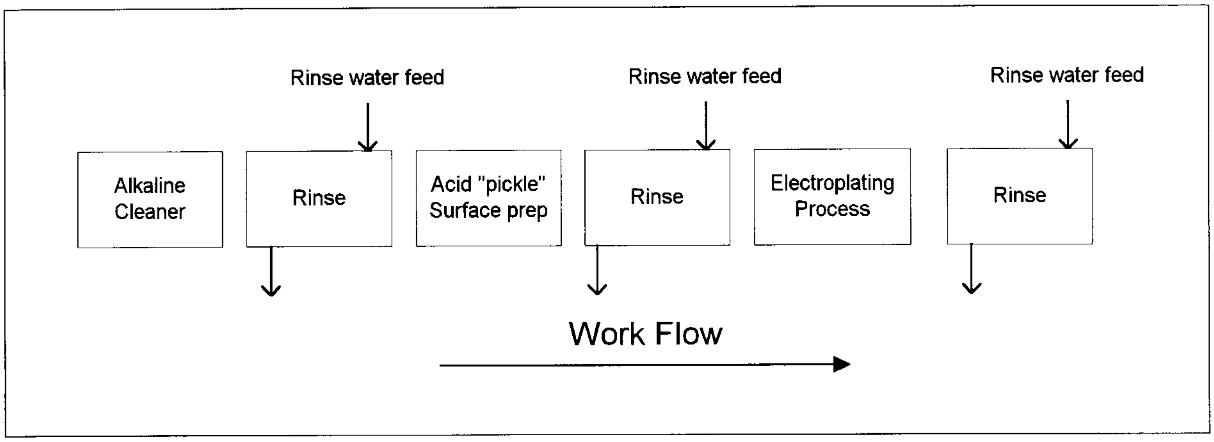
| Process | Flow (gallons/day[a], avg.) |
|---|---|
| Milling and extraction | 75,000 |
| Caustic refining | 11,000 |
| Further processing | 5,000 |
| Deodorizing | 5,000 |
| Acidulating | 19,000 |
| Tank car washing | 5,000 |
| Packaging | 10,000 |
| Subtotal | 130,000 |
| Margarine | 70,000 |
| Salad dressing/mayonnaise | 50,000 |
| Total | 250,000 |

[a]gallons/day = gallons per day

dressing processing. The effects of process control and its impacts on wastewater loading are outlined in the next section. As noted, these loadings are representative for an operation running reasonably well from a process loss control standpoint. But actual loadings depend on how well plants are run.

A final source of wastewater is contaminated runoff from truck and rail loadout areas and from tank farm drainage. During rainy periods, runoff from these sources can contribute the equivalent of five to 10 gal/min to total daily average flow and, in fact, may affect peak flows to a much greater extent.

FIGURE 39




During the past 15 years, the metal finishing industry has made great strides in reducing water use. In a 1994 survey by the National Association of Metal Finishers, 68 percent of respondents had made substantial reductions in water use through pollution prevention techniques. On average, these shops had reduced water flow by 30 percent or about 20,000 gpd. Even with these achievements, metal finishing businesses still continue to have large opportunities to further reduce water use. Water efficiency within an integrated pollution prevention program can provide these advantages for metal finishers:

- Lowering operation cost by reducing water bill.
- Reducing wastewater treatment costs.
- Potentially improving pollutant removal efficiency in wastewater treatment.
- Reducing or delaying need for treatment capacity expansion.

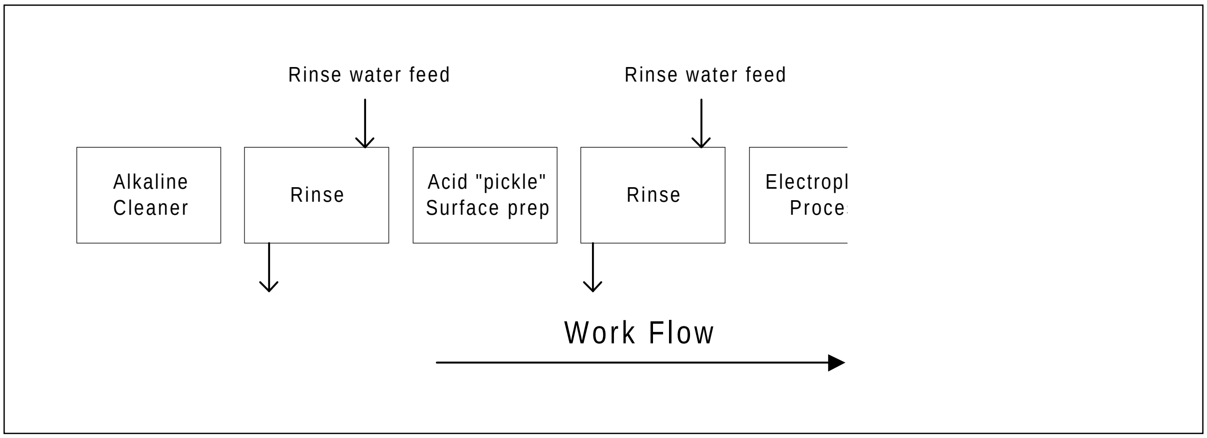
Improving rinsing efficiency represents the greatest water reduction option for metal finishers. A rinsing efficiency program also is the first step to enable metal finishers to implement progressive pollution prevention techniques, such as chemical recovery from the more concentrated wastestream and the potential of closed-looping the electroplating process.

## Improving Rinse Water Efficiency

In the metal finishing industry, rinsing quality has a dramatic affect on product

# METAL FINISHING

FIGURE 39

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## Improving Rinse Water Efficiency

In the metal finishing industry, rinsing quality has a dramatic affect on product quality. Improvements in rinsing efficiency must be carefully integrated into quality control and assurance programs. Rinsing efficiency improvement techniques for metal finishers include improved rinse tank design, flow control techniques, and alternate rinse tank configurations. *(See Figure 40.)*

## Rinse Tank Design

Proper design of rinse tanks will improve rinsing efficiency and reduce water use. Optimum rinse tank designs provide fast removal of chemical solutions or "dragout" from the parts. These techniques can enhance rinse tank design:

- Provide agitation to tank by air blowers (not compressed air), mechanical mixing, or pumping/filtration systems.
- Prevent feed water short-circuiting by properly placing inlets and outlets on opposite ends of the tank.
- Use inlet flow baffle, diffusers, distributors or spray heads.
- Select the minimum sized tank appropriate for all parts/products.
- Consider spray rinsing instead of immersion for flat-surfaced parts.
- Consider ultrasonic rinsing applications where applicable.

## Flow Control Techniques

### *Flow Restrictors*

The use of flow restrictors is a very effective means to ensure excessive water is not fed to the process line. Flow restrictors are installed in the feed line of a tank. They are commonly elastomer washers with an orifice that is squeezed smaller with increasing line pressure. They are available in rates ranging from

FIGURE 40

**Survey Rinse Water Efficiency Applications**

| Technique | Percent of business using technique | Success rating[2] |
|---|---|---|
| Flow restrictors | 70 | 4.1 |
| Counter current rinse | 68 | 4.2 |
| Manually turn off rinse water when not in use | 66 | 3.6 |
| Air agitated rinse tanks | 58 | 3.7 |
| Spray rinses | 39 | 3.8 |
| Reactive or cascade rinsing | 24 | 3.8 |
| Conductivity controllers | 16 | 3.3 |
| Flow meter or accumulator | 12 | 3.7 |
| Timer rinse controls | 11 | 3.25 |

[1]Based on NCMS/NAMF study in 1994 – 318 metal finishers responding.
[2]Success rating based on scale of one to five with five being highest.

0.1 gpm to greater than 10 gpm. The flow rate of a restrictor should be chosen to provide sufficient water for quality rinsing. Restrictors work best in consistent production applications.

### *Flow Cut-off Valves (Manual and Automatic)*

Water flow to rinse tanks should be shut off when the process lines are not in use. This can be done manually or automatically. A foot actuated feed valve can be used in job shops that have discontinuous processing demands. The rinse water valves can be activated only when components are being rinsed. For larger continuous operations, solenoid valves can turn off rinse water lines when power to the electroplating line is turned off. For automatic conveyorized lines, photosensors also can be used to turn on water valves or spray heads only when parts are passing that rinse stage.

### *Conductivity Meters and Controllers*

The most accurate way to control rinse water flows and purity can be achieved using conductivity controls. The use of conductivity meters and control valves will substantially reduce rinse water flow and ensure a set water purity standard is always being met in the tank. Electrical conductivity increases as the concentration of contaminant ions increases.

Conductivity meters indicate the concentration of contaminant ions in the rinse water in units of micromhos ($\mu$mhos), also referred to as microsiemens. Specific conductance can be roughly correlated to total dissolved solids (TDS) in mg/L using empirical data.

Many metal finishing facilities have installed conductivity controllers on the rinse tanks which trigger the introduction of fresh water only when the conductivity

## CASE STUDY

### Conductive Controller

Artistic Planting and Metal Finishing in Anaheim, California, installed electrodeless conductivity controllers on nine rinsing tank systems. Artistic Plating is saving 55,000 gallon per week, which equates to a 43 percent rinse water savings. The conductivity system resulted in decreased rinse water use, wastewater generation, wastewater treatment chemical use, and sludge generation. Artistic Plating experienced no adverse quality effects using the controller. Total system payback was one year.

FIGURE 41

**Acceptable Rinse Water Contaminant Limits**

| Rinse bath for | Conductivity in micromhos ($\mu$mho) |
|---|---|
| Alkaline cleaner | 1,700 |
| Hydrochloric acid | 5,000 |
| Sulfuric acid | 4,000 |
| Tin acid | 500 |
| Tin alkaline | 70-340 |
| Gold cyanide | 260-1,300 |
| Nickel acid | 640 |
| Zinc acid | 630 |
| Zinc cyanide | 280-1,390 |
| Chromic acid | 450-2,250 |

## CASE STUDY

### Rinsing Efficiency

C & R Electroless Nickel in Gastonia, North Carolina, reconstructed it electroless nickel line to incorporate several pollution prevention techniques and improve processing efficiency. Single-rinse tanks were switched to a system of multiple counterflow rinse tanks to reduce water consumption. Restrictive flow nozzles on water inlets were added to better control and reduce water consumption. The process line upgrade reduced water consumption by 87 percent, from 7,500 gallons to less than 1,000 gallons per day.

reaches a certain set point. This practice significantly reduces water consumption, typically by 40.

Conductivity rinse water flow controllers are most useful on discontinuous electroplating operations. The cost of installing each rinse water conductivity controller will be between $1,000 and $2,000 and typically will have an economic payback of about one year. In the past, conductivity controllers required high maintenance to prevent fouling of electrodes. Newer inductive loop or electrodeless sensors are less susceptible to fouling than conventional electrode types. Determining the optimum set point for these controllers also is imperative to conserve water and maintain quality. Figure 41 can be used as a starting point for determining acceptable rinse water purity standards.

Portable conductivity meters also can be used to establish a fixed flow rate to maintain an appropriate rinse water quality. Once rinse water purity levels are established, permanent flow restrictor valves can be installed in the water supply line to the individual rinse tanks. This technique is suggested only where electroplating production is consistent. Again, use Figure 41 as a starting point.

## Flow Meters

Relatively inexpensive meters or accumulators can be installed on the main water feed line to process line or on individual rinse tanks. While meters and accumulators do not actually save water, they do allow for careful monitoring of usage and can identify optimum water utilization (or excessive waste), leaks, and system failures.

## Alternative Rinsing Configurations

### *Counter Current Rinsing*

Counter current rinsing is the practice of overflowing rinse water between a series of rinse tanks so that the water flow is in the opposite direction to work flow. This results in the final rinse being the cleanest. Counter current rinsing significantly reduces water usage without sacrificing rinsing efficiency. A common configuration for a counter current rinse is two to three rinse tanks in series. Water consumption can be reduced more than 90 percent just by adding a second counter flowing rinse to a single rinse tank. *(See Figure 42.)*

If floor space is a problem, a partition could be installed in the existing rinse tank with a metal divider acting as a weir. This modification can be made only if there is sufficient room for the parts rack or barrel in the tank.

## Reactive Rinses and Reuse

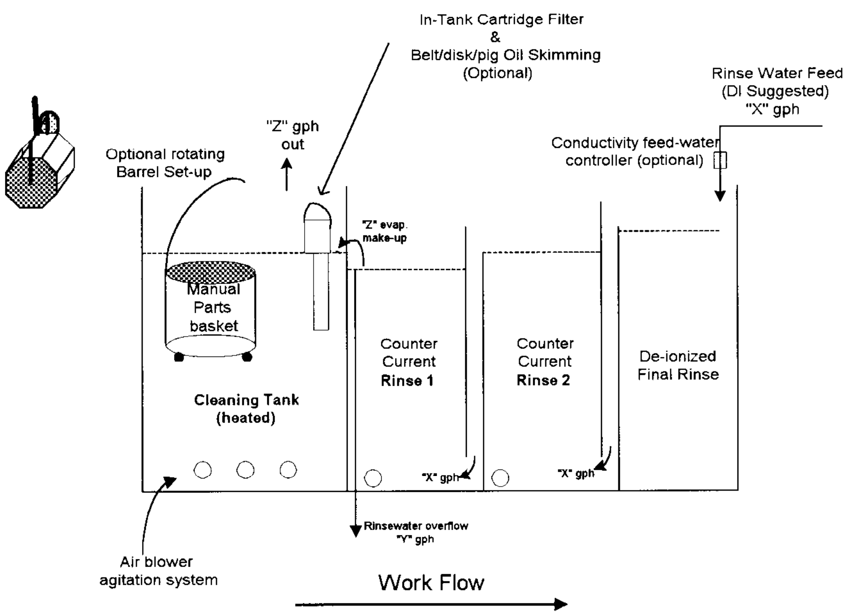
A reactive rinsing system involves diverting the overflow from an acid rinse to an alkaline rinse tank. *(See Figure 43.)* The acid ions neutralize the alkaline ions without causing contamination of the rinse water or compromising plating quality. By reusing acid rinse baths for alkaline cleaner rinses, the effectiveness of the alkaline cleaner rinses can be improved while reducing water consumption by 50 percent. Furthermore, the rinse water from single rinse stages following plating baths has been shown to effectively clean products in rinses following acid or alkaline cleaning without affecting the rinse effectiveness. Rinse water sometimes can be reused from a critical rinse to a less critical rinse in the same processing line or between processing lines. Care should always be taken to ensure cross contamination is not problematic.

## Spray Rinsing

Spray Rinsing can be incorporated into existing metal finishing process lines to further reduce water use. Typically, spray rinses can be used directly over heated process tanks or over a dead rinse to reduce drag-out. By spraying drag-out back into its process tank or into a concentrated holding tank, less water will be needed for final rinsing. Spray nozzles for these applications typically have flow rates ranging from .04 to 1.0 gpm. Nozzles can

**Improved Washing/Rinsing Line Schematic**

(Cross-section View)




Water Balance: X-Z=Y gph
"X" must be determined by rinsing purity criteria.
"X" is dependant upon concentration of dragout solution, rate of dragout, and rinsing purity.
Typically required rinsing purity is 400-1000 mg/l total contaminants.
"Z" can be estimated by eq. gal/hr/ft^2 = e ^ (0.02655T-5.95) where T = degrees F
and ft^2 is tank surface area (assumes agitated tank).
"Y" is hydraulic wastewater loading (gph).

Good drag-out reduction practices strongly recommended: 10 sec drip time over tank.

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FIGURE 42

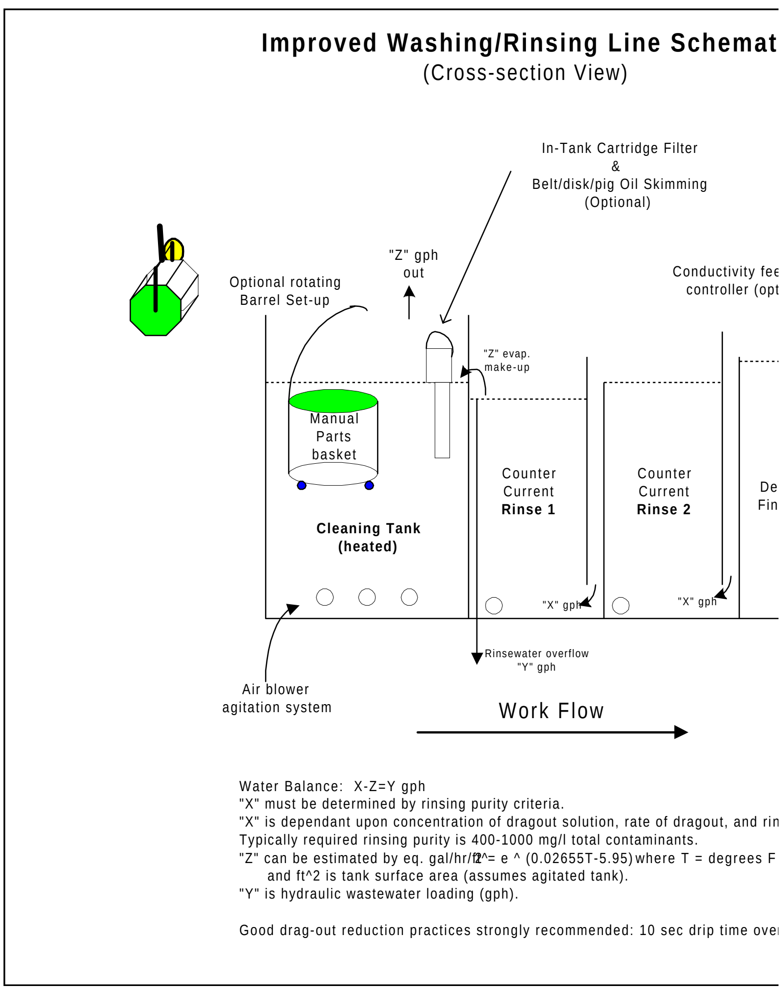
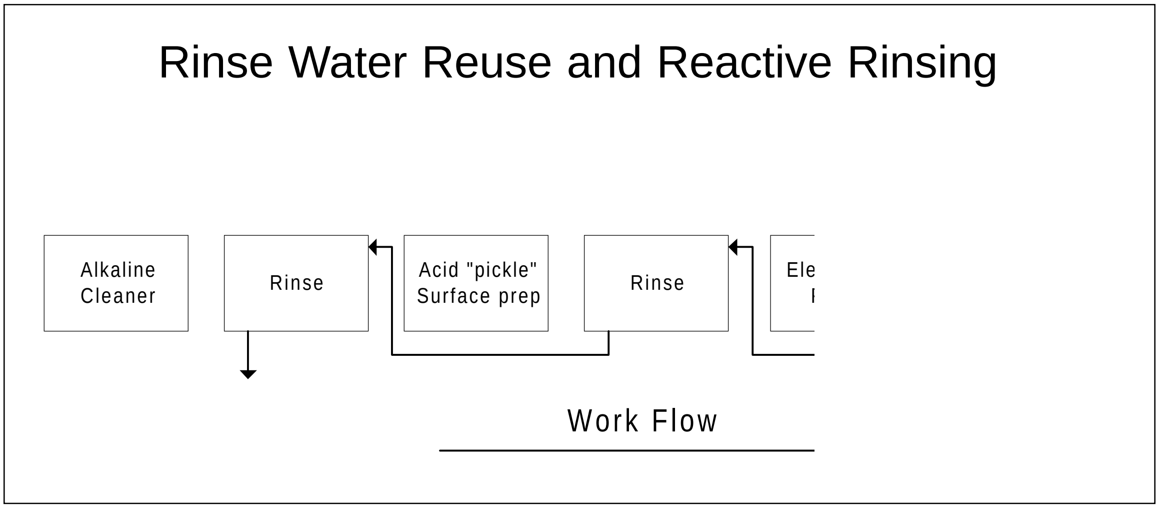


FIGURE 43




be hydraulic nozzles, which spray water only or air-atomized nozzles which use compressed air. Nozzle spray patterns are available in full cone, hollow cone, flat fan, and finer misting and fogging types. Spray angle and length of spray pattern is important when specifying the number and spacing of nozzles. Components of spray systems include a water supply, filter, switch, check valve, and nozzle(s). The approximate installed cost for a spray system over an existing tank is less than $2,000. Case studies have shown these systems are paid for in less than one year in water and chemical savings.

## Reducing Drag-out to Improve Rinsing

The term "drag-out" refers the residual solution that still is adhering to a part when it leaves a process bath. The drag-out is the solution that must be rinsed off the part. By employing techniques that reduce the volume of drag-out, metal finishers can rinse parts using less water. Potential drag-out reduction techniques for metal finishers include:

- Operating bath formulations at a minimum chemical concentrations.
- Maximizing bath operating temperature to lower bath viscosity.
- Using wetting agents to reduce surface tension. Up to a 50 percent drag-out reduction can be achieved.
- Racking parts to maximize drainage. Drag-out rates for very poorly drained parts are three to 12 times the rates for well drained parts with vertical, horizontal and cup shaped surfaces.
- Extending drainage time over process tank or dead rinse tank.
- Increasing drip time from three to 10 second reduces the drag-out remaining on a part by an average of 40 percent.
- Using spray or fog rinsing over the process tank or dead rinse tank
- Positioning drainage boards between the process tank and next rinse tank.

By reducing the volume of process solutions carried out of the plating tank, metal finishers can reduce rinse water, conserve expensive bath formulations, and directly reduce the pollutant mass loading to wastewater.

## Wastewater Reuse Techniques

Some electroplating shops are reusing treated wastewater for non-critical rinsing steps such as after alkaline cleaners and acid pickling steps. The reuse of conventionally treated wastewater (via hydroxide precipitation) should be cautioned due to the introduction of high dissolved solids into the plating line. Drag-out and drag-in from conventionally treated water can contaminate other process baths with contaminants such as sodium. In conjunction with advanced membrane separation techniques such as reverse osmosis, wastewater reuse becomes more feasible from an operation standpoint. Some companies have successfully closed-looped electroplating rinse tanks by employing continual cationic and anionic exchange reclamation of metals.

An electro-coagulation/ultraviolet process patented by Pasco, Inc., has been successfully applied to treat and reuse alkaline and acid rinse waters and bath dumps. The process offers cost effective high quality water reuse and low sludge generation due to no needed chemical additions for solids coagulation and flocculation treatment stages.

Other novel applications of wastewater treatment techniques such as electro-coagulation and absorptive/adsorptive media hold promise to enable electroplaters to close loop their operations.

# 6 Auditing Methodology and Tools

A facility water audit or survey is the key activity of any water efficiency program. This chapter provides supplemental information and tools for the water audit team conducting the plant survey. *(Also see Chapter 3.)*

## Water Audit Preparation

Thorough preparation for the water audit will ensure maximum results and efficiency. Collect the following information regarding the facility's water use, and identify all personnel familiar with the operation.

1. The exact location of the facility included in the audit.
2. The physical size of the facilities, including the number of buildings and floor space (in square feet) for each.
3. Plumbing drawings, riser diagrams, and irrigation plans.
4. Names and phone numbers of facility contacts.
5. Specific services or products produced at the site:
   - Record the number of meals served, number of guest rooms, and occupancy data for service establishments, such as restaurants, hotels, hospitals, military bases, and schools.
   - For manufacturing sites, identify the amount of water used per quantity of product produced (that is, gallons per ton of product or gallons per gross of widgets).
   - For schools and other such institutions, record the amount of water used per person per day.
6. The operating schedule of the facility, number of employees per shift, maintenance shifts, and other operating information.
7. A water use profile (graph) showing the total water use and water used per unit of product per month.
8. Copies of the proposed billing rates for energy, water, and wastewater for the next two years.
9. List of all water-using equipment,

including the manufacturer's recommended flow requirements.

10. Inventories of sanitary fixtures and any water-saving features.
11. Outdoor water use and irrigation controls.
12. Previous water and energy surveys.
13. All water delivery records from water meters, tank trucks, or the facilities' own wells. Accurate water meters are essential for a valid water audit. Source water meters indicate the amount of water supplied to the site. Sub-meters indicate water used for specific processes and individual buildings on the site. Obtain the following meter information before starting the audit:
    - Location of all water supply meters that record deliveries from utilities, wells, and other water sources.
    - Location of all on-site process and building meters.
    - Sizes of all meters.
14. Any calibration test results for meters to adjust past meter readings to reflect actual water use.

If the firm has never performed a significant water efficiency study, experienced help may be needed. Experienced assistants may be available from the following:

- Other units within the organization.

## Measuring In-Plant Water Usage

*Sub-metering* is an excellent way to accurately account for large water uses in specific processing equipment for departments within the plant. Sub-metering helps personnel become familiar with water use for all operations and indicates whether equipment is using water when it is not needed. (In some rinses, water is left running continuously, even when the need is only occasional.)

To obtain the appropriate size for a sub-meter, use the actual flow rate rather than just pipe size. Use temporary strap-on meters to determine the approximate flow. Then, the correct size of the positive displacement meter can be determined before installation. Temporary meters also will indicate whether it will be cost-effective to install permanent meters.

*Bucket and stopwatch* is a simple and accurate measurement tool. To use this method, collect a specified amount of process water for a specific time period (e.g., one quart per minute, which is equivalent to 0.25 gpm)

*Micro-weirs* are small hand-held weirs that are used to measure low flows of water (0.5 to six gpm) in tight spaces, such as under lavatory faucets.

- Local, state, or university technical assistance services.
- Consultants who understand the processes.
- Water, gas, energy, and electric utilities.

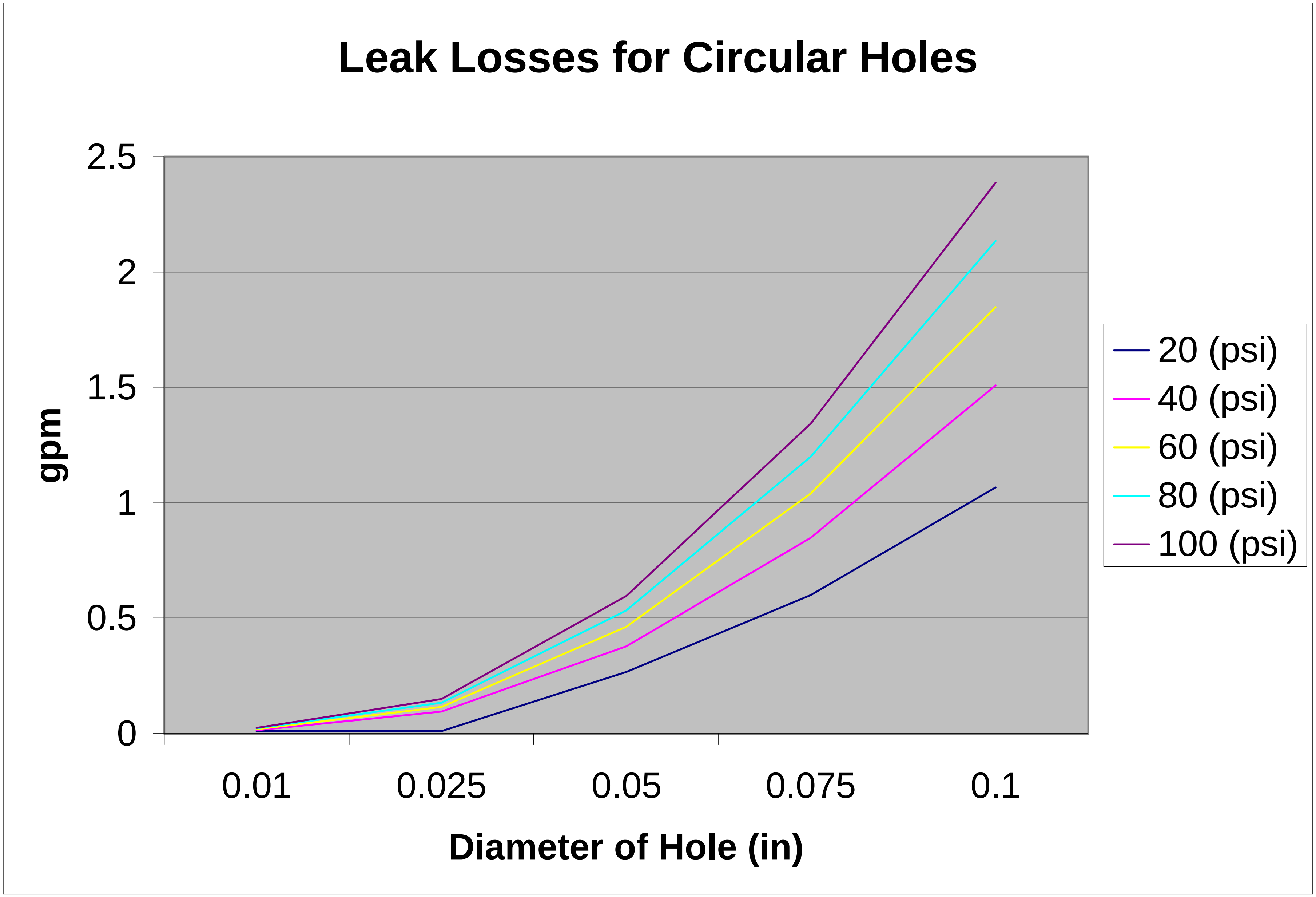
## Conducting the Water Audit

The next step is to conduct a walk-through survey with facility personnel who are knowledgeable of how water is used in each area of the facility. Use direct observation and measurements. Identify and record all pieces of equipment that use water. Check with equipment operators who may have important first-hand information. Use the following procedure to conduct the step-by-step survey.

1. During the walk-through, record hours of operation for each piece of equipment. Identify water piping layouts, particularly in areas of older equipment, to aid with identifying water uses. Note those pieces of equipment that have multiple uses of water (e.g., water-cooled ice machines).
2. Identify water flow and quality as needed for each use. This information may be needed to determine if discharges from one use can be re-used as a potential supply for a different application. Include these parameters:

    - Temperature.
    - Water quality indicator parameters, such as pH, TDS, and conductivity.
    - Other key water quality parameters such as BOD, COD, metals, or oil and grease.

3. Measure the actual amount of water being used. The most direct way to measure flow rates is with a bucket and a stopwatch. Consider installing meters on major water-using processes or plant departments to record the quantity of water used.
4. Check water quantity and quality of water specified within the equipment operating manuals. Equipment sometimes is operated at higher flows than required by the manufacturer's specifications. Ask qualified engineers to review the specifications and adjust flows accordingly. Further, investigate whether the processes can still operate properly with further reductions in water flow. Be sure to record flow rates before and after changes are made to evaluate the effects of the reduced flow.
5. Read water meters regularly and compare actual water use to the facility's water reduction goal. After determining daily use rates, the frequency of the readings should be adjusted to be consistent with the volume of water used, the cost of reading the meters, and potential excessive use fees. For example, large water users (more than 50,000 gpd) should continue to read meters daily. Commercial businesses using water for sanitary purposes only might read meters biweekly or monthly.
6. Identify flow and quality of wastewater resulting from each use.
7. Include any internally generated fluids in the water audit. Water may be generated as a by-product of processing raw materials, such as fruits or from oil/water separa-


Leak Losses for Circular Holes
gpm
2.5
2
1.5
1
0.5
0
0.01
0.025
0.05
0.075
0.1
Diameter of Hole (in)
20 (psi)
40 (psi)
60 (psi)
80 (psi)
100 (psi)

tion equipment. Determine the quantity and quality of these fluids and whether there are potential on-site uses for these fluids, such as housekeeping or cooling.

Use survey results to prepare a water balance diagram *(See Figure 10, Chapter 3.)* to depict all water uses from source through on-site processes, machines, and buildings, and finally, to evaporation and discharge as wastewater. If unaccounted for water is greater than 10 percent, revisit the major areas of water use, talk further with plant operators, or take additional measurements.

## Leak Detection

All facilities will experience some leaks. Leaks may range from a fraction of a percent up to several percents of total water use. Common locations to find leak are in piping joints, restroom fixtures, pump seals, hose nozzles/shut off valves, drinking fountains, processing equipment, and other locations. Eliminating leaks typically includes tightening or replacing fitting.

Leaks can best be identified by visual or audio observation. Water fixtures and process equipment should be observed both during use and during down time. All employees should be responsible for notify maintenance personnel of leaks, and maintenance personnel should make leak repair a priority. Underground and under-the-floor leaks can be detected through a leak detection survey. If an underground leak is suspected, but not identified, facilities should consider having a leak detection survey conducted by a consulting or service firm. Sonic leak detection equipment ranges in price from $900 to more than $4,000.

## Determining Water Loss by Leaks

Determine the volume of water loss by leaks is importance to determine both water and cost savings by repairing the leak. One of the simplest methods to determine leak loss is the bucket and stopwatch method. A small drip also can

FIGURE 44

**Drips/Second to GPM Conversion**

| No. drips per second | Gallons per minute |
|---|---|
| 1 | .006 |
| 2 | .0012 |
| 3 | .018 |
| 4 | .024 |
| 5 | .030 |

Five drips per second is a steady stream.

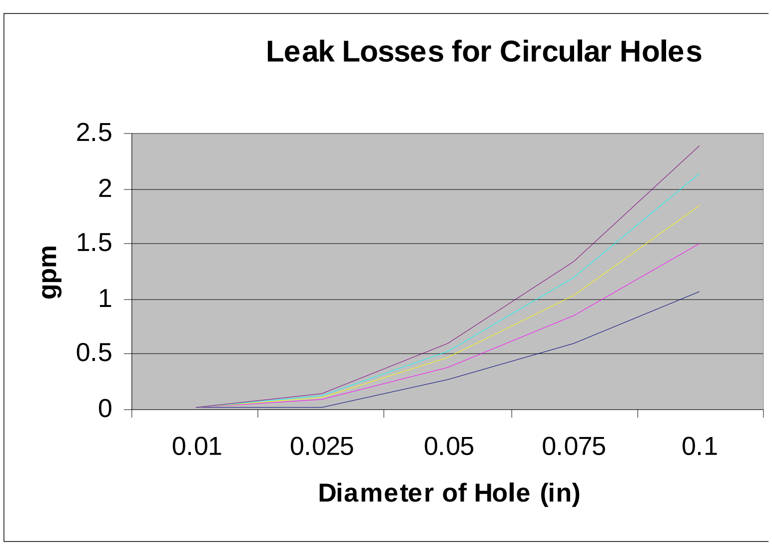



FIGURE 45

## Water Leak Equations

*Rates of water loss for a roughly circular hole can be estimated using the Greeley equation (See Figure 45.):*

Q = (30.394)(A)(square root of P)
Where Q is leak rate in gpm, A is the cross-sectional area of the leak in square inches, and P is the line pressure in pounds per square inch (psi).

Leaks in joints or cracks can be estimated by this equation:

Q = (22.796)(A)(square root of P)
Where Q is leak rate in gpm, A is the area of the leak in square inches, and P is the line pressure in psi. For example a 1/32" wide crack, 1" long will lose 4.5 gpm at 40 psi.

be measured by the bucket and stopwatch method. Mathematical estimates of leaks also can be used.

## Water Meter Issues

The size and accuracy of a facility's water meter is important when accurately accounting for water use. Typical type of meter use for commercial and industrial setting include positive displacement, turbine, and compound meters. Figure 46 shows typical applications for meter types and sizes. Water meters can become less accurate when the intended water use of a facility has changed or when substantial water conservation activities have been implemented. Water meters should be of adequate size but not oversized. If a meter is oversized for the facility's needs, the facility could be paying unwarranted service charged for the oversized meter. Properly selected and sized water meters can become inaccurate due to wear, which is affected by age and water quality. In-place field testing using a pitotmeter for large meters and portable meter test unit for smaller water meters can be conducted.

FIGURE 46

### Types of Meters and Applications

| Type | Common sizes | Typical Applications |
|---|---|---|
| Positive displacement | 5/8 - 2 inches | Commercial, medium hotels, apartment complexes, and industrial plants |
| Class II Turbine | 2 - 6 inches | Medium/large hotels, large apartment complexes to large manufacturing and processing plants |
| Class I Turbine | 8 - 12 inches | Industrial, manufacturing, processing, pump discharges |
| Compound, high velocity styles | 2 - 4 inches | Medium hotels have special high and low demands for schools, public buildings, and hospitals |

# Water Survey Data Sheet

This data collection sheet is designed to assist auditors during assessments. Some items may not be appropriate for all assessment situations.

## Assessment Information

Company name ______________________________ Date of assessment ________

Address ______________________________________________________________

Phone/fax _____________________ Audit coordinator _______________________

Assessment team members ______________________________________________

Assessment objectives (special concerns) ___________________________________

## Background Information About Water Use

Average water use/bill (for previous year) __________________________________

Average sewer use/bill (for previous year) __________________________________

Size and location of meter(s) ____________________________________________

Primary water source __________________________________________________

Secondary water source ________________________________________________

Number of employees _________________________________ Shifts per day _____

Operating days per week _________ Size of plant (square feet) __________________

Type of facility (manufacturing, college, health care, office, etc.) ___________________

If manufacturing, list products and annual production rate. _______________________

If service or institutional sector, list clients, occupancy rates, and meals served per year,

etc. ________________________________________________________________

Other pertinent facility data ______________________________

Current and past water efficiency program measures (policies, training, awareness, and goals) ______________________________

## System Parameters

Number, types, and sizes of buildings at complex ______________________________

Grounds (approximate area in acres) ______________ Garages/motor pool/support buildings (approximate square feet) ______________________________

On-site water treatment description, rate, and costs ______________________________

Wastewater treatment description, rates, and operating costs ______________________________

## Water Use in Manufacturing Processes

Volume used directly in the product per year ______________________________

Description of water uses in processing ______________________________

Volume used in production processes (i.e., plating) ______________________________

Comments ______________________________

## Washing and Sanitation

Volume used for cleaning, washing, and sanitation ______________________________

Description of washing and sanitation practices ______________________________

## Cooling and Heating

Description of cooling tower/evaporative coolers (rated tonage, types, and uses) _____

______________________________

Water rate used in cooling towers and equipment ______________________________

Description of once-through cooling requirements ______________________________

Volume used in once-through cooling (air compressors, air conditioners, vacuum pumps, rectifiers, hydraulic equipment, degreasers, etc.) ______________________________

Volume used in boiler blowdown and steam ______________________________

## Domestic

Toilets (number, types, and tank volumes) ________________________________

Urinals (number and volumes) ________________________________________

Lavatory sinks (number and estimated flow) ______________________________

Showers (number and estimated flow) __________________________________

Other ____________________________________________________________

## Landscaping/Outdoor Use

Landscape irrigation (estimated gallons per unit of time) ______________________

Acreage/square footage landscaped and description _________________________

Watering/irrigation system, techniques, and schedule ________________________

__________________________________________________________________

Others/Comments __________________________________________________

## Kitchen/Canteen

Dishwasher(s) description and use _____________________________________

Volume used for dishwashing _________________________________________

Kitchen faucet/pre-rinse sprayers [number and flow rate (gpm)_________________

Ice makers, air or water cooled, and water usage ___________________________

Garbage disposals in use? ___________________________________________

Comments _________________________________________________________

## Other Uses, Leaks, and Unaccounted for Water

List any quantifiable leaks and estimated rates. ______________________________

Other uses of water (air washers, wet scrubbers, ornamental ponds, dust control, etc.)

__________________________________________________________________

## Selected Ideas for Efficiency and Cost Savings

Low-flow plumbing fixtures ______________ Timers/electric eyes, etc. ______________

Re-use of water in process ______________ Gray water reuse potential ______________

Use cooling jackets with temperature sensors __________________________________

Use chillers/preventing evaporation losses _____________________________________

Xeriscaping (use of certain plants, landscaping, etc.) _____________________________

Drip irrigation versus overhead or spray watering _______________________________

Effectiveness of air cooling versus water cooling ________________________________

Effect of piping friction and heat loss _________________________________________

Potential to reduce meter size _______________________________________________

Inspected for leaks ________________________________________________________

Obtain credit for water, which does not go into sewer (i.e., manufacturing uses, lawn uses, etc.) _______________________________________________________________

Install additional meters to monitor water not being sewered ______________________

Employee education and training needs _______________________________________

Other _____________________________________________________________________

## Additional Comments

Factors that could affect, increase, or decrease in water use ______________________

Other major inefficiencies uncovered and assessment opportunities, such as lighting, solid waste reduction, heat recovery, pollution prevention, etc.) ____________________

___________________________________________________________________________

Positive recognition ideas for previous water efficiency measures ___________________

Other _____________________________________________________________________

# 7 Resources

## National Water Efficiency Programs

**Waterwiser**
6666 West Quincy Avenue
Denver, CO 80235
Phone: (800) 559-9855
Web site: http://www.waterwaiser.org
*The Waterwiser clearinghouse is a unique information source created to assist water professionals and other interested parties with locating current and comprehensive information about water efficiency topics. Waterwiser has a wide array of information services, including an on-line conference.*

**U.S. EPA's Water Alliances of Voluntary Efficiency (WAVE) Program**
U.S.EPA
401 M Street SW (4204)
Washington, DC 20460
Phone: (800) 993-7288
Web site: http://es.epa.gov/partners/wave/wave.html
*The Water Alliances for Voluntary Efficiency (WAVE) program's mission is to encourage commercial businesses and institutions to reduce water consumption while increasing efficiency, profitability, and competitiveness. Initially limited to the hotel/motel sector, the program is expanding to assist other businesses sectors.*

**American Water Works Association**
6666 West Quincy Avenue
Denver, CO 80235 USA
Phone: (303)-794-7711
Web site: http://www.awwa.org/

**North Carolina American Water Works Association and Water Environment Association**
P.O. Box 11322
Raleigh, NC 27604
Phone: (919) 387-0646

## Landscaping Associations

**The Irrigation Association**
**8261 Willow Oaks Corporate Drive**
Suite 120
Fairfax, VA 22031
Phone: (703) 573-3551
Fax: (703) 573-1913
Web site: http://www.irrigation.org

**American Society of Irrigation Consultants**
P.O. Box 426
Byron, CA 94514-0426
Phone: (925) 516-1124
Fax: (925) 516-1301
Web site: http//www.asic.org

## North Carolina Assistance Providers

### *Addressing Water Efficiency, Pollution Prevention, and Energy Efficiency*

**North Carolina Division of Pollution Prevention and Environmental Assistance**
P.O. Box 29569
Raleigh, NC 27626-9569
Phone: (800) 763-0136 or (919) 715-6500
Fax: (919) 715-6794
Email: nowaste@p2pays.org
Web site: http://www.p2pays.org

*The North Carolina Division of Pollution Prevention and Environmental Assistance (DPPEA) provides free, non-regulatory on-site pollution prevention assessments, including water efficiency to businesses, industries, and municipalities in North Carolina. DPPEA resources also include technical fact sheets and manuals on pollution prevention and a clearinghouse of more than 13,000 references. A matching grant program is also available for innovative pollution prevention and water efficient technologies.*

**North Carolina Division of Water Resources**
(Water supply assistance, planning, allocation, and conservation)
Phone: (919) 733-4064
Web site: http://www.dwr.ehnr.state.nc.us/home.htm
*The Division of Water Resources provides technical assistance to water systems with water supply planning, leak detection, water conservation, and water shortage response planning.*

**NCSU's Industrial Extension Service**
North Carolina State University
College of Engineering
Raleigh, NC 27695
Phone: (919) 515-2358
Web site: http://www.ies.ncsu.edu
*The North Carolina State University Industrial Extension Service and the North Carolina Energy Division can provide energy audits and energy conservation courses for a small fee. This assistance targets nearly all basic unit operations of a manufacturing facility ranging from compressors to HVAC units. Contact Jim Parker at (919) 515-5438 for additional information about energy and related water management issues.*

**NCSU's Industrial Assessment Center**
**Department of Mechanical and Aerospace Engineering**
Box 7910
Raleigh, NC 27695-7910
Phone: (919) 515-1878
Contact: Steve Terry
*Another program at North Carolina State University, called the Industrial Assessment Center (IAC), provides preliminary energy, waste, and water reduction audits free of charge for small and medium-sized industries within a 150-mile radius of Raleigh.*

**Manufacturing Extension Partnership**
Industrial Extension Service
North Carolina State University
Phone: (800) 227-0264
Web site: http://www.ies.ncsu.edu/ieswww/programs/mep/
*The Industrial Extension Service at North Carolina State University recently introduced the North Carolina Manufacturing Extension Partnership (NC MEP) Program. The NC MEP team of engineering specialists offer technical assistance to North Carolina manufacturers such as industrial management, computer applications, plant engineering, and material handling. Limited technical assistance, information, and site visits are provided free of charge. More extensive support and consulting are priced according to project length and required resources.*

**Waste Reduction and Technology Transfer Program (WRATT)**
Land-of- Sky Regional Council
25 Heritage Drive
Asheville, NC 28806
Phone: (828) 251-6622
*The WRATT program provides water efficiency, multimedia, and greenlights assessments to busnesses and industries in western North Carolina. The WRATT program utilizes volunteer engineers and scientists to perform on-site assessments and report recommendations.*

**North Carolina Cooperative Extension Service**
North Carolina State University
College of Agriculture and Life Sciences
Raleigh, NC 27695
Phone: (919) 515-3173
Also see your local county agents.
*The Cooperative Extension Service can provide technical assistance, publications and research about water efficient landscaping.*

## State Government Organizations

**North Carolina Division of Water Resources**
(Water supply assistance, planning, allocation, and conservation)
Phone: (919) 733-4064
Web site: http://www.dwr.ehnr.state.nc.us/home.htm

**North Carolina Division of Water Quality**
(Water reuse permitting, wastewater permitting, tax credits, concentration/mass-based wastewater permit issues)
P.O. Box 29535
Raleigh NC 27626-0535
Phone: (919) 733-5083
Web site: http://www.h2o.enr.state.nc.us/

**North Carolina Division of Pollution Prevention and Environmental Assistance**
(Technical and financial assistance to businesses, industries, and municipalities)
P.O. Box 29569
Raleigh, NC 27626-9569
Phone: (800) 763-0136 or (919) 715-6500
Web site: http://www.p2pays.org

**North Carolina Division of Energy**
N.C. Department of Commerce
P.O. Box 29571
Raleigh, NC 27626-0571
Phone: (919) 733-2230

## Other Water Resource Information

Water Librarian's home page
http://www.wco.com/~rteeter/waterlib.html

Toilet Information, testing and repair
http://www.toiletology.com

EPA EnviroSense
http://www.epa.gov/envirosense/

## Vendors

Use local resources first. Many suppliers that a facility currently uses may represent manufacturers of water efficient plumbing hardware, fixtures, controls, treatment, and process equipment.

*General Domestic/Plumbing*
Sloan Valve Co. (800) 580-7141
Zurn Industries (800) 997-3876
American Standard, Inc. (800) 223-0068
Delta Faucet Co. (519) 659-3626
Elkay Manufacturing Co. (630) 574-8484
Kohler (800) 456-4537
Niboc Inc. (800) 642-5463
Crane Plumbing (847) 570-3566
Gerber Plumbing Fixtures Corp. (847) 675-6570
Mansfield Plumbing Products (614) 825-0960
Eljer Plumbingware (800) 423-5537
Universal-Rundle (800) 955-0316
U.S. Brass Inc (800) US-BRASS
Other Plumbing contacts: Web site: http://www.plumbingnet.com/listc.html

*Pressure Reducing Valves*
Watts Regulator Co. (978) 688-1811
Wilkins (805) 238-7100;
Cash, A.W. Valve Mfg. (205) 775-8200

*Water Saving Toilet Retrofits*
Aqua Saver (Water Saving Devices for Gravity Toilets) (800) 723-6954
Rectorseal Corp (Early Closing Flapper Valves) (800) 231-3354

*Commercial Bathroom Efficiency*
Bradley Corporation (312) 463-2454
Kohler Plumbing (414) 457-4441
Chicago Faucet Company (847) 803-5000
Coyne & Delany Co. (804) 296-0166
Microphor, Inc. (800) 358-8280
Sloan Valve Company (847) 671-4300

*Pressurized Flush Toilet*
Sloan Valve Flushmate (800) 875-9116

*Foodservice Plumbing*
T&S Brass and Bronze Works (800) 476-4103
Fisher Manufacturing Company (800) 832-8238
Niagra Conservation (800) 831-8383
Resources Conservation (800) 243-2862

*Foodservice Dishwashers*
Champion (910) 661-1979
Hobart Corporation Representative (704) 527-6381

*Spray Nozzles*
FOGG-IT Nozzle Co. (415) 665-1212
Spraying Systems Co. (704) 392-9448
Milton Industries, Inc. (312) 235-9400

*Valve Shut-off (foot controlled)*
Pedal Valves, Inc. (800) 431-3668
T&S Brass and Bronze Works (800) 476-4103

*Auditing Tools*
MicroWier Company LLC (503) 235-0792

*Waterless Composting Toilet*
Bio-Sun Systems, Inc. (800) 847-8840

*Cooling Tower & Boiler Water Treatment and Control*
Marley Cooling Towers (913) 664-7400
Nalco Chemical Co. (708) 305-1000

*Vehicle Washing Water Recycle*
Sobrite Technologies (309) 467-2335
Earth Care Technologies (360) 697-2376
Custom Applied Technology Corporation (888) 536-7100
Waste Water Management, Inc. (561) 747-8028
Specified Equipment Co. (800) 328-2747
Kleer-Flo (800) 328-7942
N/S Corporation (800) 782-1582

California Steam (800) 432-7999

*Laundry Water Reuse*
Hydrokinetics (800) 582-5599
GuestCare, Inc. (214) 243-3035

## Consultants and Service Providers

Advanced Conservation Technologies, Inc. (Leak detection)
13813 Turkey Foot Road
North Potomac, MD 20878-3935
Phone: (301) 840-0500
Fax: (301) 840-0081

American Leak Detection, Inc.
(Leak detection)
888 Research Dr., Suite 109
Palm Springs, CA 92262
Phone: (760) 320-9991
Fax: (760) 320-1288
Web site: http://www.leakbusters.com

American Water & Energy Savers
(Water performance)
12922 SW 132 Court
Miami, FL 33186
Phone: (305) 378-8923
Fax: (305) 378-4401

Amy Vickers & Associates, Inc.
(Program implementation, audits, retrofits)
Amherst Office Park
441 West Street, Suite G
Amherst, MA 01002-2967
Phone: (413) 253-1520
Fax: (413) 253-1521

AquaMetrics (Audits, retrofits)
1114 Chesterton Avenue
Redwood City, CA 94061-1324
Phone: (650) 366-8076
Fax: (650) 366-2804

ERI Water
(Leak detection)
49 Edge Hill Road
Newton, MA 02167

Best Management Partners
(Water performance, audit, and retrofits)
1704 Elm Street
El Cerrito, CA 94530-1909
Phone: (510) 620-0915
Fax: (510) 620-0916

California Water Conservation Co.
(Water performance, audit, retrofits)
7277 Hayvenhurst Avenue, Suite B-5
Van Nuys, CA 91406
Phone: (818) 787-5588
Fax: (818) 787-5599

CTSI Corporation
(Water management, audits, retrofits)
2722 Walnut Avenue
Tustin, CA 92780
Phone: (800) 660-8028
Fax: (714) 669-4309

Health Consultants
(Water management, audit, retrofit, leak detection)
Leak Tec Division
122 Space Park Drive
Nashville, TN 37222-4597
Phone: (800) 769-3394

John Olaf Nelson Water Resources Management
(Performance, audits, retrofits)
1833 Castle Drive
Petaluma, CA 94954
Phone: (707) 778-8620
Fax: (707) 778-3566

Maddaus Water Management
(Water management/performance)
9 Via Cerrada
Alamo, CA 94507
Phone: (510) 820-1784
Fax: (510) 820-2675

Margiloff & Associates
(Water management, audit and retrofits)
621 Royalview Street
Duarte, CA 91010-1346
Phone: (626) 303-1266
Fax: (626) 303-0127

Planning & Management Consultants, Ltd.
(Water management, leak detection, audits)
6352 South Highway 51
Carbondale, IL 62903
Phone: (618) 549-2832
Fax: (618) 529-3188

United Energy Associates, Inc.
140 North Orlando Avenue, Suite #150
Winter Park, FL 32789
Phone: (800) 742-3362
Fax: (407) 740-0169

**Volt VIEWtech**
(Management, audits, retrofits)
3430 E. Miraloma Avenue
Anaheim, CA 92806
Phone: (619) 573-0105
Fax: (619) 573-1854

**Water Management, Inc.**
117 Clermont Avenue
Alexandria, VA 22304
Phone: (703) 370-9070
Fax: (703) 370-9179

**Water Management Services, Inc.**
(Leak detection)
5677 Oberlin Drive, Suite 110
San Diego, CA 92121
Phone: (619) 824-0900
Fax: (619) 824-0901

**WaterTech International, Inc.**
(Water management, leak detection)
One Kendall Square, Suite 2200
Cambridge, MA 02139
Phone: (800) 981-1106
Fax: (781) 592-8005

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