A Water Conservation Guide for Commercial, Institutional and Industrial Users

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New Mexico Office of the State Engineer

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Section 1: Introduction

SAVING WATER IS GOOD FOR BUSINESS

> ### *What Is Water Conservation?*
>
> Water conservation is defined as any action that reduces the amount of water withdrawn from water supply sources, reduces consumptive use, reduces the loss or waste of water, improves the efficiency of water use, increases recycling and reuse of water, or prevents the pollution of water (New Mexico Office of the State Engineer, 1997).
>
> Conversely, water waste is the excessive use of potable water that is unproductive or does not reasonably sustain economic benefits or life forms, particularly where there is a shortage of potable water.
>
> Drought combined with population growth places a burden on once-adequate water supplies. That is why water conservation is an important consideration as New Mexico begins a new millennium.

The importance of water to the State of New Mexico cannot be overstated. The quality of life for New Mexico's population and the future growth of the state depends on water.

Although rainfall varies throughout the state, New Mexico averages less than 13 inches of precipitation per year. Because of our arid climate, water is a precious and limited resource. Therefore, water conservation is every New Mexican's business.

This manual was developed to help commercial, institutional, and industrial water users conserve New Mexico's most precious natural resource. Therefore, this manual includes useful data that can be used by decision makers to develop comprehensive conservation plans, including:

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

While ensuring the wise use of the state's water resources is a smart idea for New Mexico, it is also smart for businesses and institutions concerned with the "bottom line." Efficient water management can reduce operating costs for water and energy without sacrificing production quality. In many cases the payback period for water conservation improvements is economicaly viable—ranging from one to five years.

Furthermore, site managers who have a thorough knowledge of their plant's water use will be better able to reduce the impact of any potential mandatory water regulations necessitated by drought or other water shortages. Perhaps best of all, a well-planned and efficiently implemented program of water conservation on the part of the commercial, institutional and industrial sector will help to extend community water supplies—and help to make future growth possible.

WHERE NEW MEXICO'S WATER COMES FROM AND WHERE IT GOES

Who Can Benefit From This Manual?

- government facilities, including military bases
- schools, colleges, and other institutions
- hospitals and medical offices
- hotels and restaurants
- office buildings and shopping centers
- service businesses
- manufacturers

In 1995, water withdrawals from surface and ground water sources in New Mexico totaled 4,449,167 acre-feet. Surface water accounted for 2,542,562 acre-feet or 57.15% of the total, while ground water accounted for 1,906,605 acre-feet or 42.85%. Perhaps most importantly, 62.09% of the water withdrawal (or 2,762,497 acre-feet) was depleted (i.e., consumptively used). Surface water supplies are already fully appropriated, and, in several areas of the state, ground water is being depleted faster than it can be replenished.

Facility managers have a tremendous responsibility to conserve our most precious resource. While commercial, institutional, and industrial water use (excluding irrigated agriculture) accounts for approximately 6% of total statewide water use, the total used by this sector amounts to an estimated 266,950 acre-feet or 86.98 billion gallons of water annually. Truly, every gallon of water saved is important.

Furthermore, New Mexico's population continues to increase. From 1990 to 1995, the state's population increased 10.49% from 1,526,318 to 1,686,477. Approximately 74% of the state's population lives in urban communities where demand for water is highest. As a result of this growth, communities are struggling to keep up with the demand for water and sewer services.

What Is Water Used For?

Water is used by commercial, institutional, and industrial customers for five primary purposes:

— indoor domestic use (restrooms, kitchens, and laundries)
— cooling and heating
— landscape irrigation
— processing of materials
— as an ingredient

While water use varies widely by industry type and by individual facility, virtually all sites can save water by re-evaluating the manner in which water is used.

TYPICAL WATER USE BREAKDOWN

Here is an overview of some key industries and the areas in which they use water.

Office Buildings

Office buildings, service businesses, and other commercial establishments typically use water for these purposes: restrooms and other domestic uses, cooling and heating, and landscaping. Some office complexes and industrial parks also have restaurant or cafeteria facilities onsite, which may be leased to a foodservice company or may be operated by the corporate tenant or building owner.

Computer and Electronics Manufacturers

Rinsing in the printed circuit board and electroplating industry is a necessary process, but it consumes large quantities of water. At semiconductor manufacturing plants, the largest quantity of water use occurs in the rinsing and cleaning of silicon wafers. Because the products are extremely sensitive to even microscopic contaminants, water purity is vitally important.

The chart below shows a typical breakdown of water use in the computer and electronics industry. Many water conservation opportunities exist within this business category which will be discussed at length in later sections of this manual.

Food Processors

Food processing companies typically use water for washing and sanitation, cooling and heating, processing food products and miscellaneous other functions. Typically, the opportunities for water conservation include:

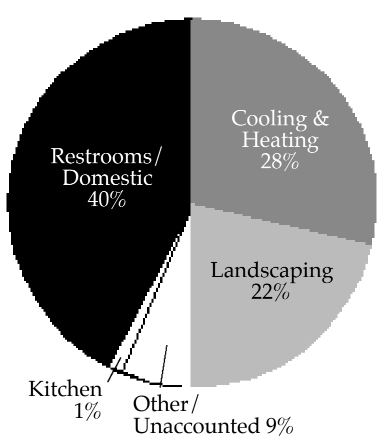
— Reusing water in another process (i.e., using rinse water in cooling towers)

— Modifying processes to consume less water

— Recycling water within a specific process (where health regulations allow)

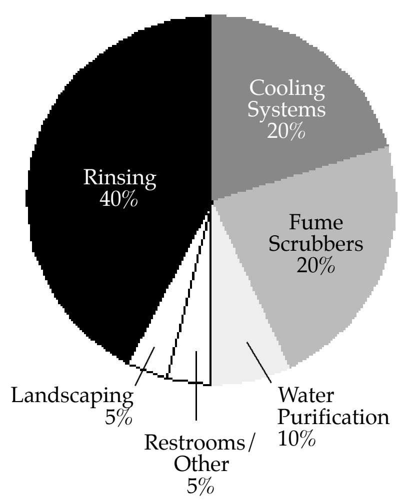
— Modifying cooling towers to recycle water

Figure 1-1
Water Usage at Office Buildings



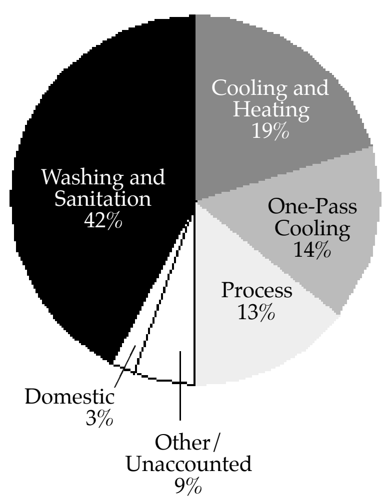
Source: City of San Jose, Environmental Services Department

Figure 1-2
Water Usage at Computer/Electronics Manufacturers



Source: City of San Jose, Environmental Services Department

Figure 1-3
Water Usage at Food Processors

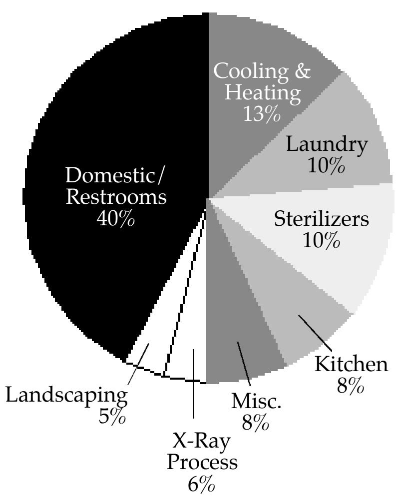


Source: Denver Water

Hospitals

Studies have shown that domestic uses (sinks, toilets, and showers) account for the largest percentage of water used in hospitals. Therefore, water-saving measures, such as ultra-low-flow toilets and low-flow showerheads, can have a significant impact on water use. Cooling and heating functions also provide a significant possibility for water savings, as do laundry and sterilization functions.

Figure 1-4
Water Usage at Hospitals

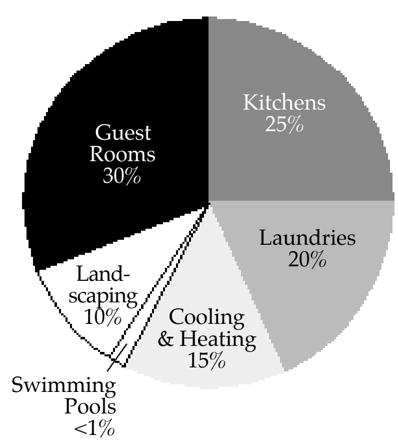


Source: City of San Jose, Environmental Services Department

Hotels and Motels

Hospitality industry businesses, primarily hotels and motels, use water for a variety of functions including laundry, preparation of food, cooling and heating, and landscaping. Typically, the largest percentage of water use occurs in guest rooms. Therefore, many of the water conservation approaches that have been successfully used to reduce water among residential customers (such as installation of ultra-low-flush toilets, low-flow showerheads, and faucet aerators) are recommended for hotels and motels.

Figure 1-5
Water Usage at Hotels and Motels

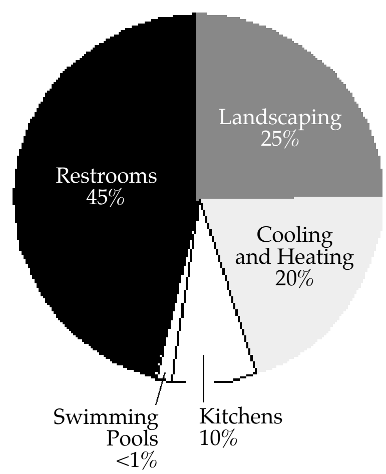


Source: City of San Jose, Environmental Services Department

Schools

School and educational facilities typically use water in these major areas: restrooms, landscaping, cooling and heating, and kitchens/cafeterias. Plumbing fixture standards for toilets and sink faucets should be followed, and cost/payback periods for installing ultra-low flow toilets and low-flow faucet aerators (or retrofitting existing plumbing equipment) should be among the first water conservation options considered.

Figure 1-6
Water Usage at Schools



Source: City of San Jose, Environmental Services Department

EIGHT KEYS TO SUCCESSFUL WATER MANAGEMENT

1. **Water management plans must be part of an integrated approach that examines how changes in water use will impact all other areas of operation.**

2. **Water conservation involves two distinct areas: technical and human.** The technical side includes collecting data from water audits and installing water-efficient fixtures and procedures. The human side involves changing behaviors and expectations about water usage and "the way things should be done." Both areas must be addressed for a water conservation program to succeed.

3. **A water conservation plan depends upon accurate data.** Before water-saving measures are implemented, a thorough water audit should be conducted to determine where water is being used. Then, water use can be monitored to track conservation progress.

4. **A successful water conservation plan follows a logical sequence of events.** Implementation should be conducted in phases, starting with the most obvious and lowest-cost options.

5. **An effective plan examines not just how much water is being used, but how it is used and by whom.** When analyzing a water audit, ask the next question: "Can this process be done as well or better using less water?"

6. **The quality of water needed should be matched with the application.** Many commercial, institutional, and industrial applications do not require the use of potable water. Whenever possible, substitute recycled water used in one process for use in another. (For example, spent rinse water can often be reused in a cooling tower.)

7. **The true cost of water must be considered when conducting a cost analysis.** The true cost of water is the amount on the water bill PLUS the expense to heat, cool, treat, pump, and dispose of/discharge the water.

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

Common Water Units

1 cubic foot (cf) = 7.48 gallons

1 ccf (commonly used by water utilities as "1 unit") = 748 gallons

1 acre-foot = 325,851 gallons

1 million gallons per day = 3.07 acre-feet per day

Section 2: *How to Create a Successful Water Conservation Program*

ESTABLISH SUPPORT AND SECURE RESOURCES

Water conservation is a cost-effective component of efficient site operation for virtually all commercial, institutional, and industrial facilities. Conserving water can result in additional resource and cost savings in areas that include wastewater treatment, energy use, and chemical consumption.

However, a comprehensive water conservation program cannot be established overnight. Careful planning and systematic implementation are needed to ensure success.

This section of the manual provides a step-by-step guide to developing a successful water conservation program for virtually any type of facility.

Voluntarily reducing water use today—by installing low-water-use xeriscapes—may help mitigate the effects of tomorrow's drought restrictions.

Top Management Support

The full support of top management—both ideologically and financially—is essential to the success of any water conservation program. Although water conservation programs are a proven way to save money and resources in the long term, your program may require an initial investment. In addition, water conservation measures can also impact ongoing facility operations. Without management support and the necessary resources, a comprehensive water conservation plan is virtually impossible.

The primary reasons that top management should support a strategic, comprehensive water conservation program include:

1. Cost Savings. Water-conserving technologies are cost-effective. Investing in a long-term water conservation strategy can significantly reduce water costs. In addition, other operating costs can also be reduced, including charges for:
— water heating
— water softening
— wastewater disposal
— chemical treatment
— reverse osmosis filtration
— disposal of aqueous toxic waste

The payback period (the time it takes for water savings to pay for the up-front costs of renovations and improvements) can be as short as a year or less.

2. Production Efficiency. Using water more efficiently may make additional water available for increased production without necessitating the purchase of additional water.

3. Public Relations Benefits. Water-use issues are important throughout New Mexico, so the news media report positive stories about water conservation. A successful water conservation program can generate positive media coverage and an enhanced public image for your business or institution. Conversely, water waste can generate negative publicity for your organization. As water supplies increasingly become viewed as a "public" resource, it will be even more important to be viewed as a responsible steward of the water supply.

4. Drought Allowances. Droughts are an inevitable part of New Mexico's weather pattern. However, your facility may feel little drought impact if you have already made water conservation a regular daily practice. Some U.S. water utilities have enacted mandatory drought reductions that allow firms which demonstrate ongoing water conservation to maintain their regular water use levels.

5. Mandatory Compliance. Throughout New Mexico, water utilities are examining water used by the commercial-institutional-industrial sector in an effort to promote conservation. In some communities, such water conservation is voluntary; in others, water conservation is either a requirement or it is "economically encouraged" by placing water surcharges on high-volume users. If current trends continue, complying with water conservation regulations will be mandatory for a majority of commercial establishments.

ACTION ITEMS FOR MANAGEMENT

Once top management has committed its support to a water conservation program, the following actions should be taken to turn that commitment into a tangible plan:

1. Establish the major goals and priorities of the water conservation program. These broad-based goals will set the tone for the specific water conservation measures which will later be identified and enacted.

2. Appoint a Water Conservation Manager who is empowered to enact a comprehensive water management plan. (See section below.)

3. Issue an organization-wide directive announcing the appointment of the Water Conservation Manager. A strong message of support for the facility's comprehensive water conservation program should be included in this announcement.

4. Provide funding for the program. Initial funding will be needed to launch the program, and continued funding will be required to implement water-saving infrastructure and process changes.

5. Emphasize the importance of the water conservation program to all employees. (See the section entitled "Getting Employees to Participate.")

6. Recognize and publicize achievements in conservation, both large and small. Ongoing communication will reinforce management's continued support for the water conservation program.

Figure 2-1
Before Conservation

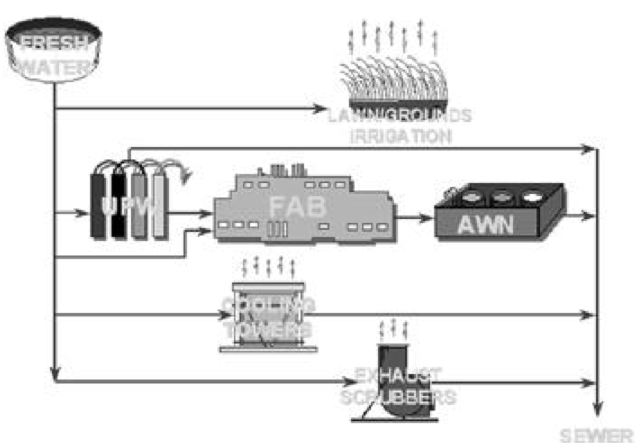
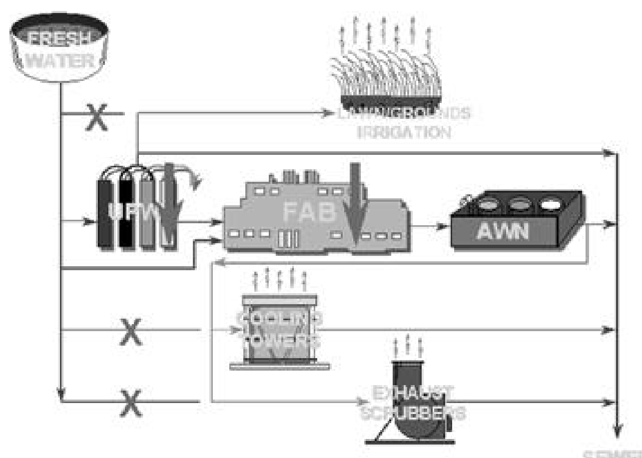


Figure 2-2
After Conservation



Water conservation measures enacted at Intel's plant in Rio Rancho have dramatically changed the way water flows through the facility.

RESPONSIBILITIES OF THE WATER CONSERVATION MANAGER

The Water Conservation Manager is responsible for transforming a commitment to water conservation into a workable plan designed to systematically achieve an organization's water reduction goals. The Water Conservation Manager, as empowered by top management, should have the resources available to create and implement specific water conservation plans and measures.

The Water Conservation Manager should:

1. Research institutional and regulatory considerations and constraints that will have an impact on water use decisions.

2. Review and evaluate the organization's existing or previous water conservation programs. Rate previous conservation efforts and determine their overall effectiveness. Note areas that were successful and areas that were not effective.

3. Establish a budget for the water conservation program. Secure the necessary funding. (Seek outside funding, if needed.)

4. Schedule onsite water audits of all water-using equipment and processes. Oversee the auditing process, both initially and during follow-up and routine inspections. (See "Conduct a Water Audit" section for more information.)

5. Create the water conservation action plan. This plan should include establishing the goals of the program as well as the details for implementing specific water conservation measures.

6. Establish the process by which the water conservation plan will be documented and evaluated.

7. Establish and coordinate an employee communications program (in conjunction with the organization's communications staff, if any). To realize maximum effectiveness, employees should be informed about the program and its goals. Employees should also be told how they can participate in the organization's conservation efforts.

8. Implement the water conservation program. Install water conservation equipment and begin water conservation measures.

9. Evaluate the water conservation program on a regular basis. Make any needed modifications to improve water reduction efforts.

10. Report water conservation progress to top management. Fine-tune the plan if necessary to make additional water-use reductions.

Setting Specific Water Conservation Goals

The water reduction goals should be specific, measurable, and achievable. Goals should be stated in terms of gallons saved and percentage of water saved. Goals should also include the time frame for achievement, the area of the facility where the water savings will be realized, and by what means the savings will be achieved. Support each specific action item with a cost/benefit analysis where applicable.

An example of a specific goal:

Reduce water used to irrigate the company's landscaping by 50% by August 1. To achieve this goal, two-thirds of turfgrass area will be converted to low-water-use xeriscape. The irrigation system will be modified so that turfgrass and xeriscapes will be watered using separate irrigation zones to achieve the maximum water savings.

Cost: $6,000

Annual water savings: 350,000 gallons

Payback period (water savings plus landscape maintenance savings): 2 years

Three Areas of Water Savings

Water conservation falls into three general areas:

1. Reducing losses (i.e. fixing leaky faucets and pipes)

2. Reducing use (for example, installing ultra-low-flush toilets and automatic shut-off faucets or eliminating once-through cooling)

3. Reusing water that is currently being discarded (such as using treated rinse water to irrigate landscaping)

CONDUCT A WATER AUDIT

Unless you know how much water your facility is now using, there's no way to know how much water—and money—you can save.

In order for a water conservation program to succeed, it is imperative that a recordkeeping system be established to monitor operation and maintenance costs, revenues, and water use.

The first step in the quantification of water use is a water audit—a detailed examination of where and how much water enters the system, and where and how much water leaves the system. Water system audits facilitate the assessment of current water uses, provide data needed to reduce water and revenue losses, and forecast future demand. With this information, a facilities manager can target system improvements where conservation efforts are most needed.

A major objective of a water system audit is estimating and reducing unaccounted-for water use. Unaccounted-for water includes losses through leaks, inoperative system controls (such as blowoff valves and altitude-control valves), and water used from unmetered sources such as wells.

The following Water Audit Checklist provides a step-by-step approach to conducting an accurate and thorough examination of current water usage.

(See next page)

Figure 2-3

Potential Water Savings from On-site Water Audits

Type of Business	Number of Site Audits	Average
Car Wash	12	27%
Church–nonprofit	19	31%
Communications & Research	10	18%
Corrections	2	14%
Eating & Drinking	102	27%
Education	168	20%
Healthcare	90	25%
Hospitality*	222	22%
Hotels & Accommodations	120	17%
Landscape Irrigation	6	26%
Laundries	22	15%
Meeting/Recreation	20	27%
Military	1	9%
Offices	19	28%
Sales	56	27%
Services	58	30%
Transportation & Fuels	24	31%
Vehicle Dealers & Services	12	17%
Total Sites	741	

Hospitality includes "eating and drinking" and "hotels and accommodations"

Data from the Metropolitan Water District of Southern California, the City of Tucson, and the Massachusetts Water Resources Authority were tabulated to determine the average potential savings available by implementing cost-effective conservation measures. ("Cost-effective" was defined as measures that "would have a simple payback [period] usually acceptable to the type of business where the audit was conducted.")

Source: "Study of Potential Water Efficiency Improvements in Commercial Businesses" (April 1997). U.S. Environmental Protection Agency and the State of California Department of Water Resources.

WATER AUDIT CHECKLIST

STEP 1: Preparation and Information Gathering

Before beginning the actual water audit, collect pertinent information from company and utility records. Identify the people who are familiar with daily operations—particularly operations and maintenance supervisors and staff. Collect the following information:

— building and location information, including physical size of the facilities, floor plans, plumbing schematics and drawings
— operating schedules, including total number of employees and number of employees per shift
— location maps identifying each water supply meter that measures incoming (source) water, plus each water meter that records onsite use. (As commonly defined, a "submeter" measures water use for specific processes and individual buildings within a site.)
— inventory of plumbing fixtures
— inventory of all water-using equipment with manufacturers' flow rates
— outdoor water use data, including irrigation systems, watering schedule, and water volume
— utility records (water and sewer) for the past two years
— records that show actual water use during the past two years (including meter and submeter readings, water wells and water tank deliveries)
— any prior water and energy audits
— anticipated water and sewer billing rates for the next two years (from utility)

Use the above water records to determine the amount of water used to provide services or produce products. Graph the results to show monthly water use.

— for service establishments (i.e., restaurants, hotels, hospitals, military bases and schools): get records for meals served, rooms occupied, etc. Using monthly water use data, determine the water used per patient, guest room occupied, meal served or applicable service rendered.
— for manufacturing sites: divide the amount of water used by the quantity of product manufactured to determine the gallons per ton or gallons per unit produced.

NOTE: If your facility or organization has not attempted significant water conservation measures in the past, it may be beneficial to seek experienced outside assistance. Information and professional help may be available from other sites of your own company or organization, outside water and energy consultants, the New Mexico Office of the State Engineer's Water Use and Conservation Bureau, and local water, wastewater and/or energy utilities. Another source of information is the Water Wiser Website at www.waterwiser.org.

WATER AUDIT CHECKLIST
(CONT.)

STEP 2: Conduct Facility Survey

After the information in Step 1 has been collected, the next step is a physical survey of the facility.

— Walk through the facility with production people and supervisors to understand how water is used in the various areas and production centers.

— Identify and list all equipment that uses water, including water-using process equipment, cooling towers, boilers, reverse osmosis filters, rinsing tanks, kitchen equipment, faucets, toilets, showerheads, etc.

— Check the water-using equipment against your inventory information. Compare floor plans, plumbing drawings, and schematics with actual conditions. Note discrepancies so an accurate record of equipment can be created.

— Record hours of operation for each piece of water-using process equipment. Whenever possible, verify schedules of use with operating personnel familiar with the building use and equipment.

— Note devices, equipment, and/or plumbing fixtures that use water for more than one operation. (For example, some ice makers use water for making ice and for cooling.)

— Calibrate all existing water meters to ensure accuracy.

— Measure the amount of water used by each water-consuming fixture or piece of equipment. If permanent meters have not been installed, a temporary strap-on flow meter that uses ultrasonic waves to measure water flow can be used. In some cases, a bucket and a stop-watch can be used to measure the flow rate in gallons per minute (gpm).

— Compare your water-use measurements with the manufacturers' listed and/or recommended flow rates. Note any discrepancies.

— Ask for water conservation suggestions from employees who are familiar with each water-use process.

— Measure water quality, too. Knowing the quality of water as it flows through a facility may point out areas where water discharge from one process can be rerouted for use in another process.
(For example, reverse osmosis reject water might be suitable for use as initial rinse water.) Water quality considerations include: chemical make-up, pH level, conductivity, total dissolved solids (TDS/ppm), waste content, and temperature.

— Measure exterior water use, especially water used for irrigation. Obtain diagrams of all irrigation systems and inventory all sprinkler heads and water-delivery devices to determine flow rate.

— Determine daily water usage for the major operating and production areas. Add these area totals to get total facility usage. Make sure that your total consumption figures match the total usage figures from your water utility, water well meters, and other water source records.

"Implement high-payback measures now. You don't need a complete audit to know that fixing a leaky toilet is smart water conservation."

—Darell Rogers
Water Conservation Officer
Sandia National Laboratories

WATER AUDIT CHECKLIST
(CONT.)

STEP 3: Prepare An Audit Report

After the completion of the physical inspection of the facility, in which each water-use area was carefully examined and water-use data was recorded, it is time to collate the data into a final audit report. This report will provide the "baseline" by which your water conservation efforts will be measured.

Your report should include the following:

— an updated set of facility diagrams, blueprints and water flow charts.

— a current list of all water-using equipment with manufacturers' recommended input/output flow rates and the actual flow rates recorded during your water audit.

— a current schedule of operation for all areas and equipment, including shift scheduling, number of employees per shift, production levels, average occupancy rates, etc.

— a month-by-month landscape irrigation watering schedule (landscape irrigation varies dramatically by month and by season)

— a water flow chart that shows the movement of water from the time it enters the facility until it is discharged

— water use figures (total facility, and broken out by operating areas and processes)

— any additional water-use observations revealed by the walk-through audit and analysis

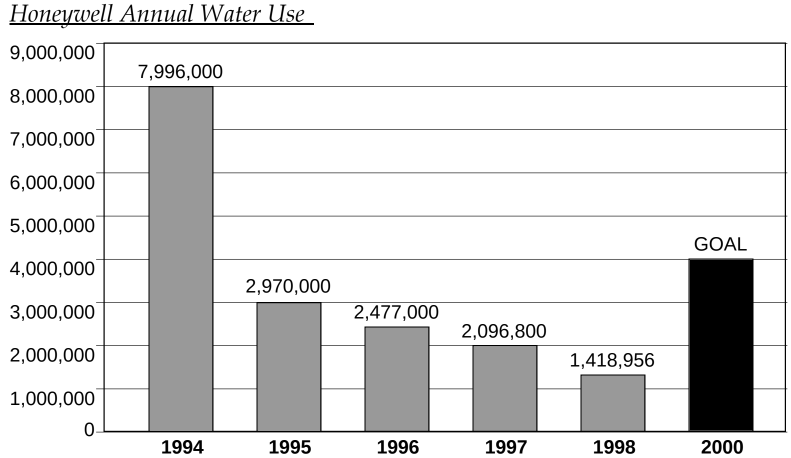
— an evaluation of the total cost of water used by the entire facility (see Step 4)

NOTE: Major discrepancies between your facility's total water consumption figures and the sum of each water-using area may indicate underground leaks in your water delivery system. Further (more detailed) water measurement may be required to pinpoint the leak. Make sure your Plan of Action includes these leak-detection activities.

"We want to send the message to others that water conservation can be done with limited resources and money. We reduced our overall water consumption 82% without spending a lot of time, brainpower or money. We found we really can make a difference."

—Dave Colton
Facility Services Manager
Honeywell

Figure 2-4
Honeywell Annual Water Use



WATER AUDIT CHECKLIST
(CONT.)

STEP 4: Determine Total Water Cost

The line item on your utility bill is the most obvious expense associated with water use, but it is far from the total cost of water use. Some water utilities charge a fixed fee or an environmental surcharge in addition to the cost for actual water used. (Water quantity is typically billed in “units” that equal one hundred cubic feet [ccf], which is equal to 748 gallons.)

The cost of water can also vary. Some utilities charge different rates based upon the amount of water used. And water rates may vary seasonally. (Summer rates may be higher than winter rates, because water demand is greater during the summer months.)

In addition to the utility cost, the total cost of water also includes the cost of:

— heating
— cooling
— energy cost of pumping water from wells or to onsite locations
— pretreating, including filtering, purifying, and softening
— chemical treatment, including treating boiler feed and cooling tower water
— predisposal treatment
— disposal of hazardous aqueous substances
— sewer discharge, which can be based on the amount of water discharged, total dissolved solids, and other water-quality considerations

Using the above information, add up the total annual cost for water and water processing. This total will be your current baseline for water cost. Calculate the cost for each unit of water consumed by dividing the total cost by the quantity of water used.

It may also be advantageous to calculate the cost of water used per production unit. To calculate that figure, divide the total cost of water use for a production run by the number of units produced during that run.

NOTE: Be sure to note monthly differences in water costs, if any. Your “per unit” cost of water may be higher in the summer months, which could make water conservation efforts even more cost effective during these months.

PREPARE A PLAN OF ACTION

Now that you know how much water your facility uses—and exactly how much that water costs—you can begin to formulate a plan of action to implement water conservation measures.

As you begin to prepare your conservation plan, determine which equipment and fixtures will produce the most cost-effective water savings while maintaining or improving production quality and water services to employees, occupants, and customers. Keep in mind that your most cost-effective water conservation activities will typically be in areas which use the most "expensive" water (i.e., water that requires the most pre-use treatment, heating or cooling, and predisposal treatment).

Evaluate each possible water conserving measure by using these guidelines:

— potential annual water savings (water costs only)

— potential annual savings from reduced water processing

— implementation costs (annualized)

— ongoing operational costs (if any)

— time required for implementation

— payback period (the time required for the cost of the conservation measure to be paid for by water cost savings)

Also keep in mind that water rates are likely to increase in the future. With increasing water rates, it may be cost effective to implement some water conservation measures now to ensure future savings.

After you've estimated the cost and potential payback for your major water conservation options, you can begin the process of classifying potential actions. You may find it valuable to use the following categories:

1. *Cost Effective and Practical*—
   Water-saving measures that should be enacted as soon as possible.

2. *Potentially Viable*—
   Measures that need further evaluation. Additional data may need to be collected during a testing period.

3. *Not Recommended*—
   Based upon current information, these measures are not currently cost effective. However, they could be implemented as a response to drought conditions or as cost/benefit ratios change.

Where to Look for Water Savings

Most water conservation measures fall into four broad areas:

1. Domestic plumbing fixtures
2. Cooling and heating
3. Landscape irrigation
4. Processing of materials

Your plan of action should examine each of these areas. Review all equipment and water-using devices for possible water-efficiency improvements. In some cases, water-using equipment can be replaced. In other cases, retrofitting existing equipment will be a better solution.

Procedural changes can often result in substantial water savings.
For example, some companies have found that discharge water from rinse tanks can be rerouted for use in nearby cooling towers.

NOTE: Your organization's water conservation measures must meet all regulatory and public health requirements. Check with applicable municipal, state, and federal agencies.

Dollars and Sense

Cost-effective water conservation measures pay for themselves in reduced utility and energy bills. Bottom-line savings may be the most obvious way to justify enacting changes that conserve water, but there are additional reasons to make water-wise changes that make sense and provide benefits:

1. *High visibility*—
   Measures that will communicate your organization's commitment to water conservation in a very "public" way can help your organization's public image.

2. *Ease of implementation*—
   Water conservation measures that can quickly be enacted, even those with longer payback periods, are a good way to show that your organization is serious about saving New Mexico's most precious natural resource.

3. *Employee/customer goodwill*—
   Enacting water conservation measures suggested by your employees, customers, or the public is also a good way to generate goodwill and positive employee/public relations.

ACTION PLAN CHECKLIST

An Action Plan should typically contain:

1. A statement of the organization's commitment to water conservation.

2. The organization's water conservation goals, including the time frame for realizing the goals.

3. Alist of the water conserva tion actions that will be taken, prioritized by effectiveness and implementation cost. Include the anticipated implementation dates.

4. Recommendations for additional (future) measures for consideration, including process changes and new water-saving equipment.

5. Funding sources for specific measures that will require capital expenditures. Indicate whether loans or rebates are available from water utilities.

6. Review and evaluation process. Schedule follow-up water audits of specific areas (especially high water-use areas) and report on water conservation results.

Sample Payback Period Calculation

COOLING TOWER IMPROVEMENTS

Specifications:
250 tons of refrigeration capacity, operating 150 days per year. Current efficiency is 3.0 cycles of concentration before water is flushed from system.

Proposed Conservation Action:
Add conductivity controller and pH controller. Treat water with chemicals to increase cycles to 5.0.

Water Consumption (Before Improvements):
22,000 gpd for 150 days/year = 3.3 million gal/year

Water Consumption (After Improvements):
18,000 gpd for 150 days/yr = 2.7 million gal/year

Annual Water Savings:
600,000 gallons/year

Cost Savings:

Water & Sewer	$2,200
Chemicals	$1,900
TOTAL:	$4,100

Capital Cost of Improvements:
$5,500

Payback Period (in years) = Capital Cost ($) / Net Annual Savings ($)

$5,500 / $4,100 = 1.34 years

(sample for illustrative purposes)

EMPLOYEE EDUCATION AND PARTICIPATION

Employees can have a major affect on the success (or failure) of a water conservation program. Therefore, it is imperative that they be informed about the program and made an integral part of all water reduction efforts. The following steps can serve as a guideline for effectively informing employees of the program and enlisting their full support and participation on an ongoing basis.

1. Distribute a letter to all employees from the leader of the organization. The letter should announce the conservation program, introduce the Water Conservation Manager, detail specific goals, ask for employee support, and invite feedback.

2. Establish an employee water education program. The education program should communicate information about:

— the importance of and need for water conservation in New Mexico
— the company's water conservation program, including specific goals
— the importance of each individual's contribution to the success of the water conservation goals of the entire organization
— how specific water savings measures by individuals can reduce consumption
— how specific water savings measures by employees working together as a "team" can result in major water use reductions
— new procedures and water conservation equipment

3. Use a wide variety of methods to communicate the ongoing water conservation message. Utilizing many communications media will help to keep the message current, and it will reinforce the importance of the organization's water conservation efforts. Consider using the following communications vehicles:

— company newsletter
— memos
— paycheck stuffers
— email
— posters and signs
— water conservation "progress reports"
— new and/or revised operating guides and manuals that describe changes made to implement water-saving measures

4. Establish a schedule for regular communication with employees about water conservation. Even with the best of intentions, the initial excitement of a new program will begin to fade unless the importance of water conservation is regularly communicated. Make sure that employees are kept abreast of the specific water reduction measures that have been enacted and the water and energy saved by these measures.

5. Get employees involved.

— Establish incentive programs to encourage and reward participation.
(One option: offer employees a percentage of the first year's direct savings from water and energy conservation.)
— Create a "Water Conservation Ideas Box" where employees can submit suggestions on how the organization can save water.
— Promote slogan and poster contests.
— Create friendly "team" competition between shifts, operating areas, divisions, and/or locations.
— Reward employees with a "pizza party" or similar celebration when water goals are met.
— Reward employees who spot leaks and other instances of water waste.

6. Implement effective new ideas submitted by employees. Recognize and reward the contributions made by individual employees, groups, and the organization as a whole.

BEGIN WITH CERTAIN SAVINGS

Now it's time to begin to implement your water conservation plan. The best place to start is with the most obvious ways to save water.

Leak Detection and Repair
Using the information in your water audit, locate and fix leaky faucets, faulty fittings, and broken pipes and hoses. New water pipes and fittings are generally water tight when they are first installed. However, as pipes settle, some joints can become partially opened, which can cause leaks. Leakage tends to increase due to pipe corrosion and deterioration of joint compounds. Faucets can also develop water-wasting leaks from compacted washers and faulty handles.

A systematic program of leak detection and repair can prevent future water waste. On a regular basis, thoroughly check the following areas:

— restrooms and shower facilities (in tank-type toilets, conduct dye tests to locate hidden leaks)
— kitchens, dishwashing facilities and food-preparation areas
— washdown areas and janitor closets
— water fountains
— water lines and water delivery devices
— process plumbing, including tank overflow valves
— landscape irrigation systems

NOTE: Shut off water supply and check meter readings. If the meters continue to advance, you could have underground leaks.

No-Cost Adjustments
Check your water audit for any changes that can be made quickly and at no cost—and make these modifications as soon a possible. Here are a few suggestions:

— Close down restrooms and other potential water-using areas that are not being used.
— Recalibrate machinery and water flows to perform to the manufacturers' original specifications.
— Eliminate water usage if an alternative exists. (i.e., stop hosing down sidewalks, use a broom instead)
— Decrease frequency of vehicle washing (unless you recycle the water).
— Keep lines of communication open with employees and water users, and implement their suggestions whenever appropriate.

Installing Timers
In areas where water use is periodic, consider installing timers to automatically shut off water flow when water is not required. For example, timers could be installed on process equipment to automatically shut off water flow at the end of a production cycle and/or the end of a work shift.

Use of Cold Water
For many uses, particularly hand washing, thousands of gallons of water can be wasted every year when employees let lavatory water run while waiting for hot water. Where feasible:

— Convert restroom sinks to cold water only.
— Post signs informing users that only cold water is available.

NOTE: This would not be applicable in facilities that are required to provide hot water for health reasons.

Efficient Landscape Watering
Even before you begin a major retrofit or redesign of your irrigation system, you can make sure that it is not wasting water.

— Adjust sprinkler heads to ensure that landscape plants are being watered, not pavement.
— Water during the early morning hours to reduce evaporation.
— Install rain/moisture sensors to turn the irrigation system off when rainfall occurs.
— Manually adjust irrigation timers to eliminate unnecessary watering after rainfall (if system has no rain sensors).
— Use hose nozzles that automatically shut off when not in use.

LOCATE AREAS OF MAJOR WATER SAVINGS

After the most obvious, lowest-cost, and "easiest" water-savings procedures have been implemented, the next logical step is to begin to implement the long-term measures that will result in the greatest water savings. These measures may include replacing outdated equipment, making modifications to existing equipment, establishing more efficient operational procedures, and exploring new procedures that will use significantly less water without negatively impacting production and/or service quality or quantity.

Many of the long-term conservation measures require time, effort, and additional expense to implement. However, after the initial payback period, these measures will result in cost savings every year. As utility rates for water, energy, and wastewater disposal increase, the annual conservation savings also increase.

The following approaches can be applied to water usage at virtually any site. Use these areas of focus, along with your facility's specific water conservation plan, to begin to generate significant long-term water reductions.

Install Meters and Controls

As you discovered during your facility's water audit, the first step in water conservation is knowing how much water is being used—and where. Meters can determine current water use and monitor any subsequent changes in consumption. Other controls and switches can ensure that the water supply is shut off when appropriate.

- — Install water meters wherever water use is not currently being measured.
- — Install "submeters" to measure water use by subprocesses and specific pieces of equipment.
- — Install interlock solenoid valves with power switches or time clocks to shut off water flow when equipment is not in use.
- — Install temperature control valves.
- — Install limit switches on tanks to eliminate over-filling.

As part of your ongoing water monitoring process, regularly inspect all meters, controls, valves and other devices for leaks and improper settings.

Adjust Metered Flow

Sometimes equipment is operated with higher water flows than necessary. Where input water flow to equipment is higher than manufacturer specifications, reduce water flow to match manufacturer's recommendations.

- — Install flow restrictors to ensure a constant, specified flow throughout a range of water pressures.
- — Once metered flow has been reduced to manufacturer specifications, carefully experiment with slightly reduced flow rates to further improve water efficiency.

(Record flow rates before and after changes to evaluate the effects of using less water on production quality.)

Reduce Water Pressure

Water pressure higher than that required for specific applications will unnecessarily result in increased water consumption.

- — Survey the water pressure at specific points and through specific lines at your site.
- — Contact your local water utility for assistance in measuring the water pressure in pounds per square inch (psi) at key delivery and usage points at your facility.

Excessive water pressure will also increase leakage rates. For example, an increase in water pressure from 25 psi to 45 psi can be expected to increase water use (and water lost to leakage) by 30% (AWWA, 1986).

LOCATE AREAS OF MAJOR WATER SAVINGS
(CONT.)

Reuse and Recirculate
Whenever possible, use water more than once. High-quality water, not seriously affected by one process, can typically be used in another process to achieve direct and immediate water savings.

— Water used for heat transfer—heating and cooling water that is otherwise unchanged and not chemically altered—can be pumped into holding tanks and used in another process.

— Water used for rinsing can often be reused in applications that do not require high-quality water. For example, spent rinse water can often be reused in other rinsing applications or in cooling towers.

— Water can be reused sequentially. Examine your facility for processes where water can be used in one process, then pumped to another process location for reuse. (Treatment may be required between processes to maintain minimum water quality.)

— "High value" or "high quality" water, such as deionized water, can be treated and reused.

Water that is chemically altered in its use, such as rinsing and cleaning water, may also be reused. In some cases, the initial rinse water is highly contaminated and must be discarded. However, subsequent rinse water that is minimally contaminated can be reused for further rinsing or for other uses.

NOTE: To ensure that all water quality specifications are met, test the quality of all water before it is reused, and treat wastewater (if necessary).

Switch from Potable to Nonpotable
Many water use applications do not require potable (drinking quality) water. When pure water is not required, consider switching to alternate water sources including:

— reclaimed municipal water
— treated process water (onsite)
— treated process water (offsite)
— collected rainwater (particularly for landscape irrigation)

PUBLICIZE YOUR SUCCESS

In addition to saving water, energy and money, there is an additional benefit to conservation: positive public opinion. Because New Mexico is an arid state, water conservation is of ongoing public interest. News media throughout the state routinely cover "good news" stories about companies, institutions, and industrial facilities that take a proactive stand on water conservation.

Internal Communication
Keep your employees informed about your commitment to water conservation, your ongoing conservation program, and your water conservation successes. Reinforce the message that they are helping your organization reach its water conservation goals. Congratulate them for their efforts and ask for their continued support and action. (For more information see the "Employee Education and Participation" section on page 25.)

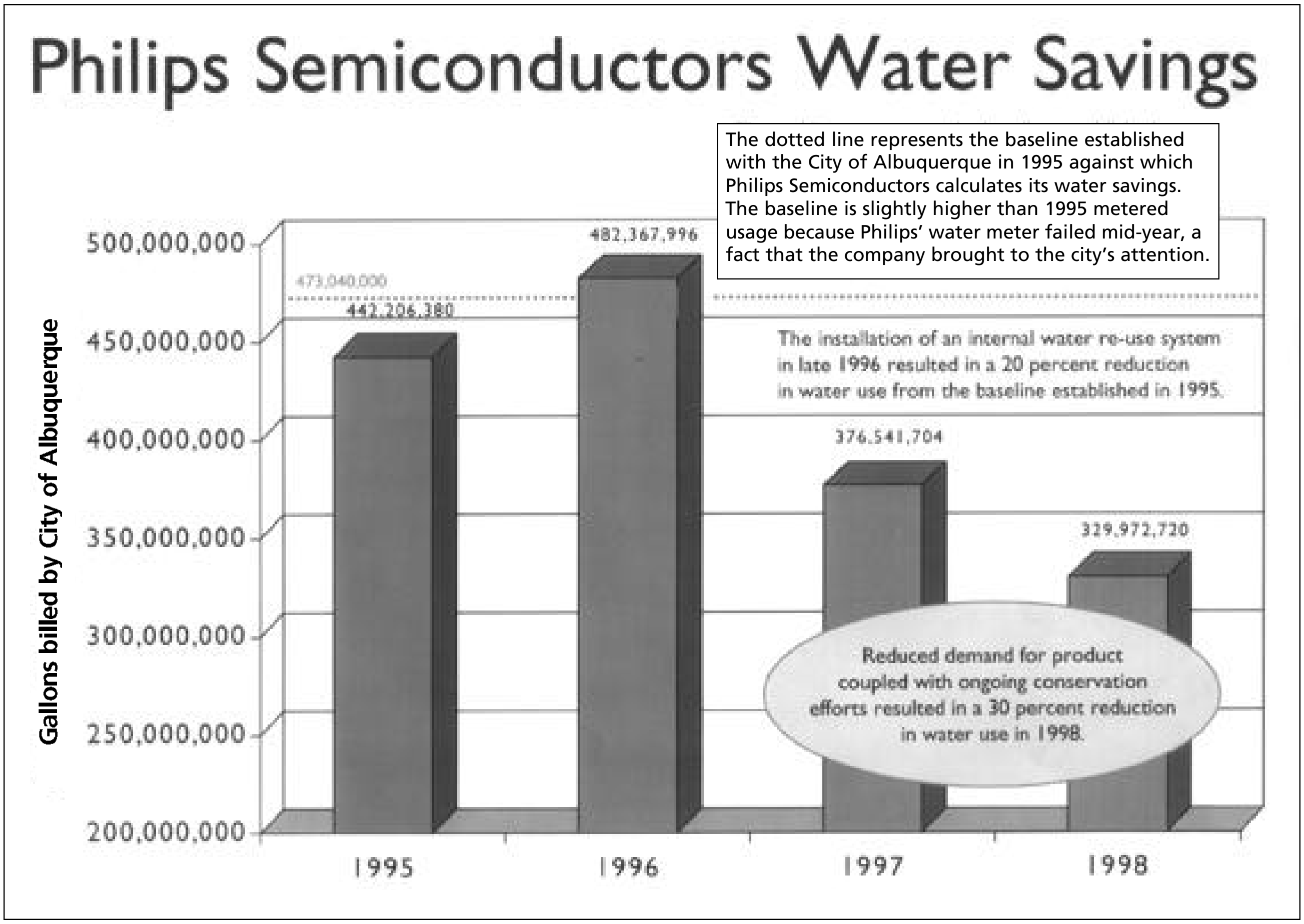
Intel published a brochure to answer questions about its water use and water conservation efforts in New Mexico.

External Communication
Conducting a public information campaign can help create a positive public image of your facility and organization. Tell the public about your commitment to wise water use!

The following activities can serve as a guide to "spread the word" about your successful water conservation program:

— Invite members of the local news media to a news conference at your site to announce the inauguration of your water conservation program.
— Invite members of the local news media to tour your facility to see first-hand the conservation measures that you've enacted.
— As conservation goals are reached, send news releases to local and trade media. These news releases should detail the specific water conservation measures enacted and the number of gallons (or percentage of water) saved annually.
— Participate in water conservation advisory committees sponsored by local utilities or state and federal agencies.
— Attend workshops and seminars, and share your organization's water conservation strategies and successes.
— Create displays presenting your water conservation results for posting in your lobby and other public reception areas.
— Distribute water conservation materials to local schools and organizations. (Tell the media in advance of any public appearance to be made by an organizational representative.)
— Develop printed brochures and materials for distribution at trade shows and other public forums.
— Serve as a "water conservation mentor" for other organizations or facilities.
— Sponsor water conservation events for the public. Consider hosting a Water Fair at your facility.
— Contact local radio and television talk shows to offer an organization leader or representative as a guest "expert."
— Phone local reporters to keep them abreast of your ongoing successes.

The news media and the public deserve to know about an organization that is a socially responsible member of the community. Your water conservation program is good news, because every gallon of water your organization saves means more water is available to help improve the quality of life in your community— for today's residents and for future generations.



<u>*Figure 2-5*</u>
Results of the Philips Semiconductors Water Conservation Program

Section 3: Water Conservation Guidelines for Indoor/Domestic Use

In commercial and institutional settings, indoor/domestic activities can account for the largest amount of water use. In office buildings, for example, estimates for restroom and kitchen water use range from 41% to 80% of total water use (Denver Water; Department of Water Resources, State of California, p. 40). Table 3-1 shows the percentage of water that is typically used in restrooms, kitchens, and laundries at selected commercial and institutional facilities.

Table 3-1

DOMESTIC WATER USE AT VARIOUS FACILITIES

Facility	Restrooms	Kitchens	Laundry
Hotel	30%	25%	20%
Restaurant	15%	60%	N/A
Hospital	40%	8%	10%
School	45%	10%	N/A

Source: City of San Jose

There are three primary approaches to saving water indoors:

1. **hardware solutions**, such as replacing a high-flow fixture with a water-efficient version
2. **operational solutions**, such as finding alternatives to using water for cleaning tasks, instituting a regular leak inspection and repair program, and optimizing the water efficiency of appliances
3. **personnel solutions**, such as educating employees to conserve water and to report leaks.

Clearly, not all solutions will fit every situation. Conservation actions at hospitals and convalescent homes, for instance, may be limited by health concerns. Before implementation, make sure the water conservation measures are consistent with health department regulations.

On the other hand, some water conservation steps are mandated by law. The National Energy Policy Act of 1992 stipulates that toilets and other plumbing fixtures manufactured after January 1, 1994 meet low-water-use standards (see Table 3-2). Your city or municipality may have similar, perhaps even more restrictive, requirements. The City of Santa Fe, for example, requires that low-use fixtures be used in all remodeling and construction. Santa Fe also stipulates that water conservation signs be posted in public restrooms.

Some of the water conservation measures discussed below are inexpensive, yet they can have tremendous potential paybacks. For example, instituting a monthly water audit, conducting weekly leak detection surveys, or serving water only upon request in a restaurant can make significant contributions to water conservation. Also, do not forget that reducing water use often leads to additional cost savings in energy, maintenance, and consumable chemicals. When looking for ways to save money, be sure to ask your city or water utility if it offers rebate programs on plumbing fixtures and/or free audits. (NOTE: Use the worksheet on page 43 to compute the cost savings of proposed indoor/domestic water conservation changes.)

One conservation idea that is often overlooked is the installation of a pressure-reducing valve on the domestic water supply line. High water pressure can waste water and damage plumbing, which is why the Uniform Plumbing Code requires a pressure-reducing valve when the main pressure exceeds 80 pounds per square inch (psi). Reducing pressure further, to 60 psi, will further reduce water use. In fact, most plumbing systems perform adequately at pressures as low as 40 psi. (Arizona Municipal Water Users Association, 1997, p. 39.)

RESTROOMS/SHOWER FACILITIES

Most toilets, urinals, showerheads and faucets in use today were designed with little regard to water conservation. These devices are responsible for much of the domestic water needlessly washed down the drain. As noted previously, Table 3-2 shows the degree to which plumbing fixtures have become more water efficient over the last decade and gives an idea of the considerable water savings that can be achieved in restrooms and showers. Table 3-3 lists the approximate costs of these water efficient fixtures. In some cases, saving water may be as simple and inexpensive as adding a $2.00 aerator to a faucet.

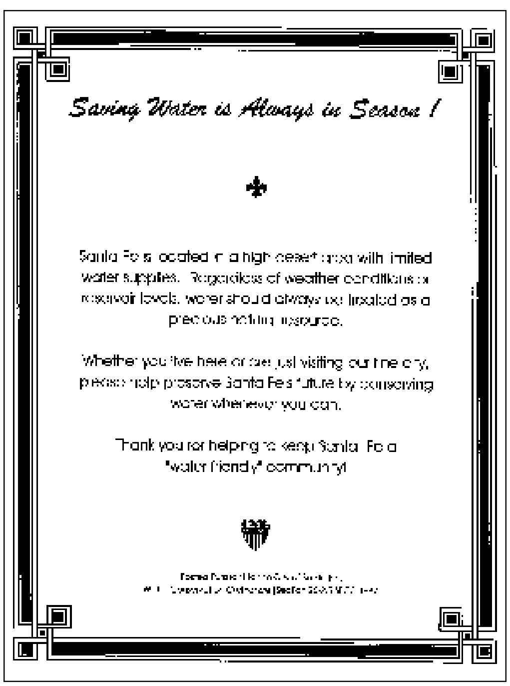
Table 3-2

*FLOW RATE COMPARISONS: CONVENTIONAL FIXTURES VS. FEDERALLY MANDATED STANDARDS FOR NEW FIXTURES IN COMMERCIAL FACILITIES**

(Units are gallons per flush (gpf) or gallons per minute (gpm)

	Federal Standards	**Conventional Models**
Toilets (all types)	1.6 gpf	3.5 to 7 gpf
Urinals	1.0 gpf	2 to 3 gpf
Lavatory Faucets	2.5 gpm	3 to 5 gpm
Kitchen Faucets	2.5 gpm	3 to 5 gpm
Metering faucets	0.25 gallons per one-time use	n/a
Lavatory and kitchen replacement aerators	2.5 gpm	n/a
Showerheads	2.5 gpm	5 to 7 gpm

** mandated by the National Energy Policy Act of 1992*



The City of Santa Fe's Water Conservation Ordinance requires hotels and motels to post water conservation messages in every guest room.

Table 3-3

APPROXIMATE COSTS OF LOW-FLOW PLUMBING FIXTURES AND RETROFITS

FIXTURE	COST RANGE
Kitchen faucet 2.0, 2.2, 2.5 gpm	$40-$260
Lavatory faucet 2.0, 2.2, 2.5 gpm	$25-$170
Lavatory faucet (metering type)	$120-$210
Showerhead 2.0, 2.2, 2.5 gpm	$15-50
ULF toilet	$80-$600
Urinal flush valve	$100 and up
Urinal fixture	$100-$350
Infrared faucet control (or ultrasonic) and faucet	$300 and up
Infrared toilet/urinal control	$250 and up
Toilet tank displacement device (bag)	$3-$5
Toilet tank dam	$7 for a pair
Toilet insert device	$3-5
Toilet valve replacement device	$15-$20
Toilet early closure device	$5-13
Faucet flow restrictor	$5-7
Faucet aerator 2.0, 2.2, 2.5 gpm	$2-$10

Toilets and Urinals

Americans flush nearly 4.8 billion gallons of water down the toilet each day. In many buildings, toilets are responsible for one-third of the water use (U.S. General Services Administration, p. 3-6), so they make an attractive target for conservation. There are several low-cost retrofits available, and you may find that replacing older toilets with newer models has a reasonable payback period of a few years compared to the 20-year life of the commode (ibid, p. 3-6). If the toilets in your facility were installed before the 1970s, they probably consume between 5 and 7 gallons per flush (gpf). By the 1980s, "water-conserving" 3.5 gpf models were available. As of January 1, 1994, the federally mandated standard became ultra-low-flush (ULF) 1.6 gpf. The first ultra-low-flow toilets experienced several flushing-related problems; newer models address these difficulties by having steeper sides and an exposed trapway, which increases the velocity of the flush and eliminates the need for double flushing.

Two kinds of toilets are common: gravity tank and flushometer. In gravity-fed tank toilets (the type usually found in homes), the flow of water down from the tank creates a siphon action which carries waste from the bowl to the soil pipe. In a flushometer toilet, the flush valve (also known as the flushometer) opens to a pressurized water supply pipe, from which a measured amount of water is released, forcing wastes into the sewer system. Many institutions and large facilities utilize this latter type of toilet.

There are also several types of urinals. One common type is the siphonic jet urinal, in which an elevated flush tank provides enough force to flush out foreign matter such as cigarette butts and gum wrappers. These urinals operate through the use of a siphon device, which automatically discharges the tank's contents when the water level in the tank reaches a certain height, thereby periodically rinsing the urinal without the need for user assistance. This makes siphonic jet urinals more sanitary than other urinals, but it also means they consume more water than washdown or washout urinals, which must be activated by the user.

To reduce water use in commodes, consider these options:

- Keep toilets in good working order. Periodically inspect and replace valves and ballcocks in tank toilets. (Flapper valves are prone to deterioration, which can cause toilets to leak and thereby waste water.) Inspect diaphragms or other worn parts in flush valve toilets, and inspect the pin hole and rubber diaphragm in siphonic jet urinals.

- Test for leaks. A federal study once estimated one in five toilets leaks, (Schultz, 1996, p. 19) and leaks may account for up to 20 percent of a toilet's water use (Wilson, 1996, p. 8). Dye-test all tank type toilets for "silent leaks" every six months by putting a dye tablet or several drops of food coloring in the tank. Do not flush. Wait 10 minutes to see if any of the dye has leaked into the bowl. Deteriorated flapper valves are a common source of leaks; they are inexpensive and easy to replace. Also make sure that the chain connected to the valve is not so long that it can become lodged under the valve.

- Adjust flush valve. Ideally, the valve should be adjusted to use as little water as possible per flush without impeding waste removal or violating the manufacturer's recommendations. In general, though, valve adjustment is not as effective as retrofitting. In urinals, existing flushometer valves can be fitted with hardware that reduces water consumption in the valve.

- Retrofit tank-type toilets by:

— installing a commercial displacement device in the tank, which enables the toilet to flush using about 0.75 gpf less water. One popular type of displacement device is a toilet tank dam, which consists of flexible sheets of metal or plastic that prohibit some water in the tank from flushing, saving about 0.5-1.0 gpf. NOTE: Before installing any tank device, make sure it is compatible with the specific toilet.

— replacing or amending the flush valve in the tank with an early closure device that uses less water while maintaining the original pressure and flush force. These devices, which must be installed by a plumber, reduce consumption by 1.0-2.0 gpf.

— installing a dual-flush adapter, which saves as much as 0.6-1.2 gpf by using two different flushes, one for solid waste and the other for liquids and paper. (NOTE: Signs must be posted to instruct users how to operate toilets retrofitted with these devices.)

• Retrofit flush valve toilets by:

— installing an insert or valve replacement device to reduce flush volumes by 1.0 gpf. Some of these devices consist of plastic orifices perforated with holes in a "wheel and spoke" pattern, while others actually replace existing valve mechanisms

— replacing or amending the existing valve with an early closure device to save 1.0-2.0 gpf (see tank toilet retrofits above)

— installing a dual-flush adapter (see tank toilet retrofits above)

— adding an infrared or ultrasonic motion sensor to control flushing. Besides eliminating double flushing, these devices help prevent the spread of disease and are more easily used by individuals with disabilities.

• Retrofit urinals by:

— installing timers to shut them off when the building is not occupied (not necessary for washdown or washout urinals)

— installing infrared or ultrasonic sensors to control flushing (see flush valve toilets)

• Replace old toilets with ultra-low-flush (ULF) toilets and urinals. Replacing 5.0 gpf toilets with ULF 1.6 gpf models may save your facility hundreds of thousands of gallons of water a year. (See Table 3-4.) Manufacturers now offer ULF toilets in the $80-$300 range, comparable in price to conventional models. Check with your utility or city for toilet rebate programs.

• Install a waterless (no-flush) urinal. Made of a urine-repellant material, a waterless urinal has no handles, sensors or moving parts. A trap made of an immiscible liquid floating on top of a urine layer blocks sewer gases and urine odors from escaping into the bathroom. Replacing a 2.0 gpf urinal with a waterless variety in a typical office building can save 44,000 gallons per year (assuming urinal was used 200 times a day for 220 days per year).

COMMODE USE PER CAPITA

How many flushes a day should you assume in calculating how much water toilets flush down the drain? For the nation as a whole, 6 flushes per capita per day is a reasonable assumption (Wilson, 1996, p. 8). For work day alone, one source estimates commode use per capita as follows: Women flush toilets 4 times a day on average and run faucets for 2 minutes; men flush toilets once a day, use urinals 3 times a day and run the faucet for 1.2 minutes; janitors flush toilets and urinals once each and run the faucet for 30 seconds.

(Source: Darell Rogers, Sandia National Laboratories)

Table 3-4

WATER SAVINGS EXAMPLES: REPLACING 5.0 GPF TOILETS WITH 1.6 GPF MODELS

	# of Toilets	# flushes per day per toilet	# days used per year	Water savings per toilet flush (gpf)	Total annual gallons saved
Restaurant	6	20	365	3.4	148,920
Manufacturer	10	20	300	3.4	204,000
Office Building	25	20	260	3.4	442,000
School	30	20	200	3.4	408,000
Hospital	60	6	300	3.4	367,200
Hotel	70	5	300	3.4	357,000

Source: Based on City of San Jose examples

Faucets

To save water, try a number of easy, low-cost modifications to conventional faucets. Another option: replace old fixtures with newer faucets that control the length of time water can run and prevent water flow when not in use.

- Check frequently for leaks. A faucet leaking one drip per second wastes about 36 gallons a day (U.S. General Services Administration, p 3-21).

- Modify conventional faucets:

— **Install an aerator.** Attached to the faucet head, an aerator reduces water use by adding air to the water stream. Many faucets with aerators consume as little as 1.0 gpm. This low-cost option is attractive when the entire faucet does not need to be replaced.

— **Adjust flow valve** to reduce water flow.

— **Add a flow restrictor**, a washer-like disk that installs in the faucet head, which reduces maximum flow to 0.5-2.5 gpm.

- Replace existing faucets with water-conserving faucets (especially if the existing faucets need to be replaced due to wear and tear). The following types of water-conserving faucets are available:

— **metered valve faucet—** delivers a preset amount of water before shutting off

— **self-closing faucet—** features a spring-loaded knob that automatically shuts off the water when the user releases the knob.

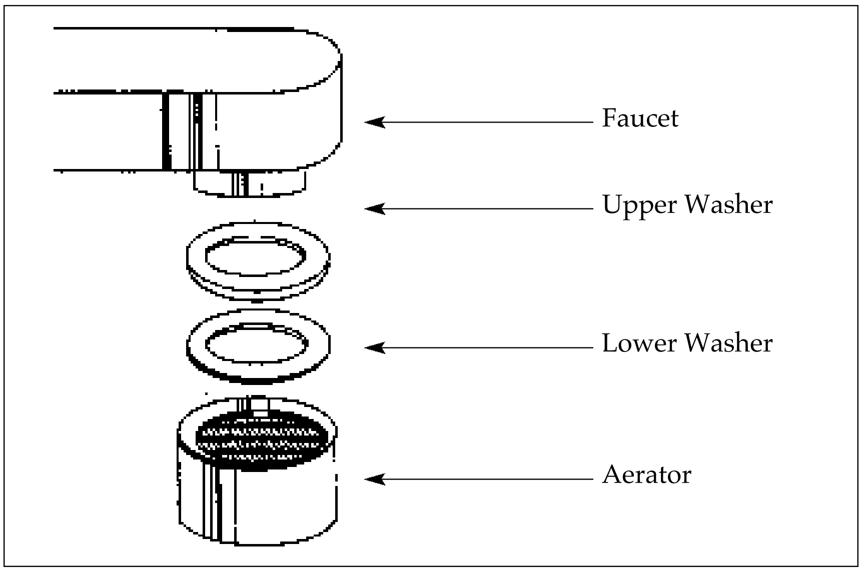
— **infrared and ultrasonic sensor faucets—** are activated when the user's hands are placed beneath the faucet; they shut off the water flow when the user's hands are removed from underneath the faucet. An added advantage of this system is that it minimizes the spread of disease and helps people with disabilities.

Showers

Ordinary showerheads typically use from 5-7 gallons of water per minute, which means a 5-minute shower will use 25-35 gallons. To save water:

- Retrofit showers with new water-conserving showerheads or aerators to reduce use to 2.5 gpm or less.

- If showers are connected (i.e., not operated individually), install individual control valves on each one.



KITCHENS, CAFETERIAS, & STAFFROOMS

Kitchens are a choice target for water conservation because they contain many high-water-use appliances—from dishwashers and garbage disposers to ice makers and frozen yogurt machines. Here is a menu of conservation ideas:

Dishwashing Machines

- Check your dishwasher to ensure that it is not using more water than is specified by the manufacturer. Most commercial machines require from 2.8 to 8.0 gpm to both clean and sanitize. (Black & Veatch, 1993, p. 11.) Consider installing pressure or flow regulators to limit water flow to the manufacturer's specification.

- At prewashing stations, which are used to dislodge large food particles, reduce water flow to the minimum required. Manual pre-wash units, which shut off when the operator lets go of the nozzle, are the most water efficient, using between 1.8 and 2.5 gpm instead of the 4.5 gpm of conventional sprays. Make sure the nozzle is accurately directing rinse water. For automatic prewashers, which typically use between 3.0 and 6.0 gpm, conservation options include installing low-flow, high-pressure spray heads or a flow reduction valve in the water supply line. Check prewashing fixtures frequently for leaks since they tend to receive a lot of rough handling.

- Run only full loads in rack-type dishwashers.

- For conveyor-type machines, make sure that water flows only when dishes are present. Some machines are designed to dispense water if the conveyor moves, whether it is carrying dishes or not. If this is a problem, install an "electronic eye" sensor system, which will turn on water only when dishes are moving on the conveyor belt.

- Recycle final rinse water to be used in the next dishwasher load or prewash load, or for use in the garbage disposer.

- Channel dishwasher wastewater to the garbage disposer and food scrapping troughs.

- Consider replacing the scrapping trough system, which typically relies on a 3-5 gpm flow of water to wash garbage to the garbage disposer. Instead, install a conveyor system that uses no water. If this is not cost effective, use the scrapper system only when needed (or eliminate the system altogether because it is not necessary to dispose of food waste to the sewer system).

Garbage Disposers

Commercial disposers use 5-8 gpm, or even more if connected to a scrapping trough. Since food waste does not have to be discharged to the sewer system, many commercial and institutional facilities have eliminated these high-maintenance fixtures altogether. Instead, they use a garbage strainer, which requires far less water, about 2 gpm. Food waste accumulates in a strainer basket as a recirculating stream of water passes through, washing out the soluble material and small particles to the sewer. The remaining waste is dumped in the garbage.

If replacement with a strainer is not possible, consider the following:

- Make sure the flow of water to the disposer is controlled by a solenoid valve, which automatically closes when the disposer motor turns off. Check that the valve is working properly. Keep in mind that many disposers have two water supply lines, one to the bowl and one to the grinding chamber.

- If the unit is set to operate for a preset duration every time the disposer is turned on, reduce the run time to the minimum necessary.

- Determine from the manufacturer the minimum acceptable water flow rate and adjust the disposer accordingly. Install flow regulators to avoid excess flow due to high water pressure.

- Recycle. Use dishwasher or other wastewater in the disposal.

Ice-Making Machines

Icemakers use water in two ways: for cooling the machine and for freezing water into ice. A water-cooled ice machine producing 800 pounds of ice per day and running at 75% capacity will consume about 900 gallons of water a day just for cooling. That amounts to 328,500 gallons a year. As for the ice-making process itself, there is a wide range of water consumption depending on the manufacturer and type of machine.

Ice cube makers use the most water, typically 20-25 gallons to produce 100 pounds of ice cubes; but some machines use considerably more, up to 90 gallons of water per 100 pounds of ice. Machines that make ice flakes, on the other hand, consume far less, about 15-20 gallons of water to produce 100 pounds of ice. The reason for this disparity is that ice cube makers bleed off more than half of the water to remove impurities and minerals, which would cloud up the cubes. In contrast, ice flakes are not expected to be clear, so no bleed-off is required.

Here are some options aimed at reducing water use in icemaker cooling and ice production:

- Retrofit water-cooled machines. Many water-cooled units employ single pass cooling. Save water by tapping into an existing recirculating chilled water system or by cooling the machine with an existing remote air-cooled condenser. These changes are relatively inexpensive and have quick payback periods.

- Reuse spent cooling water. If retrofitting isn't possible, find other uses for the water after it has cooled the unit instead of letting it go down the drain.

- Replace water-cooled units with air-cooled versions. The typical useful life of icemakers is five years, so replacement is a near-term option. The downside of air-cooled units is that they use slightly more electricity and do not produce quite as much ice as water-cooled models.

- For ice cube makers, use softened water if available. This will reduce the amount of bleed-off needed to make clear cubes.

- Use ice flake machines instead of ice cube makers wherever possible.

- Adjust machine to dispense only the amount of ice required.

KITCHENS, CAFETERIAS, & STAFFROOMS
(CONT.)

Frozen Yogurt and Ice Cream Machines

Like ice makers, frozen yogurt and soft serve ice-cream machines can be cooled by either water or air. Water-cooled units use 2-3 gpm when they are in use, and many of these employ single-pass cooling. Consider replacing a water-cooled machine with an air-cooled model that does not require any water for condenser cooling. Alternately, retrofit the unit to be cooled by an existing chilled water system or by remote air-cooled condensers.

Additional Ideas for Kitchens, Cafeterias, and Staffrooms:

- Presoak utensils and dishes in a basin of water rather than in running water.
- Instead of using fresh water to wash down the cooking area, use water from the steam table.
- Turn off the continuous flow used to wash the drain trays of coffee/milk/soda beverage islands. Clean as needed.
- Reduce the flow to dipper wells or troughs for ice cream and butter scoops.
- Turn off food preparation faucets that are not in use. Consider installing foot triggers.
- Use the refrigerator to thaw frozen foods instead of thawing under running water. If water-thawing is required, use a low-flow stream. Do not use running water to melt ice in bar sink strainers.
- Use a water softener only where needed, such as a water heater feed line or ice cube maker. Optimize regeneration and rinse cycles for ion-exchange water softeners to minimize calcium-laden reject water or sodium-laden rinse water. Use a hardness sensor rather than a timer to control regeneration so that soft water will be produced only when it is needed. Check settings so that the flow rate and the duration of flushing cycle are correct.
- Install aerators or water-saving faucets.
- Install a hot water on-demand system at sinks if obtaining warm water requires employees to keep the water running for a long time. To avoid higher energy costs, choose a system that doesn't require that a recirculating pump run constantly.
- Serve water only on request.

LAUNDRIES

Laundries are another high-water-use area, especially for hospitals, convalescent homes, hotels and motels, diaper services, and commercial linen services. Washer-extractors are the most common type of commercial washing machine, varying in size from 25 to 400 dry pounds per load. These machines typically consume about 2.5-3.5 gallons of fresh water per dry pound of laundry. There is no internal recycling; fresh water is added for each wash and rinse cycle.

To reduce water consumption:

- Wash full loads only.

- Consult your laundry chemical supplier for laundry methods that require fewer wash and rinse steps. Changing chemicals or your washing program can eliminate several fills of the washer-extractor for wash or rinse steps. Provide laundry scales to weigh loads if none are available.

- Install a rinse water reclamation system. These computerized systems divert rinse water to a storage tank for reuse as wash water. Expect water savings of 25 percent or more.

- Reduce water use by up to 50 percent by installing a reclamation system that recycles both rinse water and wash water. Wastewater from the laundry process is treated and then reused in initial wash cycles.

- Replace your conventional washer-extractor with a continuous batch-washer ("tunnel washer"). Since batch-washers reuse rinse water from all but the first rinse, this type of washer uses only 1.0-2.0 gallons of water per dry pound of laundry— a 60 percent savings. Additional benefits include energy savings due to the recovery of heat from the load itself during rinse cycles, reduced labor costs because the system is automated, and, in some cases, reduced chemical usage.
  The disadvantages are high initial capital costs and the need for careful scheduling of loads to avoid having to reset equipment controls.

- Install coin-operated washing machines in common rooms of rental housing. In a recent study, the Multi-housing Laundry Association, a not-for-profit trade association, found that each washer in apartments used an average of 11,797 gallons of water annually versus 3,270 gallons per apartment unit served by coin-operated machines in common laundry rooms.
  (From the LaundryWise Home Page, www.laundrywise.com)

The Santa Fe Lodgers Association and the City of Santa Fe provide guest room cards that encourage guests to forego daily linen changes.

CLEANING & MAINTENANCE

Replacing a water-cooled ice-maker with an air-cooled version or installing an ultra-low-flow toilet immediately produces significant and readily observable reductions in water use. But changing the way in which your facility goes about doing myriad routine operations such as cleaning and maintenance can also add up to impressive water savings. Consider making the following changes and adjustments:

"The maintenance staff needs to understand that they are an important part of the (water conservation) program, and that they need the proper training for the program to be successful."

—Lonnie Burke
Water Conservation Coordinator,
Presbyterian Healthcare Services

- Think about how floors and other areas are cleaned. Is water necessary? Would brooms or wet wash rags work as well as hoses?

- Find alternative cleaning methods that require little or no water for washdowns.

- Switch from "wet" carpet cleaning methods, such as steam, to "dry," powder methods.

- Clean windows only when they are dirty, not on a rigid schedule.

- If it is necessary to use water (e.g., grocery store meat cutting rooms, commercial kitchens, and medical facilities), employ high-pressure, low-volume sprays (which work better than low-pressure, high volume sprays). Use portable high pressure pumps where needed to reduce the amount of water used for cleaning by up to 40 percent. When cleaning with water, stick to budgeted amounts for each job.

- Install spring-loaded valves or timers on all manually operated hoses.

- Install an on-demand water heater near sinks and other places where warm water is needed to avoid having customers and employees run water while waiting for hot water.

- Reuse reject water or process wastewater from other parts of the facility to clean areas requiring grease removal (provided this complies with health regulations).

- Inspect steam lines and traps, all plumbing fixtures, hot and cold water lines, drinking fountains, and water-using appliances routinely in order to catch problems early and to keep these devices operating optimally.

- Read water meters monthly and compare to previous years to ferret out leaks.

- Set up an easy procedure for employees to report leaks. Establish water conservation teams to search for water conservation options. Place a "Water Conservation Suggestion Box" in a conspicuous place and ask for employee suggestions. Assign an employee (or a water conservation team) to evaluate water conservation opportunities.

- Repair leaks and malfunctions promptly, not only to save water but to show employees that their reports of leaks are taken seriously.

- Shut off the water supply to equipment in areas that are not currently in use.

Table 3-5. Quantification of conserved water for indoor domestic use exclusive of evaporative cooling at commercial/institutional facilities. Note that for many facilities (such as schools, universities, and office buildings) the number of operating days per year will be less than 365.

Name and address of facility:

Building Identification:

Primary Use of Building:

	Restrooms					Kitchen			Laundry	
Item	Faucets	Shower Heads	Toilets	Urinals		Faucets	Dish Washers		Washing Machines	Total
1. Existing flowrate (gpm) or gallons per use (gpu)										
2. Proposed gpm or gpu										
3. Reduction in gpm or gpu = (1 - 2)										
4. Uses per device per day										
5. Minutes per use										
6. Operating days per year										
7. Number of devices										
8. Gallons of water conserved per year = (3 x 4 x 5 x 6 x 7)										
9. Cost of water per 1000 gallons										
10. Dollar value of water conserved per year = (8/1000 x 9)										
11. Cost of retrofit or replacement										
12. Rebate amount (if any)										
13. Net cost = (11 - 12)										
14. Payback period in years = (13 ÷ 9)										

Source: Wilson, January 1998. Procedure for Quantifying Conserved Water for Commercial/Institutional Facilities.

Table 3-6

SAMPLE SAVINGS CALCULATION: HOTEL WATER CONSERVATION

Action	Annual Water Savings		Other Savings ($/yr)	Total Savings ($/yr)	Annual Costs ($/yr)	Net Savings ($/yr)	Capital Costs ($)	Payback Period (yr)
	Gal/yr	$/yr						
Toilet Retrofit	650,000	2,470	0	2,470	0	2,470	3,700	1.5
Showerhead Retrofit	2,840,000	10,790	6,450	17,240	0	17,240	5,550	0.3
Cooling Tower Improvement	650,000	2,470	2,000	4,470	0	4,470	5,000	1.1

Source: Arizona Municipal Water Users Association. (1997). Facility Manager's Guide to Water Management.

Section 4: *Water Conservation Guidelines for Landscaping*

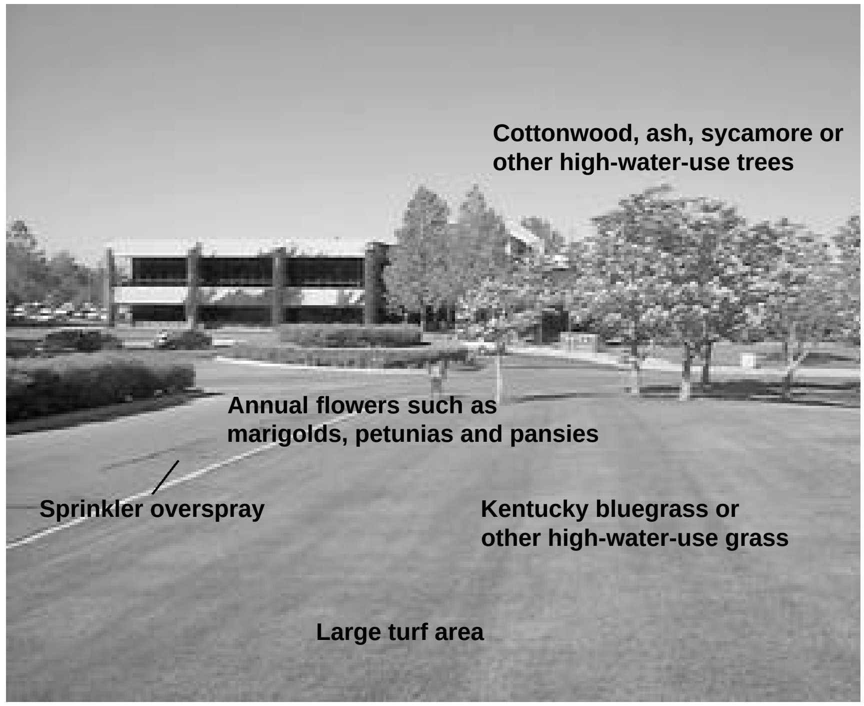
The natural landscapes of New Mexico are varied and beautiful. From the cool northern mountains to the hot deserts of the south, New Mexico's native plant life has one thing in common: the ability to survive on very little water. Although rainfall varies throughout the state, New Mexico averages less than 13 inches of annual precipitation.

Most of the plants used in traditional landscaping require supplemental water to thrive in New Mexico. For example, Kentucky bluegrass is native to regions that receive in excess of 40 inches of annual precipitation. To make up the difference between a plant's water requirements and the natural precipitation it receives, additional water must be added in the form of irrigation.

If your facility maintains any landscaping, then exterior water-use management should be an important part of your overall water conservation program. The following pages offer an overview of water-saving strategies for landscaping and other exterior applications.

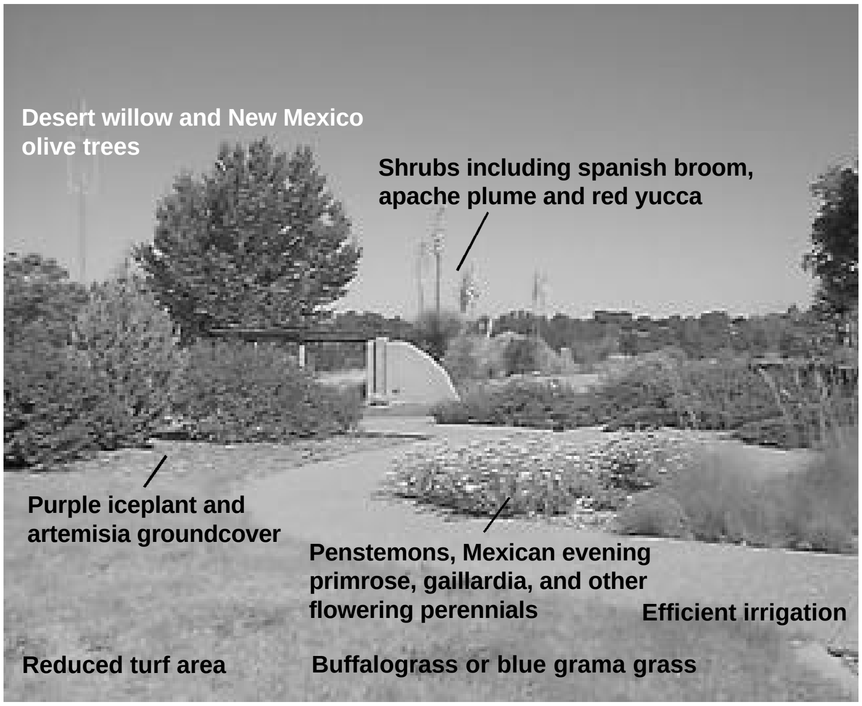
NOTE: An increasing number of municipalities in New Mexico are enacting landscape ordinances to encourage and/or require exterior water conservation. Check with your local water utility to learn whether a landscape ordinance is in effect (or is in the development stages) for your community.

A Typical "Water-thirsty" Landscape



<u>Typical supplemental water needed:</u> 25 gallons per square foot per season
The traditional Midwest-inspired landscaping is appropriate in areas which receive more than 40 inches of annual precipatation. But, in New Mexico, particularly during the hot summer months, this type of landscape requires a tremendous amount of supplemental water.

A Typical "Water-wise" Landscape



<u>Typical supplemental water needed:</u> 5-10 gallons per square foot per season
Southwestern landscaping respects our state's natural, dry environment. Using the principles of xeriscaping (water-saving landscaping with native and drought-tolerant plants), a water-wise landscape can reduce supplemental irrigation by more than 50%.

GET PROFESSIONAL HELP

A landscape architect and a landscape installation firm can be invaluable resources in the design, planning, and implementation of a new, water-wise landscape for your facility. Some firms can even provide "turn-key" services that include installing a complete water-efficient xeriscape and training on-site maintenance personnel on the proper care of plants and the use and upkeep of the irrigation system.

Water-wise landscapes use eficient drip irrigation and micro-sprayers wherever appropriate.

AN INTRODUCTION TO XERISCAPE

The term "xeriscape" is derived from the Greek word "xeros," which means dry. Xeriscape can be defined as "water-efficient landscaping appropriate to the natural environment." The goal of a xeriscape is to create a visually attractive landscape that uses plants selected for their water efficiency. Properly designed and maintained, a xeriscape can use less than one-half the water of a traditional turf-dominated landscape.

The Principles of Xeriscaping

1. Planning and Design
An efficient and beautiful xeriscape begins with proper planning and a good design. Consider the physical characteristics of the site. Where are the "micro-climates," i.e., the areas that naturally receive the most sun, rainwater run off, and shade? Also consider your organization's needs. For example, do you need a shaded patio for employee breaks and/or special events? Your plan should reflect the natural characteristics, design preferences, and goals for your landscape.

2. Soil Improvements
To enable your soil to better absorb water, you may need to add soil amendments before you plant. The water-retention abilities of most New Mexico soils is improved with the addition of organic matter. If you're landscaping with native and water-wise plants, however, soil amendments may not be necessary (unless you're dealing with heavy, hard-packed clay). For these hardy natives, just loosen the soil before you plant.

3. Appropriate Turf Areas
Reduce the area devoted to turf-grasses. Instead of using cool season grasses that need lots of supplemental water (such as Kentucky bluegrass), consider drought-tolerant grasses such as buffalograss and blue grama. Also consider replacing some turfgrass areas with water-wise groundcovers.

4. Low-Water-Use Plants
Whenever possible, select native and low-water-use plants. A delightful variety of water-wise plants can grow in all of New Mexico's climatic regions. Some add year-round greenery; others are perfect for adding seasonal color.

5. Efficient Irrigation
Awell-planned and well-maintained irrigation system can significantly reduce landscape water use. Design your landscape using the "zoning" concept to group plants together which have similar water requirements. Then design irrigation zones so low-water-use plants are drip irrigated and turf areas are watered separately from other plantings.

6. Mulching
Mulches cover and cool the soil, minimize evaporation, reduce weed growth, and slow erosion. Covering the soil with mulch (such as shredded bark or crushed rock) also provides visual interest to the landscape while offering a protective cover until plants mature.

7. Proper Maintenance
Xeriscapes are low maintenance but they are not no maintenance. Your facility's maintenance staff will still need to periodically fertilize, prune, weed, mow, and control pests. To ensure continued water savings, keep irrigation systems properly adjusted and maintained.

CREATING A WATER-WISE XERISCAPE

One of the keys to creating a successful xeriscape is planning for different areas of landscape function and use. By grouping plants of similar water needs into specific zones, landscapes can be created which are both functional and reflect the natural beauty of New Mexico.

Typically, there are three xeriscape zones:

Zone 1—Arid
The Arid Zone features the most drought-tolerant vegetation. Choose native plants and other species that require very little supplemental watering. Often land contouring can be used to direct rainwater to these xeric plants to provide virtually all the water they need.

Best Locations for Arid Zones:
— narrow strips of landscape (such as between curbs and sidewalks)
— farthest-removed areas of landscape
— hottest and sunniest areas of landscape

Zone 2—Transition
The Transition Zone features moderate-water-use plants. This intermediate zone is used to blend lush "oasis" areas with the "arid" areas of the landscape. Transition Zone plants need infrequent supplemental watering (typically once a week) after they have become established.

Best Locations for Transition Zones:
— sunny and mostly sunny areas near walkways, front entrances, etc.
— in between Arid Zones and Oasis Zones

Zone 3—Oasis
The Oasis Zone is where the highest-water-use plants are grouped, creating the lushest zone in the landscape. The Oasis Zone includes the lawn area, which is typically the landscape area that requires the most supplemental irrigation.

Best Locations for Oasis Zones:
— high-visibility, high-use areas (near employee break areas, sports and outdoor recreation areas, etc.)
— shady areas (such as the north and east sides of walls and buildings)
— anywhere water collects (where rainwater drains off a roof, at the base of a slope, etc.)

THREE GOOD REASONS TO XERISCAPE

1. Xeriscapes save water.
Using native and other drought-tolerant plants can reduce water use by more than 50%.

2. Xeriscapes save time.
Downsizing turf areas can significantly reduce the time spent mowing, fertilizing, and maintaining.

3. Xeriscapes save money.
Reducing water use and maintenance time will reduce your water bill and your maintenance costs.

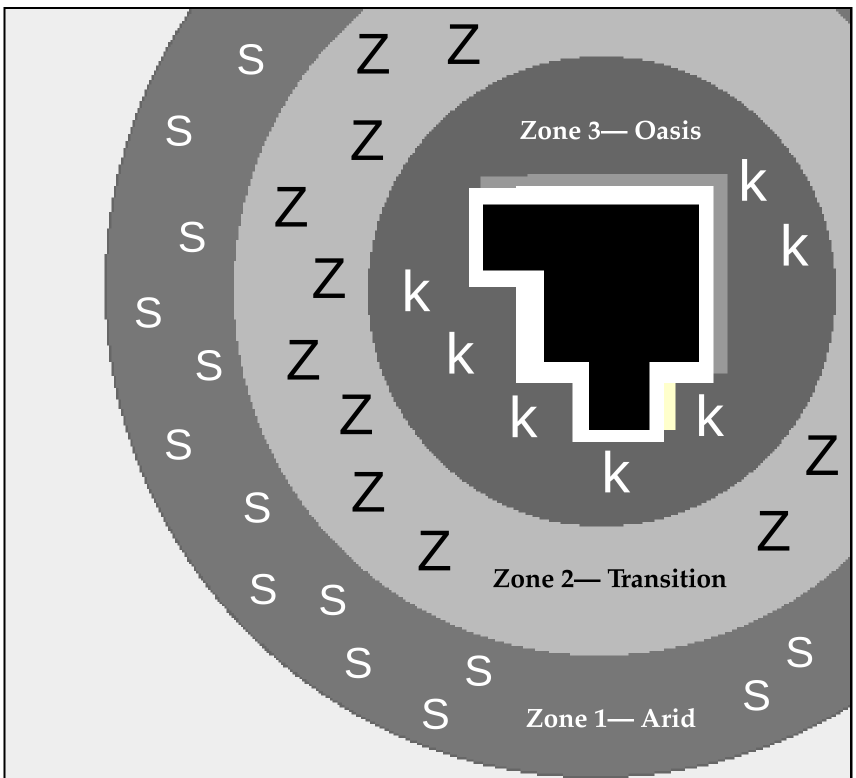


Figure 4-1: The Three Xeriscape Zones

DESIGN & OPERATION OF LANDSCAPE IRRIGATION SYSTEM

Regardless of the type of landscape at your facility, two primary guidelines of water conservation apply to landscape irrigation:

1. Apply water in the most efficient means possible.
2. Apply water only where and when it is needed.

This section of the manual reviews the basic types of irrigation systems and water-delivery devices and offers ways to conserve landscape water use.

Immediate Water Savings

The following tips and guidelines on efficient landscape irrigation can provide significant and immediate water savings:

— To minimize evaporation, water early. The best time to water during warm months is before 9:00 a.m.

— Adjust sprinklers to water landscape plants, not sidewalks, streets, and parking lots.

— Adjust sprinklers and other water-delivery devices to concentrate water at the root area of plants, not on trunks and leaves. Topical watering results in unnecessary evaporation and runoff. Also make sure that sprinkler heads are set at the proper height (as recommended by the manufacturer) to prevent them from becoming blocked by tall grass or other nearby plants.

— Refrain from watering when it's windy or raining.

— Water deeply and less frequently instead of lightly every day. Deeper watering encourages plant roots to grow deeper, which in turn will enable plants to become more drought-tolerant because they will be able to draw moisture from a larger volume of soil.

— Eliminate overwatering. Measure moisture at root level to determine when plants need water.

— If plants are being watered with a hand-held hose, attach a nozzle or sprayhead with an automatic shutoff option to avoid water waste.

— Stop using water to clean sidewalks, driveways, parking lots, tennis courts, pool decks, and other hardscapes.

Modifications That Can Provide Water Savings

The following maintenance, retrofit, and replacement options can provide additional landscape water savings:

— Select low-water-use trees, shrubs, perennials, and groundcovers instead of high-water-use turfgrass.

— Install separate valves for turf and for other types of plants (trees, shrubs, groundcovers, etc.) to ensure that each type of plant material receives only the amount of water it needs.

— Mow turfgrass higher—and never remove more than 1/3 of the turfgrass blade. Longer leaf surfaces promote deeper rooting and shade the plant's root zone, thus making the turfgrass more water-efficient.

— Don't plant turfgrass in areas less than 10 feet wide. Small turf areas are virtually impossible to water efficiently using sprinklers. For these small and uneven areas, use water-wise plants and a drip irrigation system instead.

— Carefully regulate when and how much water is delivered to each zone of the irrigation system.

— Install an irrigation timer to schedule watering times and durations. Select a timer with a manual override feature that will enable your maintenance staff to cancel a scheduled watering in the event of rain.

— Adjust watering schedules to compensate for changing seasons.

— Install a soil moisture sensor, called a soil tensiometer, to automatically test the soil moisture to determine when and how much water should be delivered.

— Inspect irrigation systems regularly. Replace or repair broken sprinkler heads, broken pipes, and other leaky, dirty, or damaged components.

— To prevent water lines from freezing, place shut-off valves in freeze-protected sites rather than running water continuously.

Sprinkler Systems

Sprinkler systems are the traditional method of irrigating turfgrass lawns. Although watering alternatives have been developed in recent years, most notably subsurface irrigation and turf bubblers, sprinklers are generally recognized as the most efficient and effective method of lawn irrigation.

In New Mexico, where cool-season turfgrass (i.e., Kentucky bluegrass and tall fescue) is definitely an "oasis" plant, lawns should be located where they can be the most visible and useful— such as near front entrances, employee break areas, and activity areas.

To maximize water conservation, replace old sprinkler heads with newer, water-efficient models— and choose the right sprinkler for the job:

— **Fixed-spray** sprinklers produce a tight, constant fan of water that is ideal for small landscape designs.
— **Pop-up** models retract when not in use, so they will not be damaged by lawn mowers or foot traffic.
— **Stream rotors** usually feature multiple rotating streams that are designed for medium-sized turf areas.
— **Impact rotors** are typically used to irrigate large turf areas such as golf courses and athletic fields.

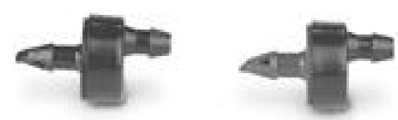
Pop-up sprinkler heads

Impact rotor

Drip Systems

Drip irrigation is the perfect method for watering most xeric (water-efficient) shrubs, perennials, and trees. Drip irrigation systems save water because they deliver slow, steady amounts of water directly to plant root zones. As a result, drip systems reduce water lost to evaporation, runoff, and overspray.

Drip emitters— Each drip emitter connects to micro-tubing and delivers water to specific plants at a slow, consistent rate, typically from one-half gallon to four gallons. A drip emitter rated at "2 gph" will deliver two gallons per hour.



Multi-emitter Hydrant— In some cases, multi-emitter hydrants can replace existing sprinkler heads when converting a turf landscape to xeriscape. The four or eight independent outlets in a multi-emitter hydrant can be fitted with emitters that deliver different amounts of water.

Multi-emitter Hydrant

Drip Systems (cont.)

Micro-tubing

Micro-tubing— The micro-tubing (typically 1/4" diameter) delivers water to individual drip emitters.

Pressure regulator— Most drip systems require less water pressure than that of a typical sprinkler system. (A typical drip system operates best at 20 pounds per square inch [psi].) A pressure regulator ensures even water distribution throughout an irrigation zone.

Filter— Drip systems require a built-in filter to keep particles in the water (such as sand and silt) from clogging the small emitters.

Filter

Irrigation System Components

(Common to Sprinkler and Drip Systems)

The following components are common to both sprinkler and drip irrigation systems:

Controller/Timer— The controller (or timer) is the "brain" of the system. It regulates the water cycles to activate the control vales at the times and days you select. Electronic controllers enable you to precisely adjust watering times, program multiple cycles, and skip cycles when it rains.

Valves— Control valves are used to turn the water on and off. Automatic valves are wired to the controller and programmed to open and close at specific times and days. Manual valves must be opened by hand to water a specific zone.

Manual Shut-off Valve— Most systems have a manual shut-off (also known as an "isolation valve") that allows you to shut off the irrigation system for service or emergency repairs.

Backflow Preventer/Anti-Siphon Valve— A backflow preventer keeps irrigation system water from being siphoned back into potable water supplies. Backflow preventers are required by ordinance in most municipalities.

Pipes— The water pipes are the "skeleton" of an irrigation system. They send water underground throughout the landscape to the water-delivery devices (sprinklers, drip emitters, etc.). Most irrigation systems use PVC pipe or polyethylene tubing.

Controller/Timer

Valves

Backflow Preventer/Anti-Siphon Valve

LANDSCAPE IRRIGATION AUDITS

The first step in the quantification of water use is a water audit. Because landscape irrigation is a distinct area of water use with unique challenges and characteristics, many facilities choose to conduct separate audits and follow-up inspections of exterior water-use systems.

Purpose

A detailed examination of how much water enters the irrigation system and where it is used will help assess current water-use practices. Amajor objective of a landscape water audit is the identification of water waste and inefficiencies that can be immediately corrected. Included in this category are leaks and broken pipes, broken or malfunctioning sprinkler heads, areas of water overspray, etc.

A thorough water audit will also reveal landscape areas that, from a water conservation perspective, require redesign or retrofitting. Also note where water use appears to be both efficient and effective (as revealed by healthy plants and no apparent water waste).

Pre-Audit Checklist

1. Consult with facility personnel who are familiar with the landscape irrigation system.
2. Compile irrigation system plans, landscape plans, and maintenance records pertaining to the facility's entire irrigation system.
3. Assemble water-use records, including utility bills and meter readings, applicable to landscape watering for the past 12-24 months.
4. Obtain a current watering schedule, listed on a zone-by-zone basis.

Procedure for Conducting a Field Audit and Test

After the appropriate information and records have been assembled, conduct a walk-through inspection of the grounds with onsite maintenance personnel and outside irrigation auditors (if any).

— Turn on each watering zone individually. Identify and inspect all water-delivery devices (sprinkler heads, bubblers, drip emitters, etc.).

— Compare your irrigation system plans and blueprints to the actual water-using equipment in each irrigation zone. Update your plans to show the actual equipment. If possible, record detailed information about each piece of equipment. (For example, record spray pattern, throw distance, and water-delivery-rate for each sprinkler head.)

— During your walk-through survey, note the location of all faucets, shut off-on valves, flush valves, solenoids, booster pumps, timers, and other irrigation system components.

— Carefully record the landscape area served by each irrigation system zone. Include the plant types contained in the zone, soil types, terrain information, and other relevant data.

— Note problem areas where water is being wasted. Also observe areas where too little water delivery is causing the plant material to die or become stressed.

— With assistance from your local water utility (if necessary), test the water pressure at several key points in each irrigation zone. Too much water pressure will result in overwatering; too little water pressure can result in dead or stressed plants.

— Test sprinkler heads to make sure they are delivering consistent amounts of water over the entire area. (This can be done by placing "catch cans" of the same size and depth in various spots in a watering zone to collect water. After 10 minutes, compare the depth of water in each can.)

— Run each irrigation zone for its prescribed watering period. Then randomly choose areas for spot checks of irrigation depth to see if the plant materials are receiving proper water for their root zones.

EFFICIENT WATERING DEPTH

8-10 inches	flowers and lawns
2 feet	groundcovers and shrubs
6-8 feet *(once a month)*	established trees

Source: City of Albuquerque

Preparing an Audit Report

After you've fully documented your facility's existing irrigation system and landscaping, prepare a complete water audit report. Include an updated schematic of all irrigation system components and corresponding plant materials. Your report should also include:

— a list of repairs needed immediately to prevent additional water waste

— retrofit options that can be done in the short term to enhance water-use efficiency (e.g., replace older model sprinkler heads with newer, more-efficient models).

— long-term recommendations for landscape water conservation (e.g., turfgrass area reductions, conversion of curbside landscaping to xeric plantings, etc.)

NOTE: For more information about how to conduct a landscape irrigation audit, see the Landscape Irrigation Auditor Training Manual published by the Irrigation Association.

After completing a landscape audit, consider contacting an outside landscape architect and/or irrigation company for additional ideas about landscape water conservation at your facility.

TRAINING LANDSCAPE MAINTENANCE PERSONNEL

As noted in Section 1 of this manual ("Eight Keys to Successful Water Management," page 12), a successful water conservation program involves two distinct areas: technical and human. The technical side involves hardware and data collection. The human side involves changing behaviors and expectations about water usage. In short, a "cultural change" is necessary to move from established operating and maintenance practices to new, water-conserving practices.

The importance of educating your facility's landscape and maintenance staff cannot be overemphasized. Maintenance workers and trades people must be informed about the technical aspects of the program. They must also be convinced of the merits of the program in order for it to be successful. Part of the education process must position the water conservation program as a tool to improve workers' job effectiveness and performance—not a way to make them look bad or eliminate jobs.

Introducing the Water Conservation Program

Before embarking upon a water conservation program—and long before installing a xeric landscape—it is important to meet with the maintenance staff to educate them on the merits of water conservation. Ideally, this initial meeting should take place prior to the Landscape Audit described above. If it is not possible to meet with all maintenance personnel prior to the audit, make sure the maintenance staff knows that maintenance/landscape supervisors and managers played an active role in the audit.

Share with the maintenance staff the primary goals of the facility's water conservation efforts, the changes that will be made to the landscape plant materials (replacing turf with native and water-wise plants, for example), and changes that will be made to the irrigation system. Enlist their support in making the plan a quantifiable success.

Elements of a Training Program

Atraining program for landscape maintenance personnel will make them more effective water conservers. A training program should include:

— **Irrigation Scheduling—** Include an overview of the water requirements of different species of plants, signs of plant stress due to overwatering and under watering, use of soil probes and soil cores to check soil moisture, best time of day to irrigate, and an overview of evapotranspiration (ET) rates.

— **Irrigation System Operation—** Include a basic overview of the irrigation system and its components, water application techniques of the components, use of automatic controllers to turn water on and off, manual override of controllers, and the landscape's watering zones.

— **Irrigation System Maintenance—** Cover how to spot problems in irrigation equipment and make the necessary repairs or replacements. Include a basic checklist for a regular walk-through inspection. (See "Irrigation System Testing and Maintenance Checklist" on page 57.)

— **Landscape Maintenance—** Cover the practices that reduce the need for irrigation water. These practices include:

- — proper height for turf mowing
- — proper frequency of turf aeration and dethatching to increase water retention
- — proper fertilization schedules to maintain plant health and drought tolerance
- — soil preparation and mulching practices to increase water retention

Irrigation Certification

Ideally, your facility's landscape maintenance manager should be trained in exterior water use management and be a certified Landscape Auditor. Landscape Auditors are certified by the Irrigation Association. For more information about the organization and its certification classes, contact the Irrigation Association at 8260 Willow Oaks Corporate Drive, Suite 120, Fairfax, VA22031; phone (703) 573-3551.

FIVE LANDSCAPE WATERING TIPS EVERY MAINTENANCE PERSON SHOULD KNOW

1. If water runoff is a problem, particularly in turf areas, use a two-step watering process. Run the sprinklers for half the needed time, wait one hour, then water for the remaining time. This approach enables the first delivery of water to be fully absorbed into the soil.

2. Inspect plants regularly (daily if possible). Plants show signs of stress when they need water. Grass will lie flat after being walked on and will lighten in color when it needs to be watered. Shrubs, perennials, and trees will often drop leaves, droop, or lose their gloss when underwatered.

3. Avoid overwatering, which not only wastes water but can cause lawn and plant disease.

4. Irrigate trees and shrubs longer and less frequently than shallow-rooted plants such as grass and flowers.

5. Remember that new plantings need more water than established plants. After plants become established, however, make sure irrigation water is reduced.

What is Evapotranspiration (ET)?

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

Note that ET, for various types of landscape plants, is normally related to a reference ET_R for a cool season grass by a coefficient (K_L). Thus ET = K_L x ET_R. While the ET_R for grass may be 0.23 inches per day (Albuquerque in July), the ET for low-water-use plants may be less than 0.12 inches per day (i.e. $K_L = 0.50$).

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

IR = ET - Re ÷ Ef

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

Field tests conducted by Sternberg (1967) suggest that evaporation and drift losses may range from 17 to 22 percent of sprinkler discharge in the daytime and 11 to 16 percent at night.

IRRIGATION SYSTEM TESTING & MAINTENANCE CHECKLIST

For peak efficiency, your facility's irrigation system staff should conduct regular inspections and make needed adjustments. Use the following checklist as a guide to routine testing and maintenance.

Monthly

— Check for leaks. Inspect water lines, sprinklers, emitters, and other components. Look for wet spots in the landscape to help locate broken pipes, leaky sprinkler heads, etc.

— Replace broken sprinkler heads, bubblers, micro-sprayers, and drip emitters immediately with identical or equivalent parts to ensure even water delivery throughout the irrigation zone.

— Locate and clean any dirty sprinkler heads, drip emitters, clogged tubing, etc.

— Use your water meter and water bills to help reveal the presence of hidden leaks.

Spring

— Set controller for watering times and durations. (Remember to adjust the timer clock for the beginning of Daylight Savings Time.)

— Replace back-up battery in controller.

— Test manual shut-off/isolation valve.

— Check the water pressure in each irrigation zone. Adjust as necessary to match the manufacturers' recommendations for the water-delivery devices in your irrigation system.

— Check and clean filters.

— Check and clean screen in sprinkler heads. Adjust pattern to eliminate water waste due to overspray.

— Test sprinkler heads to make sure they are delivering consistent amounts of water over the entire area.

— Inspect all drip emitters. Make sure emitters are applying water to the entire root zone of each plant.

Summer

— Adjust controller for watering times and durations during the hottest months.

— Check and clean filters.

— Inspect all drip emitters and clean if clogged.

— As plants grow bigger, move drip emitters to the edge of the plant's root ball to encourage additional root development.

Late Summer

— Adjust controller to shorten watering times and durations during New Mexico's rainy season.

Fall

— Adjust controller to further shorten watering times and durations as the weather cools.

— Adjust controller clock for the end of Daylight Savings Time.

— Test manual shutoff/isolation valve.

— Check and clean filters.

— Inspect all drip emitters and clean or replace if necessary.

Winter

— Adjust controller to further shorten watering times and durations.

— When daytime temperatures are below 40 degrees F., discontinue automatic watering and turn on irrigation system manually as needed.

IRRIGATION WITH RECLAIMED WASTEWATER

In their search for ways to reduce exterior water use, many of New Mexico's commercial, institutional, and industrial facilities have begun to use recycled water and reclaimed wastewater to irrigate their landscapes. Water can be collected, treated, and reused onsite. In addition, reclaimed wastewater is available from some water utilities (generally at rates far below those charged for potable water).

Water available for onsite recycling falls into two broad categories: graywater and blackwater. Graywater is water that is generated by bathroom sinks, showers, clothes washing machines, rinsing, and other processes. Blackwater is water flushed down toilets and urinals, and water discharged from kitchen sinks and other food processes that contains oil, fat, and/or grease. Graywater generally does not contain fecal matter and food waste; blackwater does. (U.S. General Services Administration, p. 4-2)

The presence of toxic chemicals and pathogenic microorganisms in untreated wastewater creates the potential for adverse health effects. Thus, the acceptability of reclaimed water for landscape irrigation depends on its physical, chemical, and microbiological quality. For this reason, graywater recycling is far more common than blackwater recycling because graywater generally requires less treatment before it can be safely reused.

Graywater Recycling Systems

In a typical graywater recycling system, water that would normally be discharged for municipal sewage treatment is collected, treated to remove suspended solids and contaminants, and reused. The basic graywater system will include the following components:

— storage tanks
— color-coded PVC piping (typically purple) to distinguish reclaimed water pipes from potable water pipes
— filters
— pump
— valves and controls

The need for reclamation facilities to reliably and consistently produce and distribute reclaimed water of adequate quality and quantity is essential and dictates that careful attention be given to the reliability features during the design, construction, and operation of the facilities. Graywater recycling and treatment systems must be installed in accordance with local plumbing codes and by professional, licensed plumbing contractors. (U.S. General Services Administration, page 4-7.) General guidelines for the reuse of wastewater in New Mexico have been prepared by the New Mexico Environment Department and may be obtained from that agency.

Opportunities and Challenges of Using Reclaimed Water

— Relatively clean water—reclaimed from process rinses, reverse osmosis reject water, and other uses—that is used to irrigate your site's landscape is essentially "free," and it can reduce your facility's water use substantially.
— Reclaimed water, particularly reclaimed municipal water, typically contains more salts than potable water. High salinity can have an adverse affect on plant life. Watch for salt accumulation on the soil surface where plants are drip irrigated.
— If high salinity is a problem when irrigating turfgrass, combine reclaimed water with potable water.
— When in doubt, consult with a professional water quality company for assistance in establishing a reclaimed water use program.

Section 5:
Water Conservation Guidelines for Cooling and Heating

COOLING TOWERS

Cooling and heating present great opportunities for water conservation. Not only do cooling towers, chillers, small evaporative coolers, boilers, and steam generators consume a great deal of water, but they frequently use water inefficiently. Understanding how to optimize the performance of heating and cooling equipment is essential to any industrial, commercial or institutional water conservation plan. These guidelines are designed to save water as well as reduce energy and chemical costs.

At hospitals, industrial plants, office buildings, and other facilities with large cooling needs, cooling towers can be the largest single water user. Cooling towers use huge volumes of water because they are designed to remove heat by evaporation. Just as human bodies cool off when sweat evaporates in a breeze, a cooling tower cools a circulating stream of water by exposing water droplets to an airflow. This causes a portion of the water to evaporate, taking heat with it. The remaining, cooled water then flows to an air conditioning unit or other equipment and a heat exchange occurs; the equipment is cooled and the circulating water is heated. The warmed water then returns to the cooling tower to be exposed to an airflow, cooled, and the cycle begins anew. (See "Typical Cooling Tower Operation" diagram in Figure 5-1.)

Water can be lost from a cooling tower in three ways: evaporation, bleed-off, and drift.

Evaporation. The primary purpose of a cooling tower is to take advantage of the heat transfer that occurs when water evaporates. When a portion of a circulating stream of water evaporates, it cools the water that remains. The rate of evaporation from a cooling tower is typically equal to approximately 1% of the rate of recirculating water flow for every 10 degrees F in temperature drop that the cooling tower achieves.

Bleed-off or blowdown. The water that evaporates from a cooling tower is pure; left behind in the water that remains are suspended and dissolved solids. As pure water continues to evaporate each time the water passes through the cooling tower, the concentration of dissolved solids increases. Ultimately, the dissolved solids must be removed in order to prevent damage to the system in the form of scaling, corrosion, and other problems. Bleed-off (also called blowdown) is the discharge of a portion of the circulating water to remove the suspended and dissolved solids.

Drift. Water droplets and mist carried out of the cooling tower by air flow is called drift. In well-maintained towers, water loss due to drift should be very small. (Typically, drift can vary between 0.05% and 0.2% of the flow rate through the tower.) Because the droplets still contain dissolved solids, drift is considered a part of bleed-off.

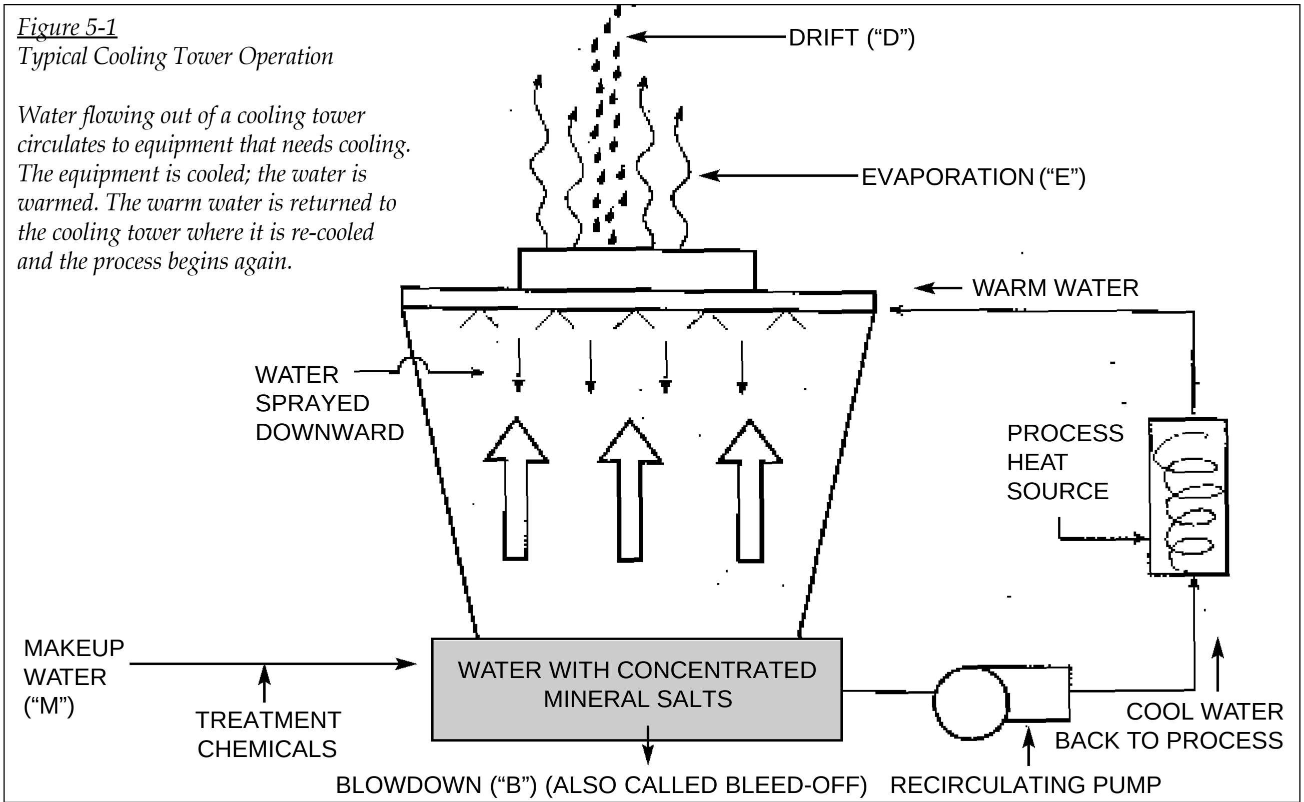
Water added to the system to replace water lost via evaporation, drift, and bleed-off/blowdown is called "make-up water." Therefore, the water balance in a cooling tower system can be stated as the relationship between make-up water (M), evaporation (E), bleed-off (B), and drift (D):

$$M = E + B + D$$

Since the evaporation rate depends on how much cooling is needed and, to a lesser degree, the weather, evaporative loss presents no viable opportunity for conserving water. Instead, facilities must focus on reducing the amount of water that is discarded as bleed-off from the system.

Figure 5-1
Typical Cooling Tower Operation

Water flowing out of a cooling tower circulates to equipment that needs cooling. The equipment is cooled; the water is warmed. The warm water is returned to the cooling tower where it is re-cooled and the process begins again.



Water Quality and Efficiency

Conserving water in a cooling tower is largely a function of water quality. Left uncontrolled, the quality of water circulating through a cooling tower system will deteriorate. Poor water quality—which includes water with high levels of dissolved solids—degrades the efficiency and longevity of cooling towers due to these problems:

Scale. When water-borne minerals such as calcium carbonate are deposited on the surfaces of the cooling tower, they form a film called scale. Scale reduces the cooling capacity of the tower by acting as an insulator. Excessive scale build-up can sometimes obstruct the flow of water, resulting in higher energy costs. Other scale-inducing minerals include silica, calcium sulfate, and iron oxides.

Corrosion. Corrosion of the metal surfaces of the cooling tower can be caused by a low pH (acidity) of the water due to contamination from air pollutants. High mineral concentrations in the cooling water may also generate a high conductivity, which leads to corrosion if the water passes by and conducts a current between two different metals. Finally, scale, dirt, and the water itself may wear away metals.

Biofouling. The warm, moist environment of a cooling tower beckons to algae, bacteria, slime, and fungi. These organisms can impinge or clog water flow, promote scaling and corrosion, and corrupt the heat transfer efficiency of the system.

As the concentration of total dissolved solids increases, a portion of the circulating water must be discharged as bleed-off to prevent the above conditions from damaging the system. Clearly, the less bleed-off water required, the greater the water savings.

To minimize bleed-off, facilities often rely on an outside water treatment vendor to supply chemicals for use in the cooling tower's circulating water. These chemicals include scale inhibitors (e.g. organophosphates) and corrosion inhibitors (e.g., polyphosphates). Inhibitors make it possible for the water to "hold" much larger concentrations of minerals in their dissolved state (commonly referred to as "total dissolved solids" or TDS), thereby postponing bleed-off until much higher mineral concentrations are reached. (An additional benefit of minimizing bleed-off is that treatment chemicals stay in the circulating water longer, thus reducing chemical cost.)

Water Conservation Measures
There are several ways to improve the water-use efficiency of a cooling tower by reducing the water lost to bleed-off:

— **Operate bleed-off** on a continuous basis, rather than by the "batch" method. Most cooling towers are bled-off automatically when the mineral concentration, as measured by conductivity, reaches a specified level. This is usually done by the batch method, releasing large quantities for a preset period of time or until the conductivity reaches a preset low level. Unfortunately, this method can lead to wide fluctuations in the conductivity, which wastes water. Instead, try to operate the bleed-off on a more continuous basis, keeping the conductivity closer to the limits. Set the bleed-off timer for a shorter time, or set the low-end conductivity higher, not much less than the bleed-off start level.

— **Install conductivity and flow meters on make-up and bleed-off lines.** This will allow the operator to closely monitor the volumes of water being used and verify that the system is operating at optimum parameters. Meters that display total water flow as well as current rate of flow are most useful.

— **Read meters regularly.** Keep a log of make-up and bleed-off consumption and dissolved solid concentration, evaporation, cooling load and concentration ratio.

— **Add an automatic control** to shut off the unit when it is not being used (i.e. at night or weekends).

— **Select your treatment vendor with care.** Tell vendors that water conservation is a high priority and ask them to estimate the quantities and costs of treatment chemicals and volumes of bleed-off water, as well as the expected concentration ratio. Keep in mind that some vendors may be reluctant to improve water efficiency because it means the facility will purchase less treatment chemicals.

— **Adjust pH by adding sulfuric acid.** Carefully adding a controlled amount of sulfuric acid to the cooling tower water lowers the pH and prevents scale by converting a portion of the scale-forming minerals into more soluble forms. This option may reduce water consumption by up to 25 percent. Make sure that workers are fully trained in the proper handling of acids. Also note that acid overdoses can severely damage a cooling system, so use a timer and add acid at points where the flow of water is well-mixed and reasonably rapid. Also be aware that lowering the pH may mean you may have to add a corrosion inhibitor.

— **Install sidestream filtration.** Routing cooling tower water through a rapid sand filter or high efficiency cartridge filter is a particularly good method for improving water quality in places where airborne contaminants and water cloudiness are common and for systems with narrow passages susceptible to clogging. Filtration improves cooling tower efficiency and cuts down on the need for maintenance. Sidestream filtration is particularly helpful if your cooling tower is subject to dusty atmospheric conditions.

— **Treat water with ozone.** Ozone not only kills viruses and bacteria, but it may also control corrosion by oxidizing inorganics and soluble ions. Ozonation can improve water quality without the need for additional chemicals. (NOTE: While ozone is a powerful oxidizing agent, its effective life is less than one hour. This means it must be produced at the site. Ozone is also highly corrosive. Materials compatibility must be considered in any system that uses ozone.)

— **Recycle and reuse.** Even if you have done everything possible to improve water quality, you can still save water by finding other uses for bleed-off water. You may also discover additional sources of make-up water such as single-pass cooling systems used elsewhere in the facility. Some high-quality municipal treated wastewater may also be acceptable provided the tower is operated at somewhat conservative concentration ratios.

— **Explore other options.** Some vendors claim that magnets and electrostatic field generators dislodge mineral deposits and scale without the use of chemicals. Be aware that these claims are unsubstantiated. Investigate these systems thoroughly before a possible purchase.

Figure 5-2
Pros and cons of Cooling Tower Conservation Options

OPTION	PROS	CONS
Improving Conventional Treatment	Low initial capital cost Low operating cost Low maintenance requirements	Concentration ratio is limited based on the quality of the make-up water (typically 3.5)
Sulfuric Acid	Low initial capital cost Low operating cost Concentration ratios up to 6 possible	Potential safety hazard Potential for system damage
Sidestream Filtration	Greater operating efficiency Longer periods between shutdowns Possibly reduced biofouling and scale	Moderately high initial capital cost Limited removal of dissolved solids Pumps add extra energy cost
Ozonation	Concentration ratio of 10 or higher possible Elimination of all or additional chemical treatment No treatment required for discharge to sewer system	High initial capital investment Complex system requiring outside vendor Additional energy costs Possible health hazards Highly corrosive—system materials must be compatible
Recycle, reuse	Drop in overall facility water consumption	Possible requirements for pretreatment with concomitant increase in energy and chemical costs Increased potential for biofouling if water quality is poor

Sources: Facility Manager's Guide to Water Management (Arizona Municipal Water Users Association) and Uses of Water and Water Conservation Opportunities for Cooling Towers (Black & Veatch)

COOLING TOWER TERMINOLOGY

Bleed-off or blowdown. The discharge of a portion of the circulating water to remove suspended and dissolved solids left behind when pure water evaporates from the tower. If untreated, these solids may cause scaling and other problems.

Concentration ratio (CR) or cycles of concentration. The concentration ratio is an indication of how many times water circulates in the cooling tower before it is discharged as bleed-off. The concentration ratio is expressed as a relationship between the concentration of total dissolved solids of the bleed-off (CB) and the concentration of total dissolved solids in the makeup water (CM): CR = CB/CM. From the standpoint of water conservation, a high CR is desirable.

NOTE: If CM and CB are not measured by a meter, CR may be calculated by dividing the concentration of one or more dissolved solids in bleed-off water by the concentration of dissolved solids found in makeup water. For example, if the incoming makeup water has 100 ppm of calcium carbonate and the tower bleed-off water has 300 ppm of calcium carbonate, then the cycles of concentration = 300/100 = 3.0.

Another way of estimating cycles of concentration is to use conductivity. If incoming makeup water has a conductivity of 400 and the bleed-off water conductivity is 1200, then cycles of concentration = 1200/400 = 3.0.

Drift. Water droplets and mist lifted out of the cooling tower by air moving through the tower. In well-maintained towers, water loss due to drift should be small. Because the droplets still contain dissolved solids, drift is considered a part of bleed-off.

Evaporation rate. The rate at which water is lost through evaporation. A approximate guideline states that cooling towers lose 2.4 gallons per minute per 100 tons of cooling. For example a 700 ton tower loses 16.8 gallons per minute (2.4 gpm/100tons X 700 tons).

Make-up water. Water added to the system to replace water lost via evaporation, drift, and blowdown. Drift is usually small, so if you meter the bleed-off (B) and makeup (M) rates, you can calculate the evaporation rate (E): E = M - B.

Tons. Unit of cooling capacity equal to 12,000 BTUs (British Thermal Units) per hour. Cooling towers in typical facilities range from 50 tons to more than 1,000 tons.

Total Dissolved Solids (TDS). The concentration of minerals and other dissolved solids in the cooling tower circulating water. As the concentration increases, a portion of the water must be discharged to prevent damage to the system.

HOW MUCH WATER CAN BE SAVED?

The graph in Figure 5-3 shows the relationship between the concentration ratio (CR) and the amount of water consumed by a cooling tower. To determine the percentage of cooling tower water consumption that can be conserved by increasing the concentration ratio, use the following equation:

$$\text{Percent conserved} = \frac{CR2 - CR1}{CR1\,(CR2 - 1)} \times 100\%$$

where: CR1 = concentration ratio before increasing cycles, and
CR2 = concentration ratios after increasing cycles.

EXAMPLE 1: Increasing the concentration ratio from 2 to 4 results in a water savings of 33%.

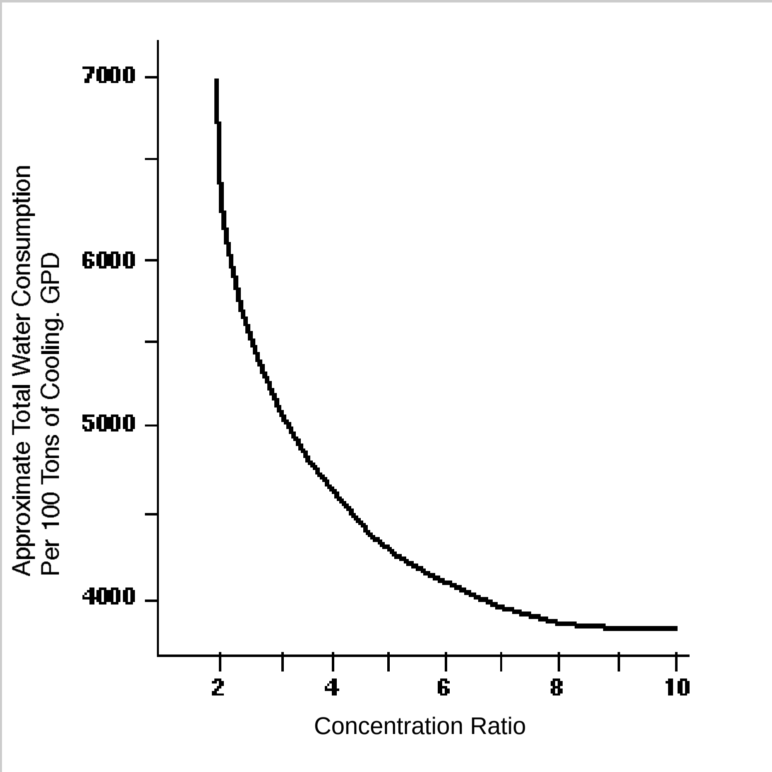


Figure 5-3:
Cooling Tower Water Consumption vs. Concentration Ratio

Sources: "Uses of Water and Water Conservation Opportunities for Cooling Towers" by J. Douglas Kobrick, P.E. and Mark D. Wilson, Black & Veatch; City of San Jose Environmental Services Department

SINGLE-PASS COOLING SYSTEMS

Single pass (also known as "once-through") cooling systems present another significant opportunity for conservation. In these systems, water is channeled through a piece of equipment and then disposed down the drain. The types of equipment that typically utilize single-pass cooling include: CAT scanners, degreasers, rectifiers, hydraulic presses, x-ray processors, condensers, air conditioners, air compressors, welding machines, vacuum pumps and viscosity baths.

Here are some ideas on how to save water in single-pass systems:

— Modify equipment to operate with a closed-loop cooling system that recirculates the water instead of dumping it. For small equipment, it may be possible to tap into an existing recirculating chilled water loop.

— Replace water-cooled equipment such as compressors and vacuum pumps with air-cooled models. Air-cooled ice makers, ice cream and frozen yogurt machines are available, as is other equipment that uses water-cooled condenser units.

— If the above options are not viable, try to find another use for the single-pass effluent, in boiler make-up supply or landscape irrigation, for example. Also look for other appropriate sources of water to feed single-pass cooling, such as reverse osmosis reject water.

SMALL EVAPORATIVE COOLERS

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

When water evaporates it leaves behind scale and mineral deposits on the pads. This reduces the volume of air flowing through the pads and compromises the performance of the cooler. In areas where water is very hard and/or the air is dusty, pads may become clogged very quickly.

Bleed-off water serves to dilute the mineral concentration of pan water and reduces scale and dirt build-up on the pads. There are two types of bleed-off systems. The once-through or pumpless type is simpler and less expensive than the recirculating or pump type, but it consumes more water and requires constant drainage. (Wilson, May 1996, Appendix B, p.1)

To reduce water used by evaporative coolers:

— Keep a tight rein on the amount of bleed-off water. For most small coolers, bleed-off volume should be less than a few gallons per hour for each 1,000 cubic feet per minute of air flow (Wilson, Appendix B, p.2). In addition to saving water, lower bleed-off rates also lead to greater thermal efficiency.

— Avoid single-pass or pumpless coolers. Recirculation saves water and increases the thermal efficiency. But if recirculation is not an option, consider using the bleed-off water for irrigation or other uses.

— Replace worn or torn pads.

— Inspect the recirculation pump and reservoir level controls periodically during the warm months when the system is running.

Figure 5-4:
Typical Evaporative Cooler

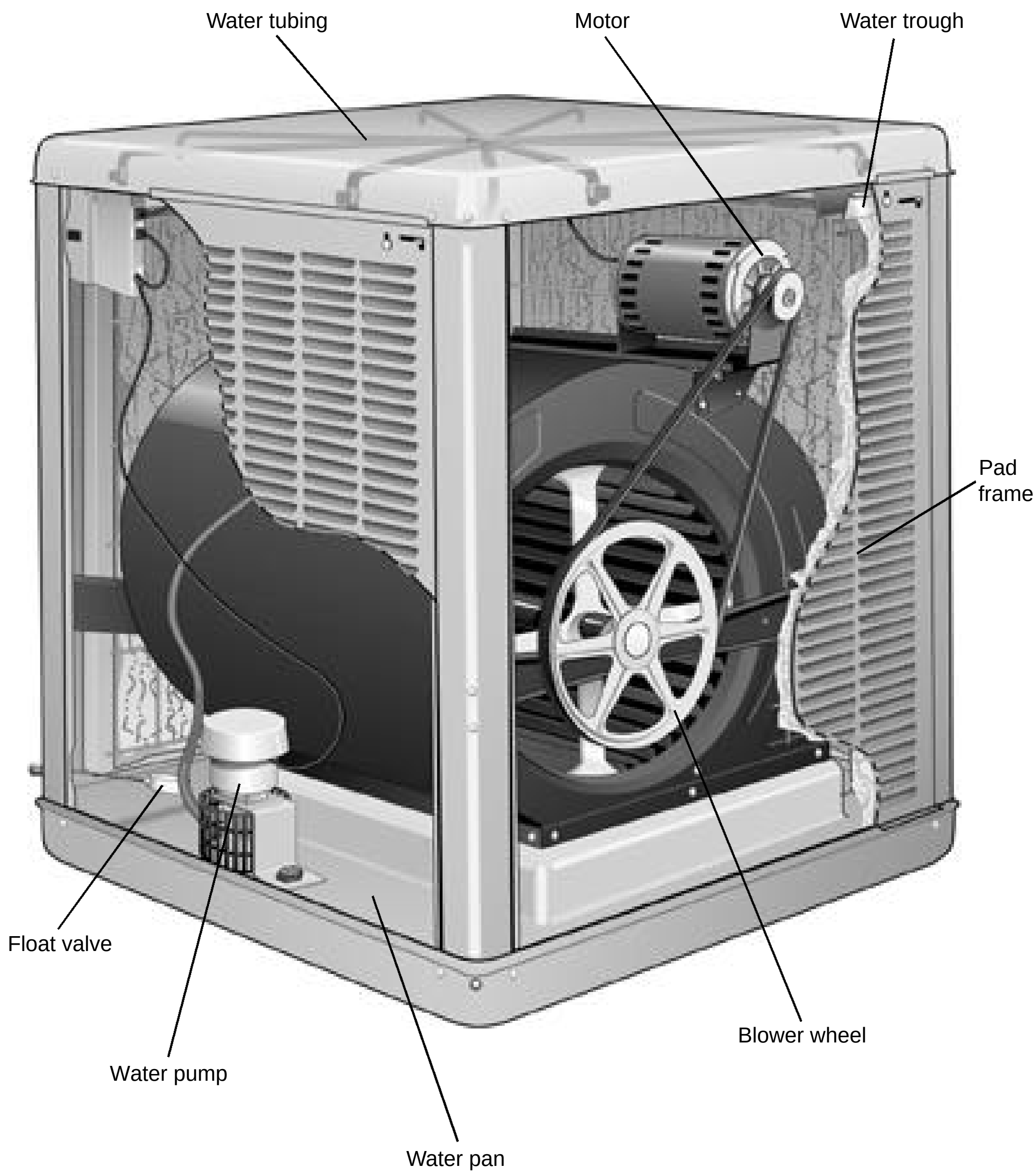


Illustration courtesy of Champion Coolers

BOILER AND STEAM SYSTEMS

Boilers and steam generators are used in large heating systems, in cooking, or in facilities where processed steam is required. Water consumption rates of boiler systems vary depending upon the size of the system, the amount of steam used, and the amount of condensate return.

Several different designs for boiler/steam generators are available. The most common is the fire tube boiler, called the shell and tube design. In this type of unit, a gas or oil fired heater directs heat to the tubes and water in the shell to produce steam. The water in the boiler is treated with various chemicals to inhibit corrosion and scale formation in the steam distribution system. In many systems, after the steam is used (for heating, cooking etc.) the condensate is returned to the boiler. This can be considered a water conservation measure because it reduces the need for boiler feedwater make-up.

Water is added to a boiler system to make up for the water lost as steam, and to periodically blowdown the boiler to expel any scale that may have built up. If the boiler system is not equipped with a condensate return system, all the water used to generate steam is lost, and make-up water must be added. (Black & Veatch, 1993, p. 25)

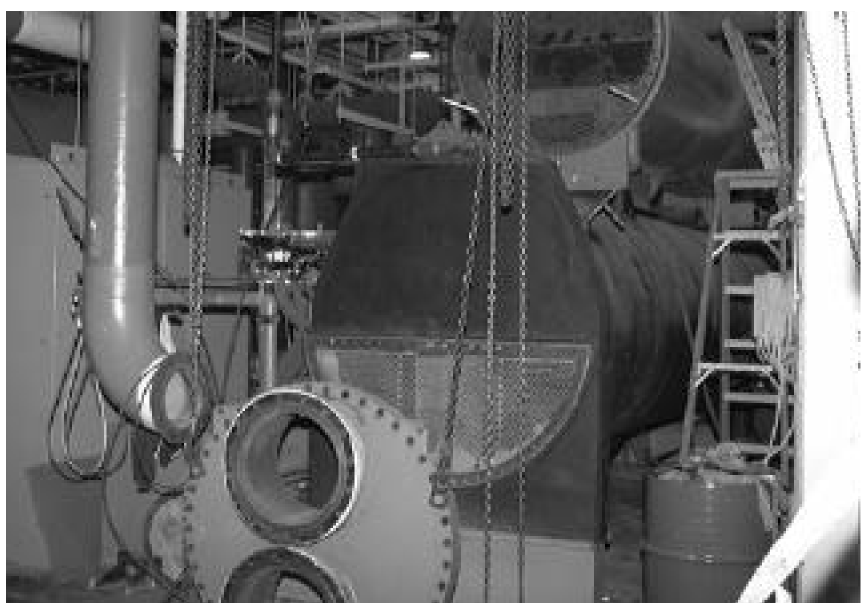
To conserve water:

— Regularly check steam traps and lines for leaks and make repairs as soon as possible.

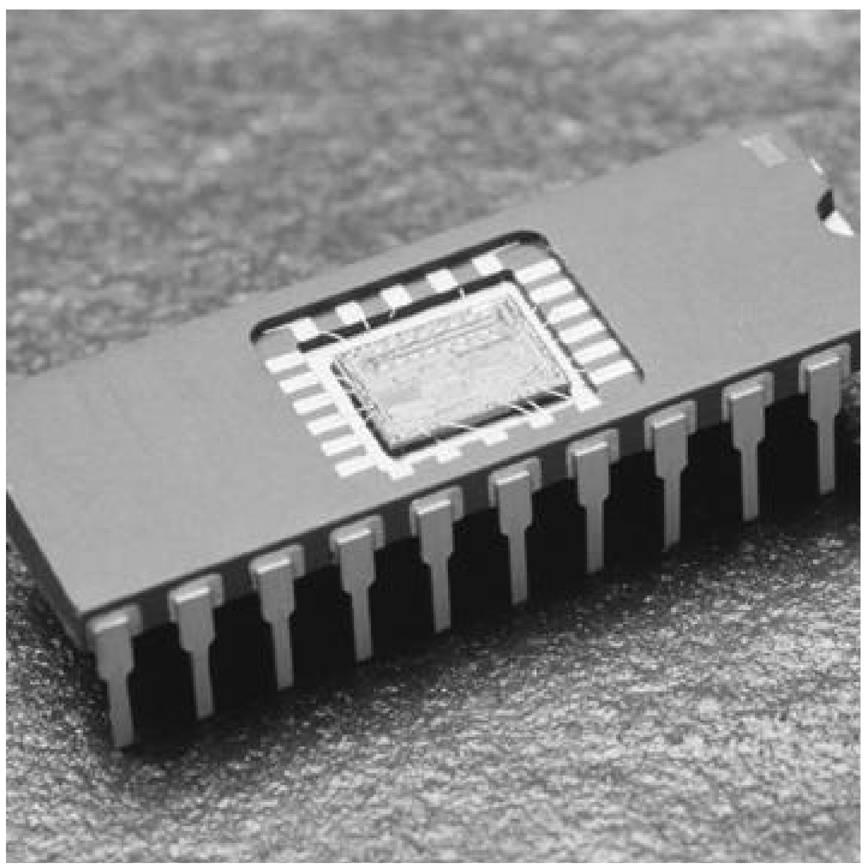
— If your system does not already return steam condensate to the boiler, consider making modifications that would do so. This conserves energy as well as water because the relatively hot condensate needs less heating to produce steam than make-up water from other sources. Recovering and returning steam condensate may cut operating costs by up to 70 percent.

— Install an automatic control to turn off the unit when it is not in use during nights and/or weekends.

— Install an automatic blowdown control for boilers to better manage the treatment of boiler make-up water.



Section 6: *Water Conservation Measures for Specific Processes and Industries*



Water plays an integral role in many New Mexico manufacturing processes from metal plating and finishing to semiconductor chip fabrication. The above-mentioned facilities, with their heavy reliance on rinsing and reaction baths, are among the state's largest industrial water users. But many are also among New Mexico's most innovative and dedicated water conservationists; a few have even pioneered water-saving techniques or equipment that have been adopted by their other facilities outside New Mexico. (See, for example, the case studies in Section 7 on Intel and Tuscarora.)

Every industry's production line has its own unique elements and requirements. In this section, several specific industries are addressed. In addition, virtually every plant manager can obtain water savings by considering and adapting these more general guidelines:

— Review each process to determine if less water can be used and if the most recent water-saving technology is being employed. Pay particular attention to the rinsing steps; in many cases operators use an excessive amount of water, far more than what is required to ensure product quality.

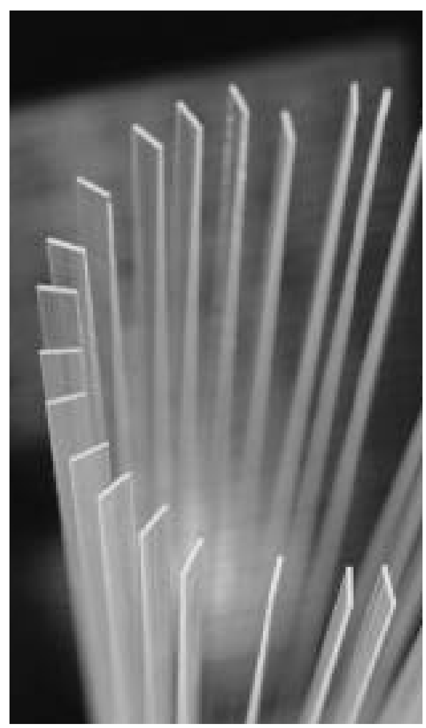
— Go beyond the standard information provided by equipment manufacturers to investigate the real need for water use.

— Install pressure reducers if high water pressure is not required.

— Use reverse osmosis and de-ionized water only where it is essential.

— Make sure all controls, sensors, and valves are checked frequently and repaired promptly.

— Investigate counter-current rinsing, spray systems, flow reduction devices, solenoid or timer shut-off valves, pH or conductivity probes, and batch processing for water-saving opportunities.



RINSING AND CLEANING

There are several types of rinse baths used to remove contaminants from the surface of a product or component. Static rinse baths wash away contaminants when the workpiece or product is dipped in to it. The bath must be periodically drained and replenished with fresh water.

Constant overflow rinse baths, also known as "running rinses," wash away contaminants with a continuous flow of water to the tank. The flow rate varies widely and is often not metered. The overflow of spent water is typically sent down the drain.

The most water-efficient rinsing system uses a counter-current or counter flow arrangement, in which the rinse water progresses from tank to tank in a direction opposite to the processing order. In this way the cleanest water is used for the final product rinse. It is then used again to rinse the product in earlier rinse steps where water quality is not as critical.

To conserve rinse water, focus on:

1. controlling water flow
2. increasing the efficiency of the rinse process
3. reclaiming spent water.

Water Flow

— Avoid excessive dilution. Determine the maximum allowable contaminant concentrations in the rinse tanks. Install flow meters or manually operated flow control valves instead of orifice plates for flow control. This will allow for greater operating flexibility, including the ability to respond to changes in supply pressure. These devices are inexpensive and simple to operate, but they do require operator attentiveness.

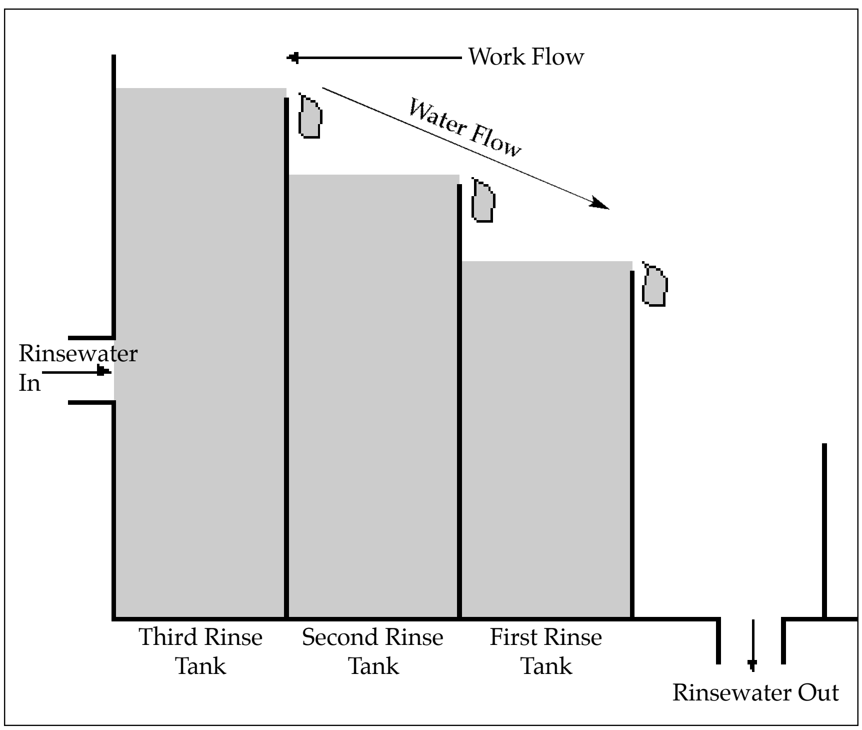
— Use measured amounts of water rather than continuous streams.

— For automatic flow control, use conductivity or total dissolved solid (TDS) meters to monitor rinse water concentration and to trigger electrically operated flow control valves. Be aware that this option will not work well if there are rapid variations in make-up water TDS due to changes in water supplier sources.

— Reduce the rate of "trickle flows" which run continuously even when processing is not taking place.

— If possible, install timers or shut-off valves to turn off water flow whenever a process is shut down or temporarily taken out of service.

Figure 6-1
Three-stage countercurrent rinse



Rinsing Efficiency

— Install spray rinse systems directly above the process baths where possible. Water savings of up to 60 percent (compared with immersion tank water use) may be possible (Arizona Municipal Water Users Association, 1997, p. 73). Spray rinsing is most effective for parts that are flat, have small holes, or are cup shaped. You may be able to adjust the flow rate so it equals the evaporation rates from the process bath.

— Use sequential rinsing, in which spent water from one process is used as rinse water for another compatible process. For instance, rinse from an acid bath might be used for rinsing in a caustic bath rinse.

— For multi-tank rinsing, consider making the first tank a static rather than continuous rinse. This conserves water because a high percentage of the contaminants is discharged into the first rinse tank, which is allowed to become more concentrated than the rinses that follow. Less water is used to periodically dump and refill the tank than is used for continuous overflow rinses.

— Use counterflow rinsing. Converting from one rinse tank to two counterflow tanks has been reported to reduce water consumption by over 50 per cent, in some cases. Adding a third tank can save another 10 percent. (ibid, p. 73). The disadvantage of this system is that it may require additional floor space as well as more tanks and piping.

— Eliminate plenum flushes where not required.

— Instead of cleaning one item at a time, consider batch processing. Processing several workpieces at the same time makes more efficient use of process water, saves time, and increases productivity.

— Schedule wet process production so rinses are operated fewer hours during the day.

— Reduce rinse water in solvent degreasing by installing tamperproof conductivity meters to control make-up water to rinse tanks.

Reclamation and Other Ideas

— Reclaim spent rinse water; treat it if necessary. Reuse rinse water for lower-grade process steps or for other facility applications such as cooling tower make-up water (See Section 7 for the case studies on Intel and Sandia National Laboratories, for example). Water can be selectively separated from solids using a number of membrane technologies including reverse osmosis, electrodialysis, ultrafiltration, and microfiltration.

— Improve the quality of wastewater and reap the economic benefits of recovering chromium, copper, silver, and other valuable materials.

— If there is a circulating de-ionized water loop in the facility, consider returning the final portion of rinse water to it. The water that flows at the end of a rinsing sequence usually becomes only slightly contaminated, and may even be of better quality than the facility's incoming water supply (City of San Jose, Computer and Electronics, p. 5). Direct reject de-ionized water to other uses.

— Recover, treat, and reuse filter backwash water. Recycle water in test tanks. Recycle water used in head-polishing machinery.

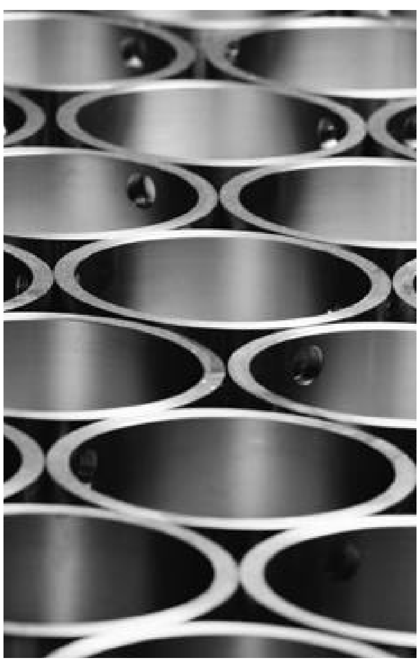
— Install ultrasonic cleaning equipment for reusable containers and degreasing.

— Instead of caustic jet spray rinses, use a burn-out oven for cleaning used engine parts. Then bombard the cleaned parts with beads and shot to remove residue. This also reduces the need for toxic waste disposal (State of California, October 1994, p. 36).

— Recycle "clean-in-place" rinse water. Use it for the next caustic wash.

Plating and Metal Finishing

Many of the measures outlined in the previous section apply to plating and metal finishing as well as other industries. For plating and finishing processes, there are additional ways to reduce "drag-out," the liquids and chemicals that are carried on workpieces from one tank to another. Reducing drag-out saves water because the rinse water does not have to be replenished as often.



— To minimize drag-out, allow enough time for the workpiece to drain into the plating tank before it is moved to the rinse tanks. Drain times of 10 seconds or more have been used successfully and have cut drag-out by 67%. (University of Missouri). Also tilt or orient the workpieces so that liquids can drain more easily as they are removed from the baths and so only a small surface area comes in contact with the solution surface as the pieces are removed.

— Use wetting agents in the plating baths, which can reduce drag-out by as much as 50% by reducing surface tension. Make sure, however, that the resultant foam is compatible with waste treatment systems (ibid).

— Consider reducing the metal concentration in the plating baths. Concentrations as low as 29 ounces of chromium per gallon have been used effectively in plating shops (ibid).

— Explore increasing the plating bath temperature. Increased temperature lowers the viscosity of the plating solution so that it drains off the part more easily. Note, however, that high temperatures break down brighteners and increase carbonate buildup in cyanide solutions. The evaporation rate from the process tank will also increase. To counteract evaporation, add water from a rinse tank.

— Install air knives. Air blown on the surface of the parts as the racks are raised from the tank helps fluids drain back into the tank.

— Install drain boards between the process and rinse tanks to collect drag-out and route it back to the process tank.

— To improve the efficiency of rinsing, try agitating, lifting and lowering the tank to increase the circulation of the rinse water. Consider forcing air or water into the immersion rinse tank. Let the workpiece stay in the rinse water for a longer period of time.

— Consider evaporator/condenser systems or membrane systems for separating rinse water from plating solutions, for recycling, or for both.

— To extend the lives of the baths, inspect all parts before plating. Parts should be clean, dry, and free of rust and mill scale. Pre-wash or wipe dirty parts using old solvent.

— When the alkaline bath declines due to evaporation and drag-out loss, consider dumping only part of the bath rather than the entire amount. Then add fresh chemicals and water.

MEDICAL CARE FACILITIES

Medical care facilities, such as hospitals and nursing homes, have unique water conservation opportunities and challenges. In addition to utilizing the domestic and indoor conservation measures previously mentioned, medical care facilities should consider water conservation measures in the areas described below.

Sterilizers and Autoclaves

In many hospitals, sterilizers and autoclaves may use as much water as the cooling towers and heating system. (City of San Jose, Hospitals & Healthcare Facilities, p. 3 and p. 11). It is not unusual for medical care facilities to have five to 10 of these units available 24 hours a day. Some older models are notorious water users, running water constantly with no way to meter or control the flow. Typical continuous-flow rates range from 1.0-3.0 gpm in sterilizers and from 0.5-2.0 gpm in autoclaves (Black & Veatch, 1993, p. 33-34).

Water in sterilizers is used to produce steam, to cool the steam, and, in some cases, to draw a vacuum in the unit to speed drying of the surgical instruments, trays, and tools being cleaned. Autoclaves use ethylene oxide instead of steam as a sterilizing medium, but water is used to carry off spent ethylene oxide, and, in some cases, to create a vacuum to aid in drying.

Conservation measures include:

— Check that the flow rates being discharged do not exceed the manufacturer's recommended value. Ask if the flow can be reduced to a minimum acceptable level.

— Retrofit units with solenoid-operated valves that shut off the flow of water whenever the unit is not in operation.

— Choose new sterilizers or autoclaves that are designed to recirculate water and that allow the machine's flow to be turned off when the unit is not in use.

— Instead of using water to cool sterilizer steam, consider installing a small expansion tank to allow the steam to cool to temperatures acceptable for discharge into the sewer system. Talk to the manufacturer or service contractor to make sure this modification does not affect the sterilizer's performance.

— Alternatively, reuse cooling water and/or the steam condensate. Send this water to the boiler or cooling towers instead of down the drain. (See the Presbyterian Healthcare case study on pg. 95.)

— Use a high-quality supply of steam to maximize the water efficiency of the sterilizer.

— Shut off all units not in service.

X-Ray and Photo Processing

Film processing, including x-ray development in hospitals and other medical facilities, is commonly done with automatic machines. In general, these processors utilize a series of tanks and dryers to develop, stop, fix, harden, wash, bleach, and dry the film. Water is used principally in the rinse or wash cycle, and, in older machines, this water can run continuously. New machines are more water efficient (and reduce the amount of silver in wastewater as well).

To save water:

— Install an inexpensive flow-rate meter in the supply line to ensure that the correct flow of rinse water is being received by each processor.

— Install a control valve in the piping to each unit. Adjust water flow to the minimum rate possible. Many hospital X-ray processors use a higher flow rate than necessary to ensure acceptable quality. The average hospital unit requires about 2.0 gallons per meter (gpm) or less, but in practice the actual flow rate is typically greater than 3 or 4 gpm. (Arizona Municipal Water Users Association, 1997, p. 76). Post a list of minimum acceptable flow rates near each machine.

— Install a pressure-reducing device on any equipment that does not require high pressure.

— If the processor utilizes a solenoid valve that shuts off rinse and cooling water flows when the unit is not in use, make sure the valve is working properly. It is not uncommon for processor valves to operate incorrectly, allowing continuous water flows. Some machines without solenoid controls can be retrofitted.

— Consider recycling rinse bath effluent as make-up for the developer / fixer solution.

— Replace old equipment with water-efficient models. Look for machines equipped with a squeegee to remove excess chemicals from the film as it travels from one tank to the next. Depending on the system, a squeegee can reduce the amount of chemicals carried between tanks by up to 95 percent (ibid, p. 76). The lower the amount of chemicals carried over to the wash cycle, the less wash water is required.

Miscellaneous Medical Facility Processes

Below are several more ways to save water in medical facilities.

— Do not rely on running a stream of water through an aspirator to create a vacuum.

— Draw on the hospital's recirculating systems for cooling in place of single-pass cooling for laboratory instruments.

— In water-ring vacuum pumps, check the flow rate of the water ring seal and its control. Install a flow restrictor or replace with an oil-ring vacuum pump (See the Presbyterian Healthcare Services case study, pg.95).

— Use softened water only where it is needed. Ensure that the flow rates and cycle times are properly set during the regeneration cycle, when water is used to flush the resin and to refill the brine tank. Monitor water quality before starting the regeneration cycle to ensure that water will be used most efficiently.

OTHER PROCESSES

Here are a few conservation ideas for other kinds of processes.

Painting

— Use an electrostatic process to paint metal surfaces. This will reduce air pollution and eliminate the need for water curtains.

— Recycle water used to collect overspray paint by treating water with dissolved air flotation and a filter dewatering system to separate toxic solids.

— Replace water-wall paint-spray booths with a dry filter medium to collect overspray.

Dyeing

— Reuse water from light-colored applications for batch dyeing operations.

— Consider separating rinse drains and recycling some rinse water as dye bath make-up.

Fume Scrubbers

Wet fume scrubbers use water sprays to remove pollutants from production exhaust gases before they are released to the atmosphere. Even though most scrubbers recirculate some water, losses due to evaporation and discharge can add up; flow rates between 5 and 10 gallons per minute are common.

— Install flow meters to measure the water flowing into the scrubber for make-up water. Make sure the flow does not exceed the rate specified by the manufacturer for proper operation.

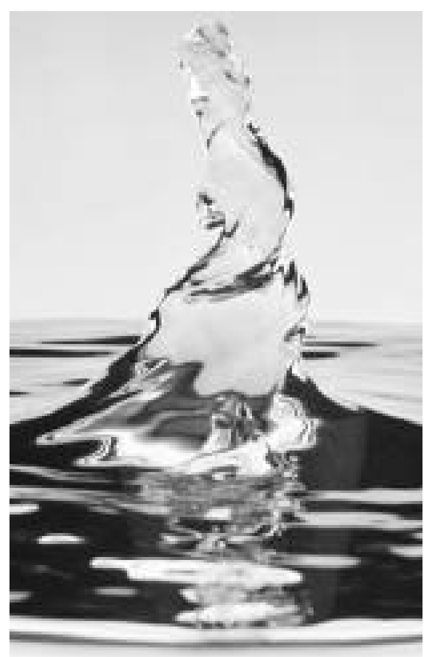
— Instead of feeding fresh water into the scrubbers, explore the possibility of using lower grade, non-potable water. (Be careful not to create any cross reactions between the chemicals in the water and those in the exhaust stream.)

— Explore treating and reusing the water normally discharged from the scrubber. Consider replacing wet scrubbers with a bag house variety (See Ponderosa Products case study, pg. 84.)

Making Use of Degraded Water

— Reuse reverse osmosis reject water for other uses. Depending on the reject water quality, uses may include process cooling, equipment cooling, fume scrubbers, photo processing, washing areas not needing ultra clean water, and irrigation.

NOTE: Because reverse osmosis filtration concentrates naturally occurring minerals into the reject water, caution should be applied in selecting an application for this mineral-laden water.



Section 7: *Case Studies in Commercial, Institutional and Industrial Water Conservation*

INTEL, RIO RANCHO

Intel is the world's largest maker of computer chips and the largest private employer in the Albuquerque metropolitan area. It is also among New Mexico's top industrial water consumers, using the same amount of water per year as nine Albuquerque golf courses. Intel has aggressively pursued water conservation in response to the community's and its own concerns.

The Intel campus consists of three manufacturing plants called "fabs." Fabs 7 and 9 primarily make memory devices for cellular phones, laptop computers, and other portable electronic products. The two-building Fab 11, completed in 1995, is a state-of-the-art facility producing microprocessors or the "brains" that orchestrate data processing in personal computers. Currently all these devices are fabricated on silicon wafers, 6 or 8 inches in diameter.

In 1993, when Intel was still contemplating Fab 11, Fab 7 and 9 were using about 2.8 million gallons per day (mgd). It was estimated that the addition of Fab 11 would bring Intel's consumption up to approximately 10 mgd if no additional conservation measures were taken. With conservation however, Intel's water use since 1996 has held steady at about 4 mgd even though its chip production has increased 70 percent since 1995.

INTEL

1993: Projected Water Use (after plant expansion):
10 million gallons per day

1998: Actual Water Use:
3.86 million gallons per day

Water Savings: 61.4%

Intel once used fresh water for all its operations: fabs, air pollution scrubbers, cooling towers (which provide air conditioning), and irrigation. With conservation measures, much of the water is now recycled. (See Page 15.)

Only 15% of the water it uses is lost to evaporation, scrubbers and irrigation. The rest is pretreated and then piped directly to the City of Albuquerque's sewer system and treatment facility, where it eventually returns to the Rio Grande Basin.

Intel has reduced its manufacturing water use by:

- Increasing the efficiency of the system that purifies incoming water
- Reducing the amount of water needed in production by optimizing the existing "wet benches" that rinse wafers during their six weeks of processing and ulti mately redesigning the wet benches
- Reusing outgoing water by channeling it to cooling towers and air pollution scrubbers

Purification. Chip manufacturing is an immaculate process because even tiny amounts of impurities can degrade or ruin semiconductor devices. Therefore, the air in Intel's clean rooms is 1000 times cleaner than a hospital operating room.

Similarly, the water used to rinse the chemicals that etch and clean the chips must be ultrapure, free of the minerals that are contained in city and well water. In addition to sodium, calcium, and other minerals common to most New Mexico water, Intel also has to contend with high levels of silica in its well water. Using conventional reverse osmosis (RO) technology, Intel was able to turn every two gallons of incoming water into one gallon of ultrapure water and one gallon of concentrated "graywater," which is used for irrigation or sent to the sewer system. In other words, the filtering system with this technology was 50 percent efficient.

In 1995, engineers began adding chemicals called scale inhibitors to the water. This increased the solubility of silica, essentially increasing the graywater's capacity to hold and carry away dissolved silica so that it doesn't precipitate out or scale the membranes of the RO system. Scale inhibitors increased the filtering efficiency to 65%: Intel produced 1 gallon of ultrapure water from only 1.54 gallons, instead of 2 gallons, of incoming water. This saved 209 million gallons of water in 1996.

Intel boosted the efficiency even more by working with a consultant who pioneered a new purification process called the High Recovery Reverse Osmosis Process (HRROP). The team discovered that silica's solubility dramatically increased at high pH or alkalinity. But when the team increased the pH, the solubility of other minerals became a problem. So the researchers first softened the water to take out the other minerals and then raised the pH to keep the silica dissolved during conventional reverse osmosis. As of January 1999, a pilot program indicated that this approach will increase purification efficiency to over 85%: Every 1 gallon of ultrapure water will require only 1.176 gallons of input water (saving an additional 700,000 gallons of incoming water per day). Ironically the 0.176 gallons of rejected graywater from the $5 million system is too highly concentrated with minerals to be used for irrigation. Intel hopes to use treated effluent from the City of Rio Rancho for watering its grounds instead.

Processing. Wafers are rinsed by submersion in a tank or wet bench of ultrapure water. The tank fills and overflows continuously (to prevent the growth of bacteria), carrying away chemical residue and outgassing carbon dioxide. When Intel began looking carefully at the rinse step, it discovered that it could maintain its production quality with 75% less overflow water.

Intel also asked Sandia National Laboratories to develop a fluid dynamics computer model of flow in the tank and found that 50% of the water was not actually rinsing the wafers. So the company worked with the equipment manufacturer to design a new wet bench; by changing the shape and volume of the tank as well as the way in which water flows in and out, Intel saves half of the water previously required, as well as saving energy and chemicals. This wet bench, the first to be redesigned with conservation in mind, has been installed at other Intel sites around the globe.

Intel reduced the trickle of ultrapure water in other process steps as well as in equipment during shift changes of personnel. Further water reductions in the manufacturing process have resulted from replacing some water-based vacuum generation equipment with an air-based system.

These and other conservation efforts have not only saved water, but have also boosted production capacity by decreasing the amount of time wafers spend in rinse cycles. In some cases, conservation has also eliminated the need to purchase additional manufacturing equipment.

Facilities. Intel's North and South Energy Centers support the fabs by providing chilled water and steam for production, as well as controlling the temperature and humidity in the clean rooms and capturing pollutants before the exhaust is released to the air. Intel saves approximately 757,000 gallons of water a day by routing rinse water from some of the fabs to cooling towers and air scrubbers.

Landscaping. Intel has xeriscaped its 31 acres of grounds and upgraded its irrigation systems, resulting in an expected 60% reduction in the amount of water used to sustain its landscaping.

SANDIA NATIONAL LABORATORIES, ALBUQUERQUE

Sandia National Laboratories (SNL) is operated for the U.S. Department of Energy by the Sandia Corporation, a Lockheed Martin Company. SNL designs all non-nuclear components for the nation's nuclear weapons and conducts a wide variety of research, from the development of solar cells and computer chips to fusion. Located in six separate sites on Kirtland Air Force Base, SNL employs more than 8,000 people working in 765 buildings encompassing 5.4 million square feet.

As if the sheer size and diversity of Sandia's activities and funding weren't daunting enough, a facilities manager contemplating water conservation is also hampered by the fact that few buildings are metered. (At the time most were built, water was considered an unlimited resource.) There also are no meters measuring how much water SNL takes in as a whole; most of its water comes from wells owned and operated by Kirtland. Based on sewer flow, cooling tower evaporation rates, steam plant condensate losses and other factors, Darell Rogers, Sandia's Water Conservation Officer, estimates that Sandia used approximately 400 million gallons of water annually before any conservation measures were enacted.

> *SANDIA NATIONAL LABORATORIES*
>
> **1995 Water Use:**
> 400 million gallons*
> **1998 Water Use:**
> 324 million gallons*
> (19% reduction)
> **2004 Water Goal:**
> 280 million gallons
> (30% reduction)
> *estimated

Figure 7-1 shows Sandia's estimated water use by category. Even without a complete water audit, it was clear that the production of ultrapure water used in the microelectronics facility plus the water used for cooling and steam generation accounted for most of Sandia's consumption. Since these areas lent themselves to several easily implemented, high-return remedies, conservation measures were implemented in these areas first. Rogers says these early successes may help obtain the funding, resources and support for a more thorough audit and an institution-wide commitment to water conservation.

Microelectronics Development Laboratory (MDL).

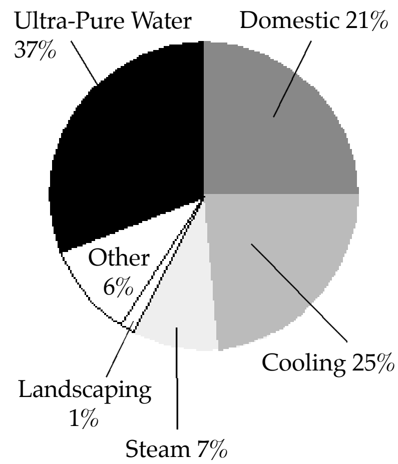
Ultra-Pure Water Production. Sandia's Microelectronics Development Laboratory uses ultrapure water to process semiconductor wafers. The facility had been consuming an estimated 128 million gallons per year. In 1996, more efficient, larger-surface-area reverse osmosis membranes were installed along with better valves for more precise control of the flow of water. Amanifold was also added to the reverse osmosis pump, which converted it to a more efficient two-stage pump. These changes reduced the lab's water use by 30-38 million gallons a year, resulting in savings of $78,000 in water and sewer costs. Moreover, because the reverse osmosis system is more efficient, it requires fewer hours of operation, resulting in an annual energy savings of $22,000. The total cost of the project was $107,113; payback was less than one year.

Reuse and Recycle Wastewater. Figure 7-2, a schematic of water flow in the Microelectronics Development Laboratory (MDL), shows several recycling opportunities. The first phase of Option 4 was completed in 1997. Sandia now pumps a portion of MDL's processing waste water to an adjacent cooling tower. The water, considered too contaminated for reuse in the plant, is treated in an acid waste neutralization system prior to entering the cooling tower. This saves 8-12 million gallons of water and $20,000 per year.

Options 1 and 3 are currently being investigated. Recycling spent rinse water from the wet benches of a semiconductor facility (a "fab") and returning it for reuse to some node of the plant ultra-pure water (UPW) system offers the greatest opportunity for water savings in semiconductor manufacturing. In addition, because spent rinse waters, by most metrics, are of much higher quality than incoming municipal water, the quality of the UPW produced is enhanced by this tactic. Unfortunately, some spent rinse waters contain contaminants, typically organics, not found in municipal waters. Worse yet, certain of these contaminants can degrade the performance of other components in the UPW system such as reverse osmosis membranes and ion exchange resins. This risk perceived to be associated with rinse water recycling continues to limit the widespread acceptance of recycling at many U.S. semiconductor manufacturing sites in spite of the conservation, costs and performance advantages that could accrue. With today's billion dollar investment in a production facility, even a small interruption in production can cost more than a year's water savings.

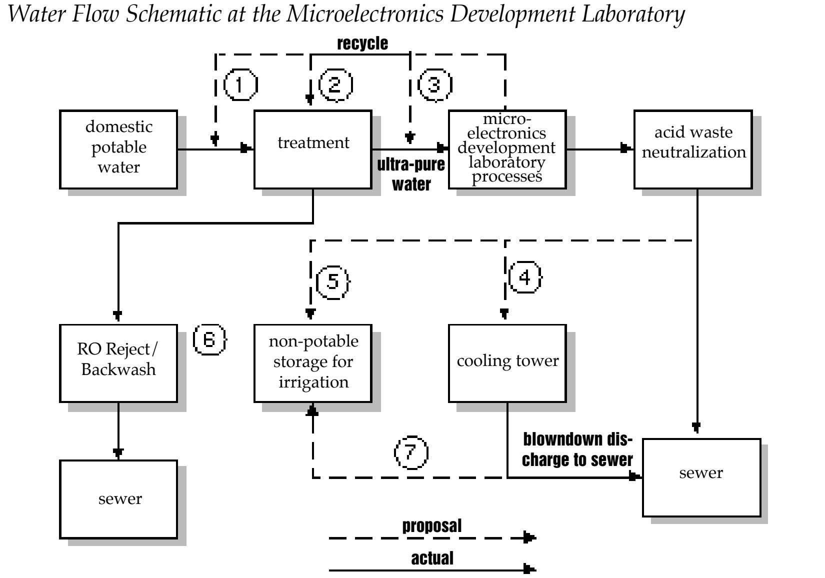
To minimize the recycling risk, SEMATECH, a consortium of chip manufacturers, funded a project at Sandia to develop and demonstrate near real-time sensors for detecting the presence of objectionable contaminants in the rinse waters collected for recycling. These fast responding sensors allow contaminated water to be diverted from the recycle loop before entering the UPW system, avoiding any of the upsets that so worry management and production staff. Incorporation of such technology, not yet completed, could reduce the MDL's water consumption by 50% and allow the US semiconductor industry to save on the order of 30 billion gallons of water per year.

Figure 7-1
1996 Water Consumption at Sandia National Laboratories



As a first step, engineers have separated the drainage systems of two kinds of discharge that occur during processing: (1) deionized water used in wafer rinse baths; and (2) various acids used to etch and clean the wafers in processing tanks. Keeping the higher quality

Figure 7-2
Water Flow Schematic at the Microelectronics Development Laboratory



rinse water apart from the acids should increase the amount of water that can be recycled. MDL is also looking into ways of recycling the acids themselves: on-site reprocessing and reuse of the acid in Wet Chemistry Process benches; collection and off-site reprocessing of the waste acid; and on-site use of the waste acid to regenerate ion exchange resins. This project, which cost $35,000 to implement, will reduce water consumption and wastewater discharge by 1-2 million gallons and save over $10,000 in operating and maintenance costs annually (thus providing full payback in 3.5 years).

Steam Plant

In continuous operation since 1949, the steam plant supplies an average of 680,000 kg/day of saturated steam for space heating and laboratory processes. Not surprisingly, it is a big water user. Through a series of projects begun in 1995, engineers have reduced water consumption by 15 to 25 million gallons a year, and have eliminated 11.5 million gallons a year of discharge into the sewer system, with a cost savings approaching $100,000 a year. The following water-saving measures have also dramatically cut energy and chemical costs:

Replacement of aging dealkylizer and improvement of synthetic resin. Before well or city water is converted to steam, it is processed through a dealkylizer to lower its pH and a water softener to remove minerals. Both systems now use a new resin, which, combined with higher dealkylizer efficiency, allows for the processing of 43% more water before the resin has to be recharged. Since recharging requires water, the new resin cuts the amount of recharge waste water by 1.2 million gallons a year. The new system also improves water quality.

Leaks repaired in the condensate return lines. The steam that condenses to water is valuable, not only because it can be used again, but also because its high temperature requires less energy to be reboiled to steam. Moreover, this water has already been treated. By repairing leaks in these lines, plant staff increased the amount of condensed steam recaptured from 52% to 68%, equivalent to 12 million gallons a year of water savings.

Reduced frequency of boiler blowdown. Minerals and treatment chemicals in water can precipitate out as scale inside a boiler. To prevent this build-up, the concentrated slurry is periodically removed in a process known as blowdown, which was producing an estimated 5.7 million gallons of wastewater a year. Greater water purity from the improved resin (see above) means that blowdowns are performed less frequently, saving about 2.7 million gallons a year.

Recycling cooling water. The plant uses cold water to cool feedwater pump bearings, fan bearings and conductivity meters (which monitor water quality). By channeling this water to the boilers instead of to the sewer, the plant now saves 6 to 10 million gallons per year.

Cooling Towers

SNL has 23 evaporative cooling towers that use an estimated 78 million gallons a year. While one can't do much about evaporation loss—that's the whole point of the process—there are ways to enhance the performance of the system. Typically, cooling towers are purged of concentrated water (blowdown) fairly often so operators don't have to worry about the towers scaling up. But this practice, with its large margin for error, uses more water than is really necessary. By closely monitoring the hardness of the water with conductivity meters, operators can more precisely determine when blowdown is needed, thereby saving 5 to 15 million gallons of water a year.

The "cycling up" (increasing the amount of input water relative to blowdown water) also saves on chemical costs since fewer blowdowns means the treatment chemicals stay in the system longer. Another beneficial byproduct: it was discovered that the water flow in the chillers was 25% below design specifications. When this is remedied, the efficiency of the chillers is expected to improve 6%, which will save $10,000 a year in energy costs.

Domestic

While bathrooms, kitchens and other domestic settings require far less water than the industrial side of SNL, they still present opportunities to conserve. ATransit Time flow meter (which uses ultra sonic waves to measure water flow) is being used to obtain a baseline for each building. Comparing water use with the number of people and activities in each building will help identify possible sources of waste and leaks (e.g., water flowing at midnight).

* More definitive water use totals will be available after meters are installed in 1999.

BORDER FOODS, DEMING

No discussion of New Mexico would be complete without chile peppers. And no survey of New Mexican businesses would be complete without Border Foods. One of the largest processors of green chiles and jalapeno peppers in the world, Border Foods roasts and processes approximately one million pounds a day and ships its Rio Luna brand of canned chiles to all 50 states and several foreign countries. And business is hot: over the last five years Border Foods has grown 300%. The company recently purchased a second plant in Las Cruces.

After peppers are delivered, they are washed. Chiles are roasted and peeled, jalapenos are de-stemmed. Then the peppers are inspected, cut or diced and acidified to prevent the growth of botulism. The seeds are removed and the peppers are heat treated to kill bacteria before they are canned or frozen. From farm cart to shopping cart, Border uses fresh water to wash raw peppers, carry away the peels, and cool the peppers after heat treatment. With the 200,000-square-foot plant running 20 hours a day, that works out to about 60 million gallons a year.

By law, Border cannot reuse the peppers' wash water. But the company has reduced its process water use 27% percent by recycling at two other stages in the production line. In 1992 the staff began recycling the peel-laden water by straining out the solids and chlorinating the water before it is used again to take peels away.
That brought water consumption down from about 0.70 gallons of water per pound of raw pepper in 1992 to 0.68 gallons per pound in 1993, which resulted in water savings of approximately 20,000 gallons per day.

Starting in 1994, Border also began reusing the cooling water after it was treated. Both recycling projects were expanded as the plant grew. Water use fell from 0.59 gallons per pound in 1994 to 0.51 gallons per pound in 1995. (After 1995, water use per pound went up because Border Foods increased production of its jalapeno peppers by 300%, and jalapenos are canned in brine water).

In addition, Border Foods recycles the 47 million gallons of wastewater it generates each year, using it to irrigate its nearby 100 acres of alfalfa and grass farms. The wastewater supplies all the water needed for irrigation.

BORDER FOODS

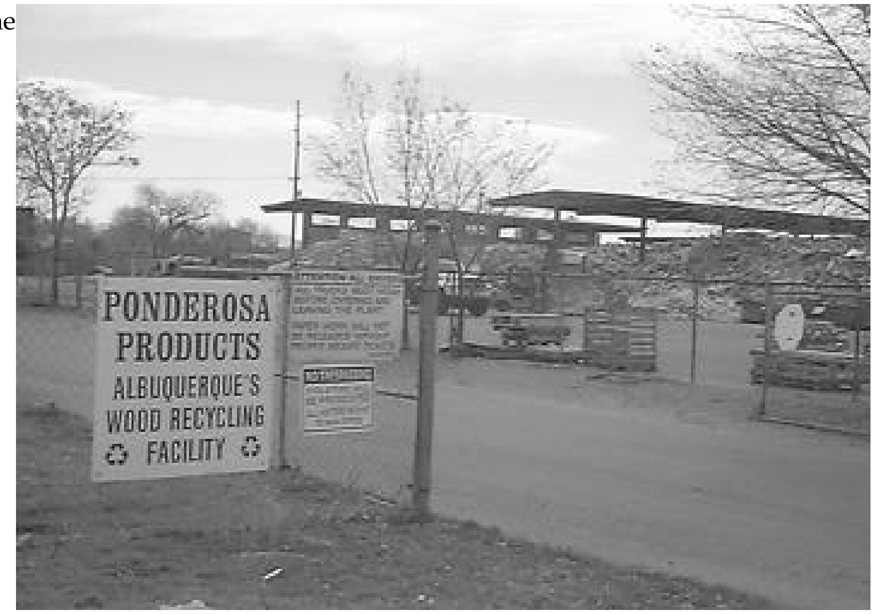
1992 Process Water Use:
0.70 gallons/pound of product

1995 Process Water Use:
0.51 gallons/pound of product

Water Savings: 27%

PONDEROSA PRODUCTS, ALBUQUERQUE

Chances are the stereo cabine or kitchen shelves in your home are made from particleboard—the kind of particleboard produced by Ponderosa Products. The Albuquerque plant, which has 130 employees and sales of $16-20 million annually, processes 500,000 pounds of scrap wood each day in the manufacture of particleboard.



The process of making particleboard requires water consumption in these two major areas:

1. Steam is used to heat up the 20-board press to more than 300 degrees F. While inside the press, wood chips are fused with a glue-like resin to become particleboard panels.

2. Wet scrubbers are used to remove wood dust from the factory's exhaust.

Ponderosa started investigating ways to cut back on water use in 1989 when it was using approximately 63 million gallons a year. At that time James Barham, Environmental Manager, estimated that the company could save about $148,000 a year in water costs.

Boilers

Barham's first project was to capture and reuse the steam condensate from the boilers. The boilers are used to make the steam required to heat up the particleboard press to more than 300 degrees F.

At first, the recovery rate was quite low, and very little condensate was recycled back into the boilers. But over the years, the project was expanded until today the recapture rate is about 50%. Ongoing efforts will attempt to increase the recapture rate even further.

Wet Scrubbers

Wet scrubbers use the most water in the plant, requiring about 330,000 gallons a day. In 1992, Ponderosa began recycling some of this water, which it was required to treat before releasing it to the sewer system. Using wire screens and other inexpensive materials from the local hardware store, the staff

PONDEROSA PRODUCTS

1989 Water Use:
63 million gallons

1998 Water Use:
27.3 million gallons

Water Savings: 57%

devised a system to remove solids and reuse the water in the scrubbers—thus saving approximately 90,000 gallons daily.

Further water reduction came in 1995 from replacing one wet scrubber with a baghouse (which functions much like a series of vacuum cleaners that filters out dust and particles without using any water). This equipment change saved Ponderosa 15,000 to 20,000 gallons a day. The company had originally purchased this wet scrubber at a time when water was considered cheap and bountiful—a situation that Ponderosa no longer felt applied to Albuquerque's water resources.

Ponderosa's efforts have resulted in a 57% drop in annual water consumption. Admitting that a drought and the water restrictions it could bring would cause major problems for the Ponderosa plant, Barham is continually looking for further ways to reduce water consumption. He gets ideas by brainstorming with employees. Then he inspires management to make changes, not an altogether easy task. "If you show management where they can save money, then their ears perk up," he says. According to Barham, the facility's long-term goal is to have zero discharge to the city's sewer system.

COMMITTED TO RECYCLING

Water isn't the only resource being recycled at Ponderosa Products. After particleboard is manufactured, it is sanded. The waste from the sanded material is called sanderdust, which is recycled: it is burned as fuel in the boiler.

Wood waste is also generated from the trimming of each board after it is manufactured. The trimmed material is recycled and used to manufacture more boards.

Since the plant's inception in 1969, Ponderosa has used more than 4 billion pounds of wood waste that would have otherwise been burned or buried in landfills.

EL REY INN, SANTA FE

New hotels are required to install water-saving toilets, faucets, and appliances. Older hotels, however, can be faced with the expensive prospect of retrofitting in order to conserve water. Fortunately, not all water-saving programs need to be expensive or high tech. In fact, curbing water use can be as simple as placing a printed card in each room asking guests to consider using their linens and/or towels more than once. These reminders, now found in more than 200,000 hotel guest bathrooms around the world, receive serious consideration by at least 70% of guests, saving hotel owners 5% on utilities costs, according to the Green Hotels Association.

The City of Santa Fe's Water Conservation Ordinance requires that a water conservation sign be posted in every public restroom. The city also provides conservation signs and cards for use in hotel and motel guest rooms.

The 86-room El Rey Inn has been using in-room water conservation cards for more than six years, and the staff reports that most people who stay for more than one day agree to forego having their sheets, and sometimes their towels, changed every day.

Holly Kenney, General Manager at the El Rey Inn, has also installed 1.5 gallons-per-minute showerheads as well as low-flow toilets. The performance of the low-flow toilets has been mixed, however. As a result, air-assisted versions are being installed whenever a bathroom is remodeled or repaired.

Kenney has also held a cash-prize contest for employees who submit water conservation ideas. Many of the ideas have already been implemented. Some, like catching rainwater from the roof for landscaping, may be implemented in the future. But the main purpose, according to Kenney, was to get her staff thinking about saving water—and by that criterion the contest was very successful.

EL REY INN

1995 Water Use:
1.42 million gallons

1997 Water Use:
1.19 million gallons

Water Savings: 16%

WATER CONSERVATION ASSISTANCE FOR HOTELS

The Green Hotels Association® publishes a newsletter for member hotels that includes water- and energy-saving ideas. The association's mailorder catalog offers water conservation products including toilet tank fill diverters, aerators, low-flow massaging showerheads, and other products. For more information contact: Green Hotels Association, P.O. Box 420212, Houston, TX 77242-0212; (713) 789-8889; fax (713) 789-9786; www.greenhotels.com

MARRIOTT HOTEL, ALBUQUERQUE

At the corporate level, Marriott Hotels takes energy and water conservation very seriously. Conservation is integral to Marriott's facilities management and its bottom line. The corporation strives to support its hotel engineers by providing easily accessible, up-to-date information on saving water.

The 17-story Albuquerque Marriott has aggressively clamped down on water waste. Employees have been trained in the importance of water conservation, and are briefed every day during every shift to spot and report potential problems. The hotel's dedication to water conservation has generated impressive results in the following areas:

MARRIOTT HOTEL

1994 Water Use:
42.19 million gallons

1998 Water Use:
26.8 million gallons

Water Savings: 36.5%

Grounds

Much of the facility's water savings resulted from watching for leaks in the irrigation system and repairing any faulty lines or valves immediately. In 1996, the staff discovered a leak that had probably gone undetected for years. Another leak in the 18 year-old system was detected in the summer of 1998, which cost the hotel close to 1 million gallons (and may partially explain why the facility's 1998 consumption increased from the previous year).

Prior to 1997, the hotel replaced many of its high-water-use plants and trees with drought-tolerant varieties. Where appropriate, the staff eliminated sprinkler systems and converted to drip irrigation. Efficiency timing tests were performed on all outdoor irrigation zones to study how long it took for the turf to become adequately saturated. This information was used to reduce watering times.

Erik Rems, Director of Engineering for the Albuquerque Marriott, is working toward metering the landscape irrigation system separately from the hotel's interior water system so that leaks can be detected and fixed more quickly.

Guest Rooms

In 1997, water-displacement devices were placed in the existing toilets of all 411 rooms, saving 1 to 1.5 gallons per flush (approximately .5 million gallons annually). The following year, the hotel replaced the 2.5 gallons/minute sink aerators in each guest room with 1.5 gallons/minute fixtures. The new aerators are expected to save between 160,000 to 165,000 gallons a year.

Ice Machines
More savings came from modifying the six water-cooled ice machines. Instead of running the water through the machines and then sending it down the drain, the staff reconfigured the pipes so that the water re-circulates in a closed loop, saving approximately 1 million gallons a year.

Laundry
The staff met with the hotel's laundry vendor to fine-tune all of the laundry equipment. Scales were installed to ensure that load sizes were optimum. In 1997, the hotel replaced three of its washers with new, more water efficient models. Rems plans to replace one more washer in the next few years. He is also considering recycling laundry graywater by using the last rinse water to start the next load in a new wash cycle. He expects this will save about two gallons per occupied room (approximately 230,000 gallons a year).

Kitchens
When it started its water conservation program in the mid 1990s, the Albuquerque Marriott set up a maintenance program in the kitchen, banquet and "back of the house" areas, replacing malfunctioning equipment and fixing leaks right away.

Swimming Pool
Pool equipment is regularly inspected to ensure proper operation. Rems is researching the possibility of temporarily pumping out and storing the 30,000 to 40,000 gallons of pool water when major maintenance (i.e. repainting or acid washing) is undertaken. After the job is completed the water would be pumped back into the pool. "I'd never even dream of dumping out that water," he said.

MISSISSIPPI POTASH, CARLSBAD

Mississippi Potash (MPI)—a division of Mississippi Chemical Corporation of Yazoo City, Mississippi—operates three plants in Carlsbad 24 hours a day, seven days a week, 365 days a year. The company produces potash (potassium chloride), which is used as an agricultural fertilizer and industrial-grade chemical, from carbonate minerals mined 2,000 feet below the surface. The raw ore is cut, crushed, transported by conveyor belt, hoisted up out of the mine, and transported to the mills. From July 1997 through June 1998, the company mined 5.3 million tons of raw ore and produced 922,555 tons of potash.

Milling Process

At the East Plant, raw ore is crushed and dissolved into a concentrated sodium and potassium brine solution ("leach brine") creating a slurry, and through phase chemistry, potassium chloride (KCl) salt is extracted. The sodium mineral is separated from the potassium mineral and discharged as a waste salt to the tailings pile. The tailings brine water is decanted and flows to the catch basin at a rate of 1,450 gallons per minute.

> *MISSISSIPPI POTASH*
>
> **Without recycling:**
> 2.18 billion gallons a year
>
> **With recycling:**
> 1.05 billion gallons a year
>
> **Water Savings:** 52%

Insoluble minerals are extracted and discharged to a disposal area known as Laguna Toston at a rate of 1,000 gallons per minute, of which 600 gallons per minute is water. Discharge to Laguna Toston is lost to infiltration and/or evaporation.

Fresh water used in the plant for wash down is collected and returned to the mill. Less concentrated brine water in the catch basin is pumped back to the mill for reuse at a rate of 1,200 gallons per minute. Air pollution control equipment (wet scrubbers) utilize recycled water for removing particulate matter from the emission stream. Each of three wet scrubbers use 40-60 gallons of fresh water and 80-120 gallons of recycled water per minute.

At MPI's West Plant, the raw ore is dissolved into concentrated brine solution creating a saturated brine slurry. The slurry is conditioned with a chemical known as a "collector," and, through a flotation process, potassium chloride mineral (KCl) is extracted.

Sodium chloride salts left on the bottom of the agitation tanks are pumped off as discharge to the tails pile. As the tails brine solution flows and cools, salts precipitate naturally creating a tails pile. Decanted brine water continues to the catch basin at a rate of 300 gallons per minute. Decanted brine water in the catch basin is pumped back to the mill for reuse at a rate of eight hundred (800) gallons per minute. The air pollution control equipment (wet scrubber) utilizes recycled water for removing particulate matter from the emission stream. The wet scrubber uses 40-60 gallons of fresh water and 140-150 gallons of recycled water per minute.

MPI's North Plant receives granular potash from the West Plant via truck. Under-sized material is compacted by pressing into a cake and run through a flake breaker. Compacted potash is screened again for size with the granular conveyed to the product storage warehouse. Wet scrubbers utilize recycled water for removing particulate matter from the emission stream. Each of the two wet scrubbers use 40-60 gallons of fresh water and 70-80 gallons of recycled water per minute.

Water Conservation

According to Jeff Campbell, Environmental Coordinator, all of Mississippi Potash's personnel are aware of the current water situation in New Mexico and are instructed to minimize water use as much as possible. All MPI plants conserve water by collecting, impounding, and recycling water. (MPI has no landscaping and utilizes low-flow toilets.)

The East Plant milling process requires 3,300 gallons per minute of water. Through collecting and recycling brine water, only 1,500 gallons per minute of fresh water is used in the plant. The use of recycled brine water saves 1,800 gallons per minute.

The West Plant milling process requires 1,100 gallons per minute of water. Through collecting and recycling brine water, only 300 gallons per minute of fresh water is pumped to the plant from the Caprock water well field. The use of recycled water nets a fresh water savings of 800 gallons per minute, or nearly 73%.

The North Plant compaction process requires 200 gallons per minute. Between 40-80 gallons of fresh water and 70-80 gallons of recycled water per minute is used for dust suppression and wet scrubber water supply. The use of recycled water saves 70-80 gallons of fresh water per minute.

Table 7-3

MISSISSIPPI POTASH WATER USE

Plant	**Ogallala Aquifer Fresh Water (gpm)**	**Plant Process Water Demand (gpm)**	**Conservation Via Recycle (gpm)**
East	1,500	3,300	1,800
West	300	1,100	800
North	200	0	80
Total	**2,000**	**4,150**	**2,680**

LA VIDA LLENA LIFECARE RETIREMENT COMMUNITY, ALBUQUERQUE

As the center's name suggests, residents of La Vida Llena Retirement Community enjoy "the full life," but they try to do it without wasting water. With 300 apartments and a 100-bed health care center situated on 20 acres, La Vida Llena is one of Albuquerque's largest retirement communities. Residents do not pay for water directly.

From 1994 to 1998, La Vida Llena reduced water use by 34.3 million gallons of water per year, a whopping 83% decrease. A large part of the community's water savings has come from diligently inspecting for leaks. In 1998, the staff discovered a multitude of irrigation leaks, one cooling tower leak, several boiler leaks, and a major water seepage under a kitchen floor. For months, the kitchen staff had noticed the floor was unusually warm, but it wasn't until the floor was dug up that the 15 gallon-a-minute hot water leak was discovered. Before it was fixed, this leak cost La Vida Llena thousands of gallons of water and countless dollars in wasted energy.

LA VIDA LLENA

1994 Water Use:
41.2 million gallons

1998 Water Use:
6.9 million gallons

Water Savings: 83%

La Vida Llena's water conservation program also included changes in the following areas:

Grounds
In the five years prior to 1999, La Vida Llena converted about 20 percent of its approximately 5 acres of landscaping to xeriscaping. The staff replaced inefficient, oversized sprinkler heads and adjusted watering times after saturation tests revealed they had been overwatering many areas. And, instead of addressing leaks only when someone happened to notice water flowing, La Vida Llena's grounds vendor now monitors the irrigation system for leaks on a weekly basis.

Cooling Towers
La Vida Llena was losing water in its cooling towers because no one in-house had been trained to properly apply and monitor scale inhibitors. In 1997, the community hired a contractor to manage its cooling towers more efficiently. According to Jaime Beltran, Director of Environmental Services, the cooling tower blowdown is only about 5 to 10% of what was once discharged into the sewer.

Pool and Spa
Beltran had the opposite problem with the pool and spa. The pool service company was adding chemicals indiscriminately and would often have to dump half the pool water to get the chemicals into control. When La Vida Llena cancelled its contract with that pool service company in 1997, the retirement community not only saved water but improved the pool's water quality as well. The maintenance staff installed better filters

and a high-flow-rate pump (so that water is filtered more frequently). Most importantly, the staff tests the pool chemistry continuously, adding chemicals only when needed. As a result, only 100 gallons of water is lost each week to evaporation and backwashing, compared to the thousands of gallons wasted previously.

Bathrooms
Even in the summer with the evaporative coolers running, toilets and showers use the most water. Since the fall of 1997, Beltran has been installing water-saving low-flow showerheads on a regular basis. He has also changed out about 10% of the toilets from 3.5 gallon to 1.6 gallon models. "Some residents are reluctant to go to low flow," he says. "The general perception is that they don't flush as well—although our residents have been satisfied with the performance of low-flow toilets." Moreover, unlike conventional apartments where managers can change fixtures when a tenant vacates, La Vida Llena's residents are often there for years or even decades. "They have had these toilets forever, so they don't want to change," says Beltran.

Education
With its own in-house TV station, La Vida Llena has an easy way to get the word out about reducing water use, and from time to time it discusses low-flow fixtures and other aspects of conservation. However, notes Jack Booth, Executive Director, many of the residents are very active in the Albuquerque community, and more often than not it is the residents who bring back information on water conservation to give to La Vida Llena's management.

TUSCARORA INC., LAS CRUCES

Tuscarora is one of the world's largest manufacturers of custom molded foam packaging used to cushion stereo components, computers and other equipment. The Las Cruces plant is one of 35 Tuscarora plants worldwide. The company, conscious of environmental concerns, supports recycling of expanded polystyrene packaging. And led by its Las Cruces and Juarez, Mexico plants, Tuscarora has also taken steps to reduce its water consumption.

While production at the Las Cruces plant increased 40% from 1995 to 1996, water use only rose 10%. In 1997, production increased an additional 12%. Even with the dramatic increase in plant production and a change in manufactured product from expanded polystyrene to expanded polypropylene (which requires more process water), the plant has reduced water consumption from its 1994 pre-conservation baseline rate. The company has implemented the following water conservation measures:

Recycle Cooling Water. Tuscarora uses steam from a boiler to expand foam pellets and then fuse them inside a mold. Once the desired material density is reached, water cools the material to prevent it from expanding further outside the mold. The plant had recycled this cooling water for several years, but in 1995 the staff installed new equipment that significantly increased the amount of water that can be recycled. Randy Boles, plant manager, says that with recirculation, the system consumes five times less water than the previous single pass cooling.

Install Reverse Osmosis Unit. Another source of water savings has come from replacing softeners and potentially dangerous chemicals with a reverse osmosis (RO) system that removes dissolved solids from the water destined for the boilers. The RO unit was an expensive capital outlay, but it is inexpensive to run. By decreasing the need for blowdown, the RO unit saves water and the cost of treatment chemicals, which could present problems for the treatment of the waste water. Anticipated payback period for the RO capital cost is less than five years.

Install Meter. The company also has installed a meter to measure the waste water leaving the plant. This helps to monitor the plant for leaks or other manufacturing process anomalies.

All these measures helped to reduce water use. But merely examining water use statistics can be misleading, as noted above. For example, Boles says the plant stopped processing expanded polypropylene in mid-1998, and this change alone should result in significant water savings in 1999.

"We are continually making improvements—both small and large—to reduce our water consumption," said Boles. "We learn from other Tuscarora plants and they learn from us. If any plant finds a way to save money or resources, it's spread throughout the company to different plants. I'm proud to say that the Las Cruces plant and the one in Juarez have been instrumental in changing water use company-wide."

TUSCARORA INC.

1994 Water Use:
23.4 million gallons

1998 Water Use:
20.5 million Gallons

Water Savings: 12.4%

HONEYWELL HOME & BUILDING CONTROL, ALBUQUERQUE

Honeywell is a worldwide maker of heaters, fans, humidifiers, vaporizers, electronic air cleaners, water filtration products, thermostats, and home security systems. The Albuquerque plant, with more than 250 employees in 110,000 square feet, assembles thermostats, building controls, and commercial burner and boiler controls.

In 1994, water consumption at the Albuquerque plant was 8 million gallons a year. Most of this water went to assembly operations. Specifically, water was used to clean circuit boards before electronic devices were assembled.

By requiring the circuit board manufacturer to supply cleaner boards, by changing the type of flux used, and by improving its soldering process, Honeywell eliminated the need for process water. The result was dramatic: Honeywell's 1995 water consumption dropped to 3 million gallons a year, a 63% reduction.

Every year since then, the Albuquerque plant has reduced its annual water consumption by

HONEYWELL

1994 Water Use:
8,000,000 gallons

1998 Water Use:
1,419,000 gallons

Water Savings: 82%

500,000 gallons, an additional 50% reduction. This is how:

— **Bathrooms.** As part of its remodeling projects, Honeywell replaced toilets and urinals with low-flow, automatic flush models. There have been no problems with stopped-up toilets and maintenance costs have been reduced.

— **Humidifier.** The company installed a more water-efficient temperature and humidity control system. (In the process of upgrading the humidifier, facility engineers discovered a hidden water discharge pipe and replaced it with a closed-loop system to eliminate humidifier discharge water.) The new system reduced the plant's water consumption by over 350,000 gallons a year.

—**Landscaping.** Honeywell has achieved substantial water savings by modifying its landscaping. With help from the City Albuquerque engineers and the plant's landscaping contractor, unnecessary grass was removed, the irrigation system was redesigned, and an electronic rain sensor and timer was installed. These simple upgrades enabled Honeywell to use water more efficiently and reduce its landscaping water consumption by half.

According to Dave Colton, Facility Services Manager, here's what Honeywell learned:

"The Albuquerque plant views its water conservation efforts as an extension of Honeywell's worldwide commitment to resource and energy conservation, as well as its pledge to utilize environmentally sound production practices.

"We want to send the message to others that water conservation can be done with limited resources and money. We reduced our overall water consumption 82% without spending a lot of time, brainpower or money. We found we really can make a difference."

PRESBYTERIAN HEALTHCARE SERVICES, ALBUQUERQUE

Since its establishment 90 years ago, Presbyterian Healthcare Services has experienced healthy growth. In Albuquerque alone, Presbyterian now has 24 locations and more than 60 irrigated acres of landscaping. Amidst the growth, the healthcare organization became one of the city's largest water users. Under the direction of Lonnie Burke, water conservation coordinator, Presbyterian has also been honored as one of Albuquerque's top water conservers.

In the fall of 1995, Burke began the organization's water conservation program by studying water bills and conducting a water audit. It was no easy task. Presbyterian's main hospital campus on Central Avenue had grown to comprise more than 16 city blocks, resulting in a complex tangle of plumbing and energy infrastructure—and water waste. After auditing past water use, he began to install individual meters on equipment that used large volumes of water, including cooling towers, boilers, and irrigation systems. Burke used this information to determine the efficiency of these systems and to estimate water savings and cost payback of any proposed conservation projects.

PRESBYTERIAN

1994 Water Use:
145.2 million gallons

1998 Water Use:
118.3 million gallons

Water Savings: 19%

An unanticipated benefit of the audit was the discovery that Presbyterian had been overpaying for water services. In particular, Burke found that a number of meters at the main hospital were being charged for sewer services when they were used for irrigation only, and Presbyterian was paying for two eight-inch meters when it only had one. Moreover, the city computer was charging Presbyterian for water it did not use. Facility engineers would sometimes turn off one of three main meters to the main hospital to make repairs. While the water use at the meters was zero, the computer would assume the meters were faulty and would charge the hospital what typical water usage at that meter had been in the past. According to Burke, these discoveries saved Presbyterian $42,000 annually.

New Irrigation System

Presbyterian's largest water-use reductions have come from changes in landscape irrigation practices. According to Steve Tennyson, grounds maintenance supervisor, Presbyterian's past emphasis, common in the city, was to get the grass as green as possible without regard to water use.

Tennyson and crew began paying attention to water use versus water need. They replaced inefficient sprinkler heads with better quality models that provided a more uniform spray. As they did so, it became apparent that the irrigation system had to be upgraded. The staff also installed a master valve on the 32-acre northside campus so that water stops flowing in the irrigation line when the system shuts off—thus preventing water lost to leaks. With these relatively simple efforts, Presbyterian cut its irrigation consumption by 8.1 million gallons between 1994 and 1996.

Starting in 1997, Presbyterian began installing a computerized irrigation control system at the main and northside campuses. The new system monitors water use for each zone, detects broken lines or missing sprinkler heads, and shuts down the problem zone until it is repaired. Though still not complete, the new system, coupled with other conservation measures, brought down Presbyterian's irrigation usage to 67.9 million gallons in 1998—a 25% drop from the 1994 level. According to Tennyson, one year's worth of water savings paid for the initial $31,000 cost of the system.

Tennyson took advantage of training programs offered by the City of Albuquerque and by the national Irrigation Association before reducing lawn areas and installing xeriscapes. The two-acre San Mateo facility now has only 1,600 square feet of turf. The majority of the landscaping consists of moderate- to low-water-use plants and native trees on a drip irrigation system.

Other Savings

Additional water savings have come from these changes in Presbyterian's facilities:

— **Autoclave Condensate and Cooling Water Recycling.** Autoclaves use steam to sterilize surgical instruments, trays, and other medical equipment. Burke has already saved 0.5 million gallons annually by collecting the sterilizer steam condensate previously dumped down the drain and recycling it back to the boiler. Presbyterian also plans to replace at least one autoclave with a more water-efficient version, saving 1.8 million gallons annually.

Also in the works: Burke plans to reclaim the autoclave's cooling water, which is currently discharged to the sewer. Feeding this water to the cooling towers instead will save 8 million gallons a year and will provide two-thirds of the water required by the cooling towers.

— **Pump Replacement.** Medical pumps provide suction to remove bodily fluids, and medical air pumps supply purified air for breathing. Since older models are cooled and lubricated with water, substantial water savings can be reaped by replacing them with new oil-cooled versions. Indeed, at Kaseman Hospital, part of the Presbyterian network in Albuquerque, replacing two medical pumps in 1998 saved the hospital 2.6 million gallons annually. Burke is also planning to replace six medical vacuum pumps and four medical air pumps at the main hospital. He estimates this will save 5 million gallons annually.

— **Turning Off Water.** Burke noticed that six older x-ray developers were left running continuously at night after urgent care facilities had closed, wasting up to three gallons of water per minute. Burke asked technicians to turn off the water flow at night. "Sometimes it's really simple to save water," Burke said.

— **Bathroom Retrofits.** By early 1999, Burke had replaced 21 high-water-use toilets with 1.6 gallon commodes in heavily used public washrooms. Additional low-flow toilets, faucet aerators, and low-flow showerheads will be installed. By the time the bath room retrofit project is completed, Burke estimates savings of at least 6 million gallons a year.

— **Personnel Involvement.** Burke stresses that even the most comprehensive conservation plan can be derailed if the maintenance and trades staff are left in the dark. "By installing the parts wrong, or installing the wrong parts, you can make the investment in new equipment to save water useless," he said.

"If a maintenance person incorrectly changes out a tank flapper on a 1.6 gpf toilet without installing the proper part, the toilet could end up consuming 3.5 gpf. That's why the maintenance staff needs to understand that they are an important part of the program, and they need the proper training for the program to be successful."

—Lonnie Burke

LOS ALAMOS NATIONAL LABORATORY, LOS ALAMOS

Los Alamos National Laboratory (LANL) occupies 43 square miles of land in northern New Mexico. Owned by the U.S. Department of Energy, LANL has been managed by the University of California since 1943, when the Laboratory was established as part of the Manhattan Project to create the first atomic weapons during World War II. Today the Lab conducts programs in energy, nuclear safeguards, biomedical science, environmental protection and cleanup, computational science, materials science, and other basic sciences.

The largest institution and the largest employer in the area, LANL has approximately 6,800 University of California employees plus approximately 2,800 contract personnel. Its annual budget is approximately $1.2 billion.

As shown in Figure 7-3, water use at the Lab declined somewhat in 1993 and 1995. But overall, the demand for water has been increasing in recent years. This is due primarily to increased demand for cooling as new projects come on line. Electricity-intensive programs, such as the accelerator facility (which runs high-energy physics experiments) generate tremendous amounts of heat, which must be removed. Hence, the greater the electricity usage, the greater the demand for cooling and cooling tower water. Figure 7-4 shows the breakdown of water use. Clearly, cooling tower use overshadows all other uses, consuming 58% of the 488.1 million-gallon water budget in 1997.

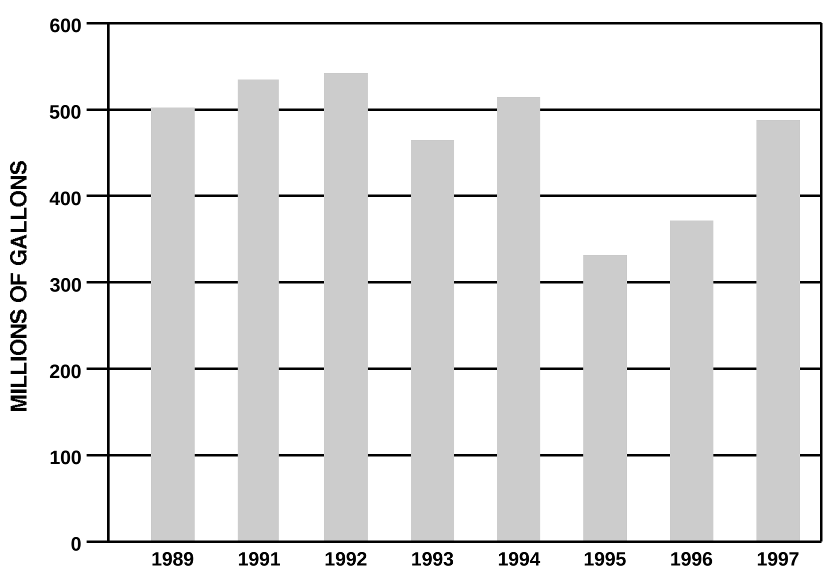
LANL

1994 Water Use:
524.8 million gallons

1997 Water Use:
488.25 million gallons

Water Savings: 7%

Figure 7-3: Water Use at Los Alamos National Laboratory



Due to limited water rights, LANL is allowed to consume a maximum of 541.6 million gallons per year. Already, however, the Lab is using about 90 percent of that amount. Any future growth will depend, in part, on aggressive conservation measures, says Jim Scott, Laboratory Associate for the Environmental Stewardship Office.

LANL has already saved 20.2 million gallons a year by reusing treated sanitary wastewater in the power plant cooling towers. Further savings may come from reducing the 88 parts per million of silica in the water sent to the cooling towers (a silica concentration slightly above that at Intel, see pg. 78). Silica precipitates out as scale, inhibiting the performance of cooling towers. Treated water will enable LANL to operate the cooling towers longer before they must be purged of scale-forming minerals.

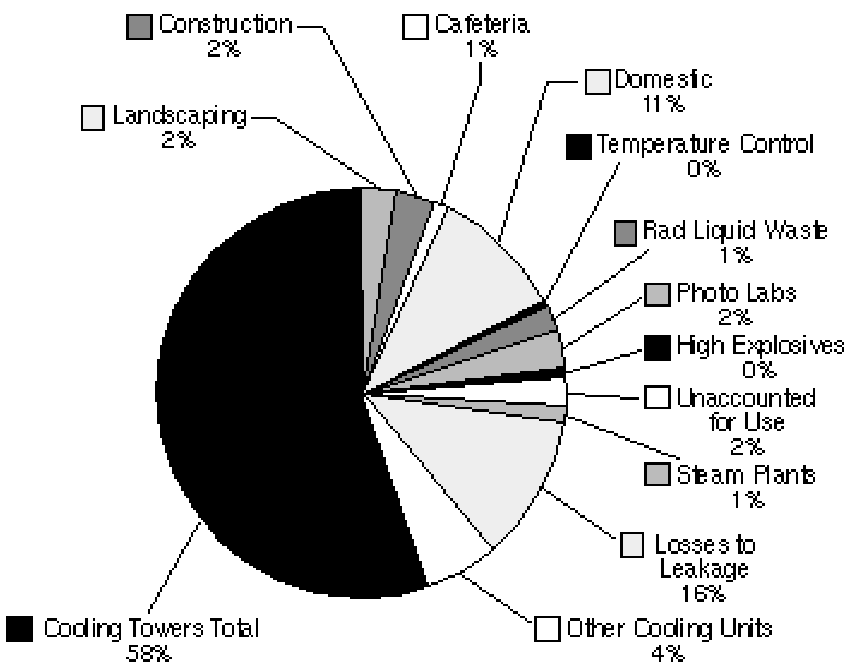
The following projects are either planned or underway:

Cooling Tower Water Efficiency Project. Los Alamos National Laboratory intends to fund pilot programs on mobile cooling towers to demonstrate various water-efficient technologies including reverse osmosis treatment. It will also explore enhanced sanitary wastewater reuse. The Lab expects water savings of about 114.0 million gallons a year from cooling tower conservation and about 94.5 million gallons a year from wastewater reuse. The project will be completed in 2002.

Leakage Repair Project. Leakage losses in the Lab's distribution system account for an estimated 16% of total usage. By identifying and repairing the leaks, the Lab will save an estimated 65.2 million to 97.8 million gallons a year. An audit to detect leaks will be completed by September 1999.

Domestic Fixtures. Low-flow fixtures will be used in all new construction. Scott estimates this will save 8.2 million gallons a year. If all existing fixtures in the laboratory were replaced, domestic water consumption would fall by 25.4 million gallons.

Figure 7-4
Los Alamos 1997 Water Usage:
1,498.39 Acre-Feet/Year (AFY)



HILLCREST PARK, ALBUQUERQUE

Built as an apartment complex in 1972 and converted to 268 condominiums in 1979, Hillcrest Park was honored with a water reduction award by the City of Albuquerque in 1998.

In 1994, with water consumption running at 24.9 million gallons annually, the homeowners' association board developed a 10-year plan to improve the property while saving water and energy. The association had an incentive to reduce water use because it pays for water and gas, while individual owners pay their own electric bills. Using association funds (collected from homeowners fees), the board took action.

Low-Flow Showerheads. In 1995, low-flow showerheads were installed, as were low-flow valves in the toilets.

Ultra-Low-Flow Toilets. Taking advantage of the City of Albuquerque's rebate program, the Hillcrest homeowners' board offered to install, free of charge, a new low-flow toilet in every homeowner bathroom. All but 10-15% of the owners took the board up on its offer, and more than 300 low-flow toilets were installed. (The cost to the homeowners' board was $45 for each toilet.) Much of the small resistance centered on worries the toilets wouldn't flush properly and stop-ups would occur. According to Hillcrest Manager Joan Justus, there are far fewer plumbing complaints with the new, ultra-low-flow toilets than there were with the older, higher-water-consumption toilets. Moreover, after the reluctant owners saw how well their neighbors' toilets worked, they wanted new toilets, too. The Hillcrest board expected the toilets to pay for themselves in three years, but, in fact, the savings were almost immediate.

HILLCREST PARK

1994 Water Use:
24.9 million gallons

1998 Water Use:
17.1 million gallons

Water Savings: 31%

Landscape Modifications. With the help of Doug Bennett in Albuquerque's Water Conservation Office, the homeowners' association revamped Hillcrest's landscaping in 1997. More than 25,000 square feet of water-thirsty bluegrass was replaced with bark, rocks, trees, and 5,000 square feet of drought-tolerant grass. The irrigation system was modified to accommodate the changes, and sprinkler heads gave way to water-efficient bubblers and misters.

"When Doug Bennett first came out for a site inspection, we discovered we were watering the street and the sidewalk," said Justus. "That's when we realized we had to do something. Now the landscape is gorgeous. In one area we have a flower bed and the water savings pays for the flowers year round."

Swimming Pool Savings. Hillcrest has also stopped draining the pool every year unless it needs resurfacing or other maintenance. And the complex makes sure the pool is well maintained with an efficient skimmer, pump, and filter system.

Why Conservation Worked

According to Justus, the water conservation efforts at Hillcrest Park were successful because the homeowners are environmentally minded and wholeheartedly supported the program. (A plaque in the Hillcrest Park office proclaims a commitment to be good stewards of the community and the world—and the homeowners back up the words with action.)

"It did take a lot of work and research by the board of directors," said Justus. "But we have saved so much money and water. The toilets paid for themselves, and the showerheads paid for themselves. We are quite proud of what we have accomplished, and we are surprised that more residential communities have not done the same things."

ETHICON ENDO-SURGERY, ALBUQUERQUE

Ethicon Endo-Surgery Inc. is a Johnson & Johnson company, which has been in Albuquerque since 1981. Employees at the 220,000-square-foot Albuquerque plant assemble, sterilize, and package advanced surgical instruments for videoscopic and traditional surgery.

In 1990, Johnson & Johnson launched its Worldwide Environmental Practices Program and Pollution Prevention Goals, setting new performance standards for each of its facilities around the world. At that time the Albuquerque plant's appearance matched that of the corporation's other sites with its signature white buildings surrounded by an expanse of verdant lawns. The lawns were so lush and extensive in fact, that golfers looking for the University of New Mexico's championship golf course next door frequently wandered into Ethicon to ask where they should go to pay their golf fees.

But as Ethicon grew aware of the need to save water, the Facilities and Environmental group was faced with a challenge: how to reduce water consumption without sacrificing the visual impact of the Johnson & Johnson park-like "look." In 1991, that lush look required 32.3 million gallons of water and five acres of Kentucky bluegrass at the Albuquerque plant. By 1998, however, Ethicon had cut the turf acreage by almost 50% and irrigation consumption was down 81% to 6.2 million gallons a year.

ETHICON

1991 Water Use:
53.3 million gallons

1998 Water Use:
27.1 million gallons

Water Savings: 49.2%

Overall, Ethicon's total water consumption fell from 53.3 million gallons in 1991 to 27.1 million gallons in 1998, a 49.2% decrease. Ethicon managed to cut back on water even though its production output more than doubled and its staff went from 700 to 900 employees.

Water conservation is part of a broader Johnson & Johnson program to save energy and reduce waste, air emissions, paper use, and pollution. Each plant is graded on how well it meets the J&J "Pollution Prevention Goals" every year. Albuquerque's Ethicon facility consistently scores well on all goals, and especially water conservation. The plant also received high marks from the City of Albuquerque, which, in 1997, gave Ethicon an award for reducing its water use.

Grounds

Ethicon retracted the grass three feet around the entire drive and parking areas and installed drought-tolerant plants that are watered only with the overspray from the lawn sprinklers. The company replaced grass with rocks in the parking lot dividers. The groundskeepers have experimented with native grasses in less visible areas to determine possible substitutes for grass in lawn areas. Finally, in 1998 Ethicon replaced a section of lawn at the main entrance with a xeriscape garden, inviting employees to join in the designing and planting. "Initially when we took some of the grass away, we got a lot of negative comments," says Juan Cedeno, Senior Environmental Engineer. "But now associates appreciate not only the fact that xeriscaping saves water, but also the beauty native vegetation can offer to our landscapes."

Plant

Ethicon's cooling towers use about 6-8 million gallons of water a year and the boilers consume over 3 million gallons annually. In 1992, Ethicon began reusing cooling water from its vacuum pumps system as make-up water for the cooling towers and boilers. Reconfiguring the once-through cooling system saved 2.1 million gallons of water annually.

Prior to 1994, steam from Ethicon's boilers was used for humidification purposes on the production floor and in the sterilization process. In 1992, Ethicon installed equipment to recover much of the condensate that was then going down the drain and pipe it back into the boiler. Cedeno estimates the $1,000-$1,500 project saved approximately 3 million gallons of water a year. And since the recovered water has already been treated for corrosion and scaling (and it is still warm), the project saves $10,250 a year in water, energy, and chemical costs.

Ethicon also worked with its chemical vendor to develop an optimum blend of scale and corrosion inhibitors to minimize the need for blowdown, or purging of mineral-rich water from the cooling towers and boilers. Like Sandia National Laboratories, the plant also uses a conductivity meter to fine tune blowdown frequency.

In 1998, Ethicon's maintenance mechanics added meters to monitor the amount of water going into the boilers and cooling towers. Previously, water usage was watched indirectly, based on the amount of scale inhibitors and other chemicals being used. The problem with this approach is that, if there is an undetected leak somewhere, it could take a very long time to identify and locate.

Domestic

Because Ethicon makes sterile medical devices, the company is regulated by the Food and Drug Administration, which requires that employees wash their hands every time they go onto the production floor. With 900 employees, that can add up to a lot of water. Originally, Ethicon installed push-down faucets that supply water for a set amount of time. But these types of faucets can sometimes malfunction, thus wasting water. In 1996-1997, the company installed faucets with infrared sensors for automatic on-off control.

"Little things can mean a lot of water saved. Sometimes small projects can generate large savings in water conservation."

—Juan Cedeno

UNIVERSITY OF NEW MEXICO, ALBUQUERQUE

The 775-acre University of New Mexico is situated in a park-like setting where students talk in plazas, study under trees, and play Frisbee or soccer on 60 acres of cool green turf. Maintaining the garden ambience with its grass and thousands of square feet of plants and shrubs requires a lot of work. And, not surprisingly, a lot of water.

In the past five years, UNM has made a major commitment to water conservation, and the university has impressive results to show for its efforts: since 1994, overall water use is down 39%. Most of these savings have come from efforts to conserve exterior water use throughout the university grounds and at its two golf courses. Additional efforts have cut water use inside its buildings and facilities.

Grounds

"Significant water savings can be accomplished by eliminating leaks, overwatering, oversprays, and by using low-water-use plants and mulches," said Mary Vosevich, associate director of UNM's Environmental Services Division. "We also avoid high maintenance areas that offer little payback, such as curbside strips of grass."

UNM

1994 Water Use:
1,028 million gallons

1998 Water Use:
625.7 million gallons

Water Savings: 39%

To reduce landscape water use, UNM has focused on the following areas:

Grass. UNM's Kentucky bluegrass turf was installed back when little or no thought was being given to water use. As more drought-tolerant grass types became available, UNM considered changing to a new variety, but the groundskeepers soon discovered that seeding from scratch on a busy 25,000-student college campus was a losing proposition. Similarly, tests showed that drought-resistant buffalograss did not survive trampling very well. UNM settled on overseeding bluegrass with fescue, which reduced water use by an estimated 10 to 15%.

Soils. Made primarily of eroded granite, central New Mexico's highly granular soil lets a lot of water percolate through and escape out of the reach of roots. UNM now prepares its flower and groundcover soil with an Agri-soak type of material that retains moisture.

Irrigation. UNM's old irrigation system was a patchwork of independent systems controlled at more than 100 different sites. This caused considerable waste, with sprinklers turning on during the rain and broken sprinkler heads gushing water undetected for hours.

In 1994, UNM began converting the old system into a centrally controlled, computerized system that responds to environmental conditions. Each site is customized; the computer knows how much water is needed under normal conditions based on slope, shade, student traffic, and other factors. The computer gathers data every two minutes from a weather station monitoring changes in wind, temperature, humidity, and precipitation. Then the computer make adjustments, watering less on cloudy or windy days. The computer also shuts off the water when the temperature dips below freezing. In addition, the system will automatically alert grounds management and cut off water to an area if it detects too much water flow (indicating a leak or broken head) or too little water (indicating a clogged head or line).

By the spring of 1999, UNM had converted about 20% of the campus's landscape to computer controls, including the sports field near the gym. Additional areas will gradually go on line until the system is campus wide, reducing UNM's irrigation consumption by an estimated 25 to 35%.

Vosevich acknowledged that the computerized system is a convenient tool, but to get the full benefit requires constant oversight. "It should never be used to replace the person in the field who can evaluate the condition of the plants and stick his or her hand in the ground," she said.

Landscaping. To avoid runoff into streets and parking lots, UNM has installed gravel borders immediately adjacent to parking areas. The university has converted some areas to xeric landscaping, and it has plans for a xeriscape demonstration garden to educate the public about low-water plants.

Golf Courses

UNM has two golf courses: the 240-acre South Championship Course built in 1965 and the North Course, Albuquerque's second oldest, with 9 holes on 70 acres. UNM estimates that nearly 263.8 million gallons, or 42.2% of the university's total water use in 1998, occurred at its two golf courses. Because the golf courses account for such a high percentage of water use, UNM has concentrated much of its water conservation efforts at the golf courses. These efforts have paid off: from 1994 to 1998, water used in irrigating the golf courses dropped 35.2%.

Much of that improvement came from modifying the plumbing of the original irrigation design (which sometimes flooded parts of the course) to make it more water efficient. According to Randy Hisey, course superintendent since 1997, "The secret to managing turf is to develop a healthy root system." Hisey estimates that he has doubled the root length from 1-1.5 inches to 3 inches. Deeper roots mean the turf can draw moisture from a greater volume of soil, which means it requires less water. Hisey has cut water use by:

— Instituting a better fertilization program. Hisey cut down on nitrogen and uses organic phosphorous and potassium, which he says are better for the roots and which build denser cell walls. This fertilizer makes turf more drought resistant.

— Watering more deeply to develop the root system, while cutting back on overall watering time.

— Practicing vericutting, which thins out grass like a comb, allowing for better water percolation and deeper roots.

— Increasing the aeration of the turf.

— Conducting field audits to see which areas need more or less water.

— Replacing a variety of sprinkler heads having different flow rates with heads discharging water at the same rates. This produces more uniform coverage and reduces the need for spot watering.

— Capping off sprinkler heads that were not needed.

Hisey has also recently installed a computerized system to regulate water flow. The system's centralized control makes the course easier to manage, and it takes out some of the human error. In the previous system, watering times were set for each station, regardless of how much water was flowing to the heads. Now, by taking into account variations in water pressure and flow, the computer applies the correct amount of water. Hisey says a similar system at the City of Albuquerque's Los Altos course eliminated dry and wet spots and cut water usage by 25%.

Further water savings are expected from the elimination of 40 acres of turf in the South Course. Hisey also plans to obtain a weather station, which will determine environmental conditions more accurately and more easily than the currently used evapo-transpiration (ET) monitors.

Buildings and Facilities

Outdoor water use overshadows the university's indoor use, but inside use is far from insignificant. UNM has 7 million square feet of facilities that operate virtually 24 hours a day.

The increasing use of computers, lasers, and other high-tech laboratory equipment has meant a greater demand for cooling. As a result, all new buildings are being designed with a chill water system for cooling. This closed-loop system requires no additional make-up water. In addition, low-flow faucets and toilets will be installed in all new construction (including the recent projects at Popejoy Hall, the Health Sciences Center, and UNM Bookstore).

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