SAND97-1403C
SAND--97-1403C

# THE INTEGRATED WATER CONSERVATION PROGRAM AT SANDIA NATIONAL LABORATORIES

CONF-970854--

RECEIVED
SEP 23 1997
OSTI

Darell Rogers. P.E.
Site and Systems Engineering
Sandia National Laboratories
P.O. Box, MS 0901
Albuquerque, NM 87185
(505)844-5842
(505)844-5318 FAX
dmroger@sandia.gov

(Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-ACD4-94AI85000)

## I. INTRODUCTION

Sandia National Laboratories (SNL), located on Kirtland Air Force Base (KAFB) in Albuquerque, NM, is implementing a comprehensive water conservation program. Because the average rainfall in this metropolitan area of 500,000 is approximately 8 inches per year, conservation of this precious resource is critical to the economic health of the city and state, and the continued operations at SNL/NM.

The future water supply for Albuquerque is a dominant water issue in New Mexico. Public-supply, industrial and military water requirements in the Albuquerque area are primarily met by ground water from the Albuquerque Basin. Ground water in the basin is the only current water supply utilized for the City, and recent studies indicate that the most productive zone of the aquifer is much less extensive and thinner than was formerly assumed. Water level declines, greater than predicted by hydrologic investigations in the 1960's, have occurred in the basin. Furthermore, the potential for ground-water contamination in the basin, particularly by natural occurrences of arsenic, is of concern to water-management officials. This situation has caused the City to reassess its future water needs and evaluate the potential effects of the city water use on ground- and surface-water resources in the Albuquerque Basin. As a major employee, significant water user , and long-standing member of the Albuquerque community, SNL/NM is committed to City's effort to preserve the integrity of the Albuquerque Basin for future generations.

SNL/NM consists of six separate locations, comprising 17,832 acres, within the boundaries of KAFB. There are a total of 1765 building and structures, 534 of which are greater than 1000 $ft^2$, totaling 6,700,000 $ft^2$. Building types include office buildings, laboratories, warehouses, and trailers. The SNL/NM staff consists of 7,330 Sandia Corporation employees, 585 students, and 1,724 contractor employees.

As with many DOE facilities constructed during the 1940s and 1950s, meters were not installed to measure water use. SNL/NM is taking a novel approach to conducting its site-wide water audit without the use of meters to establish a water balance for SNL/NM. The water audit uses sanitary sewer flows; employee counts at building and standard water use per employee; and flows through industrial process. These data are analyzed and corrected as necessary to estimate water usage.

Like many of the DOE sites across the country, SNL expanded as its mission changed to meet the nation's energy and national security needs. Facilities and the accompanying infrastructure were designed and constructed as necessary to address the immediate need. Consideration was not given to coordination of site services, such as water supply, steam supplied heat and wastewater treatment. Meters were not installed because water was considered an unlimited resource and costs were simply amortized for the site. As a result, water audits, necessary to establish a water budget are difficult to conduct, and water reduction opportunities are difficult to implement. Without a systematic approach, water conservation successes are achieved piecemeal without consideration of site-wide benefits.

The water conservation program, coordinated by the Mechanical and Civil Systems Engineering Department is structured to comply with the Energy Policy Act (EPACT) of 1992, the Pollution Prevention Act (PPA) of 1990, Clean Water Act (CWA), Safe Water and Drinking Act (SWDA), and Executive Order 12902 (E.O.), Energy Efficiency and Water Conservation at Federal Facilities. At a local level the program is driven by a Memorandum of Understanding (MOU) between KAFB, the Department of Energy (DOE), SNL/NM, the city of Albuquerque (COA), the state of New Mexico and the National Research Energy Laboratory. This unique document requires cooperation between the agencies to mitigate its impact on the Albuquerque aquifer, and sets a specific goal for SNL/NM to reduce water use 30 percent (%) by the year 2004.

Each regulatory driver mentioned above is, by itself, incomplete. EPACT and E.O. 12902 address water conservation primarily as it relates to energy conservation. Through prioritization and comprehensive facility audits, E.O. requires implementation of cost effective water conservation measures; however there are no specific targets for water use. The CWA focuses primarily on limits for discharges, while the SWDA addresses standards for potable water. The PPA and the Pollution Prevention Department (P2) Plan emphasize a multi-media approach to pollution prevention, and include resource conservation in their scope, but provide little guidance or direction.

Despite the numerous regulatory drivers, it is difficult to employ a truly systematic approach to water conservation. Barriers to implementing a systems approach include:

- conflicting strategies for waste and wastewater management, energy efficiency, and water conservation;
- identifying and integrating the needs of a large site with many facilities and funding sources;
- a poor understanding of the economic benefit to implementing water conservation measures;
- obtaining the necessary funding to implement projects;
- and various institutional barriers related to the perceived risk of change. Reactions such as, "It will never work", "We've never done it that way before", and "You'll never save anything (water, money, energy)" are typical.

To address this need, SNL/NM is taking a systematic, comprehensive approach to water conservation. The approach is to estimate the water consumption for all of SNL/NM by type of consumption. For each type of water consumption, all cost effective measures for reducing, reclaiming, and/or recycling that usage will be ranked. These water conservation measures range from the simple such as retrofitting plumbing fixtures with low cost devices to reduce water required to "flush" toilets to the very complex. As an example of the very complex, an Microelectronics Development Laboratory (MDL) lab will implement a near zero water discharge from clean room wet benches. Deionized (DI) water can be sent back to the DI water input generation stream when the DI water is not being used for rinsing wafers

This paper will discuss completed, ongoing and proposed projects at SNL/NM to reduce water consumption and recycle water to maximize its use, and how water conservation has resulted in energy savings, reductions in wastewater discharges, reductions in water treatment chemicals, and reduction in hazardous waste. Additionally the paper will discuss preparation of SNL/NM's Water Conservation Plan, and solutions to overcoming programmatic and bureaucratic hurdles to achieve reductions in water use, wastewater discharges, chemical use and energy.

## II. METHOD

### WATER CONSERVATION PROGRAM

In 1996 SNL/NM appointed a Water Conservation Officer to coordinate and expand its efforts to reduce water on site and to promote water conservation. The Water Conservation Officer is a staff member of the Site and Systems organization, the group that has both the information and responsibility for coordinating site infrastructure programs. The Water Conservation Officer is a professional engineer with over 15 years of experience (8 years at SNL/NM) with a full knowledge of and a dedication to water conservation issues. This

## DISCLAIMER

was the key element in developing the SNL/NM program. Without a strong, qualified leader to promote the program, success will be limited.

The approach taken to develop and implement the Water Conservation program include the following elements:

- Identify and immediately implement high profile, high return water conversation projects. It is important to gain support for the program and demonstrate that it can be successful.
- Identify and obtain funding to conduct the program. Because water conservation is a multi-displinary program, there are a variety of sources available. These include: General Plant Project (GPP) funds, line item funding, Operation and maintenance funding, and site and DOE pollution prevention funds. Examples of projects funded by these sources is presented below in the Results section
- Emphasize and continually remind site personnel and management of the regulatory drivers for the program. At SNL/NM the key document is the MOU.
- Seek allies and integrate the program with similar efforts. At SNL/NM the Water Conservation Officer works closely with the site Pollution Prevention Coordinator and Energy Manager.
- Promote the program. Such efforts at SNL/NM include publishing articles in the site newsletter and weekly bulletin, and construction of a Water Conservation Home Page.
- Conduct a site-wide audit and develop a Water Conservation Plan. For SNL/NM the MOU requires a site-wide audit and completion of a Water Conservation plan. EPACT and EO 12902 contain similar, less definitive language. Beyond the regulatory drivers, however, it is essential to conduct a water audit and establish a water balance to effectively determine which projects to implement. The Water Conservation Plan, a logical follow-up to the water audit, establishes goals, support, schedules, and ranks projects.

In establishing its water conservation program, SNL/NM first identified and began implementing selected water conservation projects, advertising existing water conversation successes, sought site support, identified funding and conducted water conservation awareness activities, prior to attempting a complete site-wide audit and develop a comprehensive Water Conservation Plan. While these items are critical to a successful, sustained program, it is not necessary that the water audit be the first order of business. Enough information is usually available to determine, critical needs and, in the beginning stages, easy to implement, high return projects are easy to find. It may also be necessary to establish some success and credibility to obtain the funding and resources to conduct a quality audit and publish a meaningful plan.

## WATER AUDIT AND PLAN

Good data is the first order of business in conducting a water audit. Ideally the site should be sufficiently metered to be able to measure all significant and critical flows. This unfortunately is not the case at SNL/NM. Only ten (10) of the 534 buildings have water meters: water is not metered at the main water header to the site. Metering needs have been identified and a money was obtained to install them in FY 1998. Money to conduct an audit, however, became available in FY 1997. Given this situation, SNL/NM proceeded with its water audit, using available information. The approach is unique and is yielding surprising results, that will be compared to metered measurements. The water audit is complete and data is being compiled and analyzed. Preliminary results will be presented in the Results section. The Water Conservation Plan will be complete by Sept. 30, 1997.

Given the limitations, SNL/NM used metered sewer flows, process knowledge of major water users (cooling towers, evaporative cooling, ultra pure water production, irrigation, and industrial facilities) standard water use for building occupants, existing water meter flows, and data from portable water meters to conduct a site-wide audit. During the site-wide audit water consumption and the types of water use were evaluated for major users, and water reduction conversation opportunities (WCOs) were identified and evaluated.

Survey forms were developed to capture water usage throughout SNL/NM. A general building form was used for all buildings. This form focused on data primarily related to personnel. Using standard conversions quantities and flow rates for: toilets, urinals, faucets, sinks, showers and drinking fountains were estimated. Other forms were developed to capture the Heating, Ventilating, and Air Conditioning (HVAC) water, Cooling Tower water, and Steam Plant water Usage. When evaporative cooling HVAC and process water usage were significant in any building, a note was made for an engineer to go back and do a detailed survey of that building in order to capture the HVAC and process use. Other forms, as needed, were used to capture that water usage.

Methods used to collect the data for the building surveys and other information necessary to complete the site audit are summarized below.

**Cooling towers.** Data was gathered to evaluate chemical treatment for the cooling towers by reviewing operating records and analyzing samples of individual cooling towers. The Cation/Anion balance identified anomalies which were corrected by confirmation testing. An evaluation was made of the quality of chemistry control under minimal test and control procedures established by the chemical supplier/vendor.

The cooling tower evaluation used chemical mass balance to provide information where flow metering data was not available. Actual chemical delivery rates were not available, therefore the purchased quantities were used together with chemical control data to estimate total water consumption for 25 cooling tower systems. Some systems have more than one cooling tower sharing a common sump. For these systems, the multiple cooling towers are treated as bays of a single larger cooling tower.

Chemical feed records are kept for each cooling tower system. From these data and the average chemical control concentration, chemical mass balance determined the gallons of blowdown per year from each cooling tower system.
This total blowdown value ($BD_t$) includes drift loss:

$(BD_t)$ = (lbs chemical delivered) x $(10^6)$ / [parts per million (ppm) product].

Makeup flow is approximated by:

$(BD_t)$ x (cycles of concentration).

To calculate how much makeup can be saved by blowdown reduction:

$(BD_t)$ x (1.0 - (% cycles decrease)) = (reduced makeup flow).

Similar calculations estimate the chemical cost savings by increased cycles of concentration. Chemical savings are approximately equal to blowdown reduction. In general, diminishing returns occurs at about 5 cycles of concentration.

From this data, evaluation was made of the quality of chemistry control under minimal test and control established by the chemical supplier vendor. The many small cooling towers remotely located over the SNL/NM site make for time consuming and labor intensive chemistry control in spite of simplified test methods. It has been necessary, therefore, for chemical control limits to be very conservative to tolerate loss of chemical feed. This conservatism leaves room for improved control, and reduced blowdown to conserve water to lower cost of chemical treatment.

**Steam Plant.** The two primary sources of water consumption at the Steam Plant are condensate losses and boiler blow-down (water sent to the sewer to prevent buildup of solids). Boiler water chemistry was reviewed to establish the quality of chemistry control and the potential for reduction of boiler water blowdown with attendant lowering of chemical treatment cost. Daily logging of chemical consumption from calibrated chemical feed pumps provides on-going chemical cost values for production of steam. These same numbers were used together with product phosphate assay, to perform chemical mass balance for a determination of total boiler water loss via normal blowdown, bottom blows and leakage. Percent Orotho Phosphate ($PO_4$) assay contained in the phosphate chemical feed can be expressed as:

(Total lbs. of boiler water lost) = (Boiler $PO_4$ concentration) x ($10^6$) / (lbs. of $PO_4$ delivered).
Units are typically expressed as pounds per hour. When analytical test results and chemical consumption values are accurate, very good numbers can be derived for total boiler water blowdown.

The mass balance flow numbers were used for cross check on other values. For example: (Metered Feedwater Flow) - (Blowdown) = Steam Produced with the exception of leakage, vents, drips, etc. Chemical mass balance is a major tool for diagnostics when compared against other known values.

**Process water** usage varied considerably depending on the process. Simple process water use was captured on the general building form. For significant process water usage, the specific process was investigated with those responsible for the process in order to understand the exact requirements and investigate all potential means of reducing or eliminating that water usage.

**Sewer Flow.** Prior to the start of the audit, a SNL/NM engineer determined the sewer flow by sewer basin. Drawings were prepared and verified depicting the sewer basins, their flow routes, and buildings contained in each basin. Three years of Environmental Operations continuous waste water flow strip charts were analyzed in order to quantify the monthly, weekday and weekend flow rates for that time period.

**Water Meters.** Where meters existed, meter readings were taken daily or weekly to gather as much real data as possible. Portable meters were placed on as many buildings as possible to determine their exact weekly profile. Buildings with the most water usage were metered first. Due to time and money constraints, few buildings had continuous weekly recordings.

**Personnel Usage Rates:** Personnel water usage for toilets, urinals, and faucets depends on two independent criteria: flow rates for the plumbing fixtures and the number of times that they are used. Flow rates for the plumbing fixtures were determined during the survey and averaged for each building. To determine the frequency of use, date was gathered through an Internet, and discussions with water experts in the southwest. Based on this information, the following daily usage rates were used: *Women*: Toilets: 4 times per day, faucets: 2 minutes a day; *Men:* Toilets: 1 time per day, Urinals: 3 times per day, faucets:1.2 minutes a day. Janitors flushed each toilet and urinal once a day and operated each faucet for 30 seconds. Rest room water usage was calculated using the number of males, number of females, average flow rates of plumbing fixtures and frequency of use. The number of personnel per building were taken from a data base maintained by SNL/NM. Percentages of males versus females were assumed constant over all buildings and were based on a personnel data base maintained by SNL/NM.

**Landscaping**. Estimates for the water used to maintain landscape areas were based on interviews with SNL/NM maintenance contractor personnel. Information was obtained about specific watering practices, specifically the timing and frequency of sprinkler system

**Water Balance.** Water consumption was divided into significant end uses. For example, in a typical office building, rest room water usage overshadows drinking fountain water usage and so drinking fountain water usage was ignored. Estimated water usage was calculated as sewer flow plus non-sewer flow. Non-sewer flows include: evaporation, steam condensate losses, irrigation, road maintenance, fire flow tests, and miscellaneous usage.

III. RESULTS

**Water Conservation Projects**

SNL/NM has successfully implemented and identified several water conservation projects. Each of these projects is briefly discussed below. Table 1 provides a summary for each project with accompany water, waste water and chemical use reductions, and cost savings. Each of these projects is separately discussed below. Much of the SNL/NM water conservation effort focuses on the MDL. MDL is a world class facility with state-of the art equipment set for processing silicon wafers and conducting Research and Development (R&D) projects in an array of microtechnologies.

MDL Water Conservation Projects

MDL has been the most active facility in terms of water conservation and typifies the systematic approach to water resources that SNL/NM is taking. This is due to the following reasons: it is a significant waster user and requires ultrapure water for its processes; MDL management and personnel are receptive to and understand the value of water conservation; and processes are metered and relatively easy to quantify.

TABLE 1. Summary of Water Conservation Projects at Sandia National Laboratories

| PROJECT | STATUS | WATER REDUCTIONS | OTHER REDUCTIONS | COST SAVINGS |
|---|---|---|---|---|
| MDL - Reverse Osmosis | complete | 38 MG | WW- 38 MG | $ 100,000 annually |
| MDL - Water Recycling | ongoing, complete in FY98 | 70-80% | | |
| MDL - Process Changes | in construction | 2.3 MG | chemicals | $26,000 |
| MDL - Cooling Towers | in construction | 12 MG | chemicals | $25,000 |
| Reuse Water for Irrigation | in design | 90 MG | | $235,000 |
| Laser Cooling Loop at CSRL | in construction | 10 MG | | |
| Steam Plant Improvements | complete | 23 MG | Fuel - 19.3 x $10^6$ scf<br>WW 11.5 MG | >$100,000 |
| Change Cooling Tower Treatment | in design | 10 MG | | |

The Microelectronics Development Laboratory (MDL) at Sandia National Laboratories, New Mexico (SNL/NM) is a world class facility with over 30,000 $ft^2$ of clean room space, a fully operational state-of the art equipment set for processing silicon wafers, and the capability to conduct R&D projects in an array of microtechnologies. Many of the operations conducted at the MDL require high purity water. Incoming water from the City of Albuquerque (COA) and well water obtained from Kirtland Air Force Base (KAFB) is processed through a water treatment facility that includes carbon absorption, reverse osmosis (RO), vacuum degassing, and ion exchange.

In any research laboratory, the infrastructure systems will not be utilized as fully as in a production facility. For excample, many of the process utilizing ultrapure water operate less than 20 percent of the time, but water continually flows through the rinse tanks to maintain the ultra pure water quality. Were the water to be turned off during periods of non-use, water quality would degrade.

Faced with these unique challenges MDL is either implementing or investigating water conservation opportunties (WCO) to make the most efficient use of water, while maintaing the necessary quality and quantity of ultrapure water to meet it production requirements. Water that can not be recycled within the facility will be recycled to another user at SNL/NM or KAFB. The ultimate goal of the MDL is to be a zero discharge laboratory, serving as a model for other operations at SNL/NM and DOE.

Figure 1 is schematic of the water and waste water flow at MDL. Existing flows are indicated as solid lines, while proposed alternatives are shown as dotted lines. Each of the MDL water conservation projects are discussed in relation to this figure.

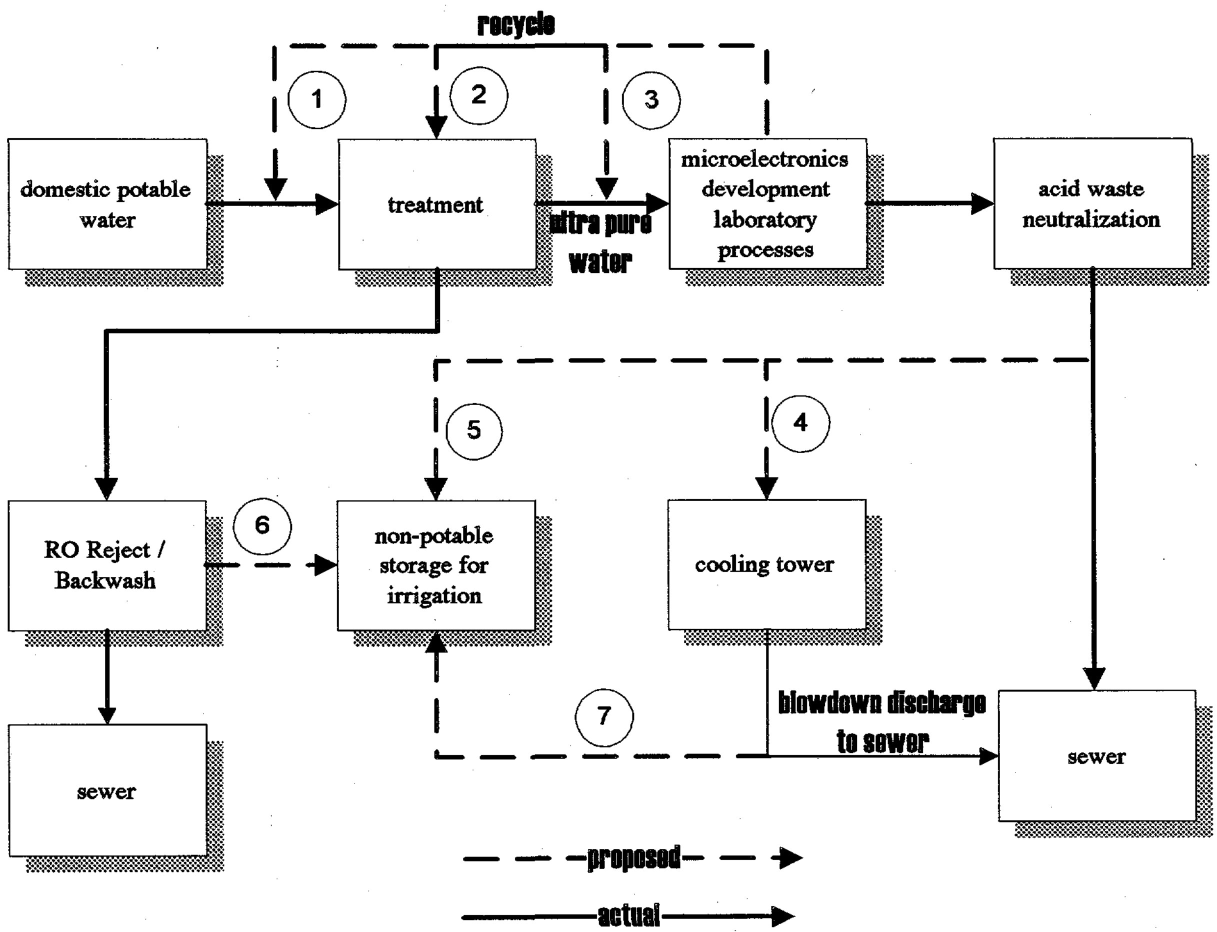


Figure 1. Water Flow Schematic at the Microelectronics Development Laboratory

*MDL Reverse Osmosis Improvements*

MDL has implemented water saving changes its ultrapure supply system through modifications to its treatment system. Modifications to the water treatment system include: new stainless steel control valves were installed for precise control of water flow; a new manifold was added to the reverse osmosis (RO) pump converting it to a more efficient two-stage pump; high surface area RO membranes were added; and the existing polyvinyl chloride (PVC) piping was replaced with industrial, water production piping.

These improvements resulted in a 38,000,000 gallons per year reduction in both water usage and sewer discharge for a cost savings exceeding $100,000 per year. Since the improved RO system is more efficient, it operates fewer hours during the year, resulting in an annual energy savings of $22,000. The total cost of the project was $107,113; the pay back is .84 years with a simple ROI of 108%.

*Water Recycling at MDL*

This research project, funded by SEMATECH, is designed to develop and demonstrate the use of near real-time sensors for detecting organic spikes in a water recycle loop to effectively eliminate the risk of recycling spent rinse water. The installation of the common drains and collection tanks, necessary to recycle the water, have been installed. The present task is to develop and test the sensors to provide a "bullet-proof" water recycle system that avoids the mistakes of the past and helps to convince the semi-conductor industry that the old problems of recycling are no longer sufficient reason to avoid it. This project has the potential to reduce water consumption at the MDL by 70-80% per year. Figure 1 shows the three recycle options available at MDL. The real-time sensors will be used to determine which of the paths the recycled water will take. Option 1 recycles the water to the beginning of the treatment train. This is the least desirable and indicates the poorest recycle water quality. Both water and waste water savings will be realized, but the recycled water will require processing through the entire water treatment train. Option 2 recycles the water within the treatment train, preferably after carbon adsorption and reverse osmosis. Additional waste water savings will be realized by less carbon filter backwash and RO reject water. Less pumping energy will be required, and materials and solid waste (activate carbon and RO filter replacement) will be reduced. Option 3 is the most cost effective recycling option, and assumes that rinse water from MDL processes is of sufficient quality to be reused directly, without additional treatment.

*Process changes for water and solvent recycling at MDL*

MDL activities consist of a series of operations (etching and cleaning) performed on silicon wafers at Wet Chemical Processing Benches. The wafers are processed as batches through a series of process tanks [i.e., sulfuric acid ($H_2SO_4$), hydrochloric acid (HCl), ammonia hydroxide ($NH_4OH$), hydrofluoric acid (HF)], and deionized water rinse tanks. The overflow and waste water from these tanks drain to a common plenum which is treated (neutralized) and discharged to the sanitary sewer. Funding ($37,500) from Pollution Prevention was obtained to change the piping arrangement at the 5 Wet Chemical Process Benches to separate the rinse water and process tank discharge. Separating these streams will increase the quantity of water that can be recycled, ensure that the rinse water will not be contaminated and that the higher quality water recycle options are available. Real time sensors (see above) will be used to select the appropriate recycle path. Separation of the process tanks discharges is the first, necessary, step to permit the recycling acid used in the cleaning process. MDL is currently investigating alternatives to discharge of this material. These alternatives include: 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 will reduce water consumption and wastewater discharge by 2.3 million gallons per day (MGD), and save over $26,000 in operating and maintenance costs.

*Reclaim Process Water from MDL for Cooling Towers*

This project will take a portion of the process waste water at MDL and pump it to the adjacent cooling tower resulting in a savings of approximately 12 million gallons of water per year. This process water, considered unacceptable for in-plant recycle, will be treated in the MDL Acid Waste Neutralization (AWN) system, prior to discharge to the cooling tower (Option 4, Figure 1). The estimated annual cost savings is $25,000. Several technical issues were addressed including a chemical analysis of the process waste water and a corresponding change to the chemical treatment program for the cooling tower. The project has been designed and is currently in the construction phase.

<u>Reuse Waste water for Irrigation</u>

KAFB currently uses 1.6 billion gallons of water per year from the city of Albuquerque and on-site wells. Eleven percent (176 MGY) is used for irrigation of the Golf Course. This project will design a holding and distribution system to capture wastewater from SNL/NM cooling towers and industrial processes. MDL will be investigated a major source of this water. Figure 1 shows potential sources of the irrigation water. These include: Option 5, direct use of the AWN effluent, Option 6This wastewater will then be used to irrigate the Golf Course. This project has the potential to reduce water consumption and wastewater discharge by 90 MGY, and save up to $235,000 per year

Laser Cooling Loop at CSRL
This project will install a chilled water loop for the lasers in building 893 to replace the once through cooling system, savings 10 million gallons per year (MGY). The project is currently in the design stage. Construction will be complete in 1998.

Steam Plant Improvements
Water saving projects implemented at the SNL/NM Steam Plant include:

- Through inspecting the condensate return line and interfacing with steam users, SNL/NM identified and repaired leaks, increasing the average returned steam from 52% to 68%.
- Replacing an aging dealkalyzer with a more efficient model resulted in an 80% reduction in chemical use (salt), and an increase in the amount of water treated between regeneration cycles.
- By adding caustic to the brine during resin regeneration cycles, silica was removed from the make-up water, lowering the concentration from 24 ppm to 7 ppm. Silica, which can form deposits in the boiler, must be removed through boiler blowdown.
- By recycling treated water used to cool fan bearings and feedwater pumps, water use and wastewater generation was reduced by 15 $m^3$ [4 million gallons (MG)].

This combination of increased condensate return, installation of a new dealkalyzer, caustic addition to regeneration, and elimination of a once through cooling loop reduced annual water usage by 87 $m^3$ (23 MG) and annual fuel usage by $19.3 \times 10^6$ standard cubic feet (scf), eliminated 43.5 $m^3$ /yr (11.5 MGY) in wastewater discharged to the sewer, and significantly reduced chemical usage. Overall yearly cost savings exceed $100,000.

Change chemical treatment and provide instrumentation for Cooling Tower operation
SNL/NM has a total of 23 cooling towers serving 42 chilled water systems on site. The estimated makeup water for blowdown, evaporation, and drift results in approximately 110 million gallons of water usage per year.

Complex-wide proposal

SNL/NM, teamed with Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and the National Renewable Energy Laboratory, submitted a proposal to DOE, Pollution Prevention to fund an effort to implement systems approach to Cooling Towers and a site-wide comprehensive water conservation approach at SNL/NM, LANL and LLNL. If funded this project will transfer water conservation technology developed at these three sites to other DOE sites through workshops and development of a DOE Water Conservation Home Page.

WATER AUDIT

Information obtained from the water audit was used to construct a water balance. Table 2 provides the summary data for one of the sewer basins at SNL/NM. Water use was balanced by sewer basin, because metered sewer flow data was the most reliable quantitative data available. Total water use within the sewer basin was calculated based on information collected on the survey forms. Non-sewer flows, such as evaporation, steam condensate losses, irrigation, road maintenance, fire flow tests, and miscellaneous usage, were subtracted form the total waster use to obtain calculated water usage to sewer. This value was compared to the metered sewer flow data. The calculated water consumption quantities were within 10% of the measured flows.

TABLE 2. Calculated Water Balance for Sewer Basin WW001

| | | | Calculated Water Usage | | Calculated Water Usage to Sewer | | Metered Water Usage | |
|---|---|---|---|---|---|---|---|---|
| Sewer Basin | Tech Area | Category Water Usage | Daily Average | Annual Average | Daily Average | Annual Average | Daily Average | Annual Average |
| | | | (gallons) | (gallons) | (gallons) | (gallons) | (gallons) | (gallons) |
| WW001 | I | Sewer - Measured Amount | | | | | 69000 | 25,185,000 |
| | | Toilets | 28,786 | 10,506,890 | 28,786 | 10,506,890 | | |
| | | Urinals | 10,063 | 3,672,995 | 10,063 | 3,672,995 | | |
| | | Sinks | 5,758 | 2,101,670 | 5,758 | 2,101,670 | | |
| | | Evaporation | 1,485 | 542,193 | | | | |
| | | Cooling Towers | 114,341 | 41,734,615 | 32,016 | 11,685,692 | | |
| | | Steam Plant | | | | | | |
| | | Process | | | | | | |
| Totals | | | 160,434 | 58,558,363 | 76,623 | 27,967,247 | | |

Below (Figure 2) is a summary of the 1996 total water use by category at SNL/NM. Note that the major category of use is the production of ultrapure water for microelectronics R&D laboratories. This includes MDL and CSRL. Water conservation projects have already being implemented at these two facilities, and other WCOs were identified during the audit. Also note that water use for landscaping is only 1% of total water use. This results from SNL/NM's long-standing practice of xeriscaping.

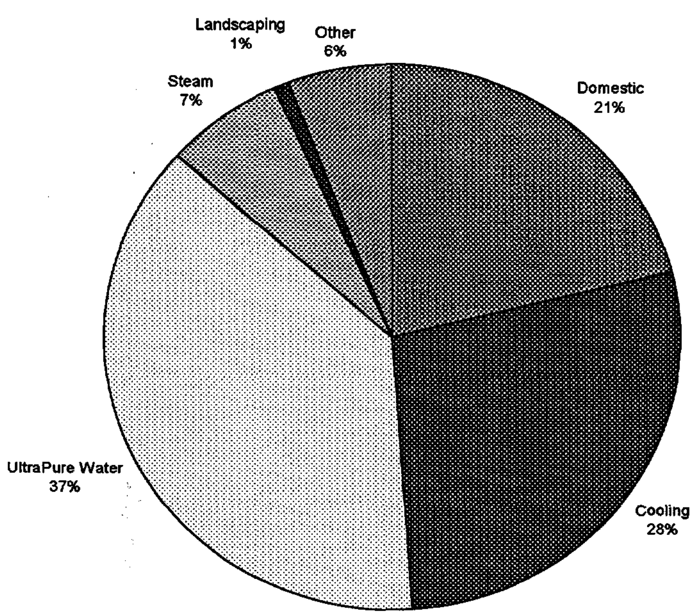


Figure 2. 1996 Water Consumption at Sandia National Laboratories, NM

WATER CONSERVATION OPPORTUNITIES (WCO)

During the water audit, WCOs were identified for all major processes. These WCOs are being prioritized and incorporated into the Water Conservation Plan. The cooling towers were identified as an area where 30% reduction in blowdown and chemical usage could be realized. Three of the WCOs considered for cooling towers are presented below.

1. Reduce Cooling Tower Blowdown and Chemical Use

Reducing cooling tower blowdown conserves water and lowers chemical treatment cost. It is therefore desirable to operate cooling towers at the minimum blowdown rate. The minimum rate is limited by buildup of alkalinity and silica, both of which may cause scale in chiller condensers when their solubilities are exceeded. Scaling potential is modified by the addition of chemical scale inhibitors.

Present technology will permit increasing the cooling water cycles with little or no increased risk scale deposits or corrosion. Any increase in cooling water cycles of concentration should be done only after selected systems have monitors in place and the new control limits verified as suitable for the existing mode of chemical treatment.

Two or more heavy-use cooling towers should be selected for installation of scale/corrosion monitors. The high-load systems with scale/corrosion monitors serve as pilot studies to verify vendor suggested limits. The scale monitor consists of a transparent tube containing a heated simulated condenser tube that is maintained at a temperature about 10 °F higher than the maximum chiller condenser outlet temperature. When control limits are pushed, visual inspection of the scale monitor tube will expose threshold scaling to identify upper control limits.

A 30% reduction in blowdown and chemical consumption is reasonable with the existing mode of chemical treatment.

2. Greater Blowdown Reduction - Supplementary Acid Treatment
(Acid feed control of alkalinity buildup in the cooling towers)

Blowdown can be further reduced after chemical optimization by adding sulfuric acid. Supplementary sulfuric acid feed to a cooling tower will neutralize alkalinity in the cooling tower water permitting increased cycles of concentration with no change in existing levels of chemical treatment Cooling water silica then becomes the limiting condition for cycles of concentration.

If current scale conditioning chemistry can permit increase in cooling water alkalinity to the near 500 ppm range, then silica is also pushed to its upper control limit which diminishes the benefit from supplemental acid feed. However any reduction of system pH and alkalinity greatly reduces the possibility of scaling caused by a chemistry upset condition.

3. Reduce Blowdown - Near Zero Discharge - Side Stream Softening
(Sidestream softening to control silica and alkalinity buildup in the cooling water system)

Sidestream softening, though capital intensive, provides very significant benefits. Normal cooling tower blowdown is routed to a packaged skid mounted sidestream softener with its associated chemical feed systems for hydrated lime, magnesium oxide, and polymer. The warm cooling tower blowdown water is reacted with lime and magnesium oxide slurry to elevated pH where calcium carbonate and magnesium silicate precipitate from solution forming a gelatinous floc within the clarifier. Polymer addition accelerates agglomeration and settling of precipitated hardness, silica, suspended solids and reduced alkalinity.

The clarified effluent from the sidestream softener is returned to the cooling tower with normal cooling tower makeup water to dilute existing alkalinity and silica in the cooling water system. Precipitated solids are removed from the bottom of the clarifier as sludge and reduced to dry powder by a sludge dryer. Cooling water blowdown is replaced by dry solids disposal, to achieve nearly zero cooling tower blowdown to waste.

Sidestream softening requires routine testing and control of chemical feeds and solids removal. Practical application would require combining blowdown from as many cooling towers as possible. The cost benefit is near elimination of cooling water blowdown, reduction of chemical demand with attendant reduction of chemical cost.

## IV CONCLUSIONS

The necessary elements for a successful Water Conservation program are:

- A strong, qualified advocate fully supported by management.
- Identification of major water users and previously implemented projects.
- Funding to support the program.
- Extensive promotion of the program and educating personnel about the benfits and requirements for implementing a water conservation program.
- A site-wide audit and a Water Conservation Plan.

A water audit can be conducted without extensive metering by using process knowledge of major water users. These include cooling towers, steam plant, evaporative cooling ultra pure water production, irrigation, and other large industrial process users. This information combined with metered sewer flow data and estimates of per person domestic use permits a good understanding of how water is being used, and can be used to establish a baseline water balance. The results indicate that calculated and measured flows agree within 10%