UC SANTA CRUZ
WATER EFFICIENCY SURVEY

FINAL REPORT

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Prepared By

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and
UC Santa Cruz

WATER EFFICIENCY SURVEY OF
UC SANTA CRUZ, SANTA CRUZ, CA

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1.0 EXECUTIVE SUMMARY

1.1 Project Summary

The Water Efficiency Survey inventoried UC Santa Cruz' existing water use facilities and assessed operations to determine the current level of water conservation practices and derive potential water saving projects for implementation.

Implementation of the combined high priority water conservation projects is estimated to result in a 15.0 percent savings in total annual water use (approximately 29.8 million gallons per year) and save approximately $500,000 per year after all the high priority projects are completed as a result of lower water, sewer, and energy bills (using 2009 price rates). Maddaus Water Management **(**MWM) estimates that the UC Santa Cruz's payback from implementation of the recommended water conservation projects will occur in approximately one year. The payback calculations in this report are simple paybacks and by definition do not take time of actual implementation into account. It is planned that the high priority projects will be implemented over the next 5 years.

Based on review of the UC Santa Cruz's historical billing data provided by the City of Santa Cruz, the main campus used an average of 544,900 gallons per day ("GPD") of potable water in the year 2006, all of which is purchased from the City of Santa Cruz. This amounted to about 200 million gallons per year (MGY) for 2006 or about 5% of the entire water demand for the Santa Cruz water service area. This does not include the Barn theatre service or the Marine Science Campus located off the main campus which uses approximately 20,000 GPD. UC Santa Cruz currently has 8 main campus meters from which the entire campus receives water from the City of Santa Cruz. The campus water use is a combination of indoor use (e.g., toilets, showers, sinks, and kitchens) and outdoor use for landscape irrigation. Based on the campus's water and sewer billing data, UC Santa Cruz currently spends approximately $1.8 to $2.0 million annually on its water, irrigation and sewer bills. UC Santa Cruz spends an additional $4.0 million annually on it's in energy bills.

1.2 Survey

From April to August 2007 MWM, UC Santa Cruz staff and students conducted a walk-through of the UC Santa Cruz campus to identify uses of water and potential water conservation options. After training by and under the supervision of MWM a team of 11 students measured faucet and shower flow rates, toilet flush volumes, looked for leaks, checked for missing faucet aerators and inspected the kitchens and characterized and measured over 500 irrigated landscape areas. Maddaus Water Management conducted a survey of the laboratories, greenhouses, cooling towers, pool, central irrigation control system, arboretum, farm, garden and checked the student gathered data. The data was placed in a database with over 2,500 rows organized by building (CAAN) number. This database was used for the analysis of this report, and also was provided to staff for future implementation and reference purposes. The results of the survey are presented below.

Table 1 – Summary UC Santa Cruz Main Campus Water Fixtures (Data Collected During Survey Conducted April – June 2007)

Fixture	Number Surveyed
Buildings Surveyed	414
Restrooms Surveyed	1,188
Restroom Faucets Surveyed	2,255
Total Surveyed Toilets	2,152
Urinals – Flush	188
Urinals – Waterless	30
Washing Machines	153
Showers	1,425
Drinking Fountains	342
Kitchens: Apartment/Office	637
Kitchens: Cafeteria & Dining Hall & Restaurant	14
Kitchen Faucets: Cafeteria & Dining Hall & Restaurant	111
Kitchen Spray Valves	17
Kitchen Ice Machines	14
Kitchen Cooking Steamers	18
Cooling Towers	4
Swimming Pools (Outdoor)	1
Laboratory Steam Sterilizers	11
Laboratory Cage Washer	1
Laboratory Fly Food Kettles	2
Laboratory Spray Valves	2
Laboratory Ice Machines	10+
Outdoor Fountains	3+
Landscape Irrigation Controllers	90

Following the on campus survey MWM estimated the water savings, costs, and paybacks associated with implementation of various water conservation projects. Based on MWM's analysis, the following water conservation projects were identified to provide significant water savings and to have a high cost-benefit ratio for the UC Santa Cruz (i.e., the money that the UC Santa Cruz will save on its water, sewer, and energy bills will off-set the cost to implement the recommended water conservation projects).

For the purposes of payback analysis, the water and sewer rates for 2009 were used which are already adopted by the City of Santa Cruz. The water rate as of January 1, 2009 is $5.61 per 1,000 gallons (from the City of Santa Cruz future rate schedule). The sewer rate as of July 1, 2009 is $7.31per 1,000 gallons. These rates are substantially higher than current rates. If the rates continue to increase faster than inflation after 2009, the water conservation projects evaluated in this report will become even more attractive.

The recommended high priority water conservation projects with a payback of less than 5 years are in Table 2.

Table 2– High Priority Conservation Projects for UC Santa Cruz

Project	Fixtures To be Replaced / Repaired	Estimated water savings (gpd)	Total Cost of Project	Payback in Years
Remove Steam Sterilizer from DI Water System in Marine Sciences Building	1	525	$ 538	0.1
Replace 9 inefficient spray valves in kitchens, cafes, and restaurants	9	1,697	$ 2,420	0.2
Replace hose in College 9/10 Dining Hall kitchen with low flow spray valve.	1	540	$ 1,381	0.3
Replace 2 spray valves in steam sterilizer room of Earth and Marine Sciences	2	180	$ 538	0.3
Install Arboretum PRVs to reduce water pressure to lines	100	1,213	$ 1,100	0.4
Install waterless urinals in "high use" restrooms.	65	16,225	$ 60,540	0.6
Conduct pilot test 1.0 gpm aerators on high use restroom faucets.	318	2,652	$ 18,458	0.7
Replace faucet aerators in non high use restrooms	2,137	17,825	$ 124,039	0.7
Replace existing showerheads in high use housing and athletic facilities	40	769	$ 6,843	0.9
Replace existing showerheads in non high use housing and athletic facilities	310	5,959	$ 53,034	0.9
Replace Flapper Valves and Diaphragms on 1.6 gpf Toilets that tested with high flush volumes.	850	8,347	$ 63,455	1.2
Implement water budgets for individual connection points that appear to be over watering that are not connected to the central control system	12	3,021	$ 8,578	1.4
Use battery-operated timers to shut water off	40	1,213	$ 3,910	1.6
Add wireless rain sensors on existing controllers	70	6,913	$ 24,885	1.8
Change operating procedure of CT-5 from conductivity set point of 1200 to 2000.	0	696	$ 8,309	1.9
Add 10 new PRVs to Farm irrigation system.	10	434	$ 2,444	2.7
Replace high flow toilets in "high-use" areas with 1.6 gpf or 1.28 gpf toilets.	204	10,450	$ 190,004	2.9
Add campus submeters for large un-metered irrigated areas use at Arboretum	1	549	$ 5,546	4.9
Install ET controllers for selected high-water-use areas.	9	2,613	$ 26,683	5.0
TOTAL High Priority Projects	4,179	81,818	$ 602,705	1.1

Each of the above listed projects is described in the Conservation Opportunities Section 5.0.

MWM estimates that, if the above water conservation projects are implemented at the UC Santa Cruz, the UC Santa Cruz will use approximately 15.0 percent less water on an annual basis or average savings of 29.8 MGY.

1.3 Recommendations

UC Santa Cruz has completed several projects in previous years to improve water efficiency including replacing hundreds of 3.5 or 5.0 gallon per flush toilets to 1.6 gallon per flush toilets. MWM recommends the above list of high priority water conservation projects and consider implementing, over time, the additional water conservation programs identified in Table 17 as resources are available.

Implementation of the combined high priority water conservation projects is estimated to result in a 15.0 percent savings in total water use and a savings of approximately $500,000 per year (2009 rates). Savings will be higher when utility rates increase. The recommended projects, when combined, have a payback of approximately 1.1 years.

2.0 INTRODUCTION

2.1 Project Objectives

UC Santa Cruz has made a commitment to conduct an engineering audit of campus water use as one of several mitigations for the environmental impacts of the projected increase in campus water use over the next 15 years. Information on UC Santa Cruz' existing and future projected water use and other pertinent information may be found in the Final 2005 Long-Range Development Plan Environmental Impact Report (2005 LRDP EIR), Volume II, Section 4.14 and Volume IV. This survey provides a menu of potential water conservation measures. However, other water conservation measures may be identified within the next 15 years that UC Santa Cruz may implement.

Maddaus Water Management ("MWM") was retained in April 2007 by the UC Santa Cruz campus ("UC Santa Cruz") to perform a water efficiency survey ("survey") and make water conservation recommendations for uses throughout the campus. The survey described in this report was conducted at the UC Santa Cruz campus in Santa Cruz, California. The water conservation recommendations included in this report are based on a payback analysis that identified the most cost-effective water conservation projects for UC Santa Cruz.

2.2 Scope of the Investigation

MWM worked closely with the campus staff to complete the water efficiency study of UC Santa Cruz campus. The project including the following steps:

1. Develop detailed scope for the water efficiency survey.
2. Gather background data.

3. Assess the efficiency of plumbing fixtures in campus facilities, existing conservation efforts, and operation of irrigation systems and the campus cooling water system.
4. Identify options of reductions water consumption including operations and retrofits.
5. Conduct an analysis of cost effectiveness for the various water conservation measures
6. Develop a prioritization of potential options for implementation over the next 5 years.

During the site survey, MWM and campus staff and students identified all significant uses of water. UC students measured the flow rates and volumes of representative fixtures. MWM interviewed staff responsible for each significant end use. Based on this information, MWM prepared a breakdown of daily water use at the UC Santa Cruz into major categories and identified potential water conservation projects for payback evaluation. As described in detail below, water conservation project recommendations were developed and prioritized based on the estimated payback from each water conservation project.

MWM identified and focused water conservation efforts on seven major uses of potable water, two major uses of irrigation water at UC Santa Cruz, and lost or unaccounted for water:

Potable Water

- Domestic (sanitary) use by students and employees (e.g., toilets, urinals, faucets, showers)
- Kitchen / Restaurant (dishwasher, spray valves, faucets, food steamers, ice machines)
- Laundry (residential facilities)
- Cooling Towers
- Ice machines
- Laboratories
- Pool

Irrigation Water

- Metered Shrub Irrigation
- Metered Lawn Irrigation

Lost and Unaccounted for Water

- Meter Error
- Leaks
- Unmetered irrigation and domestic
- Other (including authorized unmetered uses)

2.3 Goals and Objectives for the UC Santa Cruz Water Efficiency Survey

During a meeting with UC Santa Cruz Staff and Maddaus Water Management on April 10, 2007 a list of goals and objectives for the water efficiency survey were identified.

The goals of the study are:

- To help create a more sustainable campus environment by reducing water consumption in existing facilities and new development on campus.
- To minimize the contribution of projected campus growth to the need for new water supply for the City of Santa Cruz.

- Include fixture study data into the campus facilities data base so all can benefit from detailed building fixture information.
- Communicate ways to increase campus water efficiency to staff, students, purchasing, and outside vendors and consultants, etc. through campus awareness programs. Communication of the campus goal to be water efficient can be done through a variety of sources including websites, banners, articles in the campus newspaper, student competitions focused on saving water, campus banners and flyers placed on campus in high traffic areas.
- Identify improvements that could be made to campus facilities and operations to reduce campus water consumption.
- Analyze the cost-effectiveness of these potential improvements (when possible).
- Recommend top priority measures to be carried out within the next five years, and lower priority measures that may be implemented in subsequent years.

3.0 DESCRIPTION OF EXISTING UC SANTA CRUZ CAMPUS

The University of California, Santa Cruz, opened in 1965 and grew to its current (2006-07) enrollment of about 15,000 students and a total of 414 buildings and 6,217 student beds on campus. Undergraduates pursue 62 majors supervised by divisional deans of humanities, physical & biological sciences, social sciences, and arts and the School of Engineering. Graduate students work toward graduate certificates, master's degrees, or doctoral degrees in 33 academic fields under the supervision of the divisional and graduate deans. All undergraduates, whether they live on campus or off, are affiliated with one of the ten UC Santa Cruz colleges (Cowell, Stevenson, Crown, Merrill, Porter, Kresge, Oakes, Eight, Nine, and Ten). Although students take classes in any number of colleges and academic units throughout the campus, core courses within each college provide a common academic base for first-year and transfer students.

The campus includes academic and support buildings, college resident halls and apartments, family student housing, faculty/staff housing, 14 large kitchens, a fitness center including an outdoor pool, 4 cooling towers, and irrigated playing fields and landscaping.

3.1 Description of Campus Domestic Water System

The UC Santa Cruz campus receives water from eight large City meters. The two 10” meters, through which about half of the entire water delivered to UC flows, were last replaced in May 2004. The other meters are 4” and 6” meters. All of the 8 City meters are turbine meters. Five out of the eight City meters have been replaced in the last 10 years.

Table 3 – City Meters for the UC Santa Cruz Campus

UC Santa Cruz City Meter Size	Date Meter Was Last Replaced	Type of Meter	Account Number	Approximate Percent of Campus flow for past 3 years
10”	May 2004	Water	100-1200	25.0 %
10”	May 2004	Water	100-1205	23.7 %
6”	Not since 1995	Water	100-1100	4.9 %
6”	Not since 1995	Water	100-1105	6.0 %
6”	July 1997	Water	100-1300	9.2 %

6”	July 2006	Water	100-1305	15.8 %
4”	Not since 1995	Water	100-1055	4.5 %
4”	September 2000	Water	100-1050	11.0 %
10”	Unknown	Sewer	100-1000	~100%

The campus has installed submeters, individual water meters serving a particular building or area, after the main City water meters in order to monitor water use. There currently are a total of 350 submeters on campus including 60 dedicated irrigation meters that are monitored monthly by UC Santa Cruz staff but not used for City billing purposes. During this water survey, several unmetered irrigation areas were identified, and recommended for future submetering. Currently the UC Santa Cruz campus have installed a few submeters to the SENSUS Auto Read system which allows real time reading of water use data. The automatic reading meters are well liked by UC Santa Cruz staff as they are very beneficial for identifying leaks quickly, reducing time for the staff to physically read the meters, and also allowed the meters to be read on similar dates at the City of Santa Cruz allowing better comparison of water use information. An additional 306 submeters on campus are currently scheduled to be converted to automatic reading meters in two phases over the next few years. On the main campus there are 17 miles of pipeline, many of which are under the roadways. There are a variety of pipe materials on campus including ductile iron (under roads), asbestos (in non road areas) and PVC C900 (under roads). PVC piping became the campus standard in the mid 1990s.

3.2 Sanitary Fixtures

The UC Santa Cruz maintains 1188 restrooms (for student and employee use). It estimated that there are approximately 2,156 toilets, 2,255 restroom sinks, 218 urinals, 1,425 showers, and 342 drinking fountains throughout the UC Santa Cruz campus. The number of fixtures shown in Table 4 represent the number of fixtures surveyed which is not necessarily the total on campus. Although this was a very comprehensive survey, it did not include a survey of faculty staff homes, or buildings believed to be buildings/warehouses that do not use any water. In summary Table 4 lists only the items that were physically surveyed by the student teams. Table 4 summarizes the distribution of these fixtures and other water using features that were surveyed. A brief discussion of findings from the UC Santa Cruz survey is presented below:

- 738 flush valve toilets tested at an average of 2.84 gpf.
- 293 tank type toilets tested at an average of 2.66 gpf.
- Majority of campus had low flow shower heads, with an average flow rate of 1.87 gallons per minute (“GPM”).
- Measured flow rates of faucets as follows:
  - Restrooms: 1.87 gallons per minute (gpm)
  - Sinks in student kitchens 1.84 gpm
- 9 out of 17 kitchen spray rinse valves were flowing at higher than 1.9 gpm.
- Pursuant to the plumbing code,[1] UC Santa Cruz has replaced 59% of the public restrooms and guest rooms with low flow, or 1.6 gallon per flush (“gpf”) toilets.

[1] The U.S. Energy Policy Act of 1992 requires efficient plumbing fixtures in new construction and replacements

Table 4 – UC Santa Cruz Main Campus Water Fixtures
(Data Collected During Survey Conducted April – August 2007)

Fixture	Number Surveyed
Buildings Surveyed	414
Number of UC Santa Cruz submeters	350
Restrooms Surveyed	1,188
Restroom Faucets Surveyed	1,378
Restroom Faucet Aerators	1,003 (73%)
Faucets Leaks	58 (3%)
Total Surveyed Toilets	2,156
1.6 gpf Toilets	1,252 (58%)
3.5 gpf Toilets	661 (31%)
Unknown gpf Toilets (not labeled)	243 (11%)
Toilet Leaks	6 (0.3%)
Urinals – Flush	188
Urinals – Waterless	30
Washing Machines	157
Showers	1,425
Drinking Fountains	342
Kitchens: Apartment/Office	637
Kitchens: Cafeteria & Dining Hall & Restaurant	14
Kitchen Faucets: Cafeteria & Dining Hall & Restaurant	111 (Range 3 to 19 faucets per kitchen)
Kitchen Spray Rinse Valves	17
Kitchen Ice Machines	14
Kitchen Cooking Steamers	18
Cooling Towers	4
Swimming Pools (Outdoor)	1
Laboratory Steam Sterilizers	11
Laboratory Cage Washer	1
Laboratory Fly Food Kettles	2
Laboratory Spray Valves	2
Laboratory Ice Machines	10+
Outdoor Fountains	3+
Landscape Irrigation Controllers	90

3.3 Dining Facilities and Restaurants

The UC Santa Cruz operates dining commons (with shared kitchens) for 9 colleges (Kresge College is Suite/Apartment style housing) in addition to a variety of restaurants and cafes across campus. Some of the restaurants are independently owned. The large dining facilities serve

breakfast, lunch and dinner. Staff estimated that the college dining facilities and restaurants serve over 10,500 meals per day. This number can greatly fluctuate depending on the UC Santa Cruz occupancy (lower in the summer and during holiday breaks). The summer term does continue to have dining services for the summer camps and summer school attendees and employees. During food preparation and clean up the kitchens use a variety of water using equipment including dishwashers, spray valves, food steamers, ice machines, and kitchen faucets.

Dishwasher and Spray Valves

During cleanup, the UC Santa Cruz kitchens do not currently use garbage disposals; typically the dishes are first spayed with a spray rinse valve to remove large food particles, and then washed by large dishwashers. Dishwashers use a large volume of water to wash dishes. Therefore, MWM recommends that the dishwashers be loaded as efficiently as possible as determined by the manufacturer (e.g., running full racks instead of half racks or one plate at a time) to avoid any unnecessary water use.

The flow rates of the 17 spray rinse valves measured during the UC Santa Cruz survey had an average flow rate of 1.90 GPM. It is recommended that the 9 valves measured to flow greater than 1.9 GPM need to be replaced with newer low flow models as they are used frequently by kitchen staff.

Spray Rinse Valves – These fixtures are used in commercial kitchens to rinse dishes before they are placed in the dishwasher. Conventional spray valves use about 2-3 gallons/minute or more and new low flow models required by the current plumbing regulations only use about 1.6 gallons/minute at 80 psi, or 1.0 gallons/minute at 60 psi. Low flow models can save on energy, water and sewer as the fixtures typically use hot water.

Information about these pre-rinse spray valves and savings can be found at http://www.fishnick.com/equipment/sprayvalves/. The total cost to purchase and install one of the sprayers is $220

3.4 Laundry

All of the UC Santa Cruz's 157 washing machines are leased. The lease is renewed every three years. Almost all of the machines on campus are Maytag Neptune front loading commercial machines. The machines are coin operated and provided to the students in their college resident halls. It is important to ensure that the machines provided by the leasing company are the most efficient possible to minimize water, sewer, and heating cost to ensure that resources are being used efficiently. Checking with the leasing company and experimentation with alternative higher efficiency machines can possibly reduce water, sewer, and energy costs.

3.5 Ice Machines

UC Santa Cruz has 14 large air-cooled ice machines for kitchen use, in addition to units in the laboratories used for experiments. The kitchen ice machines are made by a variety of manufactures including Manitowoc, Hoshizaki and Scotsman. Air-cooled ice machines are more water efficient than water-cooled machines. Air-cooled machines typically use less than 18 gallons per 100 pounds of ice. Water-cooled machines typically use 150 to 200 gallons per 100 pounds of ice produced.

It is recommended when it is time for new installations (such as the new Biomedical building) or replacements; UC Santa Cruz should select air cooled machines and look for possible rebates. Currently Manitowoc is offering $300 to $500 rebates for air cooled machines. Air cooled machines are more efficient but do not typically cost any more than water cooled machines. For more information and an example of possible future rebates see the following website: http://www.manitowocice.com/sales/CAERebate.asp

3.6 Cleaning (Custodial)

The UC Santa Cruz has a custodial staff that cleans different parts of campus daily. The staff is responsible for cleaning the sinks, toilets, faucets, and showers. It is recommended that the staff be trained in water and chemical efficiency to ensure that water is not wasted.

3.7 Cooling

UC Santa Cruz has 4 evaporative (water) cooling towers with over 3300 tons of cooling capacity that is used for refrigeration, air conditioning, and cooling the chilled water loop. These cooling towers are metered and are well maintained. The cooling towers run all year except for 2 weeks in April and 2 weeks in September for maintenance. The chart below shows the 4 cooling towers and the approximate number of cycles of concentration. During the site visit and testing of total dissolved solids (TDS) shown in Table 5, the towers were found to be running 3 cycles. Due to the current low level of cycles, there are two recommendation projects to improve water efficiency. For water efficiency the goal is a minimum of 5 cycles as shown in the chart below.

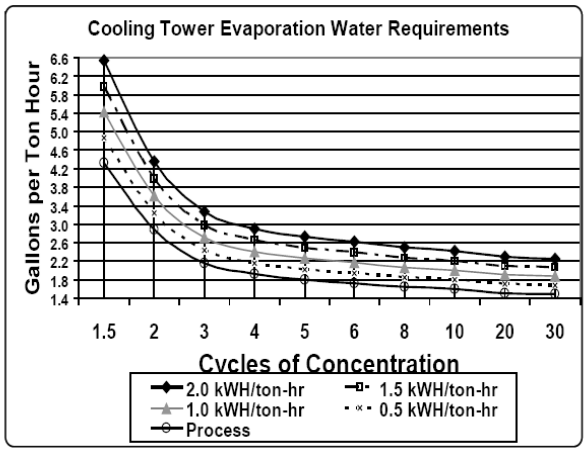


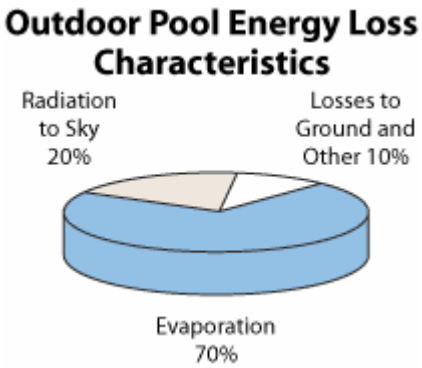
Table 5 – Cooling Tower Descriptions

Cooling Tower	Cooling Tower Mfrg and Type	Tonnage	Total Water Recirculation Rate	Read Date	TDS Incoming Water	TDS Measured in Tower	Approx # of Cycles
CT-1	Marley Crossflow/ Force Draft	1738	3000 GPM	July 24 August 1 August 8	295 270 290	1030 760 1020	3.49 2.81 3.42
CT-2	Baltimore Aircoil Vertical Counter / Force Draft	563	1062 GPM		Typically CT-2 Runs at Night.	Not running when sampled during the day	
CT-3	Baltimore Aircoil Vertical Counter / Force Draft	938	1500 GPM		Typically CT-2 Runs at Night.	Not running when sampled during the day	
CT-5 Co-Generation	Baltimore Aircoil Vertical Counter / Force Draft		675 GPM	July 24 August 1 August 8	295 290 290	900 785 870	3.05 2.71 3.00

3.8 Swimming Pool

The UC Santa Cruz has one large outdoor swimming pool that was installed in 1988. The pool is approximately 50 meters by 25 meters in size with a depth range of 3.5 to 10 feet deep. The approximate volume is 895,000 gallons which is maintained at 80.5 degrees all year round. The pool is in use all year for classes and recreation. The Physical Plant staff stated that the pool filters are backwashed once per month. The pool has never been fully drained since it was installed in 1988, which explains the current high levels TDS (greater than 2500) measured in the pool water during the site visit. The pool is typically not covered at night.

It is recommended to cover pools when not in use to reduce evaporation and keep water cleaner. In the summer, evaporation ranges from five to ten inches a month (The Association of Pool and Spa Professionals). The evaporation rate from an outdoor pool varies depending on the pool's temperature, air temperature and humidity, and the wind speed at the pool surface. The higher the pool temperature and wind speed and the lower the humidity, the greater the evaporation rate. Using a pool cover eliminates almost all evaporation. If a pool is heated, as much as 70 percent of heat is lost through evaporation (U.S. Dept. of Energy – ERRE Consumer's Guide). Covers range from single sheets of plastic to insulated materials. It is recommended for UC Santa Cruz to purchase an insulated cover to keep the evaporation of the heated pool at night to a minimum. For UC Santa Cruz, it is recommended to fully cover the pool at night only in the winter. During the summer months the pool is used to reduce heat generated by the energy Cogen plant.



http://www.eere.energy.gov/consumer/your_home/water_heating/index.cfm/mytopic=13140

3.9 Laboratories

MWM conducted a walk-through of the laboratories in the academic core area on July 31 and August 1, 2007. The purpose of the site visit was to identify water using equipment beyond the fixtures cataloged in the student survey and find potential water conservation projects.

The campus has deionized water (DI) system in the basement or on the roof of several laboratory buildings. The Physical Sciences Building has the largest DI system, which is a reverse osmosis system maintained by US Filter Corp. It is planned that this building will serve existing and new buildings in the vicinity. The DI faucets were tested in a sample of the laboratories in each building.

MWM identified the following major water using equipment:

- 1 - cage washer for animal research area
- 11 steam sterilizers used to clean and sterilize glass ware
- 2 - spray valves to prerinse equipment prior to the sterilizer
- 2 - fly food kettles
- 10+ ice machines
- water cooled vacuum pumps and compressors

Several water conservation projects based on the above listed items are evaluated in the Conservation Opportunities Section 5.0.

3.10 Landscaping

As mentioned previously, the UC Santa Cruz has separate submeters for most of the landscape irrigation. The landscaping is located throughout the UC Santa Cruz campus including the academic and housing areas, and large turf athletic fields. There is also an arboretum, garden and farm. In addition, there are many small to medium sized areas of shrubs and groundcovers in the colleges. The total irrigated area on campus is approximately 67 acres (including the farm). The landscape is irrigated via 77 different irrigation controllers. A Central Control System (Rain Master) irrigates with 13 satellite controllers about one third of the irrigated area on campus.

The UC Santa Cruz should only irrigate turf and shrub landscaping during the drier summer season (i.e., from April to October each year). The landscape does not require irrigation in the winter cooler and wet months and should be turned off during wet weather.

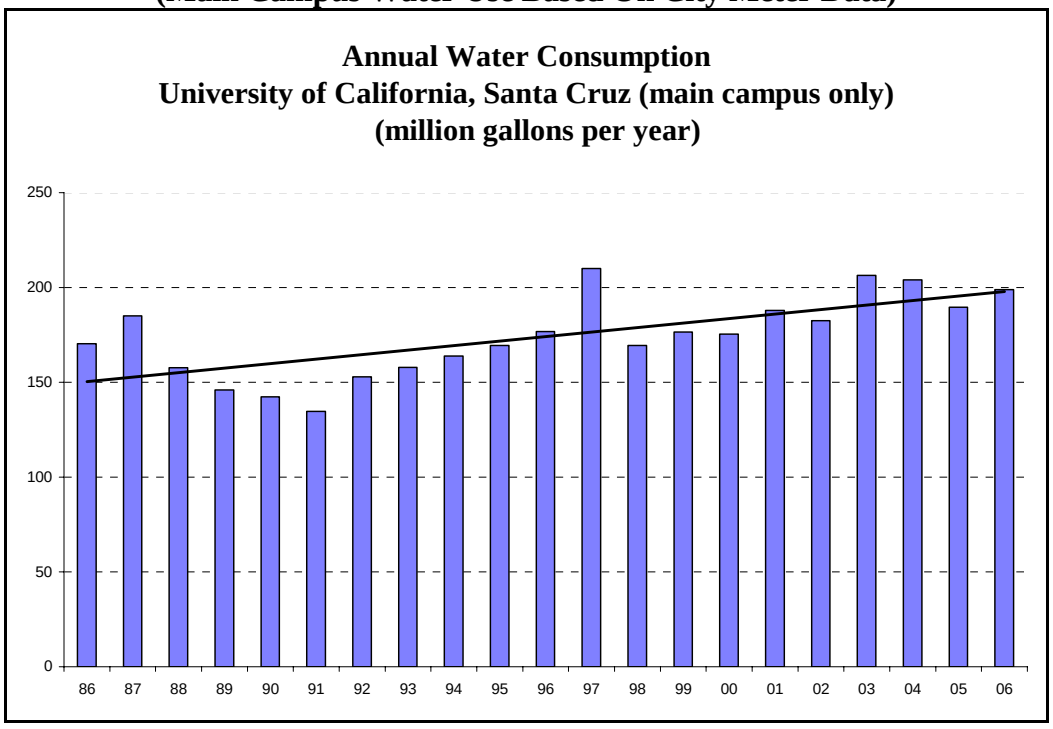
4.0 HISTORICAL WATER USE AT UC SANTA CRUZ

The City of Santa Cruz reads the UC Santa Cruz's water meters every month for billing purposes. Water usage at the UC Santa Cruz varies seasonally because the landscaping is irrigated more intensively in the summer and the occupancy rate at the UC Santa Cruz is lower in the summer (see Figure 1). In this report, water usage is reported in gallons per day (GPD). The following water use characteristics were derived based on review of the UC Santa Cruz's water and sewer bills as provided by the City of Santa Cruz:

- The highest combined total indoor and outdoor water use occurs during the school months of May, June and October
- The average total daily usage (sum of indoor and outdoor water use) in 2006 is approximately 564,900 GPD including Marine Sciences or 544,900 for the main campus only.

Figure 1 indicates that overall water use at the UC Santa Cruz has been increasing over the last three and a half years. This increased water use is due to the increase in student enrollment, new building facilities, and changes in campus activities such as types of laboratory research. This incremental increase in water use has been slower than the growth components that affect demand due to the many conservation efforts on campus. The peak water usage occurs in the end of summer when the students return to campus and there is a continued irrigation demand.

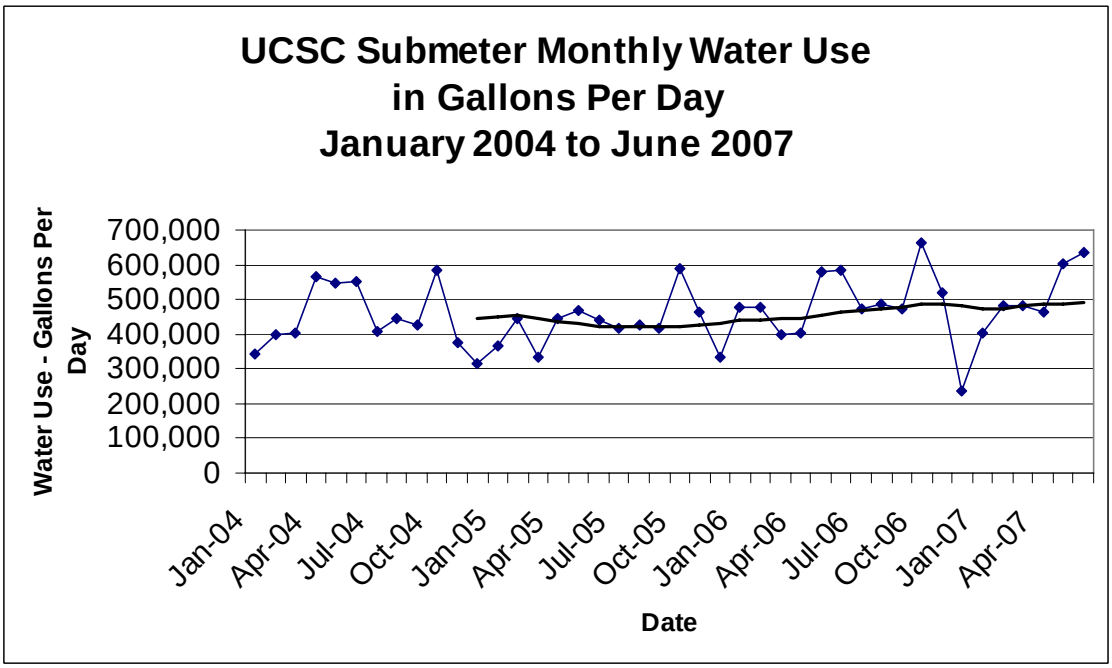
Figure 1 – Annual Water Consumption History for the UC Santa Cruz (Main Campus Water Use Based On City Meter Data)



Source: Provided by the City of Santa Cruz, July 2007

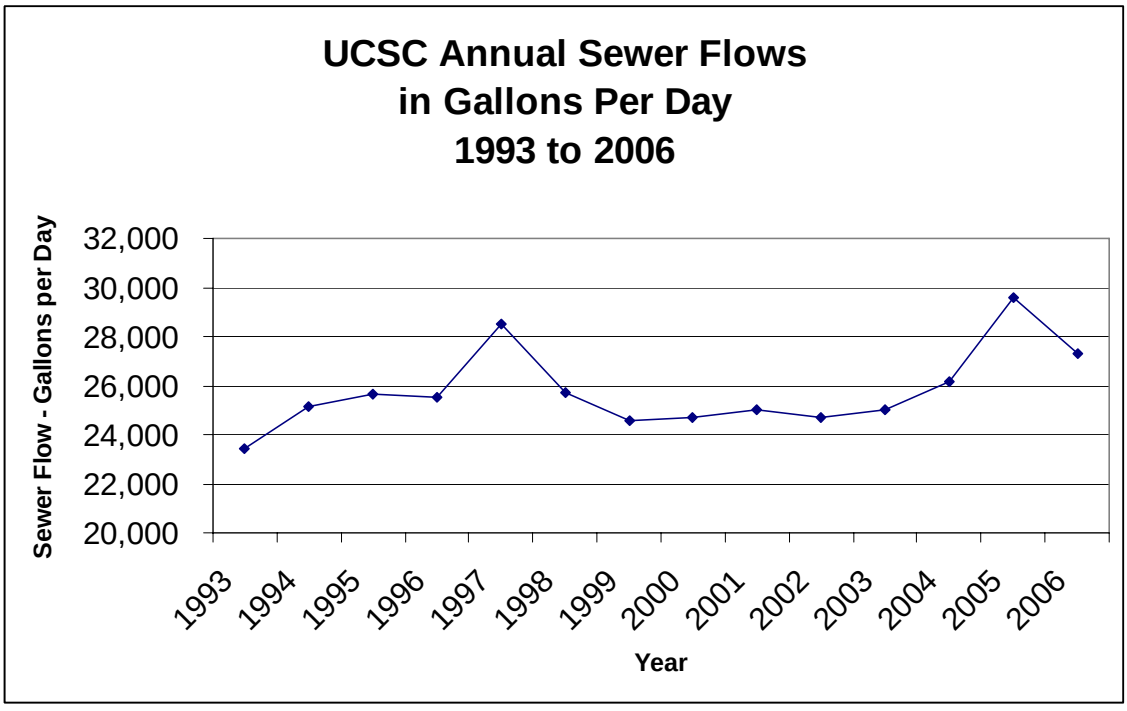
Figure 2 – Monthly Water Consumption History for UC Santa Cruz

(Total Campus Water Use Based On Submeter Data)



Source: UC Santa Cruz Submeter Data Provided by Physical Plant Department, July 2007

Figure 3 – Annual Sewer Flow History for UC Santa Cruz



Source: UC Santa Cruz Physical Plant Utilities Submeter Data, July 2007

4.1 Water Use Composition

In order to accurately account for water conservation benefits from water conservation program savings, it is necessary to establish a baseline water use from historical data. The evaluation of historical water consumption for UC Santa Cruz involved the analysis of available submetering data between 2004 and 2006. Data show that the 12-month moving average from 2004 to 2006 for the submetered system is increasing slightly and was at approximately 482,000 gallons per day for calendar year 2006. This submeter total of 482,000 gallons does not include water system loss, unmetered areas, or the Marine Sciences Lab or 2300 Delaware. This report focuses specifically on water conservation for the domestic water supply system. The historical water use was further broken down into a water system profile to establish water demands by nine individual categories. The four categories of water use analyzed are listed as follows:

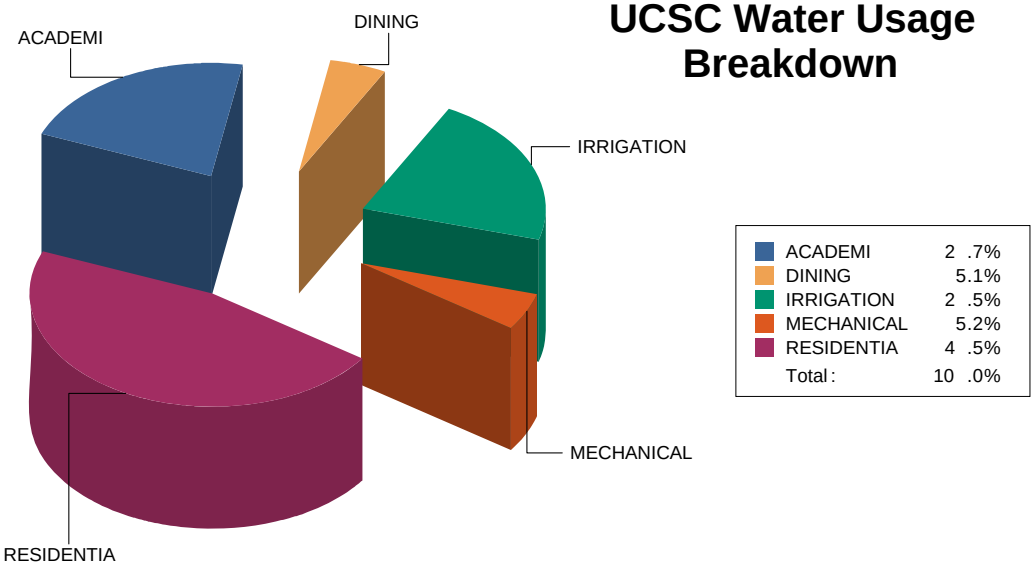
- Irrigation
- Residential
- OMP
- Other (including Central Energy Facility (CEF/Cogen) Construction Projects and Domestic System Flushing

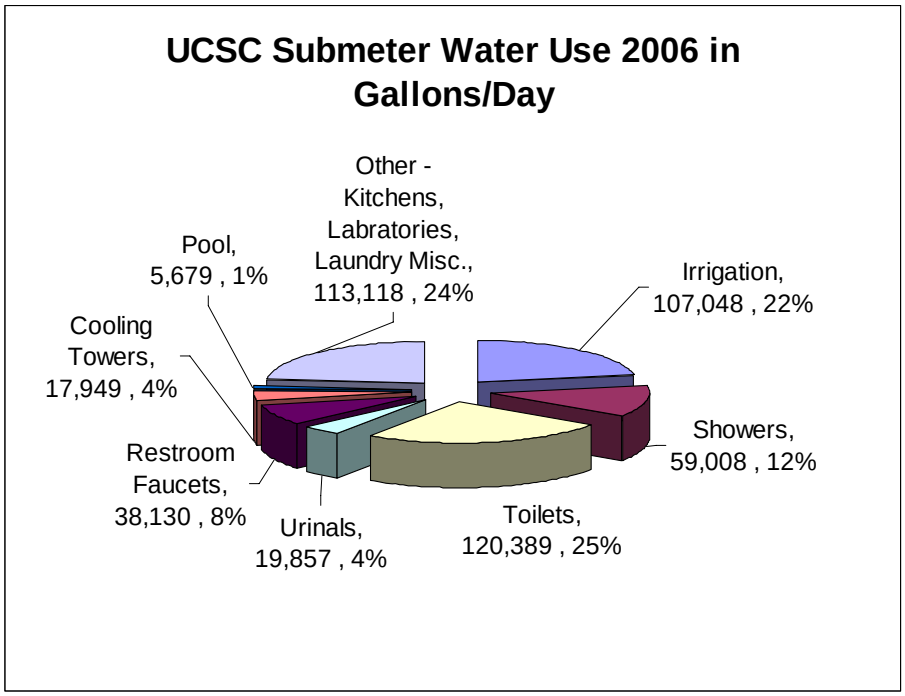
The categories were chosen to analyze domestic water use and consumption based on monthly-metered data to be consistent with the Long Range Development Plan.

The respective percent of total annual average domestic water demand based on 5 years of metered data for each category is illustrated in Figure 5. This does not include unaccounted for water. Unaccounted-for water is approximately 7.3 percent in 2006. UC Santa Cruz's domestic system is very efficient compared to the industry goal of less than 10 percent unaccounted-for water as determined reasonable by the American Water Works Association (AWWA, 1996).

MWM recommends that the focus for water conservation efforts should target the larger end uses of water so as to provide the most cost effective conservation investment returns.

Figure 4 – 2006 Annual Demand By Category for Domestic Water System





Source: UC Santa Cruz Submeter Data Provided by Physical Plant Department, July 2007

The two leading end uses of water: toilet flushing and landscape irrigation represent over 47 percent of the domestic water used on campus. Therefore, these two end uses are specifically targeted by conservation measures, in addition to evaluation of other end uses in Section 5.0.

4.2 Discussion of Irrigation System Evaluation

Irrigation System Evaluation

Description of Current Landscaping and Irrigation System

UC Santa Cruz maintains an extensive irrigation system to water the playing fields and other landscape around campus buildings. A survey by trained students was conducted to characterize the various irrigated areas. The survey was conducted in the Spring Quarter, 2007. Data was recorded on forms and transferred to an Excel spreadsheet with 30 columns and 500 rows. Each

row in the spreadsheet was a separately measured irrigated area and characterized according to the parameters listed in Table 6. The purpose of the survey was to gather data that could be used to establish landscape water requirements, develop water budgets, and then compare these budgets to actual use. A detailed three year (2004-2006) comparison was conducted using the 60 irrigation submeters. Currently there are some irrigated areas on campus that are unmetered. Water budgets were developed for all irrigated areas to estimate current water use on the 91 points of connection (POCs), as well as for the total amount of irrigation water used on campus.

Table 6 - Data Recorded in Field Landscape/Irrigation Survey

Data Point	Values recorded				
Location	1 - 500 separate areas				
Irrigation Type	Hose & bucket	Drip irrigation	Underground piping w/sprinkler		
Irrigation Schedule	Central Control	Other Controller	Manual Control		
Slope	< 5%	5-10%	>10%		
Exposure	Shady all day	Part sun and shade	Sunny most of the day	Full sun	
Soil Type	Sandy loam	Clay loam	Clay		
Landscape Type	1=Turf	2=High water use plants	3=Low water use shrubs	4=Ground cover	5=Trees
Visual Quality	Healthy	Weeds	Over watered		
Area, sq. ft.	length	width	area		

The survey and other information indicated that there are 91 separate POCs to the campus water system for irrigation purposes. Thirteen of these connections are on a central computerized irrigation system made by Rain Master. The Central control system was installed in the year 2000. A weather station is located on campus and is used to adjust the irrigation schedule to compensate for daily fluctuations in the weather and associated irrigation requirements. There are approximately 77 other individual field controllers located around campus. Some of the irrigation is controlled manually, such as at the Arboretum and most of the Farm.

Shown in Table 7 is the breakdown in landscaped area between categories 1 and 2, designated "High Water Use" and 3-5, and designated "Low Water Use" Note that about one-third of the landscaping is low water use. The percentage low water use plantings would be much higher without the playing fields. As the Farm is such a large area, totals are shown with and without the Farm. Note that about one-third of the landscaped area is on the Central control system.

Table 7 - Tabulation of Irrigated Area by Type

and Metered, Unmetered, on Rain Master System

Area	Total Area, sq. ft.	High Water Use, sq. ft.	Low Water Use, sq. ft.
All Area	2,934,771	2,087,514	849,472
Metered	2,475,371	1,760,424	717,162
Unmetered Totals	459,400	327,090	132,310
Central Control Totals	974,737	791,277	183,461
Total w/o Farm	2,380,779	1,585,287	797,707
Percent of Total w/o Farm	100	66.5%	33.5%

Development of Water Budgets for Irrigated Areas

In order to evaluate the current irrigation system efficiency water budgets were developed for each POC. Water budgets were developed by obtaining monthly weather data for the years 2004-2006 and then using this information with standard landscape water budgeting principals. The methodology was developed at Cal Poly San Luis Obispo and endorsed by the California Urban Water Conservation Council (CUWCC) and the Irrigation Association. The CUWCC has a Best Management Practice devoted to landscape water conservation (BMP 5) and expects their utility members to develop and provide to customers water budgets for 90 percent of all the irrigation accounts in their service area. In this Water Efficiency Survey the water budgets have been developed and thus the campus is in compliance with the intent of BMP 5, even though the campus is not a utility member of the CUWCC. The individual POC water budgets have been provided to campus staff in an Excel Workbook.

Shown in Table 8 is the evapotranspiration of cool season grass (the reference crop) from a local weather station owned and operated by the California Department of Water Resources. The nearest station to UC Santa Cruz is named De Laveaga. The computed evapotranspiration is the amount of water in inches per month that the cool season grass needs to thrive. Table 8 provides this information for the last three years. It is coincidental that the values for 2005 and 2006 are the same.

Table 8 - Irrigation Season Reference Evapotranspiration (Eto) Data from CIMIS Station No. 104, De Laveaga

2004 Eto (April thru October), inches	2005 Eto (April thru October), inches	2006 Eto (April thru October), inches
32.6	28.2	28.2

The Applied Water Requirement (the amount of water to apply through the irrigation system) is obtained by the following equation:

Applied Water, inches/year = Eto x Kl / DU

Where:
Eto is the annual Evapotranspiration, inches/year

Kl = Landscape or Crop Coefficient
DU = Distribution Uniformity

The values used in this project are those adopted by the campus irrigation specialists and are shown in Table 9. Note that the landscape factor reduces the amount of water needed. In the case of turf, 80% of Eto is believed to be adequate, whereas 25% of Eto is adequate for low water use plants. The irrigation efficiency for the high water use areas is higher, these are mainly flat grass areas irrigated with sprinklers.

Table 9 - Assumed Landscape and Irrigation Parameters

Landscaping Type[1]	Kl	DU
1,2	0.8	0.7
3,4,5	0.25	0.6

[1] See Table A
Kl = Landscape or Crop Coefficeint
DU = Distribution Uniformity

Using these values the applied water factor or amount of irrigation needed is given in Table 10. High water use plants and turf requires almost three times the water as low water use plant material. Because the weather changes this calculation should be made every year. For future forecasting applications averages can be used. Additional years of record are available for this purpose from the De Laveaga station. Note that 2004 was a normal year and both 2005 and 2006 are considered wet years in California. The water requirements for 2005 and 2006 were about 14 percent less than 2004.

Table 10 - Applied Water Factor for Water Budget Calculation

Landscaping Type	2004 Applied Water Factor, inches/yr	2005 Applied Water Factor, inches/yr	2006 Applied Water Factor, inches/yr
1,2	37.3	32.2	32.2
3,4,5	13.6	11.7	11.7

Evaluation of Current System Efficiency

The relative efficiency of the current irrigation can be estimated by comparing actual water use with the water budget. It should be recognized that a water budget calculated in this way is a *guide or estimate* of the water requirements and should be refined by local microclimate information such as exposure, soil type, and wind as well as visual inspection. The budgets developed in this study will serve as the best available information to gauge the efficiency of the current system.

Table 11 show the actual metered water use in annual average gallons per day (gpd). The values in the summer would be considerably higher than these values and in the winter the irrigation is near zero. Note that about half of the metered water use is being controlled by the Central control system at 13 sites. These are the playing fields and the newer building landscapes. Note that the

water use declined in the last two years (most likely in response to the weather and enhanced water management).

Table 11- Actual Metered Irrigation Use, 2004 – 2006, gpd

Tabulations	Water Use in 2004, gpd	Water Use in 2005, gpd	Water Use in 2006, gpd
Totals	121,290	99,677	107,048
Totals w/o Farm	111,338	91,808	99,088
Central control Totals	56,360.9	51,414.0	49,868.4
% Total Irrigation Water Use on Central control	46.5%	51.6%	46.6%

Water budgets for each POC have been developed and are summarized by type of area in Table 12 for the last three years. Note that about 85 percent of the irrigation use is metered, the unmetered irrigation is estimated (based on a water budget for those areas) to be about 20-22,000 gallons per day (gpd). The water budgets for the Farm are separated from the totals due to its large acreage. Generally the Farm uses considerably less than the budget because the entire area is not continuously planted or irrigated through the growing season.

Table 12 - Water Budgets for 2004-2006

Tabulations	Budget for 2004, gpd	Budget for 2005, gpd	Budget for 2006, gpd
All Area	151,306.0	131,724.5	131,724.5
Metered	128,488.8	111,067.9	111,067.9
Unmetered Totals	22,817.2	20,656.5	20,656.5
Central control Totals	55,681.0	48,131.6	49,058.3
Metered Totals w/o Farm	95,333.1	82,407.6	82,407.6

Finally Table 13 shows how the actual water use for the overall areas compares to the overall water budgets. On an overall basis, the metered areas appear to be under watering. This is because the Farm is under watering by a large margin. Without the Farm the metered areas appear to be over watering from 10 to 17 percent on an annual average basis. Those 13 areas on the Central control system are performing much better and are over watering only one to six percent. This was especially true in 2006, a wet year. The Central control system was able to cut back irrigation automatically, whereas the other irrigation time clocks were not able to be adjusted frequently enough to compensate for the unusually cool and wet weather that occurred in 2006.

Inspection of the budgets for the individual areas shows that many appear to be significantly under watering and a number of other areas are over watering a significant amount. Therefore there is room for improvement on an overall basis (for those areas not on Central control) and for about 20

specific sites estimated to be over watering. Tapping this potential is investigated in a subsequent section.

Table 13 - Comparison of Actual Use with Annual Water Budget

Performance (Over Budget)	2004 Use Over Budget, percent	2005 Use Over Budget, percent	2006 Use Over Budget, percent
Total Metered Overage	-5.9	-11.4	-3.8
Total Metered Overage w/o Farm	14.2	10.2	16.8
Total Central control Overage	1.2	6.4	1.6

Note: Negative percentage means area is under water budget; Positive percentage means area is over water budget

4.3 Discussion of System Water Loss Evaluation

Definitions

The term unaccounted for water has been used for many years to characterize the difference in metered water use between production or purchase meters and customer or building meters. Unfortunately there have never been clear definitions of what should be included in this category or what are acceptable or reasonable levels for the amount of water in this category. Historically the figure of 10 percent of water produced or purchased has been used as a guideline.

Two commonly referenced sources include a 1996 Journal American Water Works Association (AWWA) article entitled "Committee Report: Water Accountability" which stated:

Advances in technology and expertise should make it possible to reduce lost and unaccounted-for water to less than 10 percent"

The California Urban Water Conservation Council (CUWCC) established a Best Management Practice (Number 3) for "System Water Audits, Leak Detection and Repair" in 1991. It called for an annual review of the ratio of metered sales and other verifiable uses to total supply into the system. If the ratio fell below 0.9, then a full scale system water audit is indicated.

The American Water Works Association (AWWA) has subsequently adopted a different method of dealing with lost and unaccounted for water and the California Urban Water Conservation Council (CUWCC) is in the process (2007) of doing the same. Both have or are adopting a method developed by the International Water Association (IWA) that attempts to standardize definitions. AWWA, CUWCC, and IWA use the term "Non-Revenue Water" which is typically used for utilities to describe the water that is not billed to customers. Adapted to UC Santa Cruz the Non-Revenue water includes:

Fundamental Definitions for Water Not Included in (Customer or Building) Metered Use: Non-Revenue Water

- ***Real Losses****: Physical losses of leaks, bursts or breaks and overflows from the pressurized system, up to the metering point on customer service connections*

- ***Apparent Losses****: consist of all types of inaccuracies (customer meters, meter reading or estimation, billing error) and unauthorized consumption (theft of service, illegal use of fire hydrants)*

- ***Unbilled Authorized Consumption****: Metered and Unmetered consumption approved by the UC Santa Cruz; including water used for fire fighting, system maintenance/flushing and authorized campus uses (landscape irrigation)*

- ***Non-Revenue Water****: the sum of Unbilled Authorized Consumption, Apparent Losses and Real Losses*

Approach

The UC Santa Cruz Water Efficiency Survey included a water balance approach and compared campus water meter readings (submeters) with City of Santa Cruz water billed for the main campus. Monthly data for sewer flow leaving the campus was also available and used. This work can be considered a preliminary system audit, but not a full system audit that would involve calibrating meters, estimating all authorized unmetered uses. The work did not include using sonic leak detection equipment to search for leaks on the distribution system. The purpose of the water balance approach was to determine whether the campus should pursue strategies to reduce Non-Revenue Water.

The campus water balance included analyzing the following monthly data and comparing winter and annual volumes in 2004, 2005 and 2006 of:

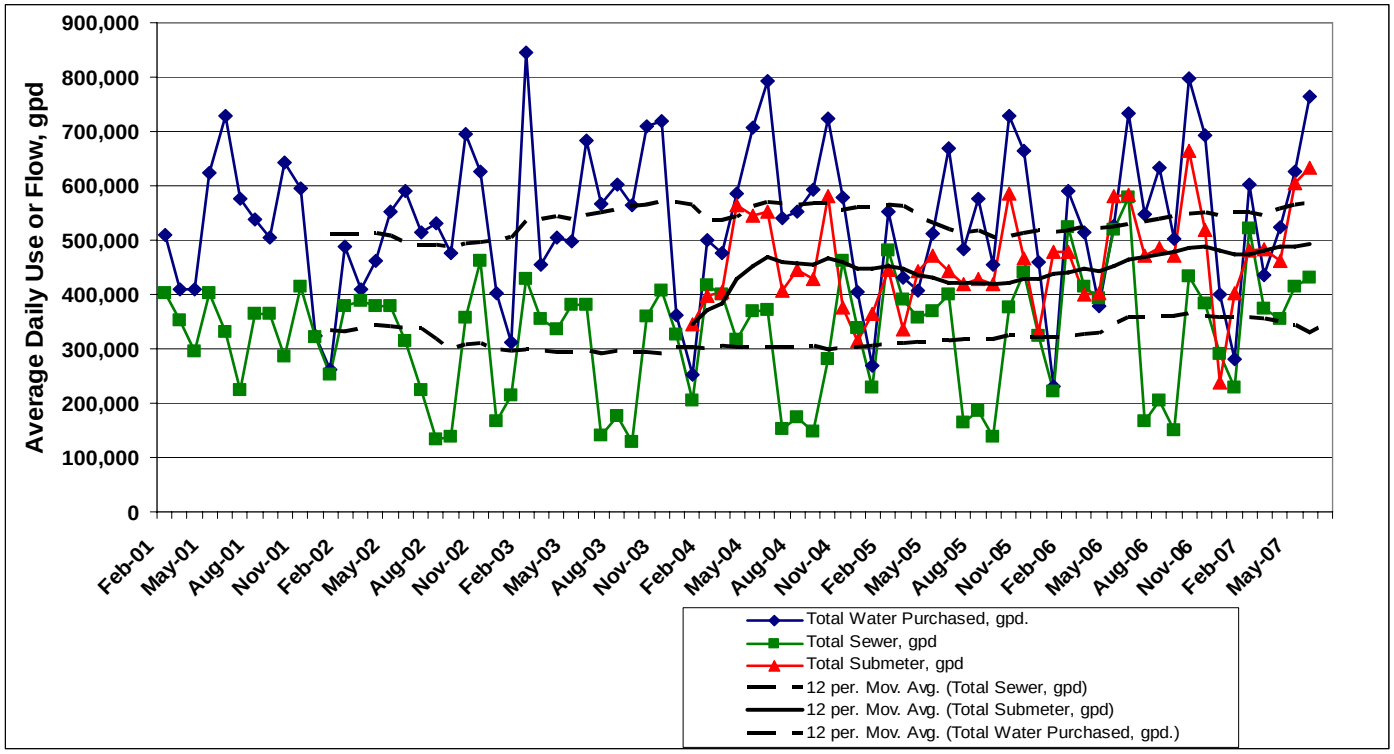
- Water purchased
- Submetered water
- Winter irrigation
- Sewer flow

Recent Levels of Non-Revenue Water (NRW)

The campus water balance used the data shown in Figure 6. Note that the water purchased and submetered uses are converging and that the winter sewer flow is converging on the submetered uses in the winter (when landscape irrigation is relatively low). The former is apparent by focusing on the moving averages, the latter by reviewing the monthly values in the winter for the submeters and sewer flow.

In terms of accuracy of meters the City Meters, the largest 10 inch meters were replaced in 2004. The 4 to 6 inch meters range in age from one year to 12 years. The UC Santa Cruz meters also range in age. Whereas there is no regular program to replace meters, meters are replaced when they stop working. Most likely some meters are over 30 years old. A number of buildings on campus are relatively new, with new meters. On average the UC Santa Cruz meters are probably less accurate than the City meters due to the age difference.

Figure 6 - Monthly Water Purchased, Submetered, and Sewer Flow Data Comparison 2004-2007



Winter Analysis

Shown in Table 14 is the comparison of water purchased, submeter readings and sewer flow in the winter. The winter is defined to be the months of December, January, February and March. The difference between City Water and submeter readings in the winter has dropped to 5-6 percent in 2005 and 2006. Using the sewer flow data but subtracting off the winter irrigation (metered and estimated unmetered) yields an even lower percentage. As the later relies very little on the submeter data, the difference here might be thought to be the background leakage, assuming the sewer flow data is accurate. Thus system leakage is probably about 5 percent or less.

Table 14 - Analysis of Non-Revenue Water for Winter Period

Year	City Water Winter, MG	Winter Submeter, MG	Winter Irrigation, MG	Winter Sewer, MG	City Water Winter, MG	% of City Water (Winter NRW)	City Water-Sewer-Winter Irrigation, MG	Final % of City Water (Adjusted Winter NRW)
2004	49.8	44	7	43	5.5	11.02%	-0.5	-1.06%
2005	53.9	51	9	44	2.3	4.36%	0.3	0.50%
2006	51.5	48	12	42	3.4	6.56%	-2.7	-5.30%

MG = million gallons NRW = Non-Revenue Water

Annual Analysis

Shown in Table 15 is the comparison of the annual volumes of City Water, submetered water and sewer flow. In this case the difference between City Water and submetered water has dropped from 19 percent in 2004 to 11 percent in 2006. When the estimate of unmetered irrigation is included in the equation the difference narrows to 15 percent in 2004, dropping to 12.5 percent in 2005 and finally to under 7.5 percent in 2006. The year to year reduction is significant. These values would include leaks and submeter error. In all likelihood both leakage and submeter error are less than five percent and overall Non-Revenue Water is now (2006) less than 10 percent of water purchased.

Table 15 - Analysis of Non-Revenue Water for Annual Period

Year	City Water Winter MG	Submeter MG	Irrigation MG	Sewer MG	City Water -Submeter, MG	% of City Water (Annual NRW)	City Water-Submeter-Unmetered Irrigation, MG	Final % of City Water (Adjusted (Annual NRW)	Year to Year Reduction in NRW, %
2004	204.0	164.7	52.6	110	39.3	19.27%	31.0	15.19%	-----
2005	188.7	157.5	44	117	31.2	16.53%	23.6	12.53%	17.5%
2006	198.9	176.8	47	130	22.1	11.10%	14.5	7.31%	41.6%

MG = million gallons NRW = Non-Revenue Water

Opportunities

The reduction Non-Revenue Water is most likely due to the improved maintenance of the UC Santa Cruz campus water distribution system, submeters and data management. Currently the UC Santa Cruz Physical Plant staff monitors the meters monthly and any meter that is out of the typical range is inspected. The fluctuation between 2004 and 2006 has been significant and could be tracked annually to verify that the system water loss is within the national guidelines. At some point in the future the level of Non-Revenue Water will stabilize at a value that is probably small and not cost-effective to pursue reducing further.

The campus water system, considering the volume of water used, has a relatively short length of mains, 17 miles, (where leaks might be present) and a relatively few number of meters (less than 400). Therefore it is reasonable to assume that a Non-Revenue Water target of less than 10 percent might be realistic. With this small of a water system, upgrading water meters or conducting sonic leak detection would not be extremely expensive. These opportunities are pursued further in Section 5.0.

4.4 Billing Rates for the UC Santa Cruz Campus

The current cost of water (as of 1 January 2007) for UC Santa Cruz is $3.67 per 1,000 gallons for the main building meter. The sanitary sewer service charge (as of 1 July 2007) is $4.79 per 1,000 gallons.[2] The UC Santa Cruz's total combined sewer and water bill is approximately $1.8 million annually, including fixed meter charges. In accordance with the City's policies, the water and sewer rates are revised every year. Historically water rates change on January 1 and Sewer rates

[2] This sewer charge assumes the "High" strength commercial category according to the Campus of Santa Cruz Billing System schedule of rates and charges.

change on July 1 every year. A rate of $0.74/therm (2007 natural gas rate) was used to estimate energy savings from lower hot water use.

UC Santa Cruz does not have a separate meter or separate bill for irrigation use. All the water used on campus for domestic, irrigation or other type of use is charged the same at a uniform rate. There is, however, another meter at the base of campus that is used to measure sewer flows. Indoor uses thus get billed both for water and sewer charges (including cooling tower drain down water), while outdoor use and any other consumptive use only get billed for water because they do not result in sewer flow.

For the purposes of payback analysis, the water and sewer rates for 2009 were used which are already adopted by the City of Santa Cruz. The water rate as of January 1, 2009 is $5.61 per 1,000 gallons. The sewer rate as of July 1, 2009 is $7.31. If the rates continue to increase faster than inflation after 2009, the water conservation projects evaluated in this report will become even more attractive.

4.5 Historical Water Conservation Efforts UC Santa Cruz Campus

The UC Santa Cruz campus has a long tradition of trying to be resource efficient. This attitude toward sustainable resource management was seen on multiple occasions when talking to staff around campus that water and energy efficiency is very important in their project planning and daily operation procedures. All across campus MWM discovered water and energy efficiency practices including:

- Physical plant who monitor meters monthly looking for leaks,
- Farm who teaches and believes in the use dry and sustainable farming practices,
- Laboratories who monitor the dionized systems,
- Dining and Housing Services department who teaches water efficiency to students, works to get efficient washing machines in contract, and had their kitchens Green Building Certified,
- Planning and construction department that includes minimum fixture standards for all new construction projects,
- Irrigation maintenance staff report daily each morning and follow the warnings provided by the Central control system of areas that need possible repairs and sends workers out daily to inspect for possible problems.

<u>Example of Past Conservation Efforts: 1989 Campus Fixture Survey</u>

During the data review for the UC Santa Cruz water efficiency survey, 1989 records indicated retrofits and campus standards revisions took place, which included the total number of toilets on campus (1,434, including 772 gravity flush and 662 flush valves). In 1989 the most efficient model of toilets had been the 3.5 gpf toilets. The 3.5 gpf toilets were made from 1980 to 1989. Before 1980 toilets used 4-7 gpf. In 1989 and the early 1990s new toilet technology had been developed for 1.6 gpf toilets. At that time all campus toilets had been retrofitted to 3.5 gpf and a decision had been made to install 1.6 gpf toilets in residence halls where they were used by fewer than 10 people or less per toilet and 3.5 gpf flush valve toilets in public areas and resident halls where there were more than 10 occupants per toilet.

Showers in residential areas had been retrofitted to 2.5 gpm or less and there was some discussion of retrofitting to 2 gpm. Lavatory faucets were at 2.5 gpm and future lavatory faucets were to have 0.5 gpm aerators (but MWM did not find many 0.5 gpm faucets). In 1989, there were 110 urinals on campus, all using 3.5 gpf. There was a proposal to retrofit these to 1.5 gpf.

In comparison to the 2007 UC Santa Cruz campus survey, there are now about 718 3.5 gpf toilets (plus maybe another 100-200 or so in student apartments that were not surveyed). In summary, the campus has retrofitted about half of the 3.5 gpf toilets to 1.6 gpf between 1989 and 2007.

Table 16 – UC Santa Cruz Campus Fixtures in 1989

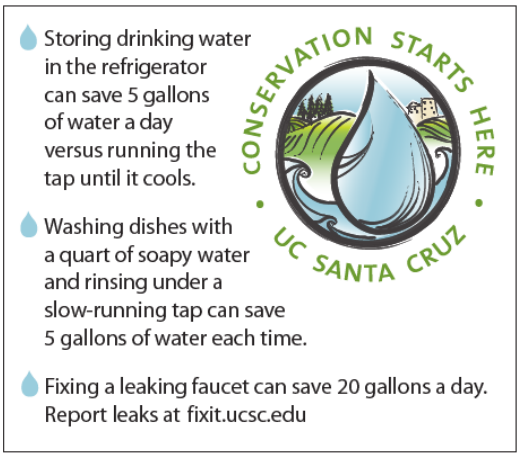
Fixture	Number
Restroom Faucets	2.5 gpm standard revised to be 0.5 gpm
Total Toilets on Campus	1,434
Toilets – Flush Valve	662
Toilets – Gravity Flush Tanks	772
Urinals – Flush 3.5 gpf	110
Urinals – Waterless	0
Showers	Retrofitted to be 2.5 gpm or less
Cooling Towers	4
Swimming Pools (Outdoor)	1 – Pool installed in 1988
Indoor/Outdoor Fountains	0

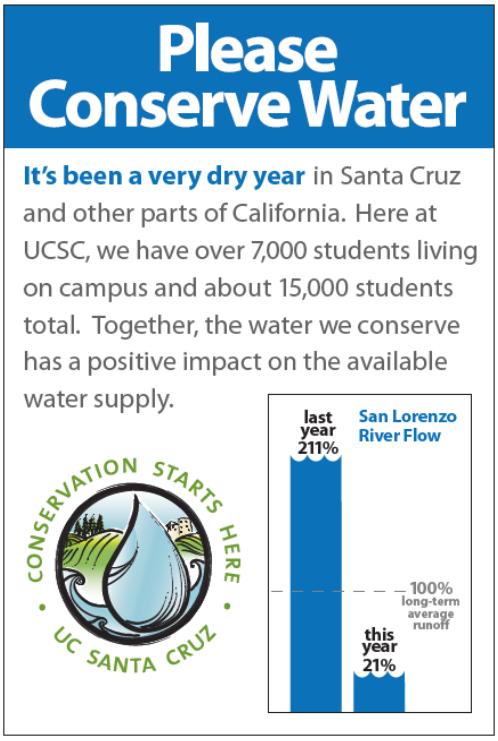
Example of Current Conservation Efforts: Dining Services Green Building Certification

UC Santa Cruz is proud of the fact that they recently were awarded a Green Building certification for their Dining Services on campus. In order to qualify for the certification, they had to meet strict water and energy standards for kitchen equipment. As part of this process, 10 kitchen spray valves were replaced with the efficient 1.6 gallon per minute models.

Example of Current Conservation Efforts: Education Campaign for Fall 2007 Students

In the Fall of 2007, UC Santa Cruz is running an education campaign including an announcement on University radio station, the College newsletters and the University newspaper, Clings and magnets will go to the students along with table jackets for the dining facilities. A large banner will be at the base of campus. Examples of the material for the campaign are provided below.





5.0 WATER CONSERVATION OPPORTUNITIES

5.1 Water Conservation Project Descriptions

The following table provides a description of the 54 projects that were identified during the UC Santa Campus water efficiency Survey.

Table 17 – UC Santa Cruz Water Efficiency Project Descriptions

Project Number	Project Goal	Potential Water Conservation Project
	IRRIGATION, GENERAL	
1	Increase water pressure to Sand Field irrigation, which is over watered to overcome poor distribution resulting from pressures below those required by irrigation system design.	Relocate the main to the high pressure side of the PRV for Sand Field.
2	Reduce runoff from sprinklers by reducing application rate.	Install MP rotator heads on sprinklers that irrigate turf on slopes.
3	Reduce use of irrigation water on Sand Field, which is over watered to overcome poor distribution (see #1, above).	Artificial turf for Sand Field.

Project Number	Project Goal	Potential Water Conservation Project
4	Improve landscape irrigation efficiency by automatically adjusting irrigation schedule as weather conditions vary. Detect and repair irrigation system leaks more quickly.	Add additional high-water-use areas to the Central control system.
5	Replace high-water-use turf with low water-use landscaping.	Remove Carriage House turf.
6	Reduce the amount of unmetered irrigation water use.	Add meters for the un-metered use except at Arboretum.
7	Replace high-water-use landscaping with lower water-use plants.	Replace high-water-use landscaping on 10% of irrigated area with lower water-use plants.
8	Improve landscape irrigation efficiency by automatically adjusting irrigation schedule as weather conditions vary.	Install ET controllers for selected high-water-use areas.
9	Improve landscape irrigation efficiency.	Develop water budgets for individual points of connection that appear to be over-watering.
10	Install rain sensors on non Central control Controllers to save water in the spring and fall.	Add wireless rain sensors on existing controllers.
	FARM	
11	Make meter readings available to staff in various units so they can improve water management in their own facilities.	Physical Plant communicate monthly meter readings to other units or enable staff to check meter readings electronically.
12	Use rainwater for greenhouse watering.	Install system to collect and use rainwater for new greenhouse.
13	Reduce water pressure in irrigation mains to avoid breaking lines.	Add 10 new PRVs to Farm irrigation system.
	ARBORETUM	
14	Increase efficiency of Arboretum water use.	Use battery-operated timers to automatically shut water off for individual drip systems.
15	Reduce water pressure in Arboretum irrigation lines to prevent breakage in drip system.	Install PRVs to reduce water pressure to lines that are in use.
16	Reduce the amount of unmetered irrigation water use at Arboretum.	Add campus submeters for the large un-metered irrigated areas use at Arboretum.
	FIXTURES	
17	Replace high-volume toilets with more efficient models in “high-use” areas.	Replace high flow toilets in "high-use" areas with 1.6 gpf or 1.28 gpf toilets.
18	Replace high-volume toilets with more efficient models in “non high-use” areas.	Replace high flow toilets in "non high-use" areas with 1.6 gpf or 1.28 gpf toilets.
19	Maintain 1.6 gpf toilet models so that they function as designed.	Replace flapper valves on toilets with 1.6 gpf that are testing with high flush

Project Number	Project Goal	Potential Water Conservation Project
		volumes. Adjust 1.6 gpf flush valve toilets with high measured flush volumes.
20	Increase efficiency of urinals.	Continue to require waterless urinals in new construction and as urinals require replacement. Replace five urinals at the East Field House that are high flow models and are used frequently.
21	Improve water efficiency of washing machines in student housing.	Where vendor can provide them, specify efficient front-loading washing machines in new contracts for laundry equipment in student housing. Currently lease renews every 3 years.
22	Reduce flow rate for restroom faucets by installing lower-water-use aerators. Campus standard is 0.5 gpm but these were only found at Grad Student Commons and a few other new buildings, and not in most new buildings. Current average faucet flow rate across campus is 1.5 gpm.	Conduct pilot test of retrofitting faucets with 1.0 gpm aerators in high use restrooms.
23	Reduce flow rate for restroom faucets by installing lower-water-use aerators.	Select appropriate aerator and replace aerators in all campus faucets.
24	Reduce flow rate of showerheads in “high-use” areas.	Replace existing "high use" showerheads in housing and athletic facilities with Bricor 1.5 gpm or 1.0 gpm showerheads, including 24 at the East Field House.
25	Reduce flow rate of showerheads in other “non high-use” areas.	Replace all remaining high flow showerheads in housing and athletic facilities with Bricor 1.5 gpm or 1.0 gpm showerheads.
26	Replace older, inefficient kitchen spray valves with newer, more efficient models.	Replace remaining 9 inefficient spray valves in kitchens, cafes, and restaurants.
27	Replace older, inefficient kitchen rinse operations with efficient spray valves.	Replace existing hose in College 9/10 Dining Hall kitchen with a low flow spray valve.
28	Eliminate water wasted through use of garbage disposals.	Remove garbage disposals.
29	Increase the efficiency of dishwashers.	Revise Campus Standards to require use of water-efficient dishwashers in new facilities and as existing machines are replaced.
	LABRATORIES	
30	Replace older, inefficient laboratory spray valves with newer, more efficient models.	Replace 2 old high flow spray valves in steam sterilizer room of Earth and Marine Sciences Building Room D473, and

Project Number	Project Goal	Potential Water Conservation Project
		Room D363.
31	Eliminate use of DI water in steam sterilizers.	Earth & Marine room D473. The equipment is actually an autoclave, and it should be converted to the typical building "soft water" rather than dionized (DI) water.
32	Eliminate single-pass cooling systems.	Eliminate fresh water single pass cooling for the air compressor and vacuum pump in Earth and Marine Sciences building. Convert to using the condensate water from the condensing loop. Conduct preliminary engineering study to determine feasibility and cost.
33	Improve management of DI Water System.	Meter the RO and DI Systems or monitor run time. Meters would allow maintenance staff to closely monitor leaks.
34	Reduce waste of DI water due to high pressure at DI water faucets.	Reduce pressure in DI water system in Physical Sciences Building.
35	Reduce waste of DI water due to high pressure at DI water faucets.	Reduce pressure in DI water system in Sinsheimer Labs.
36	Re-use heating water for fly food kettle in Earth and Marine Sciences building Room 304.	Re-plumb fly food kettle in Earth and Marine Sciences building Room 304 to route to condensate return system.
37	Reduce use of water for ice machines in Earth and Marine Sciences building.	Replace water-cooled ice machines in Earth and Marine Sciences building with air-cooled models.
38	Reduce use of water in X-ray machines.	Replace X-ray machines with models that do not use water continuously.
	GREENHOUSES	
39	Reduce plant watering requirement and load on swamp coolers used for greenhouses.	Place Saran shade cloth on 2,000 sf of Thiemann Lab greenhouse.
40	Reduce use of water for cooling greenhouses.	Replace swamp coolers for Thimann Lab greenhouse with A/C units.
	SYSTEM & METERS	
41	Improve reliability of the campus submetering system.	Develop preventative maintenance program for campus water meters.
42	Identify leaks more quickly. Convert campus water meters to automatic meter read (AMR) system. Replace 306 meters in 2 Phases.	With AMR leak detection staff will be able to detect and repair leaks faster. Use AMR to line up UC Santa Cruz read dates with City meter read dates to facilitate tracking of unaccounted-for water.

Project Number	Project Goal	Potential Water Conservation Project
43	Detect and repair leaks more quickly.	Use the ultrasonic leak detection equipment for regular system-wide audit every three to five years.
44	Identify amount of water unaccounted for with goal to reduce this amount.	Annually, conduct analysis of water not accounted for by campus submetering system.
	POOL	
45	Cover pool during school breaks or periods of limited use and at night in the winter to reduce evaporative water loss.	Purchase and use a complete set of pool covers. It is not recommended to cover pool at night during the summer as it is used by the Energy CoGen facility to reduce heat generated by the energy plant.
	NEW BUILDINGS	
46	Install water-efficient fixtures in existing buildings as they are being built or remodeled.	Update water efficiency requirements for new and remodeled buildings on campus standards.
	COOLING TOWERS	
47	Re-use cooling tower blowdown water.	Re-use cooling tower blowdown water for non-potable uses such as flushing toilets. It is recommended this be further studied during the upcoming UC Santa Cruz Water Recycling Master Plan.
48	Improve water efficiency of cooling tower no. 5. (CT-5)	Changing operating procedures of CT-5 from set point of 1200 to 2000 on conductivity meter to enable towers to run at 4 or 5 cycles.
49	Improve water efficiency of cooling towers CT-1, CT-2 and CT3.	Modify cooling tower basins to enable CT-1, CT-2 and CT-3 towers to reduce water loss when alternating between towers.
	GENERAL / OTHER	
50	Augment summer water supply using fog drip.	Evaluate potential for collection of fog for non-potable water use.
51	Augment water supply with recycled water.	Evaluate use of recycled sewer and/or rainwater for non-potable uses.
52	Increase water conservation awareness among students.	Conduct educational campaign for students arriving on campus in September.
53	Partner with the City of Santa Cruz on rebates when applicable.	Improve campus water efficiency in the most cost effective manner possible. Partner with the City of Santa Cruz on rebates. http://www.ci.santa-

Project Number	Project Goal	Potential Water Conservation Project
		cruz.ca.us/wt/wtcon/index.html. The City of Santa Cruz Currently offers rebates to business customers for high efficiency toilets, high efficiency urinals, high efficiency washing machines, x-ray film processors, and cooling tower conductivity meters.
54	Detect and repair leaking fixtures more quickly.	Post signs in restrooms encouraging people to report leaks.

5.2 Water Conservation Technology Overview and Definitions

The description of the UC Santa Cruz water using fixtures (shown in Table 4) outlines the possible future improvements that can be made for the toilets, washing machines, ice machines, dishwashers, spray valves, urinals, faucets, and irrigation equipment (see Section 3 for comments by individual area). It is recommended the UC Santa Cruz purchase water and energy efficiency equipment now and in the future as technology continues to advance. Often the cost for the more energy and water efficient devices is the same as the less efficient models. One simply needs to be aware and read or ask the manufacturers for the energy and water using specifications and compare among different models and manufacturers to ensure that the most efficient and economical model is purchased. The selection of an efficient model can greatly reduce the energy and water operation costs as much as 70 percent, which is highly desirable.

Sanitary Plumbing Fixture Standards and Definitions

National law requires that for new construction after January 1, 1992 only fixtures meeting the following standards can be installed in new buildings:

- Toilet – 1.6 gal/flush maximum
- Urinals – 1.0 gal/flush maximum
- Showerhead - 2.5 gal/min at 80 psi
- Residential Faucets – 2.2 gal/min at 60 psi
- Public Restroom Faucets - 0.5 gal/min at 60 psi (2005 amendment)

Replacement of fixtures in existing buildings is governed by the Federal Energy Policy Act that requires only devices with the specified level of efficiency (shown above) can be sold after January 1, 1994 for residential use and January 1, 1997 for commercial toilets. Only efficient models can be legally sold by manufacturers to be placed in new structures or used as replacement parts for existing fixtures. The net result of the plumbing regulations is that new buildings will be more efficient and old inefficient fixtures will slowly be replaced with new more efficient models. The national and state plumbing legislation and regulations are carefully taken into consideration when analyzing the overall water efficiency of a service area.

In addition to the plumbing legislation the US Department of Energy regulates appliances such as residential clothes washers. Regulations to make these appliances more energy efficient has

driven manufactures to dramatically reduce the amount of water these efficient machines use. Generally horizontal axis washing machines use 30-50 percent less water than conventional models (which are still sold). MWM forecasts a gradual transition to efficient clothes washers so that by 2020 this will be the only type of machines sold. New pending state and federal clothes washer standards will further increase efficiency standards. MWM forecasts given that machines last about 15 years eventually all the leased machines at UC Santa Cruz campus will be of this type.

Table 18 – Plumbing Fixture Legislation and Regulations

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Plumbing Fixture	Required by Plumbing Legislation and Regulations	Proposed Future Replacement Fixtures
Urinals	0.5 gpf by 2014 in California	Waterless
Lavatory Faucets	2.5 gpm	1.5 gpm
Toilets	1.6 gpf	1.28 gpf
High Efficiency Toilets	1.28 gpf Required by 2014 in California	1.28 gpf

gpf = gallons per flush gpm = gallons per minute

Waterless Urinals

- Saves 100% of urinal water use
- Male employees use urinals 3-4 times/day

High Efficiency Toilets recently available for sale in the US

- Use 1.6 gallon button for full flush (solid waste)
- Use 0.8 liter button for half flush (liquid waste)
- Water savings average 0.4 gallons/flush (employees flush toilets about three times per day at work)

Landscape Irrigation Technology

State of the Art ET Controller:

Irrigation controllers turn on the sprinkler and drip systems at either a specified time of day or on demand. Conventional irrigation controllers function as a time clock and work regardless of the climate, unless turned off. Many landscapers set the time clock to water the amount needed in July and then turn it on in late spring and turn it off in late fall. These controllers, called ET (short for Evapo transpiration controllers) have on-site temperature and rain sensors or an on-site weather station or receive a signal from a central computer that modifies irrigation times (sometimes daily) as the weather changes.

ET-Irrigation Controller

For a list of recommended models and more information (commonly called an ET Controller) view these web resources:
http://www.weatherset.com/Explain/ETandControllers.html
http://www.igin.com/Irrigation/pageControllers.htm
Or contact one of the manufacturers. There are many manufacturers.

Other New Landscape and Irrigation Technology:

Artificial Turf – As noted in project for Sand Field

Wireless Rain Sensors – to be added to individual controllers so they will automatically turn off irrigation when it rains. These devises save the most water with non typical rain events that occur in the spring and fall. Current systems require manual turn off of controllers.

Pressure regulators – to help reduce high pressures on drip systems lower part of campus

5.3 Water Conservation Project Costs

A summary matrix of the high priority projects and rough estimates of costs, assuming contractor labor and retail prices, is shown in Table 19. The labor rate for all projects is $85 per hour as provided by Physical Plant staff. Because some of the projects have not been fully designed and detailed cost estimates have not been completed, initial project costing includes a 20% contingency for those projects identified that would require further cost analysis or project management. In addition to the 20% contingency, the $100,000 cost to perform this water efficiency study was spread among all the high priority projects.

Table 19 – High Priority Water Conservation Projects for UC Santa Cruz

Project Number	Potential Water Conservation Project	Number of units to be Replaced or Installed	Unit Cost	Unit Labor hours	Labor Cost	Total Project Cost
	IRRIGATION					
8	Install ET controllers for selected high-water-use areas.	9	$ 2,000	1.0	$ 765	$ 26,683
9	Implement water budgets for individual connection points that appear to be over watering that are not connected to the Central control system	12	$ 500	1.0	$ 1,020	$ 8,578
10	Add wireless rain sensors on existing controllers	70	$ 80	2.0	$ 11,900	$ 24,885
	FARM					
13	Add 10 new PRVs to Farm irrigation system.	10	$ 200			$ 2,444
	ARBORETUM					
14	Use battery-operated timers to shut water off on drip systems.	40	$ 80			$ 3,910
15	Install Arboretum PRVs to reduce water pressure to drip	100	$ 9			$ 1,100

Project Number	Potential Water Conservation Project	Number of units to be Replaced or Installed	Unit Cost	Unit Labor hours	Labor Cost	Total Project Cost
	lines.					
16	Add campus submeters for large un-metered irrigated areas use at Arboretum.	1	$ 3,900			$ 5,546
	FIXTURES					
17	Replace high flow toilets in "high-use" areas with 1.6 gpf or 1.28 gpf toilets.	204	$ 400	3.0	$ 52,020	$ 190,004
19	Replace Flapper Valves and Diaphragms on 1.6 gpf Toilets that tested with high flush volumes.	850	$ 10	0.5	$ 36,125	$ 63,455
20	Install waterless urinals in "high use" restrooms. [A]	65	$ 400	3.0	$ 16,575	$ 60,540
22	Conduct pilot test 1.0 gpm aerators on “high use” restroom faucets.	318	$ 5	0.5	$ 13,515	$ 18,458
23	Replace faucet aerators in non high use restrooms.	2,137	$ 5	0.5	$ 90,823	$ 124,039
24	Replace existing showerheads in “high use” housing and athletic facilities.	40	$ 55	1.0	$ 3,400	$ 6,843
25	Replace existing showerheads in “non high use” housing and athletic facilities.	310	$ 55	1.0	$ 26,350	$ 53,034
26	Replace 9 inefficient spray valves in kitchens, cafes, and restaurants.	9	$ 50	2.0	$ 1,530	$ 2,420
27	Replace hose in College 9/10 Dining Hall kitchen with low flow spray valve.	1	$ 450	8.0	$ 680	$ 1,381
	LABORATORIES					
30	Replace 2 spray valves in steam sterilizer room of Earth and Marine Sciences.	2	$ 50	2.0	$ 340	$ 538
31	Remove Steam Sterilizer from DI Water System in Marine Sciences Building.	1	$ 100	4.0	$ 340	$ 538

Project Number	Potential Water Conservation Project	Number of units to be Replaced or Installed	Unit Cost	Unit Labor hours	Labor Cost	Total Project Cost
	COOLING TOWERS					
48	Change operating procedure of CT-5 from conductivity set point of 1200 to 2000.	0	$ -	80.0	$ 6,800	$ 8,309

A = Does not include cost of replacement cartridges for waterless urinals

5.4 Estimated Water, Sewer, and Energy Savings and Paybacks

Table 20 shows the projected water savings and the associated paybacks for the high priority projects. Projects were identified to be high priority if they had a payback of less than 5 years. The payback is defined as the number of years for the UC Santa Cruz to recover its investment in a given water conservation project, based on the projected water and sewer bill savings associated with implementation of that project. In this case, nineteen water conservation projects identified for the UC Santa Cruz have paybacks which are equal to or less than five years and are recommended.

The value of the saved water for all recommended water conservation projects is an estimated reduction in water, sewer, and energy costs of $542,000 per year (2009 rates). Savings will increase when the UC Santa Cruz's water, sewer and energy rates increase in the future.

Table 20 shows the estimated annual savings achieved by the completion of the recommended water conservation projects. In terms of priorities, projects should be implemented in the order of increasing payback. The total cost to implement the nineteen recommended water conservation projects is estimated to be approximately $603,000. The overall payback for these projects is estimated to be 1.1 years. The cost estimates presented in this report are planning level costs, sufficiently accurate to identify projects with attractive paybacks. The exact costs to the UC Santa Cruz to implement these water conservation projects will depend on the specific number and type of fixtures. In addition, MWM recommends that the UC Santa Cruz adjust the estimates contained herein based on estimates provided by plumbing contractors and engineering staff.

Table 20 - Annual Water, Sewer, Irrigation And Energy Bill Savings for High Priority UC Santa Cruz Projects

Project Number	Project	Annual Water Savings (gpd)	Annual Water Bill Savings, ($/year)	Annual Sewer Bill Savings, ($/year)	Annual Irrigation Bill Savings, ($/year)	Annual Energy Savings ($/year)	Total Savings, ($/year)
	IRRIGATION						
8	Install ET controllers for selected high-water-use areas.	2,613	$ -	$ -	$ 5,355	$ -	$ 5,355

Project Number	Project	Annual Water Savings (gpd)	Annual Water Bill Savings, ($/year)	Annual Sewer Bill Savings, ($/year)	Annual Irrigation Bill Savings, ($/year)	Annual Energy Savings ($/year)	Total Savings, ($/year)
9	Develop water budgets for individual connection points.	3,021	$ -	$ -	$ 6,190	$ -	$ 6,190
10	Add wireless rain sensors on existing controllers.	6,913	$ -	$ -	$ 14,167	$ -	$ 14,167
	FARM						
13	Add 10 new PRVs to Farm irrigation system.	434	$ -	$ -	$ 889	$ -	$ 889
	ARBORETUM						
14	Use battery-operated timers to shut water off.	1,213	$ -	$ -	$ 2,485	$ -	$ 2,485
15	Install PRVs to reduce water pressure to lines.	1,213	$ -	$ -	$ 2,485	$ -	$ 2,485
16	Add campus submeters for large un-metered irrigated areas use at Arboretum.	549	$ -	$ -	$ 1,125	$ -	$ 1,125
	FIXTURES						
17	Replace high flow toilets in "high-use" areas with 1.6 gpf or 1.28 gpf toilets.	10,450	$ 38,114	$ 27,893	$ -	$ -	$ 66,007
19	Replace Flapper Valves and Diaphragms on 1.6 gpf Toilets that tested with high flush volumes.	8,347	$ 30,443	$ 22,279	$ -	$ -	$ 52,722
20	Install waterless urinals in "high use" restrooms. [A]	16,225	$ 59,175	$ 43,307	$ -	$ -	$ 102,482
22	Conduct pilot test 1.0 gpm aerators on high use restroom faucets.	2,652	$ 9,674	$ 7,080	$ -	$ 8,218	$ 24,972
23	Replace faucet aerators in non high use restrooms.	17,825	$ 65,012	$ 47,578	$ -	$55,227	$ 167,816
24	Replace existing showerheads in high use housing and athletic facilities.	769	$ 2,804	$ 2,052	$ -	$ 2,382	$ 7,238
25	Replace existing showerheads in non high use housing and athletic facilities.	5,959	$ 21,732	$ 15,904	$ -	$18,461	$ 56,098

Project Number	Project	Annual Water Savings (gpd)	Annual Water Bill Savings, ($/year)	Annual Sewer Bill Savings, ($/year)	Annual Irrigation Bill Savings, ($/year)	Annual Energy Savings ($/year)	Total Savings, ($/year)
26	Replace 9 inefficient spray valves in kitchens, cafes, and restaurants.	1,697	$ 6,189	$ 4,529	$ -	$ 5,257	$ 15,975
27	Replace hose in College 9/10 Dining Hall kitchen with low flow spray valve.	540	$ 1,970	$ 1,441	$ -	$ 1,673	$ 5,084
	LABORATORIES						
30	Replace 2 spray valves in steam sterilizer room of Earth and Marine Sciences.	180	$ 657	$ 480	$ -	$ 558	$ 1,695
31	Remove Steam Sterilizer from DI Water System in Marine Sciences Building.	525	$ 1,915	$ 1,401	$ -	$ 1,627	$ 4,943
	COOLING TOWERS						
48	Change operating procedure of CT-5 from conductivity set point of 1200 to 2000.	696	$ 2,539	$ 1,858	$ -	$ -	$ 4,397
Total	All High Priority Projects	81,818	$ 240,223	$175,803	$ 32,697	$ 93,403	$ 542,127

Table 21 – Water Savings, Costs and Paybacks
For High Priority UC Santa Cruz Projects

Project Number	Project	Total Savings, ($/year)	Total Cost of Project	Payback, Years	Payback less than 5 years
	IRRIGATION				
8	Install ET controllers for selected high-water-use areas.	$ 5,355	$ 26,683	5.0	X
9	Develop water budgets for individual connection points.	$ 6,190	$ 8,578	1.4	X
10	Add wireless rain sensors on existing controllers.	$ 14,167	$ 24,885	1.8	X
	FARM				
13	Add 10 new PRVs to Farm irrigation system.	$ 889	$ 2,444	2.7	X
	ARBORETUM				
14	Use battery-operated timers to shut water off.	$ 2,485	$ 3,910	1.6	X

Project Number	Project	Total Savings, ($/year)	Total Cost of Project	Payback, Years	Payback less than 5 years
15	Install PRVs to reduce water pressure to lines.	$ 2,485	$ 1,100	0.4	X
16	Add campus submeters for large un-metered irrigated areas use at Arboretum.	$ 1,125	$ 5,546	4.9	X
	FIXTURES				
17	Replace high flow toilets in "high-use" areas with 1.6 gpf or 1.28 gpf toilets.	$ 66,007	$ 190,004	2.9	X
19	Replace Flapper Valves and Diaphragms on 1.6 gpf Toilets that tested with high flush volumes.	$ 52,722	$ 63,455	1.2	X
20	Install waterless urinals in "high use" restrooms. [A]	$ 102,482	$ 60,540	0.6	X
22	Conduct pilot test 1.0 gpm aerators on high use restroom faucets.	$ 24,972	$ 18,458	0.7	X
23	Replace faucet aerators in non high use restrooms.	$ 167,816	$ 124,039	0.7	X
24	Replace existing showerheads in high use housing and athletic facilities.	$ 7,238	$ 6,843	0.9	X
25	Replace existing showerheads in non high use housing and athletic facilities.	$ 56,098	$ 53,034	0.9	X
26	Replace 9 inefficient spray valves in kitchens, cafes, and restaurants.	$ 15,975	$ 2,420	0.2	X
27	Replace hose in College 9/10 Dining Hall kitchen with low flow spray valve.	$ 5,084	$ 1,381	0.3	X
	LABORATORIES				
30	Replace 2 spray valves in steam sterilizer room of Earth and Marine Sciences.	$ 1,695	$ 538	0.3	X
31	Remove Steam Sterilizer from DI Water System in Marine Sciences Building.	$ 4,943	$ 538	0.1	X
	COOLING TOWERS				
48	Change operating procedure of CT-5 from conductivity set point of 1200 to 2000.	$ 4,397	$ 8,309	1.9	X
Total	All High Priority Projects	$ 542,127	$ 602,705	1.1	X

6.0 CONCLUSIONS

In conclusion, UC Santa Cruz has done work to improve water efficiency and we found several additional projects that will further improve efficiency. MWM recommends that the UC Santa Cruz implement the water conservation programs that are cost effective and within available resources.

Implementation of the combined high priority water conservation projects is estimated to result in a 15.0 percent savings in total water use and a savings of approximately $500,000 per year (2009 rates). Savings will be higher when utility rates increase. The recommended projects, when combined, have a payback of approximately 1.1 years.

High Priority Conservation Projects for UC Santa Cruz

Project	Fixtures To be Replaced / Repaired	Estimated water savings (gpd)	Total Cost of Project	Payback in Years
Remove Steam Sterilizer from DI Water System in Marine Sciences Building	1	525	$ 538	0.1
Replace 9 inefficient spray valves in kitchens, cafes, and restaurants	9	1,697	$ 2,420	0.2
Replace hose in College 9/10 Dining Hall kitchen with low flow spray valve.	1	540	$ 1,381	0.3
Replace 2 spray valves in steam sterilizer room of Earth and Marine Sciences	2	180	$ 538	0.3
Install Arboretum PRVs to reduce water pressure to lines	100	1,213	$ 1,100	0.4
Install waterless urinals in "high use" restrooms.	65	16,225	$ 60,540	0.6
Conduct pilot test 1.0 gpm aerators on high use restroom faucets.	318	2,652	$ 18,458	0.7
Replace faucet aerators in non high use restrooms	2137	17,825	$ 124,039	0.7
Replace existing showerheads in high use housing and athletic facilities	40	769	$ 6,843	0.9
Replace existing showerheads in non high use housing and athletic facilities	310	5,959	$ 53,034	0.9
Replace Flapper Valves and Diaphragms on 1.6 gpf Toilets that tested with high flush volumes.	850	8,347	$ 63,455	1.2
Implement water budgets for individual connection points that appear to be over watering that are not connected to the central control system	12	3,021	$ 8,578	1.4
Use battery-operated timers to shut water off	40	1,213	$ 3,910	1.6
Add wireless rain sensors on existing controllers	70	6,913	$ 24,885	1.8
Change operating procedure of CT-5 from conductivity set point of 1200 to 2000.	0	696	$ 8,309	1.9
Add 10 new PRVs to Farm irrigation system.	10	434	$ 2,444	2.7
Replace high flow toilets in "high-use" areas with 1.6 gpf or 1.28 gpf toilets.	204	10,450	$ 190,004	2.9
Add campus submeters for large un-metered irrigated areas use at Arboretum	1	549	$ 5,546	4.9
Install ET controllers for selected high-water-use areas.	9	2,613	$ 26,683	5.0
TOTAL High Priority Projects	4,179	81,818	$ 602,705	1.1

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