UCSB

WATER ACTION PLAN

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UCSB Water Action Plan

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BREN SCHOOL OF ENVIRONMENTAL SCIENCE & MANAGEMENT
UNIVERSITY OF CALIFORNIA SANTA BARBARA

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Action Today for Tomorrow

THE GREEN INITIATIVE FUND
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EXECUTIVE SUMMARY

California is vulnerable to water shortages; as water demand increases, water planning will be an essential part of California's future. The University of California, Santa Barbara (UCSB; the University) recognizes the importance of water planning and conservation and has made many historical efforts to reduce water usage. The University of California, Office of the President (UCOP) mandated all universities system-wide to reduce potable water-use by 20% by 2020.   While UCSB has met this water use reduction goal, the expected growth of UCSB and increasing water costs in the coming years will require more actions to prevent significant water use and cost increases. This *Water Action Plan* (WAP) outlines a proactive campus strategy for UCSB to reduce water consumption while meeting future water demand.

The UCSB Campus (the Campus) faces distinct water challenges due to its arid coastal climate, state regulations, local water sources, and the growing campus population. This setting helps define what water-reduction strategies are most suitable for the University in the past and in the future. The Baseline for UCSB, a metric required by UCOP of all University of California (UC) campuses, estimates the historic water use at UCSB over a three-year period from 1996 to 1999. In addition to this measure, the University chose to create a Benchmark to mark reductions already made toward the 20% by 2020 requirement, defining a basis for which to encourage future reductions beyond the 2020 mandate. The Baseline average annual potable water use for the Campus was 292.7 million gallons (for the fiscal years (FY) of 1996/97 to 1998/99), while the Benchmark average annual potable water use was 218.5 million gallons (for the FY of 2008/09 to 2010/11), representing a 25% reduction in potable water use already achieved on campus.

The University has reached the 25% potable water use reduction between the Baseline and Benchmark periods through various water conservation strategies implemented between 1997 and 2008. Projects undertaken by the University targeted academic, research and other non-residential buildings, and residential buildings operated by Housing & Residential Services (H&RS). These projects also addressed landscaping, irrigation, and industrial applications. In academic, research and other non-residential buildings new faucet aerators and low-flush toilets were installed to improve restroom efficiency. In the residential buildings, H&RS installed efficient dishwashers, began using recycled water for lawn irrigation, and retrofitted bathroom fixtures in residences with low-flow faucets, showerheads, toilets, and urinals. The Campus developed an expansive recycled water system between 1994 and 2008 and installed smart irrigation, artificial turf, and xeriscaping to decrease potable water use and improve overall water use efficiency in landscaping and irrigation applications. In addition, from 1999 to 2011 the University invested in the installation and expansion of a chilled water loop for cooling of buildings. The chilled water loop connects a variety of academic buildings, which has reduced the number of cooling towers necessary on campus and enabled concomitant efficiency increases and industrial water-use reductions. Based on the success of these water reductions, the University has defined its current Benchmark level of usage and is now exploring future water conservation strategies to future reduce the consumption of potable water.

Goals in this Water Action Plan for further potable water reductions at UCSB over the next 15 years focus on implementing multiple conservation and efficiency strategies and by substituting recycled water for potable water in a variety of applications. Goals include increasing the installation of low-flow aerators, showerheads, and toilets in academic and housing buildings; improving the quality of recycled water used in irrigation and other non-potable applications; and expanding overall administrative actions to encourage water conservation. The goals of the WAP that target infrastructure changes have both financial costs and benefits; they are evaluated based primarily on their potable water savings potential and their financial benefits, which are summarized in the 'Infrastructure Goals' table (Table 1). Most of the goals have an economic payback period of one to four years. The goals of the WAP that discuss the administrative and management changes are summarized in the 'Management Goals' table (Table 2). These goals are evaluated on the expected effect of the action, savings seen in similar actions or programs, and the time frame needed to implement the action.

Due to proactive measures over the last 15 years, the University has already achieved the UCOP mandate, which calls for reducing growth-adjusted potable water use 20% by 2020. While the University has already achieved this goal, it is committed to remaining a leader in water conservation. Based on the University's past dedication to water reductions and the goals made in this document, the University should be able to reduce total potable water use by an additional 20% by 2028. While increasing demand is a major challenge to the continued reduction of water use, the Plan's extensive goals will mitigate the water demand associated with a growing campus.

In addition to water conservation goals, financial and reporting goals are also set. Financial opportunities and funding strategies to achieve the water conservation goals are identified and outlined for future use. These funding opportunities include the US Environmental Protection Agency (EPA), the California Department of Water Resources, the Bureau of Reclamation, and The Green Initiative Fund (TGIF) of UCSB. In addition to the required annual reporting of water use to UCOP, this WAP should be assessed every five years to prioritize mitigation efforts and explore new technologies and conservation techniques as they emerge.

Table 1: Summary of Infrastructure Goals in the Water Action Plan

Sector	Infrastructure Goal	Initial Cost ($2012)	Payback Period	Annual Potable Water Savings (Gal)	Annual Water Cost Savings ($2012)	Cost Per 1000 Gal Water Savings ($2012)	Implementation Horizon[1]
Academic, Research and other Non-Residential Buldings	Retrofit Aerators in Bathrooms	$9,000	<1 year	4.7 million	$23,300	$1.91	Short-Term
	Retrofit Toilets in Bathrooms	$80,400	<1 year	18.7 million	$92,900	$4.30	Short-Term
	Retrofit Urinals to 0.25 gpf in Bathrooms	$217,000	15 years	3.2 million	$15,700	$67.81	Long-term
Housing & Residential	Retrofit Showers in Bathrooms	$2,800	<1 year	6.5 million	$32,200	$0.43	Short-Term
	Retrofit Toilets in Bathrooms	$80,100	< 6 years	3.0 million	$14,900	$26.70	Short-Term
	Retrofit Aerators in Bathrooms	$1,200	<1 year	364,400	$1,800	$3.29	Short-term
	Use Recycled Water in Toilets	$333,000	18 years	5.4 million	$21,300	$61.67	Medium-Term
	Upgrade Dining Commons Dishwashers Portola Carrillo	 $34,800 $34,800	 <9 years <12 years	 889,600 646,600	 $4,400 $3,200	 $39.12 $53.82	 Medium-Term Medium-Term
Landscape & Irrigation	Expand Weather-based Irrigation Control Systems	NA	NA	3 million	$15,000	NA	Long-Term
	Install On-Site Filtration System for Commencement Green	$16,500	<5 years	831,000	$4,100	$19.86	Short-Term
	Expand Recycled Water Infrastructure for Irrigation	NA	NA	1.1 million	$5,800	NA	Medium-Term
Industrial Water Use	Increase Concentration Cycles for Cooling Towers	NA	NA	7.5 million	$37,000	NA	Short-Term

[1] "Short-Term" = 2013-2014; "Medium-Term" = 2014-2020; "Long-Term" = 2020-2028

[1] Cost: "$" = <$10,000; "$$" = $10,001-$100,000; "$$$" >$100,000

[2] Annual Potable Water Savings: "Low" = <200,000 gallons; "Medium" = 200,001-500,000 gallons; "High" = >500,001 gallons;

Table 2: Summary of Management Goals in the Water Action Plan

Sector	Management Goal	Description	Cost $2012 (Initial/Annual)[1]	Annual Potable Water Savings (Gal)[2]	Implementation Horizon[3]
Landscape & Irrigation	Conduct Annual Constituent Soil Samples	Will help to identify constituent build-ups on-campus, which will allow Facilities Management to proactively remediate soils and eliminate the idea of returning to potable water irrigation.	NA/$	Not Directly Attributable	Short-Term, Ongoing
Industrial Water Uses	Calibrate Existing Industrial Water Meters and Install New Where Needed	Will ensure maximum cooling tower operating efficiency, accurate determiniation of water use trends, and increased leak and malfunction detection capabilities.	$/NA	Low	Short-Term
	Quarterly Reviews for Industrial Infrastructure	Will facilitate proper adjustment and optimization of industrial water infrastructure to maximize water and energy savings.	NA/$	Not Directly Attributable	Short-Term
Administrative Actions	Install Real-Time Meters in All Buildings and New Construction	Will facilitate quick and efficient data collection, identify leaks within the system, and help incentivize campus water users to conserve.	$$$/$	Medium	Short-Term
	Create a Living Central Database for Water Use and Infrastructure.	Will provide realistic monitoring trends allowing the University to better predict future water needs and adjust campus population growth accordingly. Will assist with the efficient pinpointing of the most inefficient areas on campus.	$/$ (Included in WM Salary)	Not Directly Attributable	Short-Term
	Create a "Water Manager"	Will help with the effective and efficient implementation of water conservation programs and strategies across campus.	$/$$	Not Directly Attributable	Short-Term
	Implement a Campus Wide Water Conservation Education Program	Increase students' perception of water conservation activities by providing them with the knowledge and motivation to reduce water useage.	NA/$$$ (Partially Included in WM Salary)	Low	Short-Term, Ongoing
	Incorporate Water Conservation into Academics	Projects incorporated into the academic curriculum create opportunities to engage students and expand their understanding of the issues surrounding water conservation.	$$/$	Low	Short-Term, Ongoing
	Participate Campus and National Water Conservation Competitions	Competitions engage and motivate students and encourage the use of water conservation knowledge, particularly longer duration competitions that create long-term behavioral change.	NA/$ (Included in WM Salary)	Low – Medium	Medium-Term, Ongoing
	Begin Dialogue with State to Encourage Implementation of Incentives for Water Conservation	Will help explore state funding opportunities and colloboration with the State and other UC's regarding water conservation strategies and funding sources.	NA/$ (Included in WM Salary)	Medium	Long-Term, Ongoing

[3] "Short-Term" = 2013-2014; "Medium-Term" = 2014-2020; "Long-Term" = 2020-2028; "Ongoing" = May require action at short, medium, and long horizons

INTRODUCTION

Fresh water is a limited resource, with several competing uses that pose an ever-increasing burden on water supplies. In California, the state's growing population and regions of semi-arid climate magnify water shortage problems. To meet future water demands, California will need to take drastic measures to reduce overall water consumption, and specifically potable water consumption.

Regional Geographic and Regulatory Context

The State of California has a varied climate and physiography, ranging from the temperate rainforests of the Northwest to the arid deserts of the Southwest and from the large mountain ranges to the coastal plains and the Central Valley. As a result, the State experiences a wide range of precipitation and water availability. With a history of periodic droughts, California works continuously to meet the growing water demand of the State with local water resources. In the coming years, climate change is forecasted to exacerbate the competition for existing water resources in the State of California. According to the California Department of Water Resources (DWR), climate change will continue to have a profound impact on California water resources, evident in dynamic snowpack levels, sea level, and river flows. These changes are expected to shift more precipitation from snow to rain, reducing mountain snowpack. Snowpack in the Sierra Nevada Mountains provides the State with critical water supplies in the spring and summer, supplying water through the drier seasons. Less snowpack will result in less late summer water availability, and increased rainfall will intensify flood risks and add additional challenges for water supply reliability.[1] Given the risks and challenges that climate change poses to the State of California's water supply, proper planning and preparation is necessary.

In an effort to plan for the future of water resources in California, the State has passed several regulations that address water conservation. Senate Bill (SB) X7-7 specifically targets water conservation and requires that all urban water districts reduce consumption by 20% by 2020.[2, 3] The University of California, Office of the President (UCOP) modeled the 'Sustainable Water Systems Policy' after SB X7-7 by urging a 20% reduction in potable water use in all the campuses within the University of California (UC) system by 2020. The State has put in place the CalGreen Building Code regulations, Title 24, which detail green building standards including potable water efficiency requirements for residential and non-residential buildings in the state of California.[4] The California Code of Regulations, Title 22, also plays a large role in water conservation by delineating quality expectations for recycled water. The law outlines appropriate uses for recycled water, requirements for plumbing, and the necessary treatment for various approved uses.[5] This is particularly relevant at the University of California, Santa Barbara (UCSB; the University) where recycled water is already widely used for irrigation with potential to expand recycled water use to other applications allowed by Title 22.

University of California, Office of the President Mandate

The UC system has formally recognized the value of water as a scarce resource and the importance of addressing water conservation in the UC system, and in October 2010 the UC Sustainability Steering Committee formed the UC Sustainable Water Systems Working Group. The Group is composed of students, staff, and faculty from each of the UC campuses and medical schools. The Working Group developed policy language for the Sustainable Water Systems Policy, which was accepted by the UC Sustainability Steering Committee on September 9, 2012. Each of the UC campuses and medical centers are planning to complete and implement a *Water Action Plan* by the Fall of 2013, in accordance with the defined policy language (APPENDIX: I).

Water and the UCSB Campus

This statewide context for water use exerts an overarching influence on the sources and the uses of water on the UCSB campus. Although it has driven many of the past and future policies regarding water use, local conditions are no less important in explaining past conditions and determining future trajectories. UCSB has long recognized the importance of addressing water issues and proactively implementing solutions. Current campus potable water consumption (based on 2008-2011 averages) is approximately 25% less than it was in 1996-1998. UCSB projects that the faculty, staff, and student population will increase by 13% in the next eight years.[6] This population increase, combined with the anticipated growth of on-campus housing to accommodate a larger quantity of faculty and staff, will raise UCSB's demand on current water supplies. Acknowledging the need for water conservation, UCSB has taken proactive steps to reduce water consumption. Looking forward, the University seeks to continue to decrease overall water use while meeting the demands of its current and future users.

UCSB Physical Context

The 1055 acre UCSB Campus is located in Santa Barbara County on the Pacific coastline. The local watershed that contains the campus is bounded to the Northwest by the east-west trending Santa Ynez Mountains and to the Southeast by coastal bluffs and the Pacific Ocean. The University enjoys a Mediterranean climate with typical temperatures ranging from lows in the 40's °F to highs in the 80's °F. Average annual rainfall is less than 20 inches a year, but precipitation data is highly variable from year-to-year and between seasons.

UCSB is made up of four principal campuses: the 422 acre Main Campus acquired in 1948, the 184 acre Storke Campus purchased in 1962, the 273 acre West Campus purchased partly in 1967 and partly in 2007, and the 174 acre North Campus purchased in 1994. The University also owns two apartment buildings in Isla Vista (El Dorado and Westgate). Through all of its land holdings, UCSB currently occupies nearly 8 million California-Adjusted Gross Square Feet (CAGSF) of built-out space (APPENDIX: VI).[7]

UCSB Water Sources

The Campus is nestled next to the town of Goleta and receives its water from the Goleta Water District (GWD). GWD uses a mix of local surface water supplies from Lake Cachuma in the Santa Ynez Valley, groundwater from the Goleta Groundwater Basin, recycled water from the Goleta Sanitary District, and imported State Water Project (SWP) water to meet the district water demand. The area relies heavily on Lake Cachuma, receiving 76% of its water from the lake in the past 10 years.[8] The district gets the remaining supply of its water from the SWP (16%), recycled water (6%), and groundwater (2%)."[9] These sources are mostly steady in supply from season to season but can vary significantly in drought years.

Water & Energy Nexus for UCSB Water Sources

The relationship between water and energy use is commonly termed the water-energy nexus. This relationship is particularly important in California, where water is conveyed over long distances and water shortages have inspired the use of energy-intensive technology to increase water availability. The energy embedded in water refers to the sum of energy inputs within the water use cycle, which comprises many stages: collection, conveyance, treatment, distribution, end use, and wastewater treatment. Each step has energy implications.

The embedded energy in water delivered by GWD varies dramatically depending on the source. The greatest energy demand, roughly 2,900 kilowatt-hour/acre-foot (kWh/AF), is required to deliver State water to Lake Cachuma (Table 1). This is much more than the energy intensity of local surface water supplies from Lake Cachuma, a gravity-fed system with zero energy embedded in conveyance. The energy intensity for supplying groundwater is also much lower than State water. It is estimated that GWD used 1,520,000 kWh to pump groundwater in 2009 at an average energy intensity of 830 kWh/AF. At 760 kWh/AF, even recycled water is less energy intensive than State Water (APPENDIX: II).

Table 1: Energy embedded in GWD multiple sources of water

GWD Source	Supply side embedded energy (kWh/AF)*
Cachuma	70
Groundwater	830
Recycled water	760
State water delivered to Cachuma	2,900

*Marginal energy use, not including distribution energy costs to end users

State water not only has the highest embedded energy per AF but also is the most expensive water source for GWD. State water is considered a "marginal supply" for GWD since it is the most expensive; therefore, it is often the last supply to be used to meet demands. This means that any water efficiency measure GWD or the Campus takes will save an average of 2,900 kWh for each acre-foot of water saved. Energy savings result in cost savings and also reduce greenhouse gases (GHGs). EPA uses 6.8956×10^{-4} metric tons CO_2 / kWh to convert reductions of kilowatt-hours into avoided units of carbon dioxide emissions. The associated GHGs would be 2.03 metric tons CO_2 per AF. On average, recycled water uses an estimated 2,180 kWh/AF less than State water. GWD uses on average 1,000 AF/yr of recycled water but can use up to a potential capacity for up to 3,000 AF/yr. If recycled water was expanded to full capacity, the substitution would virtually eliminate the use of State water and save an estimated 4,420 kWh and 3,050 metric tons of CO_2 annually. However, availability is limited by storage limitations and seasonal water demands.

Magnitude of UCSB Water Use

Analyzing UCSB water use from a watershed perspective can show what level of university water consumption is sustainable, based on local climate, geography, and population. For example, if UCSB were to use only the water that falls on campus properties, current campus consumption of potable water would have to be reduced by over 11 Mgal/yr, approximately 20% (Figure 1).[i] This contrast is not a standard sustainability metric, but the comparison highlights the need to consider UCSB as part of the surrounding region, from which it draws much of its water supply. UCSB's population is approximately 34% of the entire population served water within the Goleta Water District, yet the percentage of water use in the City of Goleta attributable to UCSB is only 5%.[10] Even though the University has a comparatively small water footprint relative to its population, the Campus' water planning and consumption will help define future water availability and water pricing for the City of Goleta. For example, if the University's water demand grows beyond what local supplies can provide, then GWD may have to source water from the much more expensive State Water Project, which in turn could raise the average cost of water for all GWD customers.

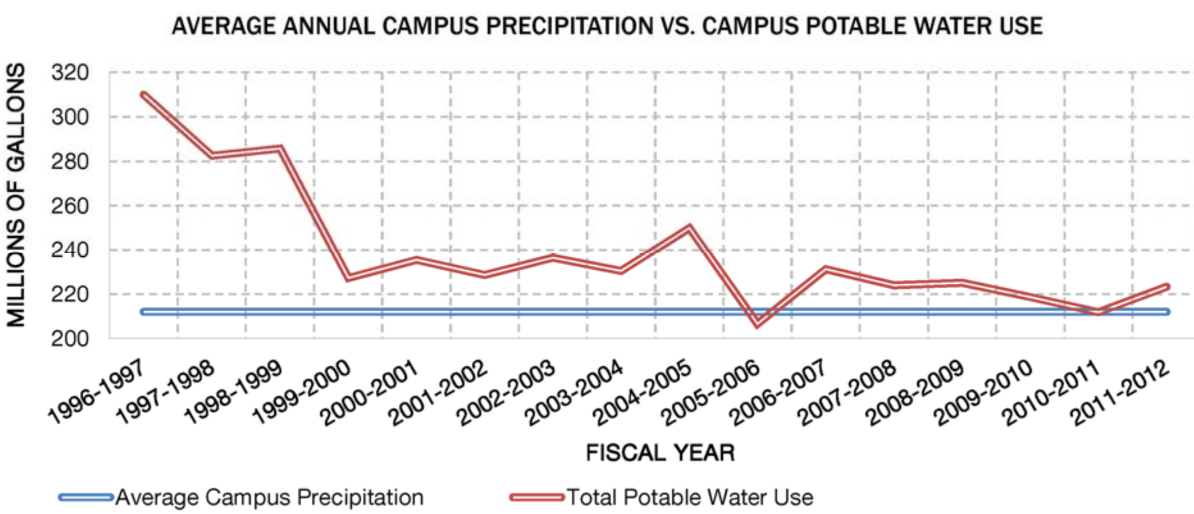

Figure 1: A comparison between UCSB's potable water use and the long-term average annual precipitation that falls on the UCSB campus.

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[i] This calculation assumes an 18 inch annual precipitation based on a 10-year precipitation average from 2001-2011.

Motivation for UCSB's Water Action Plan

The overarching purpose of this *Water Action Plan* (WAP) is to identify future water reduction strategies at the Campus in accordance with objectives set forth by UCOP. Anticipating future pressures and continued constraints on water usage at UCSB, this document outlines the most effective avenues to achieve a more sustainable campus water system in light of anticipated water stressors.

In addition to being located in a naturally water scarce area, UCSB is experiencing other drivers relevant to future water consumption. These are (1) campus population growth, (2) increased on-campus residences, and (3) water-cost increases. One stated goal of the Long Range Development Plan (LRDP) is to house a larger number of faculty and staff in on-campus housing. Not only will student population increase in the coming years, but also will the number of faculty and staff living on Campus, likely raising the number of full-time water users on-campus beyond an already anticipated 13% population growth by 2020. Finally, current water rates are $3.71/HCF, but GWD projects water rates to increase by roughly 11% by 2015.[11]

These three factors create a perfect opportunity for UCSB both to evaluate its water use and to compile a plan to identify water conservation strategies. The WAP has been designed to achieve these two objectives.

Scope of the UCSB *Water Action Plan*

Geographic Scope

The WAP accounts for all on- and off-campus water use of UCSB-operated buildings. The Plan's geographic scope includes all Main Campus academic buildings and residential halls, plus the on-campus housing units not on the Campus utilities grid: San Clemente Graduate Student Housing, Storke Apartments, Santa Catalina Residential halls, Santa Ynez Apartments, and West Campus Housing. The only off-campus buildings included in the scope of the WAP are IV Theatre, Embarcadero Hall, El Dorado apartments, and Westgate apartments. These off-campus properties are included in the geographic scope because UCSB is responsible for their utilities. The WAP does not include off-campus faculty housing (e.g., West Campus Family Housing) when reporting campus water use, because faculty residential units' utilities do not fall under the operational control of UCSB. Nor does the Plan account for distant, off-campus water consumption such as UCSB natural reserve infrastructures and satellite campuses. The reference map below labels the UCSB built environment; academic, research, and other non-residential buildings are colored purple and Housing & Residential Services (H&RS) buildings are colored orange (Figure 2).

Figure 2: UCSB existing built environment.[12]

Temporal Scope

The UCSB WAP considers a 15 year historical scope, representing FYs (i.e., July to June; hereafter abbreviated FY) 1996/97 to 2010/11. The University has data on both potable and recycled water for this period; based on historical water-conservation progress and campus growth over these 15 years, the WAP recommends water conservation and efficiency strategies for consideration over the next 15 years. This planning horizon encompasses UCSB's Long Range Development Plan and Climate Action Plan timelines and aligns its projections with growth predictions from each of these documents.[13,14]

Water-Type Scope

"Water" for the WAP is broadly categorized into potable water, water suitable for human consumption; and non-potable water, water unsuitable for human consumption. The WAP examines UCSB's historical and current use of potable and non-potable water types. The category of "non-potable water" includes graywater, blackwater, industrial water, stormwater, and recycled water (APPENDIX: III):

- Graywater (wastewater with little-to-no fecal content) is excluded in this document's analysis because its practical applications at the University level are limited by legal statutes (e.g., Title 22).
- Blackwater (wastewater with significant fecal content) is acknowledged by the WAP in the context of sewage effluent.

- Stormwater (runoff from precipitation events that flows over land and impervious surfaces) is acknowledged by the WAP from a watershed perspective in a campus-wide, comprehensive way that recognizes stormwater as a resource. Also addressed are aims to protect and restore the integrity of the waterbodies surrounding the Campus.
- Recycled water (wastewater treated with the intention of reuse) and industrial water, which include water provided for specific industrial applications, are examined by the WAP because of their potential role in reducing potable water consumption.

ESTABLISHING A CAMPUS WATER USE BASELINE

Under the direction of University of California, Office of the President (UCOP), UCSB is required to reduce potable water use 20% by the year 2020 as compared to water use during a "Baseline" period. According to UCOP policy, a Baseline is to be calculated by averaging annual campus potable water use during a three-year consecutive time period. Each University of California (UC) campus can pick any consecutive three-year period between FY 1995/96 and 2009/10; UCSB chose FY 1996/97 to 1998/99 as its three-year Baseline because it was the earliest available time frame with a reliable data set for water types used on campus.

Along with picking a Baseline, each UC campus is required to report potable water use in gallons per year, gallons per weighted campus user (WCU), and gallons per California-Adjusted Gross Square Footage (CAGSF; OSGSF50). Weighted Campus User is the standardized per capita metric used for all the UC campuses that normalizes varying water users by weighting students, staff, and faculty by their different degrees of time spent at UCSB (i.e., full-time students, part-time staff, etc.). California Adjusted GSF is the standardized area metric used to normalize water use spatially across the UC campuses (APPENDIX: V, APPENDIX: VI).

UCSB's Baseline water use has been calculated in accordance with UCOP requirements. (APPENDIX: I). During the UCSB Baseline period, average potable water use for the Campus was 292.7 Mgal/yr and roughly 13,900 gal/WCU and 62 gal/CAGSF (Table 2).

Table 2: UCSB's average annual potable water use during the Baseline period

Baseline FY	Total (Gal)	Gal/WCU	Gal/CAGSF
1996/97-1998/99	292.7 million	13,900	62

BENCHMARKING WATER USE ON THE UCSB CAMPUS

Purpose and Delineation of UCSB's Benchmark

In addition to the University of California, Office of the President (UCOP)-mandated Baseline, the objective of selecting a three-year water-use Benchmark is to mark reductions already achieved by UCSB and encourage further reductions. The Benchmark will serve as a check point from which the University can reevaluate historical water use and water-conservation strategies and launch new conservation efforts that move beyond the major conservation steps taken since UCSB's Baseline era. These efforts are detailed below in 'Campus Historical Water Use & Water Reduction Progress.'

FY 2008/09, 2009/10, and 2010/11 constitute the three-year period selected for benchmarking UCSB's water use. This timeframe was selected to consider the impact of concurrent climate factors, campus growth, and infrastructure changes on water use. These three years constitute a conservative Benchmark intended to push UCSB to move forward with further water reductions that are reflections of new conservation efforts, not simply lasting effects of historical conservation strategies (APPENDIX: VII). During the UCSB Benchmark period, average water use for the Campus was 218.5 Mgal/yr, roughly 7,940 gallons per weighted campus user (WCU) and 30 gallons per California-adjusted gross square footage (CAGSF) (Table 3).

Table 3: UCSB's average annual potable water use during the Benchmark period

Benchmark FY	Total (Gal)	Gal/WCU	Gal/CAGSF
2008/09-2010/11	218.5 million	7,940	30

Total Reductions to Date

Increases in water use efficiency, major industrial water infrastructure improvements, and significant replacement of potable water with recycled water earned UCSB substantial reductions in potable water use from the Baseline average annual use of 292.7 million gallons (1996/97 to 1998/99) to the Benchmark average annual use of 218.5 million gallons (2008/09 to 2010/11). As evidenced in Figure 3, total potable water use dropped significantly in the late 1990s followed by little change for more than a decade. This stagnation since the late 90s can be attributed to an almost doubling in the student population living in campus housing and an eight to twelve percent growth in student enrollment coupled with ongoing conservation efforts. In light of this historical population growth, the stability of total potable water use required a simultaneous decrease in per capita potable water use (Figure 3).

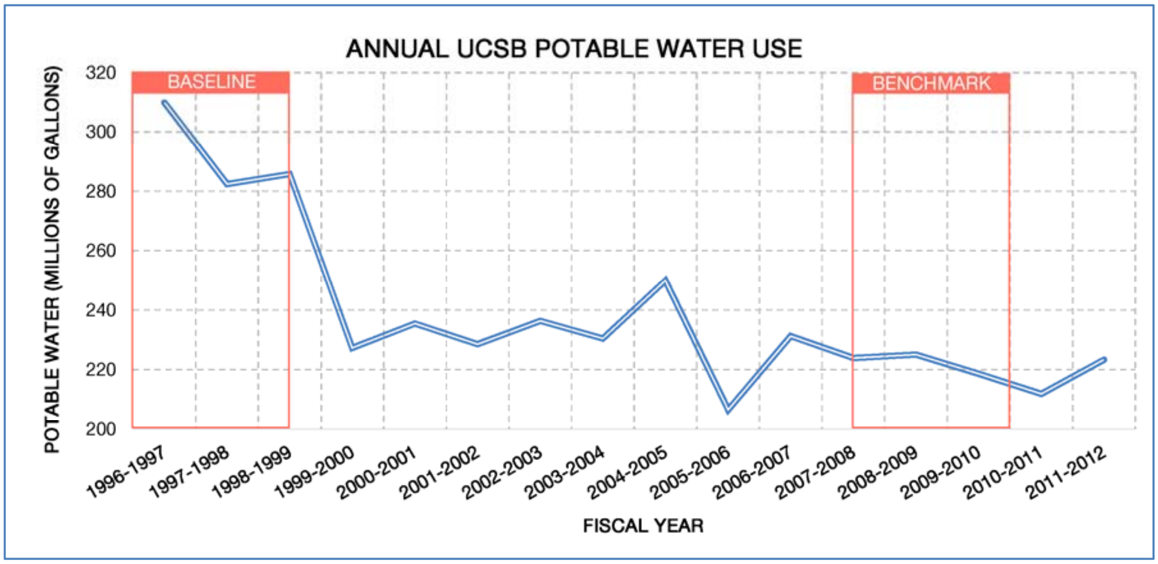

Figure 3: UCSB total potable water trends from FY 1996/97 to 2011/12 in gallons per year.

In total, the University has reduced potable water use 25% from the Baseline to the Benchmark. When normalized by Weighted Campus User and California Adjusted GSF over the same time period, reductions reached 43% and 52%, respectively (Table 4, Figure 4, 5).

Table 4: Percent reductions in potable water use from the Baseline to the Benchmark

Baseline to Benchmark	Reduction
Total Potable Water	25%
Potable Water/ Weighted Campus User	43%
Potable Water/ CA-Adjusted Gross Square Footage	52%

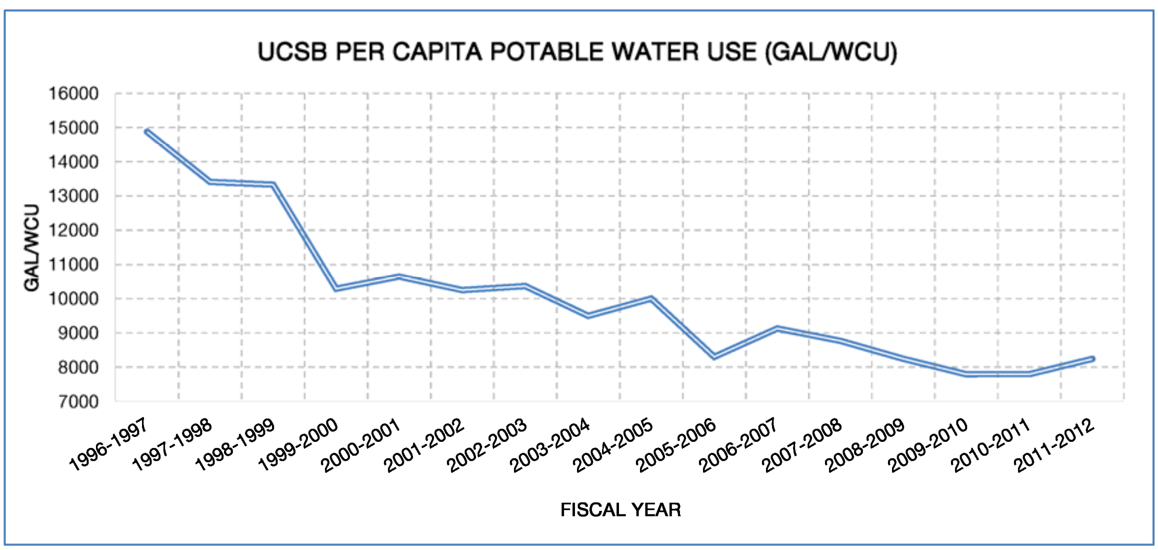

Figure 4: UCSB potable water use trends normalized by weighted campus user (WCU), a UC standardized population metric, from FY 1996/97 to 2011/12 in gallons per year.

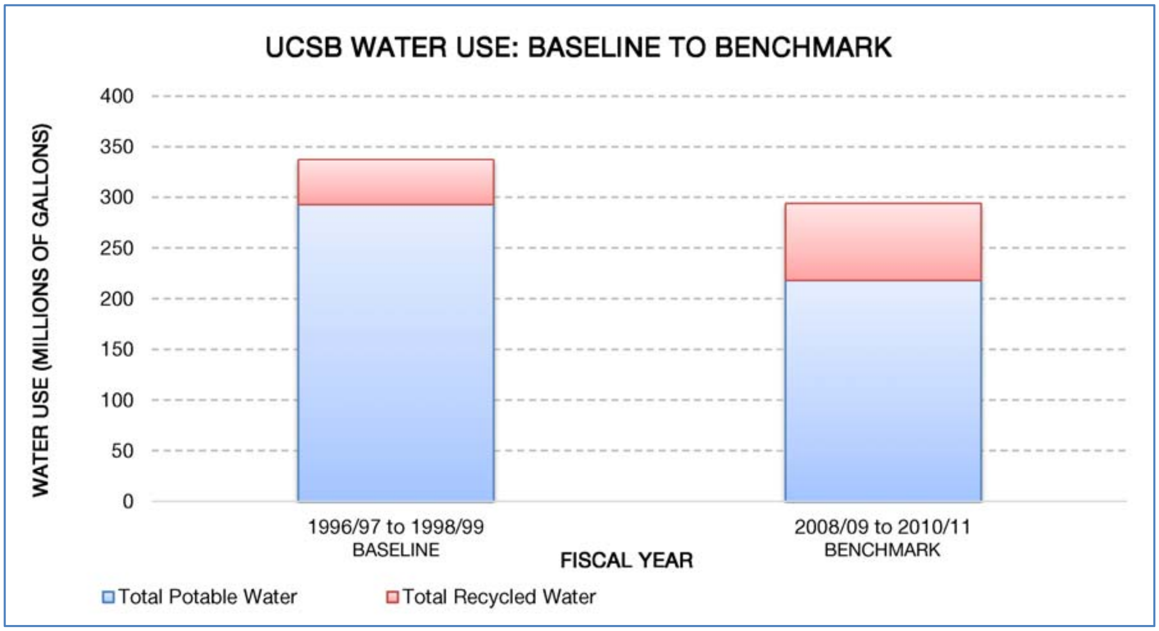

Figure 5: UCSB's potable and recycled water use from the Baseline to the Benchmark.

HISTORICAL WATER USE REDUCTIONS

The following summary of historical water use reductions and conservation actions reconstructs UCSB water-use history and identifies the water-related actions that have led to a 25% reduction in total potable water use between FY 1996/97-1998/99 and 2008/09-2010/11. Water on-campus is used within two broad categories: academic, research, and other non-residential buildings; and Housing & Residential Services. However, water used for irrigation and industrial applications is embedded in each of these categories. Therefore, the WAP analyzes water use and water-use reductions as they fall into each of the following four "sectors": academic, research, and other non-residential buildings (42%); Housing & Residential Services (43%); irrigation and landscaping (1%); and industrial applications (14%) (Figure 6) (APPENDIX: X).

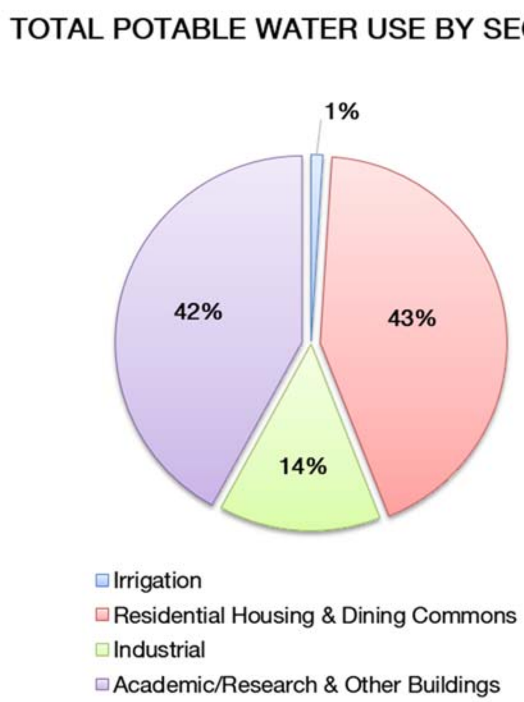

Figure 6: Estimated total potable water use by sector.

Academic, Research, and Other Non-Residential Buildings

Academic, research, and other non-residential buildings (e.g., the University House, the Faculty Club, the University Center, etc.) include all non-Housing & Residential Services (HR&S) buildings on the UCSB main campus (APPENDIX: VIII). This sector, accounting for approximately 55% of total Campus potable water use, has reduced potable water consumption by approximately 40% from UCSB's Baseline period to Benchmark period.

In the late 1980s, UCSB instituted a water-efficiency program in reaction to a severe local drought. Thousands of low-flow toilet valves and sink aerators were installed and concurrent conservation efforts were instituted including plumbing maintenance, leak-repair, and water audits.[15] Chronicling further water-reduction efforts in non-residential restrooms after the 1980s drought, however, has proven a more complicated process. Retrofit records have not been well-kept and misleading fixture labels and untraceable records of maintenance work and retrofits have blurred past water use patterns and conservation opportunities.

Through grants from The Green Initiative Fund (TGIF), a student-generated environmental fund at UCSB, restroom retrofits have continued on a smaller scale in the past decade, replacing aerators, and high-flow toilets and urinals. However, a thorough restroom audit was necessary to better assess the true state of retrofits on campus. In the summer of 2012, on-campus restrooms were visited; the number and flow rate of all faucet, aerator, toilet, and urinal fixtures were recorded. Each faucet flow rate was manually measured and a sample of toilet flush flows across campus was gathered.

According to the audit results, approximately 61% of faucets have aerators in place, and the average faucet flow rate across campus is 2.01 gallons per minute (gpm). Newer or retrofitted buildings generally have faucets with lower flow rates; some restroom flow rates average as low as 0.5 gpm, whereas less efficient restrooms have average flow rates up to 3.8 gpm. The aerator brands in use have market-specified flows of 0.5-2.2 gpm. About 20% of toilets in on-campus academic buildings have dual-flush valves, which theoretically save roughly 0.6 gpf every time a lighter flush is used (given ratings of 1.6 gpf/solids, 1.0 gpf/liquids). Additionally, 35% of urinals are waterless, whereas older models in place flush up to 2 gpf (Figure 7).

The in-situ testing of fixtures such as aerators and toilet valves performed during the audits re-evaluated old fixtures performance. Older or poorly installed fixtures frequently failed to meet the efficiency standards for which they are designed, and even new fixtures may exceed their advertised flow rates. For example, a number of aerated faucets found across the UCSB campus flowed at rates over 4 gpm, indicating that the 2.0 gpm aerator was no longer properly in place or that wear over time had decreased function. Toilet flow audits indicated that real flows far exceeded expected toilet flows. A sample of 31 toilets across campus yielded an average flush of 3.5 gallons, with a standard deviation of 1.2 gallons. A conservative estimate based on the extrapolation of in-situ testing suggests that over 87% of campus toilets flush at a level higher than the current public restroom efficiency standard of 1.6 gpf (APPENDIX: IX) (Figure 8). Challenges to the success of historic conservation efforts include the removal or theft of aerators and the wearing out of fixture components, such as diaphragms in toilet valves.

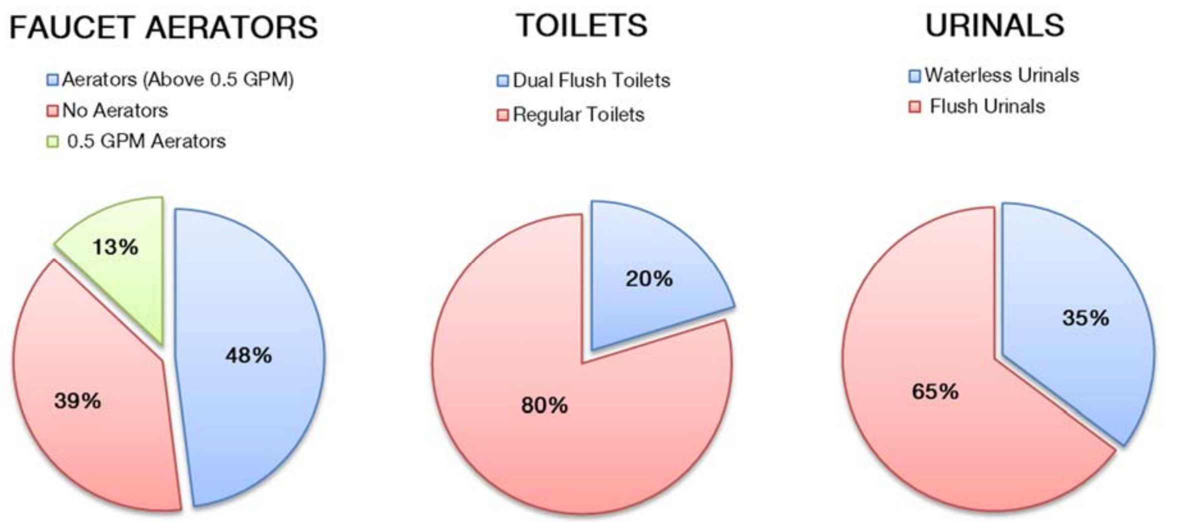

Figure 7: Academic, research, and other non-residential building bathroom audit breakdown.

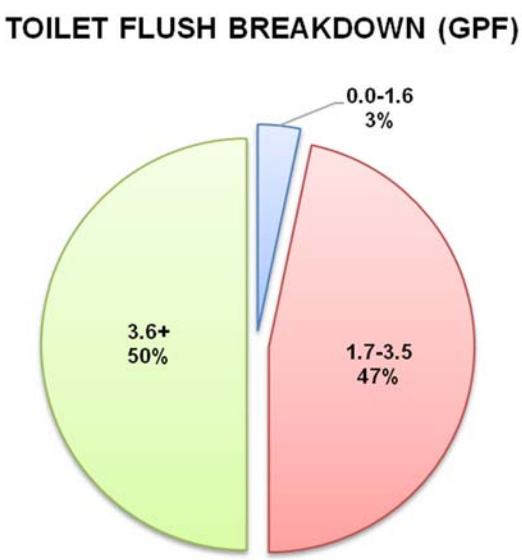

Figure 8: Toilet flush breakdown in gpf based on in-situ testing of a sample of 31 toilets across campus; pie-chart breaks represent the current public restroom efficiency standard (1.6 GPF) and the previous efficiency standard (3.5 GPF).

Apart from numeric audit results, discussions with regular restroom users as well as Facilities Management staff paint a more complete picture of UCSB water use efficiency challenges. For example, waterless urinals have been installed in some older buildings. The plumbing in these older buildings are susceptible to line blockage, and facilities staff ran into problems with urea build-up in piping junctions because there was insufficient water to usher the liquid waste through the system in place. From user perspectives, feedback also indicated that toilets governed by automatic sensors were hypersensitive and flushed more than required.

Lab water use is often overlooked when it comes to conservation efforts. With close to 750 laboratory spaces in over 40 buildings on campus, sensitive research experiments at UCSB demand precise levels of sanitation, cooling, and heating. These specific requirements make water conservation in labs difficult. For instance, many departments require water filtered by reverse osmosis (RO) to reduce potential interference with ion-sensitive experimentation. Since the reverse osmosis process inherently produces both a product and reject stream of water, a building's RO process can potentially dump thousands of gallons of reject water per month.

LabRATS, an on-campus group that promotes sustainable lab practices, has sought to balance conservation efforts and the needs of researchers to maximize water savings, communication, good lab management practices, and high quality experimental results. LabRATS has achieved marked success in reducing lab water use, primarily through equipment replacement, low-cost adaptations to existing equipment, equipment maintenance checks, and education and outreach. Past successes include replacing single-pass-through cooling systems with closed-loop systems, replacing water-tube aerator vacuums with small electronic vacuums, ensuring autoclaves and washers are functioning properly, and posting signage on efficient and effective rinsing techniques. For example, LabRATS demonstrated that beakers rinsed three times for 30 seconds used significantly less water than beakers left under a running faucet for 10 minutes and were significantly cleaner.[16] (For goals pertaining to laboratory water use, see 'Administrative Action'). Another example of on-going water saving efforts in lab settings is the cooling loop, slated for construction in the Ocean Science Education Building (OSEB); once completed, the building will be cooled using pass-through water from the ocean rather than using potable water.

The culmination of all such efforts to reduce water consumption in academic, research, and other non-residential buildings has yielded substantial water savings. From the Baseline to the Benchmark, total potable water use in this sector was reduced by approximately 40% (Figure 9). Reductions can be attributed to restroom water efficiency retrofits, infrastructure changes (see "Industrial Water Uses"), use of recycled water instead of potable water for irrigation, and irrigation efficiency improvements (see "Landscape & Irrigation"). Although significant reductions have been achieved, restroom audits and in-situ testing reveal gaps in conservation efforts and draw attention to potential future efficiency improvements in these buildings.

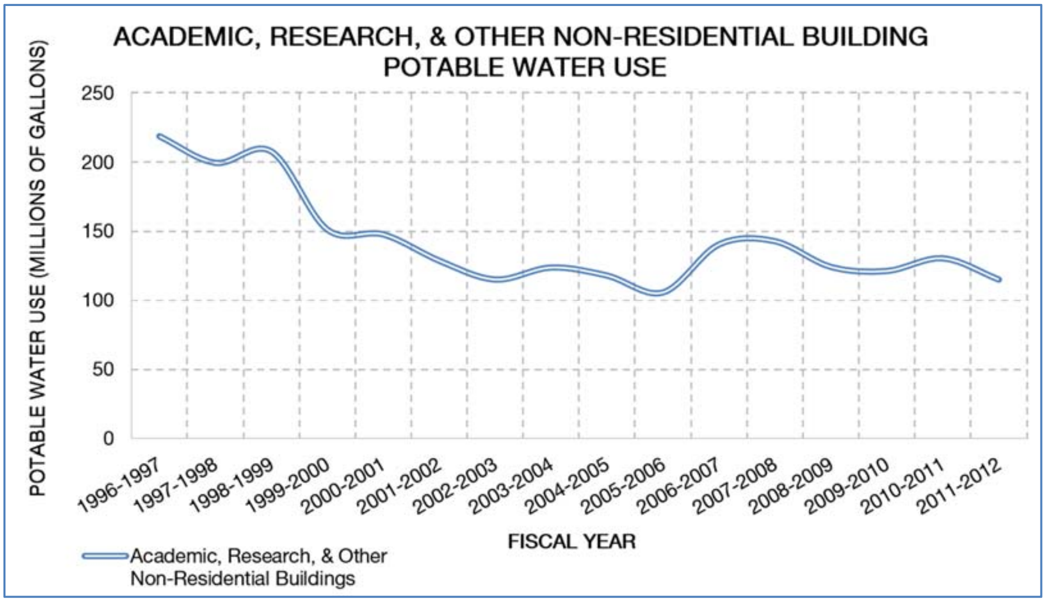

Figure 9: Potable water use in academic, research, and other non-residential buildings from 1996 to 2012.

Housing & Residential Services

H&RS buildings include four dining commons and 14 residential halls and campus-owned student apartment complexes, accounting for roughly 43% of potable water use on campus (APPENDIX: X). Similar to efficiency measures taken in the academic, research, and other non-residential buildings, H&RS implemented serious efficiency and conservation measures in the late 1980s in response to a severe drought. Some of the actions taken to save potable water are as follows (Figure 10).

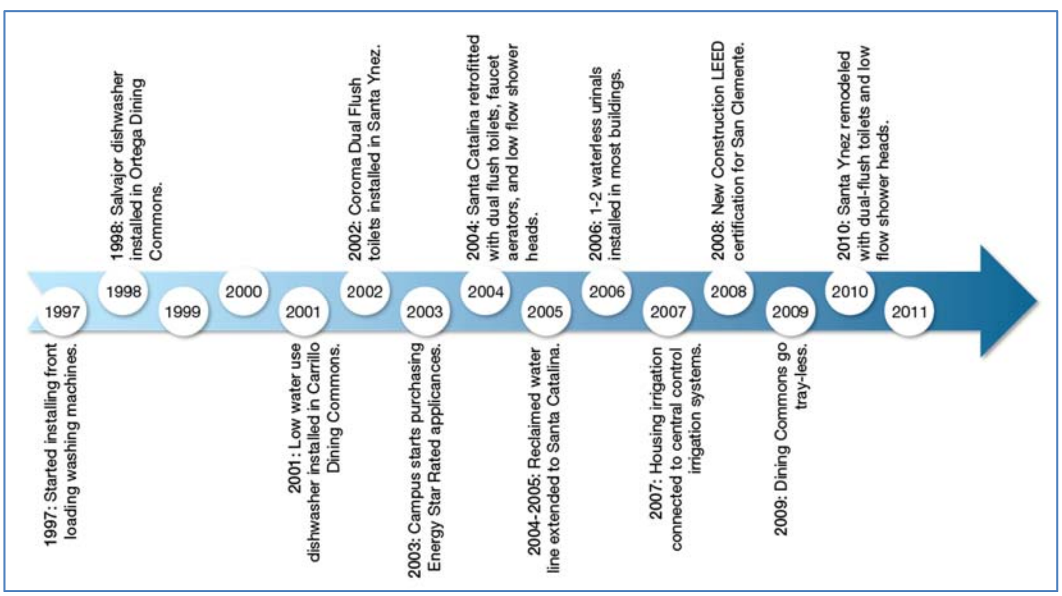

Figure 10: H&RS timeline for water efficiency measures.

In 1998, the Ortega Dining Commons installed a Salvajor washing system that filters water and reuses it for the entire shift. The system reduced the building's potable water use by almost 40%.[17] Water efficient dishwashing machines were also installed in the Carrillo Dining Commons in 2001 and in De La Guerra in 2004, and in 2003, H&RS adopted a policy to only purchase Energy Star and water efficient appliances. Apart from the dining commons, Corona Dual Flush Toilets were installed in part of Santa Ynez Apartments in 2002.

The use of recycled water for irrigation of residential lawns has also resulted in potable water savings. Since 2004/05 H&RS has saved roughly 148.6 million gallon of potable water by using recycled water for irrigation (APPENDIX: X). In 2004, recycled water lines were extended for irrigation at the resident halls of Santa Cruz, Anacapa, part of Santa Rosa, and De la Guerra. In addition to extending the lines, the whole piping system was fixed, which reduced water loss due to leaks in the system. Recycled water for irrigation was also brought to San Nicolas and San Miguel resident halls in 2007. Along with potable water savings from efficiency measures and recycled water use in 2009, all of the Dining Commons went tray-less, which resulted in additional savings estimated to be 1 Mgal/yr per year.[18]

H&RS began retrofitting bathrooms in the late 1980s. As technology has improved, H&RS has increased their standards for aerators, low flow toilets, and showerheads. Table 5 lists the current fixture standards for all building retrofits within H&RS. Until more efficient restroom fixtures are introduced to the market and proven effective for institutional use, H&RS purchasing standards will align with the following fixture efficiency standards.

Table 5: H&RS current fixture standards

Fixture	Brand	Water Use
Faucets	Chicago	0.5 gpm
Showerheads	Niagara Pismire	1.5 gpm
Toilets	Corona Caravelle	Dual Flush Tank (1.6/0.8 gal)
Urinals	Falcon, Sloan	Waterless

To get an estimate of the actual water use of the current suite of replacement fixtures, a random sample inventory was taken of bathrooms in each residential hall and a portion of the student apartment buildings. Faucet flow rates were manually measured in each bathroom and showerhead flow rates and toilet brands were recorded. Based on the sample, an estimated 90% of all faucets had 0.5 gpm aerators, 53% of the bathrooms had dual flush toilets, and 57% of the showerheads were rated at 1.5 gpm. Decreasing water use by faucets, showerheads, and toilets below the US required standards has saved an estimated 32.25 million gallons of potable water annually within H&RS buildings (Table 6) (APPENDIX: XI).

Table 6: Estimated potable water reductions for H&RS bathroom retrofits

Fixture Replacement	Annual potable water savings	Annual $ 2012 saved from potable water reductions
90% 0.5 GPM FAUCET AERATORS	3.3 MILLION GALLONS	$16,300
43% DUEL FLUSH TOILETS	2.95 MILLION GALLONS	$14,650
57% 1.5 FLOW SHOWERHEADS	8.2 MILLION GALLONS	$42,800
TOTAL SAVINGS	32.25 MILLION GALLONS	$159,900

H&RS has also taken several steps to educate its residents on the importance of water conservation. Some examples include the installation of shower timers in all the residential halls along with informational signs encouraging short showers. Other, larger programs include the Green Campus Interns, who hosted an energy and water efficiency competition in the 2011-12 academic year between the eight on-campus residential halls. This competition educated residents about the importance of conserving energy and water, leading to a decrease in consumption of both during the competition. A Baseline of use for the competition was calculated by the average use over three weeks from January 24, 2012 to February 14, 2012.[19] The estimated savings during the three week competition totaled roughly 90,000 gallons from the competition baseline. While the competition was highly successful in getting students to reduce energy and water consumption, their usage increased to above pre-competition levels.

In total, the efforts to reduce water consumption in H&RS have resulted in a reduction in water use per student living on campus by 41% from the Baseline to the Benchmark. This reduction occurred despite an 11% increase in the total potable water use due to an increase in student population.

Landscape & Irrigation

Currently, irrigation accounts for only about 1% of total Campus potable water use. UCSB has been proactive in implementing potable water conservation practices in this sector and has made great strides in switching from irrigating with potable to reclaimed water; both have reduced potable water consumption used for irrigation by 80% from the Baseline to the Benchmark. UCSB has made use of recycled water in place of potable water for irrigation a campus-wide priority, and to utilize smart irrigation and xeriscaping practices. Both Facilities Management (FM) and H&RS have incorporated water conservation practices and techniques into their daily operations.

Recycled Water Use

In 1994, the University first utilized recycled water for irrigation purposes. It is estimated that 60% of the Campus was irrigated with recycled water when the system was installed in 1994. Various recycled water line extension projects over the past eight years have increased the use of recycled water for irrigation at UCSB (Table 7) (APPENDIX: X).

Table 7: Recycled water extension timeline

Date	Recycled Water Extension Projects	Cumulative Percentage of Campus Irrigated with Recycled Water
1994	Santa Ynez Recycled Water Line	60%
1994	Rob Field Recycled Water Pump	60%
1995	Goleta Water District Recycled Mainline	60%
1995	UCSB Recycled Water Line	60%
2001	San Rafael Recycled Water Line	66%
2002	West Campus Recycled Extension	72%
2006	Academic Green Recycled	78%
2007	Recycled Housing Phase I	84%
2007	Recycled Housing Phase II	84%
2008	San Miguel Recycled Water Continuation	90%

As of 2012, 90% of the total water used for irrigation on-campus is recycled water (77,862 gal/yr). The remaining 10% of all water used for irrigation on Campus is potable, accounting for 1% of total Campus potable water use. This recycled water infrastructure has saved approximately 1.16 million gallons of potable water since 1994 (Figure 11).

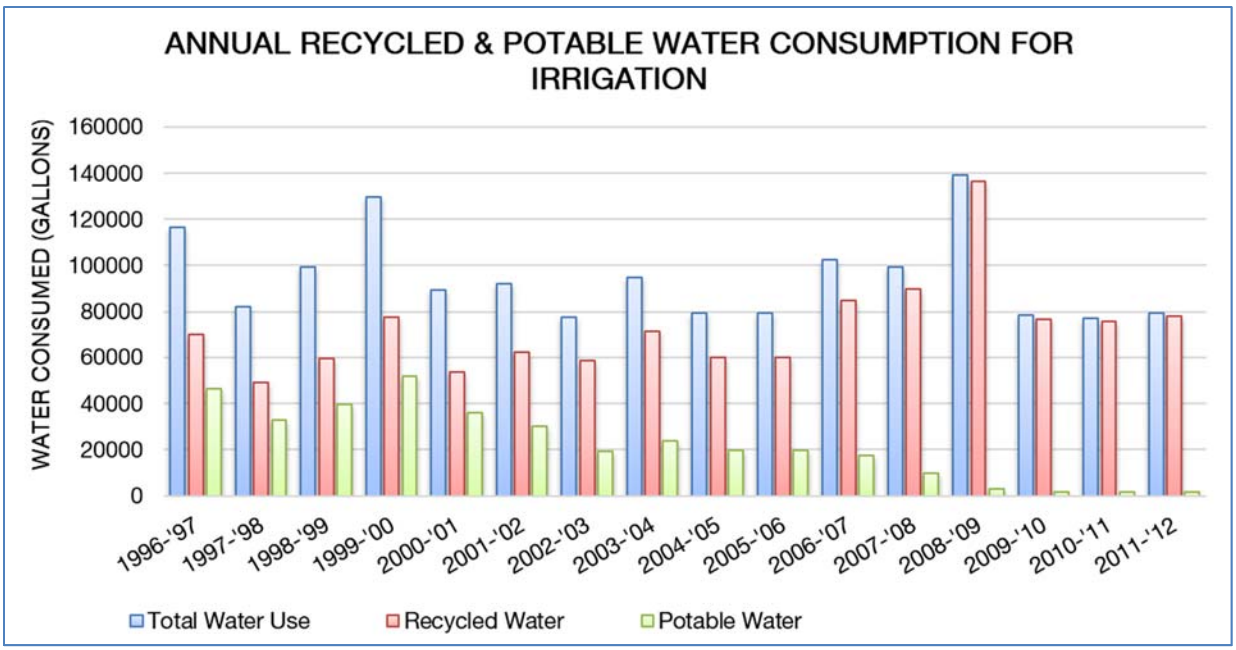

Figure 11: Annual recycled and potable water consumption for irrigation.

Smart Irrigation Practices

In conjunction with the use of recycled water on-campus, UCSB practices smart irrigation techniques, specifically the use of weather-based irrigation controllers, using matched precipitation (MP) Rotators® and drip tubing irrigation where appropriate. Weather-based irrigation controllers are used throughout the Campus to establish water schedules that reflect on-site weather conditions and soil moisture. These particular irrigation controllers ensure that the landscapes at UCSB are experiencing optimal levels of irrigation. UCSB has a central Rain Master Oasis weather-based irrigation system that controls 60% of the Campus irrigation.

MP Rotators® were installed on UCSB's West Campus in the spring of 2012. MP Rotators® deliver a multi-trajectory rotating stream of water rather than a uniform spray of water like traditional sprinkler heads. The MP Rotators'® ability to deliver water at a slower speed allows time for more water to percolate into the soil. MP Rotators® can conserve 30% more water than traditional sprinkler heads and significantly reduce the amount of runoff during irrigation.[20] TGIF issued a grant in support of retrofitting outdated sprinkler heads with MP Rotator® replacements. A total of 577 sprinkler heads were replaced, two-thirds the total number of heads in operation at West Campus. H&RS staff estimates that the retrofit will conserve approximately one-third of the water that the traditional pop-up nozzles used at West Campus.

In addition to MP rotator® heads, drip tubing irrigation is used on five-acres of the UCSB campus. Drip tubing irrigation can be one of the most efficient irrigation methods if properly maintained because it delivers water to the plant root zone, eliminating runoff and unnecessary evaporation. However, the higher level of required maintenance and the inability to irrigate broad swaths of grasses limit the practical applications of drip irrigation on the UCSB campus.

UCSB also converted Rob Field, a multi-sport outdoor athletic field, from sod to artificial turf in 2002. This transformation to artificial turf eliminated all irrigation at Rob Field, roughly 80,000 ft^2. With irrigation practices for sod normally specifying an average of 1 inch of water per week, the water savings from this artificial turf installation are estimated at 2.6 million gal/yr (3,467 HCF/yr) (APPENDIX: X).

Xeriscaping

UCSB has prioritized the use of native and drought-tolerant plant species on-campus to limit vegetative water consumption. The Chancellor's Sustainability Subcommittee on Landscape & Biotic Environment, composed of university staff and faculty and local landscape specialists, chooses plant species that are appropriate for the UCSB environment. Plant species are primarily chosen based upon maintainability, survivability, and longevity.

Industrial Water Uses

Water use in industrial applications at UCSB falls into several categories: cooling tower make-up water, boiler feed water, reverse osmosis system feed water, and lubrication water for equipment such as vacuum pumps, which supply vacuum to laboratory buildings on campus. RO and lubrication uses constitute a small amount of the consumptive water use on Campus, with the majority of industrial water used in cooling towers and boilers. Collectively, industrial applications account for approximately 14% of potable water use on Campus. The following sections will therefore specifically address the University's history of water use and efficiency in these areas.

Cooling tower water use and associated evaporative losses constitute one of the highest industrial consumptive water uses on the UCSB campus. Before 1999/00, the Campus chilled water infrastructure was building-specific, meaning that buildings had their own cooling towers, chillers, pumps, and electric control equipment. This decentralized configuration is inefficient for three primary reasons: 1) multiple buildings incur the water losses associated with individual cooling towers; 2) all cooling towers must remain in operation simultaneously, whereas if the systems were connected, only a few running cooling towers would be needed on average to supply the cooling needs of the whole campus; and 3) each individual building has to replenish evaporated water ("makeup water") to their cooling towers. Decentralized cooling systems exacerbate the fundamental water issues that all cooling towers face: water losses due to evaporation and drift (fine droplets entrained in the air stream from the draught fans), concentration of impurities in water, and the concomitant need of makeup water to maintain performance. The result of the decentralized approach is thus not only more water consumption but also more energy use.

Given the numerous drawbacks of having decentralized cooling towers on multiple buildings, the University decided to address them by installing a chilled water loop starting in 1999-2000 on the east side of campus, connecting Davidson Library, Biology II, Engineering I, Brioda Hall, Physical Science Building (PSB) North, and Chemistry. At that stage, there were five main cooling towers on campus supplying chilled water to the loop. However, the chilled water loop enabled the advantage of only having to turn on as many cooling towers as needed to meet the thermal load of all the buildings connected to the loop. Other buildings added later to the loop include: Bren Hall (2001), Psychology (2002), Engineering Science (2003), Music (2003), Elings Hall (2003), Marine Science Resource Building (MSRB) (2004), Kohn Hall (2005), PSB South (2005), Psychology Addition (2007), and Nobel Hall (2007). Since these expansions, the chilled water loop has expanded westward to connect Student Affairs & Administrative Services Building (SAASB) (2008), Education & Social Science Building (ESSB) (2010), and North Hall (2011). A separate west campus chilled water loop was also connected to Humanities & Social Science Building (HSSB) and Sindecor/Theater-Dance in 2004. The western chilled water loop was later connected to the Student Resource Building (SRB) (2005), and/Theater-Dance expansions (2006). In 2010, the east and west chilled water loops were joined with an additional connection to the Event Center (Thunderdome). Plans for 2013 include connection to Cheadle and Kerr Halls. After the buildout of the chilled water loop, there are now ten cooling towers operating on campus. In addition to the five original cooling towers on the loop mentioned above, cooling towers were added to Bren Hall, Engineering Science, and Elings Hall.

The current chilled water loop serves to meet the cooling requirements for a large portion of campus and leverages a network of cooling towers and chillers. Infrastructure in this network can be turned on one by one to meet increasing campus demands for chilled water during times of peak demand, building expansion, and campus growth. Expansion of the chilled water loop has resulted in a 10% savings of industrial water use. Using the 2010/11 cooling tower water usage (31.8 million gallons) and factoring in this savings percentage, the chilled water loop has saved the campus about 3.5 million gallons per year, which constitutes a little over 1% of the Baseline water use.

CAMPUS STORMWATER MANAGEMENT[ii]

This section aims to give a brief overview of UCSB's stormwater program, providing a look at historical actions and recommending future actions Stormwater was incorporated into its own specific section as it does not directly contribute to potable water reduction; however, UCOP policy emphasizes that stormwater management must be addressed from a watershed perspective in a campus-wide, comprehensive way that recognizes stormwater as a resource and aims to protect and restore the integrity of the waterbodies surrounding the Campus. In accordance with this, the following section lists University stormwater best management practices and initiatives, as well as future goals based on the current policy and regulatory framework as governed by the State Water Resources Control Board.

Current Regulatory Stormwater Requirements

The University is currently required to comply with federal and state environmental protection regulations, such as the federal Clean Water Act. Additionally, in California, the State Water Resources Control Board (State Water Board) has adopted the Waste Discharge Requirements for Storm Water Discharges from Small Municipal Separate Storm Sewer Systems (MS4 General Permit). In 2003, UCSB was identified by the State Water Board as a "non-traditional" municipality and was required to comply with the statewide MS4 General Permit.

Historical Accomplishments

UCSB has complied with the Clean Water Act and the MS4 General Permit with the goal of preventing stormwater pollution and restoring the integrity of surrounding local waterways. Some of the most notable stormwater management accomplishments that the Campus has achieved to date include:

- Organizing educational events which include coastal cleanup days, tours of restoration projects, campus touch tanks, and LEED certified buildings;
- Providing training on best management practices to campus staff and community members;
- Developing policies and standards for new development projects such as requiring incorporation of low impact development stormwater features;
- Labeling of stormdrains throughout campus;
- Launching a comprehensive stormwater website that includes current planning documents and information on stormwater best practices;
- Creating a campus stormwater conveyance map;

[ii] This section was graciously provided by Stacey Callaway, Environmental Programs Specialist and edited by the primary authors of the UCSB Water Action Plan.

- Regularly sweeping all campus hardscape to reduce potential discharges to adjacent waterbodies;
- Implementing new best management practices on campus construction sites, maintenance yards, fueling stations, loading docks, and food facilities.

Current Post-Construction Stormwater Practices

To protect beneficial uses and promote the desired conditions of healthy watersheds, UCSB has developed post-construction stormwater design requirements for all new development projects. The post-construction stormwater design requirements were designed with the following goals:

- Maximize infiltration of clean stormwater and minimize both runoff volume and rate;
- Protect riparian areas, wetlands, and their buffer zones;
- Minimize pollutant loading;
- Provide long-term watershed protection;

Even though these post-construction design requirements are fairly new, examples of these features can be seen throughout campus at completed development projects; these locations are the Manzanita Residence Hall, San Clemente Residence Hall, Education and Social Sciences Building, and the Library Corridor. At these sites, the post-construction stormwater features used include permeable pavement, rain gardens, bioswales, disconnected roof drains, and curb cuts.

Stormwater Management Goals

On February 5, 2013, the State Water Board adopted the new MS4 General Permit, bringing more consistency to MS4 programs throughout the state except in the Central Coast Region. UCSB is located within the Central Coast Region and is required to continue implementing the old program because it is more stringent than the new MS4 General Permit. The following goals in Tables 8 and 9 will help UCSB continue to comply with the MS4 Permit:

Short Term Goals (7/1/2012-6/30/2014):

Table 8: Short term stormwater management goals

Description	Tasks	Resource Requirements
Create a stormwater program effectiveness assessment and improvement plan	Development of plan Implementation of plan	43 FTE* hours 8 FTE hours/month, 96 hours annually
Implement new post-construction design requirements	Development of requirements Implementation of requirements	27 FTE hours 8 FTE hours/month, 96 hours annually
Develop a stormwater public outreach and education plan	Development of plan Implementation of plan	80 FTE hours 27 FTE hours/month, 324 hours annually
Audit existing contract documents, design standards, policies, and procedures; and, where necessary, update to include stormwater compliance requirements	Initial development On-going implementation	60 FTE hours 32 FTE hours annually
Generate standard operating procedures for construction and stormwater inspections	Initial development On-going implementation	40 FTE hours 32 FTE hours annually
Generate standard operating procedures for outfall stormwater inspections and sampling	Initial development On-going implementation	40 FTE hours 32 FTE hours annually
Generate standard operating procedures for priority facilities stormwater inspections	Initial development On-going implementation	40 FTE hours 32 FTE hours annually
Generate standard operating procedures for spill prevention, control, and countermeasures inspections	Initial development On-going implementation	40 FTE hours 32 FTE hours annually
Generate standard operating procedures for wastewater inspections	Initial development On-going implementation	40 FTE hours 32 FTE hours annually
Continue campus stormdrain labeling	On-going implementation Costing for labels	16 FTE hours/month $2.00/ea x 500/yr initial, then as needed (estimate @50/yr)

*FTE = Full Time Equivalent Employee

Mid-Term Goals (7/1/2014-6/30/2020)

Table 9: Mid-term stormwater management goals

DESCRIPTION	TASKS	RESOURCE REQUIREMENTS
CREATE STORMWATER POLLUTION PREVENTION PLANS FOR PRIORITY HOTSPOT FACILITIES	DEVELOPMENT OF PLAN IMPLEMENTATION OF PLAN	80 FTE* HOURS 8 FTE HOURS/MONTH, 96 HOURS ANNUALLY
PRODUCE A LONG-TERM STRATEGY FOR MAINTENANCE OF POST-CONSTRUCTION FEATURES	DEVELOPMENT OF PLAN IMPLEMENTATION OF PLAN	40 FTE HOURS 4 FTE HOURS/MONTH, 48 HOURS ANNUALLY
CREATE A BEST MANAGEMENT PRACTICES GUIDANCE MANUAL FOR STAFF THAT WORK IN FOOD FACILITIES, AROUND LOADING DOCKS, IN MAINTENANCE YARDS, ON CONSTRUCTION SITES, AROUND FUELING STATIONS, AND IN VEHICLE MAINTENANCE GARAGES	DEVELOPMENT OF PLAN IMPLEMENTATION OF PLAN	80 FTE HOURS 8 FTE HOURS/MONTH, 96 HOURS ANNUALLY
DEVELOP ENFORCEMENT PROTOCOLS FOR THE CONSTRUCTION STORMWATER PROGRAM	INITIAL DEVELOPMENT ON-GOING IMPLEMENTATION	20 FTE HOURS 30 FTE HOURS ANNUALLY
DEVELOP ENFORCEMENT PROTOCOLS FOR THE MUNICIPAL STORMWATER PROGRAM	INITIAL DEVELOPMENT ON-GOING IMPLEMENTATION	20 FTE HOURS 30 FTE HOURS ANNUALLY
DEVELOP ENFORCEMENT PROTOCOLS FOR THE SPILL PREVENTION, CONTROL, AND COUNTERMEASURES PROGRAM	INITIAL DEVELOPMENT ON-GOING IMPLEMENTATION	20 FTE HOURS 30 FTE HOURS ANNUALLY
DEVELOP ENFORCEMENT PROTOCOLS FOR THE WASTEWATER PROGRAM	INITIAL DEVELOPMENT ON-GOING IMPLEMENTATION	20 FTE HOURS 30 FTE HOURS ANNUALLY
GENERATE A POST-CONSTRUCTION STORMWATER BEST MANAGEMENT PRACTICES MANUAL	INITIAL DEVELOPMENT ON-GOING IMPLEMENTATION	40 FTE HOURS 30 FTE HOURS ANNUALLY

*FTE = Full Time Equivalent Employee

STRATEGIES & GOALS FOR ACHIEVING POTABLE WATER REDUCTIONS

UCSB has financial, contractual, and policy incentives to achieve the following set of efficiency and conservation goals. Firstly, many capital investments required for increased water efficiency (e.g., restroom retrofits) would pay for themselves within a two to four year period, with continued savings thereafter. Secondly, the decrease in effluent leaving campus as a result of decreased water use will reduce energy costs required to pump the sewage effluent from Campus to Goleta Sanitary District (GSD). Additionally, UCSB is contractually restricted in their water use and sewage discharge. Goleta Water District (GWD) caps the water available to the University at almost 308 Mgal/yr (411,600 HCF/yr), and the University can account for no more than 7.09% of the effluent that GSD receives. Therefore, decreasing consumption will help the University to stay within its maximum allotted water supply and maximum allotted sewer effluent, despite planned continued campus growth. Finally, UCSB has historically been a leader in achieving real water-use reductions; to maintain its institutional standing in the field of water conservation, UCSB has expressed its intention to meet or exceed current efficiency expectations and keep pace with other institutional leaders in the field of water conservation.

The goals below include payback periods, based on financial calculations that assume 1) a 4% annual increase in potable water costs; 2) a 5% annual discount rate; and 3) a 15% project contingency value.

Academic, Research, & Other Non-Residential Buildings

The following goals target restroom fixture water efficiency and are based on available water use data as well as a restroom audit of all Campus academic, research, and other non-residential buildings. Academic, research, and other non-residential buildings account for approximately 55% of campus potable water consumption based on a 10 year average (FY 2002/03 to 2011/12); this sector will continue to be a major focus of water-conservation efforts.

Goals:

1) Implement and prioritize aerator retrofits:

- Replace aerators (where applicable) with flow rates above 0.5 gpm with tamper-proof 0.5 gpm aerators. Recycle old stocks of aerators.
- Reference the *Water Action Plan* (WAP) restroom audit (APPENDIX: XI) to target highest flowing faucets for first retrofits.

The current average faucet flow rate across campus based on in-situ testing of all bathroom faucets is 2.0 gpm (APPENDIX: XI). If UCSB could fully implement aerator retrofits to the 0.5 gpm standard, water savings would be on the order of 4.7 Mgal/yr with cost savings of approximately $23,300 annually (APPENDIX: IX). As a caveat, some specific faucet types, like push-type faucets, may not be compatible with 0.5 gpm aerators because the design requires higher flows, but these faucet types are few in number at UCSB. Ultra low-flow aerators with flow rates less than 0.5 gpm exist but are discouraged by custodial staff, whose cleaning efforts are undermined by the extra low-flow that does not provide water fast enough to streamline their cleaning practices; therefore, it is advised that retrofits adhere to the current public restroom efficiency standard of 0.5 gpm when applicable. The cost of a retrofit to replace all aerators with flows greater than 0.5 gpm and install aerators on un-aerated sinks (840 aerators altogether) is approximately $9,000, including tamper-proof aerators and labor costs. Although tamper-proof aerators are more expensive than regular aerators and place the retrofit at the higher end of the cost spectrum, they would also extend the lifespan and therefore cost-effectiveness of the initial aerator investment. Almost 40% of faucets in academic, research, and other non-residential buildings do not presently have aerators, but at one time all of the faucets on the UCSB Campus had aerators. Aerator removals via theft or maintenance operations are the only viable explanations for the absence of aerators. Therefore, investing in tamper-proof aerators would guard against unexpected losses in faucet efficiency. The retrofit investment would pay itself off within one year (Table 10).

Table 10: Aerator retrofits costs including installation costs

Aerator Retrofits	Annual potable water savings (gal)	Annual water cost savings ($ 2012)	Payback Period (approx. cost $2012)
0.5 gpm	4.7 million	$23,300	<1 year ($9,000)

2) Implement and prioritize toilet retrofits:

- Replace toilet valves that exceed 1.6 gpf with dual flush High Efficiency Toilet (HET) valves (1.6 gpf/0.8 gpf) (note: most toilet valves indicated as 1.6 gpf exceeded 1.6 gpf)
    - Consult with the Facilities Management (FM) Lead Plumber and Utilities Manager to select an ergonomic dual-flush retrofit toilet valve kit. Brand options include Kohler, Sloan, Zurn, etc.
    - Implement new purchasing standards for facilities making 1.6 gpf/0.8 gpf a 'ceiling' for toilet valve flush rates
    - Recycle old stocks of toilet valves and diaphragms
    - Reference the WAP restroom audit (APPENDIX: XI) to target highest flowing toilets for first retrofits
    - Perform in-situ testing on dual-flush valves after installation to ensure proper function
- Employ preventative maintenance when retrofitting old, inefficient restrooms with high-efficiency toilets (HET's)
    - Study building plumbing to avoid installation of HET's along low-sloping horizontal lines where there is exceptionally high waste discharge (e.g., highly trafficked buildings)

- o Consider installing higher volume flow toilets farther from the sewer on the drainline to provide additional flow for the solids transport
- o Consider installing automatic flush valves on HET's or urinals at the end of a horizontal drainline to add extra periodic flows to flush the lines
- o Change the toilet paper to a low-flow friendly variety[21]
- o Design new buildings to accommodate the high efficiency toilet effluent flow without frequent maintenance, considering building traffic, pipe width, pipe slope, etc.[22]

- Do not use sensor-flush toilets in new buildings, as they save no water[23]
- Pilot lower flush toilets as they enter the market to test for potential maintenance issues; if pilot toilet projects do not pose significant plumbing challenges, adjust purchasing standards appropriately (APPENDIX: XII)

The average flush rate for on-campus academic, research, and other non-residential buildings based on the in-situ testing and subsequent extrapolation of a sample of 31 toilets is 3.7 gallons per flush (gpf) (APPENDIX: IX). Flush rates for the primarily Sloan brand toilets ranged from 1.6 to 5.25 gpf with one outlier toilet flushing at about 9 gpf. Flushes were consistently higher than manufacture specifications. These high flows can be attributed to corrosion or wear-down of fixtures over time (e.g., old, leaky toilet diaphragms allow more water to flow than new diaphragms), poor initial installation (e.g., if dual flush valves are not installed correctly, there will be no variability between flush options), and/or malfunctioning fixtures that do not perform at the advertised efficiency standards. Estimated water savings for a full toilet retrofit to a conservative 1.6 gpf standard are approximated to be 18.7 Mgal/yr with water cost savings of approximately $93,000/yr. If properly functioning, dual-flush valve toilets can reduce average flush rates to 1.22 gpf assuming more short flushes than long flushes, yielding a higher water savings of 22.2 Mgal/yr.[24] Replacing all the toilet valves on campus with a dual-flush retrofit toilet valve kit (1.6/0.8 gpf) would cost approximately $80,000 including installation costs; the payback for toilet retrofits is therefore less than a year (Table 11) (APPENDIX: IX). A full toilet retrofit alone is estimated to reduce annual potable water use in academic, research, and non-residential buildings by about 16%, reducing potable water consumption for the whole university by approximately 8%. Thus, if thoughtfully implemented, considering plumbing implications and verifying flow rates post-installation, toilet retrofits can provide significant and cost-effective water-savings opportunities.

Table 11: Toilet retrofits costs including installation costs

Scenario	Annual Potable Use (gal)	Annual potable water savings (gal)	Annual water cost savings ($ 2012)	Payback Period (approx. cost $2012)
Status Quo	33.3 million	--	--	--
Full Campus Retrofit	14.6 million	18.7 million	$92,900	<1 year ($80,400)

3) Implement and prioritize urinal retrofits:

- Replace urinal valves that exceed 0.5 gpf with low-flow or no-flow valves (e.g., 0.0, 0.125, 0.25 gpf); Implement new purchasing standards for facilities making 0.25 gpf a 'ceiling' for toilet valve flush rates. Recycle old stocks of urinal valves and diaphragms
  - Reference the WAP restroom audit to target the highest flowing urinals for first retrofits (APPENDIX: XI)
- Monitor plumbing where waterless urinals are in place to test for potential maintenance issues; if existing waterless urinals do not pose significant plumbing challenges such as detrimental salt build ups in plumbing lines, re-evaluate facilities purchasing standard to consider water-free urinals where plumbing lines have sufficient drainage capacity

Urinals are a peripheral focus of the WAP and are not easily tested on-site for flow rates; therefore, the above goals come with a note of warning. The University should switch to waterless urinals where feasible, but is cautioned against preemptive installation of waterless urinals without further pilot tests. Historical water-free urinal fixtures on the UCSB campus have caused urea build-ups in pipes and odor problems. Low flow 0.25 gpf urinals are a suitable alternative to water-free urinals when maintenance difficulties outweigh water savings. A best estimate suggests that a retrofit of all urinals that exceed 0.25 gpf (251 urinals) would yield annual water savings on the order of 3.2 million gallons and associated water cost savings of $15,700; alternatively, a completely waterless retrofit would yield annual water savings on the order of 4.2 million gallons and associated water cost savings of $20,800 (Table 12) (APPENDIX: IX). The costs of the retrofits, including installation, could be paid back in approximately 11 to 15 years. Based on these numbers, toilet and aerator retrofits are much more water efficient and cost-effective retrofits and should be prioritized over urinal retrofits. Consultation with the Facilities Management Lead Plumber for advice on urinal retrofit choice and feasibility is strongly encouraged to appropriately place and best understand the maintenance implications of high-efficiency urinals.

Table 12: Urinal retrofit costs including installation costs

Retrofit Scenario	Annual Potable Use (gal)	Annual potable water savings (gal)	Annual water cost savings ($ 2012)	Payback Period (approx. cost $2012)
Status Quo	4.2 million	--	--	--
0.25 gpf	1.0 million	3.2 million	$15,700	15 years ($216,500)
Waterless	0	4.2 million	$20,800	11 years ($216,500)

Housing & Residential Services

The following goals target dining commons and restroom fixture water-efficiency and are based on available water use data as well as audit data for Housing & Residential Services (H&RS). From the Baseline to the Benchmark, average potable water use per student living on campus housing has dropped 41%. While this represents a large improvement, potable water use for H&RS has increased 11% and total water use has increased 31% during the same time frame. With student population growth projected at 1% per year and a campus goal of housing all new students on campus, H&RS will need to further reduce average potable water use per resident in order to keep total potable water use down.[25]

The majority of water used within H&RS can be broken down into three sections: irrigation, dining commons, and restrooms. The following goals target dining commons and restrooms. Irrigation goals can be found in the "Landscape & Irrigation" section.

Goals:

1) Restroom Retrofits

Restrooms represent a significant portion of water use in a residential setting, and as with academic buildings (see previous section), are a natural target for water reductions within H&RS. Toilets, showers, and faucets represent three out of four of the greatest indoor water users (Figure 12). The main way to reduce water use within bathrooms is to improve the efficiency of these fixtures (see "Administrative Action" section below for behavioral goals). To get an estimate of the actual water use of the current suite of replacement fixtures, a random sample was taken of bathrooms in each residential hall and a portion of the student apartment buildings. Findings suggest that over 10 million gallons of water can be saved annually by continuing to retrofit bathrooms with high-efficiency fixtures (APPENDIX: IX).

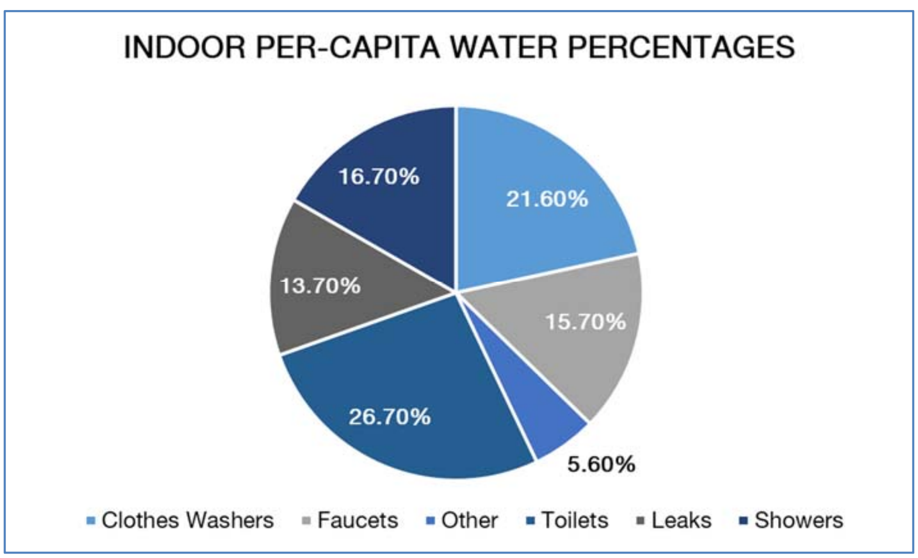

Figure 12: Indoor per capita water percentages.[26]

2) Implement and prioritize shower retrofits:

- Replace all showerheads that exceed 1.5 gpm with high-efficiency showerheads
- Perform in-situ testing on showerheads to ensure proper functionality
- Develop a pilot project to see if adjustable shower heads would be used appropriately

Showers are the second-largest water user within bathrooms but water use can be greatly reduced by switching from 2.5 gallons per minute (gpm) showerheads to 1.5 gpm showerheads, which saves a gallon of potable water per minute and around 8 gallons for a typical-length shower. While the majority of showers within H&RS have already been switched to 1.5 gpm, the residential hall inventory suggests that there are still 43% of showers with a manufacturer's flow rate of 2.5 gpm. Switching the remaining 43% of showerheads from 2.5 gpm to 1.5 gpm would save an estimated 6.5 million gal/yr (Table 13) (APPENDIX: IX).

Table 13: Shower retrofit costs, including installation

Scenario	Annual potable water savings (gal)	Annual water cost savings ($ 2012)	Payback Period (approx. cost $2012)
Switching the remaining 43% standard 2.5 gpm to 1.5 gpm	6.5 million	$32,200	<1 year ($28,00)
Switching remaining 2.5 gpm showerhead to adjustable flow	9.5 million	$47,100	<2 year ($50,600)
Switching all showerhead to adjustable flow head	14 million	$69,400	< 2 years ($117,400)

H&RS already has plans to make the aforementioned retrofits but shower water use could be further reduced. Significantly more efficient technology is currently available. For example, Niagara Pismire, a company from which HR&S currently purchases 1.5 gpm showerheads, also makes a showerhead called the Tri-Max with adjustable flow rates. The Tri-Max allows the user to change the flow rate while showering. Students could use an ultra-low-flow 0.5 gpm setting while soaping, shaving, or shampooing, and then switch to 1.0 or 1.5 gpm for rinsing. Assuming an average resulting flow rate of 1 gpm, switching all showerheads to a brand similar to the Tri-Max could save an estimated 14 Mgal/yr. This also translates to a significant reduction in energy use since reduction would be primarily of hot water.

A pilot project should be implemented to test the effectiveness of using adjustable showerheads. The project should be combined with education and outreach so that students not only know that they can adjust the flow of their showerhead but that they are also aware of the importance of conserving water. If the pilot study determines that students do in fact switch to 1.0 gpm and 0.5 gpm while soaping, shaving, or shampooing, retrofitting showerheads across campus with adjustable flow rates would be cost-effective, with a payback period of less than 2 years.

3) Implement and prioritize toilet retrofits:

- Replace toilet valves that exceed 1.6 gpf with dual flush HET valves (1.6 gpf/0.8 gpf)
- Consult with the FM Lead Plumber and Utilities Manager to select an ergonomic dual-flush retrofit toilet valve kit. Brand options include Kohler, Sloan, Zurn, etc.
- Perform in-situ testing on dual-flush valves after installation to ensure proper functionality
- Employ preventative maintenance when retrofitting old, inefficient restrooms with HETs

Toilets account for roughly 30% of an average home's indoor water consumption and are by far the largest users of water within residential halls. H&RS should continue to install high-efficiency toilets. Considering HETs, dual flush toilets are at minimum 20% more efficient than the required 1.6 gpf U.S. standard. Currently only about 57% of toilets within H&RS have dual flush valves. Reaching 100% dual flush toilets within H&RS could save 3 Mgal/yr (APPENDIX: IX).

This estimate is conservative because it assumes that all toilets within student housing are either dual flush or the standard 1.6 gpf. If there are still 3.5 gpf toilets in student residences that have not been retrofitted since 1996 when the 1.6 gpf standard was adopted, then the savings potential could be much higher. If it is assumed that all toilets that are not dual flush flow at 3.5 gpm, water savings estimates are 13.7 Mgal/yr (Table 14) (APPENDIX: IX).

Table 14: Toilet retrofit costs including installation costs

Scenario	Annual Potable Use (gal)	Annual potable water savings (gal)	Annual water cost savings ($ 2012)	Payback Period (approx. cost $2012)
Status Quo (57% Flowing AT 1.6 GPM)	17.65 million	--	--	--
Full Campus Retrofit	13.7 million	3.9 million	$19,400	< 5 years ($80,126)
Status Quo (57% flowing at 3.5 gpm)	31.1 million	--	--	--
Full Campus Retrofit	13.7 million	17.9 million	$ 88,597	< 1 years (80,126)

For concerns about the impacts high-efficiency toilets may have on plumbing drain lines, see APPENDIX: XII.

4) Implement and prioritize aerator retrofits:

- Replace all aerators with flow rates above 0.5 gpm with tamper-proof 0.5 gpm aerators. Recycle old stocks of aerators.
- Reference the WAP restroom audit (APPENDIX: XI) to target highest flowing H&RS buildings for first retrofits.

An estimated 10% of bathrooms in H&RS have aerators higher than the current efficiency standard of 0.5 gpm. Although this is a low number, aerators are inexpensive to replace and they can be one of the most cost-effective water conservation measures; for details, see "Academic, Research, & Other Non-Residential Buildings" above. If the remaining 10% of aerators were replaced with 0.5 gpm aerators, approximately 364,900 gallons of water would be saved each year (APPENDIX: IX) (Table 15).

Table 15: Aerator retrofit costs including installation costs

Aerator Retrofits	Annual potable water savings (gal)	Annual water cost savings ($ 2012)	Payback Period (approx. cost $2012)
0.5 gpm	364,900	$1,810	< 1 Year (1,164)

5) Plan for the use of recycled water in toilets and urinals of buildings proposed to be built on the UCSB campus:

- Plumb new buildings (e.g., Sierra Madre Family Apartments and San Joaquin Residence Halls) on the UCSB campus to accommodate recycled water use in toilets and urinals
    - Design new buildings with a storage tank on the building roof (with a capacity greater than a 1,000 gallons)
    - Feed two lines into the storage tank (recycled and potable) to enable redundant water sourcing
    - Separately plumb the toilets and urinals with a single recycled water line feeding from the storage tank; plumb all remaining fixtures (e.g., showers, sinks, etc.) with potable water pipes

According to Title 22, tertiary treated recycled water can legally be used in toilets and urinals; to use recycled water for these applications on the UCSB Campus, permission must also be attained from Goleta Water District. The replacement of potable water with recycled water is a strategy to decrease dependency on non-local water supplies by augmenting local water supply. To use recycled water in place of potable water, buildings must be, in part, dual plumbed. Recycled water is, at present, a less reliable water source than is potable water; therefore a building using recycled water in toilets and urinals must have a backup capacity to use potable water. The redundant plumbing ensures that water will always be available for toilet and urinal flushes. However, there must be a degree of separation between potable and recycled water sourcing; therefore, to use recycled water in toilets and urinals, there is a greater capital investment required to plumb new buildings. A fully dual-plumbed building (two pipes connected to every restroom) has been estimated to increase total plumbing costs by approximately 8.9% and total building costs by 0.23%.[27] A minimalist dual-piping strategy such as the one mentioned above would decrease the initial investment in plumbing while adhering to legal restrictions on the use of recycled water in restrooms.

An economic analysis of the use of recycled water in both Sierra Madre Family Apartments (SM) and San Joaquin Residential Hall (SJ), selected for their upcoming construction, reveals the potential benefits of investing in dual plumbing in new buildings on the UCSB campus. Retrofits designed to accommodate recycled water in the same capacity in older buildings are extremely expensive and logistically complicated, therefore the SM/SJ case-study focuses on the use of recycled water in toilets and urinals of buildings already planned on the UCSB campus (primarily H&RS Buildings).[28] Replacing potable water in toilets and urinals with recycled water in SM and SJ would cost approximately $333,000 in 2012 dollars. This investment would yield an estimated annual potable water savings of roughly 5.4 million gallons (~7,250 HCF) and a concurrent water cost savings of $21,300 per year in 2012 dollars (Table 16). These cost savings are generated by the price differential between potable water and recycled water. The University already plans to connect SM and SJ to recycled water lines for irrigation purposes; therefore, there would be no costs associated with the dual plumbing of the two new housing units other than the initial, incremental capital investment in the building's partial redundant plumbing and the roof water-storage tank. The payback period for the project is roughly 18 years. This payback period is significantly longer than the payback period for restroom retrofits, but the water-conscious precedence of the investment is a non-economic incentive to be considered (APPENDIX: IX).

Table 16: Recycled water use in toilets and urinals

Recycled Water Use Scenario 3	Annual potable water savings (gal)	Annual water cost savings (cost of potable less the cost of recycled) ($ 2012)	Payback Period (approx. cost $2012)
Toilets and Urinals in Sierra Madre & San Joaquin plumbed with Recycled Water	5.4 million	$21,300	18 years ($333,000)

6) Dining Commons Equipment Efficiency Upgrades

Together, commercial dishwashers and pre-rinse spray valves (PRSVs) in the typical restaurant dish room represent the largest consumption of water, accounting for approximately two-thirds of all water use within the commercial food industry.[29] As such, dishwashing should be targeted for potable water reductions within the dining commons.

High-efficiency 1.15 gpm sprayers have already been installed in all four dining commons; therefore, efforts should focus on switching out old inefficient dishwashers with new high-efficiency models. Currently none of the four dishwashers in use within the dining commons meet the latest Energy Star efficiency requirements for water (see APPENDIX: IX). The Champion dishwasher (Model #UC-CW6-3T) in Portola Dining Commons and the Stero Co. Model # STPCW-22 in Carrillo Dining Commons should be the first to be replaced to maximize water savings. Replacing these two dishwashers would save an estimated 1.5 Mgal/yr, which would also be accompanied by significant energy savings from reducing the amount of water heated within the dishwasher (Table 17).

Table 17: Current water consumption of commercial dishwashers on campus

Dining Commons	Dishwasher Make and Model	Water use per hour at 20 psi	Average annual water use (Gal)	Energy Star dishwasher: Average annual savings (Gal)	Annual Water Cost Savings ($2012)	Pay Back Period (cost $ 2012)
Portola	Champion washer (Model #UC-CW6-3T)	426	1,150,200	889,600	$4,400	<9 years ($34,800)
De la Guerra	Hobart FT900 Flight-Type dishwasher	198	534,600	274,000	$1,350	<31 years ($34,800)
Ortega	Stero machine, model # SCT-94SM	277	747,900	487,300	$2,410	<16 years ($34,800)
Carrillo	Stero Co. Model # STPCW-22	336	907,200	646,600	$3,200	<12 years ($34,800)

To get maximum water efficiency from each dishwasher, it is important to keep the rinse pressure maintained at the manufacturer's specifications, usually 20 psi and only wash fully loaded racks; commercial dishwashers use the same amount of water no matter how many dishes are loaded in the rack. When racks are fully loaded, average water use per dish washed is reduced significantly.

To reduce water use within the dining commons outside of dishwashing, the following Best Management Practices (BMPs) should be followed:

a. Connection-less/Boiler-less Food Steamers

Connectionless and boiler-less food steamer technology yields significant water use reductions in food service due to the elimination of condensate-cooling water. In a connectionless steamer, steam is generated using a reservoir at the bottom of the compartment and water is added and drained manually at the beginning and end of the day, unlike conventional steamers, which connect to a water line and continually consume water.

b. Air-cooled Ice Machines

Air-cooled machines are the recommended option because they are more water efficient and energy efficient than water-cooled machines.[30]

Based on payback periods, toilet, shower, and aerator retrofits are the most cost-effective way of reducing water and should be prioritized over replacement of dishwashers. Conservatively, H&RS can save 10 million gallons of potable water annually just from bathroom retrofits. If this is combined with longer-term goals of switching out old dishwashers and replacing potable water with recycled water in the toilets in SM and SJ residence halls, H&RS services will be capable of reducing its annual water consumption by over 27 million gallons, resulting in over a 20% reduction in total H&RS water use.

Landscape & Irrigation

Further potable water reductions in this sector are possible if the University continues expanding its practices of smart irrigation techniques, increasing the quality and usage of recycled water, and emphasizing xeriscaping techniques. The following goals were made after analyzing water usage data, identifying potential water- and money-saving irrigation techniques and practices, and collaborating with landscaping specialists from the University.

Goals:

1) Expand weather-based irrigation control system

To further reduce potable water use and ensure optimal amounts of water are being applied to the University's landscapes, UCSB should expand the weather-based irrigation system to include all of the University's landscapes. Of the 45% (3,018,708 ft^2) of landscape that is unincorporated under the weather-based irrigation system, 334,980 ft^2 are irrigated with potable water (APPENDIX: XIV). The irrigation schedule for this landscape is manually controlled, and if irrigation schedules are left unmonitored, overwatering can occur. Through consultation with UCSB's Facilities Management landscape and irrigation staff, it was determined that overwatering can amount to 0.5 inches/ week. If the University were to expand the Rain Master Oasis system to include all landscapes, it could reduce unnecessary irrigation and reduce expenditures of potable water for irrigation (Table 18).

Table 18: Water consumption and expenditures due to overwatering with potable water

Percentage of Landscape NOT Covered by Rain Master Oasis	Overwatering by 0.5 inches/ week (gal)	Annual Total due to Overwatering (Mgal)	Annual Cost due to Overwatering ($2012)
45%	103,000	5.37	$26,640
35%	80,300	4.18	$20,710
25%	58,000	3.01	$14,960
10%	22,900	1.19	$5,920

Weather-based irrigation control is not feasible everywhere because landscapes being included under the weather-based irrigation control system must have Internet access. Jon Cook, Facilities Management's Associate Director of Landscape & Custodial Services, judges that economic feasibility limits the further expansion of weather-based irrigation control system by 25%. Much of the landscaping not presently covered by the weather-based irrigation system are in remote locations where Internet access via Ethernet connection is unavailable, and for which expansion could be quite costly depending on site-specific requirements. However, with potable water prices increasing yearly, expanding Internet access and Ethernet connections in order to include more landscapes irrigated with potable water may become economically viable (APPENDIX: XIV).

2) Increase the Current Water Quality of Recycled Water for Commencement Green

High concentrations of sodium, chloride, and boron in recycled water can render soil sterile and damage landscapes. The recycled water UCSB currently receives suffers from this condition, which is a serious issue at Commencement Green. The landscape at Commencement Green is a low-lying, downward sloping lawn located at the southern-end of the UCSB Main Campus, adjacent to Campus Lagoon. The dynamics of the landscape and high water table level allow for the sodium, chloride, and boron in the recycled water to accumulate in the soil in high concentrations, particularly for the 51,829 ft^2 southern half of the lawn. Sodium and chloride are present in extremely high concentrations to depths of 36 inches (APPENDIX: XIV). High concentrations of sodium can cause clay particles to plug soil pores, resulting in reduced soil permeability from what is termed soil dispersion.[31] The combination of soil dispersion and a high water table essentially ensures that the concentrations of sodium, chloride, boron, and other nutrients continue to increase. Currently, the concentrations of these chemicals are high enough to be slowly sterilizing the soil and killing vegetation (APPENDIX: XIV).

The University should install a reverse osmosis system on-site at Commencement Green that would raise the water quality of the recycled water. This is the best treatment option for this landscape, as it would reduce constituent concentrations and is considered a permanent solution. AXEON Water Technologies provided a quote that would meet the needs of Commencement Green (APPENDIX: XIV). The major components of the system include a 2,000 GPD reverse osmosis system, 5,000 gallon storage tank, and a 350 gpm repress pump. The financial breakdown of this goal is compared with temporary solutions that are also being considered in Table 19.

Table 19: Commencement green treatment options

Treatment Option	Permanent or Temporary	Upfront Cost ($2012) at 5%	Recurring Cost ($2012) at 5%
Soil Replacement	Temporary	$470,980	$1,550 (every 8 years)
Soil Medium	Temporary	$333,730	$1,550 (every 4 years)
On-site Treatment System	Permanent	$16,490	$400 (Every 2 Years)

The on-site R/O system for Commencement Green is a permanent solution that will solve the soil quality issues caused by the current quality of the recycled water. The achievement of this goal is significantly less expensive over the long term than the temporary solutions that are also being considered, and also has smaller recurring costs. Installing a reverse osmosis system would also eliminate the prospect of switching back to irrigation with potable water in the area, an unsustainable and costly alternative with increasing potable water prices.

3) Expand the recycled water infrastructure

The University is currently in the process of expanding the recycled water line along UCen Road. This expansion will allow landscapes that were previously irrigated with potable water to now make the switch to recycled water. This project will be completed in 2013.

The University should expand the recycled water line to other areas landscapes that currently being irrigated with potable water. Irrigating with recycled water for the remaining 10% of Campus that is irrigated with potable water would save approximately 6.3 million gallons of potable water annually.

4) Conduct annual constituent soil samples

With the UCSB soils experiencing consistent constituent buildup due to recycled water quality and the soil characteristics on-campus, UCSB should collect annual soil samples. Soil samples at strategically selected locations throughout campus from depths of 6 inches to 32 inches would thoroughly reveal constituent concentrations and could help to identify future soil quality problem areas. Annual samples would allow for the University to take preventative and proactive measures for soil remediation and would help to identify areas of most concern before severe plant damage occurs. In regards to water conservation, proactively identifying problem areas would also reveal areas for additional on-site water filtration systems. As previously mentioned, these systems would increase the quality of recycled water and eliminate the potential need for the Campus to switch from recycled to potable water at a particular location. (APPENDIX: XV)

Industrial Water Uses

The following actions target reductions in industrial water consumption on-campus, based on available water use data, the potential for significant water savings, and the future expansion of the Campus. Goals include increasing cooling tower cycles of concentration (increasing water reuse in the towers), calibrating and installing industrial use water meters, and conducting regular quarterly reviews to assess cooling tower and other industrial infrastructure performance. This sector accounts for approximately 14% of UCSB potable water used, based on cooling tower consumptive data provided for years 2010/11. The potential savings are roughly 3% to 4% of the total campus potable water use, based on cooling tower actions alone. Other industrial infrastructure such as vacuum pumps, reverse osmosis systems, and boilers may account for even more savings, but the magnitude of potential water-conservation efforts in these operations are negligible compared to the gains that can be made by optimizing cooling tower operation. With this in mind, the University should work to achieve the following goals:

Goals:

1) Increase concentration cycles for cooling towers to reduce water consumption and increased operational efficiency:

2) **Adjust Johnson Controls computer automation system:**

- Adjust make-up water and blowdown settings to achieve up to 7 cycles of concentration.
- Gradually step up cycles of concentration to the maximum goal to evaluate the potential for scaling and operational instability.

3) **Utilize current chemical supplier, Nalco, as a consultant for implementing necessary chemical treatment changes:**

- Determine the appropriate amount of make-up water chemical dosing to accommodate increased cycles of concentration.
- Determine if additional side stream filtration is needed to reduce specific conductivity of the cooling water, which will allow for more cycles of concentration.

The average cycles of concentration for all campus cooling towers are estimated at 3 (APPENDIX: XVI). However, based on the quality of potable water supplied by GWD, the maximum cycles of concentration were calculated to be approximately 7. It is possible to operate the cooling towers at an even higher number of cycles, but risk of scaling and equipment malfunction increases since constituents such as alkalinity, total dissolved solids, and sulfates are more prone to precipitate out of the cooling water and cause damage to wetted surfaces. If the Campus raised the cycles of concentration to 7, several benefits would be gained over the status quo. First, a switch to 7 cycles of concentration would drop the yearly water consumption of cooling towers from approximately 31 million gallons to 24 million gallons, based on metered cooling tower water use data from 2010-2011. This results in an annual cost savings of approximately $37,000. Second, chemical treatment costs for cooling tower water should decrease as cycles of concentration are increased. The Campus currently spends approximately $70,000 annually in chemical treatment for cooling towers. Increasing cycles of concentration to seven would result in an annual treatment cost of $28,000, marking an annual savings of $42,000 (Table 20). Thus, significant water savings can be achieved with negligible cost, assuming that scaling conditions are monitored to ensure continued system performance. An adjustment to the cycles of concentration will require only a small adjustment to the Campus HVAC control system and chemical treatment systems. As it is likely that actual cooling tower performance may vary compared to calculated estimates, a pilot feasibility assessment should be conducted using one or two of the campus cooling towers.

Table 20: The annual water usage and water savings in gallons as well as the water cost and payback period for implementing increased cycles of concentration

Scenario	Annual Potable Use (gal)	Annual Potable Water Savings (gal)	Annual Water Cost Savings ($ 2012)	Payback Period (approx. cost)
Status Quo	31.8 million	--	--	--
4 Cycles	27.8 million	4.0 million	$19,700	--
5 Cycles	26.1 million	5.7 million	$28,400	--
6 Cycles	25.0 million	6.8 million	$33,600	--
7 Cycles	24.4 million	7.5 million	$37,000	--

4) Calibrate existing industrial water use flow meters and install new meters where required.

Properly installed and adjusted flow meters on the make-up and blowdown lines of cooling towers will allow HVAC system operators to closely monitor the volume of water being used and verify that the system is operating at optimum cycles of concentration. Ideally, the meters would be set up to transmit meter data into the Campus Java Application Control Engine (JACE) system so that operators in FM can remotely check the performance of the system, as well as log meter readings in the EEM central database. Currently, the meters installed on campus cooling towers require manual reading, which is a time-consuming endeavor since most of the cooling towers are in hard to access areas. In addition, the cooling towers on Engineering I, Cheadle Hall, and the Student Health Building lack meters altogether on the blowdown lines. The cost for meters, depending on pipe size and advanced features, range from $150 to more than $1,000 (APPENDIX: XV). An ideal first step would be to calibrate the existing 17 meters on cooling towers and install three new meters on the cooling towers missing a blowdown line meter. With costs of about $200 for a basic meter, $50 for removal and installation of a meter (based on a $50/hr labor rate), and $30 per meter for calibration, the overall cost of this suggested action would be approximately $2,500. A calibration schedule for industrial meters should then be established to certify meters on a five year recurring basis. A later switch to 'smart' water meters that integrate with campus control systems could be implemented to fine-tune cooling tower operation.

5) Regular quarterly reviews to assess cooling tower and other industrial infrastructure performance.

Engineers, facility managers, and other personnel in FM should meet quarterly to discuss the performance of cooling towers and other industrial infrastructure. For cooling towers, variables such as cycles of concentration, specific conductivity, and chemical treatment concentrations need to be assessed to determine whether they fall within specific limits. In addition, the review should be a forum to discuss indications of leakage, overflows, and other types of water loss (or other deleterious conditions), as well as corrective actions to remedy these conditions. The review should additionally apply to other industrial equipment, such as vacuum pumps and reverse osmosis systems that may be present in laboratory and research buildings. Although water use from this equipment is not addressed by the goals in this plan, it has potential to consume significant amounts of potable water (APPENDIX: XV).

Administrative Action

This section recommends actions that address procedural processes, behavioral incentives, and University policy. Effectively addressing these areas can enable further water reductions by embedding sustainable water practices into daily routines.

Goals:

1) Install real-time meters in all existing buildings, and require that all new construction include meters

Knowledge of current water use is the foundation of future conservation efforts. The current metering system at UCSB is inconsistent and sparse in coverage. While all residential buildings have meters, only a small handful of non-residential buildings are metered. In addition, many existing meters malfunction and are in need of replacement. No meters on-campus can be remotely monitored; all must be manually read. A standardized, real-time metering system will facilitate the efficient collection of water-use data, thereby establishing accurate, current use data and enabling quick identification of inefficient or excessive water use. Standardizing the Campus system with remote monitoring will allow ease of data collection and consistency in reporting. For example, departments of state-funded buildings do not see their water use. If these departments were provided reports of monthly use, they may be more conscious of water consumption.

In addition, this information can be easily published in the main lobby of residential and academic buildings by installing real-time monitors, incentivizing conservation by increasing public accountability. This long-term goal would provide students, faculty, and staff with real-time feedback about building utility usage and efficiency, which is expanded on in Goal 7 in this section. A real-time metering system can quickly identify water waste such as system leaks and inefficient water application. The current system is unable to identify and quantify system leaks. A well-designed metering system can streamline water billing by allowing bills to reflect the actual quantity of water used rather than estimated quantities.

Accuracy in water billing will avoid bureaucratic discrepancies and will prevent water users from either over or under paying for their water consumption. For example, the water metering system at Stanford University reports the volumetric water use every 15 minutes and records the average usage at different times of day at that meter point[32]. Because of this, the system was able to detect a water leak at Oval Park, the main entrance lawn on campus. When the meter point at Oval Park began reading volumes of water significantly higher than the average, an alert` was sent out to Stanford's Facilities Planning and Management. This enabled staff to turn off the water to Oval Park and prevent further water loss while the line was fixed. Overall, between July 2011 and June 2012, Stanford detected over 200,000 gallons of water leaking using a real-time metering system[33]. Savings in the following years would be significantly less, assuming that UCSB repairs leaks as they come to their attention.

2) Create a living, central database for water use and water infrastructure data that builds on the existing set of documents archived by the *Water Action Plan*

a. Develop and maintain a user-friendly system to record water consumption

Include aggregated water use (total recycled water, total potable water, and total water use) and disaggregated water use (water use by sector, water use by metered building, water use normalized by weighted campus user (WCU), California-Adjusted Gross Square Footage (CAGSF; OSGSF50), and season).

b. Develop and maintain an archive of bathroom fixtures organized by building

Include estimated installation date, manufacture efficiency standards, retrofit dates, repairs (date, reason), and in-situ testing records (when available).

c. Develop and maintain an archive for irrigation fixtures

This archive would be organized by the Campus Zone System and contain various irrigation practices and specific details of the irrigation infrastructure. Specifically, it would include irrigation types at UCSB and respective location, areas included and not included under the weather-based irrigation control system, and equipment specifications such as product type, model, installation date, and any repair details or infrastructure upgrades.

Database development and maintenance would enable UCSB to monitor trends in the University's water consumption. Consequently, UCSB would be better equipped to realistically predict future water needs and either limit or expand planned university growth accordingly. Additionally, monitoring trends can help pinpoint excessive water use and/or attribute water savings to concurrent conservation efforts. Apart from water use data, comprehensive and centralized water fixture archives can direct effective and efficient facilities maintenance efforts by funneling retrofit efforts to the least-efficient buildings.

3) Create and fill a 'Water Manager' position within Facilities Management to ensure sufficient maintenance and upkeep of Campus water infrastructure

As a collection, the goals outlined in the WAP are extensive and, when achieved, will require consistent monitoring. The creation of a 'Water Manager' position within Facilities Management would ensure the effective and efficient achievement of the above goals. Potential tasks for this position are as follows.

- Design, implement, and maintain a central water database as discussed in Goal 2 of this section. This database will include water use numbers, currently installed water fixtures (location, last install, retrofit, repair), in-situ test numbers, etc.
- Oversee metering program as discussed in Goal 1 of this section. This will include overseeing installation, data collecting, aggregating, and publishing leak and high usage identification, etc.
- Facilitate educational programming by initiating ideas, implementing pilot programs, communicating with faculty and administrative staff regarding conservation projects, and educational opportunities.
- Serve as a liaison to GWD and GSD to keep open communication with respect to contracts, water costs, and funding opportunities.

- Devise incentive programs for water conservation at the University, local, and University of California (UC) System levels to encourage continued focus on water conservation.
- Assist with stormwater management by collecting data on current BMPs on-campus.
- Facilitate preventative maintenance by monitoring the Central Water Database and preempting old fixture failure and plumbing problems with annual restroom inventories as indicated in Goal 2 of this section.
- Research the permitting and financing of new water projects. This may include a decentralized treatment system to improve the quality of recycled water for irrigating the Commencement Green.
- Communicate with Environmental Health & Safety, Design and Construction, and other UCSB departments to recommend water conservation BMP's and ensure that water systems meet health codes.

This position will help the University proactively and efficiently address maintenance concerns and ensure the continued implementation of water conservation strategies.

4) Implement a campus-wide outreach and awareness education program

In order to better students' perception of water conservation activities, outreach programs should be implemented. The success of the on-campus residential hall competition held in 2011-2012 shows that students are capable of conserving water if they are motivated or encouraged. The goal of education programs implemented should be knowledge, motivation, and control for students to feel empowered to make changes.[34] Educating students on the importance of water conservation is the first step in encouraging thoughtful use of water on-campus and overall reductions per capita.

a. Implement a mandatory seminar on water use for incoming students

There are a number of campuses that require all incoming students to attend certain education and awareness programs as part of orientation. UCSB should implement a similar program, but geared towards water use. This education program should be included during the mandatory Freshman Orientation that students attend, and the equivalent orientation for transfer students. Alternatively, this session could be incorporated into the residence halls mandatory orientation shortly after students move into the buildings. Such an education program would alert incoming students that the University is committed to conserving water on-campus. Three factors, if readily available, will result in a decreased use of resources in buildings: "knowledge, motivation, and control."[35] Requiring students to attend an informational seminar to learn about water conservation and its importance fulfills the knowledge component of the three required factors. In addition, the seminar could present simple tips and suggestions for water conservation on-campus, as well as foster conversation to empower students to use that knowledge, fulfilling the control component. Ideally, this early introduction to water use on-campus will encourage students to participate in future water savings activities, whether that be under their own initiation or under the University's.

b. Provide a phone number for students to call or text if they see water wasting activity on-campus.

Currently, students can call the Main Facilities work order number to alert Facilities Management to instances of infrastructure water-wasting on campus, such as toilet leaks. However, this number is not heavily advertised. To foster awareness among the University population, posters advertising this number should be posted throughout campus, including residential halls, academic buildings, and other heavily trafficked areas. In addition, incoming students should be given this number during the aforementioned water seminar. This number could be used to alert Facilities Management about water-wasting activities such as leaky water fountains or broken sprinklers. The number should also be programmed to receive text messages. Texting allows immediate action without requiring a significant time investment from students, increasing the likelihood that they will report water waste. Widely advertising this number among the University population would contribute to overall water use awareness and foster ownership over water conservation. In the future, this number could be expanded to include energy-wasting activities as well, such as malfunctioning lights or HVAC issues.

c. Post informational signs on water usage in academic bathrooms

Residential bathrooms already have some signs with information and encouragement to conserve water. Increasing the presence and appeal of signs would serve as an active reminder to students to use dual flush values and not leave faucets or showers running when not in use. Signs should include information on the average use of faucets and showers when running, as well as facts about water scarcity in Santa Barbara and in California. This provides students with more information about the actual use of fixtures to help them understand the true magnitude of their water use through daily activities. These signs would also serve to keep water conservation on the campus communities' mind long after the initial water conservation education to create lasting water reductions in academic buildings and resident halls. In addition, signs should be easy to read, with a small amount of very specific information presented on any given sign. This helps to ensure students easily digest the message.

d. Choose a water conservation book for the entire campus to read one year

The book chosen every few years as a part of the UCSB Reads program, could center on water conservation issues. UCSB Reads works to encourage dialogue and understanding about a particular topic on-campus and in the Santa Barbara Community.[36] This makes water conservation an excellent candidate for the program, and would provide a fun way to reach new and old students, as well as faculty and staff over the years about the complexities of water conservation.

e. Provide information to Residential Assistants about water conservation in training and have them pass that information on to their halls

As a part of the required freshman seminar on water conservation, Residential Assistants should be provided with material during their training to post in residential halls and common areas (see Goal 4a of this section). The presence of information discussed and taught at the Orientation Session throughout the residential halls would serve as a reminder of the seminar and its water conservation suggestions throughout the year. This material would be put together by the Water Manager and based on the content presented at the start of each year (see Goal 3 of this section). This is an immediate step that can be taken to bring water conservation forward in the minds of students.

f. Install real-time dashboards in all UCSB residential halls and apartment complexes

An important factor in residential hall reductions during the year and during competitions is the availability of information to students.[37] The real-time meters mentioned in Goal 1 of this section can be used to provide students with information about their water conservation progress. Combining the use of real-time meters and dashboards will give students the ability to see the impact of certain actions when combined with monitors and dashboards. A study done at Oberlin College on a residential hall competition supports this approach, because it found that students with real-time data were more successful in conserving water than other dorms.[38] The residential hall receiving real-time water use feedback had the greatest percent reduction of water use, conserving 11%, while the average across all residential halls studies was just 3%.[39]

An important component of encouraging student action is creating motivation, which was achieved in a competition in residential halls at Dartmouth College by using real-time dashboards in 2008. The dashboards at Dartmouth displayed information about energy use as well as a polar bear that responded positively when students were conserving and negatively when students were not.[40] Though the Dartmouth competition focused on energy reduction, the residential halls saw an average decrease in 10% energy usage just by making the information available in a visually motivating way.[41] The visual representation of data engaged students, not only by decreasing utility usage during the competition, but also from lasting changes in behavior—67% of students in the competition said the real-time information system encouraged them to adopt energy savings habits.[42] This shows that real-time data has been successful in not only reducing use during competitions but in creating year-round motivation to conserve.

It is anticipated that awareness of water conservation would motivate students to reduce their water use; however, that may not be the case on a college campus where students do not pay a water bill or receive an award for conservation. The listed outreach programs that encourage water use awareness and conservation should be implemented on-campus; water usage before, during and after the programs should be monitored to document progress. If these education programs do not have a substantial impact on water use reduction, new methods of motivation will need to be researched and implemented.

5) Incorporate water conservation into the University's academics

a. Encourage professors to choose water conservation examples and topics

The University should encourage professors to utilize the Campus's unique location and water challenges as topics for class discussion. One example of a method of incorporating water conservation education into the classroom is by asking art professors and their classes to do water conservation focused installations on campus. These installations allow art students to explore the many facets of 3D art, installation and conveying a message. This also provides information to the general campus community, who will engage with the projects on a daily basis. Another such example would be using the film Chinatown in a film class, or a history class, to discuss the water issues in Southern California. Professors that are unsure of how to incorporate water conservation, or do not feel they can speak to the topic adequately, could take advantage of the University's course modules of short lectures given by other Professor's on-campus on key topics.[43] Projects incorporated into the academic curriculum create opportunities to engage students in water conservation issues through avenues that interest them and expand their understanding of the issues surrounding water conservation.

b. Encourage water-conserving behavioral change in laboratories

To improve water conservation in laboratories, the administration should require that each laboratory establish written protocols for washing glassware (if applicable). These protocols should be designed to maximize water efficiency without jeopardizing the cleanliness of the glassware. In addition, each laboratory should establish protocols that dictate what kind of water (DI, RO, purified, or tap) should be used for each laboratory process (Appendix: III). This strategy will prevent an unnecessarily high laboratory water footprint. Finally, shut-down timers should be installed on water intensive laboratory equipment, if appropriate to the experiment at hand, in order to prevent water waste after experiments are finished.[44] These types of changes will encourage more conscientious water use in labs while allowing labs to maintain the high standards at which they perform.

c. Create Living Laboratory for the treatment system at Commencement Green

If a treatment system is installed at Commencement Green, it could be used as an on-site educational opportunity to engage students and help them better understand water treatment. This could include chemistry students studying the treatment of the water and biology students studying the effects of recycled water on plants; engineering students and material science students could also benefit from the study of the reverse osmosis (RO) system through the theory of design, maintenance and the materials used to treat water. The treatment system education component could even target social science students like urban studies, global studies, politics and policy, and economics students, who would be interested in the implementation, legal requirements, theories and cost effectiveness of similar systems for cities across the globe.

6) Encourage competition in on-campus competitions and Campus Conservation Nationals or other nation-wide competitions focused on water conservation

Competitions can engage and motivate students. UCSB should try to implement residential hall competitions that last for longer durations to encourage conservation. In addition, the University should conduct competitions every one to two years in order to engage new classes of students in the importance of water conservation. In particular, longer duration or higher frequency of competitions may encourage longer-term behavioral changes, rather than just short-term adjustments to win the competition. However, it should be noted that habit conversion is specifically difficult in a residential hall setting, because residents do not pay their utilities and have no direct incentive to conserve resources. One study showed that only 44% of students said they would continue to use these conservation strategies after the competition.[45] UCSB saw a 7% on average weekly conservation during the 2012 Energy and Water Savings competition (APPENDIX: XV).

Metering would make evaluating the results of the competition more accurate. For example, the most recent on-campus utilities conservation competition had several weeks of data thrown out for several residential halls due to unlikely high values. This reduced the reliability of the competition data and made it difficult to assess the conservation results. Real-time monitors would make this effortless for the Campus for any buildings with meters installed.

The University should consider competing in Campus Conservation Nationals, which is the largest nationwide energy and water reduction competition (http://www.competetoreduce.org/). Participation in competitions such as this would provide students with motivation to conserve, as well as bringing national awareness to the UCSB campus and its water savings efforts.

UCSB should also have an annual "water conservation month" where the Campus community pledges their efforts to reduce water use. This would create focus on water conservation campus-wide, similar to a competition. In return for their pledge, they would receive rewards and acknowledgments.

7) Begin dialogue with the State of California to encourage the implementation of incentives for water conservation in state funded buildings

The State of California pays the water bills for those buildings it funds. Because of this, departments see their water bills and, therefore, have little incentive to alter water-using habits. As a means to reduce water use in state funded buildings, the Water Manager should engage the State of California in a dialogue about how the State could implement incentives for water reduction. UCSB should formulate a strong case as to why the State should consider offering water reduction incentives. Such a case might include the cost savings that UCSB has realized in their water saving efforts as well as potential cost savings that the State could achieve through incentivizing water reduction strategies. For the State, most of the cost savings will most likely be in energy. Therefore, any reduction in the use of this State Water would be a very substantial reduction in the amount of energy used by the State of California. Depending on the size of this reduction, there may be an important tie-in to the overall reduction mandated by AB32. UCSB should consider partnering with other UC's to show the State of California that water conservation initiatives on UC Campuses undertaken by the State will significantly help them to reach State conservation goals such as those outlined in SB X7-7 and AB32.

FINANCING OPPORTUNITIES

There are a number of funding opportunities available for the University to pursue the projects outlined in the goals. The aforementioned Water Manager would probably be best positioned to research and evaluate funding opportunities for the WAP. Outlined below are a few institutions that have historically provided funding for water conservation projects and a select number of particular grants for which the University may apply:

- The University's TGIF grant system has awarded a number of grants to water efficiency projects on-campus. Departments on-campus should continue to look at TGIF for funding water projects in the future. TGIF will be particularly useful for short-term, low-cost projects like expanding the metering system or purchasing aerators or low-flow showerheads.
- The Coastal Fund is another source of University funding available for on-campus projects. The mission of the Coastal Fund is to award funding to those project that help conserve the UCSB coastline. In keeping, this fund will be particularly useful for water conservation projects that have associated coastal benefits.
- The County of Santa Barbara's Integrated Regional Water Management Program (IRWMP) provides funding for projects under State Proposition 50 and Proposition 84. While funding for Proposition 50 has already been allocated, Proposition 84 funds are still available to fund projects aimed at improving water quality; protecting rivers, lakes and streams; improving flood control; promoting sustainable communities and the reduction of climate change; protecting beaches, bays and coastal waters; parks and natural education facilities; forest and wildlife conservation; and statewide water planning. More information can be found at www.countyofsb.org/irwmp.
- California's State Revolving Fund may be another available option. Although it provides low-interest rate loans only to local agencies, the University may consider engaging with Goleta Water District to apply for these loans. More information about the State Revolving Fund can be found at www.waterboards.ca.gov/water_issues/programs/grants_loans/srf/.
- The California Department of Water Resources (DWR) offers both grants and loans, which are funded through approved state propositions. For example, Proposition 50, Agricultural and Urban Water Use Efficiency, has provided grants to local agencies for projects that align with the goals of the California Bay Delta Program's Water Use Efficiency Program. Because many DWR grants and loans only offer funding to water agencies, the University may need to collaborate with Goleta Water District to receive funding from the DWR. More information about DWR grants and loans can be found at www.water.ca.gov/nav/nav.cfm?loc=t&id=103.
- The Environmental Protection Agency (EPA) often publishes grants. Since 1992, EPA has published the EPA Environmental Education Regional Model grant. The 2013 cycle (which closed in December 2012) had $2.16 million in funding. The grant provides funding to projects "that increase the public's awareness about environmental issues and provide them with the skills to take responsible actions to protect the environment."[46] This funding opportunity will

be particularly useful for more extensive and costly on-campus education programs. This fund could also be used on collaborated projects with GWD. More information about this grant can be found at www.epa.gov/education/grants/index.html#grants=0.

- The Bureau of Reclamation is another source available to the University for funding. In 2010, the Bureau of Reclamation initiated WaterSMART, aimed at saving water, discovering ways to more efficiently use existing supplies, and helping entities plan to meet future water demands. Since the WaterSMART began, the Bureau of Reclamation has granted millions of dollars to projects all across the West. Under WaterSMART, there are a number of programs for which the University could apply. For example, in early 2013 a grant program for Water and Energy Efficiency provided funding to projects that would conserve and use water and energy more efficiently. More information about the WaterSMART program can be found at www.usbr.gov/WaterSMART.
- Both grants.gov and the Catalogue of Federal Domestic Assistance are useful databases to explore potential funding opportunities. Grants.gov allows easy searching of over 1,000 federal grants. In addition, grants.gov is typically where federal grants mandate application submission. The Catalogue of Federal Domestic Assistance provides detailed program descriptions for thousands of funding programs available to the public. While not specifically water related, this Catalogue can be used as a resource for investigating new funding opportunities for the University. The Catalogue can be found at www.cdfa.gov.

SUMMARY & FUTURE STEPS

Summary & Goals

UCSB has already surpassed the "20% by 2020" potable water reduction mandate, due to its many proactive conservation practices. However, with regional water demand increasing, supply decreasing, and the University's building infrastructure and population expected to grow, UCSB must continue to decrease potable water use. Current and anticipated economic conditions of the University of California (UC) system may affect funding for major conservation projects, but there are many low-cost potable water conservation measures that can be pursued with substantial benefit. To further reduce potable water consumption, the University should make the following actions its highest priority for conservation and water-use efficiency (Table 21, 22).

If fully achieved, the Infrastructure Goals would save UCSB approximately 53.4 million gallons of potable water and roughly $230,000 of cost savings annually (Table 22). While water reductions from the Management Goals are not easily quantifiable before the management actions are implemented, they are estimated to contribute to annual potable water use reductions.

Table 21: Summary of Infrastructure Goals

Sector	Infrastructure Goal	Initial Cost ($2012)	Payback Period	Annual Potable Water Savings (Gal)	Annual Water Cost Savings ($2012)	Cost Per 1000 Gal Water Savings ($2012)	Implementation Horizon[1]
Academic, Research and other Non-Residential Buldings	Retrofit Aerators in Bathrooms	$9,000	<1 year	4.7 million	$23,300	$1.91	Short-Term
	Retrofit Toilets in Bathrooms	$80,400	<1 year	18.7 million	$92,900	$4.30	Short-Term
	Retrofit Urinals to 0.25 gpf in Bathrooms	$217,000	15 years	3.2 million	$15,700	$67.81	Long-term
Housing & Residential	Retrofit Showers in Bathrooms	$2,800	<1 year	6.5 million	$32,200	$0.43	Short-Term
	Retrofit Toilets in Bathrooms	$80,100	< 6 years	3.0 million	$14,900	$26.70	Short-Term
	Retrofit Aerators in Bathrooms	$1,200	<1 year	364,400	$1,800	$3.29	Short-term
	Use Recycled Water in Toilets	$333,000	18 years	5.4 million	$21,300	$61.67	Medium-Term
	Upgrade Dining Common Dishwashers Portola Carrillo	$34,800 $34,800	<9 years <12 years	889,600 646,600	$4,400 $3,200	$39.12 $53.82	Medium-Term Medium-Term
Landscape & Irrigation	Exapnd Weather-based Irrigation Control Systems	NA	NA	3 million	$15,000	NA	Long-Term
	Install On-Site Filtration System for Commencement Green	$16,500	<5 years	831,000	$4,100	$19.86	Short-Term
	Expand Recycled Water Infrastructure for Irrigation	NA	NA	1.1 million	$5,800	NA	Medium-Term
Industrial Water Use	Increase Concentration Cycles for Cooling Towers	NA	NA	7.5 million	$37,000	NA	Short-Term

[1] **"Short-Term" = 2013-2014; "Medium-Term" = 2014-2020; "Long-Term" = 2020-2028**

[1] COST: "$" = <$10,000; "$$" = $10,001-$100,000; "$$$" >$100,000

Table 22: Summary of Management Goals

[2] ANNUAL POTABLE WATER SAVINGS: "LOW" = <200,000 GALLONS; "MEDIUM" = 200,001-500,000 GALLONS; "HIGH" = >500,001

SECTOR	MANAGEMENT GOAL	DESCRIPTION	COST $2012 (INITIAL/ANNUAL)[1]	ANNUAL POTABLE WATER SAVINGS (GAL)[2]	IMPLEMENTATION HORIZON[3]
LANDSCAPE & IRRIGATION	CONDUCT ANNUAL CONSTITUENT SOIL SAMPLES	WILL HELP TO IDENTIFY CONSTITUENT BUILD-UPS ON-CAMPUS, WHICH WILL ALLOW FACILITIES MANAGEMENT TO PROACTIVELY REMEDIATE SOILS AND ELIMINATE THE IDEA OF RETURNING TO POTABLE WATER IRRIGATION.	NA/$	NOT APPLICABLE	SHORT-TERM, ONGOING
INDUSTRIAL WATER USES	CALIBRATE EXISTING INDUSTRIAL WATER METERS AND INSTALL NEW WHERE NEEDED	WILL ENSURE MAXIMUM COOLING TOWER OPERATING EFFICIENCY, ACCURATE DETERMINIATION OF WATER USE TRENDS, AND INCREASED LEAK AND MALFUNCTION DETECTION CAPABILITIES.	$/NA	LOW	SHORT-TERM
	QUARTERLY REVIEWS FOR INDUSTRIAL INFRASTRUCTURE	WILL FACILITATE PROPER ADJUSTMENT AND OPTIMIZATION OF INDUSTRIAL WATER INFRASTRUCTURE TO MAXIMIZE WATER AND ENERGY SAVINGS.	NA/$	NOT APPLICABLE	SHORT-TERM
ADMINISTRATIVE ACTIONS	INSTALL REAL-TIME METERS IN ALL BULDINGS AND NEW CONSTRUCTION	WILL FACILITATE QUICK AND EFFICIENT DATA COLLECTION, IDENTIFY LEAKS WITHIN THE SYSTEM, AND HELP INCENTIVIZE CAMPUS WATER USERS TO CONSERVE.	$$$/$	MEDIUM	SHORT-TERM
	CREATE A LIVING CENTRAL DATABASE FOR WATER USE AND INFRASTRUCTURE.	WILL PROVIDE REALISTIC MONITORING TRENDS ALLOWING THE UNIVERSITY TO BETTER PREDICT FUTURE WATER NEEDS AND ADJUST CAMPUS POPULATION GROWTH ACCORDINGLY. WILL ASSIST WITH THE EFFICIENT PINPOINTING OF THE MOST INEFFICIENT AREAS ON CAMPUS.	$/$ (INCLUDED IN WM SALARY)	NOT APPLICIBLE	SHORT-TERM
	CREATE A "WATER MANAGER"	WILL HELP WITH THE EFFECTIVE AND EFFICIENT IMPLEMENTATION OF WATER CONSERVATION PROGRAMS AND STRATEGIES ACROSS CAMPUS.	$/$$	NOT APPLICABLE	SHORT-TERM
	IMPLEMENT A CAMPUS WIDE WATER CONSERVATION EDUCATION PROGRAM	INCREASE STUDENTS' PERCEPTION OF WATER CONSERVATION ACTIVITIES BY PROVIDING THEM WITH THE KNOWLEDGE AND MOTIVATION TO REDUCE WATER USEAGE.	NA/$$$ (PARTIALLY INCLUDED IN WM SALARY)	LOW	SHORT-TERM, ONGOING
	INCORPORATE WATER CONSERVATION INTO ACADEMICS	PROJECTS INCORPORATED INTO THE ACADEMIC CURRICULUM CREATE OPPORTUNITIES TO ENGAGE STUDENTS AND EXPAND THEIR UNDERSTANDING OF THE ISSUES SURROUNDING WATER CONSERVATION.	$$/$	LOW	SHORT-TERM, ONGOING
	PARTICIPATE CAMPUS AND NATIONAL WATER CONSERVATION COMPETITIONS	COMPETITIONS ENGAGE AND MOTIVATE STUDENTS AND ENCOURAGE THE USE OF WATER CONSERVATION KNOWLEDGE, PARTICULARLY LONGER DURATION COMPETITIONS THAT CREATE LONG-TERM BEHAVIORAL CHANGE.	NA/$ (INCLUDED IN WM SALARY)	LOW - MEDIUM	MEDIUM-TERM, ONGOING
	BEGIN DIALOGUE WITH STATE TO ENCOURAGE IMPLEMENTATION OF INCENTIVES FOR WATER CONSERVATION	WILL HELP EXPLORE STATE FUNDING OPPORTUNITIES AND COLLOBORATION WITH THE STATE AND OTHER UC'S REGARDING WATER CONSERVATION STRATEGIES AND FUNDING SOURCES.	NA/$ (INCLUDED IN WM SALARY)	MEDIUM	LONG-TERM, ONGOING

[3] "SHORT-TERM" = 2013-2014; "MEDIUM-TERM" = 2014-2020; "LONG-TERM" = 2020-2028; "ONGOING" = MAY REQUIRE ACTION AT SHORT, MEDIUM, AND LONG HORIZONS

Future Reduction Targets

UCSB has already surpassed the 20% by 2020 *per-capita* reduction goal set by the University of California, Office of the President (UCOP) from the Baseline to the Benchmark time period. Based on the ability of UCSB to conserve water over the past 15 years and the efficiency and conservation opportunities identified in the 'Summary & Goals' section above, it appears feasible for UCSB to achieve a 20% reduction in *total* potable water use over the next 15 years (by 2028) if no population growth is assumed (Table 21, 22). Under this 'no-growth' scenario, if the University were to implement the quantified reduction strategies, gross annual potable water use would decrease from the Benchmark period by 24.4%. The short and medium-term 'implementation horizon' goals alone would yield a 20.4% reduction in total potable water use.

Thus, UCSB should strive for a 20% gross reduction in potable water use (from the Benchmark period) by 2028. A proposed implementation strategy to achieve this target would require achieving the short-term goals of this WAP during FY 2012/13 to FY 2013/14, fulfilling the medium-term goals and commencing the long-term goals between FY 2014/15 and FY 2019/20, and striving to achieve full completion by 2028. Given the high water-savings potential of the short-term goals, the University should seek an interim reduction target of 15% gross reduction in potable water use by 2020.

This 15% target for potable water reduction does not account for campus expansion and population growth. As campus populations increase, water use is expected to increase. Due to this expected population growth, the 15% reduction will look more like a 4% reduction in total potable water use between the Benchmark and FY 2019/20 (Figure 13). Thus, the goals above will counteract the increase in water consumption due to the growing Campus population and yield a net water reduction of 4% under assumed growth patterns (Figure 13) (APPENDIX: XXI). Because population growth is uncertain, so is the anticipated 4% reduction. If the 4% reduction in total potable water is normalized by projected WCU numbers in FY 2019/2020, it results in an estimated 11% decrease in potable water consumption per WCU from the Benchmark (~7,000 gal/WCU) to FY 2019/20 (~8,000 gal/WCU)(Figure 14).

The current contract between UCSB and GWD allots the University ~307.9 Mgal/yr of potable water. With no further potable water use reductions via conservation or efficiency upgrades, WCU-based projections indicate that the University would use roughly 246.2 Mgal annually by FY 2019/20 (APPENDIX: XXI)(Figure 13). By achieving the short-term goals and meeting the 15% reduction target, the potable water use projection falls to 209.3 Mgal and prevents, at least over the period of the projection, UCSB's movement towards the 307.9 Mgal/yr limit (Figure 13).

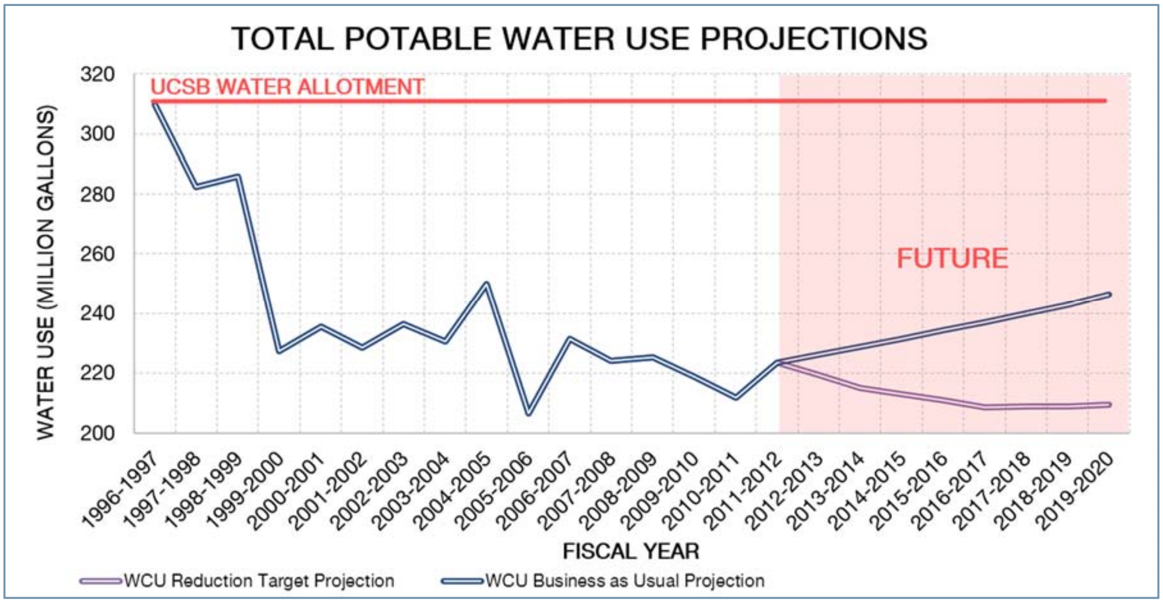

Figure 13: Total potable water use projections calculated based on expected WCU growth under two water consumption scenarios: 1) Business as Usual, and 2) Target ~4% reduction from the Benchmark by 2020 with expected campus growth (equivalent to a 15% reduction from Benchmark assuming no campus growth).

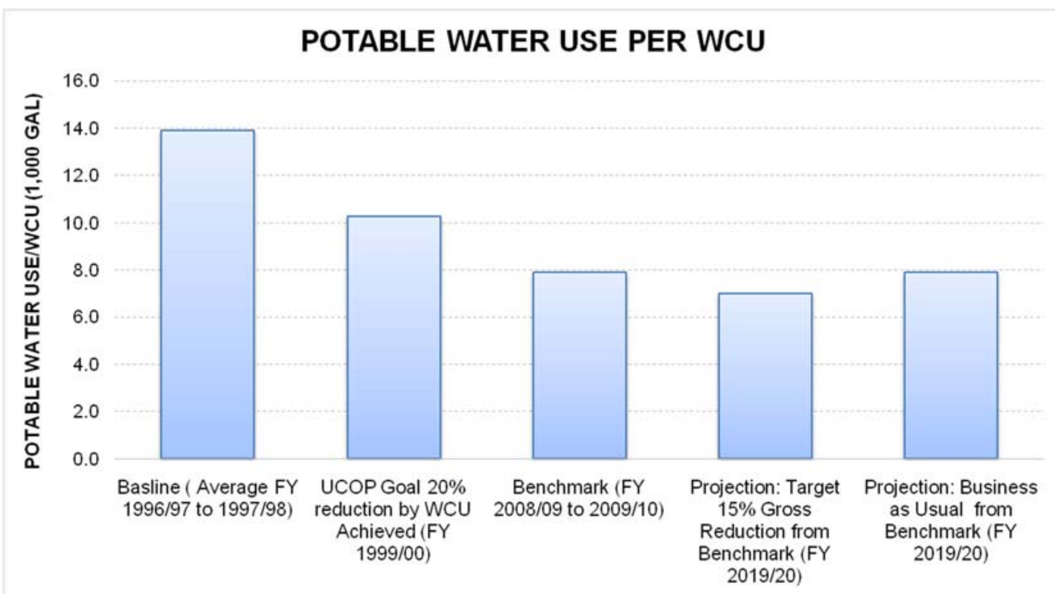

Figure 14: Potable water use and projected potable water use (normalized by WCU) for selected periods in UCSB's past and future.

Reporting Criteria & Schedule

As outlined by the Sustainable Water Systems Policy, UCSB must provide an annual progress report on implementing its *Water Action Plan* (WAP) to include progress on its potable water usage reduction. The University should participate in standard annual reporting of the following metrics, in addition to providing a detailed assessment of the Plan once every five years. The trends of the annually reported metrics should be compared to previous years to monitor campus growth and changes in potable water use in order to verify the success of campus reductions. This diligent monitoring will ensure that UCSB meets the reporting requirements outlined by the Office of the President and will guarantee that UCSB is well prepared to meet future potable water challenges.

The annual reporting and the Five Year Water Action Plan Assessment are to be completed by the UCSB Chancellor's Sustainability Committee (CSC) Change Agent Water Team. The CSC and Director of Facilities Management (FM) must then approve the annual progress reports and Five Year Water Action Plan Assessments.

Annual Reporting

Annual Campus water use reports should include total potable water use for UCSB in addition to the Weighted Campus User (WCU) metric for per capita water consumption and the California Adjusted Gross Square Footage (CAGSF) metric for spatial water use. Reporting for the WAP requires adjustments to the University standard WCU and CAGSF metrics (APPENDIX: V, VI). Water usage and corresponding water costs for both potable water and recycled water should be included.

Five-Year Water Action Plan *Assessment*

Every five years, the WAP should be reassessed and refined if needed—particularly the mentioned potable water conservation programs and practices. Evaluating the mitigation strategies will allow for the University to prioritize water conservation efforts based on the University's needs and the potable water challenges it faces at that time. During the Five-Year Water Action Plan Assessment, the University should explore additional water conservation programs and practices, conduct feasibility studies, and employ non-market valuation of water conservation strategies.

APPENDICES

APPENDIX I. Sustainable Practices Policy Section

Accepted by the System-wide Sustainability Committee 9/24/12

Section I – Acronyms

- **Adjusted Patient Day:** Inpatient Days x (Gross Patient Revenue/Inpatient Revenue) where Gross Patient Revenue is Outpatient Revenue + Newborn Revenue + Inpatient Revenue.
- **Domestic Water:** Potable and non-potable water provided for domestic indoor (e.g., toilets, urinals, showers, and faucets) and outdoor (e.g., landscape irrigation) use.
- **Gross Square Foot:** Pursuant to the definition in the Facilities Inventory Guide1, gross square footage is the Outside Gross Area, or OGSF50, and equals the sum of Basic Gross Area (the sum of all areas, finished and unfinished, on all floors of an enclosed structure, for all stories or areas which have floor surfaces) + 50% Covered Unenclosed Gross Area (the sum of all covered or roofed areas of a building located outside of the enclosed structure). OGSF50 is also known as "California Gross" or California Adjusted GSF. [47]
- **Industrial Water:** Water provided for specific industrial applications such as heating, cooling, or lubricating equipment.
- **Purified Water:** Water that is free of impurities such as microorganisms, particulate matter, and trace elements and chemical compounds responsible for electrical conductivity; primarily used in biological and engineering labs for research purposes.
- **Non-Potable Water:** Water not suitable for human consumption because it contains objectionable pollution, contamination minerals or infective agents, including:
- **Wastewater:** A blend of graywater and blackwater.
- **Graywater:** Wastewater originating from clothes washers, bathtubs, showers, bathroom sinks, or any other source that has a low likelihood of fecal contamination. Graywater may be treated or untreated prior to reuse.
- **Blackwater:** Wastewater originating from sources that have a high likelihood of fecal contamination (e.g., toilets)
- **Potable Water:** Water that meets state water quality standards for human consumption.
- **Reclaimed or Recycled Water:** Wastewater treated with the intention of reuse, including:
- Direct Potable Reuse: Treated wastewater reused for human consumption
- Indirect Potable Reuse: Treated wastewater blended with natural water sources reused as potable or non-potable water.

- Non-Potable Reuse: Treated wastewater reused for purposes other than human consumption, such as irrigation, fire suppression, and industrial processes.
- **Sterilized Water:** Water that has been cleaned to remove, deactivate, or kill microorganisms present that may be harmful to humans; primarily used in medical facilities.
- **Stormwater:** Water that originates during precipitation events.
- **Sustainable Water Systems:** Water systems or processes that maximize water use conservation or efficiency, optimize water resource management, protect resources in the context of the local watershed, and enhance economic, social and environmental sustainability while meeting operational objectives.
- **Weighted Campus User:** (1 × number of on-campus residents) + (0.75 × number of non-residential or commuter full-time students, faculty, and staff members) + (0.5 × number of non-residential or commuter part-time students, faculty, and staff members) as defined by Association for the Advancement of Sustainability in Higher Education (AASHE). When using Weighted Campus User state, whether fall-quarter/semester headcount, three quarter/two semester average headcount, or another measure was used in the Weighted Campus User calculation.
- **Watershed:** In the context of this policy, a watershed is the area of land that drains to a common waterway, such as a stream, lake, estuary, wetland, aquifer, bay, or ocean.

Section II – Policy Text

I. Sustainable Water Systems[3]

With the overall intent of achieving sustainable water systems and demonstrating leadership in the area of sustainable water systems, the University has set the following goals applicable to all campuses including medical centers:

1. In line with the State of California's law establishing a goal to reduce per capita potable water consumption by 20%[4], each campus will strive to reduce potable water consumption adjusted for population growth by 20% by the year 2020. This target will be re-evaluated and recommendations for adjustments will be made as necessary by the Sustainable Water Systems Working Group. Campuses that have already achieved this target are encouraged to set more stringent goals to further reduce campus potable water consumption.

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[3] Related sections: Green Building Design policy III.A. 5, Green Building Design procedure V.A.4, and Sustainable Purchasing procedures V.G.10.e, V.G.15, V.G.16, and V.G.17.

[4] 3 For more information on this goal, see http://www.swrcb.ca.gov/water_issues/hot_topics/20x2020/

2. Each campus will develop and maintain a *Water Action Plan* that identifies the campus' long term strategies for achieving sustainable water systems.

II. Procedures

1. Reporting Methods
    a. Explicitly identify the geographic and operational areas comprising the scope of campus water usage (e.g., the campus as defined by its Long Range Development Plan boundary, excluding third-party operated facilities).
    b. Campuses with medical centers may choose to report medical center data and progress toward the target separately from the main campus and may select a different baseline than the main campus.
    c. All campuses shall report water usage in a tabular format using the following methods:

2. **Measure per capita water consumption by Weighted Campus User (WCU) for main campuses and Adjusted Patient Day (APD) for medical centers. If necessary, WCU and APD may be combined using the following calculation: [(APD/360)* 1.5] + WCU;**

3. **Potable water usage for a baseline period selected by the campus that is three consecutive fiscal years between FY 1995/96 and FY 2010/11:**
    a. Total campus potable water usage, in gallons, for each of the three years comprising the baseline period,
    b. WCU, or APD, for each of the three years comprising the baseline period
    c. Baseline Potable Water Usage: calculate the baseline metric as follows: Step 1: Divide each years' total water use in gallons by that years' WCU or APD population. Step 2: Average the three gallons/population calculations to derive the Baseline Potable Water Usage for the campus,
    d. Multiply the Baseline Potable Water Usage figure by 0.80 to derive the campus 2020 Potable Water Usage Target, and
    e. Unless impracticable, provide average gallons of potable water usage per baseline year per gross square foot of campus built space for which potable water consumption is being reported, mirroring (c) above;

4. **Potable water usage for the most recent fiscal year[5]:**
    a. If using an average of the three most current fiscal years, which is allowed but not required, follow the method described above for deriving the baseline, but substitute the three most current fiscal years for the three baseline years,

[5] An average of the three most current fiscal years is allowed but not required.

b. If using only the most recent fiscal year, and not an average, list in the table the following:

    i. Total campus potable water usage, in gallons, for the most recent fiscal year,
    ii. WCU or APD for the most recent fiscal year,
    iii. Divide the gallons by the WCU or APD to derive the Current Potable Water Usage; and
    iv. If feasible, provide average gallons of potable water usage per gross square feet for either the three most current fiscal years, if that is the method adopted, or for the single most current fiscal year, again using the methodology described above;

5. Total campus non-potable water usage, in gallons, for the most recent fiscal year.

6. Report, or estimate if metered data is not available, water usage in the following use categories at a minimum: campus buildings, landscape, and central plant including cooling towers, identifying the quantities of potable and non-potable used for these purposes;

7. Reporting Schedule

a. Each campus will prepare a campus Water Action Plan as specified below and submit it to the Office of the President by December 2013. Each campus will share its draft plan with the Working Group by July 2013 in order to ensure collaboration on development of final plans.
b. Beginning the following year, each campus will provide an annual progress report on implementing its Water Action Plan to include progress on its water usage reduction.

8. Water Action Plans

a. Each campus' Water Action Plan and the water conservation and water efficiency strategies it contains will take into account relevant regional conditions and regulatory requirements, will recognize historical progress, and will acknowledge current campus best practices being implemented.
b. Each campus Water Action Plan will include a section on Water Usage and Reduction Strategies that:

    i. Describes the applicable types of water comprising campus water systems, including but not limited to potable water, non-potable water, industrial water, sterilized water, reclaimed water, stormwater, and wastewater;

ii. Reports water usage in accordance with the methods set forth in these procedures;

iii. Considers setting more stringent potable water reduction goals if the campus has already achieved a 20% below baseline reduction in per capital potable water consumption;

iv. Outlines campus-specific strategies for achieving the target for reduced potable water consumption;

v. Encourages implementation of innovative water-efficient technologies as part of campus capital projects and renovations (e.g., installation of WaterSense certified fixtures and appliances, graywater reuse, rainwater harvesting, and watershed restoration);

vi. Addresses campus use of non-potable water sources, and how those sources factor into the campus' overall sustainable water systems strategy;

vii. Analyzes the identified water use reduction strategies using a full cost approach by considering:

   a. Projected costs and savings of the identified water use strategies,
   b. Indirect costs and savings associated with reduced energy consumption due to the energy use embodied in water use,
   c. Savings associated with reduced or avoided infrastructure costs, and
   d. Other avoided costs; and

viii. Sets a timeline for the strategies being implemented to reach the water usage reduction target.

c. Each campus Water Action Plan will include a section on Stormwater Management developed in conjunction with the campus stormwater regulatory specialist that:

   i. Addresses campus stormwater management from a watershed perspective in a campus-wide, comprehensive way that recognizes stormwater as a resource and aims to protect and restore the integrity of the local watershed(s);

   ii. References the campus' best management practices for preventing stormwater pollution from activities on campus that have the potential to pollute the watershed (e.g., construction; trenching; storage of outdoor equipment, materials, and waste; landscaping maintenance; outdoor cleaning practices; vehicle parking);

iii. Encourages stormwater quality elements such as appropriate source control, site design (low impact development), and stormwater treatment measures to be considered during the planning stages of campus projects in order to most efficiently incorporate measures to protect stormwater quality;

iv. If feasible, cites relevant and current campus stormwater-related plans and permits in an appendix or reference list accompanying the Water Action Plan; and

v. Includes, to the extent feasible, full cost evaluation of stormwater management initiatives similar to the approach in the Water Usage and Reduction Strategies section above.

d. Each campus Water Action Plan will include a section on Education and Outreach that:

i. Presents potential opportunities for the campus to serve as a living laboratory for sustainable water projects;

ii. Supports the campus community (students, faculty, and staff) in efforts to implement sustainable water systems on campus;

iii. Identifies opportunities for pilot projects that illustrate the University's commitment to sustainable water practices through teaching, research, and service; and

iv. Identifies opportunities for new campus practices that could create behavior change across the campus population with regard to water use and watershed management.

APPENDIX II. Water & Energy Nexus for UCSB Water Sources

The embedded energy in water Goleta Water District (GWD) delivers to Goleta customers varies dramatically depending on the source.

- State Water:

It takes an estimated 2825 kilowatt-hours/Acre-foot (kWh/AF) to deliver state water to the end of the Coastal Branch, north of GWD's service area.[48] The water then has to be delivered to the Cachuma Reservoir through pipelines owned by the Central Coast Water Authority. This requires additional energy; due to lack of publically available information, calculating this additional energy was not feasible. It takes an estimated 44 kWh/AF to treat State water before it enters the local distribution systems and is mixed with Lake Cachuma water. This total energy intensity of state water delivered to GWD is 2870 kWh/AF, less the energy needed to transport water from the end of the Central Coast Branch to Lake Cachuma.[49]

- Ground Water:

GWD groundwater pumping data is not publically available; therefore the estimate for the energy intensity of groundwater is based on a fraction of GWD total reported energy use. In 2010 there was zero metered groundwater pumping by GWD. To get energy estimates for groundwater pumping for 2009, GWD average energy use for 2010 was subtracted from 2009.[50] It is estimated that GWD used 1,518,000 Kwh to pump ground water in 2009 at an average energy intensity of 762 kWh/AF.

- Recycled Water:

To get the estimated energy intensity of for recycled water, FY 2011/12 meter readings for the Goleta Sanitary Waste Water Plant were divided by the total treated recycled water for that year. The technical Services Supervisor for Goleta Sanitary District provided the following information used to calculate the energy Intensity of Recycled water as 760 kWh/AF: for FY 2011/12 the total energy use for Goleta Sanitary District was between 3,682,527 kWh and 3,731,650 kWh, of this 741,850 kWh was used for recycled water treatment. To get the energy used to treat water above discharge standards to recycled standards energy use in 2011/12 to treat recycled water was divided by the amount of recycled water produced in that year.

- Treatment and Distribution:

To get the total embedded energy per Acre-foot of the water Goleta Water District delivers, the energy required for treatment and distribution must be added to the energy intensity of supply and delivery. The sustainability plan for GWD reported its average energy consumption for 2010 to be 1,091,951 kWh.[51] In 2010 GWD didn't pump groundwater; assuming that this reported energy-use was just for treatment and delivery, an average treatment and delivery energy intensity of 73 kWh/AF was estimated.

APPENDIX III. Water Action Plan Acronyms & Water Glossary

Section I – Acronyms

1. **BMPs:** Best Management Practices
2. **GSF:** California-adjusted gross square footage*
3. **DWR:** California Department of Water Resources
4. **ESSB:** Education & Social Science Building
5. **EPA:** The Environmental Protection Agency
6. **FM:** Facilities Management
7. **FY:** Fiscal Year
8. **gpm:** Gallons per minute
9. **TGIF:** The Green Initiative Fund
10. **GHGs:** Greenhouse gases
11. **GWD:** Goleta Water District
12. **GSD:** Goleta Sanitary District
13. **HSSB:** Humanities & Social Science Building
14. **HETs:** High-efficiency toilets*
15. **H&RS:** Housing & Residential Services
16. **IRWMP:** Integrated Regional Water Management Program
17. **JACE:** Java Application Control Engine
18. **LabRATS:** Laboratory Research and Technical Staff
19. **LRDP:** The Long Range Development Plan
20. **MSRB:** Marine Science Resource Building
21. **PSB:** Physical Science Building
22. **PRSVs:** Pre-rinse spray valves
23. **RO:** Reverse osmosis
24. **SWP:** State Water Project
25. **the Campus:** UCSB Campus
26. **CSC:** UCSB Chancellor's Sustainability Committee
27. **UC:** University of California

28. **UCOP:** University of California, Office of the President
29. **UCSB:** the University: University of California, Santa Barbara
30. **WAP:** The Water Action Plan
31. **WCU:** Weighted campus user
32. **SJ:** San Joaquin Residential Hall
33. **SWP:** State Water Project
34. **SM:** Sierra Madre Family Apartments
35. **SAASB:** Student Affairs & Administrative Services Building

Section II – Keywords

36. **Adjusted Patient Day:** For hospitals, this is calculated as Inpatient Days x (Gross Patient Revenue/Inpatient Revenue) where Gross Patient Revenue is Outpatient Revenue + Newborn Revenue + Inpatient Revenue.
37. **Aerators:** Installed on faucets and showerheads, aerators prevent the flow of water from being one steady stream by spreading the stream into many droplets, thus reducing the amount of water dispensed every minute.
38. **Air-cooled ice machines:** Commercial ice machines that use air for chilling water into ice.
39. **Blowdown:** Water discharged from boilers and cooling towers to prevent the buildup of impurities.
40. **Boiler feed water:** Water supplied to boilers.
41. **California-adjusted Gross Square Footage (CAGSF):** Pursuant to the definition in the Facilities Inventory Guide1, gross square footage is the Outside Gross Area, or OGSF50, and equals the sum of Basic Gross Area (the sum of all areas, finished and unfinished, on all floors of an enclosed structure, for all stories or areas which have floor surfaces) + 50% Covered Unenclosed Gross Area (the sum of all covered or roofed areas of a building located outside of the enclosed structure). OGSF50 is also known as "California Gross" or California Adjusted GSF.[52]
42. **Central Water Database:** A database storing valuable water data including infrastructure information, upgrade schedules, and testing results.
43. **Change Agent Water Team:** A team comprised of UCSB students, faculty, and staff responsible for reporting water projects and updates to the Chancellor's Sustainability Committee.
44. **Chilled water loop:** A piping system connecting campus building cooling systems to a network of chillers and cooling towers.
45. **Commencement Green:** A large grassy open space on the UCSB Campus located directly

adjacent to the Campus Lagoon and the location of UCSB Graduation Ceremonies.

46. **Concentration cycles:** Relates to the number of cycles water in a cooling tower can circulate before the water must be disposed of due to the accumulation of impurities (see 'Blowdown').

47. **Connection-less/ boiler-less food steamers:** Boiler-less food steamers can be either completely unconnected to any water supply or can be connected to a water supply just to keep the water reservoir full. Connectionless food steamers have an individual reservoir where water is heated below the steam trays to create the steam.

48. **Cooling tower**: Devices that remove waste heat, often in the form of steam, to the atmosphere. At UCSB, cooling towers remove waste heat from the chillers (see 'Chilled water loop').

49. **Cooling tower make-up water:** Water used to replace cooling tower system losses from evaporation, drift, windage, and blowdown.

50. **Domestic Water:** Potable and non-potable water provided for domestic indoor (e.g., toilets, urinals, showers, and faucets) and outdoor (e.g., landscape irrigation) use.

51. **Dual-flush valve:** A toilet value that allows the user to choose between two flush options (typically 1.2 and 0.8 gallons per flush) based on what needs to be flushed.

52. **Dual plumb:** A structure that has two plumbing systems, typically, one for potable water and one for recycled water.

53. **Economic analysis:** A methodological approach to determine the relative rank of alternative actions based on their economic impacts. Involves setting assumptions and selecting discount rates and contingency values.

54. **EEM Central Database:** Used by UCSB, it is a software program that collects and stores utilities data.

55. **Effluent:** Discharge of water from some entity, either a body of water or man-made structure. Typically, effluent indicates a polluted discharge.

56. **Fiscal year:** Different from a calendar year, the fiscal year as used in this report runs from July 1st to June 30th.

57. **Five Year Water Action Plan Assessment:** Conducted by the Chancellor's Sustainability Committee Change Agent Water Team every five years, the assessment will ensure that the Water Action Plan goals remain relevant by exploring and adding additional conservation practices and programs to the Water Action Plan.

58. **Flow rate:** The time it takes for water to travel a given distance, represented by a unit of distance per a unit of time.

59. **Green Campus Interns:** Interns hired by UCSB and charged with providing support to sustainability efforts on campus.

60. **High-efficiency showerheads:** Showerheads that have a flow rate lower than the industry

standard, often achieved through the use of an aerator.

61. **HVAC**: A system providing heating, ventilation, and air conditioning services.
62. **Industrial Water:** Water provided for specific industrial applications such as heating, cooling, or lubricating equipment.
63. **LabRATS:** Laboratory Resources, Advocates, and Teamwork for Sustainability, a UCSB organization devoted to sustainability within on-campus research labs.
64. **Living laboratory:** Landscape or outdoor location at UCSB used for teaching purposes and encourages interaction students and landscape
65. **Lubrication water**: Water used to diminish friction in machinery in place of oil or grease
66. **Marginal supply:** The change in total supply that arises when the quantity produced changes by one
67. **Non-Potable Water:** Water not suitable for human consumption because it contains objectionable pollution, contamination minerals or infective agents, including:
68. **Wastewater:** A blend of graywater and blackwater.
69. **Graywater:** Wastewater originating from clothes washers, bathtubs, showers, bathroom sinks, or any other source that has a low likelihood of fecal contamination. Graywater may be treated or untreated prior to reuse.
70. **Blackwater:** Wastewater originating from sources that have a high likelihood of fecal contamination (e.g., toilets)
71. **Potable Water:** Water that meets state water quality standards for human consumption.
72. **Proposition 50:** Allocated $3.4 billion to fund a variety of California-focused water projects that include the CALFED Bay-Delta Program
73. **Proposition 84:** Provides funding for California safe drinking water, water quality and supply, food control, and other water conservation efforts
74. **Purified Water:** Water that is free of impurities such as microorganisms, particulate matter, and trace elements and chemical compounds responsible for electrical conductivity; primarily used in biological and engineering labs for research purposes.
75. **Real-time/ 'Smart' meters:** Meters capable of tracking and reporting live data
76. **Recycled Water:** Wastewater treated with the intention of reuse, including:
77. **Direct Potable Reuse:** Treated wastewater reused for human consumption
78. **Indirect Potable Reuse:** Treated wastewater blended with natural water sources reused as potable or non-potable water
79. **Non-Potable Reuse:** Treated wastewater reused for purposes other than human consumption,

such as irrigation, fire suppression, and industrial processes

80. **Residential Assistant**: Designated student responsible for supervising members of a residence hall
81. **Reverse osmosis:** Filtration method that uses membrane-technology to remove various types of molecules and ions
82. **SB X7-7:** California legislation mandating water conservation and efficiency programs, specially a 20% reduction in urban per capita water use statewide
83. **Sensor flush toilets:** Toilets/ urinals that flush as a result of motion from the user
84. **State Water:** Water that is provided through California's State Water Project, the world's largest publicly built and operated water conveyance system
85. **Sterilized Water:** Water that has been cleaned to remove, deactivate, or kill microorganisms present that may be harmful to humans; primarily used in medical facilities.
86. **Stormwater:** Water that originates during precipitation events.
87. **Sustainable Water Systems:** Water systems or processes that maximize water use conservation or efficiency, optimize water resource management, protect resources in the context of the local watershed, and enhance economic, social and environmental sustainability while meeting operational objectives.
88. **Sustainable Water System Policy:** Document developed by the UC Sustainable Water Systems Working Group that outlines requirements for reporting water usage
89. **Teaching species:** On-campus plant species that are used by UCSB's faculty in academic exercises
90. **Title 22:** California Code of Regulations that focuses on health and wellness. A major component of the Code are California's drinking water quality standards
91. **UC Sustainable Water Systems Working Group:** Composed of members from each of the ten University of California Campuses tasked with developing system-wide language for water conservation practices and implementing them on their respective campuses
92. **UCSB – Main Campus:** Location of the majority of UCSB's facilities, including administrative, academic, non-academic, laboratory, and residential buildings (422 acres)
93. **UCSB – West Campus:** Primarily consists of student family housing (273 acres)
94. **UCSB – North Campus:** Primarily consists of student family housing and athletic fields (174 acres)
95. **UCSB Chancellor's Sustainability Committee:** Responsible for advising the Chancellor and University administrators in matters of campus sustainability actions. Committee is compost of faculty, staff, and students

96. **UCSB Reads:** Annual event that unites the UCSB and Santa Barbra communities in a common reading experience and engage readers in stimulating dialogue about important issues.

97. **Water-energy nexus:** Relationship between how much energy is consumed in order to transport, clean, store, and dispose of water

98. **Waterless urinals:** Urinals that utilize a trap insert filled with a sealant liquid instead of water to dispose of liquid waste.

99. **Watershed:** In the context of this policy, a watershed is the area of land that drains to a common waterway, such as a stream, lake, estuary, wetland, aquifer, bay, or ocean.

100. **WaterSMART:** Water efficiency and conservation program from the U.S. Bureau of Reclamation

101. **Water competition:** Event that tracks building water usage for a given duration. Consumers of the least amount of water are often rewarded

102. **Water footprint:** Refers to a user's direct and indirect usage of potable water

103. **Water use baseline:** Three-year period representing historical water usage. Established in order to gauge water reductions; in this report, corresponding to the period 1996/7–1998/9.

104. **Water use benchmark:** Three-year time frame selected to represent current water usage; in this report, corresponding to the period 2008/9–2010/11.

105. **Weather-based Irrigation Controller:** Irrigation control system designed to irrigate based on local weather and soil conditions. Prevents overwatering

106. **Weighted Campus User (WCU):** (1 × number of on-campus residents) + (0.75 × number of non-residential or commuter full-time students, faculty, and staff members) + (0.5 × number of non-residential or commuter part-time students, faculty, and staff members) as defined by Association for the Advancement of Sustainability in Higher Education (AASHE). When using Weighted Campus User, state whether fall-quarter/semester headcount, three quarter/two semester average headcount, or another measure was used in the Weighted Campus User calculation.

107. **Xeriscaping:** A method of landscaping that reduces or eliminates the need for supplemental irrigation.

APPENDIX IV. Methodology for Baseline Calculation & Selection

The FY 1996/97-1998/99 comprise the three-year consecutive time period chosen for The University's baseline years. The Baseline was calculated by taking the average annual potable water use during the FY 1996/97-1998/99 baseline period. Monthly and yearly water use was aggregated using meter readings from UCSB utilities archives. These archives served as the primary data source for the creation of the baseline metrics. The baseline was selected for data availability as viable data on UCSB's potable and recycled water use is available from year 1996 and onwards.

APPENDIX V. Weighted Campus User (WCU)

"*Weighted Campus User* is used to normalize resource consumption and environmental impact figures in order to accommodate the varied impacts of different population groups. For example, an institution where a high percentage of students live on campus would witness higher greenhouse gas emissions, waste generation, and water consumption figures than otherwise comparable non-residential institution since the students' residential impacts and consumption would be included in the institution's totals."[53]

1. To calculate WCU, campus population is first standardized by converting students, faculty, and staff into 'Full Time Equivalents:'
    a. "Full time equivalence is calculated by weighting the student based on annual credits they are enrolled in. They are weighted based by multiplying each student by Units Enrolled in/ Units required for Full time. Staff is weighted similarly, for example quarter time employees would be weighted 25%."[54]
1. Next, WCU is calculated using a standardized equation put forth by AASHE-STARS:
    a. Weighted Campus Users = (1 × number of on-campus residents) + (0.75 × number of non-residential or commuter full-time students, faculty, and staff members) + (0.5 × number of non-residential or commuter part-time students, faculty, and staff members).

**The* Water Action Plan *uses WCU as its population metric less students' living/studying abroad (Figure 15).*

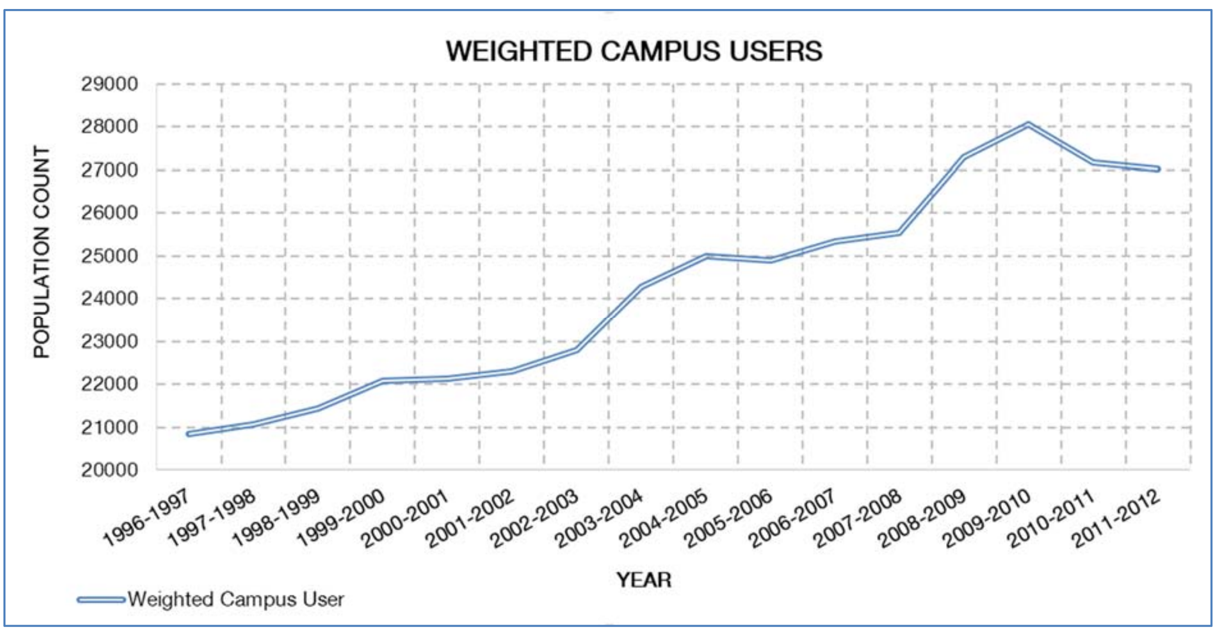


Figure 15: UCSB Weighted Campus Users from FY 1996/97-2011/12

APPENDIX VI. California Adjusted Gross Square Footage (CAGSF)

The primary spatial metric used within the *Water Action Plan* is 'Outside Gross Area' (OGSF50), otherwise known as California Adjusted Gross Square Footage (CAGSF). CAGSF equals the sum of Basic Gross Area (the total of all areas, finished and unfinished, on all floors of an enclosed structure, for all stories or areas which have floor surfaces) plus 50% of Covered Unenclosed Gross Area (the total of all covered or roofed areas of a building located outside of the enclosed structure). UCSB OSGSF50 numbers for FY 1996/97 to 2011/12 were retrieved from the UCSB Office of Budget and Planning (Figure 16).

*To align with the weighted campus user population scope, the *Water Action Plan* uses CAGSF, but omitting satellite campuses (e.g., UCSB Ventura) and Natural Reserve properties and infrastructures.

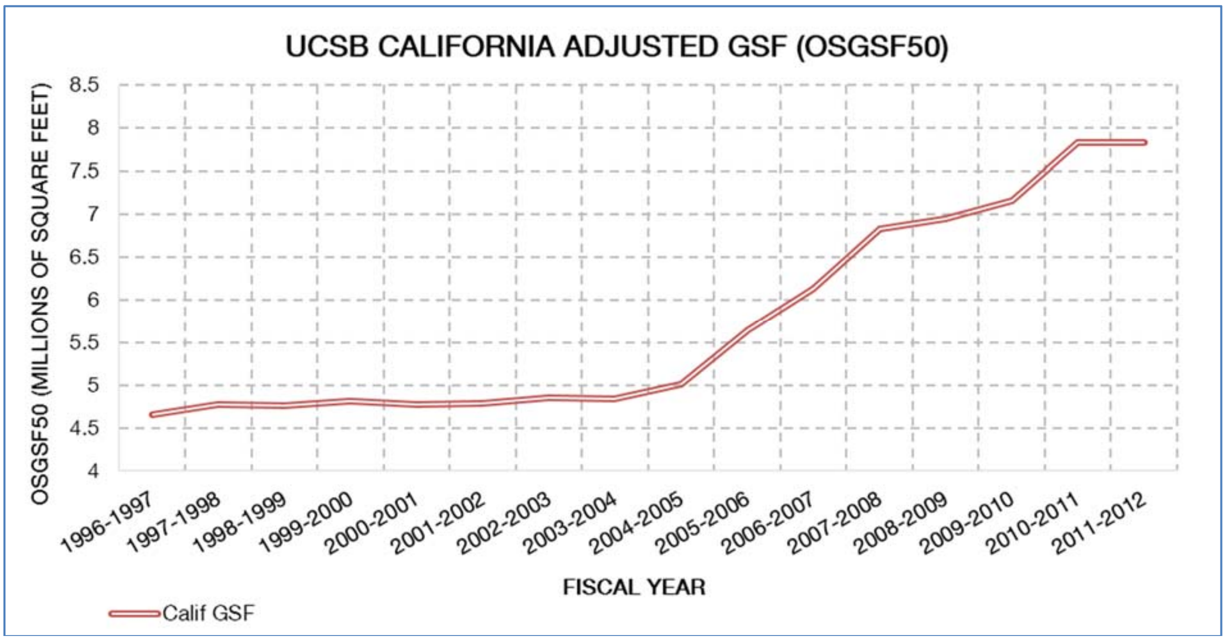


Figure 16: UCSB OSGSF50 from FY 1996/97-2011/12

APPENDIX VII. Rationale for Benchmark Selection

- Tentative three-year time frames considered for benchmarking were calculated by averaging three-consecutive fiscal years for water use. Potential benchmarks were narrowed down in a process of elimination down to FY 2007/08-2009/10 or FY 2008/09-2010/11 for the following reasons (Table 23):
    - UCSB California Adjusted Gross Square Footage has increased steadily since 2003 (concurrent with the green building initiative) with a small plateau in 2007. The upward trajectory will need to be considered in conservation efforts, and as such the benchmark should be after 2003 (APPENDIX: VI).
    - By 2006, most major additions to the chilled water loop were in place; chilled water loop expansions accounts for water savings because individual cooling towers (and associated water costs) are removed and replaced by chilled water loop water at no additional water cost (see "Industrial Water Use"). The benchmark should come after 2006 to push UCSB to look for other major water-savings investments.
    - During 2006, recycled water use rose for two consecutive years and continues to stay above 2002-2006 usage to present day. This increased use of recycled water indicates a continual transition from potable to recycled water for irrigation purposes. Although the increase in recycled water does not necessarily help lower overall water-use, the transition marks a shift towards decreased potable water-use. The benchmark should therefore come after this marked move in the direction of increased recycled irrigation in favor of conserving potable water.
    - The UCSB population continues to slowly grow and will be held at an approximate annual increase of 1%; a recent benchmark will encourage conservation measures to address the challenges of steadily increasing populations (APPENDIX: V).[55]

- After considering the above temporal restrictions, the only available benchmarking time periods were 2007/08 to 2009/10 and 2008/09 to 2010/11. 2007/08 to 2009/10 was then eliminated for climate reasons and 2008/09 to 2010/11 was ultimately selected.
    - Goleta's climate history: 2006/07 was one of the top five driest years on record in Goleta. A dry year coincides with increased water use (unless there are substantial drought/conservation measures); when averaged into the benchmark, a dry year's increased water-use may make further reductions seem easy, when realistically reductions may be a reflection of a return to an average precipitation year. Contrarily, 2010/11 is among the top five wettest years for several surrounding cities (although not for Goleta). This extra wet year shows a decrease in water consumption making the 2008/09 to 2010/11 period a conservative benchmark. UCSB is apt to use less water in wetter years, which will challenge the University to make real reductions when comparing conservation efforts of the future to the benchmark. Similarly, the original baseline comes from a wetter than average series of three years (Table 24).

Table 23: Average annual water use in gallons for UCSB's 3-year Baseline period and two potential Benchmark periods

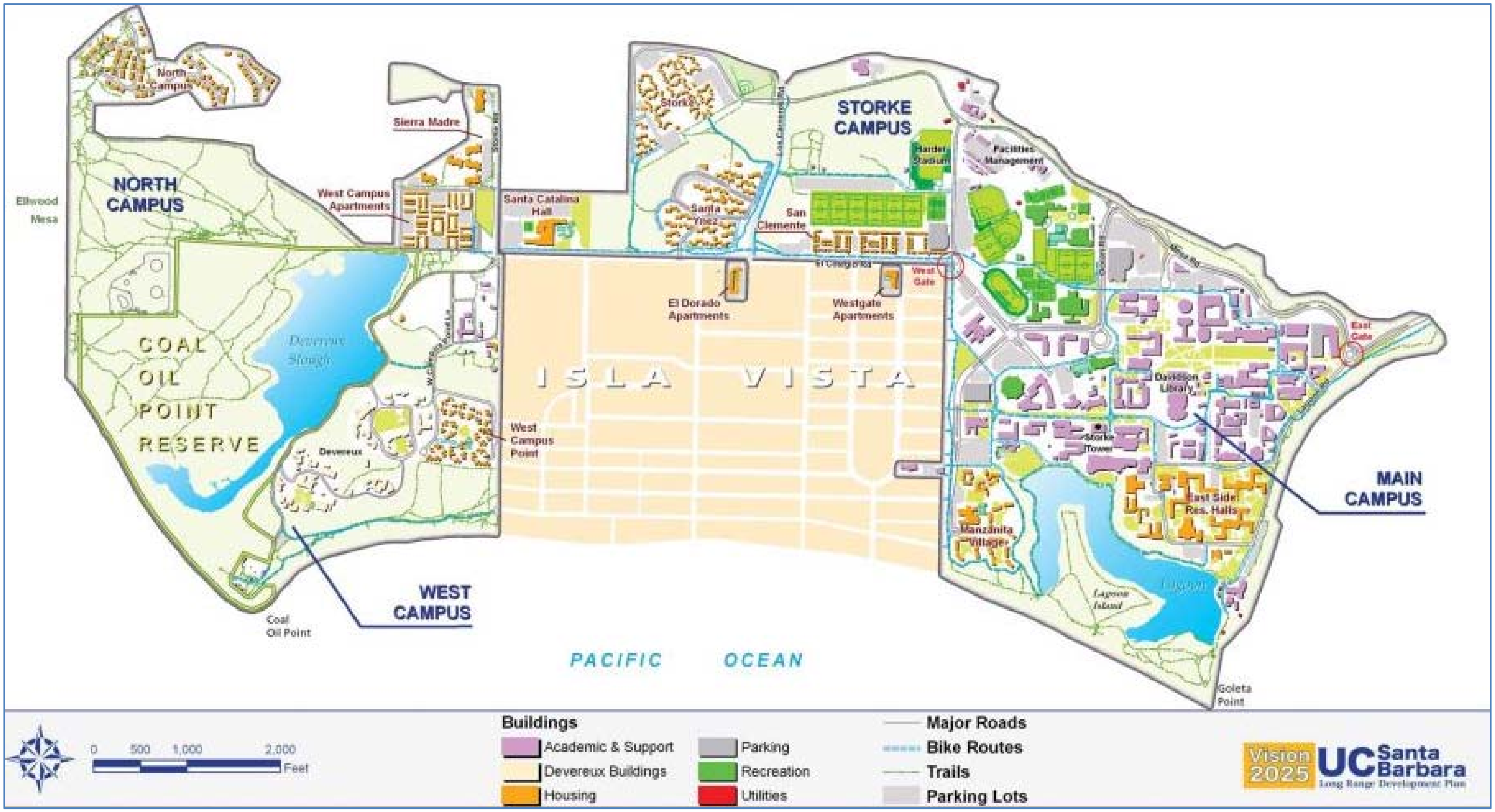
FISICAL YEAR RANGE	TOTAL (GALLONS)	POTABLE (GALLONS)	RECYCLED (GALLONS)
1996/97-98/99	337,259,723	292,717,216	44,542,507
2007/08-09/10	298,064,062	222,126,311	75,509,865
2008/09-10/11	290,558,358	216,224,430	72,023,943

Table 24: Long-term average annual rainfall in Goleta, CA and three-year annual averages for the Benchmark and potential Baseline periods

FISCAL YEAR AVERAGE	ANNUAL RAINFALL (INCHES)	TOTAL THREE-YEAR RAINFALL (INCHES)
1996/97-98/99	25.65	76.95
2007/08-09/10	16.86	50.57
2008/09-10/11	21.49	64.48
LONG TERM AVERAGE	17.89	53.67

APPENDIX VIII. Maps

Figure 17: UCSB LRDP Figure B.9. existing built environment*; Academic, Research, & Other Non-Residential Buildings* include Academic & Support and Recreation buidings; *Housing & Residential Services* includes orange buidings.



APPENDIX IX. Water & Cost Savings From Restroom Fixture Retrofits

ACADEMIC BUILDINGS

Toilets:

To calculate the amount of water saved from utilizing low-flow toilets, the following assumptions were made:

Facts & Assumptions

- Thirty-one toilets were tested for in-situ flow rates across the UCSB academic, research, and non-residential buildings (see APPENDIX: XI, XIX)
- Toilets were categorized as either old (located in a building built prior to 2002) or new/retrofitted (located in a building built post 2002 or retrofitted since 2002)
- The difference in flow rates between old and new/retrofitted buildings proved to be statistically significant ($p<0.05$)
- The following calculations are based on 2011-2012 fiscal year dollars, Weighted Campus User populations, and UCSB restroom audit data

Toilet water savings, cost savings, and retrofit cost estimates based on an extrapolation of in-situ test results:

1. Average flow rates were determined for all academic, research, and non-residential buildings; extrapolations were based on whether or not the building was old or new/retrofitted
2. A cross-campus average flush of 3.66 gpf was calculated by finding the average of all buildings weighted by number of toilets per building (Caveat: building traffic was not considered)
3. Toilet water use (total users*flushes/day) was estimated based on Weighted Campus User (WCU) populations (the standard UC per capita metric), male-female breakdowns, and number of flushes per day on average for men (0.5) and women (3) at work/school[56]
4. The average daily toilet water use was determined by multiplying the average campus toilet flow rate by total toilet use per day (see 'step 6')
5. To determine annual use, daily values were multiplied by 200 days to account for 150 days of instruction in a standard 3-quarter year plus 50 days to approximate additional usage during finals periods and summer sessions
6. To calculate potential retrofit water savings, current toilet use numbers were compared to what consumption would surmount to if all toilets were flushing at 1.6 gpf (this water savings estimate is conservative because dual-flush toilets can yield average flush rates as low as 1.22 gpf)[57]
7. Water cost savings were calculated to be roughly $92,900/year by multiplying the potential

retrofit water savings by the current UCSB contracted water cost rate between Goleta Water District and UCSB ($3.71/HCF, $0.00496/gal)

8. Retrofit costs were calculated to be roughly $80,400 by multiplying the number of toilets to be retrofitted (~930) (i.e. those estimated to be flowing over 1.6 gpf by $50 per each dual flush retrofit kit; to this number, installation costs were added, valuing the UCSB's plumber rate at 50$/hr and estimating installation to take ½ hour per toilet. Finally, a 15% contingency fee was added to the total

Faucets:

To calculate the amount of water saved from aerators on faucets the following assumptions were made:

Facts & Assumptions

- A standard EPA aerator water savings estimate was employed to estimate water savings from an aerator retrofit:
    a. EPA aerator water savings estimate: "Assuming that each building occupant washes his or her hands for 10 seconds four times per day and 250 days per year, the annual savings potential per occupant in changing from 2.2 gpm faucets to 0.5 gpm faucets would be 283 gal/yr"[58]
- The following calculations are based on 2011-2012 fiscal year dollars, Weighted Campus User populations, and UCSB restroom audit data

Aerator water savings, cost savings, and retrofit cost estimates based on an extrapolation of in-situ test results:

1. Applying the above EPA calculation to the 2.01 average flow rates on campus (91.4% of the standard EPA 2.2 gpm) and adjusting building-use to 200 days/year (see 'Toilets' step '8'), estimated annual savings would be over 4,698,000 gal/yr (APPENDIX: XI, XVIII). (Caveat: faucets are assumed to be used equally, holding constant the average flow rate derived from campus audits; buildings were not weighted by restroom use frequency)
2. Water cost savings were calculated to be roughly $23,300 by multiplying the potential retrofit water savings by the current UCSB contracted water cost rate between Goleta Water District and UCSB ($3.71/HCF, $0.00496/gal)
3. Retrofit costs were calculated to be roughly $9,000 by multiplying the number of aerators to be replaced (~840) (i.e. those shown to be flowing over .5 gpm) by $6 per each tamper proof aerator (this is a conservative cost estimate because wholesale prices will likely be lower than $6/aerator); to this number, installation costs were added, valuing the UCSB's plumber salary rate at 50$/hr and estimating installation to take ¼ hour per aerator. Finally, a 15% contingency fee was added to the total

Urinals:

To calculate the amount of water saved from low-flow and waterless urinals the following assumptions were made:

Facts & Assumptions

- Urinals were audited and categorized as waterless (137 urinals), <0.25 gpf (1 urinal), or >0.25 gpf (251 urinals) (see APPENDIX: XI, XIX)
- An weighted average flow rate of 0.65 gpf was estimated for all academic, research, and non-residential buildings by assuming flows of 1.0 gpf for urinals that were neither waterless nor < .25 gpf; 1.0 gpf was selected based on industry standards (Caveats: building traffic was not considered, and no in-situ testing was performed to verify that urinals were flowing as specified by manufacturers)
- The following calculations are based on 2011-2012 fiscal year dollars, Weighted Campus User populations, and UCSB restroom audit data

Urinal water savings, cost savings, and retrofit cost estimates based on an extrapolation of in-situ test results:

1. Urinal water use (total users*flushes/day) was estimated based on 2011-2012 Weighted Campus User (WCU) populations (the standard UC per capita metric), male student and staff breakdowns, and number of urinal flushes per day on average for men (2.5) at work/school[59]
2. The average daily use was determined by multiplying the average campus urinal flow rate by total urinal use per day (See Step 1)
3. To determine annual use, daily values were multiplied by 200 days to account for 150 days of instruction in a standard 3-quarter year plus 50 days to approximate additional usage during finals periods and summer sessions
4. To calculate potential retrofit water savings, current urinal use numbers were compared to what consumption would surmount to if all urinals flushing above 0.25 gpf were flushing at 0.25 gpf or 0.0 gpf (waterless) respectively
5. Water cost savings for each scenario were calculated to be roughly $15,700 and $20,800/year by multiplying the respective retrofit water savings by the current UCSB contracted water cost rate between Goleta Water District and UCSB ($3.71/HCF, $0.00496/gal)
6. Retrofit costs were calculated to be roughly $216,500 by multiplying the number of urinals to be retrofitted (~251) (i.e. those estimated to be flowing over 0.25 gpf by an estimate of $600 per each retrofit, including the urinal, and plumbing/tile work; this to this number, installation costs were added, valuing the UCSB's plumber rate at 50$/hr and estimating installation to take 3 hours per urinal.[60,61] Finally, a 15% contingency fee was added to the total

7. To determine the payback period, annual water cost savings (increasing by 4% each year based on water cost increases) were discounted back to 2012 dollars using a 5% discount rate

Housing & Residential Services (H&RS)

Toilets:

To calculate the amount of water saved from switching all H&RS toilets to dual flush the following assumptions were made:

Facts & Assumptions

- Calculations were made assuming that all non-dual flush toilets flush at the U.S. maximum standard 1.6 gpf. They were then made assuming that all non-dual flush toilets flush at 3.5 gpf
- Students spend an average of 250 days a year in student housing
- Dual flush average flow rate will be 1.06 gpf because for every 1 full flush (1.6 gpf), students will use a half flush twice (0.8 gpf).
- There are 7576 students living in campus housing
- The average student flushes the toilet 6.8 times a day. The EPA's Water Sense program assumes that the average household flushes the toilet 6.8 times a day
- 43% of the toilets within H&RS are dual flush, this number was based off of our audits
- The following calculations for showerhead retrofits are based on 2011-2012 fiscal year dollars, Weighted Campus User populations, and UCSB restroom audit data

Toilet water savings, cost savings, and retrofit cost estimates based on an extrapolation of in-situ test results:

1. Water savings from previous toilet retrofits is estimated at 2.95 million gallons. To estimate this the following equation was used: (6.8*7576*250*1.6) - [(6.8*7576*250*1.6)*0.57)+((6.8*7576*250*1.0666)*0.43)]
2. When a baseline flow rate of 1.6 gpf is used, water savings are estimated at 13.7 million gallons annually if all toilets were switched to dual flush. The following equation was used to make this estimate: [(6.8*7576*250*1.6)*0.57)+((6.8*7576*250*1.0666)*0.43)] -(6.8*250*7576)*1.0666
3. When a baseline flow rate of 3.5 gpf is used water savings are estimated at 17.8 million gallons annually if all toilets were switched to dual flush The following equation was used to make this estimate: [(6.8*7576*250*3.5)*0.57)+((6.8*7576*250*1.0666)*0.43)] -(6.8*250*7576)*1.0666
4. When flow of non-dual flush toilets was assumed to be 1.6 gpf water cost savings were calculated to be roughly $19,400 /year by multiplying the potential retrofit water savings by the current UCSB contracted water cost rate between Goleta Water District and UCSB ($3.71/HCF, $0.00496/gal)

5. When flow of non-dual flush toilets was assumed to be 3.5 gpf water cost savings were calculated to be roughly $88,597/year
6. Retrofit costs were calculated to be roughly $80,126 by multiplying the number of toilets to be retrofitted (~929) (i.e. those estimated to not have dual flush valves) by $50 per each dual flush retrofit kit; to this number, installation costs were added, valuing the UCSB's plumber rate at 50$/hr. and estimating installation to take ½ hour per toilet. Finally, a 15% contingency fee was added to the total. A water rate increase of 4% annual and a discount rate of 5% was used to determine payback periods

Faucets:

To calculate the amount of water saved from switching to 0.5 gpm aerators the following assumptions were made:

Facts & Assumptions

- Each building occupant washes his or her hands for 10 seconds 6.8 times per day, 250 days per year
- There are 7576 students living in campus housing
- 90% of the faucets within housing and residential services already have 0.5 gpm aerators
- The remaining 10% of faucets have 2.2 gpm aerators, this is the national minimum requirement
- The following calculations for showerhead retrofits are based on 2011-2012 fiscal year dollars, Weighted Campus User populations, and UCSB restroom audit data

Aerator water savings, cost savings, and retrofit cost estimates based on an extrapolation of in-situ test results:

1. Historical water savings from 0.5gpm aerator for 90% of housing and residential services was calculated at 3.3 million gallons annually using the following equation: ((10/60)*2.2*6.8*7576*250) - [(10/60)*2.2*6.8*7576*250)*0.10) + (10/60)*0.5*6.8*7576*250)*0.90)]
2. Future water savings from retrofitting the remaining 10% of aerators is estimated at 364,900 gallons annually using the following equation: [(10/60)*2.2*6.8*7576*250)*0.10) + (10/60)*0.5*6.8*7576*250)*0.90)] – (10/60)*0.5*6.8*7576*250)
3. Water cost savings were calculated to be roughly $1,810/year by multiplying the potential retrofit water savings by the current UCSB contracted water cost rate between Goleta Water District and UCSB ($3.71/HCF, $0.00496/gal)
4. Retrofit costs were calculated to be roughly $1,164 by multiplying the number of aerators to be replaced (243) (i.e. those shown to be flowing over .5 gpm) by $6 per each tamper proof aerator (this is a conservative cost estimate because wholesale price will likely be lower than $6/aerator); to this number, installation costs were added, valuing the UCSB's plumber salary

rate at 50$/hr and estimating installation to take 5 min per aerator. Finally, a 15% contingency fee was added to the total

Showers:

To calculate the amount of water saved from showerhead retrofits the following assumptions were made:

Facts & Assumptions

- Based on Survey results the average shower time is 8 minutes
- Each student living in campus housing showers on campus 250 days a year
- There are 7567 students living in campus housing
- 43% of showers have 2.5 gpm showerheads and 57% have 1.5 gpm showerheads
- Average gpm for an adjustable showerhead will be 1.0 gpm
- The following calculations for showerhead retrofits are based on 2011-2012 fiscal year dollars, Weighted Campus User populations, and UCSB restroom audit data

Shower water savings, cost savings, and retrofit cost estimates based on an extrapolation of in-situ test results:

1. Historical water savings from retrofitting 57% of showers with 1.5 gpm showerheads was estimated at 8,626,380 gallons annually using the following calculation: (8*2.5*250*7567) – [(8*2.5*250*7567)*0.43)+(8*1.5*250*7567)*0.57)]
2. Water cost savings of switching all 2.5 gpm showerheads to 1.5 gpm were calculated to be roughly $32,200/year by multiplying the potential retrofit water savings by the current UCSB contracted water cost rate between Goleta Water District and UCSB ($3.71/HCF, $0.00496/gal)
3. Water cost savings of switching 2.5 gpm showerheads to an adjustable showerhead was calculated to be roughly $47,100/year using the same method
4. Water cost savings of switching all showerheads to an adjustable showerhead was calculated to be roughly $69,400/year also using the same method
5. Retrofit costs were calculated by multiplying the number of showerheads to be replaced (851 and 1979 if all showerheads were replaced) (i.e. those shown to be flowing over 1.5 gpm) by $8.29 and $15.5 for per each showered (this is a conservative cost estimate because wholesale price will likely be lower than $8.29 and $15.5/ showerhead); to this number, installation costs were added, valuing the UCSB's plumber salary rate at $50/hr and estimating installation rate of 15 per hour. Finally, a 15% contingency fee was added to the total. An annual water rate increase of 4% and a discount rate of 5% was used to determine payback periods. Using this method the resulting costs were estimated at roughly $2,800, $50,600, $117,400

6. Water savings calculation:

    a. Switching the remaining 2.5 gpm showerheads to 1.5 gpm = 8*((2.5-1.5)*.43)*250*7567= 6.5 million gallons

    b. Switching all 2.5 gpm showerheads to an adjustable showerhead with three settings 1.5, 1.0, 0.5 gpm = 8*((2.5-1.0)*.43)*250*7567= 9.55 million gallons

    c. Switching all showerheads to an adjustable showerhead with three settings 1.5, 1.0, 0.5 gpm. = (8*((2.5-1.0)*0.43) + (1.5-1.0)*0.57))*250*7567= 14 million gallons

Dining Commons Equipment:

Dishwasher water savings, cost savings, and replacement cost estimates were made based on GPH, current prices and the following assumptions:

Facts & Assumptions

- It was assumed that dishwashers run for three hours three times a day[62]
- It was assumed all dining common dishwashers operate at the same use rate for 300 days a year. In 2012-13 there were 13 campus closure days for holidays however 352 days wasn't used because during the breaks between quarters there is a decrease in operation hours for the dishwashers
- The following calculations are based on 2011-2012 fiscal year dollars, Weighted Campus User populations, and UCSB restroom audit data

Dishwasher water savings, cost savings, and retrofit cost estimates based on an extrapolation of in-situ test results:

1. The Price of seven energy star dishwashers was averaged to get the cost of replacement (Table 25). A 15% contingency fee was added to the average cost to get a total cost of $34,788
2. The GPH of four energy star dishwashers was averaged and used to get a total annual water use of 260,550 gallons if the current dishwashers were replaced with energy star dishwashers. (Table 26)
3. To get water savings estimated annual water use of an energy star dishwasher was subtracted from the dishwashers estimated current annual water use.
4. Water cost savings was calculated by multiplying the estimated water savings for each dishwasher by the current UCSB contracted water cost rate between Goleta Water District and UCSB ($3.71/HCF, $0.00496/gal)
5. To calculate payback periods a 15% contingency fee was added to the total cost of the dishwasher and a 4% annual increase in water rates was assumed. Benefits were discounted at a rate of 5%. Water savings, water cost savings, and payback periods are listed in Table 27

Table 25: Average price of energy star dishwashers

Energy Star dishwasher	$
Hobart CLPS86ER	49,250
Hobart CLPS86E	39,655
Hobart CL54E	22,024
Champion 44DR	15,855
Champion 64	31,237
Champion 66DR	23,430
Average	30,242

Table 26: Average GPH of four energy star rated dishwashers

Energy Star dishwasher	GPH
Hobart FT900D	90
Champion 44DR	112
Champion 66DR	112
Hobart FT900SD	72
Average	96.5

Table 27: Dishwasher calculations

Dining Commons	Dishwasher	Water use per hour at 20 PSI	Average annual water use	Energy Star dishwasher: Average annual savings (Gal)	Annual Water Cost Savings	Pay Back Period (cost 2012 $)
Portola	Champion washer (Model #UC-CW6-3T)	426	1,150,200	889,600	4,400	<9 years (34,800)
De la Guerra	Hobart FT900 Flight-Type dishwasher	198	534,600	274,000	1,350	<31 years (34,800)
Ortega	Stero machine, model # SCT-94SM	277	747,900	487,300	2,410	<16 years (34,800)
Carrillo	Stero Co. Model # STPCW-22	336	907,200	646,600	3,200	<12 years (34,800)

APPENDIX X. Water Use Calculations & Methodology

Total Reductions

Monthly water use data was collected and aggregated from campus utilities bills starting in FY 1996/97 up until FY 2011/12. These utilities bills cover all water use on campus except for student housing off of the main campus (see 'Scope of UCSB WAP: Geographic Scope'). The Manager of Environmental & Energy Programs for Housing and Residential Services provided total water use for student housing off of main campus from FY 1996/97 until 2011/12. To get the total water and potable water reductions of 74 Mgal/yr, the average water use during the benchmark period was subtracted from average water use during the baseline (APPENDIX: IV). To get a 25% reduction in potable water use from the baseline to the benchmark period was used the following formula: (Baseline water use - Benchmark water use)/(baseline water use). To adjust potable water use by population growth we divided potable water use during the Benchmark period by the Universities Weighted Campus User averaged over the three-year baseline period (APPENDIX: V). The same was done for the Benchmark period to get a reduction of 43% in potable water use (gal) per WCU. To get gallons of potable water use per California-Adjusted Gross Square Footage (CAGSF) the same methodology was used, the average potable water use over the three year period was just divided by the average CAGSF over that same period to get a 52% reduction in potable water per CAGSF.

Sector water use breakdown

To break out water use by sector, total use, potable water use, recycled water use, and water use billed to recharge accounts was recorded for each month from the Campus utilities bills. The recharge account consists of all non-state funded buildings, which are responsible for paying their own utilities since they aren't funded by the state. Because of this, water use for all non-state funded buildings is recorded and billed on each utilities bill. The recharge account is broken down into three categories: H&RS, research buildings, and 'other buildings' (Event Center, Rec Center, Faculty Club, and The University Center). This data was aggregated by month and year to get the breakdown of total water use for the following sectors: Academic, Non-Academic, State and non-State Funded, H&RS, and Irrigation (Table 28, 29). For industrial water, only one year of metered data was available. Potable water use for industrial was estimated by Facilities Management using metered data for FY 2010/11 to be 14%. All industrial water on-campus is used for non-residential buildings.

Table 28: Total water use by sector break down in gallons (State vs. Non-State funded)

Year	State (gal)	Non-State (Minus H&RS) (gal)	H&RS (gal)	Total water (gal)	Estimated Irrigation (gal)
1996-1997	260,325,006	10,409,016	91,429,309	362,163,332	87,053,305
1997-1998	225,383,437	10,828,793	83,105,735	319,317,965	61,464,939
1998-1999	240,740,616	11,322,156	78,235,101	330,297,872	74,194,291
1999-2000	201,902,234	9,438,759	74,111,909	285,452,903	96,974,968
2000-2001	177,700,875	10,093,466	87,794,375	275,588,715	66,849,667
2001-2002	164,920,780	10,427,845	99,826,043	275,174,668	68,971,280
2002-2003	141,960,072	16,870,817	121,313,089	280,143,978	58,171,985
2003-2004	166,056,323	11,167,092	106,623,420	283,846,835	71,038,082
2004-2005	149,470,514	13,389,198	131,748,599	294,608,311	59,420,397
2005-2006	122,634,258	29,436,967	99,236,096	251,307,321	59,509,924
2006-2007	173,252,755	23,490,158	97,946,937	294,689,849	76,650,034
2007-2008	130,290,062	66,590,492	94,081,004	290,961,558	74,164,722
2008-2009	189,276,074	17,617,156	120,291,250	327,184,480	104,175,401
2009-2010	134,493,866	25,761,314	115,790,969	276,046,149	58,564,075
2010-2011	147,226,004	26,616,045	94,602,396	268,444,445	57,741,981
2011-2012	125,165,186	28,942,503	127,456,092	281,563,781	59,433,495

Table 29: Total water use by sector break down gallons (academic, research, and other non-residential buildings)

Year	Academic/Research	Other	H&RS	State	Estimated Irrigation
1996-1997	172,070,023	1,480,208	91,429,309	260,325,006	87,053,305
1997-1998	149,842,871	1,739,288	83,105,735	225,383,437	61,464,939
1998-1999	159,416,923	2,608,427	78,235,101	240,740,616	74,194,291
1999-2000	131,548,765	5,494,524	74,111,909	201,902,234	96,974,968
2000-2001	115,826,980	6,549,195	87,794,375	177,700,875	66,849,667
2001-2002	108,461,394	5,629,091	99,826,043	164,920,780	68,971,280
2002-2003	98,113,958	5,302,941	121,313,089	141,960,072	58,171,985
2003-2004	109,858,372	5,317,902	106,623,420	166,056,323	71,038,082
2004-2005	100,223,484	6,030,795	131,748,599	149,470,514	59,420,397
2005-2006	86,101,566	17,340,175	99,236,096	122,634,258	59,509,924
2006-2007	115,699,101	15,697,871	97,946,937	173,252,755	76,650,034
2007-2008	89,461,695	56,891,599	94,081,004	130,290,062	74,164,722
2008-2009	123,145,717	14,195,783	120,291,250	189,276,074	104,175,401
2009-2010	89,392,856	20,373,944	115,790,969	134,493,866	58,564,075

Academic (Academic water use includes all state funded buildings plus research buildings (MSRB, CNSI, MRL, ITP))

Academic water use was calculated by aggregating water use for state funded buildings with the water use for research buildings from the recharge account.

Non-Academic (includes Hollister, University House, Faculty Club, & The University Center)

Non-Academic water use was calculated by aggregating all the water use for all the buildings listed above from the recharge account (Figure 18).

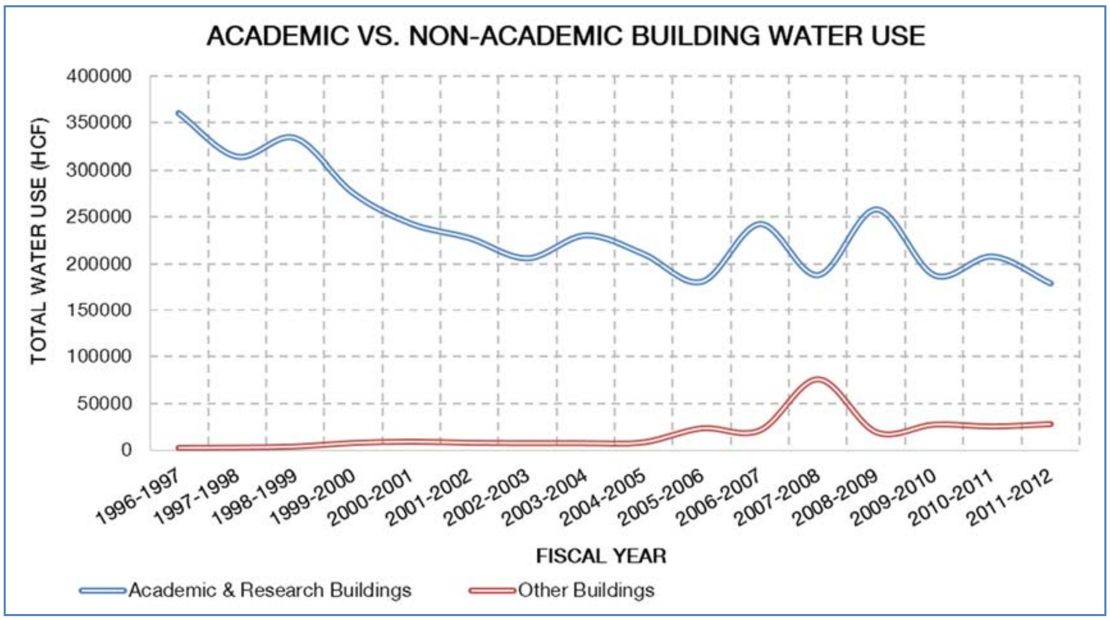


Figure 18: Academic, research, and other non-residential building total water use (recycled and potable) broken down by academic and non-academic buildings; FY 1996/97-2011/12.

State & Non-State Funded

For state funded buildings water use was calculated by subtracting the amount of water used by the recharge accounts from the total water bill for each month. Non-state funded buildings water use was calculated by subtracting H&RS water use from the total water billed for the recharge account during each month (Figure 19).

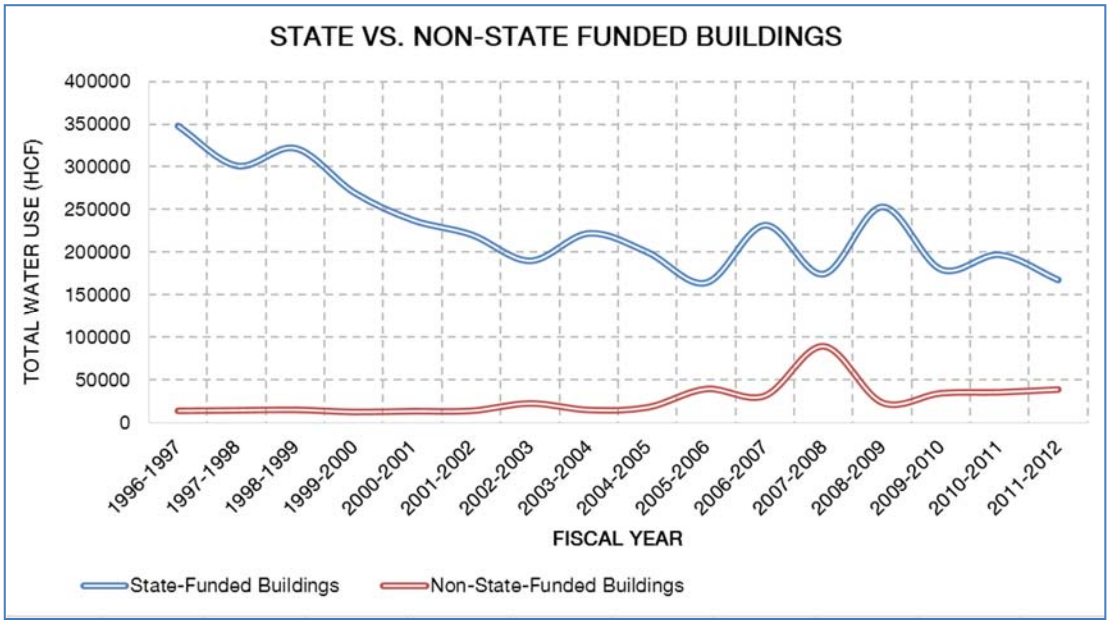


Figure 19: Academic, research, and other non-residential building total water use (recycled and potable) broken down by state-funded vs. non-state funded buildings; FY 1996/97-2011/12.

Housing & Residential Services (H&RS) (includes all Campus residential facilities and their irrigation, the dining commons, plus El Dorado and Westgate Apartments)

To get water use for H&RS, data for water use in student housing off campus was combined with H&RS water use billed through the recharge account for main campus.

Irrigation & Landscaping

As of 2011/12, Recycled water on campus is only used for irrigation and accounts for 90% of all irrigation on campus. This means that in 2011/12 potable water accounted for 10% of the total water used for irrigation. According to Jon Cook Associate Director of Landscape, Environmental & Custodial Services at UCSB recycled water accounted for about 60% of water use for irrigation in 1996/97. Estimated growth in the percentage recycled water used for irrigation were calculated by taking the total number of expansions in the recycled water line and dividing that by the increase in the percentage covered with recycled (Table 30). These calculations indicated the total percentage of potable and recycled water used for irrigation. To get the estimated potable water used for irrigation each year the percentages in Table 30 and the following formula were used.

1. **Formula:** Total Recycled / % of campus irrigated with recycled = potable used for irrigation (X) / (1- % of campus irrigated with recycled).
2. Solving for X gives us potable water used for irrigation in gallons, this was added to the total amount of recycled water used to get total water used for irrigation.

In order to calculate the annual potable water savings from converting Rob Field from natural grass to turf, Jon Cook, Associate Director of Landscape & Custodial Services was consulted. It was determined that an estimated 80,000ft^2 of natural grass that was irrigated 1 inch/week was replaced with artificial turf. This meant that the natural grass received 49,870.15 gal/week. Multiplying that number by the amount of weeks in a year, 52, it was determined that the natural grass of Rob Field received 2,593,247.8 gal/yr.

Table 30: Assigning percentages for potable and recycled water used for irrigation

Year	Percentage of Recycled Water used For Irrigation	Percentage of Potable Water used for Irrigation
1996-1997	60	40
1997-1998	60	40
1998-1999	60	40
1999-2000	60	40
2000-2001	60	40
2001-2002	66	34
2002-2003	72	28
2003-2004	72	28
2004-2005	72	28
2005-2006	72	28
2006-2007	78	22
2007-2008	84	16
2008-2009	90	10
2009-2010	90	10
2010-2011	90	10
2011-2012	90	10

APPENDIX XI. Restroom Audits

Academic Restroom Audits

A thorough audit of all academic, research, and other non-residential buildings on the UCSB campus was performed over the summer of 2012. An undergraduate intern recruited volunteers to record the following information for every restroom within the scope of the audit:

- Building name, building number, restroom room-number, restroom gender
- Toilets: number of toilets, brand of toilet bowl, brand of toilet valve, flush style (motion or handle), (flow-rate was unavailable)
- Faucets: number of faucets, presence/brand/reported flow rate of aerators, in-situ testing of each faucet flow rate
- Urinals: number of urinals, brand/reported flow rate
- Notes: broken toilets/sinks, showers, etc.

From this information, efficiency breakdowns for all audited buildings were aggregated by fixture (toilet, aerator, urinal), and average faucet flow rates were calculated by building and for the entire campus (Figure 20).

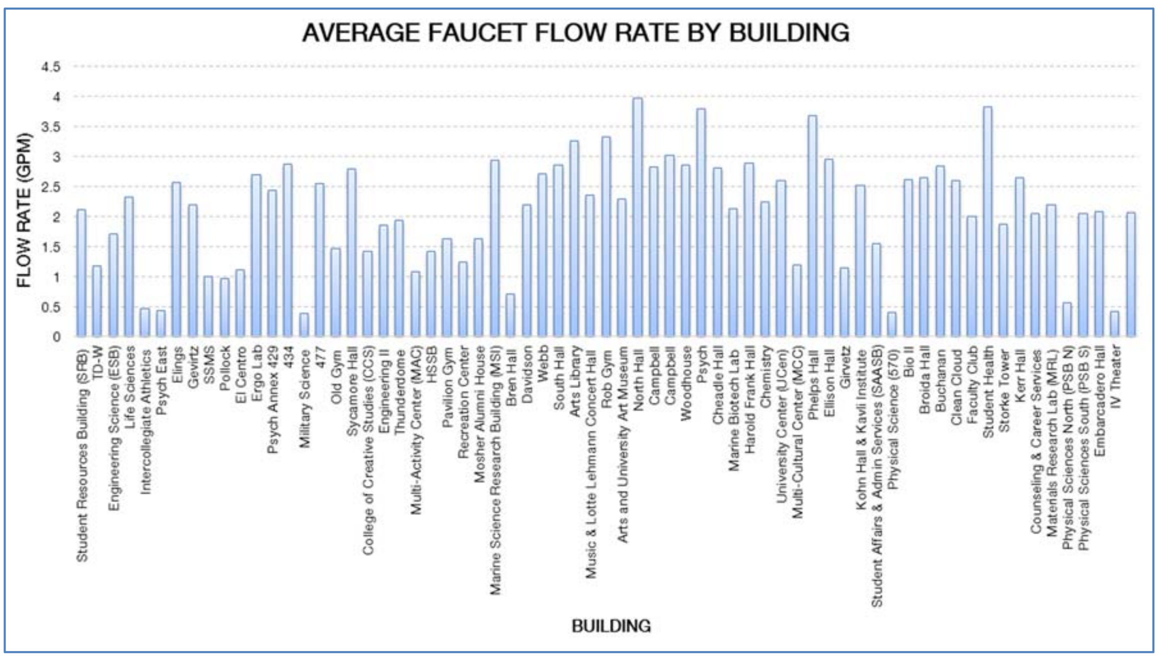


Figure 20: Average faucet flow rate by building in academic, research, and other non-residential buildings

Toilet In-Situ Testing

A sample of 31 toilets from 31 different buildings across UCSB campus was tested on-site for flow rates. Vertical standpipes were removed and flush water was redirected using tubing that connected toilet piping to a five-gallon bucket. The bucket was labeled with graduated gallon markings. After a complete flush, the water was allowed to settle in the bucket and the approximate gpf metric was recorded for each toilet tested. Flush rates for the primarily Sloan brand toilets ranged from 1.6 to 5.25 gpf with one outlier toilet flushing at ~9 gpf (Figure 21).

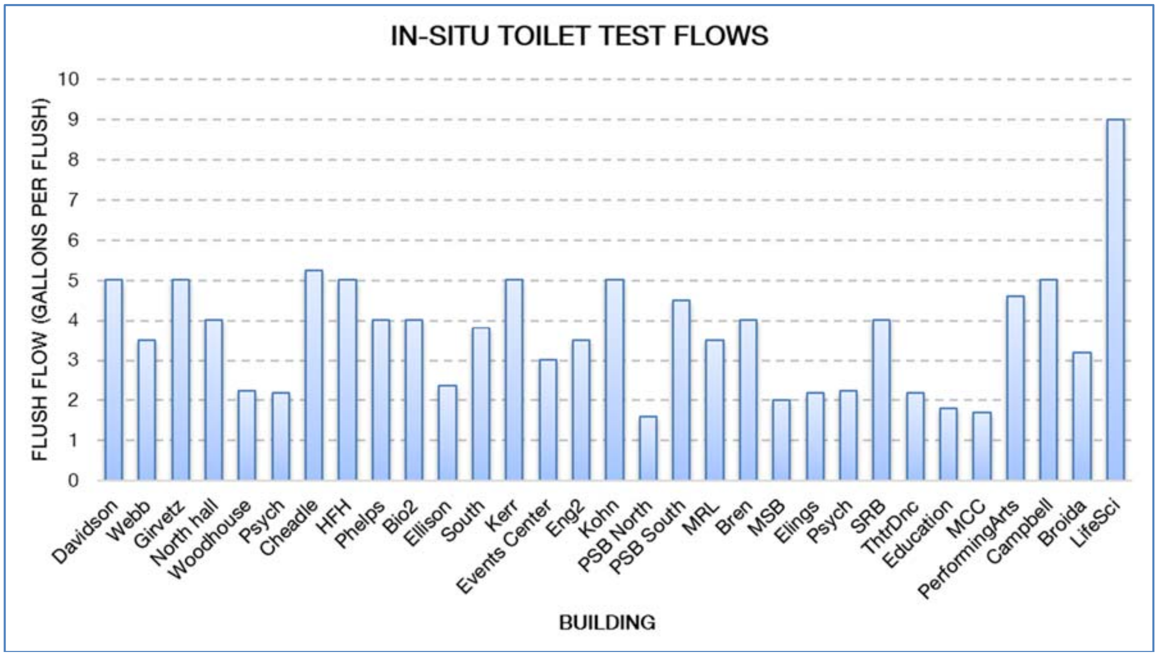


Figure 21: Toilet flush breakdown in gpf based on in-situ testing of a sample of 31 toilets across the UCSB campus

Housing & Residential Services (H&RS) Restroom Inventory

A sample audit of Housing & Residential Services buildings was performed during the summer of 2012. The following information was recorded for a sampling of restrooms in each residential building and then extrapolated for each building based on building floor plans and occupancy numbers:

- Building name, building number, restroom room-number, restroom gender, restroom floor
- Toilets: number of toilets, brand of toilet bowl, brand of toilet valve, flush style (motion or handle)
- Faucets: number of faucets, presence/brand/reported flow rate of aerators, in-situ testing of 1-2 faucets per restroom
- Urinals: number of urinals, brand/reported flow rate
- Showers: number of showers, shower head flow-rate, presence of hour-glass manual shower timers
- Notes: broken toilets/sinks, showers, etc.

APPENDIX XII. Challenges to Institutional Indoor Water Use Efficiency

Technical Challenges to Restroom Fixture Efficiency

Unlike residential units, commercial and institutional restroom fixtures are subject to high frequency use "in assembly occupancies, business occupancies, public buildings, transportation facilities, schools and other educational facilities, office buildings, restaurants, bars, other food service facilities, mercantile facilities, manufacturing facilities, military facilities, and other facilities that are not intended for private use;" often public restroom fixtures are also subject to abuse such as excessive paper disposal (toilet paper, disposable seat covers and paper towels) and aerator theft. [63] To compound high frequency use and misuse in commercial restrooms, long horizontal plumbing lines necessary to multi-toilet restrooms are more prone to pipe blockage than is residential plumbing.

Toilets & Urinals:

The long horizontal distance waste must travel before reaching a vertical drop in commercial plumbing poses a roadblock to the installation of High Efficiency Toilets (HET's) and urinals (HEU's).[64] HET's and HEU's have high potential water savings; when replacing inefficient toilets and urinals, a single HET or HEU in a commercial setting can save in a year up to 19 and 20 thousand gallons of water respectively.[65] Historically, public restroom toilets would flush anywhere between 3.5 and 5 gpf. Plumbing lines built prior to the 1990s were designed to accommodate concurrent flushes, meaning they expected each flush to push waste through the horizontal stretch with upwards of 3.5 gallons of momentum. As of 1992, the EPA established new public restroom standards that required new buildings and necessary retrofits to install low-flow toilets that flushed at 1.6 gpf toilets.[66] Similarly, urinal efficiency standards were tightened to 1 gpf, whereas previously it was common to use 2 gpf. All of a sudden, commercial plumbing was now expected to usher the same quantity of solid waste and liquid waste through piping with approximately one-third the volume of water.

Since then, even more efficient toilet fixtures have come on the market including the 1.6/.8 gpf dual flush toilet valve that offers a higher-flow flush for solid waste a lower-flow flush for liquid waste. Some ultra-low flow technology, such as the Niagara Company's 'Stealth' toilet that flushes at .8 gpf, is specifically *not* recommended for commercial applications due to potential plumbing problems and insufficient line-clear. A recent study on the drain line transport of solid waste in public buildings identified pipe slope, toilet paper type, and flush volume as the three factors with the largest effect on the drain line transport of solid waste.[67] Of particular interest is the flush volume factor, because toilet paper selection is easily changeable, re-plumbing is difficult and costly, but flush volume is an efficiency metric that can be controlled with cost-effective retrofits. The study demonstrated that attempts to clear a blockage in a 135 ft. line with two 90 degree turns using a 5 gallon flush failed 7 out of 39 times. This finding suggests that replacing old toilets with high efficiency models may require extra consideration when drain line slope is inadequate and blockage is likely. The same study indicated that compared to all other flow specs, the .8 gallon flush performed noticeably poorly in commercial lab tests yielding high blockage rates. A 2005 study found that an HET with flows under 1.6 gpf and a four inch sewage pipe installed at a 1% slope is adequate to move 200g of media 6-10.5 meters with no supplemental flow; thus, when adequately plumbed, new buildings should have no problem accommodating HET's. [68]

Other trials faced by commercial toilet efficiency include malfunctioning and underperforming technology. Toilet fixtures in flushometer model toilets are sometimes installed improperly or suffer from scale build-up over time. In flushometer toilets, a pressurized valve controls the flush flow as opposed to tank-type toilets, which use gravity to empty tank storage and clear the toilet bowl. These pressurized valves in flushometer toilets control the flow of water, and if improperly installed, they can release more water than intended. Similarly, if hard water causes scale build-up over time, the ability of the valve to open and close the diaphragm is hindered and toilets are allowed to flush at higher volumes than market specifications.[69] Alternatively, market specifications may not hold true under commercial water pressures, or fixtures may simply underperform. For example, higher-pressure commercial systems can force through more water in a flush that advertised by fixture engineers who may have tested the toilets or urinals at lower water pressures. Oftentimes, fixtures are simply flawed and do not function as intended; for example, automatic toilet sensors can over-react to motion and flush more than necessary.

Faucet Aerators:

Just as toilet efficiency standards increased in stringency in 1993, so did faucet aerator efficiency requirements. Aerators in public restrooms are now expected to flow at 0.5 gpm, whereas the previous standard was 2.2 gpm. Efficient sink technology has less risk with respect to blockage, because there is more vertical drop in the water lines. However, aerators that are not tamper proof and can easily be removed thereby fouling efficiency efforts and releasing sink flows as high as 4.5 gpm. Aerator theft is a real saboteur of conservation efforts, particularly for schools and universities. Aerators are also subject to degradation over time that can lead to increased flow rates. Besides aerator theft and degradation, existing faucet technology thought to be efficient is now being revealed as inefficient. For example, sensor-activated faucets that were once thought to save water are now understood to use more water than manual faucet valves.[70]

In summary, the frequency with which commercial restrooms are used, the lack of regard by users, the lengthy time between maintenance and retrofit actions, the contrast of age between old plumbing infrastructure and new efficiency fixtures, and the misapplication of technology has hindered efficiency efforts in the commercial and industrial sector.

APPENDIX XIII. Economic Analysis of Recycled Water Use in Toilets

Case Study: Sierra Madre (SM) & San Joaquin (SJ) Housing Units

To calculate the potential potable water savings and cost savings generated by the replacement of potable water with recycled water in SM and SJ, two housing buildings slated to be built on the UCSB West Campus, the following steps were taken:

1. Annual potable water use in toilets and urinals was estimated based on extrapolations from similar housing units for both SM and SJ:
2. Aggregated 2011-2012 potable water use provided by Housing & Residential Services for West Campus Family Housing and Santa Catalina Residence Halls served as the proxy for water usage for SM and SJ respectively
3. Estimates for SM and SJ were made based on average unit water use from West Campus Family Housing and average occupancy water use from the Santa Catalina Residence Halls respectively; these housing units' restroom fixtures meet the current EPA efficiency standards (APPENDIX: XVIII)
4. The total annual water use estimates for each building were summed and multiplied by a toilet-urinal water-use-factor of 30% in order to estimate total potable water used in toilets and urinals (this estimate is conservative because residential hall water use does not include kitchen, cooking, or dishwashing applications, therefore potable water consumption attributable to toilets is likely greater than 30%).[71] It was found that a combined total of 7,256.41 HCF would be used each year in the two residential hall buildings.
5. The estimated total potable water used in toilets and urinals annually in SM & SJ represents the potable water savings potential if toilets and urinals were plumbed with recycled water
6. To estimate the cost of water in the next 15 years, the following steps were taken:
    a. The cost of potable water in 2012, $3.71, and the cost of recycled water in 2012, $0.71, were projected into the future based on three annual water rate increases: 2%, 4%, 7%. These increase rates were selected based on projected water costs from Goleta Water District annual reports.
    b. Then the savings per year of using recycled water versus potable water was calculated by finding the difference between the costs of the two types of water in 2012, $2.93. This was then projected using the same three annual water rate increases, 2%, 4%, and 7%, over the next 15 years.
    c. The anticipated building costs for both SM and SJ were summed and multiplied by this 0.115% incremental cost factor
    d. Water cost savings were then calculated by multiplying the quantity of potable water saved by the difference in current potable and recycled contracted water costs with Goleta Water District

Assumptions

Assumptions for all Scenarios

- For all of the scenarios calculated, the cost of the building with traditional plumbing lines was not included, and was assumed to be constant between all three scenarios.
- Initial 2015 rates were based on GWD Schedule of Charges (Price projections through 2015 based on water type). Potable and Reclaimed 2015 costs were based on urban water cost increase and reclaimed water cost increase.
- Nine cost-increase and discounting scenarios were run for the water cost savings given the following water-cost increase rates and discounting rates. Three discounting rates were also used: 3%, 5%, and 7%. These discounting rates were selected using The University standard (5%) and a 2% sensitivity analysis on either side of the 5%.
- It was assumed that there would be no other efficiency upgrades that would lower the water consumption of SM and SJ relative to the West Campus Family Housing and Santa Catalina Residence Halls. It also assumed that the same number of people would live in the building each year and all water use would remain constant over the projected time period.
- Assumed that construction costs for both SJ & SM would be incurred in 2015 and that the residential halls would be ready for move-in in 2016, which is when the benefits of the investment into recycled water would begin to accrue. However 2012 was assumed to be the starting year for all projections.

Additional Assumptions for Scenarios 2 & 3

- In addition, it was assumed that there would be no incremental maintenance for building, because only one set of pipes would exist for being used
- It was assumed that permitting is only a time cost, not monetary.

Scenario 1: Building the new housing with single line plumbing using all potable water – Business as Usual.

The following steps were taken to calculate the water cost associated with building the residential halls with traditional plumbing lines where potable water is used in toilets:

1. Since the cost of the building is assumed to be constant, the first step was to multiply the anticipated water use for the two buildings by the cost of water each year in the three rate increase scenarios.
2. Next the cost of water over a 15-year period was discounted back to the present based on three possible discounting rates, 3%, 5% and 7%. These discounting rates were chosen because they represent a range of options for the university on which to evaluate the cost of water in the present.

This information demonstrates the cost of water in the first 15 years of the lifespan on the SM and

SJ residential buildings if they are built traditionally in 2012 dollar (Table 31). The values are all negative because this is the total value of the water cost over the next 15 years.

Table 31: Net present value for not installing recycled water lines in residential halls

Net Present Value for Scenario 1: Business As Usual in 2012 Dollars to 2027 (15 years)			
	Discount Rate of 3%	Discount Rate of 5%	Discount Rate of 7%
Annual Water Rate Increase of 2%	$(294,626)	$(246,520)	$(207,846)
Annual Water Rate Increase of 4%	$(354,308)	$(295,143)	$(247,764)
Annual Water Rate Increase of 7%	$(467,971)	$(323,055)	$(323,055)

Scenario 2: Installing dual plumbing in the new housing

To calculate the costs associated with replacing potable water with recycled water in these two buildings, the following steps were taken:

1. Beyond the initial cost of the building, the incremental cost of partial dual plumbing was estimated to be 0.23% of total building costs[72].

2. The anticipated building costs for both SM and SJ were summed and multiplied by this 0.23% incremental cost factor to find that the total additional cost for the two buildings to built with full dual plumbing will be $575,000.

3. The annual water savings were then calculated based on the difference in value between potable and recycled water in the three water rate increase scenarios. This is projected 15 years into the future to determine the amount of money saved on the water utility due to recycled water being used in place of potable water.

4. The annual water savings for each of the three rate increase scenarios was then summed and discounted back to the present based on the three discount rates used in Scenario 1 to find the total present benefit of the saved water utility.

5. The net present benefit was then subtracted from the incremental cost of the two housing buildings to find the net present value for Scenario 2 (Table 32).

The net present value numbers are all negative because the savings of using recycled water will only outweigh the incremental cost of installing the dual plumbing system in 20 to 100 years. This shows that the payback period for installing dual plumbing is highly dependent on the water rate increase and the discount rate used.

Table 32: Net present value for installing recycled water lines in residential halls (Scenario 2)

Net Present Value for Scenario 2: Installing Dual Plumbing in New Housing in 2012 Dollars to 2027 (15 years)			
	Discount Rate of 3%	Discount Rate of 5%	Discount Rate of 7%
Annual Water Rate Increase of 2%	$(428,566.98)	$(466,559.00)	$(497,101.80)
Annual Water Rate Increase of 4%	$(381,432.39)	$(428,158.87)	$(465,576.55)
Annual Water Rate Increase of 7%	$(291,666.68)	$(355,378.63)	$(406,114.78)

Scenario 3

To determine the payback period for the incremental cost of dual plumbing and a storage tank required to use recycled water in toilets and urinals, the following economic analysis was performed:

1. The incremental cost of partial dual plumbing was estimated to be 0.115% of total building costs, the same value used for Scenario 2. For Scenario 3, since the entire building would not need to be dual plumbed this estimate is half the anticipated incremental cost of full dual plumbing, for a total of $287,500.[73]

2. The anticipated building costs for both SM and SJ were summed and multiplied by this 0.115% incremental cost factor.

3. Added to this incremental plumbing cost was the capital cost of the necessary storage tanks. These tank estimates were based on one 1,000 gallon plastic vented storage tank per building at the price of $500 each, roughly $1,000 total.[74] These tanks would be placed on the roof, since the tank is vented. These pumps would cost approximately $500 per pump.[75] Alternatively more expensive tanks could be purchased to maintain water pressure if roof installation is restricted for a specific building or significant water pressure cannot be maintained.

4. The sum of the incremental plumbing costs and the additional tank capital investments account for the marginal costs necessary to replace potable water with recycled water, which amounts to $291,500. This was then multiplied by the 15% contingency fee for a total of $332,925.

5. The same calculations done for Scenario 2 were then done for Scenario 3 to predict total water savings over the next 15 years based on the three annual water rate increase. The annual water savings is based on the difference in value between potable and recycled water in the three water rate increase scenarios. This was projected 15 years into the future to determine the amount of money saved on the water utility because recycled water was used in place of potable water.

6. The annual water savings for each of the three rate increase scenarios was then summed and discounted back to the present based on the three discount rates used in Scenario 1 & 2 to find the total present benefit of the saved water utility.

7. The net present benefit was then subtracted from the incremental cost of the two housing buildings to find the net present value for Scenario 3 (Table 33).

Similar to Scenario 2, Scenario 3 best benefits The University in scenarios were high annual water rate increases are expected. However, because of the assumed lower incremental cost of installation of the dual plumbing system, Scenario 3 has a positive net present value for The University in several of the scenarios calculated. In addition it has a significantly lower negative net present value when compared to any outcome in Scenario 1 or Scenario 2.

Table 33: Net present value for installing tank storage for recycled water lines in residential halls

Net Present Value for Scenario 3: Installing Tank Storage for Recycled Water in 2012 Dollars to 2027 (15 years)			
	Discount Rate of 3%	Discount Rate of 5%	Discount Rate of 7%
Annual Water Rate Increase of 2%	$(100,241.98)	$(138,234.00)	$(168,776.80)
Annual Water Rate Increase of 4%	$(53,107.39)	$(99,833.87)	$(137,251.55)
Annual Water Rate Increase of 7%	$36,658.32	$(27,053.63)	$(77,789.78)

APPENDIX XIV. Landscape & Irrigation Goals

Weather based irrigation controllers

Facts & Assumptions

- To estimate water consumption and respective expenditures due to overwatering, Jon Cook, Associate Director of Custodial & Landscape Services was consulted. He determined that approximately 45% of the Campus' landscape is not covered under the weather-based irrigation control system. It was determined, and approved by Jon Cook, that overwatering occurs at 0.5 inch/ week on areas not incorporated under the weather-based irrigation control system. For this calculation, the 2012 cost of potable water was utilized.

To calculate estimates for annual potable overwatering and the associated costs, the following economic assessment was conducted:

1. The Campus Landscape and Irrigation map, which provides information for total irrigation acreage and acreage for irrigation of sod and ornamentals, was used to determine the acreage of landscape in which potable water was used for irrigation. The entire UCSB irrigated landscape is 154 acres. The 10% of landscape irrigated with potable water was found to have represented 17.11 acres (APPENDIX: X).
2. The same map and information was then used to find the acreage of irrigated landscape not included under the weather-based irrigation system. It was determined that the unincorporated 45% represented 69.3 acres.
3. It was determined that the landscape unincorporated under the weather-based irrigation control system and irrigated with potable water was 7.69 acres (334,976 ft^2).
4. Using the estimation of overwater of 0.5/ inches per week, it was determined that 45% of landscape not included under the weather-based irrigation system and irrigated with potable water was 103,284 gal/week (5,370,788 gal/yr).
5. The quantity of potable water used due to overwatering was then multiplied by the 2012 cost of potable water ($3.71/ HCF) to determine the annual expenditure in overwatering at 0.5 inches/week.
6. Steps 2-6 were followed again to obtain overwatering numbers and associated expenditures if the weather-based irrigation control system was expanded and only 35%, 25%, and 10% of UCSB's landscape were unincorporated.

From the above methodology and calculations, 2012 potable water expenditures as a result of overwatering were determined to be somewhat insignificant. The annual expenditures for the 45% of landscape irrigated with potable water and unincorporated under the weather-based irrigation system only amounted to $4,780 when overwatering occurred at 0.5 inches/week. However, with the potential water rate increases by GWD, future overwatering expenditures have the ability to significantly increase. Three different rate increase scenarios were evaluated.

In the first scenario, GWD initiates an annual 2% potable water rates increase. The 2012 base rate for potable water was $3.71/HCF. This amount was evaluated at a 2% rate increase over a period of fifteen years with respect to the expansion of the weather-based irrigation control system. Figure 23 depicts that if the weather-based irrigation control system is not expanded, annual water expenditures would increase an estimated $9,000 by 2026. Depending on the associated costs of expanding the weather-based irrigation system's infrastructure, it may be UCSB's best interest to expand the system in order to avoid future costs of overwatering with a 2% annual rate increase.

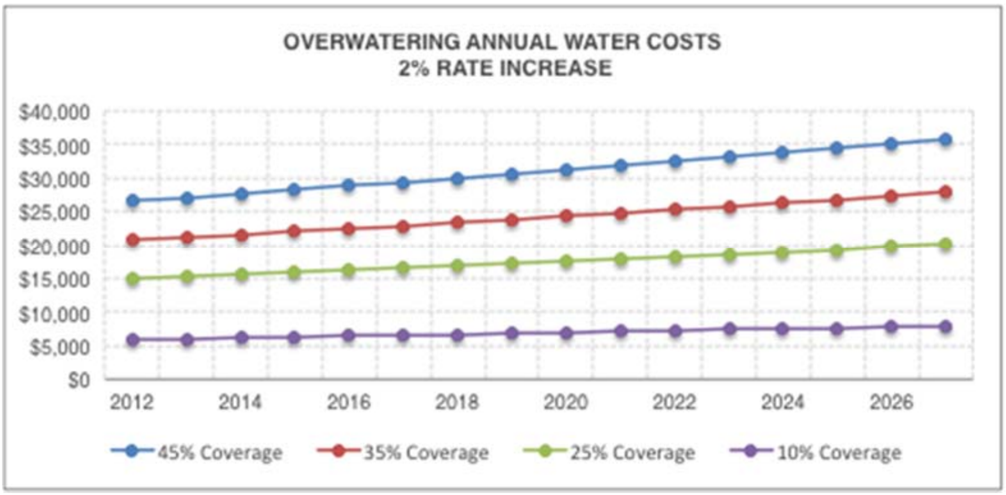


Figure 22: Overwatering annual potable water costs based on a 2% rate increase.

The second scenario was evaluated with a 4% rate increase. Figure 24 shows that overwatering .5 inches/week would result in expenditure increases from $26,636 to $47,971 if the weather-based irrigation control system were not expanded to include additional areas irrigated with potable water. Expanding the system to include 65% of landscapes irrigated with potable would only see expenditures increase from $26,636, the current annual expenditure, to approximately, $26,948. In the face of a 4% annual potable water rate increase, expenditures on overwatering by 0.5 inches/ week would only be an estimated $300 if the weather-based irrigation system were immediately expanded to include 70% of the landscape irrigated with potable water.

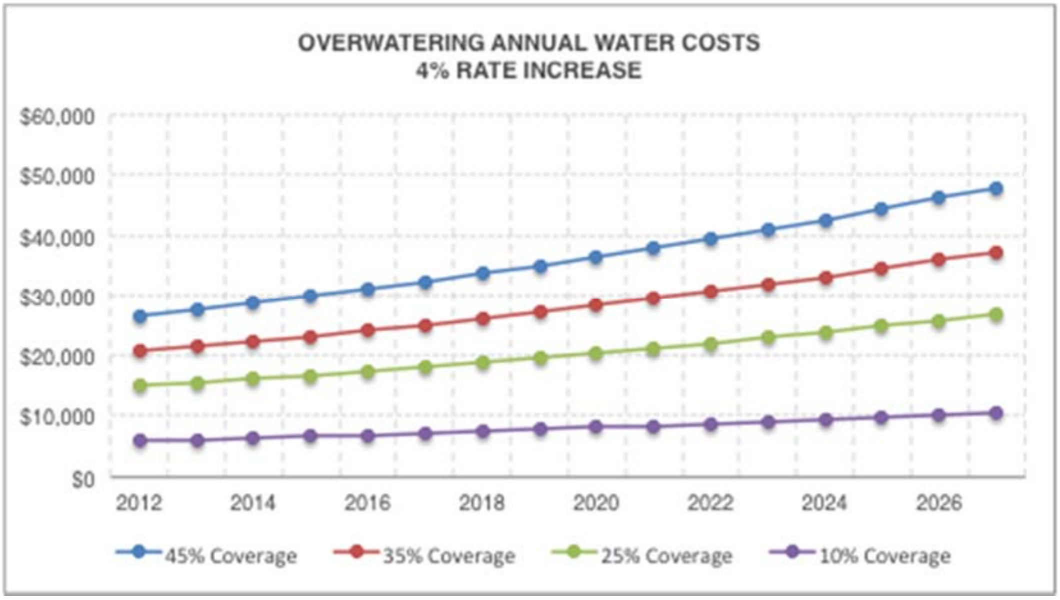


Figure 23: Overwatering annual potable water costs based on a 4% rate increase.

The final scenario was evaluated using a 7% potable water rate increase by GWD. At 7%, not expanding the weather-based irrigation system would result in significantly higher annual expenditures due to overwatering 0.5 inches/week than those highlighted in Figures 23 and 24 (Figure 25).

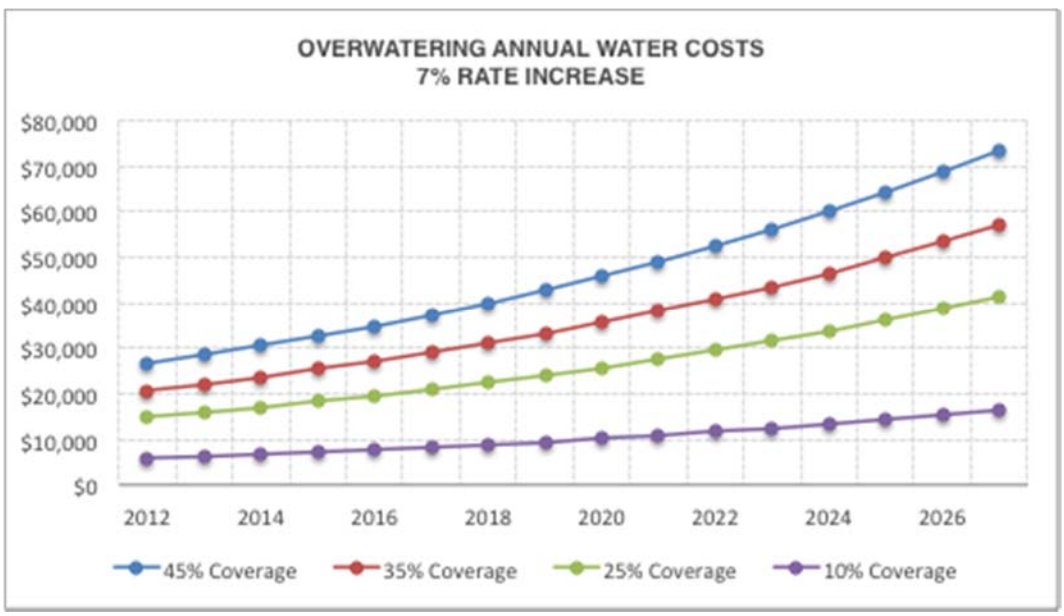


Figure 24: Overwatering annual potable water costs based on a 7% rate increase.

Increase Recycled Water Quality: Commencement Green

Jon Cook estimated the costs of replacing and treating the soil at Commencement Green. The following facts and assumptions were populated upon his best estimates.

Switch to Potable Water

Facts & Assumptions

- 2012 cost of potable water: $3.71/ HCF
- Irrigation average: 0.5 inch/week

Soil Treatment

Facts & Assumptions

- Costs of treating soil (applying gypsum and sulfur) lasts 4 to 5 years.
- Gypsum: 5000 lb/ pallet with a per-pallet cost of $900.
- Gypsum is applied at 100 lb / 1000 ft^2.
- When applying the gypsum, the soil should be flushed by irrigating at least 1.5 in/week
- Labor: $5/1000 ft^2
- Sulfur: $40/50 lb sack, apply 8 lb/ 1000^2 ft

Soil Removal Costs

Facts & Assumptions

- Commencement Green: 51,829.39 ft^2
- Irrigation average: .5 inch/week
- Irrigation maximum: 1 inch/week
- $4/$ft^2$ to purchase and replace sod (grass) $8/$ft^2$ for ornamentals
- No permits needed for soil removal
- $80,000 for soil removal, which includes labor and machinery (work needs to be contracted out). Soil needs to be disposed of via a "soil broker"
- Import soil $80,000. This price is variable depending on source of soil.
- Plant replacement: 9/ft^2 to roll out sod, fix irrigation, purchase soil amendments, and labor costs (double this for ornamentals)

Soil Medium Costs

Facts & Assumptions

- Soil medium (comprising of pea gravel and nitrolized wood shavings): $5.56/ ft^2
- French drains: $40,000
- Upgrade irrigation infrastructure: $300

- Labor: $5/1000 ft^2
- Seeding: $5,000

On-site Treatment System

Facts & Assumptions

An on-site treatment system to increase the quality of the recycled water at Commencement Green needed to meet the following criteria:

- Site-specific for Commencement Green
- Capable of filtering eight irrigation stations. Each station irrigates at a maximum 350 gpm daily. Each irrigation station runs one after the other, never at the same time.
- Decrease constituent concentrations to the following:
    - Total dissolved solids (EC): 1,200 mg/L
    - Chloride: < 200 ppm
    - Boron: < 0.75ppm
    - Sodium: < 150 ppm
    - SAR: 7
    - Bicarbonate: < 200 ppm
    - pH: 6.5 – 7.5
    - Chlorine Residual: 1.5
    - BOD: 2 mg/1

Using the aforementioned facts and assumptions for switching to potable water, soil treatment, and soil removal, the following steps were used to determine the cost of the potential solutions for Commencement Green:

Soil Treatment

1. For soil treatment, gypsum needs to be applied at 100 lbs/ 100ft^2. Using the square footage of Commencement Green (51,829.39 ft^2), it was determined that 5,182.94 lbs of gypsum are needed to treat the soil at Commencement Green. With the price of gypsum at $900/ 5,000 lbs, it is estimated that the cost of gypsum for Commencement Green is $932.96.
2. Sulfur needs to be applied at 8 lbs/ 1,000 ft^2, and for Commencement Green, 414.63 lbs of sulfur are needed. With the price of sulfur at $40/ 50 lbs., it is estimated that the cost of sulfur for Commencement Green is $360.00.
3. Labor costs for this project are estimated at $5/ 1,000 ft^2. The estimated labor cost to treat the

soil at Commencement Green is $259.14

4. To determine the total cost of treating the soil at Commencement Green, the costs of applying gypsum, sulfur, and the labor required are estimated at $1,552.06

Soil Replacement

1. For soil replacement, the soil removal estimation of $80,000 for Commencement Green was utilized, and added to the estimated cost of importing soil, $80,000.
2. Sod replacement and the necessary irrigation upgrade were estimated at \$6/ ft^2 for Commencement Green, which totals $310,976.34.
3. To determine the total cost of soil replacement, the costs of soil removal and replacement, and sod replacement were added together to get an overall cost of $470,976.34

Soil Medium

1. The cost of the soil medium (pea gravel and nitrolized wood shavings) was determined to be \$5.56/ ft^2. Using the dimensions for Commencement Green, the total cost for the soil medium is estimated at $288,171.40
2. The cost of installing French Drains and upgrading the irrigation infrastructure were estimated at $40,000 and $300, respectively.
3. Seeding for the soil medium was estimated at $5,000 and the total labor required was estimated at \$5/ ft^2
4. The total cost for installing a soil medium at Commencement Green was estimated at $333,730.54.

On-site Treatment System

1. A quote for an on-site filtration system capable of treating the recycled water to the aforementioned standards was requested from AXEON Water Technologies. Given the requested water quality standards and the irrigation schedule of Commencement Green, AXEON recommended their following products:
    a. 3.2 – 9.0 GPM Carbon Filtration System Timer: $824.42
    b. 8 GPM UV Sterilight: $1,176.59
    c. XP4-30 Chemical Injection 4 GPD System: $1,253.70
    d. S-100 Antiscalant: $814.00
    e. 2.3 – 6.0 GPM Zeolite Filtration System Timer: $1,656.14
    f. Flexeon BT-2000 Commercial Tap 2,000 GPD RO System: $3,297.54
    g. Flexeon BT-2000 Outlet Pump, 110V: $146.12
    h. 5,000 Gallon Storage Tank: $5,778.00
    i. Repress pump 350 GPM: $4,483.80

2. The total cost of the Reverse Osmosis filtration system and all the necessary components sums to $16,490.06

Expand the Recycled Water Infrastructure

In order to determine the potable water savings of converting UCSB's landscape irrigated with potable to recycled water, the following economic analysis was preformed:

1. Irrigation and landscape water use by water type was examined. This analysis determined that 10% of the Campus' landscape was irrigated with potable water (APPENDIX: X).
2. A three-year average (2009/10 – 2011/12) of the 10% potable water used for irrigation was then calculated. This particular three-average was chosen because it was the most recent and after the latest recycled water infrastructure expansion.
3. Potable water savings from expanding the recycled water infrastructure to incorporate all of UCSB's irrigated landscapes is 8,527 HCF/yr, which is approximately $31,635 per year.

APPENDIX XV. Estimating Costs and Water Savings for Management Goals

The following are best estimates based on the knowledge gleaned from conversations with various Campus stakeholders and Internet research. Because of this, the following should be used solely as guidance.

- *Goal 1: Conduct annual constituent soil samples*

Cost: There is no initial cost associated with collecting and testing soil samples. Annual costs would include paying a FTE to collect the samples and ship to a lab. In addition, the lab must receive payment for testing each collected sample. Annual costs will most likely be less than $100,000.

Water savings: There are no direct water savings associated with this goal; however, soil monitoring will help with early detection of rising levels of constituents, allowing for the exploration of alternatives to flushing the soil with potable water.

- *Goal 2: Calibrate existing industrial water meters and install new ones where needed*

Cost: There are 10 cooling towers on Campus, each with two meters: one for blowdown and one for makeup water. Two meters need replacement ($500 per unit for analog and $1,000 per unit for digital). The remaining 18 meters need calibration, at roughly $50 per unit. To update the entire system (calibrate 18 meters and install 2 analog meters), the initial cost is $1,900 (18 * $50 + 2 * $500). There is no annual cost associated with this goal.

Water savings: While it is difficult to determine the water savings associated with this until after the installation and calibration, savings will most likely be less than 200,000 gal/yr.

- *Goal 3: Conduct quarterly reviews for industrial infrastructure*

Cost: While there is no initial cost associated with this goal, annual costs would include the time it would take a FTE to visit each of the cooling towers on campus to assess the status of the infrastructure. This cost will most likely be less than $100,000/yr.

Water savings: There are no direct water savings associated with this goal; however, these reviews will help with early identification of failing infrastructure.

- *Goal 4: Install real-time meters in all buildings and new construction*

Cost: There are currently 55 meters already on-campus. However, these are unable to be read and monitored remotely; they must be manually read. New real-time meters cost roughly $8,000 per unit and 31 meters are required for full campus coverage. If the University wanted to install the 31 new meters, the cost is $248,000 (31 * $8,000). If the University wanted to update the 55 existing meters and install 31 new meters, the initial cost is $688,000 (86 * $8,000). The annual cost associated with this goal is most likely less than $1,000/yr as it will likely include the software required to read and display the real-time data and any annual equipment checks that should be performed.

Water savings: An estimated 200,000 gal/yr, which will most likely be higher in the first year due to identification of all old leaks as well as leaks occurring that year. This number is based on what Stanford University saved between July 2011 and June 2012 with their real-time metering system.[76]

- *Goal 5: Create a living central database for water use and infrastructure*

Cost: This cost is associated with the time it will take a FTE to inventory, record, update, and reference the database. It was assumed that the Water Manager will be responsible for this goal and that this individual will be an Analyst III making $55,000/yr.[77] Also, assuming that this would take 15% of the Manager's time, the annual cost is $8,200 ($55,000 * 0.15). It should be noted, however, that this $8,200 is folded into the cost for the Water Manager and is not in addition to the Water Manager cost.

Water savings: There are no water savings directly attributable to this goal; however, the database will facilitate efficient identification of future water savings projects.

- *Goal 6: Create a "Water Manager" position*

Cost: Initial costs would include the amount of time it would take a FTE to write the requisition, collect and read resumes, interview candidates, and make the final selection. The annual cost is $55,000, assuming that the Water Manager would be hired as an Analyst III.[78]

Water savings: There are no direct water savings associated with the Water Manager position; however, this individual will facilitate full implementation of water savings projects outlined in the WAP.

- *Goal 7: Implement a Campus-wide water conservation outreach and awareness education program*

Cost: Many of the components associated with creating a Campus-wide education program would not have additional costs. It was assumed that the Water Manager would be involved in developing educational curriculum and carry out many of the education goals on Campus as dictated by the job description. Assuming this would take 20% of the Manager's time, the cost would be $11,000 ($55,000 * 0.2). Additional costs for the outreach are assumed to be the fliers, signs and promotional material that would be posted across campus. Assuming $400 for 1,000 flyers, $300 for 20 lawn signs, and $120 for 100 postcards totals an estimated $820 in promotional costs.[79] The educational materials for campus should be reprinted every few years. Based on this estimate, the total cost of an education program would be approximately $11,820; most of this total cost would occur annually as part of the Water Manager's salary.

An additional expense for the education program is installing real-time dashboards. The Oberlin study found that dashboards are roughly $10,000 per unit.[80] There are a total of 14 residential halls and apartment complexes on Campus that would receive at least one dashboard, putting the total minimum initial cost at $140,000 (14 * $10,000). There would likely be minimal annual costs associated with dashboard maintenance, particularly any software and Internet fees.

The total cost for an education program would be approximately $153,000, with $140,820 occurring only once, and $11,000 occurring annually.

Water savings: Water savings for this goal are not easily estimated. All education activities can result in reduced water use, however water savings attributed to awareness and dashboards are not easily estimated or monitored.

- *Goal 8: Incorporate water conservation into academics*

Cost: Based on Stanford's feasibility study of the Lotus Living Laboratory, creating the living laboratory component of the residential hall was $90.19 per square foot.[81] The treatment facility recommended for the on-site treatment of water at Commencement Green has a 5,000 gallon tank and a treatment system (APPENDIX: XIV). Based on this information, we assumed the living lab would be 500 square feet. The total cost then of the living laboratory would be 45,095, which includes the $16,490.06 cost of the treatment system (APPENDIX: XIV). In addition to the initial building cost, the living lab would have annual maintenance and operation costs, including activities like tours.

Water savings: The on-site water treatment system for Commencement Green will save an estimated 831,000 gallons (APPENDIX: XIV). However, the actual living laboratory will not have any direct water savings.

- *Goal 9: Participate in Campus and national water conservation competitions*

Cost: The majority of this cost is associated with creating the competition plan, reading meters, and disseminating information about the competition to the residential halls involved. Assuming this will take 15% of the Water Managers' time, the cost is $8,250 ($55,000 * 0.15). The competitions will have no initial cost, just cost associated with each competition.

Water savings: The water savings associated with competitions are not easily estimated. Historically at UCSB, each week of a competition will save, on average, 7% of the baseline water consumption of a residential hall. The three week competition in 2012 showed approximately 90,000 gallons, or a 22% total savings, over the 3 weeks of the competition. UCSB can expect to see similar savings in future competitions and will likely see more water savings the longer the competition duration.

- *Goal 10: Begin dialogue with the State of California to encourage implementation of incentives for water conservation*

Cost: Assuming that beginning a dialogue with the State will take up 15% of the Water Manager's time, the cost will be $8,250 ($55,000 * 0.15). This effort will have no initial cost, only annual costs that are already included in cost of Water Manager's position.

Water savings: The water savings associated with this are not easily estimated; however, given the high number of State-funded buildings on Campus, this goal has the potential to provide the University with substantial savings.

APPENDIX XVI. Industrial Goals

All calculations for cycles of concentration were based on 2010-2011 data for UCSB cooling tower meters provided by Mikhail Kovalchuk. This data was deemed to be an acceptable representation of cooling tower water use during the benchmark period. As a brief summary, approximately 32 million gallons of water was consumed annually for cooling towers uses over the benchmark period.

Before further data and calculations are discussed, it is important to introduce some terminology.

- **Cycles of concentration (COC)-** the number of times water circulates within the cooling system before it is lost to blowdown. It typically measures the ratio of an ion in the cooling water (C_{cw}) to that of the make-up water (C_{mu}). Typically the ions considered are magnesium or silica, but in this case chlorides are used.
- **Make-up water (MU)-** the water added to replace evaporative losses, blowdown, drift losses, and system losses

According to Seneviratne, 2007, significant water savings can be achieved if the cycles are less than 5 in typical cooling water applications.[82] UCSB's average cooling tower cycle is calculated as follows:

4. The relationship between Blowdown, Makeup, and ionic concentrations is defined by the following equation:

$$Blowdown = Makeup * \left(\frac{C_{mu}}{C_{cw}}\right) \qquad (Equation\ 1)$$

5. Since UCSB's makeup and blowdown lines for cooling towers are metered, the ionic ratio can be calculated as follows by using Equation 1:

$$10{,}949{,}509.0\ gal = 31{,}827{,}860\ gal * \left(\frac{C_{mu}}{C_{cw}}\right)$$

$$\therefore\ \frac{C_{mu}}{C_{cw}} = 0.344$$

6. The average COC for all campus cooling towers can be calculated as follows:

$$COC = \frac{C_{cw}}{C_{mu}} \qquad (Equation\ 2)$$

7. The ionic concentration of chloride in the makeup water can be estimated from the Goleta Water District drinking water quality reports; this was determined to be 19 mg/L. We can therefore solve for the ionic concentration of the cooling water using Equation 2:

$$0.344 = \frac{19\ mg/L}{C_{cw}} \quad \therefore C_{cw} = 55.8\ mg/L$$

8. Thus, the annual average cycles of concentration for UCSB cooling towers is:

$$COC = \frac{55.8\ mg/L}{19\ mg/L} = 2.93\ cycles\ of\ concentration$$

9. Given that the Campus cooling towers are operating at the annual average of 2.93 cycles, it is necessary to estimate the maximum theoretical cycles that the cooling towers can operate based on the quality of the make-up water. Berg, Lane, and Larson (1963) provide an empirical relationship for estimating the maximum permissible concentration ratio for minerals in the cooling water to the minerals in the make-up water.[83] The calculation for the maximum cycles of concentration is as follows:

10. Equation for maximum cycles of concentration:

$$COC_{max} = 2400/H, where\ H\ is\ the\ hardness\ (in\ mg/L\ of\ CaCO_3) \qquad (Equation\ 3)$$

11. Thus, the maximum permissible cycles of concentration for UCSB are:

$$COC_{max} = \frac{2400}{339\ ppm\ CaCO_3} = 7.0\ cycles\ of\ concentration$$

12. Given that we know both the initial and maximum COC for cooling towers, we can calculate the percentage cooling water consumption that can be conserved by increasing the cycles of concentration. The savings are calculated as follows:

13. Equation for calculating percentage savings of make-up water:

$$Percent\ conserved = \frac{COC_n - COC_i}{COC_i(COC_n - 1)} * 100 \qquad (Equation\ 4)$$

14. Equation 4 was used to produce the following table that indicates the percentage water savings with respect to cycles of concentration (Table 34).

Table 34: Water savings in cooling towers with respect to cycles of concentration

WATER SAVINGS WITH RESPECT TO CYCLES OF CONCENTRATION:		
INITIAL COC	NEW COC	PERCENTAGE WATER SAVINGS
2.93	4	12%
2.93	5	18%
2.93	6	21%
2.93	7	23%

When the percentage savings are compared to average potable water use for cooling towers, the total savings of cooling tower make-up water is significant. As cycles of concentration approach 7, the amount of water conserved exceeds 7 million gallons (Figure 26). The trend is nonlinear, with greater savings occurring over the first several increases of COC. If cooling tower performance and heat removal is a concern, gains in water conservation can still be made by raising the cycles of concentration only one or two units.

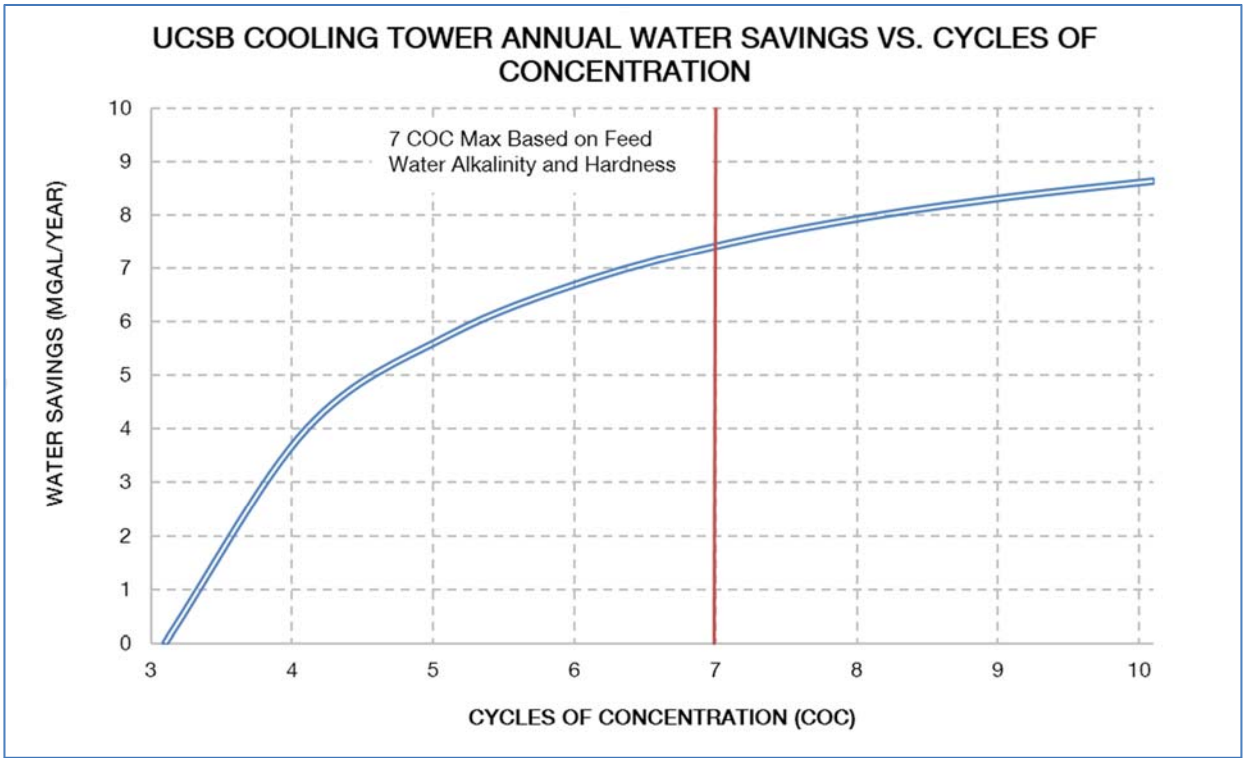


Figure 25: UCSB cooling tower annual water savings based on cycles of concentration.

Another important factor in increasing the cycles of concentration on Campus cooling towers is the use of chemicals to treat the cooling water. Berg, Lane, and Larson (1963)[84] provide an equation to calculate the approximate chemical treatment costs of make-up water. Adjusted for 2012 dollars, this equation is represented as:

$$Chemical\ cost\ (cents/1000gal) = 7.42\left(0.033(160\ ppm\ CaCO_3) + \frac{74}{COC}\right) \qquad (Equation\ 5)$$

When Equation 5 is calculated for a range of COC values, the savings in chemical treatment become readily apparent. As cycles of concentration approach 7, the cost savings from reduced chemical treatment exceeds $40,000 (Figure 27). As with the water savings discussed in Figure 26, the trend is nonlinear, with greater chemical cost savings occurring over the first several increases of COC.

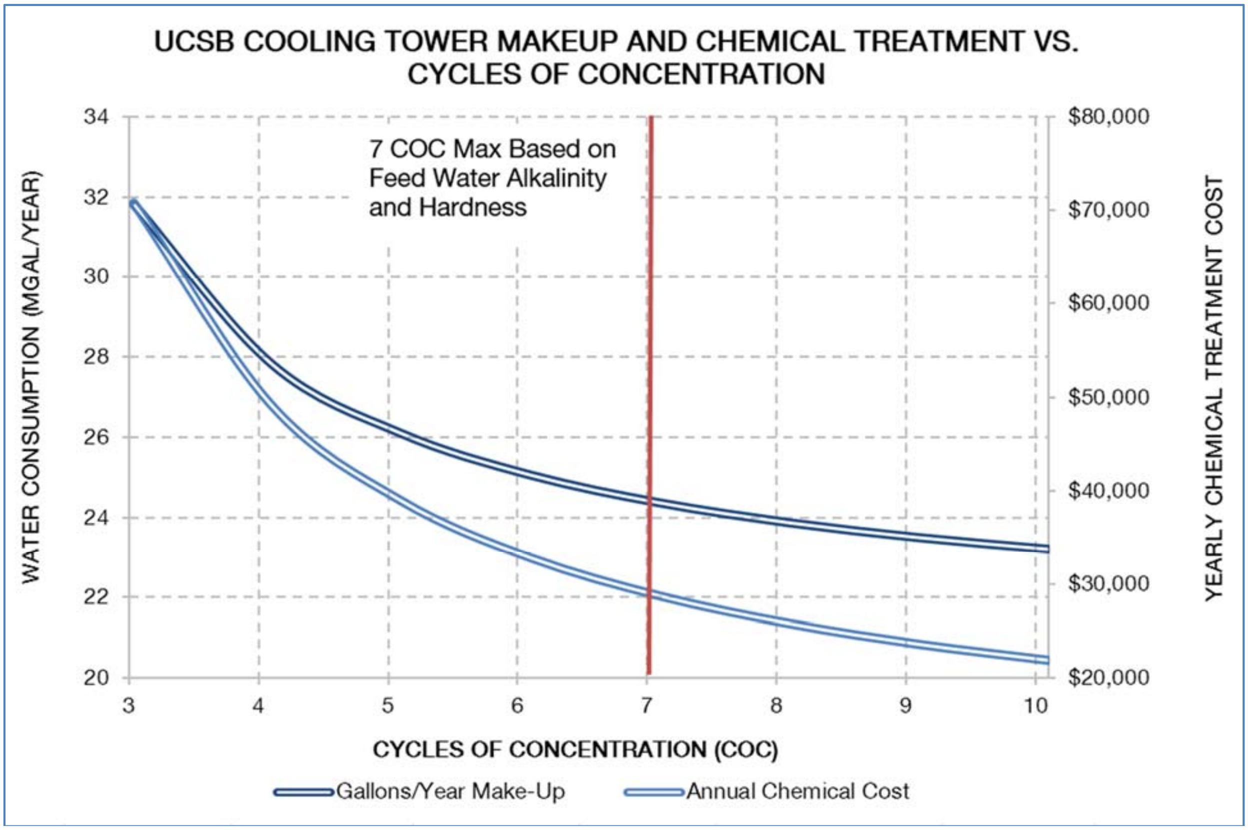


Figure 26: UCSB cooling tower makeup water consumption and chemical treatment cost based on cycles of concentration.

From the above methodology and calculations, it is clear that there exists significant water savings potential by increasing the cycles of concentration in the Campus cooling towers. In addition, in the face of potential water rate increases by Goleta Water, increasing COC will act as a cost buffer. To explain this more clearly, three different water rate increase scenarios were evaluated.

The first scenario is one in which Goleta Water begins a series of 2% yearly water rate increases. The 2012 base rate was $3.71 per HCF; this amount was evaluated at a 2% rate increase over a period of fifteen years with respect to different cycles of concentration. As seen in Figure 28, continued use of business as usual cooling tower COCs results in the annual cooling tower water costs increasing from $160,000 to approximately $213,000. If cooling tower COC levels were increased to 7, water costs by year 2027 would remain at $160,000. Thus, even in the face of a 2% yearly water rate increase, a switch to 7 cycles of concentration would offset the potential losses if a business as usual strategy is maintain.

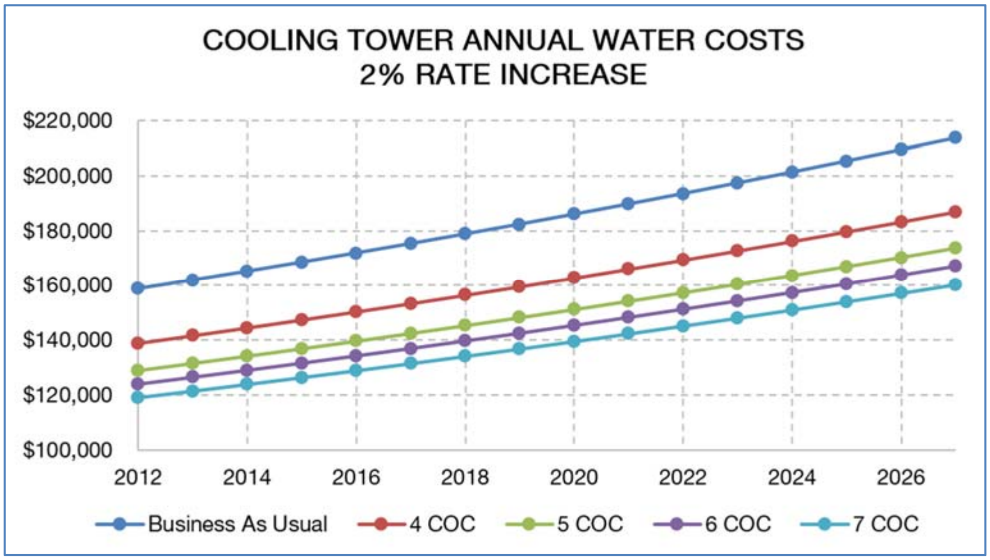


Figure 27: Cooling tower annual water costs for different cycles of concentration scenarios based on a 2% rate increase.

A second scenario was evaluated using a 4% rate increase by Goleta Water. As seen in Figure 29, a 4% increase in potable water rates would result in the annual cost of cooling tower water reaching over $280,000 by year 2027. If cooling tower COCs were increased to 7, annual cost of cooling would be reduced to approximately $214,000 by 2027. It is important to note that unlike the first scenario, in this scenario, even if 7 COCs are maintained by year 2027, the final water costs will be higher than the initial year 2012 costs operating under business as usual.

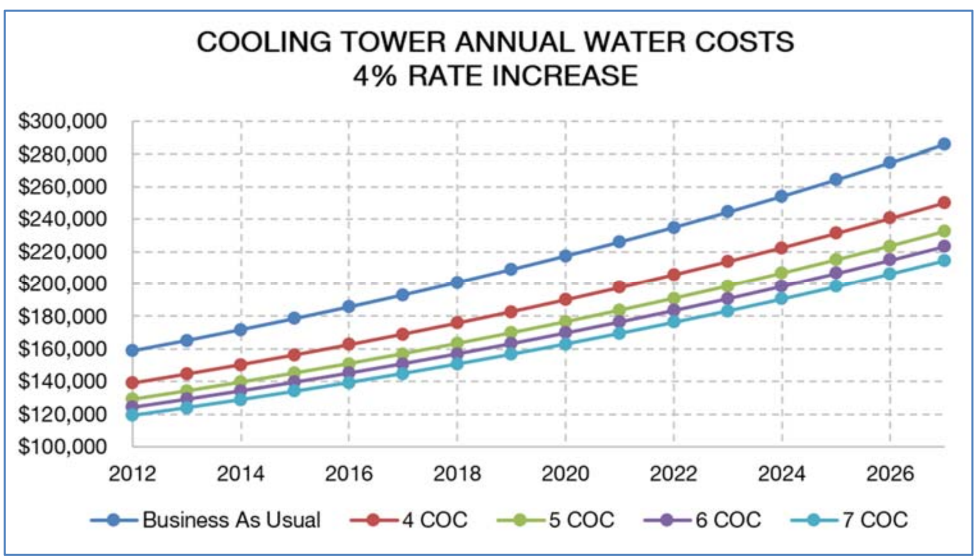


Figure 28: Cooling tower annual water costs for different cycles of concentration scenarios based on a 4% rate increase.

A final scenario was evaluated with a 7% rate increase by Goleta Water. In Figure 30, a similar trend is seen as in Figure 29. Overall, the costs in year 2027 are significantly higher than business as usual costs in 2012 for all varying levels of cooling tower cycles of concentration.

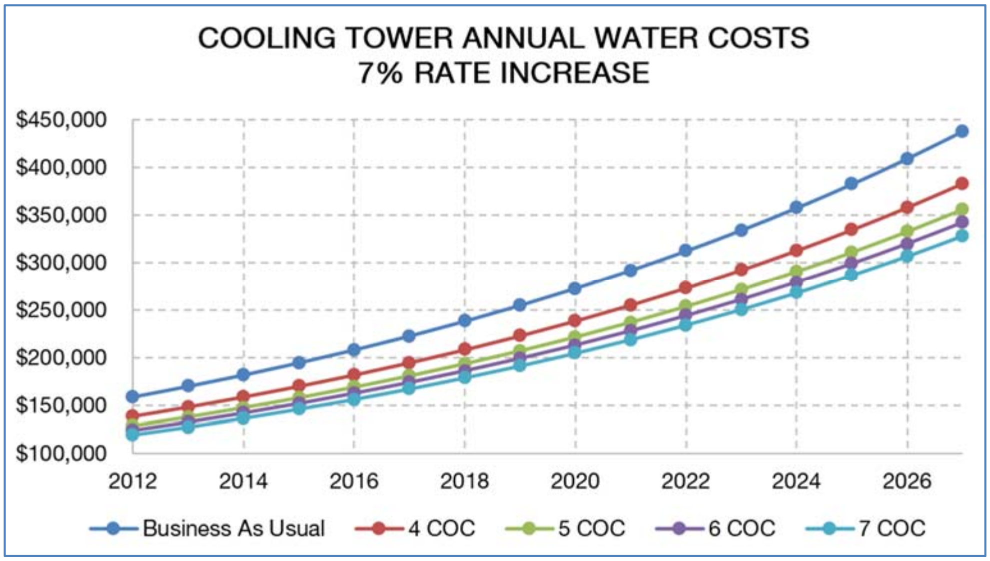


Figure 29: Cooling tower annual water costs for different cycles of concentration scenarios based on a 2% rate increase.

APPENDIX XVII. UCSB Water Sources

The Goleta Water District (GWD) supplies UCSB's water. The following are the water sources from which GWD draws its water:[85]

- Lake Cachuma

  GWD entitlement to Lake Cachuma water is 9,322 AFY. Additional water flows over the dam during years when the dam reaches capacity, known as spill water. Average deliveries of entitlement and spill water from 1997 to 2008 have 10,675 AFY. While Lake Cachuma is a primary source of water, water entitlements can be reduced during drought periods.

- Groundwater

  GWD has an adjudicated right to 2,350 AFY of groundwater from the Goleta Groundwater basin; any unused groundwater during a year is stored in the basin for later use. The Goleta groundwater basin dropped to historical lows during the drought of 1986-1991 but since then, pumping has largely been forgone, allowing the basin to rise and achieving near-historical high levels in recent years. Operations of the basin are implemented pursuant to the voter-enacted SAFE Water Supplies Ordinance and the Wright Judgment.

- Recycled Water

  GWD purchases recycled water from Goleta Sanitation District (GSD) for non-potable uses, primarily for landscape irrigation, with UCSB as its largest recycled water consumer. GSD facilities are designed to be able to treat 9.2 acre-feet per day (3 Mgal/day), and deliver on average 1,000 AFY (325.9 Mgal/yr), or 30% of the total annual production capacity. This is due to limited recycled water storage availability and seasonal demand patterns whereby customers require most deliveries during the summer.

- State Water

  Through the Central Coast Water Authority (CCWA), GWD has the right to 7,000 acre-feet of state water a year, with an additional 450 acre-feet as a part of the CCWA drought buffer. GWD purchased 4,500 acre-feet of capacity in the Coastal Branch of the California Aqueduct, which serves as an upper maximum of water available for delivery to the District. GWD stores State Water in either Cachuma Reservoir or San Luis Reservoir, but long-term storage of State Water in Cachuma Reservoir can be unreliable, as Lake Cachuma spills every three years on average. State water supply is unreliable, as it depends on total supply in the system, is subject to an uncertain regulatory future, and can be quickly and unilaterally decreased during drought years. It is also the most expensive source of water for GWD (costing on average $1,300 more than Lake Cachuma water per acre-foot).

APPENDIX XVIII. EPA Residential & Commercial Restroom Efficiency Standards

Table 35: EPA commercial restroom efficiency standards[86]

National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances

Adapted from information provided by the U.S. EPA Office of Water, the Alliance for Water Efficiency, and other sources)

Fixtures and Appliances	EPAct 1992, EPAct 2005 *(or backlog NAECA updates)*		WaterSense* or Energy Star*		Consortium for Energy Efficiency	
	Current Standard	Proposed/ Future Standard	Current Specification	Proposed/Future Specification	Current Specification	Proposed /Future Specification
Commercial Toilets	1.6 gpf[4]/6.0 Lpf Except blow-out fixtures: 3.5-gpf/13 Lpf Note: Some states prohibit blow-out at 3.5 gpf	1.28 gpf/ 4.8 Lpf proposed by efficiency advocates for tank-type only	Tank-type only: WaterSense at 1.28 gpf (4.8L) with at least 350 gram waste removal + LA Spec.	Flushometer valve/ bowl combinations: WaterSense specification in development. No release date promised.	No specification	
Commercial Urinals	1.0 gpf	0.5 gpf/ 1.9 Lpf proposed by efficiency advocates	WaterSense = 0.5 gpf/1.9Lpf (flushing urinals only)		No specification	
Commercial Faucets	Private faucets: 2.2 gpm at 60 psi[5] Public Restroom faucets: 0.5 gpm at 60 psi[5] Metering (auto shut of) faucets: 0.25 gallons per cycle[6]			WaterSense draft specification now under consideration	No specification	

APPENDIX XIX. Data Collection

A multifaceted data-collection effort enabled a detailed reconstruction of historical UCSB water use. Both quantitative and qualitative water data were collected using the following methods:

- Personal Communication

  Interviews, emails, and phone-calls with water stakeholders and experts yielded a wealth of information. Personal communication built a strong understanding of University water systems, enabled the reconstruction of a timeline of significant water-related campus actions (e.g., major infrastructure changes), and engaged an extended network of project advisors. Facilities employees, academics, business representatives, water providers, and education and outreach groups were instrumental to the data collection process (see 'Acknowledgements').

- Utilities/Billing Documents

  Historical water use numbers were compiled from existing facilities' utilities records, billing documents, and Goleta Water District customer records.

- Aggregated Water Use Data

  Housing & Residential Services provided aggregated water-use data.

- On-Site Audits

  A campus bathroom audit was performed to record existing bathroom fixtures (e.g., aerators, toilet flush valves, shower-heads) and manufacturing performance standards. In-situ testing of flow rates was performed on a sample of faucets and toilets.

The data collection culminated in the following macro-level visual representations of UCSB's water use from FY 1996/97-2011/12 (Figures 31, 32):

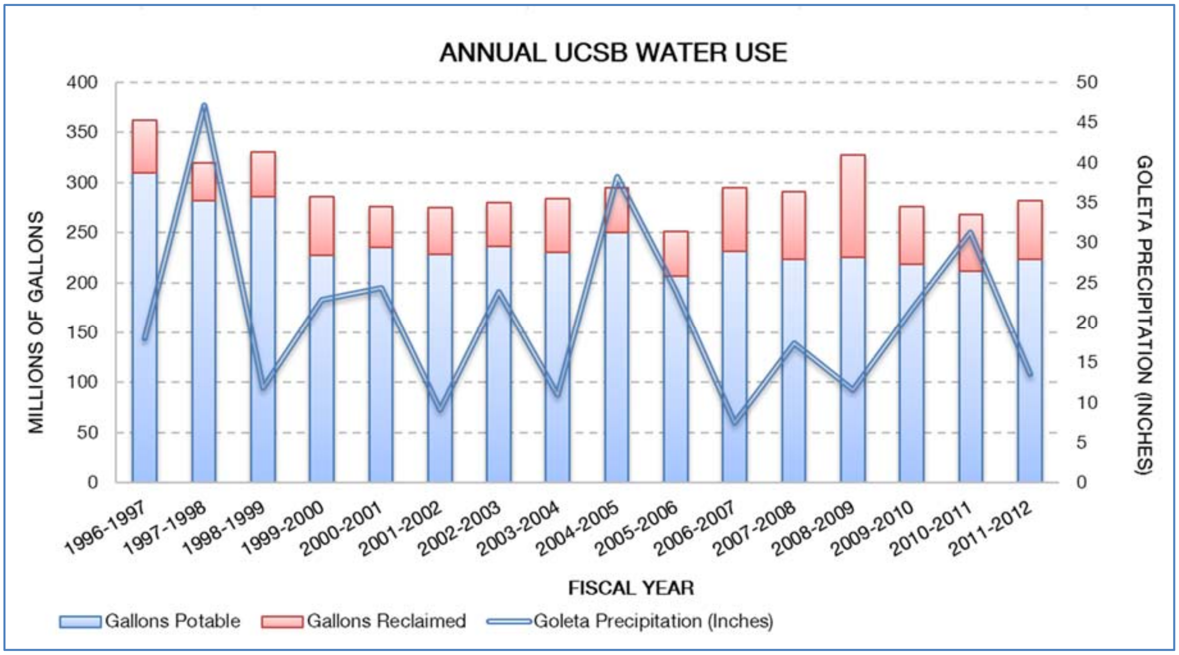


Figure 30: UCSB potable and recycled water use from FY 1996/97-2011/12 overlain with annual precipitation in Goleta, CA.

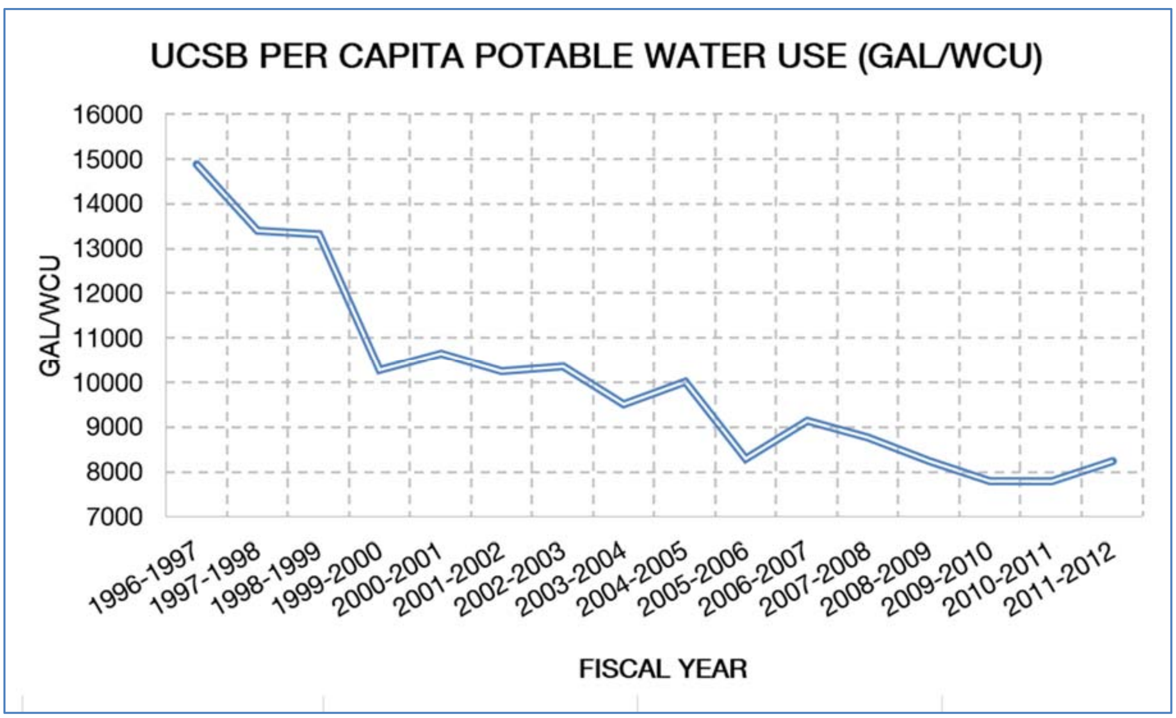


Figure 31: UCSB potable water use trends normalized by weighted campus user (WCU), a UC standardized population metric, from FY 1996/97 to 2011/12 in gallons per year.

APPENDIX XX. Survey for UCSB Water Action Plan

Purpose of the Study

In drafting the WAP for UCSB, The University of California Office of the President (UCOP) requires that the plan address the Campus community and how to educate and involve the greater community in water conservation measures[87]. The survey proposed here is intended to implement that requirement by understanding current perceptions of water use on campus and by determining if campus residents feel the need to conserve water and what they already know about water conservation. This information was used to target educational materials and outreach programs based on the current state of awareness and gain an understanding of Campus' perception of recycled water. To set goals for the implementation of a recycled system, an understanding of people's acceptance of recycled water in their housing residence was needed.

Background Information and Secondary Data

Petersen et al. (2005) found that three factors, if readily available, will result in a decreased use of resources in buildings: "knowledge, motivation and control."[88] These factors must be carefully considered in a residential hall setting because residents do not pay their utilities and thus have no direct incentive to conserve resources or a reminder to bring total utilities usage to consciousness.[89] Thus, the major struggle in conserving resources where residents live with a fixed total cost is to create awareness of total use and to provide incentives to conserve resources, such as water. Understanding the current knowledge, motivation and control of campus residents and giving them greater access to these factors will be an informing component of the WAP.

The study by Petersen et al. (2005) organized a competition in 20 of the 25 residential halls at Oberlin College to educate and monitor water and electricity use.[90] They found that the two residential halls receiving real-time feedback had the greatest percent reduction of water use (11%), while the average across all residential halls studies was 3%.[91] Students responded to a survey stating that the most popular conservation methods during the competition were "ensuring the faucets were not dripping (55%), taking shorter showers (48%) and turning the water off while they brush teeth (48%)", while washing clothes, showering less and flushing toilets were less popular.[92] Despite the ease of these conservation techniques, only 44% of students said they would continue to use these conservation strategies and 17% of students said that flushing the toilet less is an unacceptable method for saving water.[93] The study revealed that changing water conservation habits are particularly difficult to implement on a lasting level. In contrast, while the reductions in water use were modest, total electricity during the competition was reduced on average by 36%; one residential hall reduced usage by 56%.[94] The drastic difference between electricity and water shows the relatively inelastic demand for water and the importance of education to encourage campus residents to use the most popular and simple conservation techniques.

An additional element of achieving future water reductions on the UCSB Campus may be to expand the use of recycled water. For the goals involving recycled water to be successful, Campus residents need to understand and support the use. While recycled water is perfectly safe for consumption, many people feel that recycled water should only be used for activities like irrigation, and not for those activities that have significant human contact.[95] A 2010 Australian study found that 90% of those polled felt recycled water was appropriate for use in toilets, and watering and other irrigational uses received over 80% approval, but approval dropped drastically for things like laundry, air conditioning, or filling up a pool.[96] These findings suggest that people consider water less safe than it actually is, demoting recycled water to the uses of graywater and dismissing graywater entirely. Discovering if this attitude holds true in the UCSB campus community helped to inform education components of the WAP goals.

Approach

Research questions

Does the Campus Community perceive a need to conserve water, and if so what are they currently doing to reduce their water footprint? In addition, what are peoples' perception of recycled water and its' "yuck" factor?

Information from the Campus community acquired

- Each individual's environmental perspective.
- How much water campus residents perceive they are using.
- Do campus residents perceive a need to conserve water?
- Types of water use practices.
- Do campus residents actively try to reduce their water use?
- What is campus residents' current knowledge of recycled water?
- Do campus residents think recycled water is safe?
- What uses do campus residents think are appropriate for recycled water?

Sampling Plan

The target population was the campus community including faculty, staff, graduate students, and undergraduate students who live on the UCSB campus in Santa Barbara. The UCSB University Announcements was used to contact the campus community. The sample size included the entire undergraduate, graduate student population, faculty, and staff, all of whom receive the University Announcements. The population reached was roughly 32,000.

Methodology

The survey was disseminated over the internet and was quantitative and structured. The survey consisted of a series of questions that targeted the perceptions, knowledge, and practices of the population listed above. These questions consisted of yes/no questions, multiple choice responses, lists of activities that students could respond to on a scale and open comment boxes for overall environmental perspective and types of water practices. To incentivize the UCSB community to participate in the survey, all participants were entered into a raffle drawing for two $50 gift cards.

Results of the Survey

The survey was answered by 1,137 people from the UCSB communities who were over 18 years of age and actively enrolled as a student or employee at UCSB. 88% of the respondents considered themselves "environmentally friendly."

Water Conservation Awareness

Ninety-seven percent of those who responded to the survey believed that people should work to conserve water and 85% believed that UCSB residents should do more to reduce their water consumption. Most responders (77%) said that they try to reduce their water use every day. According to results, the UCSB community undertakes many basic conservation methods, like turning off the water while brushing their teeth, taking shorter showers, not flushing when only urinating, doing larger loads of laundry and/or less loads of laundry every month (Table 34). Some common reasons given for why individuals try to reduce their water consumption were because they naturally do these things, they are not hard changes to make, and they want to make an impact on the environment. However, some of the reasons respondents are unwilling to undertake conservation efforts include the perception that some of these activities are unhygienic, threaten the enjoyment of a water-related activity (e.g., a long shower), or they lack the knowledge of how to reduce the water consumption of the activity while still being able to do the activity.

Table 36: Activities that UCSB campus community members already undertake to conserve water

Activity	Number of people actively using this activity	Percentage of people actively using this activity
Turnning off the water while brushing their teeth	1046	94%
Taking shorter showers	664	60%
Not flushing the toilet after urinating	320	29%
Doing larger loads of laundry to reduce the total number of loads	916	82%
Doing fewer loads of laundry each month	709	10%
Other activities	110	10%

Attitudes towards Recycled Water

For recycled water use to be successful and reduce overall potable water consumption, campus residents need to understand and support its use. While recycled water can be treated to standards making it safe for consumption, many people feel that recycled water should only be used for activities like irrigation but not those activities that have significant human contact.[97]

The survey results showed that 71% of respondents were aware of the definition of recycled water. However, 24% of all respondents were not aware that recycled water is currently being used on-campus at UCSB for irrigation of lawns and landscaping. Students showed an interest in recycled water use. Of those surveyed, 60% said they like recycled water or had positive feelings about its use, while 36% of all respondents were neutral or had negative feelings about recycled water. While 90% of people agree or strongly agree with the use of recycled water on campus, 8% of respondents are neutral or against the use of recycled water in toilets. Only 60% of people feel that recycled water is safe for use near humans. While many people said they would accept use in toilets, not nearly as many are comfortable with use near humans (which would logically include toilet use). The biggest concern with recycled water in the survey seemed to be quality issues, with many participants citing some kind of concern about quality as the reason they are not interested in using recycled water.

In California, recycled water use must be labeled. Thus, in order to incorporate more recycled water into buildings for use near humans, UCSB would need to make the Campus community aware of the installation, usage, reasoning and treatment of the water to ensure that the process moves smoothly. The expansion of recycled water use, however, can be an important part of the overall path to a sustainable future for UCSB, and the results of this survey suggest that such an outcome is feasible.

APPENDIX XXI. Water Use Projections

Water use projections through FY 2019/20 were estimated based two metrics: the number of people on campus, using campus population growth (Weighted Campus User [WCU]) and the area of campus buildings and other developed space (measured by California Adjusted Gross Square Footage; CAGSF; OSGSF50) (APPENDIX: V, VI) (Figure 33). The WCU projections were used to calculate water use projections, because water users, rather than built-out space, are likely to drive water consumption in the long term. CAGSF alone does not correlate with increases in potable water use. For example, the construction of multiple parking garages has little to no effect on water consumption after construction; the drastic increase in CAGSF around FY 2004/05 to 2010/11 that included parking garage expansion did not result in a corresponding fluctuation in water consumption, supporting the belief that water users, not developed infrastructure, drive water consumption on Campus (Figures 3, 16). This is consistent with the overwhelming use of recycled water for landscaping, the primary water use that is not WCU-dependent.

Both projection methodologies are detailed below for reference.

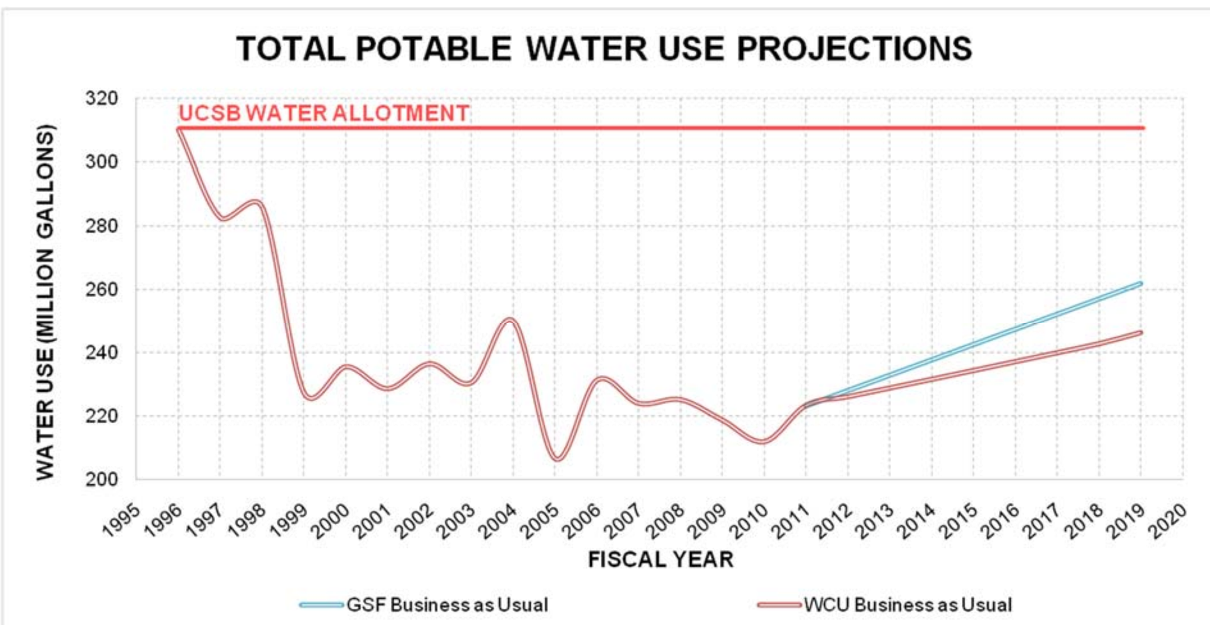


Figure 32: UCSB total potable water use projections based on business-as-usual water consumption patterns (assuming constant water use per WCU) under growing campus infrastructure (California Adjusted Gross Square Footage--CAGSF) and campus populations (Weighted Campus Users--WCU).

1. GSF projections:
   The annual projections of the California Adjusted Gross Square Footage (CAGSF; OSGSF50) align with build-out projections in the UCSB Climate Action Plan (CAP) and are based on most-likely campus expansion, rather than full build out according to the UCSB Long Range Development

Plan (LRDP).[6,98] Total expected spatial growth was calculated using the CAP's total expected growth: 1.52 million CAGSF. The total expected build-out was assumed to increase equally year-by-year between 2011/12 and FY 2019/20.

2. WCU projections:
To project campus population growth, the Weighted Campus User metric was extrapolated into the year 2020. All weighted campus user projections align with the UCSB Long Range Development Plan (LRDP) and Climate Action Plan (CAP).

The following methodology was used to project WCU:

i. Student populations (undergraduate and graduate) were increased by 1% each year. Staff and faculty growth was set to reach 6039 by 2020 (in accordance with the CAP); the total growth between FY 2011/12 and 2019/20 was averaged to a uniform increase of ~125 staff/faculty per year.

ii. This average total increase in faculty and staff per year was then distributed to the different levels of employment (ladder-rank, non-ladder-rank, etc.); the annual increases in staff, separated by level of employment, was based on the average percentage of total staff that each level of employment constituted from FY 1995/96 to 2011/12.

iii. Student and faculty and staff populations were added together (excluding study-abroad students).

3. Total Potable Water Use Projections:

a. *Business as Usual Scenario*:
Average potable water use per WCU and CAGSF from the Benchmark period (FY 2008/09-2010/11) was used to project total potable water use from FY 2013/14 thru FY 2019/20 under the Business as Usual Scenario (BAU). BAU suggests no further water conservation or efficiency efforts will occur on campus. To get BAU projected potable water use for each year, the average potable water use per WCU from the Benchmark period was multiplied by the projected WCU for that year. This was repeated using the CAGSF metric in place of the WCU metric.

Equation: (#gal/WCU)*(#projected WCU) and (#gal/CAGSF)*(#projected CAGSF)

b. *15% Target Reduction by 2020 Scenario*:

i. The average potable water use per WCU and CAGSF was projected for each year from 2013/14 thru 2019/20; initially, the 15% reduction in total potable water use from the Benchmark period by 2020 was calculated assuming no population growth. Then, a new 'water used per WCU' or 'water use per CAGSF' factor was calculated for each year. The

[6] Should the University complete 100% of the build-out scheduled in the LRDP, UCSB is expected to exceed GWD's water-allotment.

average annual total potable water consumption of the Benchmark period, decreased by an assigned annual reduction percentage and divided by the Benchmark average WCU and GSF respectively, resulted in the new 'water use per WCU' and 'water use per CAGSF' metric for each projected year. These 'water used per WCU' and 'water use per CAGSF' numbers were multiplied by projected WCU and GSF numbers respectively to yield a projected annual water use accounting for growing populations and developed space. The following shows the assumed breakdown of reductions achieved each year:

Table 37: Projected Percent Savings in Potable Water

FISCAL YEAR	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20
SAVINGS	**3%**	**3%**	**2%**	**2%**	**2%**	**1%**	**1%**	**1%**

Reductions by each fiscal year were based on the reduction strategies the University could feasibly implement in a given year.

ii. These projections do not account for the effect increasing water prices may have on demand. For this reason, total potable water projections may overestimate future potable water use.

APPENDIX XXII. Archived Water Documents

Through the creation of the *Water Action Plan*, documents have been archived with water data pertaining to UCSB's past, present, and future water use. The *WAP_Document_Archive* (2013) includes the following documents:

- **Academic_Research_Other_Sector_Water_Use:** Water use numbers from academic, research, and other non-residential buildings on UCSB Main Campus from 1996-2012.
- **Main_Campus_Restroom_Audit_2012**: A thorough audit of all academic, research and other non-residential buildings on the UCSB campus performed over the summer of 2012 that includes toilet, faucet, urinal, and other water fixture information by building/restroom.
- **Aggregated_Audit_2012_Aerators_Urinals_Toilets:** Aggregated statistics on restroom fixtures across campus based on the 2012 restroom audit of the UCSB Main Campus; includes in-situ flow testing on a sample of 31 toilets across campus as well as retrofit cost estimates.
- **Primary_Water_Data_Archive_Baseline_Benchmark:** Annual water use for all of campus from fiscal year 96/97 to 2011/12. Including water use for the baseline and benchmark using four different metrics; total water use (Gal), potable water use (Gal), Gallons per waited campus user (WCU), and gallons per California gross square footage (GSF).
- **H&RS_Water_Use:** Annual and monthly aggregated Housing & Residential Services water use from the main campus recharge account and apartment buildings off of the main line.
- **Water_Use_by_Sector:** Annual water use from 96/97 to 2011/12 broken out by sector.
- **WAP_GSF:** California-Adjusted (OSGS50) Gross Square Footage used to normalize water-use from years 1996-2012; adjusted for the geographic scope of the WAP.
- **WAP_Weighted_Campus_User:** Campus population (per capita) metric from 1996-2012 used to normalize water use numbers.
- **UCSB_WaterUse_vs_Precipitation:** Comparison between annual potable water use and precipitation that falls on the UCSB campus.
- **Main_Campus_Water_Use_by_Sector (From Invoices):** Monthly main campus water use broken out by state and non-state funded buildings, and Academic & research and other buildings using the utilities bills for main campus.
- **Meter_Inventory_Of_Campus_2012.xlsx**: Lists the meters currently installed on campus, and those building lacking meters.
- **Res_Hall_Inventory_&_Water_Use_Calculations:** An inventory of residential halls and apartments on the UCSB campus performed over the summer of 2012 that includes toilets, faucets, showers, and other water fixture information by building/restroom. From this information, extrapolations were made to calculate historical and future water savings.
- **Aggregated_Audit_2012_Aerators_Urinals_Toilets:** Aggregated statistics on restroom fixtures across campus based on the 2012 restroom audit of the UCSB Main Campus; includes in-situ flow testing on a sample of 31 toilets across campus as well as retrofit cost estimates.
- **GIS_Data**
  - **Potable_Reclaimed_Distribution:** Pipe infrastructure schematics for potable and reclaimed water pipes on the UCSB Main Campus.

    - **Reclaimed_Water_System:** Detailed map of the reclaimed water delivery system on the UCSB Campus.
- **Economic_Analysis**
    - **EA_Irrigation**
    - **EA_Toilets**
    - **EA_Industrial**

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