University of California, Berkeley

UC BERKELEY WATER USAGE & CONSERVATION STUDY REPORT

Chancellor's Advisory Committee on Sustainability

Prepared for: Chancellor's Advisory Committee on Sustainability

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December 4, 2010

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EXECUTIVE SUMMARY

In order to address California's fourth consecutive year of drought, the State of California has issued a state of emergency, passed water conservation legislation, and ordered immediate action to mitigate a potential water shortage crisis. In response, the Chancellor's Advisory Committee on Sustainability (CACS) at University of California, Berkeley commissioned this report to better understand baseline water consumption and identify areas of opportunities for water conservation with a focus on domestic[1] and industrial use of potable water in campus buildings and Auxiliaries. Past reports on campus water consumption have not included all buildings and operations. In addition, there are not sufficient meters and sub-meters to adequately assess usage and trend. A feasibility study of water conservation opportunities is conducted to identify potential water saving projects.

2009 California Delta-Water Bill Package Summary (http://gov.ca.gov/issue/water-supply):

- A new seven-member board to oversee the Sacramento-San Joaquin River Delta.
- **A 20 percent conservation mandate for urban areas by 2020, with credits for cities that have made significant conservation efforts.** Agricultural entities would have to follow best practices for water use.
- New regulations to monitor groundwater levels throughout the state.
- Increased penalties for illegal water diversions, although the penalties and enforcement were significantly weakened from an earlier plan.
- A $11.1 billion bond to pay for the overhaul.

BENCHMARKING

Benchmarking research focused on other large universities' water usage profiles. Water consumption at a range of universities was examined, including other research institutions and universities who have successfully reduced their consumption[2]. Total water usage by institutions of higher education varies substantially by size, location and climate, efficiency of water usage, and other factors.

It was not possible, however, to accurately analyze UC Berkeley's usage against these benchmarks. Not all universities report water consumption and not all use the same protocol for

[1] Domestic usage includes toilet, urinal, faucet and shower usages.

[2] Benchmarking information is obtained from http://www.greenreportcard.org/ for 2010 for Arizona State University, Georgia Institute of Technology, Pomona College, UC Davis, Duke University, UC San Diego, Harvard University, and University of Washington. Follow-up phone calls were made to a smaller number of institutions.

reporting usage[3]. In addition, there has been limited analysis of broad water usage patterns in higher education.

It was possible to examine best practices at other universities. The most common steps being taken by universities are one with a relatively low upfront cost: education and outreach, enhanced leak detection and repair, improved irrigation practices, and installation of low-flow domestic fixtures (toilets, faucets, and showers). There are also examples of institutions who have reduced water usage in laundries and cooling towers or who have found ways to expand the use of non-potable water (e.g., through water reuse or rainwater capture).

There were few schools, however, who had found it economical to convert all domestic features to low flow or to implement some of the more costly projects (e.g. conversion of all cooling towers to a closed loop system). All such universities identified in this analysis were located in the southeastern United States, which is experiencing a severe drought and possible near-term water shortages. Otherwise, schools reported that relatively low water pricing meant that the financial feasibility of many projects was not sufficient for implementation.

RESEARCH OF EXISTING STUDIES AND POLICIES

There are rich resources of past studies, projects, policies and educational programs regarding water at U.C. Berkeley. One of the key documents evaluated is the "A Sustainable Water Plan for the University of California Berkeley" by Jubilee Daniels 2005.

In the report, Daniels covered historic and current water use and disposal, campus sustainability policies, main campus water audit and result, the residence halls water audit and result, and case studies of water conservation and reuse with new development and major renovations. Critical sections including main campus water audit and residence hall water audit have provided much assistance to the study. The conservation recommendations are illustrated in the graph below.

Figure 7.1 UC Berkeley Main Campus Potential Water Consumption in 2020: With and Without Conservation Practices

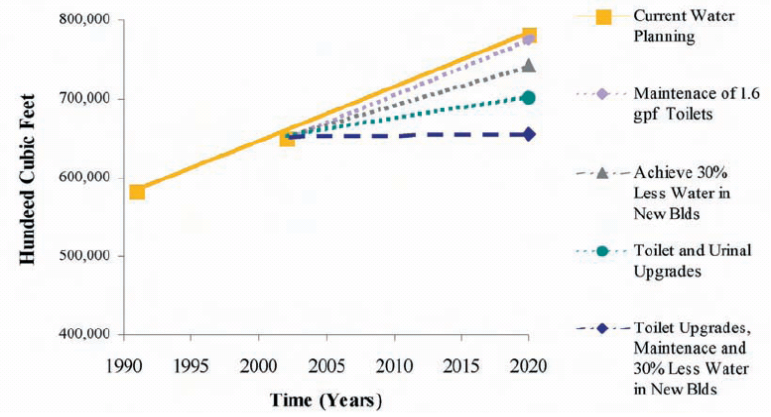

Figure 1: "A Sustainable Water Plan for University of California Berkeley" (Daniels, 2005)

[3] Key differences include how to report use of non-potable water sources and whether institutions were reporting usage by all campus buildings and operations.

DATA COLLECTION

In collaboration with U.C. Berkeley Physical Plant-Campus Services, Cal Housing, and East Bay Municipal Utility District (EBMUD), historical potable water consumption data have been collected and compiled. In the past campus Sustainability Assessments (2005, 2008, 2009), annual consumption was reported as the total of nine main campus meters covering area approximately bounded by Hearst Ave., Piedmont Ave., Bancroft Way and Oxford St. In this study, however, in addition to the above, usage at residence halls and 98 additional water accounts[4] outside of the campus boundary is studied. While there are nine major water meters on campus and a number of smaller building meters present, complete historical consumption data have not been reported on an on-going basis. Furthermore, many individual functions/locations currently do not have working water meters, making it difficult to understand usage and trend.

DATA ANALYSIS

There are three main categories of data studied: main campus accounts, 98 additional accounts and Residence Hall accounts.

- The nine main campus accounts usage has been provided by Physical Plant-Campus Services (PP-CS).
- The usage of 98 ADDITIONAL accounts including nine F & H accounts, one FIRE SERVICE account and 88 OTHER accounts has also been collected from PP-CS. Of the nine F & H accounts, two Lawrence Berkeley National Lab accounts were removed.
- Residence hall usage data is based on the historical records provided by EBMUD. It includes the list of accounts under "Housing and Dining" in the EnergyCAP Online system. Because these accounts do not provide the association with specific residence units, educated estimation is made based on investigation of the meter addresses in the system.

With the complete sets of historical usage data from 1990 to 2009, a trendline analysis is performed to study the usage pattern of the total consumption, main campus, other accounts and residence halls. Overall, other than residence hall usages, all other usages have shown remarkable reduction since 1990.

Additional analysis includes gallons/capita/day and gallons/square foot analysis. It is shown by the usage that gallons/capita/day dropped from 64 gallons in 1990 to 49 gallons in 2009 and gallons/square foot dropped from 58 gallons in 1990 to 39 gallons in 2009.

Furthermore, as it is important to understand the breakdown of the total water usage, a categorization has been developed to assist with further analysis. Because 2008 data are most inclusive and accurate, total consumption for 2008 was used for the breakdown analysis. Major categories include "Steam Plant", "Irrigation", "Lab Building", "Domestic—Residence Halls", "Domestic—Other Buildings", and "Other". Among which, "Domestic—Other Buildings" includes all campus domestic usage which is calculated based on the types of the restroom

[4] Two accounts for LBNL are excluded (6600791 and 6600801).

fixtures (3.5 gpf[5], 1.6 gpf and etc) and the total campus population (staff, faculty, visitor and student).

Domestic usage was estimated using an attendance-based analysis method. Assuming an average person (student, staff, faculty, or visitor) uses the restroom three times per day: a female uses the toilet three times, and a male uses the toilet once and the urinal twice. Based on the inventory of campus restroom fixtures, an average gallon per flush is calculated and extrapolated to total annual consumption assuming 250 days per year and 51,000 daily campus populations.

RESULTS

Change in Consumptions between 1990 and 2009

Year	1990	2009	% change
Total Consumption	739,296,692	639,886,496	-13%
Main Campus	504,155,740	435,620,240	-14%
Other Accounts	77,067,566	30,697,172	-60%
Residence Halls	158,073,386	173,569,084	10%

Table 1: Consumption Change

Total Consumption

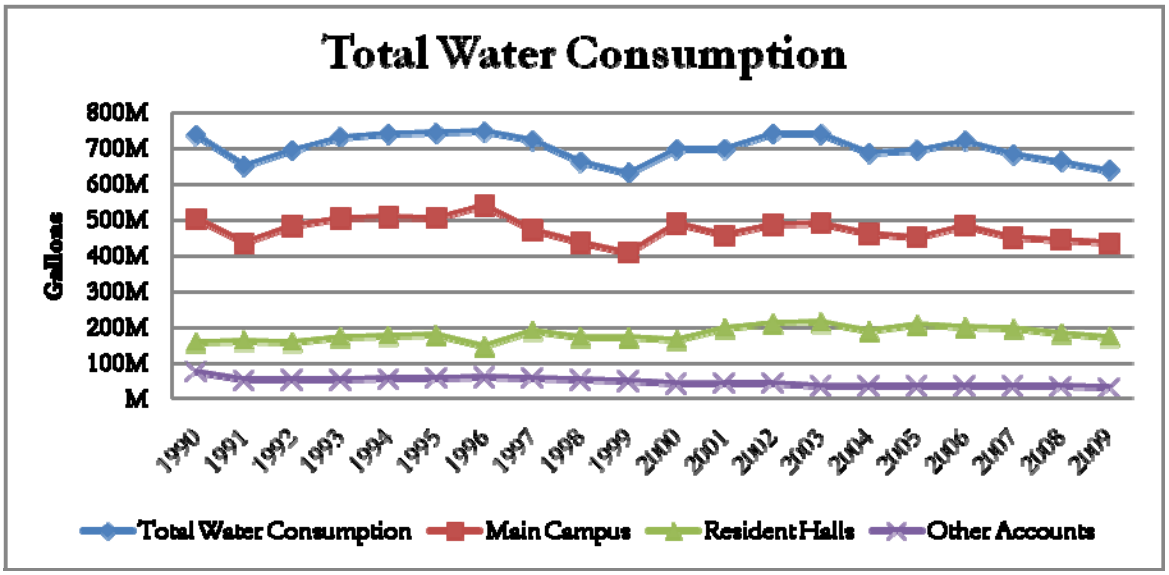

Figure 2: Total Water Consumption (Gallons)

[5] Gpf stands for gallon per flush.

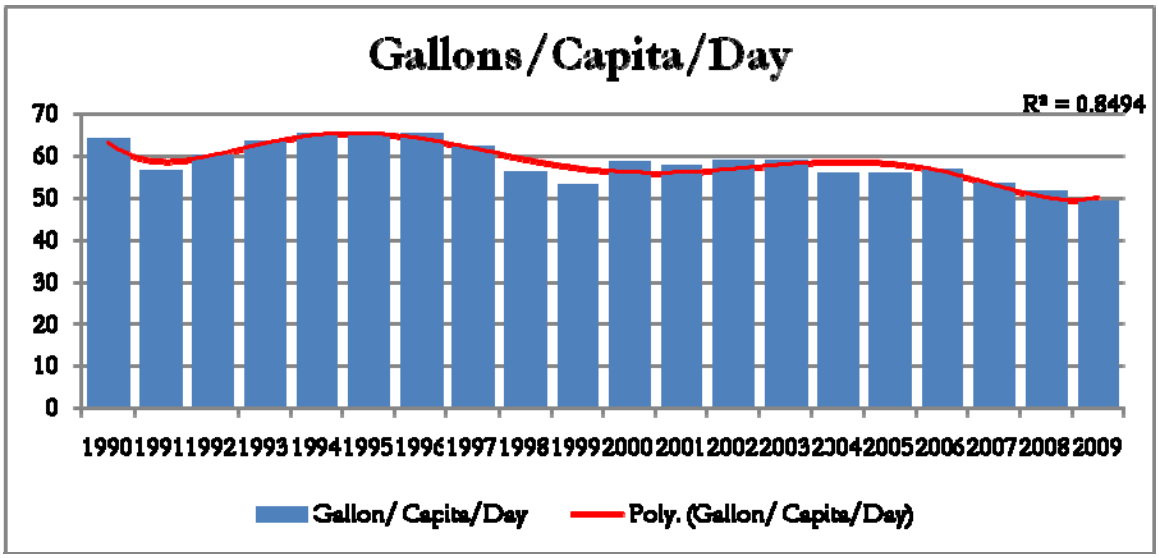

Figure 3: Total Consumption Gallons/Capita/Day

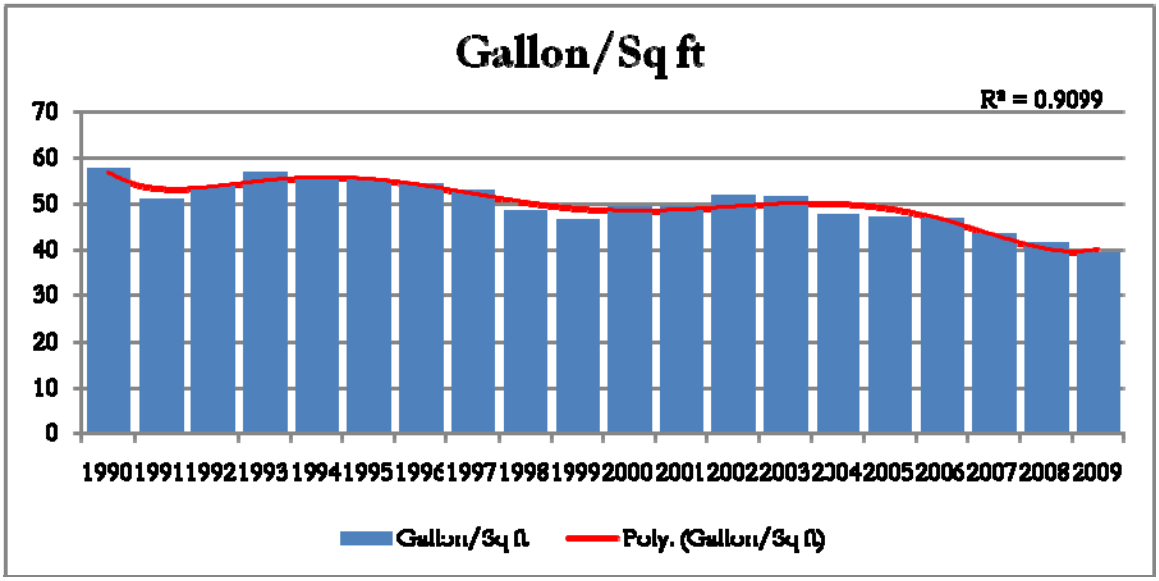

Figure 4: Total Consumption Gallons/Square Foot

Assumptions/Notes:

1. Total consumption include usage from main campus accounts (9) and additional off campus accounts (98), including industrial usages and Residence Hall usages.
2. The additional accounts (1990-1997) usage data extrapolation is based on assumption that usage in these accounts changed by the same percentage as did the main accounts.

3. Total population includes FTE staff, FTE faculty, students, and assumed 2000 visitors per day.
4. Assumed Year = 250 days.

Main Campus Accounts

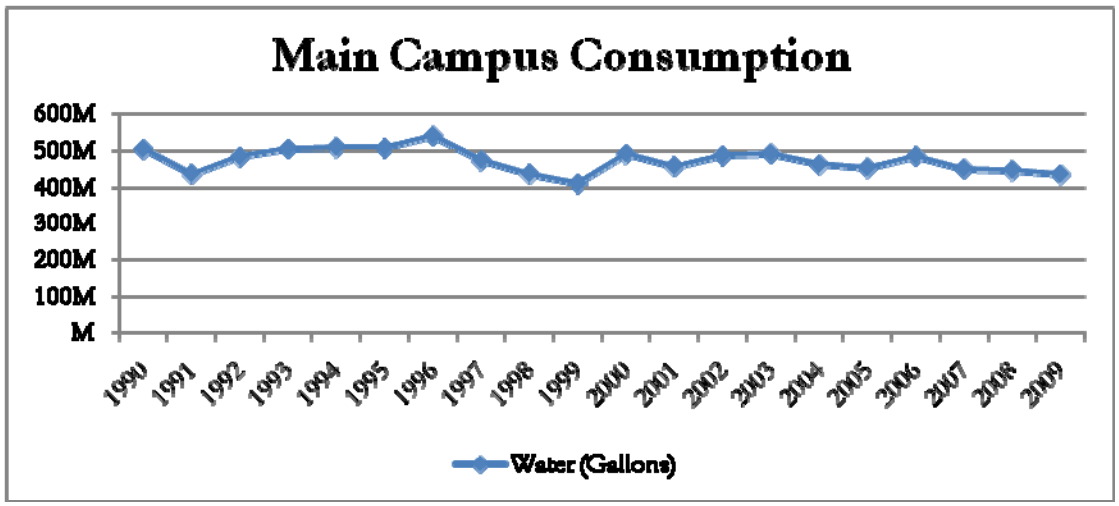

Figure 5: Main Campus Consumption

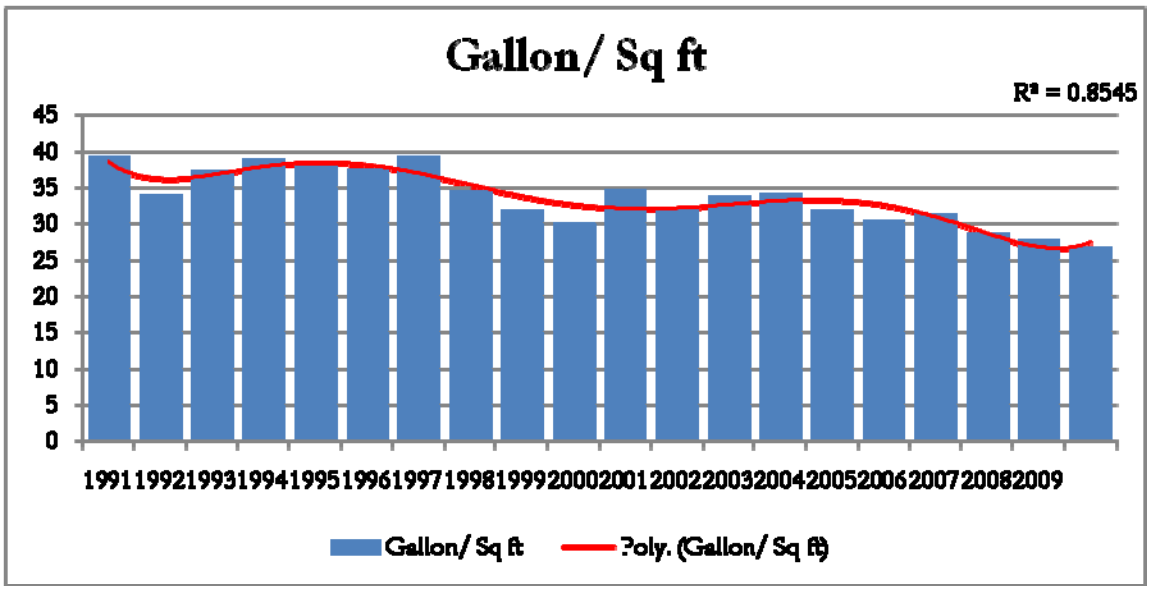

Figure 6: Main Campus Gallon/Sq Ft

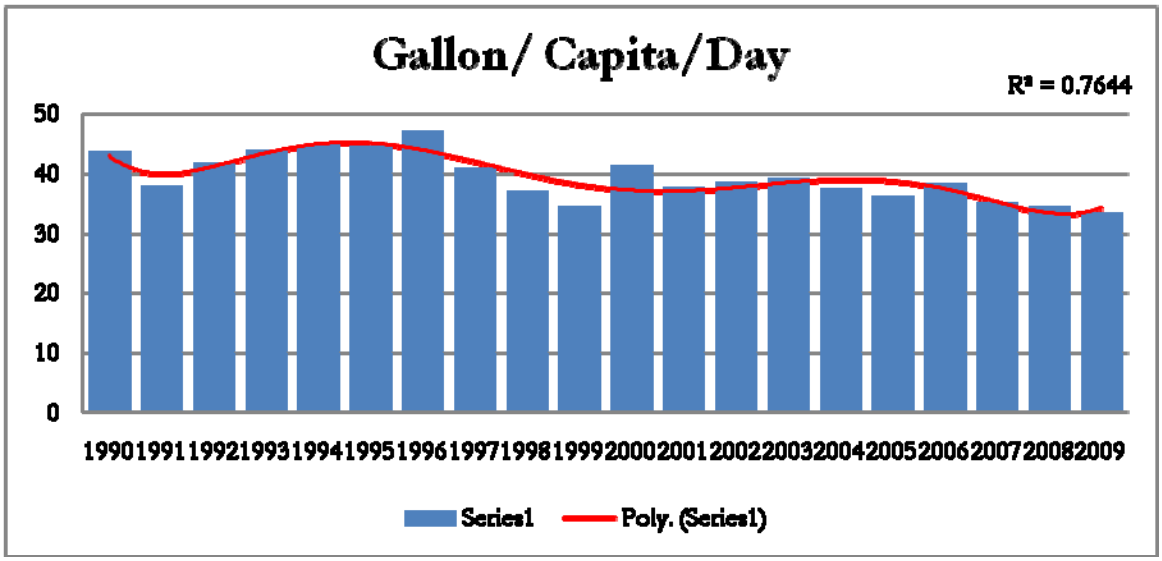

Figure 7: Main Campus Gallon/Capita/Day

Other Accounts

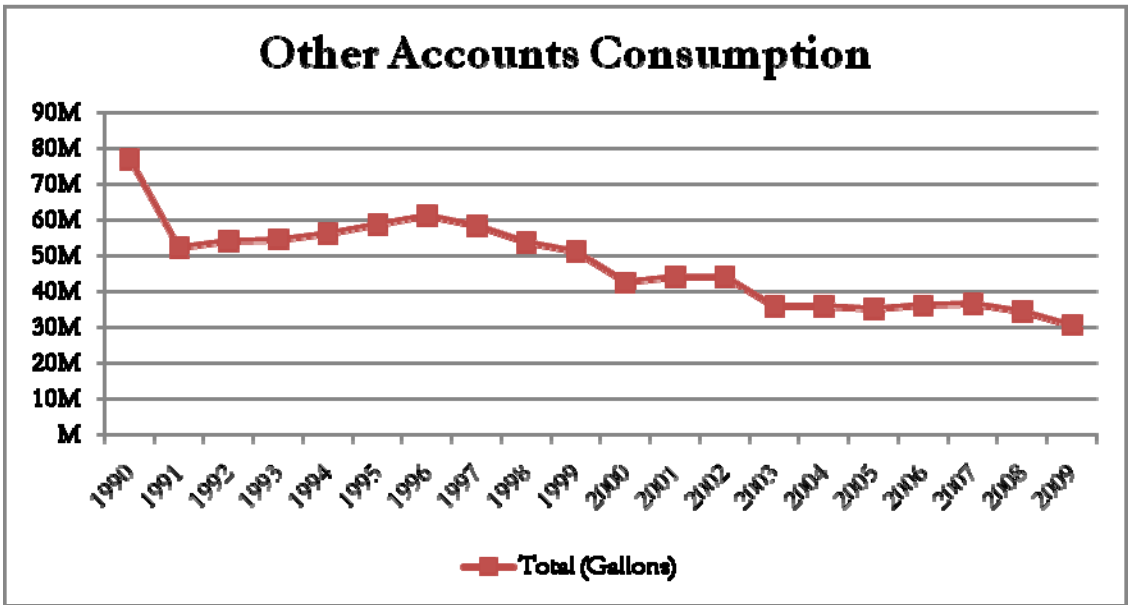

Figure 8: Other Accounts Consumption

Residence Hall Accounts

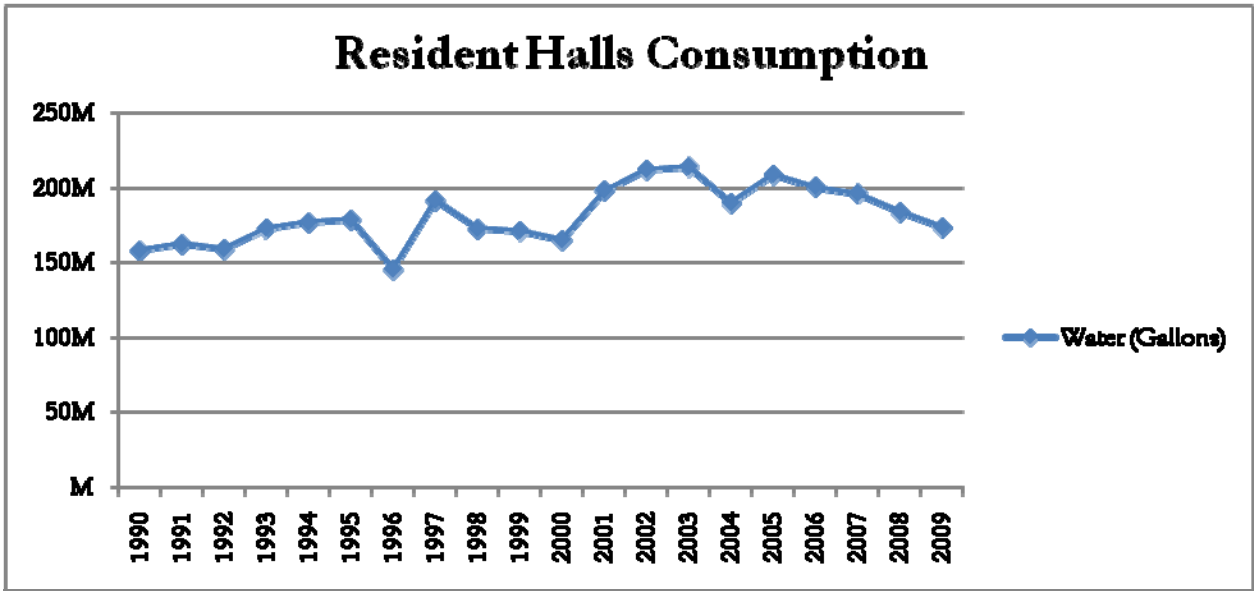

Figure 9: Residence Hall Total Consumption (Gallons)

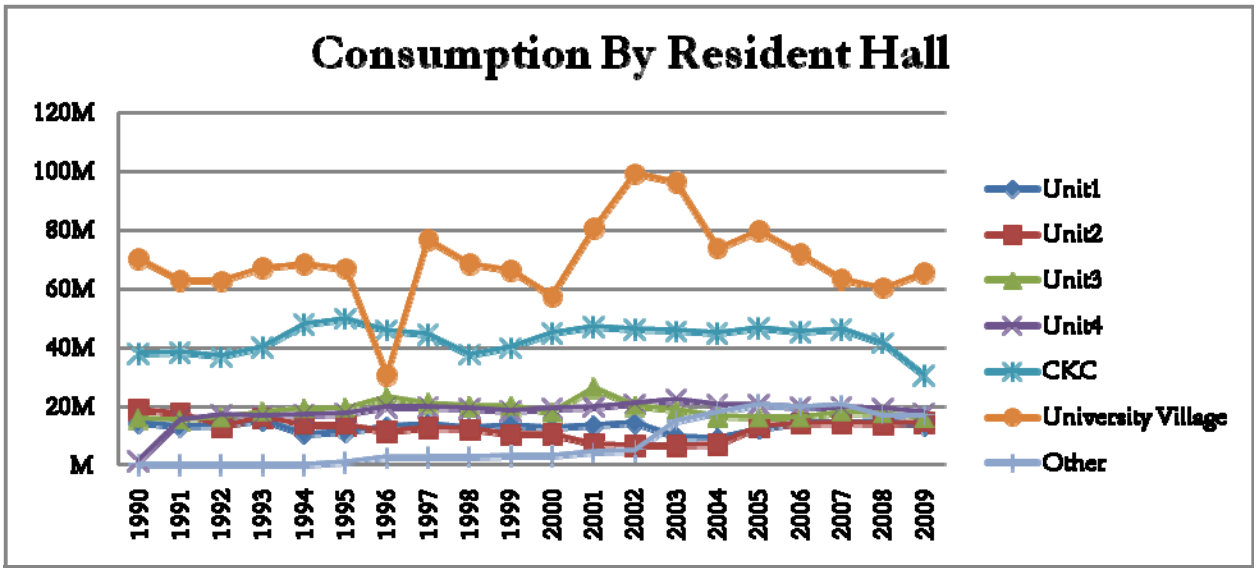

Figure 10: Residence Hall Consumption by Location

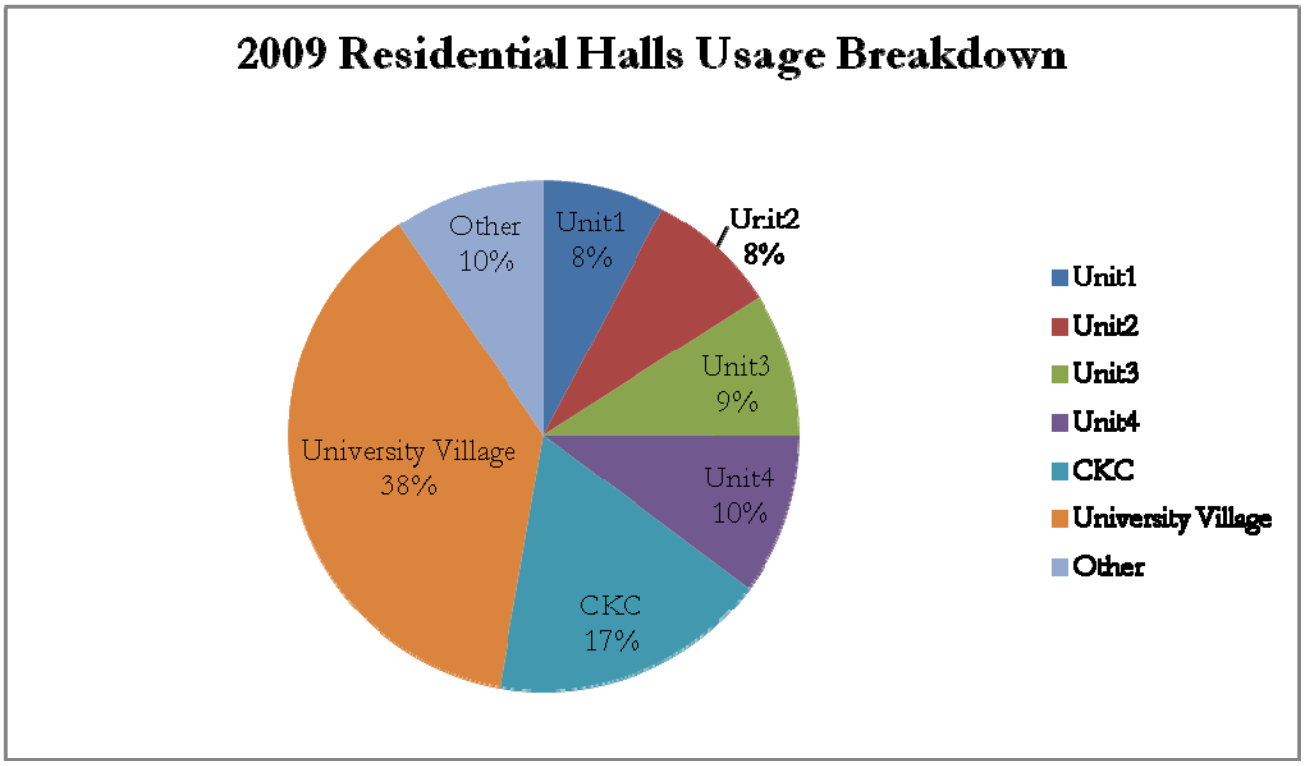

Figure 11: 2009 Residence Hall Consumption Breakdown

Assumptions/Notes:

1. 1990-2009 water consumption data are based on EBMUD records which include Unit 1, 2, 3, 4, CKC and Other. (Other includes Channing & Bowditch Apt, Haste Street Child Development Center, Manivlle Apt, RSSP Building, University Village and Westminster)

Consumption Breakdown

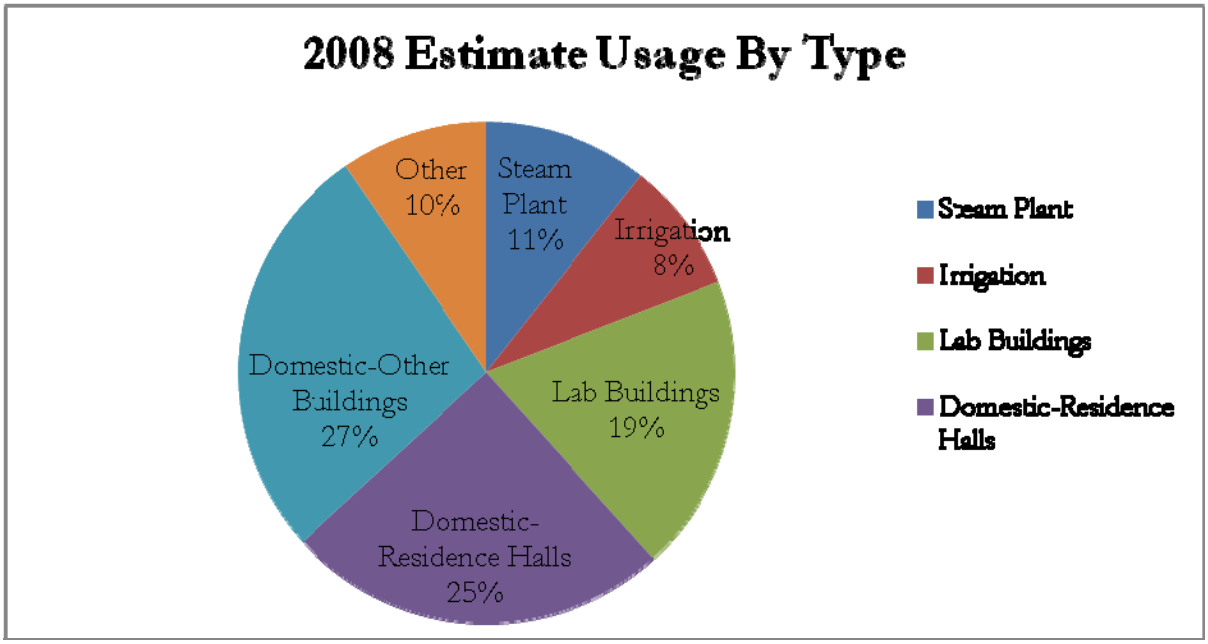

Figure 12: 2008 Estimated Campus Usage By Type

Assumptions/Notes:

1. The breakdown is analyzed from the total consumption in 2008 which includes main campus accounts, other accounts and residence hall accounts.
2. Assume Irrigation includes campus irrigation and residence halls irrigation.
    a. Assume current campus metered irrigation only accounts for 95% of campus irrigation.
    b. Assume residence halls irrigation accounts for 10% of total residence hall usage.
3. Consumption from labs buildings including Latimer, Stanley, Koshland, LSA, VLSB, Birge, Etcheverry, McCone, Soda, Cory, and Hildebrand is obtained, of which 10% is assumed to be domestic usage and 90% is assumed to be lab usage.
4. Assume 90% of Residence Hall usage is domestic.
5. Assumed 90% of ADDITIONAL accounts is domestic.
6. Assumes "Domestic-Other Buildings" includes campus restroom usages, 90% of ADDITIONAL account, and RSF showers.
    a. Assume 25% of RSF visitors shower after exercise.
    b. Assume gallon per min is 2 at RSF.
    c. Assume average length of shower is 8 min.
7. Assumes "Other" category includes swimming pools, leaks, and other miscellaneous usage.

Extrapolated Building Domestic- Campus Restroom Water Usage

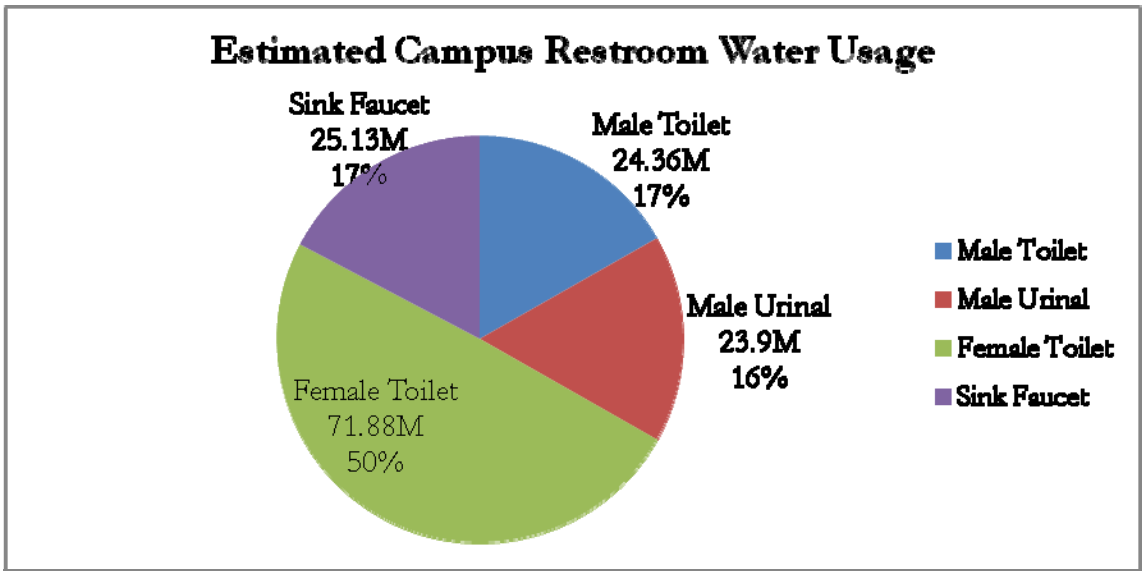

Figure 13: Estimated Campus Restroom Water Usage

Assumptions/Notes:

1. GPF (Gallon Per Flush) is calculated to be a weighted average for low flow and non low flow fixtures based on Jubilee Daniel's restroom fixture audits.
2. Assume low flow= 1.6 gpf toilet and 1.0 gpf urinal.
3. Assume non-low flow=3.5gpf toilet and 1.6 gpf urinal.
4. Assume gallon per min for faucets is 2.
5. Assume average length of hand washing is 10 sec.
6. Assume 74% of men and 83% of women wash hands after using the bathroom. (http://www.asm.org/Media/index.asp?bid=21773)
7. Assume restroom user rate is Females 3 times a day, Males 1 a day for Toilets/ Twice a day for Urinals (Vickers, 2002).
8. Assume Year = 250 days.
9. Assumed employee Male to Female ratio is 1:1.
10. Total population includes FTE staff, FTE faculty, students, and assumed 2000 visitors per day.

FEASIBILITY STUDY

A list of feasible projects is identified under three main categories: Possible Main Campus Project, Possible Auxiliary project, and Other Projects. The following table describes the Main Campus and Auxiliary Projects.

Proposed Project	Description	Annual Water Savings (gallons)	Annual Water Savings (%)	Upfront Capital Cost ($)	One Time Rebate	Net Annual Costs (Savings) ($)	Simple Payback (years)	Total Net Present Value ($)
Possible Main Campus Projects								
General Education & Awareness Campaign	Assumes broad base campus campaign to raise awareness and reduce water usage with unknown impact.			$20,000		-$10,000		
Install Water Meters in Large Buildings	Install 40 meters assuming $5000 cost per meter which includes PPCS labor costs			$200,000				
Enhanced Leak Reduction Efforts	Assumes all leaking toilets are repaired (per CalCAP course analysis)	4,265,372	0.6%	$10,000		$18,989	0.53	$127,917
Expand Sink Aerator Installations	Assumes 700 additional bathroom sink aerators are changed to 0.5 gpm from 2gpm	6,548,025	1.0%	$3,841		$29,151	0.13	$126,636
Campus Toilet Conversion	Assumes 75% of toilets are retrofitted to low-flow	25,940,000	3.9%	$527,742	$37,913	$115,482	4.24	$2,079,414
Campus Urinal Conversion	Assumes 75% of urinals are retrofitted to low-flow	5,640,000	0.8%	$265,698	$76,350	$25,109	7.54	$534,963
Replace Heat Exchangers (2)	Replace two leaking heat exchangers	2,102,400	0.3%	$100,000		$9,360	10.68	$228,834
Replace Heat Exchangers (10)	Replace 10 leaking heat exchangers	10,512,000	1.6%	$500,000		$46,798	10.68	$1,144,168
Subtotal w/ 2 Heat Exchangers Replaced		**44,495,797**	6.7%	**$1,127,281**		**$188,090**	5.99	**$3,097,763**
Subtotal w/ 10* Heat Exchangers Replaced		**52,905,397**	8.0%	**$1,527,281**		**$225,528**	6.77	**$4,013,097**
Possible Auxiliary Projects								
Behavior & Fixture Improvement in Auxiliaries	Assumes reduction in water consumption at Residence Halls and RSF through reducing shower length	16,000,000	2.4%	TBD		$71,229.95	TBD	TBD

Table 2: Project Feasibility

Assumptions:

1. Capital costs -- including hardware and labor -- are all incurred in first year.
2. Discount rate = 6%
3. Estimated annual water savings from enhanced leak reduction efforts from CalCAP course analysis (2007).
4. Assumes cost of water is $3.33 per ccf.
5. Assumes General Education and Awareness Campaign's costs include 20,000 upfront cost and 10,000 annual cost.
6. Assumes the water saving for replacing 312 aerators is 2,918,548.33 gallon per year. With additional 700 aerators replaced based on inventory check, the total estimated water saving is 2,918,548.33/312*700 (Sink Aerator Replace Program Fall 2009)
7. Assumes the cost for upgrading 312 aerators is $1440+$272.12=$1712.12 . With 700 aerators replaced the cost is estimated to be 1712/312*700 (Sink Aerator Replace Program Fall 2009)
8. Assumes the cost for converting to low flow toilet and urinal is the sum of hardware cost and labor cost. Hardware cost =$400/fixture. Labor cost=$74/hour for 4 hours/fixture. (CalCAP course analysis).
9. Assumes the water savings for converting 75% of all campus (excluding residence halls) non low-flow toilets (1011) to low flow (1.6 gpf) toilets is 25 M gallons. (Toilet Water Conservation. Joanna Zhang. Feb 2010).
10. Assumes the water savings from converting 75% of all campus (excluding residence halls) non low-flow urinals (509) to 1 gpf urinals (75%) and 0.125 gpf urinals (25%) is 6 M gallons (Toilet Water Conservation. Joanna Zhang. Feb 2010).
11. Assumes there is a $50/fixure rebate for low flow toilet. (http://www.ebmud.com/for-customers/for-residence-customers/conservation-rebates-and-incentives/high-efficiency-toilet-r)
12. Assumes there is a $200/fixture rebate for low flow urinal. (EBMUD Water Management Program. 3/20/2008)
13. Assumes upfront cost for replacing a heat exchanger is $50,000.
14. Assumes annual water saving for replace a leaking heat exchanger is 2 gpm (leak rate) * 60 * 24 *365.
15. Assumes the number of leaking heat exchanger to be replaced is 10*.
16. Heat exchanger analyses do not include credit for returned condensate or cost of re-heating new water.
17. Assumes annual savings for Auxiliaries is 16M gallons through reducing shower usage and etc. (Res Hall Conservation. Joanna Zhang. Feb 2010)
18. Assumes upfront cost for Auxiliary conservation project is $50,000 and annual operating cost is $20,000.
19. Assumes some of the major buildings already have water meters that allow real-time monitoring, some through TGIF fund. The water meter cost, including PPCS labor cost is $5000.

Other Projects to be further analyzed include:

1. More efficient irrigation-- Fix leaks in irrigation system and meter and connect all irrigation systems to the SCADA system.
2. Convert Irrigated Lawns to Dry Meadows-- Project includes a planning charrette, development of planning guide, signage, and lawn conversion of one of multiple possible sites. (Project underway with TGIF funding)
3. Install more efficient dishwashers and laundry machines
4. More efficient lab equipment
5. Cooler Tower Consolidations or Conversion to Closed Loop

COST TABLE

Fiscal Year	State-Funded Water & Sewer Expenditures	Recharge Water & Sewer Expenditures	Residence Halls Expenditure	Current Prediction of TOTAL Water & Sewer Expenditures	Net Annual Savings	% Savings
FY 07-08	$2,007,986	$866,998	$1,174,650	4,049,634	$259,320	6.4%
FY 08-09	$2,007,986	$820,166	$1,087,593	3,915,745	$259,320	6.6%
Proj. FY 09-10	$2,129,025	$954,646		3,083,671	$259,320	8.4%

Table 3: Cost Table

1. Assumes the Annual Savings is $259,320 per year.
2. Residence hall expenditure is taken from ENERGYCAP Online where the FY cost is estimated from splitting two Calendar year cost.

REUSE AND RECYCLE OPTIONS

According to "Alternative Water Reuse Scenarios for the UCB Campus with Cost-Benefit Analysis" (2008) by Bojana Anglin, Kristin Maravilla and Lindsay Miller, there are four recycle and reuse scenarios for the UC Berkeley: campus-wide recycled water, treated greywater reuse within a single building (new construction or major upgrades), grey water from dorms and campus buildings for subsurface irrigation and rainwater capture.

The campus-wide recycled water scenario assumes "about half of the water that UC Berkeley campus uses, all of which is currently potable, could be substituted with non-potable water" after it has been treated to a tertiary level. Costs associated with such scenario include pipeline

installation, site assessment, engineering reports, treatment plant, and operational costs (Anglin, Maravilla, Miller, 16).

The scenario of treating greywater for reuse purpose within a single building "involves collecting greywater from either campus dorms or buildings, treating the greywater and using it for toilet flushing" (Anglin, Maravilla, Miller, 18) Major costs include both construction costs and operational costs where "construction costs included in the cost benefit analysis consist of greywater treatment systems (tanks and air compressors), water recycling systems (ozone and RO), shipping and installation and dual plumbing" and operational cost "consists of parts replacement (motors, pumps and air compressors)" (Anglin, Maravilla, Miller, 22).

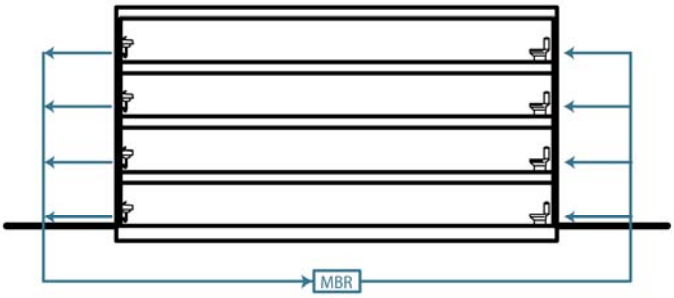

Figure 14: Greywater Schematic for Toilet Use (Anglin, Maravilla, Miller, 2008)

Grey water from dorms and campus buildings for subsurface irrigation scenario studies the "potential for greywater to be collected, screened and stored for subsurface irrigation use" (Anglin, Maravilla, Miller, 22). Construction costs include costs for tanks, pumps, lines and plumbing parts and estimated operation costs included consists of parts replacement for drip lines, landscape filter fabric, tank adaptors and pumps (Anglin, Maravilla, Miller, 25).

Figure 15: Greywater Schematic for Irrigation (Anglin, Maravilla, Miller, 2008)

The rainwater capture scenario analyzes the feasibility of capturing rainwater on building rooftops and using it for irrigation and internal plumbing. According to the report, "building rooftops comprise 24.7% of the central campus' total area (GISC, 2008)… Cumulatively, they can capture 42,308.21 CCF per year, and could supply 7% of main campus' annual water use (Escobar, 2008)." (Anglin, Maravilla, Miller, 29). The costs associated with the scenario include cost of rainwater catchment system, maintenance cost, pipe, storage infrastructure and necessary retrofitting which is hard to estimate.

Based on the cost-benefit analysis, it is shown by the report that all of the above scenarios have net present values negative or close to zero. Furthermore, the report shows that the "analysis must be considered in the context of volumetric water savings, under which they [the scenarios] all yield very little." (Anglin, Maravilla, Miller, 33).

RECOMMENDATIONS

CACS Recommendations

The Chancellor's Advisory Committee on Sustainability (CACS) reviewed an earlier version of the "UC Berkeley Water Usage and Conservation Study" and discussed the steps that the campus could take to reduce the use of potable water on campus. See the box below for the full list of the CACS recommendations approved at its February 25, 2010 meeting.

The *usage reduction target* of 20% was recommended after reviewing the project feasibility study and includes the estimated reduction in usage from the elimination of potable water for irrigation. An impediment, though, is identifying a source of non-potable water to meet current irrigation demand. East Bay Municipal Utility District (EBMUD) sells reclaimed water to its customers, but the closest reclaimed water lines are currently about a mile from campus. In conversations with campus staff, EBMUD has indicated that they may be developing plans to extend those reclaimed water lines to campus in the next 10 years, but we currently have no confirmation of these plans.

The *proposed working group* could be given a short-term, specific mandate to complete the analysis, design a comprehensive water reduction strategy and provide progress reports to CACS, the Chancellor, and the broader campus. CACS further recommends that all *large buildings are metered*. There is a project underway to install new water meters on campus, with resources from PPCS and The Green Initiative Fund. Approximately 40 more buildings would need to be metered in order to reach the CACS goal. The Committee also wants to ensure that new construction and major renovations are designed and implemented to minimize the use of potable water. The *two LEED credits* discussed will provide a framework for that effort.

At the 7th Annual Sustainability Summit on April 21, Chancellor Birgeneau addressed several of these recommendations. He indicated that funding is being sought to pay for the identified conservation projects, and indicated that the campus will address water conservation through the LEED process for new construction and major renovations. He also stated that "we ultimately should have goals for water conservation that are commensurate with the goals we have already established for carbon production."

CACS Recommendations

- Commit the University to reduce potable water usage by 20% (from 2008 levels) and to use no potable water for irrigation by 2020.
- Establish a working group to oversee the analysis and implementation of reduction projects, drawing membership from faculty, staff, students, auxiliaries, and utilities.
- By 2020, ensure all buildings larger than 50,000 ft^2 have water meters that allow real-time monitoring of usage and are web enabled.
- Beginning June 1, 2010, maximize the number of LEED™ credits achieved under Water Use Reduction Credits #3 and #4 by all new construction and major renovation projects.

Table 4: CACS Recommendations

Research Recommendation

Based on the findings of this research report, a few additional recommendations are made to the campus.

Research Recommendations

- Setting a reduction target with specific planned projects.
- Installing water meters on major campus buildings that allow real-time monitoring of usage and are web enabled.
- Promoting education and awareness campaigns.
- Investigating more recycle and re-use options.

Table 5: Research Recommendations

SPECIAL THANKS

Thanks to multiple stakeholders without whom the report would have been possible.

Lisa McNeilly: for guiding the entire research and providing valuable inputs.

Chancellor's Advisory Committee on Sustainability: for providing useful data and important comments.

Kira Stroll, Judy Chess, Lisa Bauer, Irene Seliverstov

East Bay Municipal Utility District: for providing vital residence hall usage data.

Charles Bohlig, Maureen O'Toole, James Carmody

Past Research and Projects: for providing valuable research findings.

Jubilee Daniels, Bojana Anglin, Kristin Maravilla, Lindsay Miller

Physical Plant-Campus Service: for providing essential campus account usage data.

Sara Shirazi, Gilbert Escobar, Ben Palaima

Residence & Student Service Programs: for providing central information on projects and initiatives.

Jeff Urdahl, Larry Taylor

REFERENCE LIST

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APPENDIX

Year	Total Water Consumption	Main Campus	Other Accounts	Resident Halls	Total Pop	Gallon/ Capita/Day	Sq Ft	Gallon/Sq ft	Annual % Change
1990	739,296,692	504,155,740	77,067,566	158,073,386	46,120	64.12	12,817,517	57.68	0%
1991	651,100,388	436,324,856	52,325,680	162,449,852	45,933	56.70	12,817,517	50.80	-12%
1992	696,333,895	482,945,452	54,182,618	159,205,825	46,262	60.21	12,947,468	53.78	7%
1993	732,851,099	505,176,760	54,682,814	172,991,525	46,060	63.64	12,951,334	56.58	5%
1994	742,104,292	509,056,262	56,234,367	176,813,663	45,433	65.34	13,426,331	55.27	1%
1995	744,788,978	507,283,876	58,884,722	178,620,380	45,509	65.46	13,520,471	55.09	0%
1996	747,765,098	540,818,960	61,210,806	145,735,332	45,757	65.37	13,774,993	54.28	0%
1997	723,437,989	473,642,015	58,413,534	191,382,440	46,331	62.46	13,715,959	52.74	-3%
1998	663,019,453	436,619,568	53,847,613	172,552,272	47,134	56.27	13,666,540	48.51	-8%
1999	632,337,745	409,845,656	51,204,581	171,287,508	47,552	53.19	13,637,595	46.37	-5%
2000	698,696,578	490,990,940	42,518,431	165,187,207	47,565	58.76	14,145,728	49.39	10%
2001	699,457,581	457,203,032	44,133,244	198,121,305	48,499	57.69	14,185,391	49.31	0%
2002	742,884,325	486,778,204	44,220,012	211,886,109	50,350	59.02	14,380,360	51.66	6%
2003	741,967,349	492,357,162	35,795,166	213,815,021	50,200	59.12	14,425,806	51.43	0%
2004	687,807,598	462,011,176	35,976,930	189,819,492	49,131	56.00	14,469,548	47.53	-7%
2005	696,776,670	453,033,680	35,149,268	208,593,722	49,884	55.87	14,827,825	46.99	1%
2006	722,116,551	485,434,048	36,098,106	200,584,397	50,700	56.97	15,464,279	46.70	4%
2007	683,505,456	450,766,492	36,647,138	196,091,826	51,138	53.46	15,675,971	43.60	-5%
2008	664,359,150	446,190,228	34,396,032	183,772,890	51,567	51.53	15,986,234	41.56	-3%
2009	639,886,496	435,620,240	30,697,172	173,569,084	52,013	49.21	16,297,576	39.26	-4%

Table 6: Annual Consumption

Year	Water (Gallons)	Sq ft	Total Pop	Gallon/ Sq ft	Gallon/ Capita/Day	% change from previous year
1990	504,155,740	12,817,517	46,120	39.33	43.73	0.00%
1991	436,324,856	12,817,517	45,933	34.04	38.00	-13.45%
1992	482,945,452	12,947,468	46,262	37.30	41.76	10.68%
1993	505,176,760	12,951,334	46,060	39.01	43.87	4.60%
1994	509,056,262	13,426,331	45,433	37.91	44.82	0.77%
1995	507,283,876	13,520,471	45,509	37.52	44.59	-0.35%
1996	540,818,960	13,774,993	45,757	39.26	47.28	6.61%
1997	473,642,015	13,715,959	46,331	34.53	40.89	-12.42%
1998	436,619,568	13,666,540	47,134	31.95	37.05	-7.82%
1999	409,845,656	13,637,595	47,552	30.05	34.48	-6.13%
2000	490,990,940	14,145,728	47,565	34.71	41.29	19.80%
2001	457,203,032	14,185,391	48,499	32.23	37.71	-6.88%
2002	486,778,204	14,380,360	50,350	33.85	38.67	6.47%
2003	492,357,162	14,425,806	50,200	34.13	39.23	1.15%
2004	462,011,176	14,469,548	49,131	31.93	37.61	-6.16%
2005	453,033,680	14,827,825	49,884	30.55	36.33	-1.94%
2006	485,434,048	15,464,279	50,700	31.39	38.30	7.15%
2007	450,766,492	15,675,971	51,138	28.76	35.26	-7.14%
2008	446,190,228	15,986,234	51,567	27.91	34.61	-1.02%
2009	435,620,240	16,297,576	52,013	26.73	33.50	-2.37%

Table 7: Main Campus Consumption

Year	F&H Water	Other	Total in CCF	Total (Gallons)
1990	55,395.2	47,636.3	103,031.5	77,067,566.5
1991	47,942.1	22,012.0	69,954.1	52,325,680.2
1992	53,064.7	19,372.0	72,436.7	54,182,617.7
1993	55,507.4	17,598.0	73,105.4	54,682,814.3
1994	55,933.6	19,246.0	75,179.6	56,234,367.1
1995	55,738.9	22,984.0	78,722.9	58,884,722.1
1996	59,423.6	22,409.0	81,832.6	61,210,806.4
1997	52,042.4	26,050.5	78,093.0	58,413,533.5
1998	47,974.5	24,014.3	71,988.8	53,847,612.7
1999	43,111.0	25,344.3	68,455.3	51,204,580.6
2000	31,152.5	25,690.3	56,842.8	42,518,430.6
2001	24,246.5	34,755.2	59,001.7	44,133,243.9
2002	24,293.5	34,824.2	59,117.7	44,220,011.9
2003	27,162.5	20,692.0	47,854.5	35,795,166.0
2004	29,612.5	18,485.0	48,097.5	35,976,930.0
2005	28,569.0	18,422.0	46,991.0	35,149,268.0
2006	27,144.5	21,115.0	48,259.5	36,098,106.0
2007	26,297.0	22,696.5	48,993.5	36,647,138.0
2008	25,063.5	20,920.5	45,984.0	34,396,032.0
2009	25,063.5	20,920.5	45,984.0	30,697,172.0

Table 8: Other Accounts Consumption

Year	Unit1	Unit2	Unit3	Unit4	CKC	University Village	Other
1990	14,319,020	18,611,742	15,793,221	1,251,428	37,901,964	70,169,104	26,907
1991	13,146,118	17,596,696	15,234,487	15,400,533	38,349,997	62,695,109	26,912
1992	13,426,578	13,126,613	15,945,125	17,185,192	36,879,624	62,600,835	41,858
1993	15,028,062	15,949,656	18,053,637	16,699,052	40,060,682	67,164,453	35,983
1994	10,626,826	13,487,230	19,071,738	17,076,705	48,012,548	68,490,667	47,949
1995	11,123,547	13,315,896	19,311,929	17,335,592	49,819,830	66,859,303	854,283
1996	12,961,423	11,386,091	22,951,640	19,503,411	45,954,213	30,569,246	2,409,308
1997	14,116,964	12,699,472	21,105,474	19,560,955	44,560,597	76,791,968	2,547,010
1998	12,413,055	12,024,829	19,981,941	19,168,251	37,618,467	68,573,665	2,772,064
1999	13,440,822	10,234,839	20,056,818	18,318,476	39,907,384	66,374,572	2,954,597
2000	12,495,309	10,454,787	17,713,494	19,189,353	44,838,188	57,374,659	3,121,417
2001	13,312,158	6,821,808	26,304,933	19,798,824	47,051,411	80,658,274	4,173,897
2002	14,223,250	6,593,629	20,171,997	20,732,413	46,084,277	99,294,785	4,785,758
2003	9,631,212	6,403,693	18,531,567	22,356,974	45,577,837	96,495,810	14,817,928
2004	9,053,749	7,023,722	16,584,844	20,400,996	44,829,971	73,903,200	18,023,010
2005	12,313,651	13,143,087	15,979,436	20,440,503	46,600,989	79,725,596	20,390,460
2006	14,184,349	14,119,236	15,936,816	19,781,030	45,293,636	71,864,089	19,405,241
2007	14,533,719	14,242,004	17,992,345	19,534,598	46,192,731	63,303,265	20,293,164
2008	14,840,263	13,934,496	17,358,698	19,053,636	41,539,427	60,317,999	16,728,371
2009	13,389,943	14,280,068	15,770,731	17,681,391	30,415,983	65,420,786	16,610,182

Table 9: Residence Hall Consumption

Year	Students	Facutly	Staff	Total	Visitor	TOTAL	Sq ft
1990	30638	5458	8025	44120	2000	46,120	12,817,517
1991	30372	5494	8067	43933	2000	45,933	12,817,517
1992	30622	5530	8109	44262	2000	46,262	12,947,468
1993	30341	5567	8152	44060	2000	46,060	12,951,334
1994	29634	5604	8195	43433	2000	45,433	13,426,331
1995	29630	5641	8238	43509	2000	45,509	13,520,471
1996	29797	5678	8282	43757	2000	45,757	13,774,993
1997	30290	5716	8325	44331	2000	46,331	13,715,959
1998	31011	5754	8369	45134	2000	47,134	13,666,540
1999	31347	5792	8413	45552	2000	47,552	13,637,595
2000	31277	5830	8457	45565	2000	47,565	14,145,728
2001	32128	5869	8502	46499	2000	48,499	14,185,391
2002	33145	6514	8691	48350	2000	50,350	14,380,360
2003	33076	6706	8418	48200	2000	50,200	14,425,806
2004	32814	6068	8249	47131	2000	49,131	14,469,548
2005	33558	6075	8251	47884	2000	49,884	14,827,825
2006	33933	6256	8511	48700	2000	50,700	15,464,279
2007	33948	6389	8801	49138	2000	51,138	15,675,971
2008	34623	6316	8628	49567	2000	51,567	15,986,234
2009	35013	6711	8289	50013	2000	52,013	16,297,576

Table 10: Population and Area

Campus Restroom

Non-low flow stall	1011
Non-low flow urinal	509

		Campus							Faucet	
		Stalls-M		Stalls-F		Urinals				
A	Number of Fixtures	418	137	593	266	509		118		
B	Existing average gallons/flush	3.5	1.6	3.5	1.6	1.5		1.0	2.0	
	Current State Model Assumptions/output									
H	Computed annual gallons	**16.99M**	**2.55M**	**46.72M**	**9.58M**	**15.7M**		**3.61M**	**25.13M**	**120.27M**
	Total	**95.1M**								
	Future State Model Assumptions/output		assuming replacement		75%					
I	Low flow average gallons/flush	1.6	1.6	1.6	1.6	1	0.125	1	0.5	
K	Computed annual gallons (J x A)	**10.07M**	**2.55M**	**27.7M**	**9.58M**	**9.81M**	**.25M**	**3.61M**	**6.28M**	**69.85M**
	Variance	6.92M	.M	19.02M	.M	5.64M		.M		50.43M
		41%	0%	41%	0%	36%		0%		
	Computed Water Consumption Savi	31.58M	25.94M	5.64M					.M	
		Total	Toilet	Urinal						
										50.43M
										41.9%

Table 11: 75% Toilet Fixture Replacement

Fall 08

		Male %	Male Count	Female%	Female Count
Student	34,623	0.5	17,312	0.5	17,312
Faculty	6,316	0.5	3,158	0.5	3,158
Academic Staff	8,628	0.5	4,314	0.5	4,314
Visitor	2,000	0.5	1,000	0.5	1,000
Total Count	51,567		25,784		25,784

Type	#of non low flow	Total Count	% non low flow
Female Toilet	593	859	69.03%
Male Toilet	418	555	75.32%
Urinals	509	627	81.18%

	M Toilet	Urinal	F Toilet
# of Flushes per day	1	2	3
# of Total Flushes Per Year	6,445,875	12,891,750	19,337,625
GPF	3.03	1.49	2.91
Total Gallon Per Year	19,537,389	19,171,081	56,304,230
			95,012,700

Table 12: Campus Domestic Usage Calculation

Length of Hand Washing	0.17	min		
	M	F		
% Wash hands after bathroom	74%	83%		
	Stalls-M	**Urinals**	**Stalls-F**	**Total Annual Gallons**
Total Flushes	19,537,389	19,171,081	56,304,230	
2	4,819,223	4,728,867	15,577,504	25,125,593

Table 13: Campus Domestic Consumption