

**Running Water:
Student Water Use and Conservation in Smith Houses**

Hannah Jaris
Smith College
May 7, 2009

Abstract

Water is a natural resource that is too often taken for granted. At a place like Smith College where the sprinklers are set to go off in the quad every night at midnight and there is always cool water in the dining halls, clear water in the bathrooms, and hot water in the showers, it seems as if it is endless supply. Unfortunately water is not a renewable resource and humans are quickly depleting the small percentage of freshwater that is actually available for our use. Smith is taking the first steps towards becoming a more sustainable institution through decreasing its carbon foot print. However, there is also a growing interest in looking at other issues that do not directly impact climate change, such as water use and how to reduce the amount and rate at which water is being used on campus. In order to accomplish this task behaviors surrounding water need to be identified and attitudes towards water reframed. Through this project we determined the largest and smallest consumptive behaviors surrounding water use on the Smith College campus. Working in collaboration with the Sustainability Director Dano Weisbord, analyzing several of the college's quarterly water bills, and comparing those results to the results collected from a survey distributed to a fraction of the student body about when and how they use water, we developed a series of recommendations for the immediate future and the long term that we hope will successfully help to reduce the amount of water Smith uses on a yearly basis.

Introduction

For normal household purposes, domestic water use includes drinking, food preparation, watering lawns and gardens, flushing toilets, bathing, and washing clothes. The United States Geological Service (USGS) estimated that domestic water use increased by four percent between

1985 and 1990 (USGS, 1990) and in 2000 it was estimated that about 408 billion gallons of water were withdrawn per day from natural sources such as watersheds, for domestic uses (Hutson, 2004). The use of water across the globe is a growing concern as humans continue to endanger the earth's natural resources. It is up to the leaders in the United States to educate the public on how to live sustainably. As Uhl *et al.* (2001) discuss Universities and colleges are in a unique position to address such a challenge.

The President of Smith College, Carol Christ, joined a group of other American College and University President's in November of 2007 in signing the American College and University Presidents Climate Commitment. In signing this President Christ recognized the "scientific consensus that global warming is real and is largely being caused by humans" (*American College and University Presidents Climate Commitment*). In signing their names to this document the Presidents also recognized the need to reduce global emissions of greenhouse gases by 80% in order to avert the worse impact of global warming. This commitment places responsibility on institutions such as Smith College to take a larger role in working to reestablish more stable climatic conditions. It is now the responsibility of Smith to exercise leadership in the community and throughout society by addressing the climate change challenge. This document has put Smith on the path to carbon neutrality, and water use on the Smith College campus plays a direct role in the college's carbon foot print as a large amount of electricity is required to heat water.

Becoming a sustainable campus involves a number of changes, a main one being to learn to live with limits. Living with limits involves an awareness and understanding that natural resources such as water are finite and should be used with care and prudence (Uhl, 2001). It also requires that people, especially students on college campuses realize we are in fact all

interconnected and that problems such as water conservation are not insurmountable if the responsibility is shared among individuals (Uhl, 2001).

Dano Weisbord, director of sustainability at Smith College is looking to find ways to reduce the college's carbon foot print. One of the main areas of focus is the amount of electricity used by the campus, because electricity use is the largest contributing factor to Smith's carbon footprint. According to the United States Department of Energy in the average American home water heaters account for a quarter of the home's energy use and on average, about 13% of the utility bill (Winkle, 1982). At an institution such as Smith College with a student body of about 2,600 these numbers will be much higher. Water use on campus is directly related to energy consumption because the 2,600 students require hot water, and energy is required to heat that water, which in turn requires the burning of fossil fuels resulting in the release of carbon dioxide into the atmosphere. Thus, it is of great importance to target the frequency and quantity of hot water consumption across campus. If these values are determined strategies on way to limit or reduce such behaviors can be developed and implemented.

While water use on campus directly relates to the Climate Action Plan, water consumption is an issue whose importance goes beyond that of the climate impact alone. Understanding this, Dano Weisbord and the Committee on Sustainability are hoping to address water use on campus beyond the impact it is having on the climate. Their approach would involve reducing the total amount of water used by the college. When looking at ways to reduce the amount of water consumed, there are two approaches that can be taken. The first, the efficiency approach involves spending money to purchase newer efficient models or putting money into making appliances such as shower heads, washing machines, and dishwashers, more efficient. The second approach to reduction of water consumption is the conservation approach

which relies on using less of what one already has. As Robin Winkler (1982) points on in an essay, plants have an inherent ability to conserve water by reducing water loss through transpiration, a process of moderating water use that is not available to humans. However, behavioral systems can be created to generate similar results. As the current state of the economy requires the college to re-prioritize its budget, the conservation approach is most appealing. In our study of student behavior towards water use, we take the conservation approach by attempting to pinpoint which student behaviors, if any; can be targeted to reduce water use on campus.

Methodology

Water Use on Smith College Campus

The goal of this project was to determine student behaviors surrounding water use on campus that had the potential to contribute to the reduction in the total amount of water the college uses in a year, if targeted effectively. Because water consumption cannot be defined by a single measurable behavior (Winkle, 1982) a careful assessment of the behaviors surrounding water use that need to be changed was necessary. To look at how much water Smith College currently uses and where on campus the greatest amounts of water are consumed we arranged a meeting with the Sustainability Director, Dano Weisbord. To understand just how much water Smith uses in a year we looked at the water bills the college received from December 2004 through the most recent pay period, December 2008. These water bills represented the only record of water consumption on campus as there are no current means of monitoring water use in individual buildings.

Each water bill covers water consumption over a three month period, as the college is charged for water on a quarterly system. In the December 2004 to March 2005 pay period the college consumed a total of 15,441 hundred cubic feet of water which is equivalent to an astronomical 11,549,120 gallons of water. In analyzing the data presented in the water bills we hoped to determine where on campus the most water was being used and how student behaviors were related to consumption. From the consumption values presented in the water bills, it was concluded that the student houses were the largest consumers of water on campus. Thus we designed a survey to assess student behavior towards water use within the on campus student houses. The surveys were distributed to a subsample of the student population and questioned students about their use of water within their house. Generally individual domestic activities that account for the most water used on a daily basis, such as showering, and toilet flushing, take place within an individual's place of residence.

Smith College is unique from its peer institutions in that there is not one large dining hall where all students eat, but rather a series of smaller dining halls in a number of different houses on campus. These dining halls use large industrial dish washers at every meal. While some of the larger dining halls on campus are open 24 hours a day, seven days a week, some of the smaller dining halls are only open for certain meals and are not open on the weekends. We expected that no matter the hours of dining, the amount of water used in houses with kitchens would be much higher than that used in houses without dining, because of the industrial dishwashers. We analyzed water consumption based on the values presented in the quarterly water bills and saw, unsurprisingly, that the majority of water consumed by the college was consumed in the student houses (Figure 1).

Further analysis of water consumption within the houses on campus revealed a difference in the amount of water used in houses with dining compare to water use in housing without dining. This led to the decision to distribute the survey to houses without dining. The logic behind such a decisions being that when it came time to compare the results of the survey to our analysis of the water bill we would be better able to relate student behaviors to actual values of water use if the data was not skewed by the water consumed by industrial dishwashers.

Assessment of student behavior towards water on campus

Of the 36 houses on campus we chose five to which we distributed our survey: Sessions House, Jordan House, Lawrence House, Haven/Wesley, and Park Complex. On the water bill Haven and Wesley are listed as two separate houses though for the purpose of our project the houses were combined. We deemed the easiest way to distribute the surveys to students living in these six residential houses was through the House Presidents and because there is one House President for both Haven and Wesley we pooled their water consumption for our analyses. The houses selected were those that did not have active dining halls, no industrial dishwashers, and thus a more realistic estimate of water consumption by students on campus. Students living in houses with dining have no control over how often the dishwashers run, or how much water the machines use.

The survey was distributed to a total of 340 from three of the six main residential areas on campus, Green Street, Center Campus, and the East Quad. An incentive of a gift certificate to WoodStar Café was given to encourage students to fill out the surveys. We allowed the students three weeks to complete the surveys before organizing and analyzing the data. From our analysis we developed recommendations that can be used in the future by Dano Weisbord, the Committee

on Sustainability, as well as student leaders such as House Presidents, to help Smith College reduce the amount of water we currently use on a daily basis.

Analysis of water efficiency on campus

Another goal of our project was to gauge the current level of efficiency of water use in student residences on campus. To do this we decided to test the efficiency of shower heads on in several of the houses. Morrow House used funds from their own house budget, an amount of money allocated to every student house at the beginning of each academic year, to purchase water efficient shower heads. To test typical shower head efficiency in houses campus we were granted permission from the House Presidents of Lawrence House and Sessions Houses to measure the amount of time it took to collect one gallon of water from a shower head in their houses' bathrooms. Water flow was measured in seconds. We conducted two trials for each shower and then normalized the data for each shower head to gallons of water used per minute in each shower.

Results

Analysis of Water Consumption Across Campus

In analyzing of the quarterly water bills from December 2004 to December 2008, we looked at a total of 12 statements. We did not look closely at the statements covering the three months of summer vacation as almost the entire student body is not on campus at this time and our main concern was investigating and targeting individual student behaviors towards water use when students are on campus. To determine where the largest amounts of water were being used we summed the total amounts of water used in academic buildings and summed the total amount

of water used in student houses per pay period. The decision to sum the consumption values in this way was made based on the fact that traditionally students divide their time between their house and the academic buildings. The amount of water consumed is reported in hundreds of cubic feet on each quarterly water statement. We converted this number to gallons in order to have a better visual understanding of just how much water was being used on campus. The results of our analyses are displayed in Figure 1, and showed that the student houses, by far, are the main source of water consumption on the Smith College campus.

Further analysis was conducted on the water use in houses on campus and is displayed in Figures 2 and 3. Figure 2 shows the water consumed in houses without dining. Figure three, with higher consumption values, shows the amount of water consumed, in gallons, by houses with dining. We separated this data by houses with and those without dining because after talking with Mr. Weisbord we concluded that the presence of dishwashers in a house would skew our conclusions about how and what specific student behaviors were contributing to Smith's water bill. In both Figures 2 and 3 there are clear outliers in the data, such as the above average consumption of water by Hopkins House from August 2006- November 2006.

The water use data was normalized for each house by the total number of residents in each house to make comparison of water use between houses more accurate. Figures 2 shows that on average, a student living in a house without dining, such as a resident of Morris House, will use about 3,000 gallons within a water bill pay period, which is equivalent to about three months. The water use for the average resident of a house with dining such as King House was observed to be slightly higher, about 5,000 gallons per three months, though included in this amount was the water consumed by industrial dish washers (Figure 3). Though we tried to find out how much the average industrial dishwasher in the dining hall used we were not successful.

Water use in five of the six houses surveyed showed similar rates of consumption with the occasional outlying pay period (Figure 4). Jordan House was excluded from this chart because its water use was pooled with that of other quad houses that had dining, and water use for each individual house could not be accurately separated from the sum. Because the amount of water consumed by student seems relatively constant between houses we assumed that the amount of water used by resident in Jordan House falls within the range of 3,000-5,000 gallons for three months.

Survey Data Analysis (Identifying specific student behavior)

Analysis of survey results showed that the largest consumptive behaviors of students at Smith, that is the behaviors during which students used the most water, were letting the water run while washing their face and letting the water run while waiting for it to reach the desired temperature. The lowest consumptive behaviors, the behaviors that contribute least to water use on campus were shaving and brushing teeth. These behaviors were found to be the largest and lowest consumptive behaviors on campus based on our criteria that a behavior was considered to contribute largely to water use if more than 50% of the students surveyed characterized themselves as exhibiting that behavior, and if it was preformed more than once a day. Under this criteria behavior such as washing dishes and filling water bottles, both which potentially can contribute a great deal to water use on campus become less important as these were the activities that the majority of students did the least often in the average week.

When looking at the raw survey data collected we focused on the frequency of a behavior and the duration for which it was preformed. For the purpose of our project we defined wasted water as water that went down the drain when it was not necessary. The data collected

concerning face washing on campus showed that 68% of students surveyed ran the water at least once a day while washing their face (Figure 4) and that 67% of students polled ran the water for one to two minutes while washing their face (Figure 5). An alarming 15% of students polled said they ran the water for up to four minutes while washing their face. A second largest consumptive behavior was the amount of time students spent waiting for the water to reach the desired temperature. Our analysis revealed that 89% of students polled run water one time five times per day while waiting for it to reach the desired temperature (Figure 6), and that 81% of students polled ran that water anywhere from one to ten minutes waiting for it to reach the appropriate temperature.

The two behaviors from our survey that contribute least to the total amount of water used on campus are brushing teeth and shaving. Analysis of the survey results showed that 66% of students turn the water off while they are brushing their teeth (Figure 8). This proportion of students not running water when brushing teeth seems to decrease with the number of times a day a student brushes their teeth but the survey did not normalize for the number of times each individual brushed their teeth in a 24 hour period. The results from our analysis of how much water was wasted when students were shaving showed that 52% of students do not let the water run when they shaved, a proportion of students that also includes individuals who shave every other week (Figure 9).

Showerhead efficiency analysis

The results from our shower efficiency tests are presented in Tables 1 and 2 and show that compared to the current water efficient shower heads on the market (reference) the shower

heads, in looking at gallons per minute used alone are more efficient. However, there was much room for sampling error in our tests.

Tables and Figures

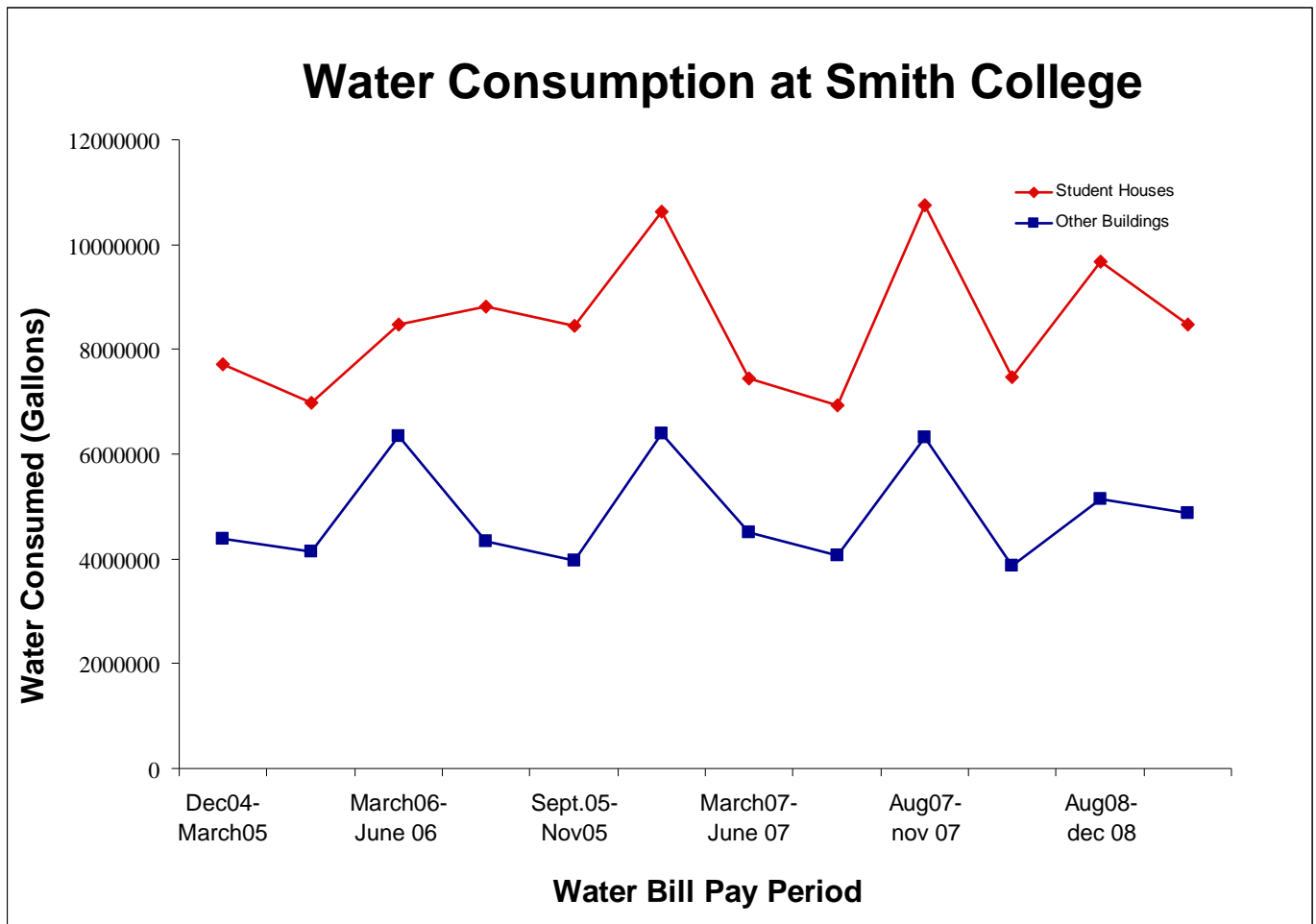


Figure 1: The raw data provided by the quarterly water bills sent to Smith from December 2004 to December 2008 were separated by buildings on campus, into either “student houses” or “other buildings”. The water consumed during each pay period was converted from hundreds of cubic feet to gallons and plotted against each pay period. The red line represents the amount of water consumed per three month period over the past four years by residential houses and the blue line represents the amount of water used by the other buildings, academic, grounds, athletics, etc., per pay period over the last four years.

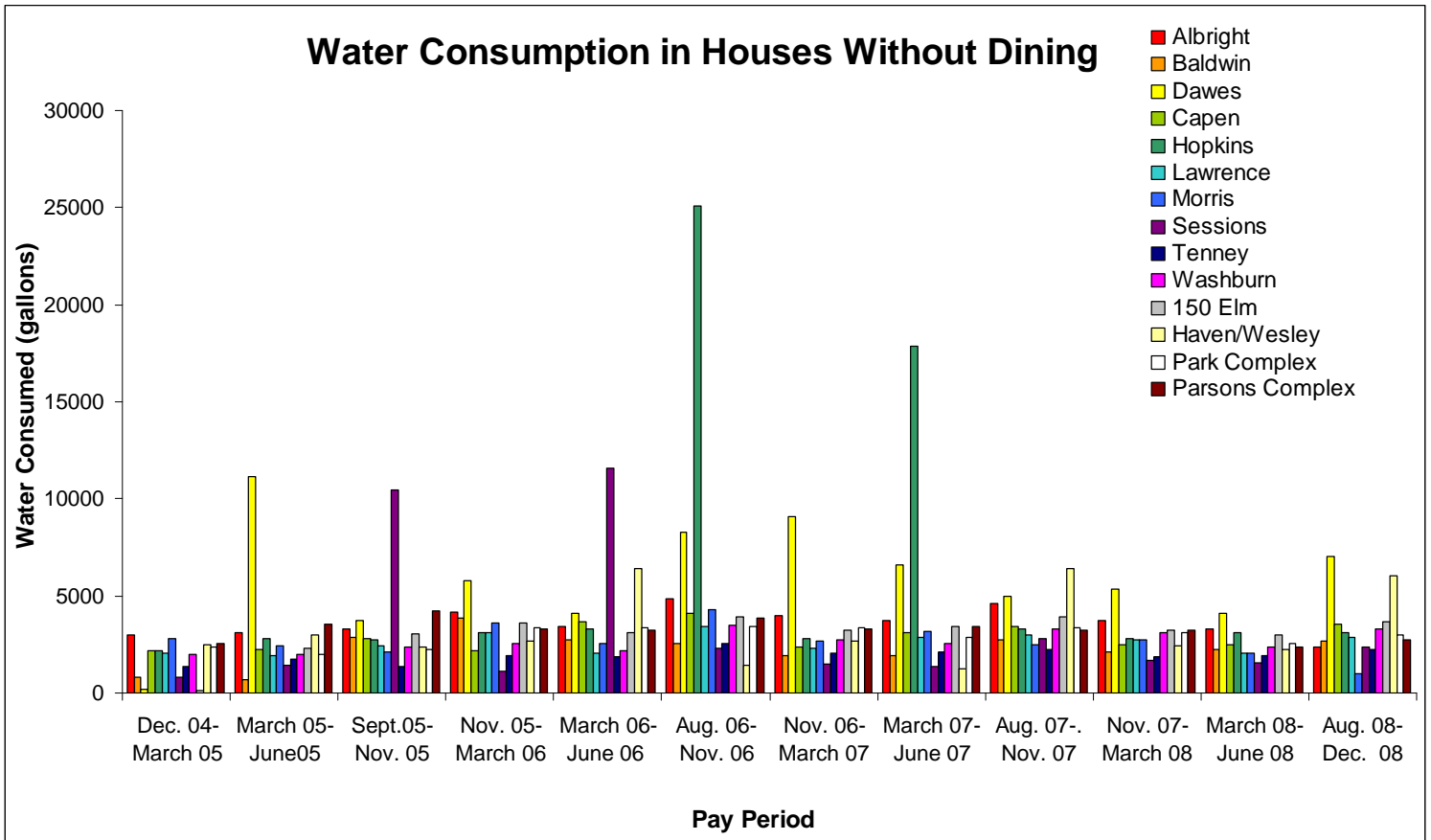


Figure 2:

Analysis of the quarterly water bills revealed that the student houses were by far responsible for the largest water usage on campus during any given pay period. Because some of the houses on campus have active dining halls while others do not, the houses were divided into houses with dining and house without dining, those without dining also without industrial dishwashers. This chart illustrates the amount of water used in houses without dining. The data has been normalized for each house by the number of residents living in that house. The summer pay periods were left out of analyses because during those months the majority of the student body is not on campus.

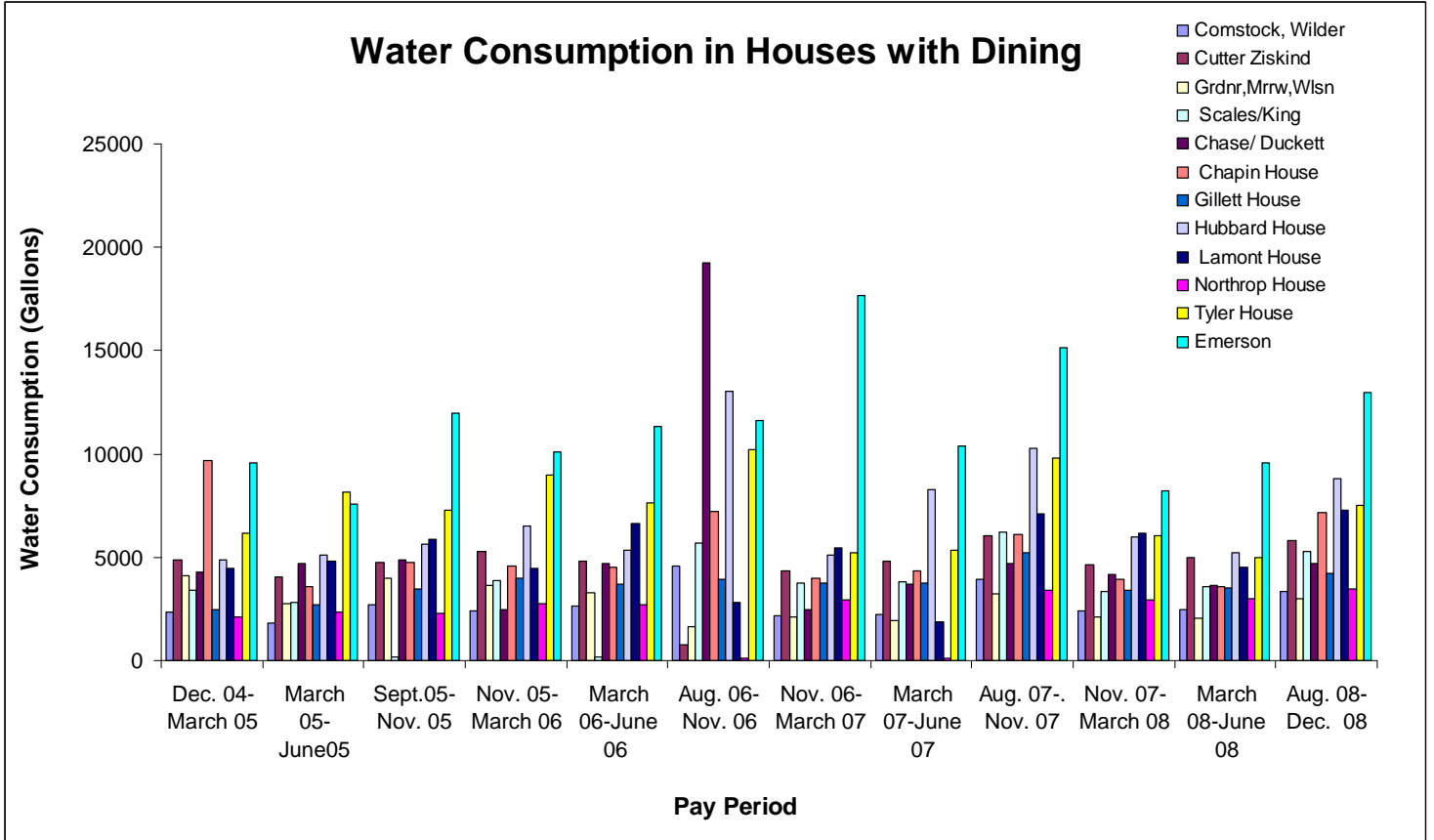


Figure 3:

Analysis of the quarterly water bills revealed that the student houses were by far responsible for the largest water usage on campus during any given pay period. Because some of the houses on campus have active dining halls while others do not, the houses were divided into houses with dining and house without dining, those without dining also without industrial dishwashers. This chart illustrates the amount of water used in houses that have active dining halls and thus have industrial dishwashers running at least five out of seven days a week. The data has been normalized for each house by the number of residents living in that house. The summer pay periods were left out of analyses because during those months the majority of the student body is not on campus.

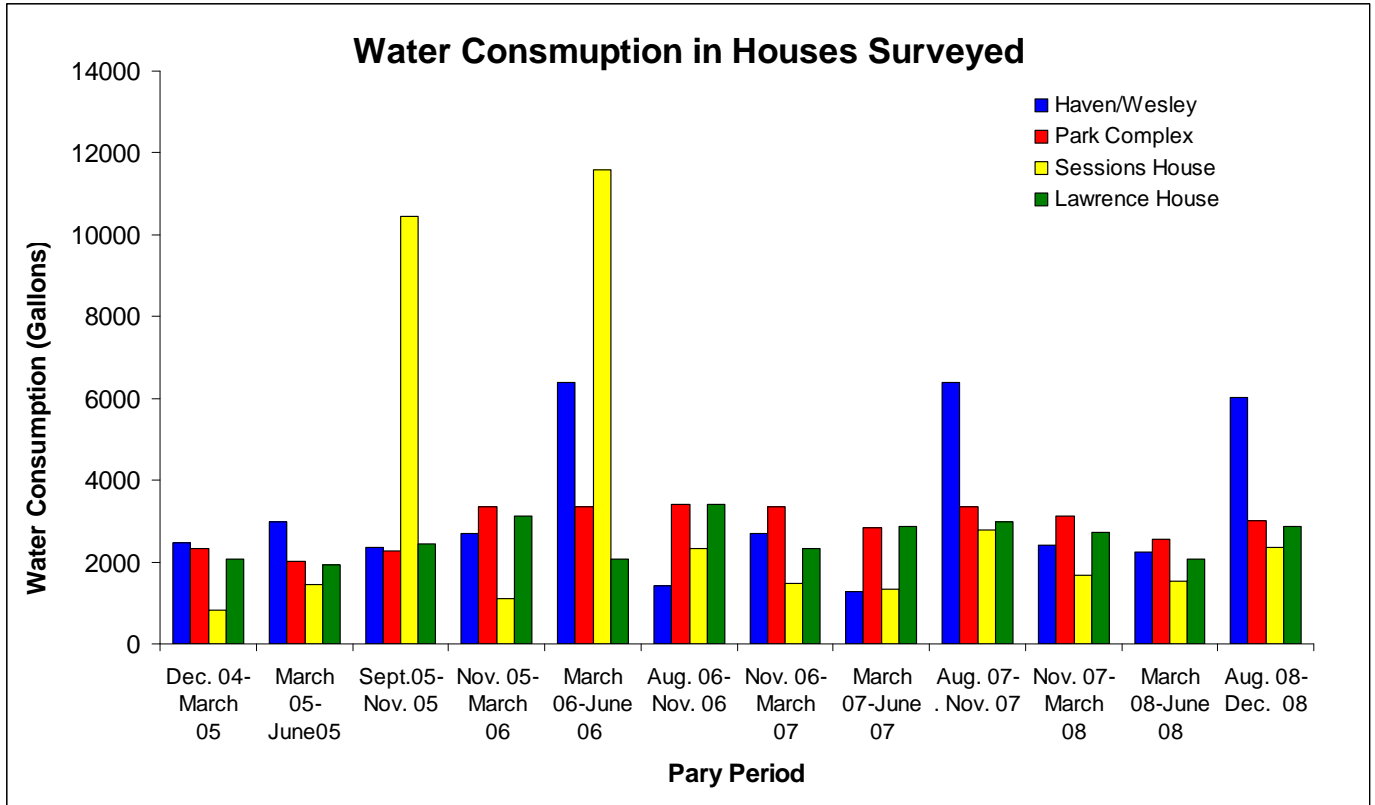


Figure 4:

The figure above shows water consumption in 4 out of the 5 houses surveyed. None of these houses have dining. Jordan was excluded from this analysis because on the water bill, the amount of water used by this house was pooled with several other quad houses that did have dining. The outliers in the data again could be due to water faucets on the exterior of the houses used by grounds keeping.

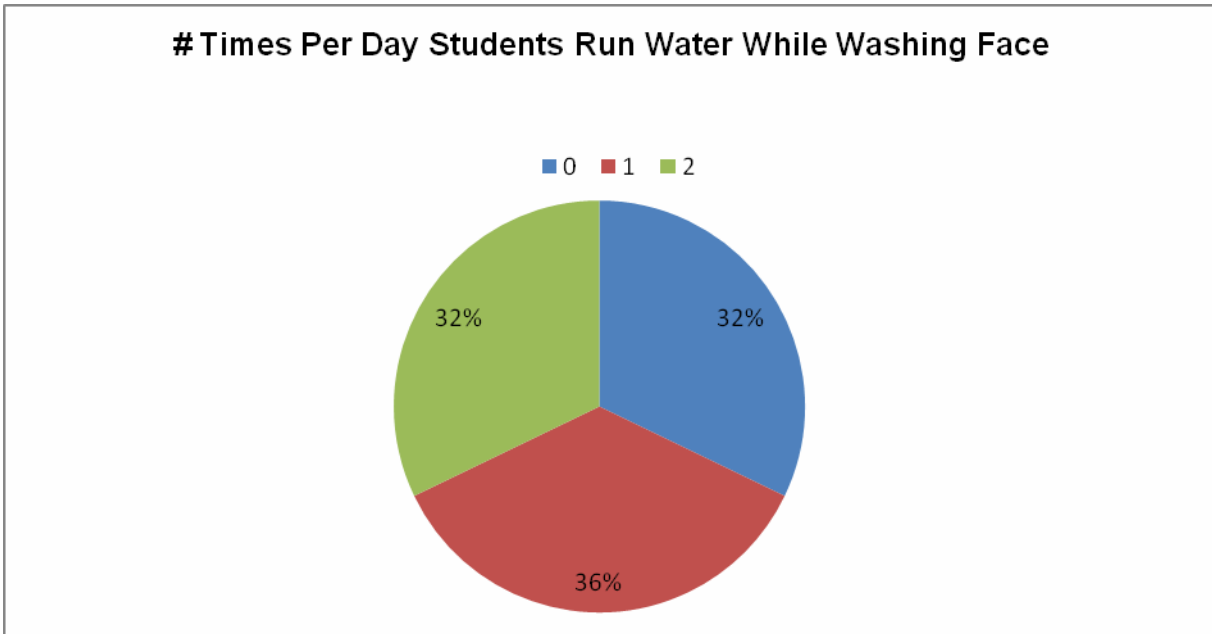


Figure 4: Results from the survey showed running water while washing your face was one of the largest consumptive behaviors on campus. This was determined by taking into consideration the frequency at which each behavior was exhibited in a day. For example, the survey showed that 68% of the students polled run water one to two times per day while washing their face.

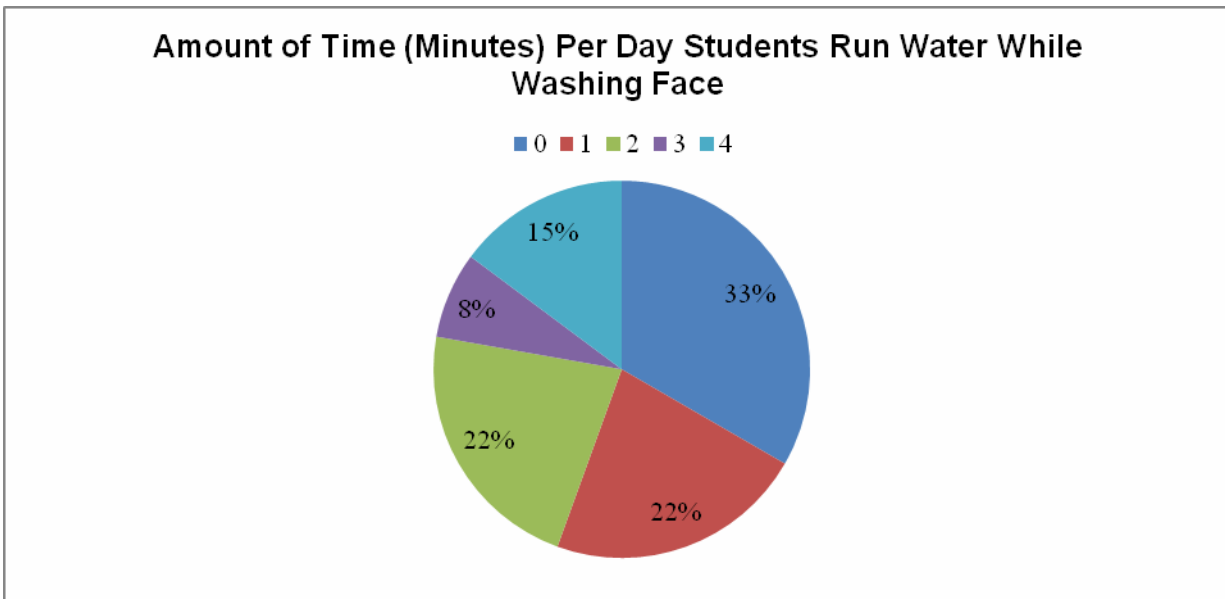


Figure 5: When determining the most consumptive behaviors on campus a second factor we used to characterize the behaviors contributing most to water use on campus was the duration, or amount of time an individual spent engaging in that activity. Results from survey indicate that 67% of students polled run the water for one to four minutes per day while washing face. Of the students polled, 15% ran the water for four minutes per day while washing face.

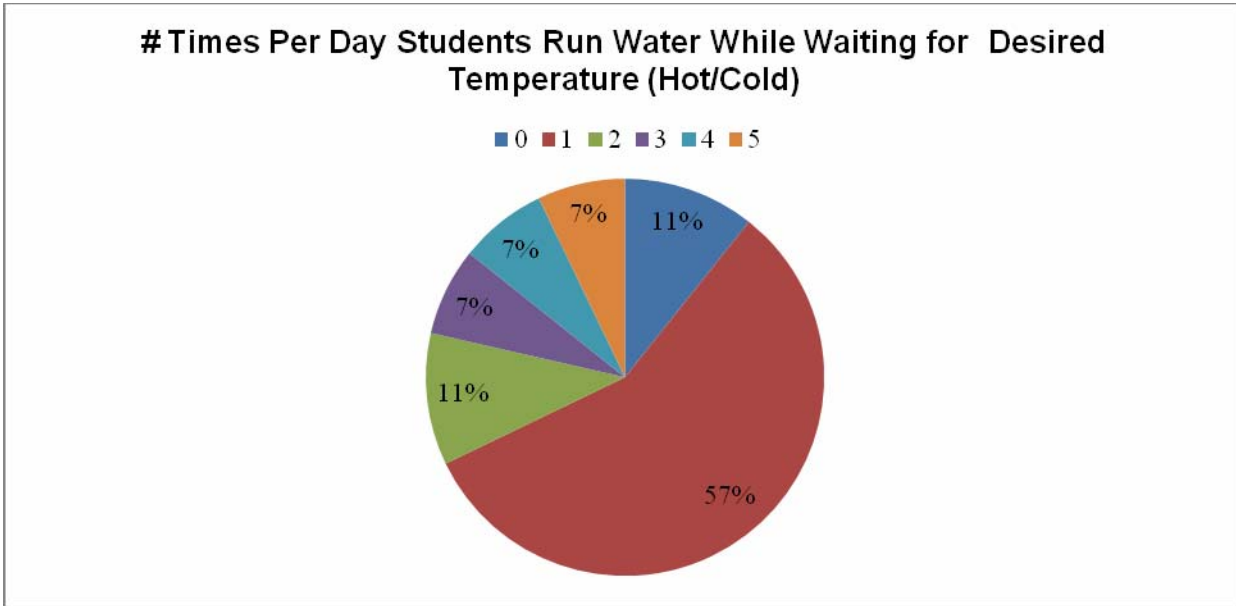


Figure 6: A second behavior questioned about on the survey that was characterized as one of the largest consumptive behaviors was allowing the water to run while waiting for it to reach a desired temperature. Results from the survey concerning the frequency this behavior is performed show that 89% of students polled run water one to five times per day while waiting for the water to reach a desired temperature.

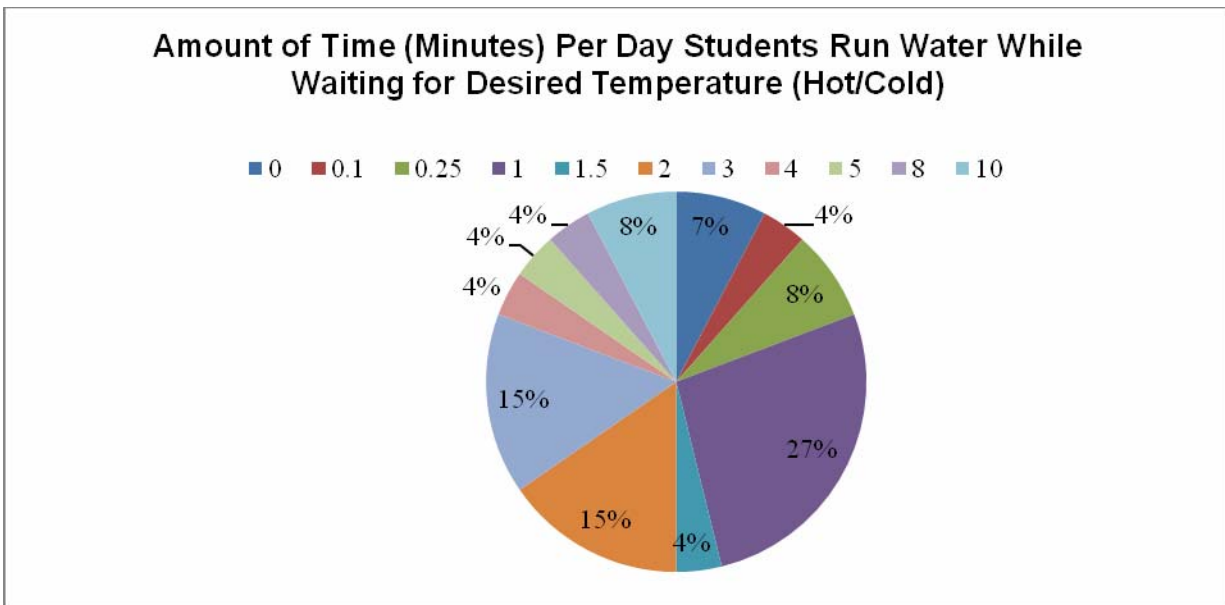


Figure 7 : Results from the survey concerning that duration, or the amount of time, that students engaged in this behavior show that 81% ran the water for one to ten minutes per day, while waiting for it to reach a desired temperature (hot/cold). Of the students polled, 50% ran the water for two to ten minutes a day, waiting for it to reach a desired temperature.

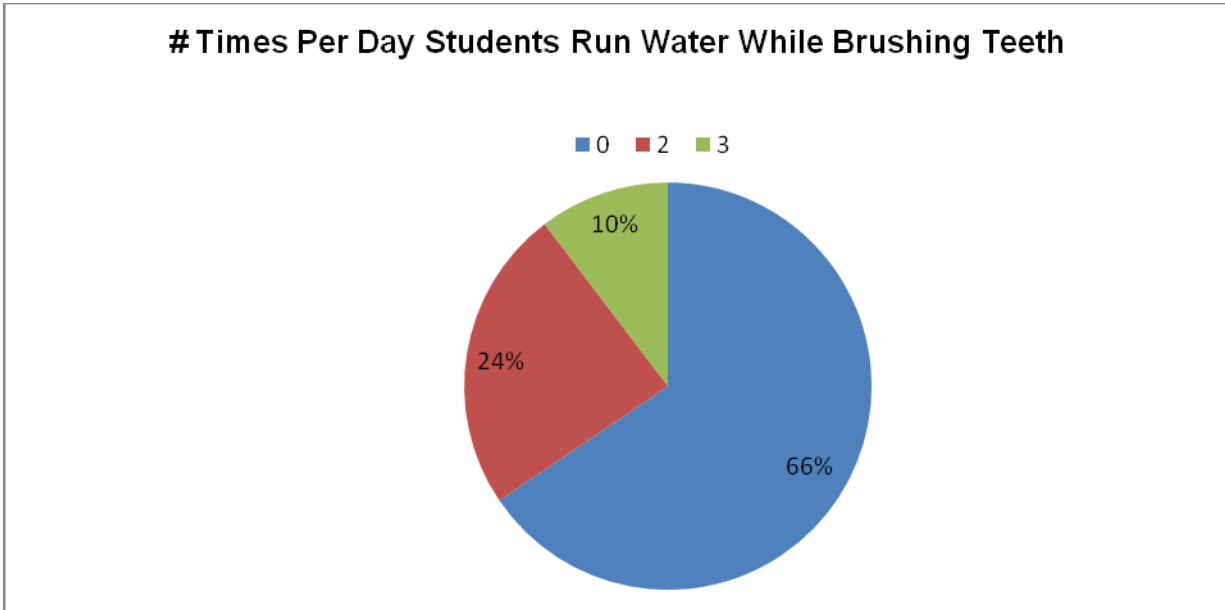


Figure 8: The survey shows that letting the water run was one of the lowest consumptive behaviors on campus because it contributed least to the total amount of water used. Results from the survey show that 66% of students polled do not run the water, 24% twice per day, and 10% three times per day while brushing teeth.

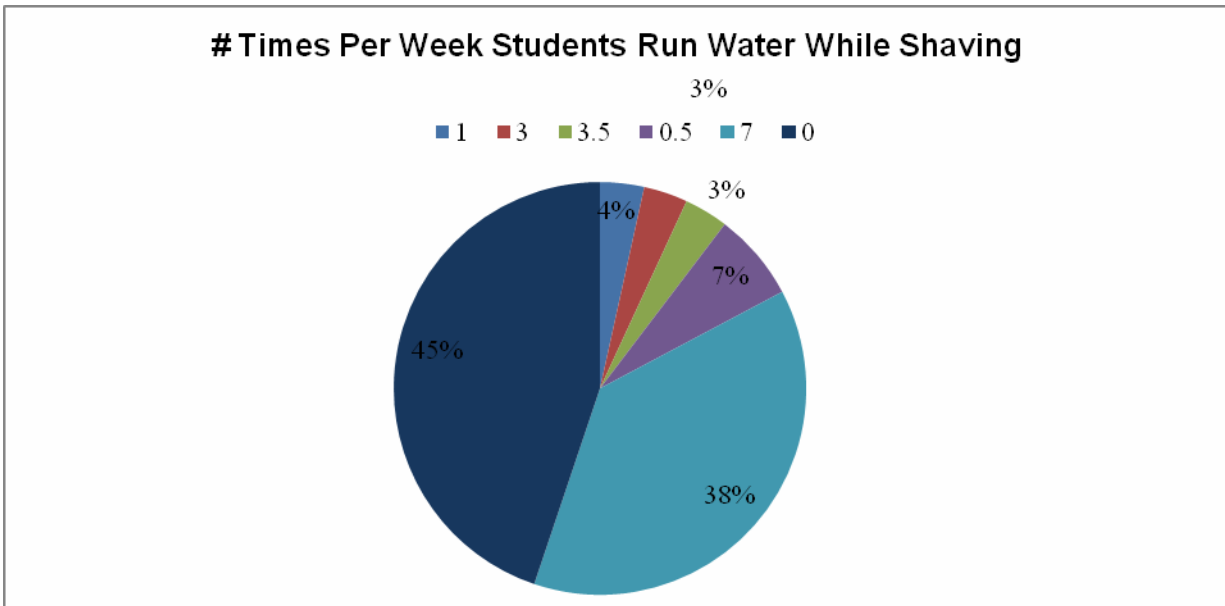


Figure 9: Results from survey also showed that running water while shaving was a second behavior that contributed little to the total amount of water used on campus. Of the total students polled, 52% of the students polled do not run the water while shaving (this includes the 7% that reported shaving 0.5 times per week or shaving once every other week).

Table 1:

The results of our tests of shower head efficiency indicate that the shower heads in Lawrence House and Sessions House are near the levels of efficiency of the water efficient shower heads currently on the market. During each trial, we recorded, in seconds, how long it took to collect one gallon of water, then normalized this value by the number of gallons collected from the shower head in one minute.

Lawrence House			
Trial Number	Location	Time (sec)	Gallons/Min.
1	Floor 1	30	2
2	Floor 1	35	1.7
1	Floor 2	37	1.6
2	Floor 2	30	2
1	Floor 3	35	1.7
2	Floor 3	40	1.5

Session House			
Trial Number	Location	Time (sec)	Gallons/Min.
1	Floor 1	30	2
2	Floor 1	30	2
1	Floor 2	35	1.7
2	Floor 2	40	1.5
1	Floor 3	30	2
2	Floor 3	35	1.7

Discussion

There is a very large focus on reducing the college's carbon foot print and determining the behaviors that affect the levels of green house gases Smith emits. Water use directly relates to this as in the average American home a significant portion of the electricity bill can be attributed to heating water. This number must be much higher for a college such as Smith in which almost all of the 2,600 students live on campus. Water use however can also be looked at independently from its effect on climate as water itself is not a renewable resource. Just as it is our responsibility to reduce the amount of carbon dioxide we release into the atmosphere, it is the responsibility of Smith College to ensure that its students are using water appropriately.

Our analyses of the quarterly water bills showed clear outliers in the water consumption data such as that seen by Hopkins House from August 2006-November 2006. This above average use of water could be due to the fact that some houses on campus are equipped with water taps that ground keeping uses when watering the lawns. Because there currently are not water use monitors in the houses to keep track of how much each individual house is using there is no sure way for us to discriminate against resident water use and college water use in these situations. This led us to conclude that the college should seriously consider installing water use monitors in the houses.

Oberlin College, winner of the Environmental Protection Agency's 3-P competition installed water monitors in several of their dormitories and saw a resulting decrease in water consumption. Realizing that a significant proportion of water consumption takes place within dormitories, a group of Oberlin students set up to face the challenge of motivating their fellow building occupants to make choices that would lead to water conservation (EPA, 2005).. They developed a prototype of a "multi-building, wireless, data monitoring system that would allow

students to see how much water they used in their dormitories. Installation of these monitoring systems and a little friendly inter-dormitory competition led to a drop in water use in the dorms where the value of water consumed was clearly displayed and easily accessible to students (EPA, 2005). Because Smith students often seem to thrive on competition, a similar experiment might reap similar results. If the residents of Smith houses are able to actually see how their consumption values compare to those of other houses, they might change their behaviors in an attempt to be the best house to conserve water.

In taking the conservation approach towards reducing water use on campus, the survey distributed to students on campus was designed to determine the behavior of students surrounding water use and assess the level of wastefulness of such behaviors. For example, face washing and teeth brushing were two behaviors students were questioned about because it is not necessary for the water to be running while an individual is washing their face or brushing their teeth. However, in looking back at the survey that was distributed, there were a number of pieces missing from the survey that would have been more helpful in determining what student behaviors are the largest contributors to water use on campus. Activities such as showering were excluded from the survey, though in hindsight should have been included, because it is assumed that the water has to run while one is in the shower. In future studies examining showering as a behavior that can be targeted to reduce water use on campus, the amount of time students spend in the shower needs to be examined as does the amount of time it takes for the water to reach the desired temperature, as we found the latter to be one of the two largest consumptive behaviors. Another factor that was left out of the survey was estimating how often an individual flushes the toilet. According to the Sierra Club, toilets are responsible for about 40% of total indoor water

use. The Massachusetts Water Resource Authority estimates that the average toilet uses 5.4 gallons of water in a single flush.

While there seem to be trends in our data, i.e. some behaviors play a larger role in water use on campus than others, the low return rate of surveys, about 10%, makes it very difficult to draw any significant conclusions from our data. Based off of the results from the very small sample size, it is seen that generally speaking Smith students are on the conservative side when using water. However, such conclusions cannot be drawn with great confidence. What can be pulled from this project is that students living in the houses on campus might change their behavior towards water use if they knew more about water itself. We saw the occasional student that takes 30 minute showers, which seems unnecessarily long. However, habits such as long showers and leaving the water running when can be broken through education.

At California State University at Northridge has reduced their water consumption by 15% by retrofitting showers, installing flush valves and faucet with water-saving devices and have also taken steps by posting water-conservation information (Smith, 1993). If there were simple signs hanging in the bathrooms near the sinks informing people that an average of 4 gallons of water are wasted if the faucet is left running for one minute, the 3% of students surveyed who run the water for four minutes while washing their face would turn the water off until they needed to rinse the soap off.

From the surveys collected and analyzed it seems that generally Smith students are somewhat responsible when it comes to using water. After completing this project it is our feeling that if students are made aware of just how much water they are letting go down the drain and thus wasting, they will change their behaviors. Every fall there are directions on the steps to self-breast examinations hanging from the shower heads that one cannot help but read as they are

showering. Something as simple as shocking, but true, facts about how much water is lost when the shower is left running or how much energy is used to heat a gallon of water would get Smith students to question their own behavior. Little steps like this would not change everyone's behavior but it would get a larger portion of the population to start thinking about what it really is, a non-renewable resource. Pamphlets such as these could be distributed via student leaders.

We also strongly recommend that student leaders become more involved in the water conservation process as they have the most direct contact with the largest number of students and can also be very persuasive. Currently every house has an earth representative. However, this position is often not taken as seriously as it should be. Perhaps giving these earth reps greater responsibility or training would change their role, make it larger within the housing community, one of the strongest communities on Smith's campus. Student leaders should be made fully aware of other ways to spend house funds besides social events.

In 2000, students at the dormitories at Penn State University consumed almost 60 gallons of water each day through showers, toilets, clothes washing, and sink usage (Uhl, 2001). Smith students fall within and above this range. We are in an age in which technology can greatly reduce water consumption without causing large inconvenience. Perhaps in the future, Smith like Penn State can look into innovative ways to discharge the college's wastewater back into the natural cycle. In the mean time, Mr. Weisbord recently announced that renovations of houses this summer will include replacing typical shower heads with water efficient shower heads. This is an excellent step in the direction of decreasing Smith's quarterly water bill and we also encourage the planners of Smith to look into heating water in the houses more efficiently as a major

complaint from students is the amount of time they spend waiting for the water to reach a desired temperature.

From this project and what little data was collected from the surveys we believe that it is necessary to reframe students' attitudes towards water and how it is used. This will require collaboration between Dano Weisbord, the Committee on Sustainability, and student leaders. We are confident that educating and making students aware of how precious a resource water is will not only contribute positively to the reframing of student attitude towards water. We are also confident and hopeful that if made aware of how much water they are actually consuming, the total amount of water used on the Smith College campus will decrease as students begin to take responsibility for their actions and thus the Earth.

Literature cited

Egan, T. 2006. "The Greening of America's Campuses". *The New York Times*. January 8, 2006. *American College and University Presidents Climate Commitment*

Estimated use of water in the United States in 1990: Domestic Water Use. 1990. United States Geological Service

Donahue, E. 2009. *Water Efficient Toilets*. Massachusetts Water Resources Authority (MWRA).

Sierra Club. 2009. Green Your Water Use: Toilets. *Sierra Magazine*

Smith, A. *Campus Ecology: A Guide to Assessing Environmental Quality and Creating Strategies for Change*. Living Planet Press, P.O. Box 1679, Venice, CA 90294.

Uhl, C. and A. Anderson. (2001). Green Destiny: Universities Leading the Way to a Sustainable Future. *Biosciences*. **51**, 36-42.

United States Environmental Protection Agency. 2005. *Greening the Campus: Improving the Environmental Performance of the Buildings and Institutions*.

United States Geological Service. 1990. Estimated Use of Water in the United States in 1990. *USGA National Circular 1801*.

Hutson, S.S., Barber, N.L. Kenny, J.F., Linsey, K.S., Lumia, S.D., and Maupin, M.A. 2004. Estimated Use of Water in the United States in 2000. *USGA National Circular 1268*.

Winkle, R.C. 1982. Water Conservation. 262-287. Conserving the Environment: New Strategies for Behavior Change.

.