

Examining Colgate University's Water Usage: A Preliminary Water Audit

Alex Coates, Joe Coplan, Jason Finder, Annemarie Heinrich, Cassie Lawson, Bess Magnuson

Executive Summary

As part of the Colgate University Environmental Seminar, *Community-based Study of Environmental Issues* taught by Professor April Baptiste and Sustainability Coordinator John Pumilio, this reports seeks to examine Colgate University's water usage across the campus. Throughout our report, we use the class definition of sustainability: the ability to maximize living, working and academic standards while minimizing ecological, economic and social impacts. In order to be a sustainable campus, Colgate must acknowledge the importance of water and realize that it is a costly semi-finite resource that is essential to life. It is vital to realize where it is being used on campus by conducting an on campus water audit. Our research aimed to conduct a water audit of the campus and to answer the questions: Where and how is Colgate University using water and where lies the potential to reduce this consumption?

After consulting with a water audit professional, Becky Fedak, we laid out a framework to research and analyze water through collecting raw data, completing a literature review, and conducting interviews. First, we collected data on sink, shower, and toilet flow rates in all six first-year residence halls. We then examined how peer institutions have performed campus water audits and the technologies they have implemented to decrease water consumption, as part of our literature review. Based on literary research and recommendations from Ms. Fedak, we divided the use of water on campus into five different categories: residence halls, dining services, service buildings, athletic facilities, and academic buildings.

We interviewed with key Colgate constituents in each of the five categories. Including Pete Babich, Associate Director of Facilities and Manager of Engineering Services; Brian Belden, Foreperson in the Facilities Department; Dan Fravil, Resident Dining Manager; Sean Graham, Director of Utilities and Public Works of the Village of Hamilton; Emmett House, Supervisor of Athletic Grounds; and Thomas Kane, Plumber and Foreperson, Facilities Department. In the interviews, we asked questions to find out about Colgate's current infrastructure and water consumption throughout campus, as well as any future plans that are being made that will decrease water consumption. We combined this data with specific building's water meter readings collected from the Building and Grounds computerized metering system with the help of Mr. Belden and Mr. Babich. Additionally, we analyzed our findings to determine where water is consumed the most throughout campus.

We found that Colgate's water source is two groundwater wells in the Hamilton area, owned and operated by the Village of Hamilton Utilities. Currently, Colgate's water metering system does not include every building on campus, so our findings are based on the buildings that are metered. Furthermore, we also found that the water meters weren't always for specific buildings, and sometimes combined buildings of different audit categories. Primary findings indicate that the residence halls use water most with 26,658,086 gallons per year, followed by athletic fields with 14,805,912 gallons per year. Campus' cooling towers and facilities use 9,152,528 gallons per year, dining services 4,345,768 gallons per year and academic buildings 3,426,588 gallons per year.

Based on our findings, we have several recommendations for Colgate. We recommend Colgate (1) installs the EcoLab Apex dishwasher in Frank Dining Hall, KG Aquatic Crayfish tanks in

Colgate's Water Use

Olin Hall, and high efficacy toilets in residence halls, (2) completes the installation of low-flow showerheads in all residence halls, (3) improves Athletic Field irrigation methods, (4) considers water issues in the construction of new buildings, (5) reevaluates the current metering systems and (6) has a water audit completed by a professional. Each of these will contribute to a decrease in water consumption and will save money over time. In order to make any improvements and recommendations regarding Colgate's water footprint, one must fully understand where and how water is being used, which is the goal of this report.

Table of Contents

Executive Summary..... 2
Introduction..... 5
Literature Review..... 6
Methods..... 6
 Literature Review..... 9
 Case Studies..... 9
 Raw Data Collection..... 9
 Interviews..... 10
Results..... 11
 Qualitative..... 11
 Quantitative..... 13
Discussion..... 19
 Academic Buildings..... 19
 Athletic Facilities..... 20
 Service Buildings..... 21
 Dining Facilities..... 21
 Residence Halls..... 22
 Limitations..... 24
Recommendations..... 24
 Overview..... 24
 Academic Buildings..... 25
 Athleti Facilities..... 25
 Cooling Towers..... 25
 Dining Facilities..... 25
 Residence Halls..... 26
 Future Consumption..... 27
Conclusion..... 27
Acknowledgements..... 25
References..... 28
Appendices A-E..... 30
 Appendix A: Audit Checklist..... 30
 Appendix B: Interview Questions..... 32
 Appendix C: Water Usage in Buildings on Campus..... 34
 Appendix: D: Uphill Pumping Station Buildings..... 37
 Appendix E: Breakdown of Sectors..... 38

Introduction

In the last century, water use has increased at more than twice the rate of the world population (Zabarenko, 2011). In addition, only one percent of the world's water is available for human use. However, water is a basic necessity for human survival (Pacific Institute Publications, 2008). Due to increasing fresh water demands, it will be necessary for individuals and institutions to acknowledge their own impact, realize the source of their local water, and learn how to consume water more sustainably. This concept applies on global and local scales, concerning smaller communities, such as Colgate University.

The topic of water consumption at Colgate is important as the University continues to strive to become a more sustainable campus. Eighty million gallons of water are used on campus each year, costing the university nearly one million dollars (Colgate University Water Bill, 2011). Members of the Colgate community continuously use the water they need, perhaps without acknowledging that it is a costly and finite resource. Currently, a comprehensive water report for Colgate does not exist. We aim to complete Colgate's first water audit that will inform readers where and how Colgate consumes water on campus.

Throughout our report, we define sustainability as the ability to maximize living, working and academic standards while minimizing ecological, economic and social impacts. Utilizing this definition of sustainability, our report seeks to evaluate and analyze water consumption at Colgate through completing a water audit for the University's entire campus. We aim to address the questions: Where and how is Colgate University using water? Where lies the potential to reduce this consumption? Based on the findings of the audit, this report will provide recommendations for Colgate University's future water efficiency and awareness.

Colgate has taken measures and will be implementing new plans to help decrease water usage on campus. This past summer, the University replaced all of the first year residence hall showerheads with low-flow substitutes. The second year residence halls will be interchanged with them in the coming year and the low-flow replacements will become a University standard. The first year residence halls' showerhead replacement saved half a million gallons when comparing September 2010 to September 2011 (J. Pumilio, personal communication, November 11, 2011). In Merrill House, new toilets and faucets were installed this semester, switching from 3-gallon flush toilets to 1.5-gallon flush toilets, in addition to timed sinks (J. Pumilio, personal communication, November 11, 2011).

Next year, Colgate plans on going "tray-less" in Frank Dining Hall, meaning trays will no longer exist and will not be washed. Going "tray-less" has the potential to save the University around 10,000 gallons annually (D. Fravil, personal communication, November 11, 2011). A hidden use of water on campus is the Crayfish tank located in Olin. Right now, the tank uses 1.6 gallons every minute, 24 hours a day, costing the school over 11,000 dollars a year (D. McCoach, personal communication, November 28, 2011). Plans have been proposed to replace

the current Crayfish tank with a tank that uses less water. One of Colgate's newest buildings, the Ho Science Center, has a state of the art recirculating system that cools down the building's lab equipment with recycled water (P. Babich, personal communication, November 7, 2011). As we compile our report, we will consider all the efforts Colgate has made to reduce its water consumption throughout the campus and its facilities.

In order to make any improvements and recommendations regarding Colgate's water consumption, one must fully understand where and how water is being used. To comprehend the use of water at Colgate, a complete evaluation of the water uses by examining different locations on campus is necessary. These sites on campus include residence halls, dining services, service buildings, athletic fields, and academic buildings. By studying each area, we were able to determine which sectors and processes use the most water and how they use it on campus. At-home water audits save an average of twenty to thirty gallons per household, and scaling it to Colgate University's size, we could potentially save thousands of gallons of water daily (Texas Water, 2011).

Formally known as a water audit, our group aimed to complete this benchmark to its full extent. We targeted to accumulate as much information as possible in order to comprehend what an official audit would entail. In order to gain a complete understanding of water use at Colgate, we completed an extensive literature review and interviewed numerous key stakeholders from the Colgate and Hamilton communities to assess water usage. Other methods included using a computer metering program provided by Colgate to measure water in different buildings. We also took samples of quantitative data in residence halls. After evaluating where Colgate currently uses their water, we were able to draw conclusions and recommend how Colgate can consume water more sustainably in the future. Throughout the paper, our report aims to frame the background, methods, results, analysis, recommendations and conclusions of our study of Colgate's current water usage and its connection to sustainability.

Literature Review

Water as a Limited Resource

Water is a vital resource on which humans depend for survival needs, such as drinking, bathing, and washing. With a growing global population and limited planetary supplies of fresh water, recognizing the value of water in the context of sustainability will be increasingly important in the coming years. It is necessary to regard water as a finite resource with an economic value that has both social and economic implications when considering basic needs (UNESCO, 2011).

The approximate 19.4 million residents of New York State rely on a constant source of fresh water in order to satisfy their basic needs and lifestyle requirements (U.S. Census Bureau, 2010). According to the New York State Department of Health, around 95% of state residents receive their water from public water supply systems (2011). Sources of these public water systems include surface water, ground water, and purchased surface and ground water. Most of the population is served by surface water (NY State Department of Health, 2011). Under the Safe Drinking Water Act (SDWA), the EPA sets legal limits on the levels of certain contaminants in drinking water (EPA.gov, 2011). Some of the chemicals tested by the EPA include lead, arsenic, copper, and many other harmful chemicals. However, as in many areas in other states, there exist a number of threats to potable fresh water. For example, after recent flooding due to Hurricane

Colgate's Water Use

Irene and Tropical Storm Lee, high levels of bacteria from human and animal waste appeared in the water system near New York City (Associated Press, 2011). In response, a \$25 million emergency fund has been proposed to repair damaged drinking water and wastewater treatment facilities (NY State Department of Health, 2011). Repairs to pump stations, electrical equipment, treatment facilities, and other critical equipment must be completed to ensure that residents of New York have access to safe drinking water. Although these dangerous levels have subsequently decreased, flooding illustrates one of many potential threats to the safety of water available for New York residents.

According to the New York State Department of Environmental Conservation, New York's water resources are plentiful, however there do exist several threats to this supply. Occasional droughts in the state are not uncommon, with "severe droughts" occurring in New York in the 1960s and 1980s (NYS DEC, 2011). Droughts, which can lead to fresh water shortages and strict regulation of water use in response, can be detrimental to health and undermine quality of life standards. A new threat to freshwater sources in the form of natural gas drilling has also been recognized. According to a press release put out by the EPA (2011), the Susquehanna River, a river flowing through Central New York, has been named the most endangered river in the nation. Hydraulic fracturing, also known as "fracking," is a process used in natural gas drilling that has been linked to many environmental hazards. As part of the fracking process used to extract natural gas, massive amounts of water are withdrawn from rivers and streams, mixed with sand and toxic chemicals and pumped underground to fracture the shale under extreme pressure. There are currently limited facilities for treating the highly toxic wastewater that results from the extraction process. Furthermore, there are few government regulations to prevent it from seeping into rivers like the Susquehanna, which provides drinking water for more than six million people (American Rivers, 2011).

Blue, Green and Grey Water

A water audit can be broken down into three separate categories of water. These categories consist of blue, green, and grey water. Blue water is an indicator of consumptive use of fresh surface or groundwater (Aldaya, 2011). 'Consumptive water use' generally refers to one of the following four cases: water evaporates, water is incorporated into the product, water does not return to the same catchment area, or water does not return in the same time period. (Aldaya, 2011). Although water is a semi-renewable resource, one cannot consume more water than is available in a certain period. (Aldaya, 2011).

In contrast to blue water, green water is an indicator of human use. Green water refers to precipitation on land that does not run off or recharge the groundwater, or stated more succinctly, precipitation that does not become blue water. Instead, green water is stored in the soil or temporarily stays on top of the soil or vegetation (Aldaya, 2011). Eventually, this type of water either evaporates or transpires through plants.

Lastly, grey water measures the pollution associated with freshwater. It is defined in *The Water Footprint Assessment Manual* (2011) as, "the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards" (p. 30). Put another way, grey water represents the volume of water needed to dilute pollutants so that they will become harmless (Aldaya, 2011).

Water Audits: A Vital Step Forward

Colgate's Water Use

A water audit consists of numerical values that can be compared to specific efficiency goals or the usage of other institutions (Dziegielewski, 2009). Audits, also referred to as metrics, are often linked to water conservation because they help to define efficiency. One process may be considered more efficient if it “can free up significant quantities of water by meeting the existing needs of individual users and various purposes of use with less water”(Dziegielewski, 2009). A successful water efficiency program can help save water, energy and money, while reducing pollution and raising environmental awareness.

Although there is no single way to calculate an audit, there is a set of generally accepted guidelines. According to Dziegielewski (2009), “the most practical water usage metrics are those that can be calculated using secondary (i.e., existing) and routinely collected data” (4). Two types of secondary data include water production records and meter reading or billing records (Dziegielewski, 2009). Metrics can then be compared in a variety of ways such as, per capita, yearly, seasonal, or indoor/outdoor water use. A complete water audit can help to provide an array of water conservation benchmarks. One benchmark includes assessing the water loss of a system. This number is often calculated as a percent, taken from the total production, or input of water, divided by the billed water (Dziegielewski, 2009). This number is known as the non-revenue water and accounts for water lost due to overflows at the service reservoir and “all types of leaks and breaks at mains, and service connections, up to the point of customer metering” (Dziegielewski, 2009).

An indoor benchmark can also be calculated to help estimate where efficient water use can be achieved. To do so, indoor water use can be broken down into specific areas, such as toilets or sinks. These numbers should take into account the mechanical parameters of the component, including values such as average use, flow rate, average number of leaks, and the number of users (Dziegielewski, 2009). The calculated numbers can help to determine efficiency goals by comparing the water usage to other available technologies. A similar outdoor water benchmark can be calculated, as well. The outdoor benchmark takes into account numbers like irrigation water requirements and area of irrigation (Dziegielewski, 2009).

Because institutions represent a major consumer of water, it is important to complete a benchmark audit. To help understand water use distribution and determine target locations for efficiency goals, it is helpful to break down the audit at various facilities. Some facilities that are recommended to break down include: cooling and heating, landscaping, laundry, kitchens, and restrooms (Perdue, 2009). To help identify opportunities and areas for improvement, there are self-assessment checklists available. Checklists such as the one written by the N.C. Department of Environment and Natural Resources, ask a series of questions specific for each facility listed previously (Appendix A).

Water Conservation at Peer Institutions and Colgate University

In recognition of the value of water within a more localized context, many of Colgate's peer institutions have taken action to reduce their water consumption. Numerous Eastern liberal arts schools of similar size to Colgate, such as Colby, Middlebury, Bucknell and Smith, have, for example, begun to replace showerheads and faucets with low-flow alternatives (Sustainable Endowments Institute, 2011). Some have also begun to install dual-flush toilets and waterless urinals in buildings on campus (Sustainable Endowments Institute, 2011). Furthermore, many schools have upgraded their laundry systems to include technologies that reduce both water and

Colgate's Water Use

energy use (Sustainable Endowments Institute, 2011).

In order to improve the ability to monitor water use on campus, many schools have installed advanced water metering systems. Additionally, institutions such as Oberlin and Smith have adopted grey water system technologies, which use wastewater from processes, like laundry and bathing, for irrigation or constructed wetlands. Yet another water-conservation method being implemented on campuses is xeriscaping (Sustainable Endowments Institute, 2011). Xeriscaped landscapes conserve water, protect topsoil and are irrigated efficiently (Sustainable Sources, 2011). Similarly, some colleges have implemented weather-informed irrigation, which measures precipitation and adjusts watering times and flow rates in order to avoid superfluous watering (Sustainable Endowments Institute, 2011).

Some campuses have also begun to manage storm water with a wide variety of strategies and technologies. Smith, Bucknell, Middlebury and Oberlin are among many schools that have constructed vegetated roofs (Sustainable Endowments Institute, 2011). Another strategy employed is the use of stone swales, which aid in water absorption. (Sustainable Endowments Institute, 2011).

Of the water conservation technologies utilized at peer institutions, Colgate has reported the installation of water metering systems, efficient laundry technologies, low-flow showerheads and faucets, and xeriscaping (Sustainable Endowments Institute, 2011). Colgate also uses porous pavement, retention ponds and vegetated swales to manage storm water (Sustainable Endowments Institute, 2011).

Each of these actions is a positive step towards sustainability and more efficient water usage on these college campuses. Several steps are involved in developing a successful program. This includes outlining a series of goals, conducting a water audit, identifying areas of improvement, and preparing a plan and schedule for implementation (Perdue et al., 2009).

Methods

In order to effectively cover water use at Colgate, we used a combination of literature review, case studies, raw data collection, and interviews with key stakeholders.

Literature Review

We conducted an extensive literature review on how to conduct a water audit and why water is important for Colgate. In this literature review we researched peer institutions that have completed water audits or implemented certain water efficient technologies. Furthermore, we reviewed Colgate's Sustainability and Climate Action Plan.

Case Studies

In order to assess the five different areas in detail, we conducted a case study within each unit. Within the residence halls, we looked more closely at first-year water fixtures, and in particular the showerheads. For Colgate dining services, we conducted a case study on water use at Frank dining hall. For academic buildings we assessed the eight Olin Hall crayfish tanks. Within the athletic facilities, we looked closely at Tyler Field, an artificial turf field. Finally, we investigated the three cooling towers within the setting of the service buildings.

Raw Data Collection

Colgate's Water Use

We began the data collection process by obtaining secondary data on water consumption through acquiring and reviewing Colgate's water bill from 2008 to 2010. Our group supplemented these numbers with more specific data from Colgate's computer program that monitors the metering system. We then collected data on the flow rate of water in first-year residence halls to find indoor benchmark metrics. In Stillman Hall, Andrews Hall, Gatehouse, West Hall, East Hall, and Curtis Hall, we measured the flow rate from a sample of sinks. On each floor, how long it took to fill a given volume of water. Two to four sinks were measured for each floor. Each flow rate of toilet and showerhead was recorded. Additionally, the number and brand of washing machines was counted in each residence hall.

Interviews with Key Stakeholders

To better understand numbers from Colgate's water bill, we broke them down further into the five categories provided by Becky Fedak, an environmental consultant. We conducted a series of interviews with key stakeholders within each sector, which helped us to apprehend certain technologies currently used at Colgate, the importance of water in various processes, and to receive quantitative data of water consumption in specific facilities. The interviews lasted, on average, 20 minutes. The complete list of specific questions can be viewed in Appendix B.

Water Audit and Water Source Interviews

In the beginning stages understanding how to conduct a water audit, we posted on the forum of the AASHE website in order to get advice from other students and schools that may have conducted their own audit. Through this forum we connected with an environmental consultant who provided steps for conducting a water audit, Becky Fedak. Ms. Fedak works for the Brendle Group which is an environmental consulting firm based in Colorado. The firm has experience working in conjunction with student groups to create a hybrid approach to conducting water audits. To learn how to complete a comprehensive audit as a student group, we began our research with a phone interview with Ms. Fedak. We asked Ms. Fedak about the feasibility of completing an audit as students. We asked about how we should begin in our data collection and the main areas and facilities on campus to focus our research.

We conducted another interview with Colgate's Sustainability Coordinator, John Pumilio, to get a better understanding of his thoughts on the importance of water conservation. Also, we wanted ensure that we had a full overview of the University's past and future plans in terms of lowering water consumption.

Additionally, we interviewed Sean Graham, Director of Utilities and Public Works of the Village of Hamilton, via telephone to discuss Hamilton's water source and consumption. We asked Mr. Graham about Colgate's initiatives from the town utility's perspective and about the issues the University faces when evaluating its water consumption.

We spoke with Peter Babich, Associate Director of Facilities and Manager of Engineering Services, about the function of the cooling towers, the metering of the Lineberry Natatorium, the importance of water, where our wastewater goes, and the efficiency of current water technologies.

Academic Buildings

Colgate's Water Use

To find out more information about Olin Hall's crayfish tank system, we interviewed Dan McCoach, Trade Supervisor. We asked about the existence of quantitative data regarding the crayfish tanks and about information on current economic and environmental impacts of the system. Additionally, we inquired about the current proposal to replace the crayfish tank system and its environmental and economic impacts.

Athletic Facilities

We interviewed Colgate University's Supervisor of Athletic Grounds, Emmett House, to gain a greater understanding of how Colgate uses water for its athletic facilities. We asked about the mechanisms used for watering athletic fields and the typical problems faced with watering the fields. We inquired about the potential for improvements in water use efficiency on Colgate's athletic grounds.

Service Buildings

We interviewed Brian Belden, Foreperson in the Facilities Department, to obtain quantitative data and gain more knowledge about the service buildings, and more specifically, the cooling towers on campus. We asked about Colgate's cooling system efficiency and whether there are other areas where Colgate is looking to improve. We requested raw water consumption data of the towers and various buildings on campus. Using the water meter computer program and under Mr. Belden's guidance, we obtained water usage data from a wide variety of buildings over different time periods.

Dining Services

We met with Dan Fravil, the Resident Dining Manager, to discuss Frank Dining Hall's water consumption and dishwashing methods. We asked him about unofficial auditing questions that Ms. Fedak had given us pertaining to dishwashing efficiencies and technologies. We inquired about the typical Frank Dining Hall traffic patterns and dishwashing schedules.

Residence Halls

We interviewed Thomas Kane, Colgate University's Plumber and Foreperson, in order to gain a better understanding of the usage of water in restrooms of first-year residence halls by asking him questions about the efficiency fixtures in these restrooms. Additionally, we received information about the installation of faucet aerators in sinks, the implementation of low flow showerheads, and amount of water in each toilet flush. Lastly, we inquired about laundry services in these dormitories.

Results

Qualitative Results

Colgate's Water Source

Colgate's Water Use

Colgate gets its water from two wells in Hamilton, owned and operated by the Village of Hamilton Utilities (S. Graham, personal communication, October 17, 2011). Two different pumping stations distribute the water. One station delivers water to buildings that are on top of the hill and the other station pumps water to the rest of the buildings on campus (P. Babich, personal communication, December 11, 2011). The uphill pumping station buildings are listed in Appendix C.

Academic Buildings

The Ho cooling system for lab equipment has controls that allow a chiller to run in the summer. The system reuses and recirculates the water (P. Babich, personal communication, December 11, 2011).

Currently, there are eight deep sink tanks used for crayfish that are sourced by two non-stop flow filters. These tanks use about 2,300 gallons of water per day (D. McCoach, personal communication, November 28, 2011). This is equivalent to 1.6 gallons of water per minute. In terms of economic implications, the water used by the tanks and the resulting sewage have cost Colgate over \$32,000 since the installation of a meter in February of 2009 (D. McCoach, personal communication, November 28, 2011). Per year, the current system of crayfish tanks have cost Colgate over \$15,000 in operating costs, which includes water, filter, and other miscellaneous expenses (D. McCoach, personal communication, November 28, 2011).

Athletic Facilities

Current watering practices used an estimated 98,000 gallons of water in 2011 to water the field before games and prior to some practices (E. House, personal communication, November 16, 2011). NCAA regulations require that the field be watered before all games, in order to maximize playability of the ball (Colgate University's Sustainability and Climate Action Plan, 2011). We found that funding for in-ground irrigation systems to water the men's soccer field has been approved for 2012. Also, there is potential that funding for the women's soccer field will also be approved (E. House, personal communication, November 16, 2011).

Present day, Colgate uses around 1,000,000 gallons per year to water its athletic fields (P. Babich, personal communication, November 7, 2011). The fields are watered using a system of irrigation called "water wheels" (E. House, personal communication, November 16). The fields are watered using a portable, above ground system of irrigation. The fields are watered from 8:00 PM to 4:00 AM. Watering at night increases efficiency because there is less evapotranspiration and thus saves water (E. House, personal communication, November 16)

Service Buildings

Colgate uses cooling towers to cool down water that is used for air conditioning in buildings across campus. The cooling towers operate between April 15 and October 15. There are three separate towers, with the most recent one being installed within the last five years (B. Belden, personal communication, November 15, 2011). Water is continually recycled through the cooling towers, until ions reach a concentration that is too high (P. Babich, personal communication, November 7, 2011). A more efficient technology does not exist (P. Babich, personal communication, November 7, 2011). According to a University of Connecticut water

Colgate's Water Use

audit report, cooling towers effectively cool water, but also lose water due to evaporation. The water that is evaporated to produce cooling must be replaced by fresh water (UConn Report).

Dining Facilities

Frank Dining Hall uses water to clean equipment and dinnerware and prepare meals. On average, Frank Dining Hall serves over three thousand meals a day, 650 breakfast meals, and 1000 meals for both lunch and dinner (D. Fravil, personal communication, Nov. 11, 2011).

Currently, Frank is equipped with a Hobart conveyer dishwashing system that runs according to demand. The initial rinse cycle uses fresh water to rinse off any residue from the dinnerware, cutlery, and trays. Next, the dishes are sanitized and cleaned through additional cycles using three large tanks of water that are recycled through the dishwasher. Recycled water tanks are dumped out and refilled after each major meal period. Whenever there are no dishes to be washed, the dishwasher shuts itself off to save water and energy. The Hobart dishwasher, installed in 2001, is considered to be an efficient model on the market. (D. Fravil, personal communication, November. 11, 2011).

Residence Halls

Current fixtures in the residence halls are thought to be efficient. There are aerators in the sinks and the first-year dorms now have low-flow showerheads. Additionally, the large sinks in Stillman Hall are used only for cleaning purposes (T. Kane, personal communication, October 25, 2011).

Quantitative

We gained access to Colgate University's monthly utility bills from June of 2007 through May 2011. The monthly data was organized by service location and the sums of each fiscal year (June through May) were expressed. This data show Colgate's annual water use and cost. Colgate's water consumption was the highest in fiscal year 2008 (approximately 113 million gallons) and lowest in FY 2010 (Figure 1). We also accessed building consumption data from Colgate's Actionable Energy Intelligence System in the Buildings and Grounds office.

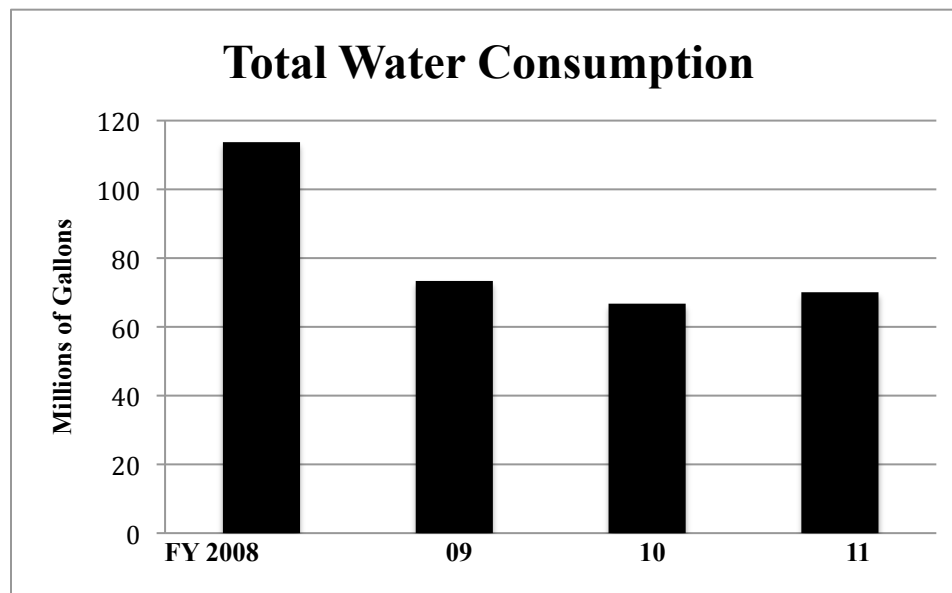


Figure 1. The above figure shows the total annual water use during fiscal year 2008-11. The data was obtained from Colgate University utility bill.

From Table 1 data, we were able to calculate the average annual cost of water. The calculated cost of water takes into account the sum of money Colgate University spends purchasing the water as well as the fee that Colgate University pays for the water to enter the public sewage system. Because the average cost was calculated this way, there may be differences between the value from Figure 2 and the amount which Colgate spends on the water. However, this cost is more reflective of the value that Colgate pays for the lifetime of each unit. The price Colgate pays per gallon of water was about the same in 2008 and 2009. However, since 2009 there has been a steady increase in the price Colgate University pays for each unit of water. In 2009 Colgate paid an average of \$8.26/1000 gallons compared to \$9.99/1000 gallons in fiscal year 2011.

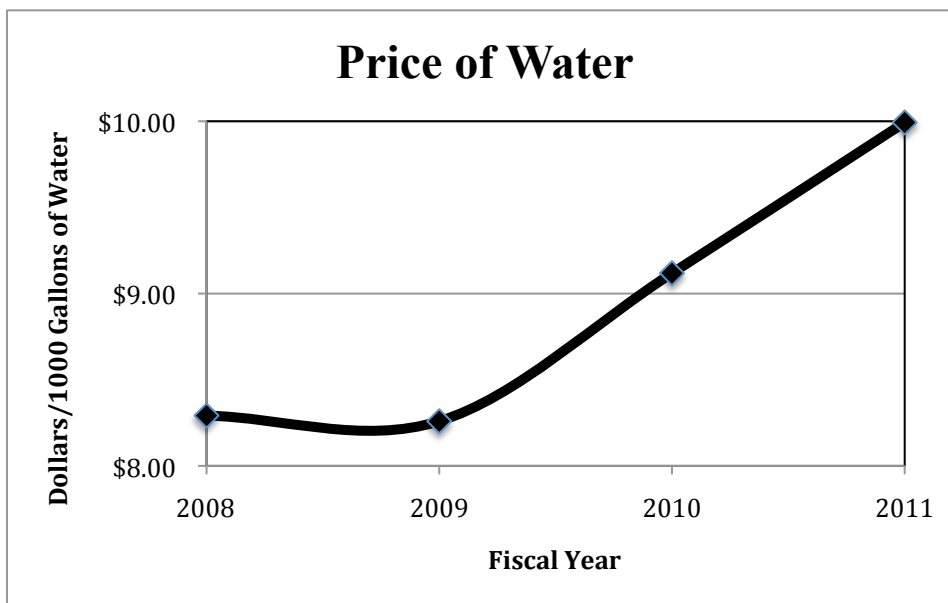


Figure 2. The cost of water was calculated by dividing the total amount Colgate spends on water by the total amount Colgate pays for water annually. Since 2009 the price of 1000 gallons of water has increased by nearly one dollar per year.

The data from the utility bills were also used to determine how Colgate University uses its water. Unfortunately, there are no sub-meters on some of Colgate University's buildings and facilities meaning that there are certain cases in which groups of buildings are all measured as one unit. For example, at the time of this audit, specific data do not exist for Drake, Alumni, Gate House, Watson House, Chapel, Human Resources, Hascall, and the Student Union. To generalize how water is used at Colgate University, buildings were separated into five categories: Residential, Academic/Administrative, Service Facilities, Athletic Facilities, and Dining Facilities. Of Course, there were some cases where it was not clear which category a building fit.

Colgate's Water Use

For example, the Alana Cultural Center was classified as an academic building and East was classified as a residential building despite it being the Center for Women's Studies as well as a resident's hall. To further break down each segment, we divided certain slices of the pie from Figure 3 into smaller slices representing water use. The same limitations and problems existed at the small scale as the large scale, but the data are still important to recognize.

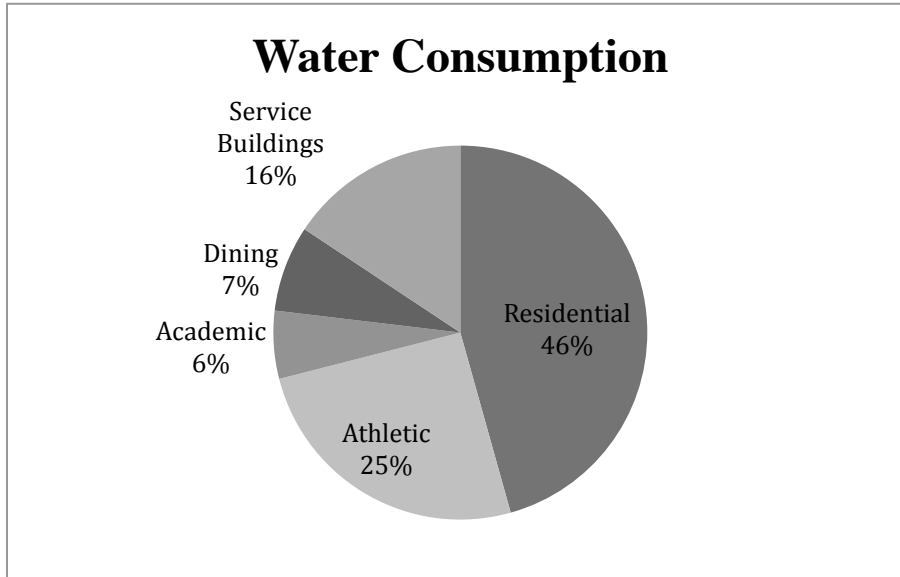


Figure 3. The percent breakdown of Colgate's total water use by various sectors of consumption. To see which buildings were considered a part of each category, one may view Appendix E.

Athletic Facilities

Colgate's Athletic department uses nearly 15 million gallons of water each year. Over half of this water, approximately 9 million gallons, of this is used at Colgate's Seven Oaks Golf Course. Other uses include athletic buildings, which use water for toilets, sinks, showers, drink fountains, and laundry. Colgate also uses water for its swimming pool and to irrigate its athletic field effectively.

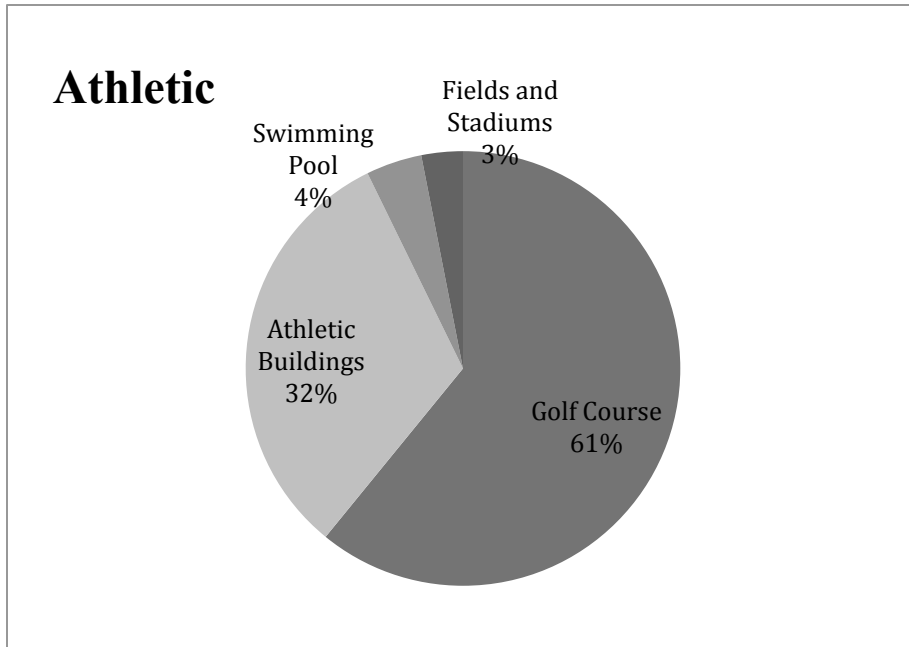


Figure 4. A breakdown of how water is used within the athletic sector. Athletic Buildings include Reid Athletic Center, the Field House, Huntington Gymnasium, 2 East Lake Road, Base Camp, and the College Street Athletic Shed and the Press Box. The fields and stadiums that are included in this data are Andy Kerr Stadium, Van Doren Field, and Tyler's Field.

Residential

Water use within the residential sector can be examined in Figure 5. The freshman and sophomore resident halls use water for sinks, showers, toilets, mop sinks, and laundry machines. The Bryant complex also includes the water used for Cutting Edge Bistro dining facility. All townhouses, apartments, and Broad Street houses all have all the water uses as underclassman resident halls, in addition to full kitchens with dishwashers. Many of the Broad Street Houses have industry kitchens with carbonated beverage dispenser and sanitizers that also use water. Overall the distribution of water use across residential building was relatively evenly distributed.

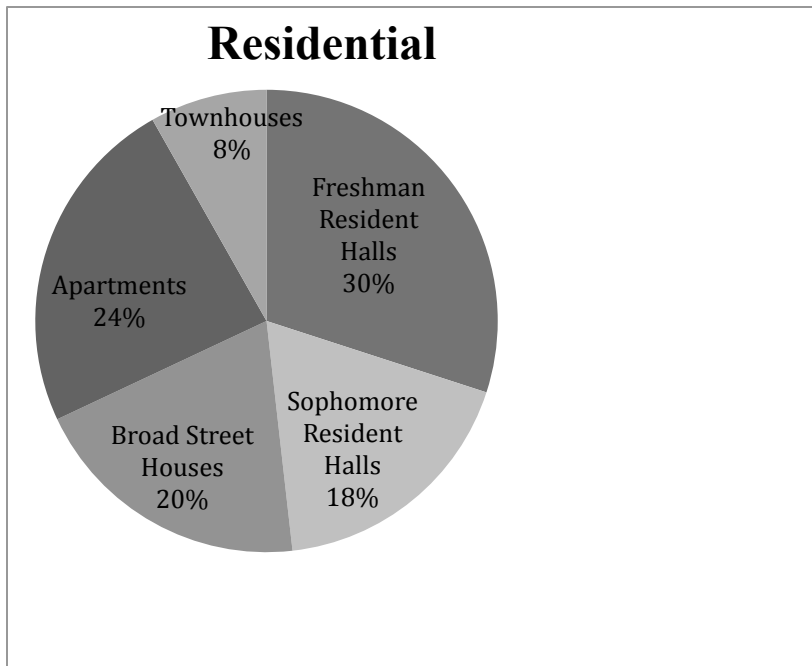


Figure 5. The above figure shows how water is used in different residential categories. The freshman sector is composed of Stillman, Andrews, East, West, and Curtis. The sophomore slice is the some of water use in Bryant, Cutten, 94 Broad, and 104 Broad. The apartment slice is composed Parker, Newell, and University Court Apartments. The Broad Street houses that make up the slice are Beta Theta Pi, Phi Kappa Tau, Creative Arts House, Phi Delta Theta, Class of 1934 House, Delta Upsilon, Loft House, Theta Chi, Delta Delta Delta, Asia House, Bunche House, Cushman House, the Loj, Gamma Phi Beta, and 116 Broad Street. Data was unavailable for Drake (sophomore) and Gate House(freshman).

Service Buildings

Colgate's cooling towers and heating plant annually use over 9 million gallons of water to regulate the temperature of campus buildings. To assess how much water Colgate University's main cooling towers use during the warmer months, one may view Figure 6. Colgate's main cooling towers used 4,519,660 gallons of water in 2011. As Figure 6 shows the amount of water used to cool Colgate's buildings fluctuates a great deal with season and temperature. This is true on a month-to-month basis, as well as on a year-to-year basis. This means that Colgate University's water consumption can dramatically fluctuate due to factors independent of Colgate's action like temperature. The fact that there is some amount of inherent randomness in the amount of water that Colgate must use to maintain its facilities is an important factor to realize.

Colgate's Water Use

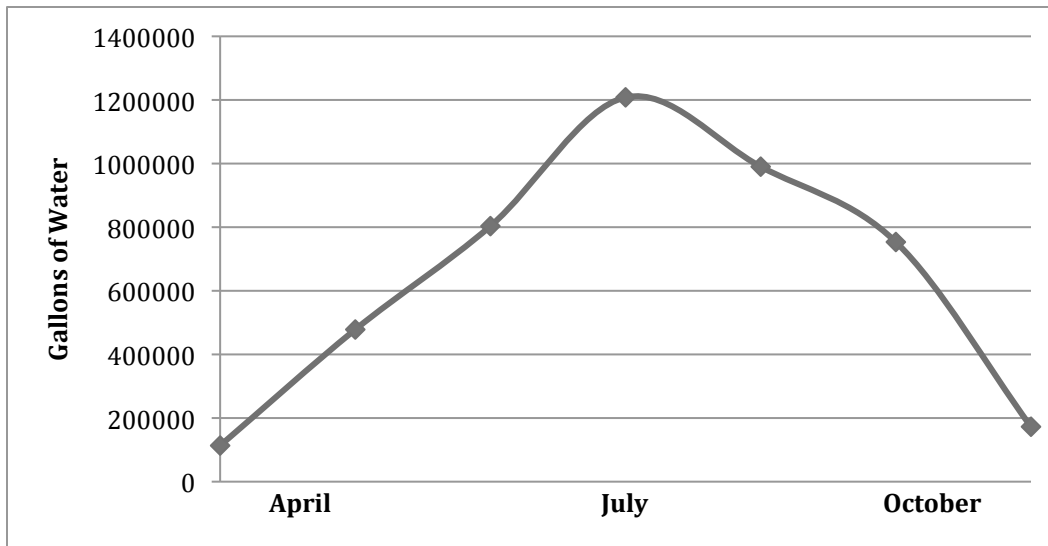


Figure 6- Each point represent the monthly amount of water used for air conditioning at Colgate in 2011. The cooling towers used the most water in July and other summer months. The cooling towers use no water before April or after October.

Dining

Between Frank Dining Hall and the O'Connor Campus Center (Coop), Colgate used over four million of gallons in its dining facilities. This figure does not include the Cutting Edge Bistro or the kitchens in residential buildings. Within dining facilities, water is used for typical bathroom uses, as well as for dining specific purposes. These include cooking and extensive cleaning and sanitizing. By looking at Frank's hourly water usage (Figure 7) and comparing it to the busy lunch and dinner periods, we can obtain insight into how the water is used. Because the hourly water consumption peaked after the busy lunch and dinner period started, we can conclude that most of the water is for cleaning as opposed to preparation.

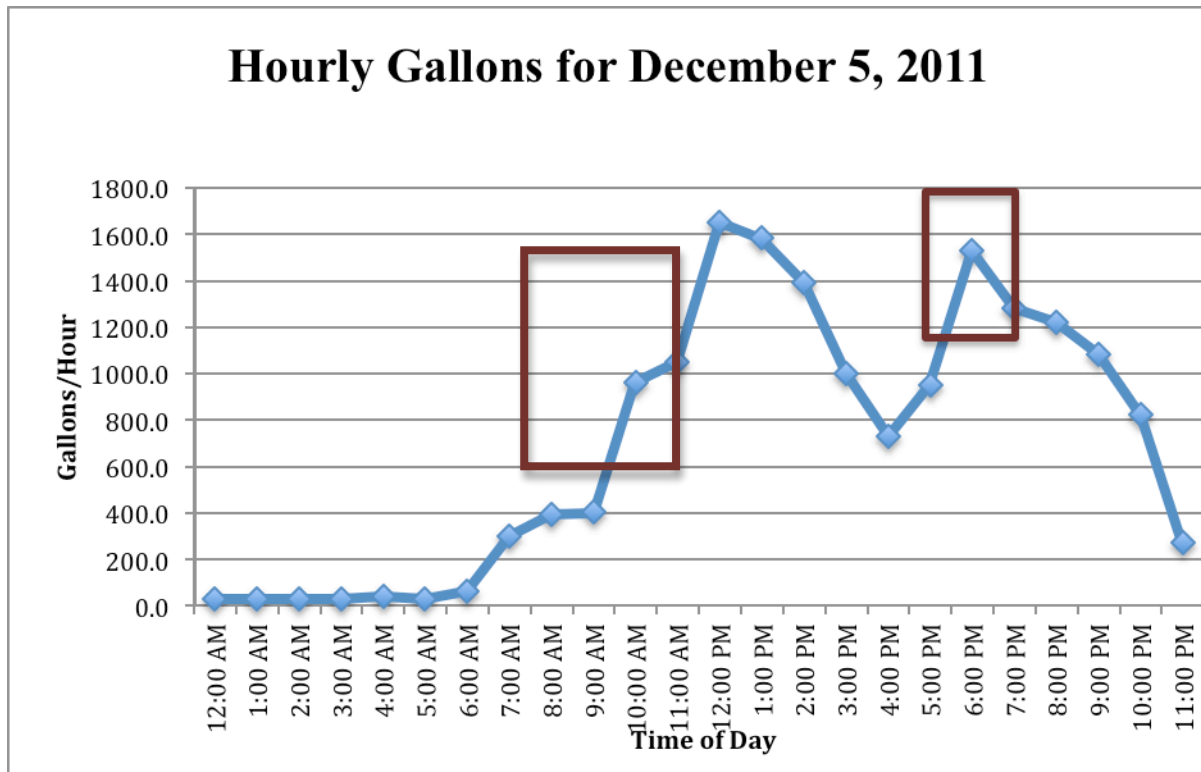


Figure 7. The hourly water consumption for a typical day in Frank Dining Hall. The boxed areas represent lunch time (11:30 AM-2:00 PM) and dinner time (5:30 PM-7:30 PM). In both cases the hourly consumption peaked after the busy periods started indicated that most of the water is used for cleaning and not cooking.

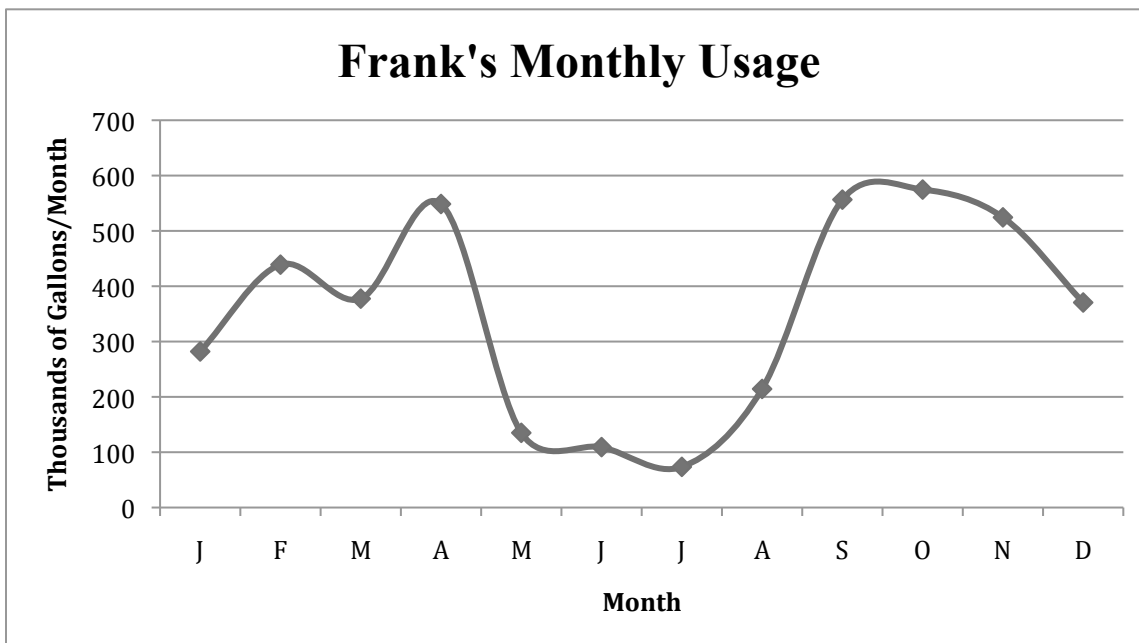


Figure 8. Frank Dining Hall's monthly water consumption in 2008. It is clear that there is substantially less water used in months with fewer classes in session.

Colgate's Water Use

First-Year Residence Halls

Sink Flow

Residence Hall	Flow Rate (gal/min)
Curtis	2.47
West	2.06
East	1.53
Stillman	1.70
Gate House	1.70
Andrews	2.97

Figure 9. Average sink flow rate in first-year residence halls

Currently, sinks are equipped with aerators. There was a very large range of flow rate within buildings due to different types of faucets. The average total for sink flow in all freshman dorms is 2.07 gallons per minute (gpm). There are a total of 170 sinks within these buildings, but the number within each building varies depending on the size and student residences within.

Toilets and Urinals

First year residence halls are currently equipped with Regal Sloan W700 toilets; these toilets use 1.6 gallons/flush (gpf). There are 136 toilets in the six residence halls; once again, each building varies in its total count depending on size and the number of students it houses. Current urinals use 1 gpf. Within these dormitories, there are 40 urinals combined.

Showers

In the summer of 2011, all 2.5 gpm showerheads within first year residential halls were replaced with 1.5 gpm alternatives. This project saved 500,000 gallons of water when comparing September 2011 with 2.5 gpm showerheads of September 2010 (John, Pumilio, Personal Communications, November 11, 2011).

Laundry Machines

Colgate recently began replacing old washing machines with Energy Star front-loading washers. This machine is more water and energy efficient using 14.8 gallons of water per cycle, while the old technology used 30 gallons of water per cycle. (Colgate University's Sustainability and Climate Action Plan, 2011).

Discussion

Academic Buildings

Colgate's Water Use

Offering 52 different majors, Colgate has a wide array of different academic buildings. The academic and administrative buildings incorporated into our report based on the meter reports represent approximately 6% of total water used. As Appendix C illustrates, the Ho Science Building used about 17,000 gallons last year. Because this is an extraordinarily low number, we have reason to believe the meter is not accurate for such a large building. Another building, designated by the school as "Science Building," uses almost 490,000 gallons last year. Although the metering system seems flawed, we believe the Ho is more efficient due to its water saving technologies. Furthermore, our findings about the Olin Hall crayfish tanks illustrate potential savings of money and water in one academic building. After four years, the new KG Aquatic crayfish system will begin to save the school by over \$7,000 annually.

Smith College is one of few peer institutions to have completed a water audit. Therefore, Smith is an important institution to which we can compare Colgate. This comparison will help create a context for the average amount of water used in different sectors by similar institutions. In comparison to Smith, Colgate's academic buildings use less water compared to the other areas. Smith's academic buildings use approximately 15% of the college's overall water, while Colgate's accounts for 6% (Committee on Sustainability, 2010).

Athletic Fields

Upkeep and processing standards of Colgate University's athletic facilities and fields required almost ten million gallons in the 2010-2011 fiscal year. This includes the water required for building function and use, and the irrigation of outdoor fields. Facilities incorporated in this figure include, from most to least water consumption: Seven Oaks Golf Course, Reid Athletic Center, Raider Power Performance Center, Lineberry Natatorium, Andy Kerr Stadium, the Stanford Fieldhouse, Tyler Field, Base camp, the College Street athletic shed, and the press box.

Although most of Colgate's athletic water consumption can be attributed to Seven Oaks Golf Course, current irrigation technology of the landscape is very efficient. The course consists of monitors that are able to measure soil moisture. Due to this, the sprinklers only turn on when additional water is needed (S. Graham, personal communication, October 17, 2011).

Colgate is watering fields at the most efficient time of the day. This is because in some climatic conditions, transpiration can account for as much as 50% loss of water (Texas AgriLife Extension Service, et al., 2011). In summer months, watering during the day can require up to 30% more water (Texas AgriLife Extension Service, et al., 2011). Even considering this fact, however, the irrigation system is still considered to be relatively inefficient according to Emmett House, Colgate's supervisor of athletic grounds. In light of this, the funding for replacing irrigation of the men's soccer team will help to save money and water and will greatly improve upon the current efficiency.

Looking more closely at the watering data, we examined water use on Tyler's Field, an artificial turf field used for the Raider women's field hockey and lacrosse teams. Current practices used an estimated 98,000 gallons of water in 2011 to water the field before games and prior to some practices as required by the NCAA. However, ecologically, turf fields require no water (E. House, personal communication, November 16). Additionally, watering turf fields uses more water than grass fields because there is a higher run-off rate due to the mere purpose and characteristics of artificial fields (E. House, personal communication, November 16). Apart from wasting water, run-off also poses a threat to pollution. This highlights an extremely inefficient aspect of Colgate's water usage, wasting water and money.

Colgate's Water Use

Colgate is relatively inefficient when comparing to other conservation-minded practices of athletic fields. These management practices use only the amount of water necessary to maintain the viability of the field (BMP Guide, 2004). In order to determine this amount, such things like field area, evapotranspiration rate, root depth and soil permeability must all be taken into account. Using automatically controlled irrigation systems instead of manually controlled ones helps to stop water waste by turning off when a break is detected (BMP Guide, 2004). In addition, conservation minded management consists of the following components: "computer controller ('digital operating system'), software, interface module, satellite field controller, soil moisture sensors, and weather station" (BMP Guide, 2004). These technologies help to "prevent overwatering, flooding, pooling, evaporation, and run-off of water, and should prevent sprinkler heads from applying water at a rate exceeding the soil holding capacity" (BMP Guide, 2004). Irrigation systems can also incorporate rainwater or recycled water (BMP Guide, 2004). Some peer institutions of similar caliber to Colgate that use weather-informed irrigation and/or irrigate with recycled water include Oberlin College, Smith College, Bowdoin College, and Colby College (Green Report Card, 2011).

In comparison, 7% of Smith College's water use is devoted to gyms and irrigation while 25% of Colgate's water use supplies athletic facilities (Committee on Sustainability, 2010). Although this may seem alarming at first, these differences make sense for a variety of reasons, allowing us to assume that our audit is correctly conducted. For one, Smith College does not maintain a golf course; the golf course at Colgate uses approximately 10% of Colgate's overall water use. In addition, Colgate hosts division one sports; thus, it can be assumed that we have more athletic facilities and fields to maintain.

Service Buildings

As illustrated by Figure 3, the service buildings on campus, primarily the cooling towers and the heating plant, account for approximately 16% of the total water Colgate consumes, which is the third highest of the five sectors we investigated. Figure 6 illustrates how the highest consumption of water by the cooling towers is during the summer months, with July being the peak. This makes sense, as the towers do not operate between October 15 and April 15. There is not much room for improvement within this sector, due to the fact that air conditioning and heating are necessary to maintain our current quality of life and the cooling tower is the most efficient technology (B. Belden, personal communication, November 15, 2011).

Smith's cooling plant accounts for 9% of its overall water, whereas Colgate's service buildings accounts for 16%. However, Colgate's value takes into consideration the heating plant, whereas Smith's numbers only accounts for the cooling plant.

Dining Facilities

By looking at Figure 8, it is clear that water usage is dependent on Colgate University's academic calendar. There is constant heavy use from late January to late April, with a lull until September, and another wave of constant heavy use until December. Given that this aligns with the school calendar, Frank Dining Hall uses more water when school is in session. Yet, when school is not in session, Frank still uses water. This may be because of reunion schedules, summer class programs and sports training, all activities that send members of the Colgate community to the dining halls outside of the school calendar.

Colgate's Water Use

As seen in Figure 7, Frank consumes inconsistent amounts of water throughout an average day. The boxes depict the main meal times, when Frank is most heavily used for dining purposes. Since meal preparation occurs around thirty minutes before each meal, and dishwashing occurs directly after one eats their meal (average meal is around 30 minutes), the highest points of water usage at Frank can be attributed to dishwashing (D. Fravil, personal communication, Nov. 11, 2011).

Many colleges and universities throughout the United States use similar dish washing technologies in their dining facilities, but there are more efficient models on the market. For instance, St. Peter's College located in Jersey City, New Jersey uses Ecolab's Apex dishwashing system, which utilizes tablet and PC technology to control and decrease water consumption (Local Sustainable Initiatives, n.d.). Sodexo, a university dining service that serves Colgate, replaced many of their university dishwashing systems across the country with the efficient Apex model, including St Peter's College. With the installment of the new dishwashing systems throughout a variety of locations, over 22,000,000 gallons were collectively saved across the country, equivalent to 34 Olympic-size pools (Did You Know?, n.d.).

First-Year Residence Halls

First-year residence halls use one third of the total residence hall water. Also, we focused our quantitative data review on these dormitories. Therefore, this discussion focuses primarily on fixtures within first-year residence halls.

Sinks

Although the sinks within freshman residential halls are equipped with aerators, there is much room for improvement as our calculated flow-rate indicates that sinks, on average, are inefficient compared to current technologies. Faucet aerators appropriate for hand washing can reduce flow rate to 0.5 gpm (Perdue et al., 2009). Many schools utilize low-flow faucets including Middlebury, Colby, Bowdoin and Bucknell (Sustainable Endowments Institute, 2011).

Toilets/Urinals

Currently, toilets within first year residential halls meet the Energy Policy Act. However, this indicates that Colgate is utilizing the bare minimal efficiency of toilets. High-efficiency toilets use 1.3 gpf; there are also dual-flush toilets. These have two separate buttons, one that eliminates solid waste with a 1.3 gpf and a second for liquid waste that uses 0.8 gpf (Perdue et al., 2009). Hamilton College has begun replacing toilets with dual-flush toilets (Sustainable Endowments Institute, 2011). Furthermore, the urinals in place are also meeting the upper legal limit requirement of 1 gpf. High-efficiency urinals use 0.25-0.5 gpf. There are also waterless urinals that do not require flushing and thus uses no water (Perdue et al., 2009). Middlebury and Colby are just two examples of peer institutions that have utilized this technology (Sustainable Endowments Institute, 2011).

Showers

The showerhead replacement project was a great step forward for Colgate University. These 1.5 gmp showerheads are the most efficient technology currently available (Perdue et al.,

Colgate's Water Use

2009). In one month this project will have saved Colgate \$5,000. Many of Colgate's peer institutions have reported replacing old showerheads with low-flow alternative including: Colby, Middlebury, Bucknell and Smith (Sustainable Endowments Institute, 2011)

Laundry Machines

The recent replacement of laundry machines has significantly improved water use efficiency of washing clothes. Literature suggests that an efficient machine uses two gallons of water per pound of clothes (Perdue et al., 2009). Among other institutions that have adopted water-saving machines are Middlebury, Colby, Bowdoin and Bucknell (Sustainable Endowments Institute, 2011).

Limitations

We acknowledge that this is not a fully comprehensive audit of Colgate University. This is due to several inhibiting factors. For one, there is limited water usage data for certain buildings because our current metering system does not monitor them. In addition, the institution is comprised of many facets and processes. To undertake each of these, as students in the given time frame, was simply not possible. Thus, in completing this research, we focused our audit primarily on secondary data to complete the most basic audit. To make this report more comprehensive, we incorporated indoor and outdoor benchmarks by utilizing data from personal data collection and interviews with stakeholders on campus. This helps to provide basic benchmark numbers regarding efficiency. These numbers can be used in comparing current practices with possible more efficient technologies and processes.

Recommendations

Overview

Below is a list of the major recommendations for Colgate based on our completion of a preliminary water audit. Following this section is a more detailed analysis of each recommendation.

1. Replace the current Olin Hall crayfish tanks with the proposed AG Aquatic aquarium system
2. Complete an irrigation audit, recycle grey-water, and reduce the watering of artificial turf on Tyler's Field
3. Investigate the replacement of the Hobart dishwasher in Frank Dining Hall with the EcoLab Apex dishwasher
4. Complete the proposed installation of low-flow showerheads in all residence hall showers, install more efficient sink aerators, and consider installing dual-flush toilets in the residence halls
5. Install a metering system for every building on campus that does not already have one and ensure that the system has an alert if the amount of used water appears to be inaccurate
6. Include water conservation, reclamation, and efficiency issues when constructing future

Colgate's Water Use

buildings on campus

7. Continue to better understand our water use

Academic Buildings

We recommend that Colgate accept the current proposal to replace the crayfish tanks with the new KG Aquatic system due to its environmental and economic benefits. Although it would cost approximately \$30,000 to implement the new system, it will pay for itself in savings within about four years. The current system costs Colgate over \$15,000 to operate each year. The new system will save Colgate approximately \$7,250 annually in operating costs. Therefore, after the system pays for itself, there will be an annual savings of approximately \$8000. Additionally, over 2,000 gallons of water will be saved each day. (D. McCoach, personal communication, October 25, 2011).

Athletic Facilities

We have several recommendations regarding Colgate's practices of watering athletic fields. First of all, we recommend Colgate complete an irrigation audit to help the University to better understand current irrigation efficiency, as well as determine the amount of water necessary to maintain viable fields.

In addition, Colgate should catch and store rainwater or recycle grey-water to use for athletic field irrigation (Green Report Card, 2011). Although there is a hefty capital investment needed for the project, Colgate should consider replacing current irrigation systems with more efficient in-ground irrigation systems. Long-term water and cost savings will outweigh the initial payment (E. House, personal communication, November 16, 2011)

Because NCAA regulation requires that the field is watered before every game, this recommendation poses a challenge. However, currently, Colgate also waters the turf during practice sessions as well, even though the NCAA does not require this. If a negotiation is made with athletic staff, Colgate could save 100,000 gallons of water annually by only watering the turf before games (E. House, personal communication, November 16, 2011). This seems like a self-evident step to being more sustainable, as an artificial turf field requires much less water input than Colgate currently uses. Colgate hopes to save both money and water by reducing unnecessary watering of the artificial turf by 2013 (Colgate University's Sustainability and Climate Action Plan, 2011).

Service Buildings

Based on the results of our investigation of service buildings, and in particular the cooling towers, we have no current recommendations for this area to become more efficient.

Dining Facilities

Generally, we found that Colgate uses efficient water practices within its dining facilities. However, there are potential improvements to decrease the consumption of water in this sector. In 2008, Sodexo announced the replacement of its dishwashing products and systems with new

Colgate's Water Use

the EcoLab dishwashing system (Sodexo, 2008). Because Colgate uses Sodexo as its dining service, the University will potentially have the opportunity to replace the Hobart dishwasher with the EcoLab Apex dishwasher in given time. By installing the state of the art EcoLab Apex dishwasher, the University could save water, energy, and money (Sodexo, 2008). After contacting a representative from the EcoLab industry, we were unable to determine the pricing of the Apex dishwasher. However, we recommend that Colgate dining services meet with a representative from EcoLab to price a new machine. Other benefits to this new product include less packaging and less required energy and labor to operate the system (Sodexo, 2008).

Residence Halls

Colgate's Sustainability and Climate Action Plan recommends that Colgate select a standardized low-flow showerhead brand. Colgate, which replaced 335 2.5 (gpm) showerheads in first-year housing in the end of the 2010-2011 fiscal year, aims to do the same in sophomore housing units by the end of 2013 (Colgate University's Sustainability and Climate Action Plan, 2011). Additionally, we recommend that Colgate replaces these 1.5 gpm showerheads in all residence houses, including Broad Street residences, the Townhouses, and other campus residences. According to the Sustainability and Climate Action Plan (2011), low-flow showerheads in first-year residences cost the school \$3,900, but resulted in an annual savings of \$28,000 and a net savings of \$24,000 after the first year. Implementation of low-flow showerheads in the second-year residences will cost \$5,900 upfront, but result in almost \$24,000 in savings and a net savings of \$17,900 (Colgate University's Sustainability and Climate Action Plan, 2011). Due to the immense savings in money and water, this recommendation should be considered.

Colgate should also install more efficient aerators in the residence halls. Estimating people use sinks 6 minutes a day for processes like brushing teeth, hand and face washing, and shaving, first year dorms use approximately 10,000 gallons of water per day, given the flow rate of sinks is 2.07 gpm. If Colgate were to replace the current aerators in first year dormitories with 0.5 gpm faucets, there would be yearly water saving of nearly 3,000,000 gallons. This would result in a yearly savings of \$28,000. Given that there are 170 sinks in these buildings, and aerators cost about \$2.15 individually it would only cost less than \$400 for the aerators. Given these numbers, this is definitely a project to consider.

In first-year residence halls, we feel that Colgate should look into the possibility of installing new, high efficiency toilets (HET) into all first and second-year residence halls. Current Colgate toilets abide by the Energy Policy Act of 1992, which mandates that common flush toilets use 1.6 gallons. However, HETs have an efficient flush volume of 1.3 gallons or less through a "dual-flush" option, which would reduce the water use by 20%. Implementation of these toilets would save Colgate money and water. Other schools that have implemented dual-flush toilets in residence halls include Northern Michigan University, Columbia University, Emory University, and Tufts University (AASHE, 2010).

Future Construction and Water Metering

In the construction of new buildings, Colgate must ensure that it considers how much water the buildings will consume and the future costs of this consumption to the school. As a higher-education institution, Colgate is responsible to take issues reclamation, conservation and

Colgate's Water Use

efficiency into consideration as it constructs new buildings. Colgate's latest building is planned to be LEED Certified, showing Colgate's care for sustainable development.

Furthermore, we recommend that Colgate install water meters on all buildings that do not currently have one. A system that would give an alert when numbers or water levels are off would also be beneficial to the school.

Conclusion

Colgate should take more responsibility in proliferating water conservation strategies through the stated recommendations. Promotion of the value of water around campus will also be important. Water is a vital aspect of our lives that influences nearly everything we do. In the upcoming decades, water will be an issue pushed to the forefront, requiring a careful re-evaluation of how we use it. Without consideration of these recommendations, the University could be faced with external consequences, such as less student interest in the school. Furthermore, the school will continue to face the current impact of the financial and environmental costs of water consumption. By considering these recommendations and the ways in which we use our water, let us act as a leading sustainable institution and provide a guiding light to similar institutions all over the nation and world.

Acknowledgements

We would like to extend our deepest thank you to everyone who has contributed to our report. First of all, thank you to Professor April Baptiste and John Pumilio for guiding us in the right direction and answering all of our questions. We appreciate your advice. Thank you to all of our interviewees, Becky Fedak, Dan McCoach, Pete Babich, Brian Belden, Dan Fravil, Sean Graham, Thomas Kane, Emmett House, and Dan Gaugh. We could not have completed our report without your expert opinions.

References

- Aldaya, M.M., Chapagain, K.A., Hoekstra, Y.A., and Mekonnen, M.M. (2011). "The Water Footprint Assessment Manual. Setting the Global Standard." *Social and Environmental Accountability Journal*
- American Rivers. (2011, May 17). *Susquehanna River Sentinel*. "Susquehanna Named Most Endangered River In The Nation: Natural Gas Drilling Posing Unprecedented Threat. American Rivers: Susquehanna Named Most Endangered". Retrieved December 14, 2011. <<http://www.americanrivers.org/newsroom/press-releases/2011/susquehanna-named-most-endangered-river-5-17-2011.html>>.
- Colgate University. (2011). "Colgate University's Sustainability and Climate Action Plan." Retrieved December 14, 2011 from <https://docs.google.com/a/colgate.edu/viewer?a=v&pid=sites&srcid=Y29sZ2F0ZS5lZH V8MjAxMS0yMDE1LXN1c3RhaW5hYmlsaXR5LWFnZC1jbGltYXRILWFjdGlvb1lw bGFufGd4OjEwNGIwYTA5Yzk0YzhhNzI>
- Colgate University Utilities Bill. (June 2007-May 2011). Accounting Office.
- Committee on Sustainability. (2010, March 15). *Sustainability and Climate Action Management Plan*. College, North Hampton, MA. Retrieved December 14, 2011 <<http://www.smith.edu/green/docs/SmithCollegeSCAMP.pdf>>.
- Did You Know?. (n.d.). *New Warewashing System Saves Water, Energy and Waste* . Retrieved November 19, 2011, from www.spcfoodservice.com/documents/apex.pdf
- Dziegielewski, B., & Kiefer, J. (2009). Water Conservation Measurement Metrics: Guidance Report. Retrieved from http://www.awwa.org/files/Publications/Streamlines/2010/030210/AWWA%20Metrics%20Guidance%20Report%20Jan-22-2010%20Final%20_3_.pdf
- Local Sustainable Initiatives. (n.d.) Retrieved on November 21, 2011 from <http://www.spcfoodservice.com/sustainability/local.html>
- New York State Department of Environmental Conservation. (n.d.) *Drought Facts*. Retrieved November 27, 2011 from <http://www.dec.ny.gov/lands/5011.html>
- Pacific Institute Publications. (n.d.). *Water Fact Sheet Looks at Threats, Trends, Solutions*. Retrieved December 6, 2011, from http://www.pacinst.org/reports/water_fact_sheet/
- Perdue, B., Freeman, D., Hunt, G., & Reeder, T. (2009). Water Efficiency Manual. Retrieved from <http://www.p2pays.org/ref/01/00692.pdf>
- Sodexo. (n.d.). Dining Services, Saint Peter's College. *Dining Services, Saint Peter's College*. Retrieved November 19, 2011, from

Colgate's Water Use

<http://www.spcfoodservice.com/sustainability/local.html>

Sodexo. (2008, April 7). "Sodexo Announces New System to Boost Positive Environmental Impact." Retrieved December 1 from <http://www.sodexousa.com/usen/newsroom/press/ecolabapex040708.asp>

Sustainable Endowments Institute. (2011). The College Sustainability Report Card. Retrieved from <http://www.greenreportcard.org/>

Sustainable Sources. (2011). Xeriscape. Retrieved from <http://xeriscape.sustainable-sources.com/#DEFINITION>

Texas AgriLife Extension Service, Texas A&M University, & Texas A&M System. (2011). Aggie Horticulture. Retrieved on November 20, 2011. <http://aggie-horticulture.tamu.edu/>

The Associated Press (2011, October 2). NY floods roil the water but little health threat. Retrieved November 27 from <http://online.wsj.com/article/APd61a8a5e60514ddaa5428ed76672282b.html>

The Neponset River Watershed Association. (n.d.) "High Efficiency Toilets." Retrieved December 1 from <http://www.neponset.org/HighEfficiencyToilets.htm>

U.S. Census Bureau. (2011). State and Country Quick Facts: New York. Retrieved November 27, 2011 from <http://quickfacts.census.gov/qfd/states/36000.html>

Water. (n.d.). Home Water Audits. *Texaswater, Texas A&M University*. Retrieved November 1, 2011, from <http://texaswater.tamu.edu/conservation/home-water-audits>

United Nations Educational Scientific and Cultural Organization. (n.d.) Valuing Water. Retrieved November 27 from http://www.unesco.org/water/wwap/facts_figures/valuing_water.shtml

Zabarenko, Deborah. (2011, October 26). "THE DAILY STAR :: Water use rising at more than twice the rate of world population." *THE DAILY STAR*. N.p. Retrieved November 1, 2011. <<http://www.dailystar.com.lb/News/International/2011/Oct-26/152211-water-use-rising-at-more-than-twice-the-rate-of-world-population.ashx#axzz1d546RLiE>>.

Appendix A: Audit Checklist

Self-Assessment Checklist (N.C. Department of Environment and Natural Resources, n.d.)

What efforts has your facility already made in water efficiency? Several questions for facility managers are listed below to help gauge a facility's present water efficiency performance.

Top Management Commitment and Resources

- Is water efficiency included in the company's environmental policy statement?
- Are water efficiency responsibilities delegated?
- Are quantitative goals established and tracked?
- How are water efficiency goals communicated to employees?
- What incentives and feedback loops exist for employee participation, suggestions and increased awareness?
- Has your facility taken advantage of available help and resources from your utilities, assistance programs, vendors or consultants?

Water Efficiency Survey

- Do you know the actual breakdown of your water uses: cooling and heating, domestic uses, process rinsing, cleaning activities, kitchens, laundries, landscaping, water treatment regeneration, evaporation, leaks and others?
- Do you know your life cycle water costs for supply water, wastewater treatment, sewer/discharge and heat and mechanical energy losses?
- Are you doing simple things such as leak inspections, eliminating unnecessary uses and using timers? Are these practices institutionalized?

Identifying Opportunities - Target Areas for Water Reduction

Domestic

- Are code-conforming 1.6 gpf commodes, 0.5 to 1.0 gpm faucet aerators and low-flow 1.5 to 2.5 gpm showerheads in use?

Heating/Cooling

- Has once-through cooling water used in air conditioners, air compressors, vacuum pumps, etc., been eliminated with the use of chillers, cooling towers or air-cooled equipment?
- Has blow-down/bleed-off control on boilers and cooling towers been optimized?
- Is condensate being reused?

Process Rinsing and Cleaning

- Have you considered improved rinsing techniques such as counter-current systems, sequential use from high quality to lower quality needs, conductivity flow controls, improved spray nozzles/pressure rinsing, fog rinsing or agitated rinsing?
- Is water turned off when not in use by flow timers, limit switches or manually?
- Is the life of an aqueous bath being maximized via filtration and maintenance control? Are "dry clean-up" practices used instead of hosing down, and is first-pass pre-cleaning conducted with squeegees, brushes or brooms?

Colgate's Water Use

On-Site Water Reuse

- Is water quality matched with water quantity?
- Have reuse applications been examined for process water, landscaping irrigation, ornamental ponds, flush water and cooling towers?

Landscaping

- Are low-flow sprinklers, trickle/drip irrigation, optimized watering schedules and water placement, preventive maintenance and xeriscaping techniques in place?

Kitchens

- Are “electric eye” sensors for conveyer dishwashers installed?
- Have new water and energy efficient dishwashers been examined?

Water Efficiency Action Plan

- Have you performed a cost analysis on water efficiency opportunities?
- Do you have a prioritized implementation schedule? Are water users informed of the changes and communication channels open for feedback?

Tracking and Communicating Results

- Do you post monthly water usage rates to employees and management?
- Are your water efficiency achievements being recognized in case study articles, media coverage, mentoring to other businesses, business environmental exchange programs or in award programs?

Appendix B: Personal Interviews

Colgate's Water Use

Pete Babich, Associate Director of Facilities and Manager of Engineering Services

1. What are the Cooling Towers, and how do they work?
2. Do any of the buildings on campus have technologies that recirculate water to cool down equipment?
3. How is the pool metered?
4. Would you recommend any improvements to our metering system?
5. Why is water important?
6. Where does our wastewater go?
7. What water efficient technologies at Colgate being used?

Brian Bedel, Foreperson in the Facilities Department:

1. How efficient are the current cooling towers?
2. For what exactly are the cooling towers used?
3. When was the most recent cooling tower installed?
4. Is the cooling tower shut off for certain times of the year?
5. When is the cooling tower using the most water?
6. Are there more efficient technologies that serve the same purpose?
7. Is there anything else you think we should know about this issue?

Becky Fedak, Environmental Consultant with the Brendle Group

1. Is it possible for non-experts to complete a water audit? If not, can we complete a considerable amount of it?
2. What should our first steps be for the audit?
3. What are the most important areas of data collection that can feasibly be completed by six undergrads?
4. Are there any crucial areas of a water audit that require significant funding?
5. Who are some of the key stakeholders (i.e. the University plumber, the University's water/sewer utility service) that we should be attempting to contact?
6. Are we being too narrow-minded by just looking at the University's water usage within our time frame, or should we be looking at the community as a whole?

Dan Fravil, Resident Dining Manager:

1. Have you considered improving rinsing techniques?
2. Is water turned off in between dishwashing?
3. Are "dry clean up" practices used?
4. Are "electric eye" sensors for conveyer dishwashers installed?
5. Have new water and energy efficient dishwashers been examined?
6. What is the dishwashing schedule?
7. Why is water important?
8. How will trayless dining contribute to a decrease in water consumption?

Sean Graham, Director of Utilities and Public Works of the Village of Hamilton:

1. What is the source of our water?
2. Where does our wastewater go?
3. Where do you think Colgate stands in water efficiency?

Colgate's Water Use

4. What technologies has Colgate installed to improve their water consumption?
5. Where is there room for improvement?
6. What problems does Colgate run into as they try to become more Water efficient?

Thomas Kane, Colgate University Plumber and Foreperson:

1. How is water used in first-year residence halls?
2. Are these technologies efficient?
3. How has the installation of low flow showerheads saved the school?
4. What are the plans for installation of low flow showerheads in other residences at Colgate?
5. How efficient is the current sink aerator technology?
6. Are there plans to install new aerators?
7. Are the washing machines as efficient as possible?
8. What do you know about the crayfish tanks in Olin Hall?
9. Is there anything else you think we should know about this issue?

Dan McCoach, Trade Supervisor (Thomas Kane also present):

1. Do you have quantitative data on how much water is being used by the crayfish tanks?
2. How many crayfish tanks are there?
3. Are there plans being put in place to replace the current tanks? If so, what are they?
4. How much do the tanks cost Colgate per year?
5. How much water do the tanks use per year?
6. How much will a new system of tanks save Colgate financially and in terms of water savings?
7. Is there anything else you think we should know about this issue?

John Pumilio, Sustainability Coordinator

1. Why do you feel water consumption is an important facet to look at?
2. What has Colgate already done to reduce water consumption?
3. Do you know of any future plans that will reduce water consumption?
4. How do you feel we compare to other campuses?

Colgate's Water Use

BUILDING	GALLONS/YEAR
PUMPING STATION	23,664,476
HEATING PLANT	5,227,024
LAKE RD, MAINT BLDG (golf course)	4,660,040
GOLF COURSE, HAMILTON	4,355,604
BLDG 2 COLLEGE ST(Parker Appt)	4,222,460
FRANK DINING HALL	4,205,680
CHILLED WATER PLANT	3,800,588
REID ATHLETIC CENTER	3,132,624
BRYAN DORM	2,236,520
CUTTEN DORM	1,907,400
CASE LIBRARY	1,238,688
GYMNASIUM	1,051,688
COLLEGE ST BRICK BLD	676,940
SWIMMING POOL	615,604
88 BROAD STREET (Beta Theta Pi)	575,960
SCIENCE BLDG	488,444
92 BROAD ST. (Phi Kappa Tau)	427,856
100 BROAD ST. (Creative Arts House)	401,676
BLDG 3, COLLEGE ST,	399,432
114 BROAD STREET(Phi Delta Theta)	398,684
COLLEGE ST BRICK BLD	391,952
49 BROAD ST(Class of 1934 House)	388,960
68 BROAD ST DELTA UPSIL	387,464
110 BROAD ST(Loft House)	371,576
THETA CHI	368,016
BLDG 4, COLLEGE ST,	365,024
84 BROAD ST (Delta Delta Delta)	326,128
ANDY KERR STADIUM	322,388
2 E LAKE ROAD, CLUB HO	317,900
40 BROAD STREET (Kappa Kappa Gamma)	306,680
TOWNHOUSE #4 Wa	299,200
ART & ART HISTORY	294,712
100 HAMILTON STREET	288,728
104 BROAD STREET(Sophomore Wellness Hous)	282,744
118 BROAD ST. (Asia House)	258,060
TOWNHOUSE #1 Wa	252,060
TOWNHOUSE #6 Wa	252,824
TOWNHOUSE #2 Wa	239,360

Colgate's Water Use

TOWNHOUSE #9 Wa	228,888
94 BROAD ST	210,936
TOWNHOUSE #8 Wa	209,440
TOWNHOUSE #3 Wa	208,692
MCGREGORY HALL	207,944
TOWNHOUSE #5 Wa	208,692
TOWNHOUSE #7 Wa	207,944
PERSSONS HALL	184,746
80 BROAD ST (Bunche House)	182,512
FIELD HOUSE	169,048
40 BROAD STREET (Kappa Kappa Gamma)	161,568
DANA ARTS CENTER	151,844
SPANISH HOUSE	151,096
Coop	149,088
1-11 UTICA ST BOOKSTORE	148,014
CUSHMAN 102 BROAD	147,356
70 BROAD ST. (The Loj)	143,616
88 HAMILTON ST (Campus Safety)	141,372
ADMINISTRATION BLDG	127,908
72 BROAD GAMMA PHI BETA	127,160
UNION BLDG	126,412
SERVICE BUILDING	124,916
ALANA CULTURAL CENTER	109,729
PRESTON HILL, HOUSE	106,964
10 UTICA ST 2ND FLOOR	100,232
TYLER (TURF) FIELD	97,988
MERRILL HOUSE	96,492
FRENCH HOUSE	74,052
116 BROAD STREET	70,132
CHAPEL HOUSE	67,320
69 HAMILTON STREET	63,580
79 HAMILTON STREET	60,588
DRAKE HALL	59,840
30 COLLEGE STREET	56,848
55 HAMILTON STREET	56,848
59 HAMILTON STREET	55,352
SPEAR HOUSE	51,612
CORNER MONT & EATON	48,620
32 COLLEGE STREET	42,636
13 E KENDRICK AVE	38,148

Colgate's Water Use

ANDY KERR STADIUM	35,904
LAWRENCE	34,106
BASE CAMP	32,912
11 PAYNE STREET	29,172
36 COLLEGE STREET	21,692
BROAD ST	20,944
HO BUILDING	17,002
4 MONTGOMERY ST DOWN	14,960
COLLEGE ST ATHLETIC SHED	12,716
35 PAYNE STREET	1,496
PRESS BOX	1,496
59 HAMILTON ST	748
OLMSTEAD HOUSE, EARL	748
GATE HOUSE	No Meter
WATSON HOUSE	No Meter
CHAPEL	No Meter
HUMAN RESOURCES	No Meter
HASCALL HALL	No Meter
STUDENT UNION	No Meter
ALUMNI	No Figures

Appendix D: Buildings Encompassed in Uphill Pumping Station in fiscal year 2010-2011

Building	Gallons/Year
Frank Dining Hall	4,205,680
Alana	109,729
Coop	149,088
Lawrence	34,106
Ho	17,002
Alumni	No Figures
Gate House	No Meter
Watson House	No Meter
Chapel	No Meter
Human Resources	No Meter
Hascall Hall	No Meter
Student Union	No Meter
Total	23,664,476

Appendix E: Breakdown of Sectors

Residential

100 broad st. (creative arts house), 100 hamilton street, 104 broad street (sophomore wellness house), 11 payne street, 110 broad st(loft house), 114 broad street(phi delta theta), 116 broad street, 118 broad st. (asia house), 13 e kendrick ave, 13 e.kendrick ave, 30 college street, 32 college street, 35 payne street, 36 college street, 4 montgomery st down, 40 broad street (kappa kappa gamma), 40 broad street (kappa kappa gamma), 49 broad st(class of 1934 house), 55 hamilton street, 59 hamilton st, 59 hamilton street. 68 broad st delta epsilon, 69 hamilton street, 70 broad st. (the loj), 72 broad gamma phi beta, 79 hamilton street, 80 broad st (bunche house), 84 broad st (delta delta delta), 88 broad street (beta theta pi), 9 e. kendrick ave, 92 broad st. (phi kappa tau), 94 broad st, andrews, bldg 2 college st(parker appt), bldg 3, college st., bldg 4, college st., broad st, bryan dorm, college st brick bld, college st brick bld, corner mont & eaton, curtis, cushman 102 broad, cutten dorm, drake hall, east, french house, preston hill, house, spanish house, stillman, theta chi, townhouse #1 wa, townhouse #2 wa, townhouse #3 wa, townhouse #4 wa, townhouse #5 wa, townhouse #6 wa, townhouse #7 wa, townhouse #8 wa, townhouse #9 wa, and west

Athletic

2 e lake road, club house, andy kerr stadium, base camp, college st athletic shed, field house, golf course, gymnasium, lake rd maintenance bldg (golf course), new driving range, press box, reid athletic center, snack shed-golf course, swimming pool, tyler (turf) field, van doren field

Academic/Administrative

1-11 utica st bookstore, 10 utica st 2nd floor, 88 hamilton st (campus safety), administration bldg, alana, art & art history, case library, chapel house, dana arts center, ho, lawrence, mcgregory hall, merrill house, olmstead house, earl, perssons hall, science bldg, spear house, union bldg, wynn

Dining

frank dining hall and o'connor campus center

Maintenance Buildings

cooling towers, heating plant, and maintenance shed