Clemson University

Environmental Audit

2019 Report

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Executive Summary

A showcase of Clemson agricultural programs is the Clemson University Student Organic Farm (SOF), a 14-acre, USDA certified organic farm located in Calhoun Fields, also known as the Clemson Bottoms. While the farm has never collected quantitative data on its operations, in recent years it began supporting various research projects. The farm utilizes the sustainable practices of drip irrigation, cover cropping, non-chemical pest management, and crop diversity. A variety of vegetables, fruits, herbs, and flowers grown on the farm are sold through the farm's market program and other farmers markets in the Clemson area. This market service is a recent replacement for the farm's Community Supported Agriculture program, which served as an outlet for selling the farm's goods through the summer of 2018. These market revenues help fund the farm, in addition to grants from the USDA and most recently by funding obtained from the Simpson Research and Education Center. The farm is staffed by 8-12 part-time students each year, and it also provides opportunities for both undergraduate and graduate students to carry out research. In addition to Clemson's Student Organic Farm, there are many other agricultural programs connected to and promoted by Clemson University. The South Carolina Botanical Gardens is a beautiful and highly visited location close to campus. In addition, there are research farms that support agricultural research, teaching, and public services.

Introduction

While Clemson University's 2013 Environmental Audit was successful in measuring the environmental impact and scale of many campus programs, it failed to assess the substantial effect of Clemson's agriculture and farming programs. Various sustainability techniques were observed by Clemson's Agriculture and farming programs to measure the efficacy and environmental impact of different agricultural practices. The sustainable practices of drip irrigation, cover cropping, non-chemical pest management, and crop diversity are utilized on the farm in the realm of sustainable agriculture. To draw attention to effective and ineffective sustainable farming practices, our team sought to collect ten years of data pertaining to the sustainability practices implemented by the Clemson Student Organic Farm. Subsequently, we found that no such data was kept, despite the many sustainable efforts being made by the Clemson Student Organic Farm.

The product not used for research by the Simpson Research and Education Center is sold on a weekly basis at the farm's market, which is open to the public. The farm's market provides some income for operations; however, the majority of funding comes directly from the Simpson Research and Education Center and national agricultural grants. Although the Clemson Student Organic Farm successfully implements sustainable agricultural practices, there is room for improvement in data management as well as reporting quantitative evidence.

The Sustainable Agriculture and Farming chapter of the 2019 Environmental Audit will provide a general overview of the Student Organic Farm and of sustainable agriculture in general. Then, it will detail all the sustainability practices that the organic farm is pursuing, including drip irrigation, cover cropping, non-chemical pest management, diversified crop landscape, and budget. We will briefly touch on other agricultural programs at Clemson. We will close the chapter with the auditing students' insights.

General Overview of the Student Organic Farm

The Clemson University Student Organic Farm (SOF) is a 14-acre, USDA certified organic farm used for organic farm research (Calhoun, 2019). It is located in Calhoun Fields and was established in 2001 ("Save Clemson," 2009). On top of supporting various research projects, a variety of vegetables, fruits, herbs, and flowers grown on the farm are sold through the farm's market program and other farmers markets in the Clemson area (Robb, 2019). This market service is a recent replacement for the farm's Community Supported Agriculture program, which served as an outlet for selling the farm's goods through the summer of 2018. These market revenues help fund the farm, in addition to grants from the USDA and most recently by funding obtained from the Simpson Research and Education Center. The farm is staffed by 8-12 part-time students each year, and it also provides opportunities for both undergraduate and graduate students to carry out research (Zehnder, 2017).

Figure SA 1: Student Organic Farm (*Photo courtesy of Bethany Williams*)

Sustainable Agriculture

According to the UC Davis Sustainable Agriculture Research and Education Program, "the goal of sustainable agriculture is to meet society's food and textile needs in the present without compromising the ability of future generations to meet their own needs." In addition, this definition of sustainable agriculture integrates three main goals: environmental health, economic profitability, and social and economic equity (Feenstra, 2019). Meeting these goals involves "building and maintaining healthy soil, managing water wisely, minimizing air, water, and climate pollution, and promoting biodiversity" ("What is Sustainable," 2019).

Examples of sustainable farming practices include planting cover crops, rotating crops, reducing tillage, and applying integrated pest management ("What is Sustainable," 2019). By implementing processes such as these, farms can ensure the growth of well-developed crops, and thus, the success of the surrounding communities for years to come.

Clemson Organic Farm Sustainable Practices

According to Dr. Geoff Zehnder, Coordinator of Integrated Pest Management and Sustainable Agriculture Programs at Clemson University, the Clemson Student Organic Farm implements many of the aforementioned sustainable farming techniques (Zehnder, 2017). The Student Farm plants cover crops every year (2017), which are invaluable in maintaining soil quality during off-season times (What is Sustainable). Cover crops help to maintain soil quality by suppressing weeds, protecting against erosion due to rain or runoff, adding active organic matter back into the soil and helping to suppress soil diseases and pests (Björkman (a), 2019). The organic farm implements non-chemical pest management practices such as pest-resistant crop varieties, as well as intentionally establishing a habitat that attracts beneficial insects to control the pest insects, helping to ensure that a healthy crop is produced (Zehnder, 2017). These techniques diversify the crop landscape (Zehnder, 2017), which aids in increasing yield, increasing the soil health, and finally, managing pests ("No-till," 2019). When crop rotation is used, it increases yield, versus when one crop is grown continuously ("No-till," 2019).

Drip Irrigation

The Clemson Student Organic Farm uses drip irrigation as a means of reducing water usage. Drip irrigation, also called trickle irrigation, is a technique in which water flows through a filter into designated drip pipes (Lamont Jr., 2019). The water is then distributed through emitters into the soil near the roots of the plants (Lamont Jr., 2019). There are many advantages to the drip irrigation method; some of these include better targeting of specific plants, prevention of unwanted plant growth, and greater efficiency in the output of water (Stauffer, 2019). Drip irrigation also can reduce labor and operating costs as well as reduce energy costs (Stauffer, 2019).

Cover Cropping

On the Clemson Student Organic farm, cover cropping has many benefits. It assists in suppressing weeds, protecting the soil from rain and runoff, reducing surface crusting, fixing nitrogen, improving soil aggregate stability, suppressing soil diseases and pests, and many other critical benefits (Björkman (b), 2019). The organic farm uses cover cropping to also break disease cycles in the soil. Cover cropping is one method of farming sustainably because it improves the agroecosystem and indirectly improves qualities of neighboring natural ecosystems. Certain plants are commonly used for cover cropping, such as rye, buckwheat, clover, and sorghum.

Non-Chemical Pest Management

Integrated Pest Management is an alternative approach to traditional pest management that uses information on the life cycles of pests and their interactions with the environment, in combination with available pest control methods, to manage pests by the most economical means while causing the least possible damage to people, property, and the environment.

The Department of Pesticide Regulation at Clemson University supports Integrated Pest Management (IPM) in South Carolina schools. IPM does not mean that pesticide use will be disallowed, or even discouraged. However, the need to protect children from exposure to pesticides dictates that emphasis must be placed on non-chemical pest management methods such as sanitation first with chemical methods being used only when necessary (Godfrey, 2017).

Diversified Crop Landscape

The Clemson University organic farm also keeps a practice of diversifying its crop landscape in order to improve soil fertility and reduce the use and need for pesticides. This means that, rather than exclusively planting corn and soybeans, farmers grow and rotate a variety of crops such as legumes and wheat. Doing so provides both environmental and energy benefits of longer, more complex crop rotations. It has been proven that that multi-year, multi-crop rotations produce high yields for each crop in the rotation, control pests and weeds with less reliance on chemical pesticides and enhance soil fertility with less need for synthetic fertilizers. This practice of diversifying the crop landscape is vital for sustainability on farms and helps move Clemson toward a healthy, sustainable food system.

Budget

The annual operating budget for the farm is set, in part, by the Simpson Research and Education Center (Robb, 2019). The farm also generates revenue for the onsite market program and has also secured funding from a variety of national agricultural grants.

Other Agricultural Programs at Clemson

In addition to Clemson's Student Organic Farm, there are many other agricultural programs connected to and promoted by Clemson University. One Clemson extension program is the South Carolina Botanical Gardens, a beautiful and highly visited location close to campus that has a variety of appealing plants. Though it is more visited than other agricultural locations around Clemson, it is still used for the purpose of educating the surrounding area about plant life and environmental conservation (Education for Everyone, 2019). In addition, there are research farms that support agricultural research, teaching, and public services of Clemson University "in an efficient and effective manner while maximizing available resources" ("Calhoun Field Laboratory," 2019). Examples of these farms are Calhoun Fields, Equine Center, LaMaster Dairy Center, Morgan Poultry Center, Musser Fruit Farm, Starkey Swine Center, and Simpson Research Farm (Research Farms, 2019).

Students’ Perspective

Clemson University was founded as an agricultural, land granted college and continues to have many programs that are sustainable and beneficial to the environment. After spending several weeks conducting thorough research on the sustainability of Clemson’s agriculture programs, we believe that collecting numerical data could be a helpful educational tool for the future of the university’s agricultural programs, especially the organic farm. If students could access the data associated with running a farm, they would have more information to draw upon in their own agricultural pursuits. Clemson works hard to make sure these agriculture programs are successful, especially the organic farm, but without quantitative data, future programs will not know how to improve. The programs could also receive more funding to improve the areas that the data shows are weak.

It was more difficult than we anticipated for our team to find resources that could lead us to numerical data. The organic farm does not keep track of the water and energy usage because they receive these resources from the university. We believe that it is the responsibility of the organic farm to attempt to observe and record their energy and water usage to improve the status of the environment, even though their budget does not require them to do so. Progress can only be made by measuring current output, fixing mistakes, and improving efficiency.

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In regards to Air Quality, Clemson has made impressive strides in reducing overall emissions and making progress towards its goal of becoming carbon neutral by 2030. This has happened despite the steadily growing campus and ever-increasing student and staff population. The University still has a ways to go to minimize or completely eliminate its carbon footprint, but plans are in place to get there. The biggest factor contributing to Clemson's overall Greenhouse-Gas emissions (43%) is purchased electricity. Key projects that have helped reduce emissions since 2007 include switching from coal to natural gas, the modernization of buildings, the replacement of inefficient equipment, and investment in mass transit. Between 2007 and 2016, gross emissions dropped 8% despite a 37% increase in campus population and a 6% jump in gross square feet during the same period. The University has numerous projects planned or under consideration to help it continue reducing emissions. These include more retrofitting of older buildings plus replacing older infrastructure and equipment—all with energy efficiency in mind. The University is utilizing a grant to switch older on-campus buses to all-electric. Additionally, the university is exploring the use of renewable energy sources such as solar panels and possibly wind turbines. It also is considering the feasibility of installing solar panel roofs in campus parking lots.

Introduction

Air quality is a key aspect of human health and wellness, which can have an immediate and noticeable impact on quality of life. Air quality is affected by a wide variety of issues, such as the burning of fuels to produce energy, the combustion engines of automobiles, natural sources such as animals' respiration, and many other minor producers of pollutants. To this end, the Environmental Protection Agency (EPA) and many state or private organizations monitor the state of air quality. The EPA, as the federal level agency, also establishes nationwide laws and regulations regarding the amount of impact one is legally allowed to have on the environment. These laws establish the baseline standards for states and organizations in the United States.

Clemson has been making good progress on the path towards its previously set goals of carbon neutrality and has made impressive strides on the reduction of its overall emission quantity. The implementation of projects such as the modernization of buildings, replacing of inefficient equipment, and investment in mass transit have all contributed to a decrease in the level of pollutants released into the Clemson air. Despite the steadily growing campus and ever-increasing student population, Clemson's carbon footprint has remained relatively stable, or even trended downwards. Furthermore, future implementation of projects that eliminate inefficiency in energy consumption and the optimization of ongoing endeavors could very well bring Clemson to its goal of becoming carbon neutral.

However, all of these changes are not without growing pains, and public perception of these plans should be considered if they are to be smoothly implemented. All of these factors should be carefully considered when analyzing Clemson's air quality improvement efforts between 2013 and 2019 and the projected progress to be made in the coming years.

This 2019 Audit will cover pre-existing laws and regulations pertaining to air quality like the Clean Air Act and the Cross-State Air Pollution Rule. It will also discuss Clemson's current air quality status and what measures are taken to reduce air pollution on campus. The audit also discusses how Clemson can improve its air quality moving forward as it continues to experience growth. Finally, students can provide insight on how they perceive air quality on campus and how it can be improved in the Students' Perspective.

Laws and Regulations

Clean Air Act

The primary regulatory body for air quality is the Environmental Protection Agency (EPA), which develops and enforces regulations on air quality through the Clean Air Act (CAA). Under the CAA, the EPA is responsible for setting the national air quality standards for pollutants that are considered harmful to people and the environment, both for ambient levels and gross yearly emissions. The EPA is also responsible for enforcing the adherence to their standards, not only performing regular metrics testing, but also imposing fines or legal action on those who fail to comply with federal regulation. One such regulation of the EPA is its establishment of national ambient air quality standards (NAAQS) for criteria pollutants such as sulfur dioxide, total suspended particulates, carbon monoxide, nitrogen oxides, ozone, and lead. Each state has to determine how to attain and maintain NAAQs by developing a State Implementation Plan. Every five years, the EPA considers revising these standards to determine if they are appropriate or if new standards are needed to protect public health. In South Carolina, the Department of Health and Environmental Control (DHEC) is the agency responsible for monitoring air quality and reporting to the EPA the levels of each of these pollutants in our air (2016). If the levels of pollutants specified in these standards are exceeded, the areas that possesses these elevated levels are labeled as nonattainment areas. To bring problem areas back into attainments, each state undertakes its state implementation plan (EPA). A major provision of the CAA is Stationary Source Permits also called Title V. This provision explains that different standards are required for newly constructed facilities as compared to pre-existing ones. New or modified facilities can be subject to new source performance standards (NSPS) requiring them to get permits before construction in order to comply with federal and state level regulations.

Cross-state Air Pollution Rule

One particularly notable piece of legislation for Clemson was finalized on September 7, 2016 and took effect on May 2017. The goal of the Cross-State Air Pollution Rule is to reduce air quality impacts of ozone pollution that crosses state lines and help downwind areas meet and maintain the 2008 ozone air quality standard by reducing nitrogen-oxide emissions during the summer months in power plants from 22 eastern states (Cross-State, 2016). Since the campus is near the edge of several state boundaries, the law is especially pertinent because the primary feature of the town of Clemson is the University, which does not inherently produce excessive amounts of pollution. Instead, pollutants from other states may have a significant impact on the measured air quality. In the years after the law was adopted, some amount of difference may be visible in the state of the local environment.

Clemson's Current Status

Clemson is on its way to becoming the very model of a progressive, energy efficient university. The implementation of initiatives tailored specifically to benefit the campus and the student population's needs could push Clemson to become a nation-wide trendsetter in progressive environmental policy. Good progress has been made in various fields such as the optimization of the university's water chillers and transit system, emission reduction, and management of emission growth inherent to University growth. There is key research underway regarding the factors contributing to the overall emissions of the University. Clemson utilizes a three-scope approach when documenting research. Scope one is related to direct emissions from on-campus natural gas, vehicle fleet, agriculture, and refrigerants. Scope two documents upstream emissions and the purchased electricity. Scope three measures indirect emissions such as commuting, solid waste, and wastewater. Each scope depicts the amount of air pollution generated by a specific sector or type of activity, as well as measures different ways Greenhouse Gases (GHGs) are dispersed throughout the campus. The research found that scope two was the major contributor to GHGs emissions with the primary source being purchased electricity (Figure AQ 1).

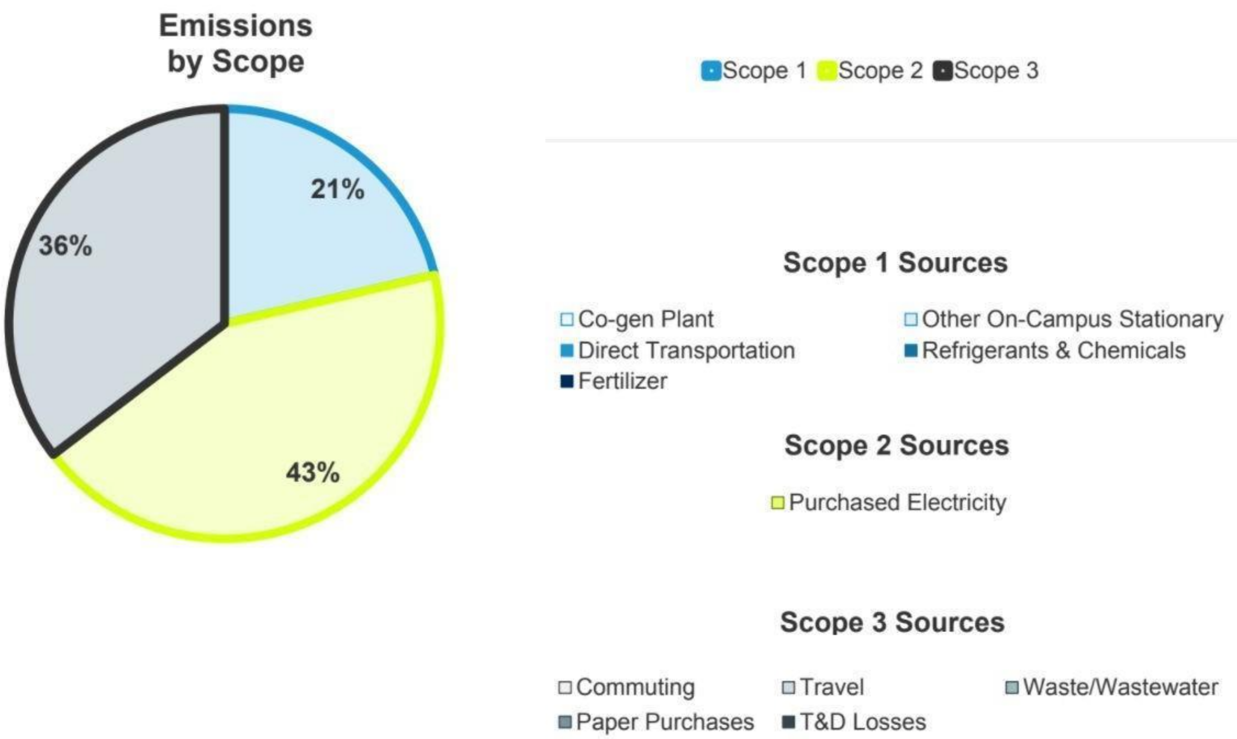

Figure AQ 1: Distribution of emissions (greenhouse gasses) by scope and the sources for each scope.

Through Clemson's progressive approach, gross emissions have decreased marginally over the span of nine years as shown in Figure AQ 2. The university measured gross emissions, campus gross square feet (GSF), and campus population. The findings indicate that the university has grown in square feet at a rate of six percent over the past nine years. Campus population has also increased by thirty-seven percent. However, while the university is in an expansion state it was able to decrease the overall gross emissions. The graph depicts a significant decrease in emissions in 2010; the decrease can be attributed to the university's initiative to eliminate coal power as a primary energy source. Instead of coal, the institution turned its focus towards natural gas which is more efficient and environmentally friendly. The program resulted in a thirteen percent decrease in emissions from 2007 to 2010. The emissions from 2010 to 2015 depicts a varying increase in gross emissions. The increase is directly correlated to the growth on campus. The increase of construction, along with the increase of student population, contributes to the overall rise in emission values. The emissions then decrease from the years 2015 to 2016. The reason for the sudden decrease in the upward trend of emissions is Clemson's building retrofitting initiative. The program is designed to update and replace outdated systems. The main focus of the initiative is updating light systems, water chiller systems and rerouting air flow. The Figure AQ 2 shows the gross emissions decreasing against 2007 baseline despite an increase in student population and gross square feet (GSF).

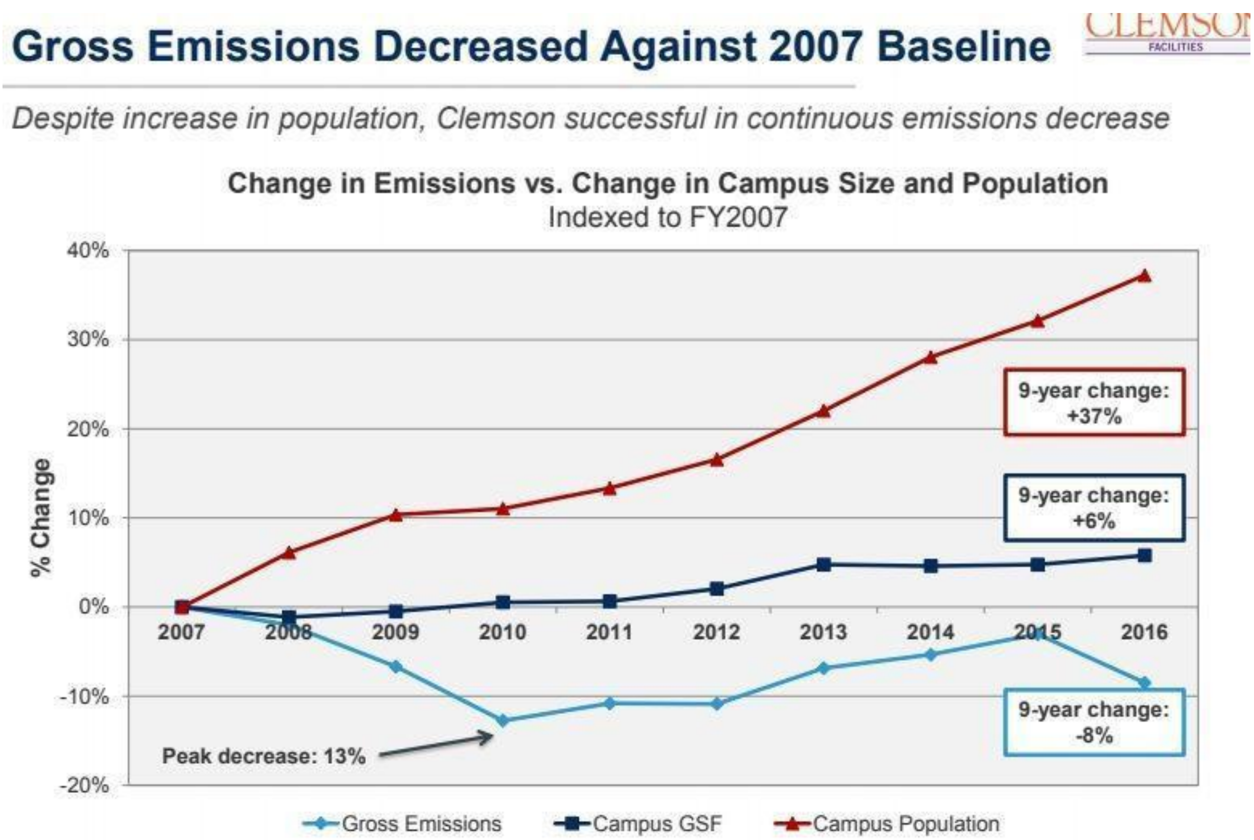

Figure AQ 2: Gross emissions trends against 2007 baseline until 2016

Clemson is doing well in its goal of becoming a low emission, energy efficient campus. Compared to peer institutions, it has both an older building profile, as well as smaller, more energy intensive buildings. This makes progress even more significant. The institution has made progress in reducing emissions; from the baseline year it has seen a decrease of total carbon emissions despite being in a state of perpetual growth. According to Tony Putnam, Director of Utility Services, addressing buildings and the equipment in them is essential to keeping the momentum that Clemson has created.

Moving Forward

Efforts have been put in place by Clemson administration to be completely carbon neutral by 2030. In going carbon neutral, the main goal is to minimize or completely eliminate the university's carbon footprint. Based on the available data, it's clear that Clemson is progressing toward this goal. Several key areas have been identified for Clemson to continue making progress toward this goal. As previously mentioned, purchased electricity accounts for the majority of Clemson's emissions. According to Thomas Suttles, manager of Clemson's energy conservation department, one of the most cost-effective ways to reduce the amount of emissions from purchased electricity is by retrofitting older buildings on campus to be more energy efficient. For example, Clemson has successfully implemented measures to optimize building-light energy consumption in buildings with a large number of fixtures and high occupancy such as Fike Recreation Center and the Academic Success Center. Clemson plans to continue investigating other buildings to see where similar improvements could be made. Another way Clemson will continue making improvements in the future is by replacing old and inefficient equipment within the existing infrastructure with newer and more efficient equipment (Putnam). A notable example is with the university's water chillers which are used to heat and cool the buildings. This type of equipment is being optimized and replaced with upgraded equipment which has shown improved performance. Also, the addition of numerous LEED-certified buildings has greatly contributed to the reduction of Clemson's overall emissions amidst the continued growth in student population and campus space. As the University continues to grow, incorporating energy efficiency into new construction projects will become more of a priority.

Transportation is another major area contributing to the current state of air quality where improvements are continuing to be made. According to Brian Maleck, Transportation Demand Management Program Coordinator, Clemson was awarded a grant to switch on-campus buses to all-electric. The hopes are that these new buses will be able to circle campus all day without needing to be charged. Additionally, there are efforts being made to minimize wasted emissions by optimizing bus routes. This would improve efficiency by accommodating for peak travel times that align with campus activity.

Lastly, to help Clemson meet its carbon neutral goal, the use of renewable energy technologies such as solar panels and possibly wind turbines is being explored (Putnam). Clemson has been working on the idea of installing solar panel roofs in campus parking lots but ultimately the return on investment determines which projects to pursue. The cost of solar power relative to the improvement made is not nearly as effective as some of the solutions mentioned earlier. But as technology advances, the use of solar power could become more financially viable in the near future. While the price of installing solar panels has tremendously dropped over the past few years, the cost of wind power is still fairly expensive. As technology advances in the state of South Carolina, offshore wind may become an option for obtaining renewable energy. If Clemson were to be a partner with an organization offering energy via offshore wind or solar power, we would be able to offset some of the power used on campus.

Overall, Clemson has been making tangible improvements which are addressing many areas of inefficiency based on historical data. When considering the trends from the available data and efforts that are currently in place, we can foresee Clemson continuing to get closer to its goal of becoming carbon neutral by 2030.

Students' Perspective

In respect to emissions produced, Clemson University has showed promising reductions. With the increasing construction on Clemson's campus to accommodate for the increase of student population, modifications need to be made in order to maintain, or even improve, Clemson's current air quality. With the increase of population stated before, an increase in cars and emissions that are accompanied by that should be expected. We believe that with Clemson's decision to go carbon neutral by the year 2030 and the introduction of electric buses on campus, we can be a trendsetter for reducing air pollution. However, there has to be willingness of students, employees, and other members of the community to take part in the initiatives set forth by organizations like Clemson University, the EPA, and DHEC. The Clemson student body is thousands strong, and if we could reach out to even half of them and establish a lasting commitment to conservation, the impact would be massive. Outreach and student body relations are time consuming processes but will potentially have the greatest influence on the state of the environment in the coming years. While it is important to keep track of the statistics involved regarding the level of air pollution, there are always other factors at work in matters such as this. The end goal is to improve the quality of life for people here in Clemson, and that includes the student body. It would be remiss to simply take measurements on data without seeing how these initiatives have impacted the students who live here. Clemson is not a closed environment that can be easily studied in a vacuum, and every small detail might be a significant indicator of the impact these changes have had on the community.

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Athletics

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Executive Summary

The Athletics Department at Clemson University faces a unique challenge. Rather than focusing solely on a single part of the environment that it impacts, it is so large that it must account for all parts of the environment. Fields and athletes require water; pesticides are used to control the lawn growth on the fields; and energy must be used to power signs, billboards, and even climate in stadiums. The massive influx of people into the city of Clemson for sporting events also brings up the question of how well the University is doing in recycling the waste of tens of thousands of people. In the past few years, the Athletics Department has seen a steady rise in the amount of energy it consumes each year, likely due to opening of the Allen N. Reeves football complex as well as the continued success of the football program. Recycling has seen a steady increase over the audit's time period and has reached 52% by 2016. Staff strives for zero waste during games. The only time it fails to come close to this is when recycled material is contaminated during rainy games. Of all athletic programs, the football program has by far the greatest use of water with over 1 million gallons used during the 2015-16 peak season, followed by the baseball and then the track programs. Overall the Athletic Department has shown improvement in sustainable practices in the area of recycling, but a worsening in areas such as energy usage. The department should continue to make strides to reduce its impact, but the progress so far seems promising.

Introduction

Clemson University Athletics faces a unique environmental challenge. The department's main duty is to support and administer Clemson's athletic teams, but maintaining the athletic facilities using environmentally friendly initiatives must be considered at the same time. As one of the biggest departments in the University, the Athletic Department provides a huge opportunity for Clemson to research and take advantage of both new and old sustainability practices. The implementation of these practices is important; therefore, being able to analyze and measure their effectiveness from both a cost and efficiency standpoint are equally crucial. From public bathroom usage to lighting Death Valley, the football facilities alone are responsible for over $800,000 in energy expenditures per year. The Athletic Department needs to not only be aware of the environmental impact of all university athletic competition, but also take steps in reducing their impact in four key categories: energy; grounds and pesticides; recycling; and water conservation.

This audit will look to document the yearly environmental impact of the Athletic Department in the four areas mentioned above. Additionally, the audit will analyze the Athletic Department's environmental practices and suggest areas for improvement. This chapter does not cover Clemson's John E. Walker Sr. Golf Course, as it is not under the direct jurisdiction of the Athletic Department.

Energy

To begin analyzing the energy usage of Clemson University Athletics, it is important to understand the sheer size of the Athletic Department's operations. The energy included in yearly reports includes not only the electricity and water used for maintenance, but also the considerable amount of energy used for Clemson's stadiums.

Over the course of the 014-15 year, the IPTAY/Security offices and Memorial Stadium/West End Zone averaged 625,715 kWh of electricity used per month. Usage peaked where one might expect, in September and October, during the peak of the football season. Similar patterns can be found across other athletic buildings as well. In comparison, the overall energy usage for the entire Athletic Department over the course of the 2014-15 year was 12,499,076 kWh. This means that the Memorial Stadium facility represents over 50% of the department's yearly energy bill. With the addition of the new Allen N. Reeves Football Complex, the energy usage in Memorial Stadium should decrease; however, the overall energy usage should remain nearly the same. This new facility provides the Athletic Department an opportunity to introduce wide scale sustainability practices that might have been difficult to implement in another older facility.

From 2013 to 2016, the Athletic Department's energy rate increased from $0.0697/kWh to $0.0775/kWh. These numbers alone are not particularly impressive; however, they denote a 10% increase in Athletics' per kilowatt-hour energy rate in just two years. With an overall energy bill of over $1.2 million annually, a 10% increase represents over $100,000 in additional cost. The Athletic Department managed to reduce its energy usage by over 141,023 kWh in the 2015-16 year. However, the annual bill was still $20,000 more than the previous year due to this increased energy cost. *Figure AT1* provides a visual example of the increase.

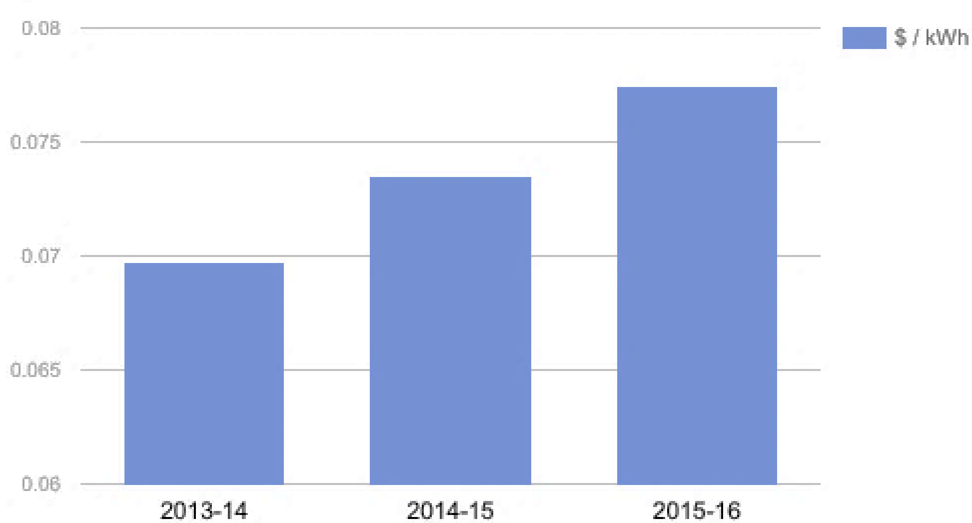

Figure AT1: Clemson's yearly energy rates from 2013 to 2016

Implementing energy saving, environmentally friendly initiatives are where Athletics can find the most opportunity to save money and have the most positive environmental impact. Energy consumed by facilities that are not in use is an area of importance, as implementing initiatives during the buildings' respective competitive seasons could take away from the teams. Therefore, we recommend focusing on decreasing energy usage in offseason buildings. As the football stadium is by far the biggest user of energy, the Athletic Department might consider powering down scoreboards and advertisement boards permanently in the offseason. Additionally, A/C and heating policies should also be reviewed in offseason buildings, as even a 1° temperature difference could net significant savings.

Grounds and Pesticides

One major issue that is important to the maintenance of athletic fields is water drainage. The athletic fields at Clemson are all sand-based fields. Sand-based fields are known for their ability to drain water quickly, a characteristic that makes them ideal for sports turf for several reasons. The first is that athletic events can become unsafe when the field is wet or there is a large amount of sitting water. Second, when water sits on a field for an extended period, it promotes the growth of harmful fungi. Once fungi begin to grow on a field, the grounds crew must use an increased amount of fungicides to keep the field healthy.

Despite the natural draining ability of sand-based fields, after a while a thin layer of thatch can build up between the living grass and the sand. This thatch is caused by grass clippings and other organic matter being left on the field where it accumulates. Unlike the sand, this thatch does not allow water to drain very easily, and it forms a layer that holds water on the field. As mentioned previously, this can cause more problems with the health and maintenance of the field. To eliminate the thatch, the Athletic Department sprays a chemical called Worm Power. Worm Power is a vermicompost that aids in thatch reduction, which, in turn, improves the drainage ability of fields ("Worm Power Turf," 2019). According to the Safety Data Sheet (SDS) for Worm Power, there are no water contamination risks and there are no other hazardous effects, indicating that Worm Power is a relatively environmentally friendly solution.

To make its irrigation strategies as efficient as possible, Athletics will also occasionally use specialized chemicals that will either drain water from a field or retain water. As mentioned before, draining water is essential to the health and maintenance of the field. Simultaneously, retaining water can be just as beneficial when done in a strategic manner. The maintenance staff uses these chemicals to carry out its strategic irrigation plan. For example, if heavy rainfall is expected, the irrigation system will not be used, and chemicals will be applied to help drain the field. On the other hand, if rainfall is not expected and a field needs to be watered, or the fields are just especially dry, chemicals will be applied to retain the water. This helps reduce the overall use of water for irrigation and increases the efficiency of irrigation strategies (M. Echols, 2017).

The grounds crew for Clemson University Athletics employs five staff members who are licensed under Category 3 Turf and Ornamentals Pest Control, a license through the South Carolina

Department of Pesticide Regulation (M. Echols, 2017). This license requires that the candidate pass a written Core Competency Exam and additional written exams pertaining to the specific categories of licensing. The Category 3 Turf and Ornamentals Pest Control is one of several subcategories of licensing that either commercial or non-commercial applicants must apply for. Clemson's Department of Pesticide Regulation administers these exams and requires that licenses be renewed on an annual basis in addition to completing ten hours of continuing education for every five-year renewal period ("Frequently Asked Questions," 2019).

In addition to following guidelines from the University and the State of South Carolina Department of Pesticide Regulation and the South Carolina Department of Health and Environmental Control (DHEC), Clemson University Athletics follows recommendations from the Sports Turf Managers Association (2018). This association promotes education and research regarding the construction, maintenance, and use of sports turf.

Table AT1 shows the chemicals used to treat athletic fields and the frequency that they are applied.

Table AT1: Annual Use Frequency for the Top Pesticides

Chemical	Type	Common Use Area	Use Frequency (Per Year)
Primo	Growth Regulator	Fairways	3-4
Round Up	Herbicide	Dormant Bermuda	1
Award	Pesticide	Fire Ant Treatment	1
RonStar	Herbicides	All playing fields	1 spot treatment
Daconil	Fungicide	Baseball field	4-5
Subdue	Fungicide	Greens	1-2
Emerald	Fungicide	Greens	1-2
Monument	Herbicide	Fairways and Rough	1 spot treatment
Banner	Fungicide	Greens	1 spot treatment
Insignia	Fungicide	Greens	2
Chipco 26GT	Fungicide	Greens	2
Trimmit	Growth Regulator	Greens	2-4
Triplet	Herbicide	Rough	1 spot treatment
Scimitar	Insecticide	Greens	1 spot treatment
Dylox	Insecticide for grub control	Soccer field	1 spot treatment

The grounds staff also strives to have zero waste. Everything from grass clippings to aerification cores are sent to university recycling services and are repurposed. Additionally, sod that is removed from football practice fields is used to cover intramural fields. *Figure AT2* shows the collection site where Athletics keeps grass clippings and aerification cores before they are sent to recycling services.

Figure AT2: Collection of grass clippings and aerification cores that will be recycled

Recycling

Clemson University's recycling program has experienced ongoing success and improvement since its inception in 1990. As the campus continues to go green, the university has worked closely with the Clemson University Athletics to reduce waste and improve recycling during home football games in the fall. Members of Clemson's recycling department filter through trash after each game and separate recyclables from trash. Since 2011, the department has improved the percentage of recycled materials from 20% to over 50% for the 2016 football season. *Figure AT 3* shows the continual improvement throughout the seasons with notable increases from 2013 to 2014 and 2015 to 2016. Recycling rates during those seasons increased by 22% and 18%. The 2015 season saw an 8% decrease, but this was due to the wet conditions during the Notre Dame and Georgia Tech games, when most of the materials were too wet to be recycled and thus rejected by the contractor.

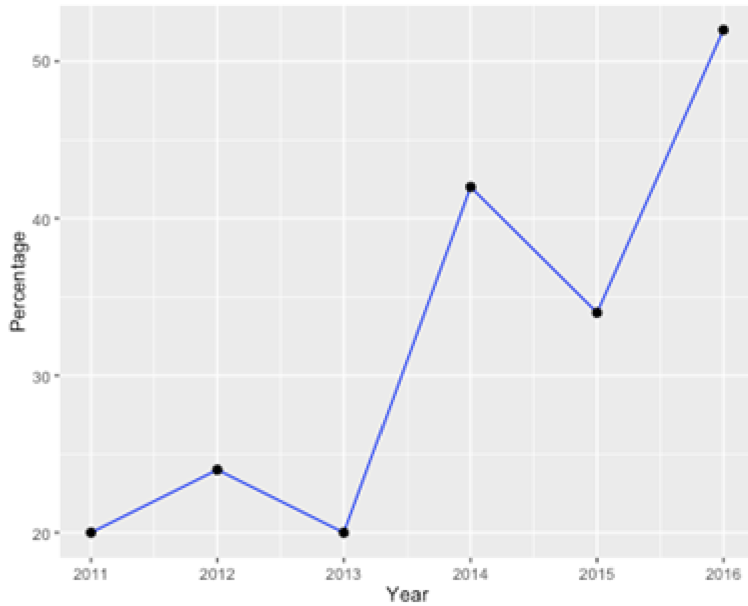

Figure AT3: Percentage of trash recycled each football season

The 2016 football season yielded the highest rate of diversion yet with a total recycling rate of 52%. As seen in *Figure AT4*, the University recycled a total of over 315,000 pounds of recyclables, recycling over 65,000 pounds during both Louisville and South Carolina games. Naturally, as attendance for the games increased, so did the amount of materials recycled. Note that the Louisville and South Carolina were amongst the biggest home games that season, and Syracuse was homecoming weekend. This can account for the rise in recycling those weekends.

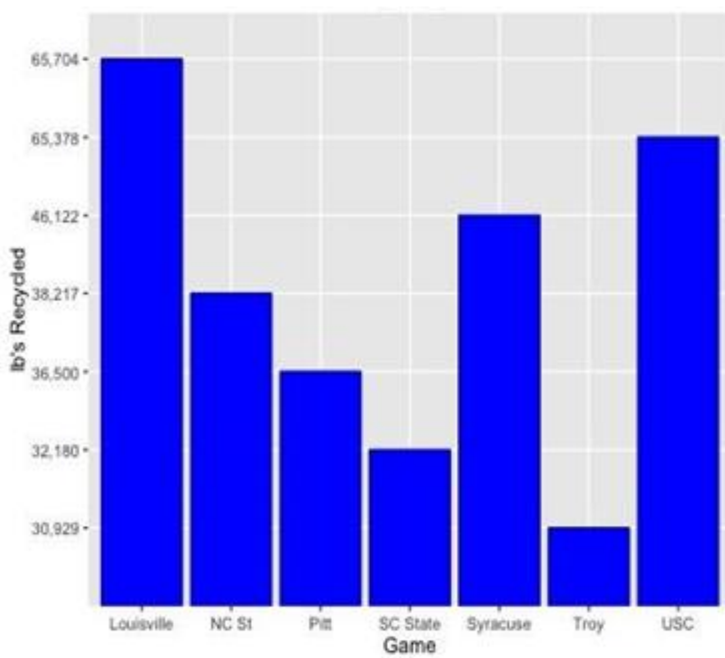

Figure AT4: Pounds of trash recycled each game during the 2016 football season

Starting in 2016, the University also began categorizing and recording the types of materials being recycled. Plastic, glass, and cardboard were the three most recycled materials making up 70% of the recyclables (*Figure AT5*). These three categories were the most recycled materials, largely due to the number of beverage containers brought to Clemson during game days.

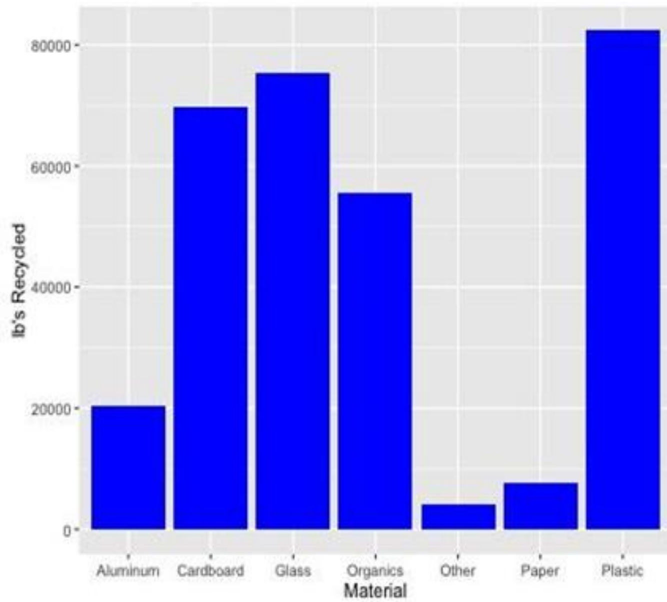

Figure AT5: Pounds of each type of trash recycled during the 2016 football season

Water

Due to the high number of athletic events and facilities surrounding Clemson, water is a heavily used resource. At all months of the year, there is a different sport or facility that is relying on high amounts of water to hydrate their players or to take care of the fields and facilities. The facilities that had the most water consumption within their respective seasons, according to data collected in 2015-2016, are the football and baseball facilities. With its peak season being in the fall months (September-December), the football operations used a total of 1,084,200 gallons of water over that span. The facilities contained in this total are the football stadium/West End Zone; the football stadium/IPTAY and security; and the indoor football practice facility. The baseball facilities peak season is in the spring and summer months (March-September). These operations consumed a total of 469,800 gallons of water over that span. The facilities contained in this total represent just Doug Kingsmore Stadium.

When compared to these massive programs with large fields to upkeep, the indoor track facility uses a minuscule number of gallons of water. The indoor track operations peak season is in the winter and spring months (December-April). These facilities consumed just 27,100 gallons of water. This comparison, displayed in *Figure AT6*, shows just how much water it takes to maintain and upkeep Clemson Athletics outdoor athletic fields and facilities.

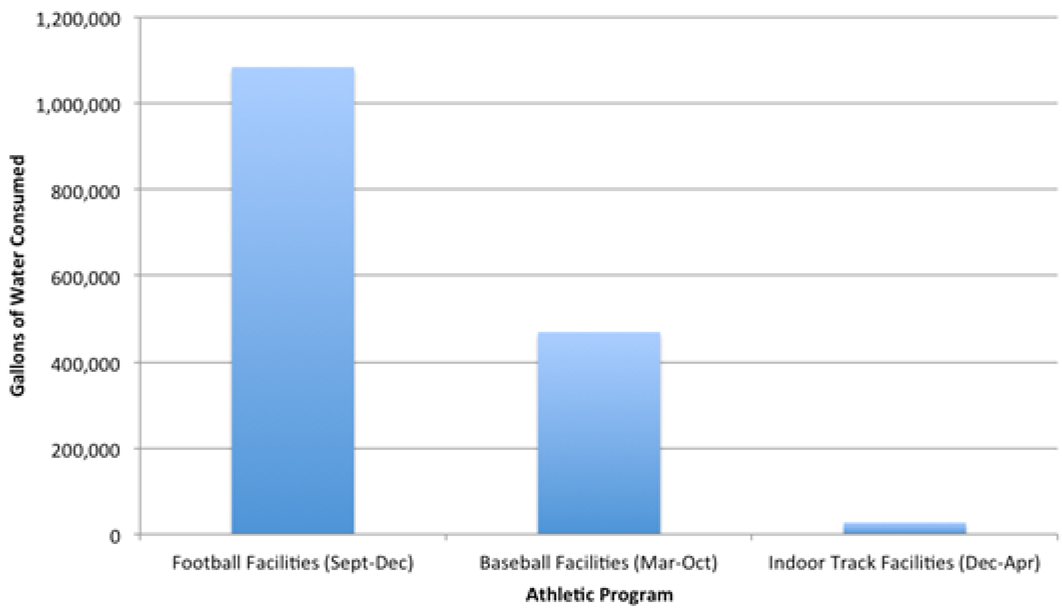

Figure AT6: Gallons of water consumed by athletics facilities during 2015-16 peak seasons

Students' Perspective

The Clemson University Athletics chapter is unique in the fact that it covers many of the other chapters in the audit. Separating this department from the rest of the university provides great insight into how athletic operations as a whole impact the environment. The strength of the department environmentally is directly related to its recycling initiatives. Specifically, the continuous improvement of recycling on football game days is a positive trend, which the university has played a major role in. Furthermore, the relationship between grounds and the university to recycle 100% of sod and other waste is a major strength of the Athletics.

However, our team found significant shortcomings in record keeping of data pertaining to these initiatives. Our findings from initial interviews in the department failed to provide any meaningful data or information necessary for this audit which could be utilized to express the impacts of these honorable practices. Rather, we had to contact other departments of the university to gain information about Athletics. By improving the relationship and communication between utility services, recycling, and facility maintenance, Clemson University Athletics can become more aware of the budget costs and environmental costs of their operations.

For future auditors of the department, our team would recommend tracking the changes related to projects such as the Reeves Complex for football and the new softball stadium that will be coming to campus by 2020. Observing these projects, along with all other athletic operations, would truly encompass the environmental impact of the university in the coming years.

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Biohazardous Waste Disposal

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Executive Summary

This chapter addresses the different ways Clemson goes about treating biohazardous waste in compliance with existing regulations on the general procedures for biohazardous waste disposal. Although this chapter serves as a comprehensive summary of the current state of the biohazardous waste department, it is not intended to be a detailed review, as some material has been omitted for security purposes. Clemson University's budget has increased rapidly in the last few years with a greater push towards collegiate research. As research funding increases, so does the annual generation of biohazardous waste. In response, the university has gained certification to treat some of its waste onsite to save money and ensure the process is done according to the policies and procedures. Even so, most of the generated biohazardous waste is contracted offsite to a private third party for disposal outside of campus limits. In the future, Clemson will likely continue to expand its research in the sciences, and increased waste will follow. Biohazardous wastes are non-recyclable, so Clemson University must ensure that the rules and regulations of hazardous disposal are maintained to reduce the number of safety issues, as well as keep the overall amount of generated waste in check.

Introduction

Biohazardous waste is an umbrella term used to describe a waste that may pose a biological hazard to living organisms. This includes but is not limited to medical waste as well as biological, animal, or plant wastes generated through research. Biohazardous waste at Clemson University includes both infectious and non-infectious wastes. Due to the potential hazards presented by biohazardous waste, they must be managed with safe and secure methods. At Clemson University, the Office of Research Safety is charged with managing the biohazardous waste program and issuing guidelines regarding biohazardous waste. It also manages the waste once it has left the labs/generation points until its disposal with an outside permitted facility.

Clemson University manages all items meeting the state's definition of an infectious waste along with any biological research agents not meeting that definition. Examples of the latter include animal carcasses, petri dishes, and other contaminated items that may resemble medical waste (J. Brock-Carroll, 2015). Due to a greater focus on research, Clemson University's quantity of biohazardous waste has increased. If not properly managed and disposed of, biohazardous waste could expose the environment to potentially harmful substances. All disposal methods utilized at Clemson University are specified and in compliance with R.61-105.

This report will provide a working definition for 'biohazardous waste' and describe generic, common methods of disposal and the applicable shipment and treatment regulations. Then it will outline Clemson University's biohazardous waste landscape and the University's typical disposal methods, its monetary implications, and the regulatory agencies that police these processes. Finally, the student auditors will offer their insights.

Biohazardous Waste Regulations

Definition

Infectious Waste must be managed in accordance with the **Infectious Waste Management Regulations, R.61-105,** which are enforced in the state of South Carolina by the Department of Health and Environmental Control (DHEC). Under these regulations, infectious waste is defined as:

- Medical waste that has been exposed to human pathogens, i.e. blood-soaked bandages, surgical gloves, etc.
- Sharps that have been exposed to human pathogens which may puncture or cut such as lancets, needles, syringes, razor blades, pipettes
- Blood or blood products such as plasma, serum, bloody excretions, secretions
- Microbiological waste such as specimens, cultures and stocks of human pathogen agents
- Pathological waste such as human limbs, organs or tissues
- Contaminated animal waste/carcasses that were intentionally infected with human pathogens
- All Biosafety Level 4 wastes
- Any other material designated by written generator policy as infectious

Common Methods of Disposing Hazardous Waste

Incineration is defined by the EPA as a treatment method involving destruction of waste by controlled burning at high temperatures (EPA). This process destroys the toxic organic components of biohazardous waste and reduces the volume. Alternatively, autoclaving is the use of pressurized (15 PSI) steam at approximately 121ºC. This sterilization technique allows the killing of infectious agents and the denaturing of proteins. The process takes between 30 and 60 minutes to complete depending on the size of the load. Autoclaves are highly effective and efficient when used properly.

Shipment and Treatment Regulations

The guidelines for infectious waste container shipment and treatment are located in the *Infectious Waste Management Regulations R.61-105*. Labeling must be visible, clear, and include the biohazard symbol (unless the waste container itself is marked with the symbol). The generator name, the Infectious Waste Generator Permit Number, and the date the container was placed in storage must also be on the label along with the words “INFECTIOUS WASTE” (or

"BIOHAZARDOUS WASTE" or "MEDICAL WASTE"). Infectious waste must be shipped to the treatment, storage, and disposal facility (TSDF) on an Infectious Waste Manifest or other DHEC approved form. This manifest must include the following:

- the generator's name
- site address
- the infectious waste generator permit number
- the number of containers including their weight in pounds
- the name of the treatment facility the waste is being shipped to
- certification that the waste is packaged, labeled, and described correctly
- certification that the waste does not include hazardous or radioactive material
- the name of the transporter
- certification that the manifest is filled out correctly
- certification that the numbers and weight of the containers is correct
- the date the waste is being transported

The generator shall retain one copy of the manifest after the transporter has accepted the shipment. There are three categories of infectious waste generators: small quantity, large quantity, and extra-large quantity. Large and extra-large quantity generators are fully regulated under the infectious waste management regulations. Clemson University is categorized as an extra-large quantity generator of infectious waste. Only the weight of infectious waste is considered for this status. Non-infectious waste is not regulated by DHEC and therefore not counted towards this status. Clemson University prefers to treat non-infectious wastes prior to on-site disposal or being sent to a permitted TSDF for incineration just like the infectious waste.

Biohazardous Waste Treated by Clemson University

Quantitative Overview

Biohazardous waste on campus is generated from research facilities, teaching facilities, medical buildings, Residence Life, athletic facilities, and other support facilities. Biohazardous waste is classified at the time of generation as either infectious or non-infectious waste. During the generation process, the containers are managed per protocol for the appropriate classification at the generation site (in the labs or other generation sites.)

In 2013, Clemson University updated their Infectious Waste Generator Permit to allow for on-site treatment of infectious waste. Up until then, the permit only allowed for infectious waste to be sent off-site for disposal. With this permit update, generators were given the option to treat infectious waste on-site in accordance with R.61-105 or continue to collect and ship waste off-site for treatment/disposal (J. Brock-Carroll, personal communication, September 29th 2015). *Figure BW 1* and *Table BW 1* show that Clemson University's treatment of biohazardous waste has increased between 2003 and 2014.

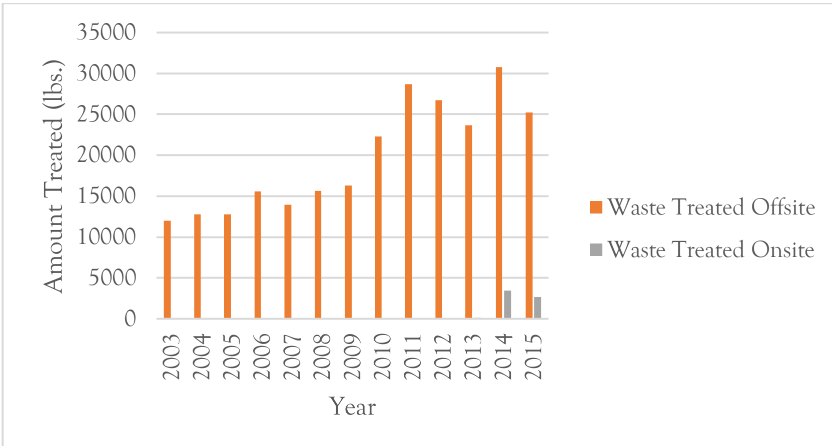

Figure BW 1: Biohazardous waste quantities at CU between 2003 and 2015

Note: 2015 includes data for the first three quarters only.

The illustrated increase can be linked to greater emphasis on research on Clemson University's campus in efforts to reach the goal of becoming a top research university (J. Brock-Carroll, personal communication, September 29th 2015). *Table BW 1* provides an annual breakdown of waste treated "on site" and "off site."

Table BW 1: Clemson Biohazardous Waste Treatment by Location

Year	Waste Treated Off-site (lbs.)	Waste Treated On-site (lbs.)
2003	11,968.10	0
2004	12,762.30	0
2005	12,762.30	0
2006	15,566.10	0
2007	13,925.70	0
2008	15,665.70	0
2009	16,288.6	0

2010	22,313.3	0
2011	28,691.10	0
2012	26,748.4	0
2013	23,681.8	92
2014	30,784.2	3457
2015	25,250.9	2644

Table BW 1 also gives numerical data to complement the trends represented in Figure BW 1. Waste treated off-site has gradually increased since 2003, with the exception of 2007. Clemson was not permitted to treat biohazardous waste on-site until 2013. The data for 2015 only reflects that of the first three quarters, as data for the last quarter is not yet available.

Disposal Methods at Clemson University

Clemson University utilizes two disposal methods for biohazardous waste. Generators may treat waste on-site as per regulation and dispose either by drain for liquids or in the dumpster for solid waste. Secondly, they may be collected in biohazard bins supplied by Research Safety for off-site incineration. Treatments on-site are done under the oversight of the Biological Safety Officer (BSO). All records of on-site treatments are maintained by the BSO as well. Off-site shipments are done under the oversight of the Hazardous Materials Manager. Biohazardous waste for shipment off-site is collected from the generation sites by Research Safety Waste Services Personnel. The waste is taken to the Hazardous Waste Management Facility where it is labeled as either biohazardous waste in accordance with the infectious waste regulations, or as non-infectious waste for incineration. Wastes at Clemson University are put into their appropriate receptacles, which are then put into shipping containers. The shipping containers are approximately 29 gallons in size with a 45 lb. weight limit. These containers are dated, weighed, logged, and stored in the biohazard walk-in cooler until time for pickup and shipment by the biohazardous waste disposal contractor. Clemson University ships their biohazardous waste every two weeks. All biohazardous wastes, whether infectious or non-infectious, are treated by incineration when shipped off-site to the TSDF.

Expenditure

The University has a specific budget and contracts for waste disposal. This includes disposal of all regulated waste, whether it be hazardous, biohazardous, radioactive, industrial, etc., and vendor contracts may include any supporting materials necessary to package and prepare the waste for shipment. The Hazardous Materials Manager in Research Safety manages the contracts.

Policy Overview

To supply a systematic overview of the many regulations that apply to Clemson University's biohazardous waste treatment plan, Table BW 2 will tabulate all relevant agencies and policies.

Table BW 2: Agencies that Regulate Biohazardous and Medical Waste and Policy Overview

Agency	Regulations/Guideline	Relevance
U.S. EPA (1989)	Medical Waste Tracking Act	Although not reauthorized, serves as a basis for most state medical waste programs
OSHA (1990)	Blood borne Pathogens Standard	Defines medical waste; requirements for handling storage, and labeling of medical waste
U.S. DOT (1991)	Hazardous Materials Regulations	Packaging, labeling, and documentation requirements for transportation of biohazardous waste
Joint Commission on Accreditation of Healthcare Organizations (JCAHO) (1995)	Accreditation requirements for health care settings	Requires written plan addressing state and federal requirements biohazardous waste as well as goals and performance standards for waste management
Institute of Laboratory Animal Resources (1996)	Accreditation requirements for animal resource operations	Procedural requirements addressing packaging, labeling, transportation storage, and decontamination of waste
USDA/Animal and Plant Health Inspection Service (1997)	Animal and Plant Health Inspection Service (APHIS) requirements	Permit requirements regarding environmental release of genetically modified organisms that may be plant pests
U.S. EPA (1997)	Medical Waste Incinerators Final Rule	Part of Clean Air Act Amendments that has set restriction emission standards on HMIWIs
CDC and NIH (1999)	Bio-safety in Microbiological and Biomedical Laboratories	Outlines requirements for waste decontamination when working with human pathogens
NIH (2001)	Guidelines for Research Involving Recombinant DNA Molecules	Outlines requirements for waste decontamination when working with genetically modified organisms including plants

Students' Perspective

As Clemson University increases its efforts to become a top research university, a spike in the overall amount of biohazardous waste generated is expected. The Office of Research Safety has done an excellent job at changing protocols and adapting to Clemson's growing need for biohazardous waste disposal and treatment. Mr. Grieger and Ms. Brock-Carroll have gone above and beyond what is necessary for the management of biohazardous waste. It is not the Office of Research Safety's responsibility to attempt to reduce the biohazardous waste generated on campus. Therefore, the responsibility falls on the university's students, professors, laboratory personnel, and departments to help in the minimization of biohazardous waste generated. Volume reduction is the most effective strategy for controlling the amount of biohazardous waste generated. With the efforts of every individual at this university, Clemson can maintain its model status of biohazardous waste treatment.

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Energy Usage

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Executive Summary

The energy chapter of Clemson University's latest environmental audit tracks campus activities during a ten-year span from 2005 to 2016. At around ten million dollars, energy cost is a significant factor in the yearly budget of Clemson University, thus it greatly impacts the lives of everyone on campus. Clemson University has several programs and initiatives to reduce environmental impact; one of the most important ones is the Net-Zero Goal. This Goal aims to achieve net zero emissions by 2030, by balancing the use of non-renewable energy with the use of renewable energy. At Clemson University, coal was the largest producer of carbon emissions until 2008 when it was phased out and replaced by natural gas in 2011. Coal use has decreased to zero as Clemson has decommissioned its last coal boiler. As of 2016, natural gas and electricity bought from power companies are the main energy sources. Each of them is responsible for about fifty percent of the total energy supply.

As Clemson grows the energy consumed by the University has also increased. To combat this problem, Clemson has set a goal of reducing its energy consumption per square foot by 20%, so Clemson is building new energy efficient buildings to reduce the energy consumption that comes with a bigger footprint. Clemson University is setting a path to a more sustainable future, but improvements must still be made to reach its goals. This audit outlines key information in the progress Clemson has made over the last decade and highlights aspects to consider while evaluating the overall sustainability and environmental impact of the university.

Introduction

In this audit, energy consumption over the past decade on Clemson's campus is analyzed. Clemson's goal, implemented in 2000, is to achieve a 20% reduction of energy per gross square foot of building space by 2020. The University also endorses a Net-Zero initiative requiring zero carbon emissions by 2030.

A variety of energy types have been utilized by Clemson University including purchased electricity, coal, natural gas, fuel oil and propane. In the last decade, Clemson made the transition to natural gas and completely phased out the usage of coal in 2011.

Energy consumption is analyzed over an eleven-year period from 2005 to 2016. Purchased electricity, contributing to approximately half of the total energy consumption, has remained a primary energy source. After coal was phased out, natural gas emerged as a leading fuel type for Clemson, accounting for about 52% of the total energy consumption in 2016.

This chapter also overviews the monthly energy and cost trends. The data confirms that energy costs are highest during the winter months when heating is needed, and natural gas is the main source of electricity for heating on campus. Purchased electricity, however, is used mostly for cooling during warmer months.

The auditors' perspective is included, highlighting several ideas for improvement regarding campus energy efficiency. Recommendations were made to switch from natural gas to biomass with cogeneration technology as a fuel source. It is noted that farming operations on campus could provide a source of biomass on site. Another recommendation is to implement solar power as an alternative form of energy. Plans have been made to include solar panels in Lee Hall and over campus parking areas. Recommendations have been made to utilize geothermal technology to offset electricity requirements for heating and cooling indoor spaces on campus.

It is important to note that in many subsequent figures and graphs, the y axis is often truncated. Had this adjustment not been made, differences in data points would be difficult to distinguish given the scale of the data. It is also important to recognize that some measurements used varying units, and the conversions of these units, along with their definitions, can be found in *Table EU1* below.

***Table EU 1*: Conversion Rates and Definitions.**

Kilowatt hour (kWh)	A measure of energy over time. One kWh is one thousand watts of power flowing over one hour of time	1 kWh = 3412.14 Btu
British Thermal Units (Btu)	the amount of energy needed to raise the temperature of a pound of water by one-degree Fahrenheit	1000 Btu = 0.2931 kWh

Energy Consumption over the Past Decade

Reduction in the use of fossil fuels and the total amount of energy used per square foot are key factors in campus-wide sustainability. The foremost energy conservation policy in effect campus-wide is a 20% reduction of energy per gross square foot of building space by 2020. Implemented on June 11, 2000, this policy's goal is to raise the energy efficiency of the university with respect to its building growth ("Energy Awareness," 2019). Also implemented was the "net-zero" goal by 2030, which involves achieving zero net carbon emissions by balancing released carbon dioxide with an equivalent amount of renewable energy such as solar, wind, or geothermal energy ("Energy Awareness," 2019). From 2005 to 2012 there were no clear trends in Clemson's energy consumption as represented in *Figure EU 1*. However, in recent years the total energy consumed by Clemson has decreased. In 2013 the total energy consumed started to show a steady decline with 2016 using 11% less energy than in 2006. It should be noted that other factors such as temperature and weather during the year can influence energy usage independently of the conservation efforts. Years with more extreme temperatures can lead to an increase in energy usage despite the overall efficiency increasing. However, the total energy usage is not the only information needed to consider if Clemson is on track to reach its goals. Energy cost, energy use per square foot, and energy sources all contribute to Clemson's sustainability goals.

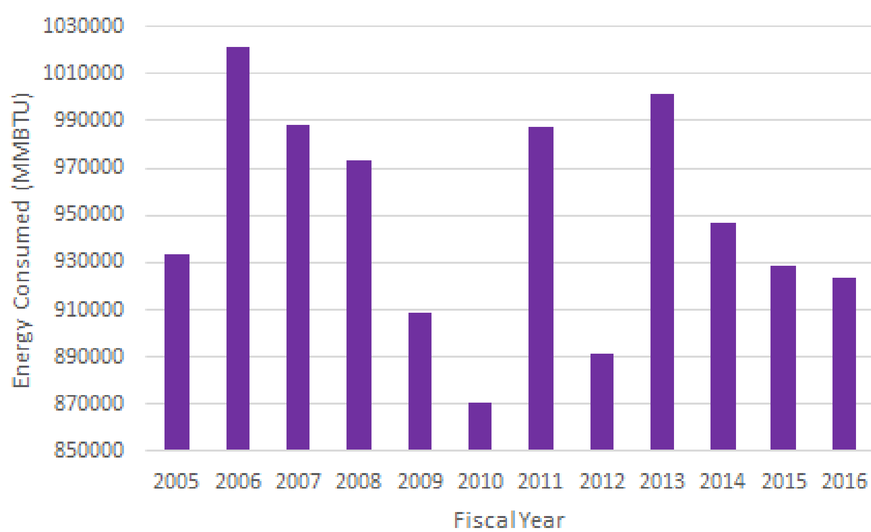

Figure EU 1: Total energy in MMBTU consumed by the university over an eleven-year period.

Despite the reduced energy consumption, the total cost of energy (*Figure EU 2*) has remained constant in recent years. This is due to the increased cost of electricity offsetting the decreasing energy usage. Although there have yet to be significant financial benefits from the reduction in energy consumption, the environmental impact is still positive.

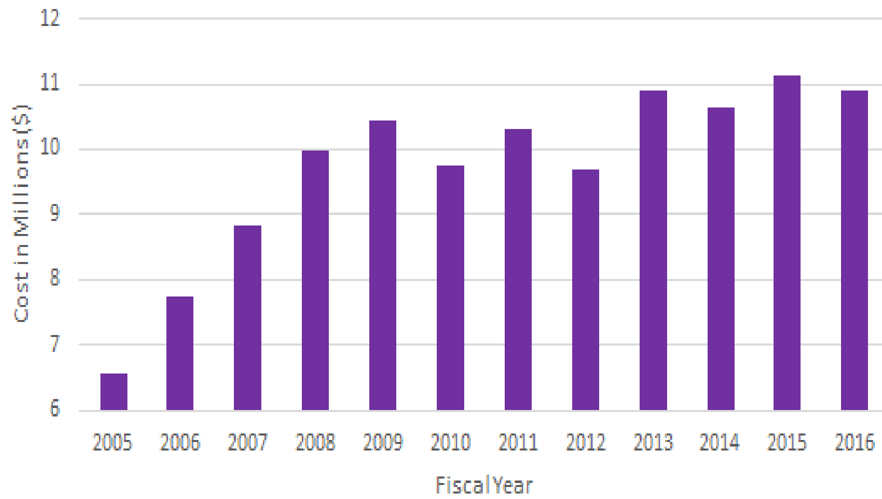

Figure EU 2: Cost of total energy used by the University over a twelve -year period.

The effect of Clemson's efficiency improvements can be seen in *Figure EU 3* and *Figure EU 4*. In recent years, the cost of Clemson's main campus energy use has remained nearly constant. This becomes significant when compared to physical area growth of Clemson's main campus over the last five years, as seen in *Figure EU 4*. The campus has greatly increased in size but has managed to maintain similar energy costs as before the new construction. This is due to improvements in the energy efficiency of new buildings and facilities built on campus. This dedication to developing new energy efficient buildings has aided Clemson in maintaining sustainability despite its physical growth.

Figure EU 3: Price of total energy consumed over the campus area over a twelve-year period.

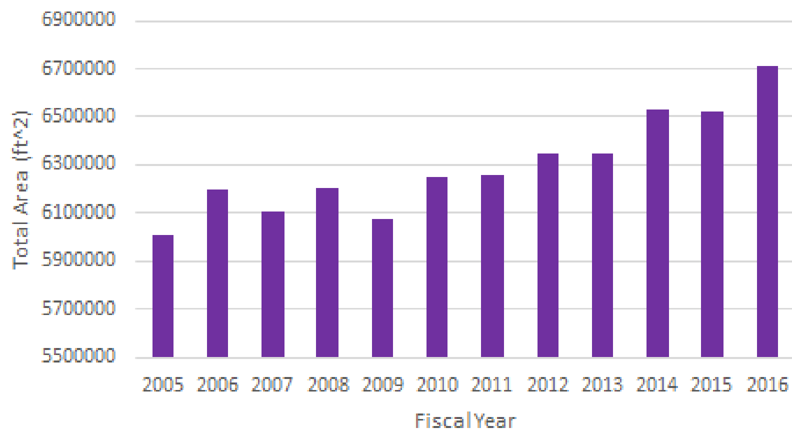

Figure EU 4: The growth of the university over a twelve-year period.

After removing buildings in 2007 and 2009, the university has been adding buildings steadily in two-year periods starting in 2010. *Figure EU 5* illustrates the implementation of Clemson's plan to reduce energy use by 20% per square foot by 2020, which currently sits at a 17% reduction per square foot as of 2016. Clemson has created a steady decrease in energy consumed per square foot in the last 4 years indicating that Clemson is on track to achieve its 20% goal.

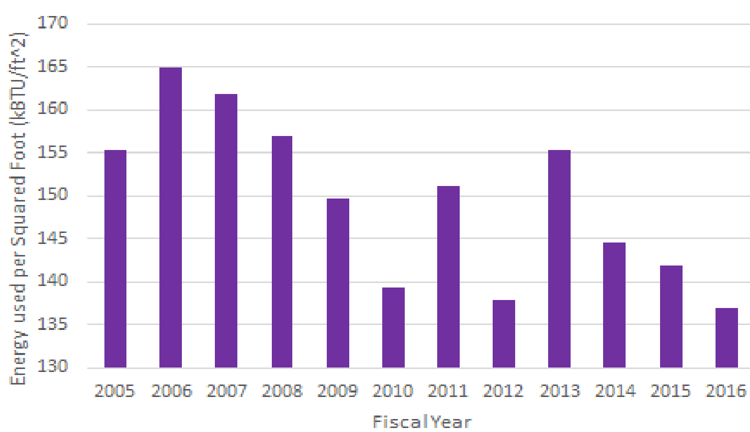

Figure EU 5: Total energy consumption over the total university area.

Fuel Types

In addition to total energy consumed, the type of energy sources used is essential in determining Clemson's environmental impact.

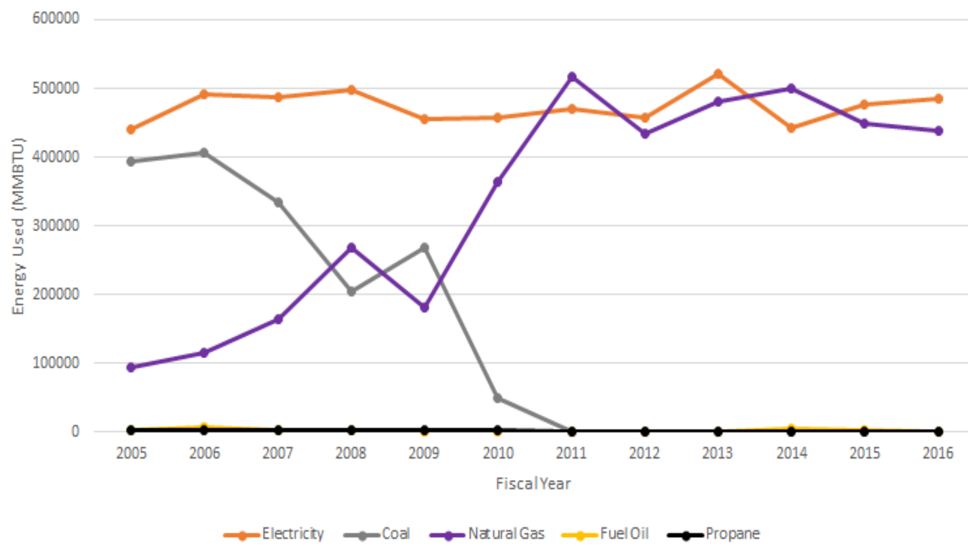

Figure EU 6: Trends of energy provided by energy type per year over a twelve-year period.

Over the last decade Clemson has become more reliant on natural gas while purchased electricity has remained a large source of campus power, as shown by *Figure EU 6*. Clemson phased out its use of coal as a fuel source with the decommissioning of the final coal boiler. Clemson was able to eliminate coal use completely as of 2011. There is a unique dip in natural gas usage and peak in coal usage in 2009 because of an increase in natural gas prices for that year, so coal was the more economical option. The following tables provide the prices, total costs, and consumption of each fuel source between 2005 and 2016. (Propane and fuel oil are negligible in comparison to the amounts of other fuels used.)

Table EU 2: Clemson University's Yearly Electricity Consumption and Cost

Total Purchased Electricity Consumption for Fiscal Year 2005-2016			
Fiscal Year	**Consumption [kWh]**	**Cost per kWh [$]**	**Total Cost [$]**
2005	129,095,858	0.0345	4,451,949
2006	143,952,972	0.0367	5,288,894
2007	142,820,019	0.0420	5,999,786
2008	145,686,155	0.0453	6,593,846
2009	133,407,947	0.0537	7,160,286
2010	133,793,979	0.0539	7,211,851
2011	137,600,172	0.0528	7,268,814
2012	134,109,520	0.0551	7,382,919
2013	152,759,836	0.0557	8,515,082
2014	129,530,268	0.0587	7,600,510
2015	139,370,591	0.0630	8,775,314
2016	141,955,929	0.0614	8,718,730

Table EU 3: Clemson University's Yearly Natural Gas Consumption and Cost

	Total Natural Gas Consumption for Fiscal Year 2005-2016		
Fiscal Year	Consumption [MMBTU]	Cost per MMBTU [$]	Total Cost [$]
2005	94,744	8.1026	767,668
2006	115,908	7.3153	847,904
2007	163,661	9.1550	1,498,315
2008	268,132	9.0670	2,431,162
2009	182,062	7.7458	1,410,221
2010	364,344	6.2472	2,276,121
2011	517,498	5.8780	3,041,852
2012	433,645	5.3146	2,304,636
2013	479,929	4.9518	2,376,527
2014	500,612	5.8941	2,950,644
2015	449,645	5.1654	2,322,610
2016	439,050	5.000	2,165,538

Table EU 4: The University's Yearly Coal Consumption and Cost

	Total Coal Consumption for Fiscal Year 2005-2016		
Fiscal Year	Consumption [tons]	Cost per ton [$]	Total Cost [$]
2005	14,598	87.0912	1,271,357
2006	15,052	101.8013	1,532,300
2007	12,376	103.7668	1,284,200
2008	7,594	115.1608	874,567
2009	9,786	185.4890	1,815,191
2010	1,952	112.3504	219,308
2011	0	0	0

Energy Consumption in 2005 versus 2016

The following two charts (*Figure EU 7* and *Figure EU 8*) provide a comparison between the types of energy contributing to the total energy consumption in 2005 versus those in 2016. Purchased Electricity remained a primary source of energy consumption contributing to about half of total energy consumption. With coal eliminated, natural gas became the leading fuel type for Clemson, increasing approximately 42% in 10 years. It accounted for 52% of usage by 2006. The removal of coal as a fuel source for Clemson has certainly led to a benefit on the environment with a reduction of the burning of fossil fuels. The increase in natural gas use comes with its own environmental concerns such as the effects of fracking on the environment. Ideally, Clemson will begin to pursue renewable energy sources to further reduce its environmental impact. In the subsequent graphs electricity references the electricity purchased from outside sources.

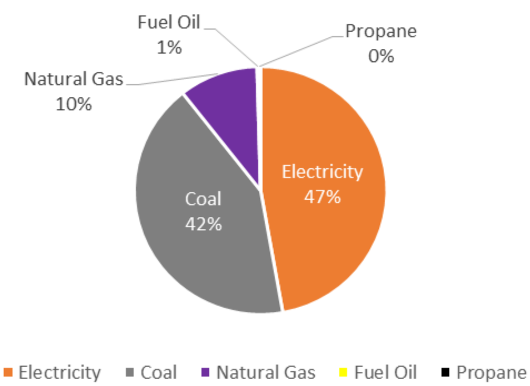

Figure EU 7: Percentage of total energy provided by each energy type for the fiscal year of 2005.

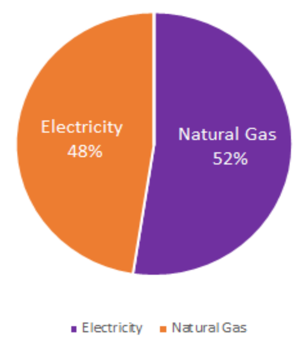

Figure EU 8: Percentage of total energy provided by each energy type for the fiscal year of 2016.

Monthly Energy and Cost Trends

Figure EU 9 and *Figure EU 10* provide a comparison between monthly energy consumption and the average temperature. As predicted, more energy is used in the colder months (November through February) than the rest of the year. During those colder months, natural gas use increases as it is burned to generate steam which is then used to generate electricity to heat buildings on campus. Purchased electricity is rarely used to generate heat in the winter but is mainly used for cooling during the rest of the year.

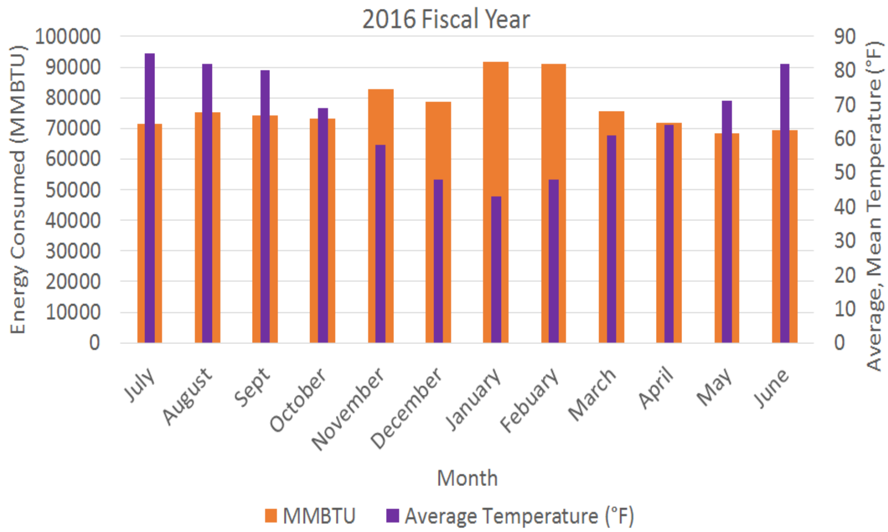

Figure EU 9: Energy consumption correlation with average monthly temperatures

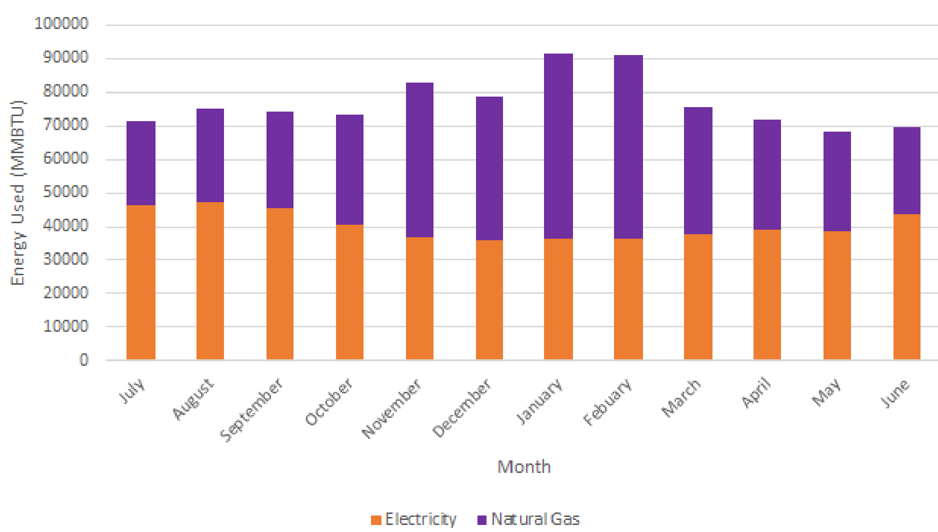

Figure EU 10: Energy type consumed per month during the fiscal year of 2016.

Figure EU 11 provides the monthly energy cost for the University in 2016. The most expensive months are notably June through September. This is a result of high electricity usage, mostly from cooling systems, which causes Clemson to spend more money on energy.

Figure EU 11: Total monthly energy cost during fiscal year 2016.

Students' Perspective

Clemson University has made strides towards its net-zero goal, but more can still be done. Currently, about fifty percent of Clemson's energy usage comes from the burning of natural gas. The choice was made to increase usage of natural gas in order to replace the use of coal on campus ("Environmental Audit," 2013). One possible course of action is switching from natural gas to biomass with cogeneration technology. Biomass is the organic waste from logging, farming, carpentry or any other processes where waste plant material is produced. Biomass burning takes organic matter that would normally be wasted and burns it for energy extraction in an efficient manner. With on-campus farming operations, we may already have one feasible source of biomass on site to supplement any fuel that is purchased. Cogeneration facilities will further help increase the efficiency of the campus by producing power and capturing wasted heat to produce hot water ("Environmental Audit," 2013). Cogeneration has an efficiency of approximately 85% (Zafar, 2019). The power produced from the facility may be used to power the campus and the hot water produced may be used for the residence hall water supply and for building heating. Changing energy types may be financially inefficient initially, but could potentially save money in the long run; a detailed look into this is needed for cost analysis and fuel sourcing (Taylor, 2019).

The Watt Family Innovation Center is a recent addition to Clemson Campus. The large building (70,000 square feet) was established in 2016 in a highly trafficked part of campus and is seen as a very modern addition. The building hosts classes and is frequently used for presentations and formal meetings. The Watt Center is LEED-silver certified, meaning that energy efficiency, storm water management, water consumption, and air quality are all taken into thorough consideration. The project is featured in the Clemson 2020 roadmap. The entire building is centered around energy efficiency. While a lot of energy is used to power the building, the benefit of high usage and productivity are significant. The Watt Center was established to meet the growing population's demand for more classroom space. The building features lights with sensors, which are centrally controlled and software-driven. The lights will detect how bright it is outside and adjust accordingly. This is important considering the entire front of the building is glass. The front of the building features a two-story mesh electronic screen, which can be programmed to display animations, graphics and messages.

Clemson University's goal to be carbon-neutral has led to other sustainable buildings on campus. Lee Hall III, for example, uses geothermal water-to-water HVAC heat pumps; eight-zone radiant heating and cooling systems; and a mechanized neutral ventilation system. In addition to these steps, Lee Hall is also planned to receive a solar panel array, although the timeline for such plans are undetermined. Almost 95% of the waste generated by building Lee Hall III was diverted from landfill. Conduits for electric cars are in place outside in the parking lot, and automated light sensors are installed with daylight sensing technology to help minimize energy consumption.

Another recommendation would be to implement solar power as an alternative form of energy. Solar power uses panels comprised of smaller subunits called photovoltaic cells. The panel allows photons, or particles of light, to knock electrons free from atoms and generate a flow of electricity (Dhar, 2017). There are many advantages to using solar power. For example, it is both a renewable and non-polluting resource. Although solar power is expensive to implement, once installed it has no cost other than upkeep. Overcast weather can limit the energy output of solar panels, and night time must also be accounted for since the panels will not generate energy without light input. In recent years, many restrictions in place regarding the implementation of solar panels have been reduced, allowing for solar usage to be more incentivized. Solar energy has been researched at Clemson and is a possibility for supplying eight percent of the University's power (Putnam).

One of the biggest uses of electricity is for heating and cooling indoor spaces on campus ("Environmental Audit," 2013). To help offset energy use, geothermal technology may be considered. Geothermal coupled heat pumps use the earth's natural temperature to help in the heating and cooling of buildings. In the summer, excess heat is dumped into the earth. In the winter, heat is pulled from the ground to help warm the building. This heat pump, combined with geothermal technology, will help increase the efficiency of the campus's heating and cooling systems. Heat pumps can even reach an efficiency factor greater than 300% which is substantial in terms of system efficiency ("Geothermal Heat Pumps," 2019). Overall, Clemson's reduction of energy used per square foot and elimination of coal have had a positive impact on the environment. If Clemson can continue to pursue clean renewable energy, it will be well on its way to meet its sustainability goals.

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Hazardous Waste

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Clemson University has developed protocols for hazardous waste management, minimization, and disposal on its campus. The purpose of this audit is to inform readers of the importance of properly discarding hazardous waste produced in teaching and research labs; it also outlines current methods of classifying and transporting waste used by the university. This information is of great significance, as improper disposal of hazardous waste can cause harmful effects upon the environment. Findings show that on Clemson's campus, there is an upward trend in hazardous waste production due to the growth of the campus each year. Conducting labs and expanding upon research each year produces more hazardous waste, necessitating minimization efforts. If the production of hazardous waste continues to increase, the practices of properly discarding waste must be adjusted accordingly. The production of additional waste could pose a threat to the environment in both Clemson and the surrounding regions. Therefore, proper management of hazardous waste is of critical importance.

Introduction

Over the past decade, Clemson University's hazardous waste production has risen slightly due to overall growth of the main campus as well as a significant jump in research activities. Under the legislative guidance of the Environmental Protection Agency (EPA), the university has developed stringent hazardous waste disposal protocols. Clemson makes handling hazardous waste a top priority to protect the university and the surrounding environment. To ensure that the waste is managed properly in labs and other waste-producing facilities on campus, Clemson's Office of Research Safety utilizes the Clemson Hazardous Waste Manual. As of today, the Office of Research Safety has been successful at controlling waste production increases with the use of vigorous waste minimization efforts. In this document, we discuss the different classifications of hazardous waste along with processing and minimization efforts by the University; information regarding construction waste and quarterly data on quantities of waste produced on Clemson University's campus is also included. We will also offer recommendations from the perspective of the student auditors.

Legislation Related to Hazardous Waste

The EPA oversees all laws pertaining to hazardous waste. The EPA also sets national standards that are not outlined by federal law, which allows states to adopt these standards into state law. The South Carolina Hazardous Waste Management Regulations (SCHWMR) apply to the storage, treatment, transportation and disposal of hazardous waste. Under these regulations, Clemson University's main campus is currently classified as a "Large Quantity Generator" of hazardous waste. South Carolina and other states that use this practice are known as an "Agreement States." The EPA supports the standards and regulations it enforces by performing extensive, cutting-edge environmental research. This research can also be used by the state of South Carolina and Clemson University to create further regulations for Clemson officials to manage hazardous wastes even more safely than environmental regulations require.

The Resource Conservation and Recovery Act (RCRA), a federal law, is administered by the South Carolina Department of Health and Environmental Control and is implemented under the South Carolina Hazardous Waste Management Regulations. This requires generators, such as Clemson University, to ensure that the hazardous waste is properly identified, managed on-site for no more than 90 days, and transported to a RCRA-permitted treatment, storage or disposal facility (TSDF). RCRA also provides information on how hazardous wastes can be classified and identified.

Classification of Hazardous Waste

The criteria for defining what constitutes hazardous waste are as follows:

- The waste contains chemicals that are potentially harmful to humans or the environment if not properly managed.
- The waste is typically ignitable, corrosive, reactive, or toxic.
- Other wastes can be classified as hazardous if the Environmental Protection Agency (EPA) has reason to believe they could be dangerous to people or the environment.

  If the material falls under any of these categories, it is considered to be environmentally hazardous. More detailed listings of hazardous wastes can be found through the EPA website. Three other classifications of hazardous waste are applicable to activities at Clemson:

- The F list: The F list includes spent solvents from non-specific sources used in general campus operations and research.
- The P and U lists: These lists include pure and commercial grade hazardous materials.

Process

The majority of Clemson's hazardous waste is produced in campus labs devoted to research and education. Other sources include general campus operations and abatement. When hazardous wastes are produced in the labs, appropriate guidelines are in place to be followed by students, staff, and faculty in order to handle the hazardous waste. These steps are outlined in the Clemson Hazardous Waste Manual, which is available in all of Clemson's research and teaching labs. The manual can also be found online.

The Hazardous Waste Manual provides the necessary guidelines for Clemson laboratories to reduce hazardous waste production. The manual has been effective in educating students, faculty, and staff on handling hazardous waste properly and minimizing potential environmental and health risks. The manual includes information on how to minimize waste by substituting non-hazardous materials when possible and returning any unused materials to clients after research is completed.

Before hazardous waste collection occurs, a waste determination process must take place for all hazardous wastes accumulated. Once classified, hazardous waste products are collected from labs and other sources on campus for transport to Clemson's hazardous waste accumulation facility. At the facility, hazardous waste is properly accumulated, categorized, compiled, and packaged for shipment. This facility is inspected weekly and the written inspection forms are kept on file. The Office of Research Safety keeps records documenting pounds generated and shipped. These records are submitted quarterly to South Carolina Department of Health and Environmental Control (DHEC).

Clemson University contracts with a disposal company to treat and dispose of its hazardous waste. Every 30 days, Clemson ships waste from the Clemson accumulation facility. Even after the contractor transports the waste off campus, Clemson is still liable for the waste, its shipment, and its disposal. Liability for the hazardous waste is from the point of generation to its final disposition. This is known as "cradle to grave" responsibility. The shipment of the hazardous waste is monitored by the U.S. Department of Transportation (DOT).

The disposal company is chosen by Clemson staff based on extensive research and site audits. Clemson Hazardous Waste Management officials visit waste disposal sites to assess their compliance with regulations. They also access company records to ensure that the contractor is not a repeat offender against regulation compliance and is properly insured. It is paramount to Clemson Hazardous Waste Management that their contractor is responsible and fully qualified.

Minimization

The main campus of Clemson University is considered a "Large Quantity Generator" of hazardous waste set forth by state and federal regulations. The majority of Clemson's successful minimization efforts occur in teaching and research labs since they are the primary producers of Clemson's hazardous wastes. Minimization efforts include using non-hazardous or less hazardous substances as well as volume reductions.

One of Clemson's largest minimization efforts is the Mercury Exchange Program, which was implemented in 2013 by the Office of Research Safety. The main goal of this program is to reduce the presence of mercury, a common and costly hazardous waste, in order to eventually make Clemson a mercury-free campus. Reducing the amount of mercury on campus reduces the health and environmental risk of this element and also prevents laboratory closures due to broken mercury-containing equipment such as thermometers and manometers. This initiative has already allowed for several hundred mercury-containing pieces of equipment to be eliminated from Clemson's campus. Although this progress is satisfactory, there are still alternative devices which can be used in order for the program to continue toward being mercury-free.

Construction Site Hazardous Waste

Construction sites can produce large quantities of hazardous waste. For example, new building construction requires the use of treated wood, paint, solvent wastes, glues, roofing tars, and cylinders. Furthermore, demolition of old buildings can result in waste products such as lead paint containing mercury-based biocides, leaded pipes, asbestos insulation, mercury-containing fluorescent lamps and PCB ballasts, along with other hazardous materials. Since Clemson's campus has seen an increase in construction over the past several years, the hazardous waste department found it necessary to create a construction site hazardous waste guide. Common materials found at construction sites are identified in the guide as industrial waste, hazardous waste, recycled waste, and other categories. The guide specifies how the waste needs to be managed and gives guidance on how to do so properly. Additionally, included are listings of the correct Clemson employee and department to contact based on which waste is being produced. This ensures that the hazardous waste is handled efficiently and properly, minimizing its effects on the safety of the surrounding people and environment.

Data

Data was collected for hazardous waste accumulation from Clemson's main campus operations. It should be noted that data from previous years may not be as accurate as data collected from five years ago to present. This discrepancy is attributed to an increase in documentation from the hazardous waste management throughout the years. An increase in documentation means more waste was accurately accounted for in data collection and, therefore, may be the cause of growth in the quantity of data.

Large spikes in waste production in the third quarters of 2010 and 2011 (*Figure HW 1*) were due to abatement and renovation of some labs. Excluding the unusual increases in specific quarters, *Figure HW 1* illustrates that the amount of hazardous waste generated remains consistent from year to year with small fluctuations. However, this constant generation could also mean that the minimization efforts are effective. Clemson is a fast-growing research institution, which means more research producing hazardous waste are most likely being conducted each year. This increase in research means more waste should be accumulated each year. Nevertheless, the data shows a slight increase in volume, suggesting that minimization efforts are working to reduce the amount of waste produced.

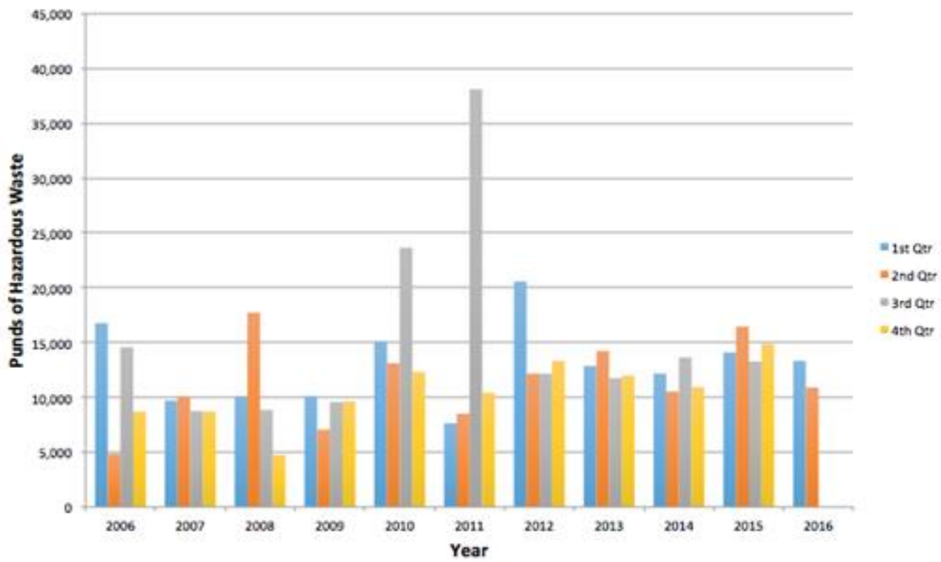

Figure HW 1: Pounds of hazardous waste from 2006-2016 per quarter. Clemson University main campus.

Students' Perspective

Clemson is taking all necessary actions to ensure that hazardous waste is disposed of properly. Procedures are in place to reduce hazardous waste, proactively protect the university from spills, perform necessary abatements, and ensure that the rules stated in the Hazardous Waste Manual are followed. Clemson should continue to conduct these procedures to ensure that the environment is protected from hazardous waste. We recommend that Clemson continues pushing these plans to minimize waste, maximize efficiency, and protect health and the environment. Clemson is effectively managing hazardous waste on all fronts, but the university should continue looking for even more opportunities for waste minimization. This will increase the effectiveness and success of an already highly successful department.

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Parking and Transportation

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Executive Summary

The 2019 Parking and Transportation chapter evaluates the various transit options on Clemson's campus. Personal vehicles are the primary mode of choice for traveling to and from campus. The University provides 4,770 parking spaces that support about half of the 23,000 students that commute to campus. There are 1,641 resident/apartment spaces for the remaining students to use. About 5,000 employees and staff have around 2,725 parking spots to choose from. In 2013, Sightlines, a consulting firm, reported that twelve percent of Clemson University's emissions were produced from students and employees commuting—eight percent from students and four percent from employees. CATbus ridership has been steadily rising. It jumped from about 1.19 million riders in FY2014 to about 1.34 million in FY2017. Clemson has added many alternative transportation options in recent years to help reduce automobile commuting. These include a commuter bus line from Greenville and Easley as well as programs such as car share, carpooling, bicycles, electric car charging stations, and new student housing closer to campus.

Campus polls indicate that the expansion of the bus program is the most popular future initiative, while vanpooling is considered the least effective option. As many of the programs are mass transit, much of their focus is aimed at freshmen, who are statistically more likely to live on campus and leave their cars at home. This may have affected the results of the polls as upperclassmen were more likely to be unaware of some of the newer, more experimental programs. However, the report also concludes that parking is not commensurate with the increasing annual number of students, faculty, and staff. As more and more individuals look for alternative transportation options, this fact will only grow more relevant as Clemson's numbers grow. With a starting metric for program popularity, Parking and Transportation Services can determine which programs should continue to be funded or expanded, and which waste valuable resources.

Introduction

Transportation is a widespread concern for all students and staff at Clemson University. It not only affects us, but also the people in the surrounding area. This audit will examine Clemson University's carbon emission impact, as well as discuss already established and potentially new solutions. Since Parking and Transportation Services Director Dan Hofmann assumed office, he has been steering Clemson University into the 21st century with new programs and ideas.

The auditors have examined the current trends and programs of the Transportation Department at Clemson University. We analyzed the number of single occupancy vehicles compared to parking spots on campus, as well as their carbon emissions. In this Audit, we will discuss alternative methods of transportation such as CATbus, community buses, and the Zipcar program. We will look at new initiatives such as a new parking lot, new housing options close to campus that will reduce commuter traffic, and electric car charging stations. We will use data provided by the Transportation department to examine the trends of all these efforts. We will close with a section on campus perspective that provides insight into how these programs are resonating with the student and faculty population.

Single Occupancy Vehicles (SOV)

Personal vehicles are the primary mode of choice for traveling to and from campus. People are more comfortable driving their own vehicle because it gives them personal security, privacy, and offers a level of convenience absent in other forms of transportation. Knowing this, Clemson University provides 4,770 parking spaces that support about half of the 23,000 students that commute to campus. Also, the approximately 5,000 employees and staff have around 2,725 parking spots to choose from. There are 1,641 resident/apartment spaces for the remaining students to use. Back in 2013, Sightlines, a private firm that does an environmental analysis for universities throughout the country, found that approximately twelve percent of Clemson University's emissions were produced from students and employees commuting. Employee commuting caused four percent and students commuting caused eight percent.

Alternative Transportation Methods

In addition to SOVs, alternative transportation methods include walking, public transportation, and biking, as well as the car share program.

CATBus

The Clemson Area Transit Bus system (CATbus) is the primary mass transit system of Clemson University and the city of Clemson. Ridership has increased steadily over the years from 1,186,226 annual riders in FY14 (*Figure PT 1*) to 1,342,572 annual riders in FY17 (*Figure PT 2*).

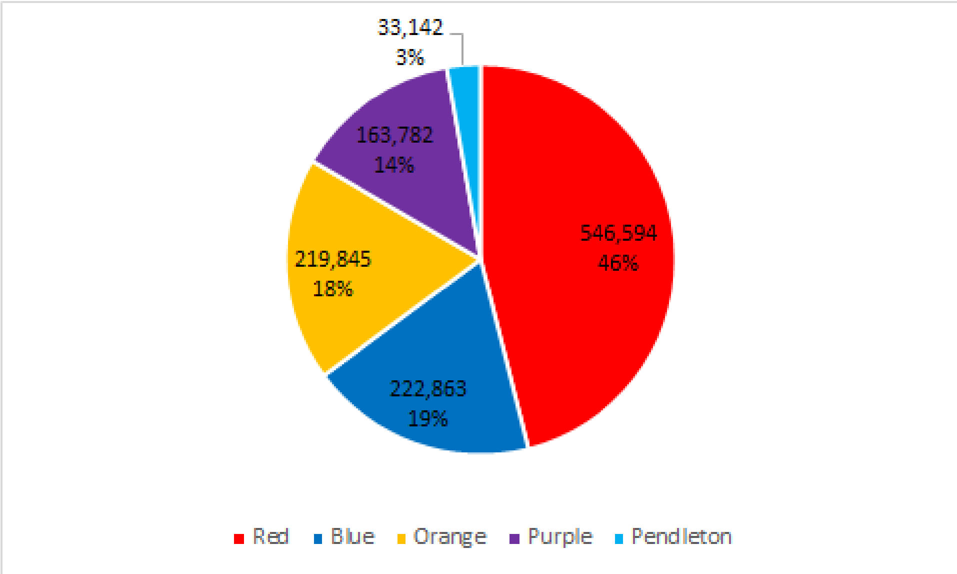

Figure PT 1: CATbus Ridership by bus line for FY14

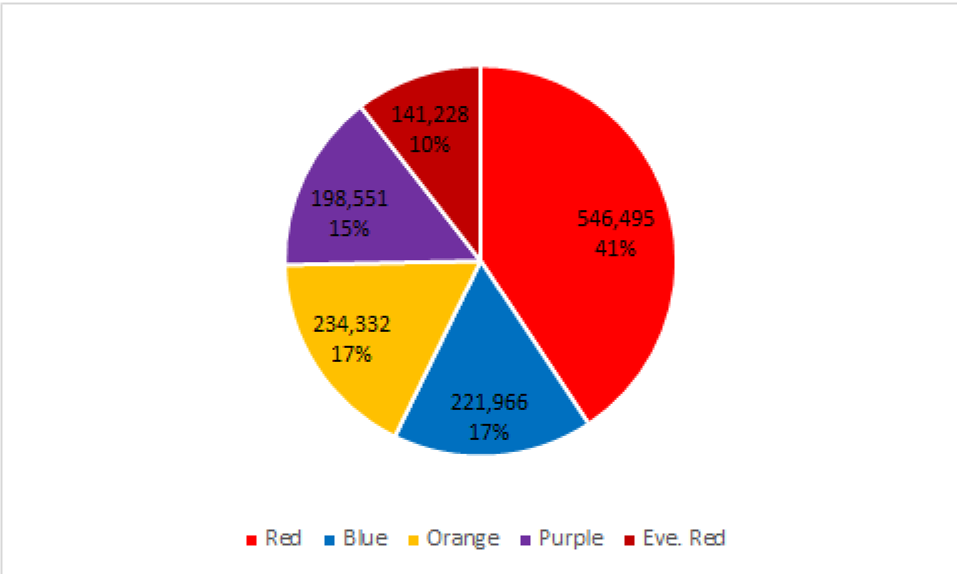

Figure PT 2: CATbus Ridership by bus line for FY17

The Red Route is an off-campus route used by over 546,000 students per year as of FY17. This alternative to a personal vehicle serves to reduce carbon emissions as well as cut down on the costs for students. It provided more than half a million rides annually in the four-year span from FY13 to FY16, and was on pace to do the same in FY17, showing no sign of any decrease in numbers. This trend can be seen in *Table PT 1*.

Table PT 1: Red Route Yearly Ridership

Red Route - Total					
Month	FY 13	FY 14	FY 15	FY 16	FY 17
Jul	17,049	16,223	15,906	16,154	15,683
Aug	49,782	51,544	50,895	57,265	66,178
Sep	84,493	99,865	95,070	99,208	96,446
Oct	81,099	83,261	95,977	85,588	86,597
Nov	67,304	67,552	61,709	72,496	64,792
Dec	34,011	34,939	36,217	34,749	26,373
Jan	61,079	62,379	70,138	68,363	57,901
Feb	69,587	63,459	65,758	78,301	72,566
Mar	57,838	56,089	60,584	64,736	60,058
Apr	77,024	72,202	73,935	73,622	
May	22,610	22,047	18,277	19,009	
Jun	14,468	16,166	16,199	17,917	

The Orange, Purple, and Blue routes serve to transport students and faculty between commuter and employee parking lots and the central areas of campus. The Orange and Purple routes, which serve the west campus, have had a slight decrease in their numbers since FY14. However, in FY17 the numbers began to rise, as seen in *Table PT 2* and *Table PT 3*. The Blue route, which serves the east campus, has also been experiencing a decrease in overall ridership each year, as seen in *Table PT 3*. While these buses still produce carbon emissions, they result in a net decrease due to the decrease in traffic in the Clemson area, especially during class times. This allows the central area of campus to be pedestrian friendly by moving the majority of vehicle traffic to the outer edges of campus.

Table PT 2: Orange Route Yearly Ridership

Orange Route					
Month	FY 13	FY 14	FY 15	FY 16	FY 17
Jul	-	-	-	-	-
Aug	13,675	14,213	12,487	14,722	20,342
Sep	37,175	39,270	38,503	38,012	40,119
Oct	36,375	35,753	36,296	30,841	36,376
Nov	29,387	27,543	22,616	25,349	28,526
Dec	10,914	12,113	11,744	9,296	6,736
Jan	25,903	25,548	31,067	22,883	24,519
Feb	31,651	27,219	26,093	31,342	35,199
Mar	23,288	23,038	24,809	24,589	28,028
Apr	30,399	28,553	27,435	21,868	
May	2,078	1,082	499	-	-
Jun	-	-	-	-	-

Table PT 3: Purple Route Yearly Ridership

Purple Route					
Month	FY 13	FY 14	FY 15	FY 16	FY 17
Jul	-	-	-	-	-
Aug	8,948	10,454	11,659	11,555	14,700
Sep	25,052	29,917	35,593	31,214	28,768
Oct	26,221	29,750	32,208	27,554	27,187
Nov	23,451	23,514	19,267	24,561	21,243
Dec	9,222	10,941	10,539	9,664	6,060
Jan	20,149	20,927	23,754	22,081	18,384
Feb	26,086	23,933	25,235	30,440	25,259
Mar	19,949	21,028	23,151	24,954	22,181
Apr	26,812	26,910	26,329	26,394	
May	1,985	1,177	536	-	-
Jun	-	-	-	-	-

Table PT 4: Blue Route Yearly Ridership

Blue Route					
Month	FY 13	FY 14	FY 15	FY 16	FY 17
Jul	-	-	-	-	-
Aug	12,593	12,263	11,699	14,399	19,286
Sep	33,647	33,655	35,783	38,688	38,608
Oct	35,403	31,488	38,910	34,878	36,844
Nov	28,731	25,572	24,202	31,381	29,379
Dec	12,223	12,210	12,757	11,855	8,780
Jan	28,046	23,852	28,745	28,386	24,170
Feb	34,550	26,629	27,927	37,852	35,035
Mar	27,053	25,020	24,939	30,177	30,761
Apr	32,394	30,068	30,395	30,867	
May	1,821	1,209	559	-	-
Jun	-	-	-	-	-

It is important to note that ridership varies greatly during the year depending on the level of activity on the university campus, largely during holidays. This variation is clearly visible in the ridership numbers of the four CATbus routes shown in *Figure PT 3*: Orange/Purple/Blue/Red Ridership Graphs. The on-campus routes do not run in the months of June and July due to the greatly decreased presence of students and faculty on campus.

Figure PT 3: Orange/Purple/Blue/Red Ridership Graphs

Community Buses

In addition to the Red Route, some of the residential communities provide their own shuttle service to the university campus. The communities that provide this service are usually the ones that are not included on the Red Route. These include Aspen, Hart's Cove, and The Cottages, among others. While no data is available for these shuttle services, it is presumed that they are popular due to their continued presence.

Greenville/Easley Commuter Route

In 2014, Clemson began utilizing a Greenville bus route controlled by GreenLink bus services. For two years it maintained strong ridership and contributed to cutting down carbon emissions in both Clemson and Greenville. This reduction in carbon emissions was made possible by allowing commuters to take one central mode of transportation to and from campus. However, in August 2016, Clemson canceled their contract with Greenlink and gave responsibility to in-house student affairs. Many faculty members, staff and students had used the Greenlink bus to commute from the Greenville/Easley area to Clemson and were fond of the conveniences it had to offer, such as free ridership and Wi-Fi. This commuter service has continued operating under the new arrangement with a changed schedule.

Car Share

Another initiative that the university has implemented is the Zipcar car share program. Through the use of a subscription program, students have the ability to rent one of a handful of cars that are placed around campus. As of spring 2017, the Zipcar program had 551 members with five available car-share vehicles. Students also have the ability to reserve the car for as long as they desire and pay a fixed hourly rate. This service gives students the freedom that comes with a personal vehicle at a reduced cost. In FY16, this program was utilized 2,018 times by members. Because the cars are shared by all subscribers, it reduces the number of cars on campus and potentially frees up space for more parking. This, in turn, helps lessen the overall carbon emissions produced by students.

Carpooling

Carpooling is a program that has been around for years. It encourages students (in groups of two or more people) to commit to driving together at least four times per week. During Fall 2016, there were 271 participants in 117 carpool groups. This reduced an estimated 154 cars from being driven into campus daily Monday-Friday. Participants received discounted parking passes and were able to park in special spots located closer than commuter lots/spots. The goals of this program are to reduce the number of cars being driven to campus, increase available commuter spots, and reduce traffic on campus and the surrounding areas.

Bicycles

Another method of transportation utilized in the area is bicycling. Bicycles help to not only minimize carbon emissions but to reduce vehicle traffic around campus, especially during the rush hour periods. With bike racks near the entrances of most buildings, riders experience a level of convenience that is nonexistent for their automobile counterparts. A new bike sharing program, BikeShare, was launched on April 11, 2017. Similar to the car share program, this program allows students to rent university-owned bicycles an unlimited amount of times, with the first two hours of each ride being free. Since the program's launch, more than 200 members have joined and taken more than 600 trips across campus. BikeShare stations are solar powered and provide an environmentally friendly service to the students and faculty of Clemson University.

New Initiatives

New Parking Lot

Due to the increase in demand for residential parking, parking lot R-6 was created. The new lot was originally created to act as an overflow lot for residential student parking during football games when west campus residents are required to move their cars. However, due to recent increases in demand for commuter parking, the Transportation department decided to reevaluate the purpose of R-6. This resulted in a new lot for commuters, located next to the armory at the junction of Perimeter Road and Highway 76. In view of R-6's secluded location, the transportation department added a bus stop that brings students to campus every fifteen minutes to encourage students to park in this lot (Hofmann).

Electric Car Charging Stations

Clemson University had initiated an electric car charging program in 2016. Although there were only thirteen active permits on campus initially, they had accumulated an impressive amount of energy consumption with 8,378-kilowatt hours at $0.075/kWh. When converted to gallons of gasoline, 8,378 kWh of electricity comes out to approximately 250 gallons. The environmental impact of electrical power is apparent and is a viable alternative to fossil fuels, which add to carbon emissions around campus. Parking and Transportation Services expects an increase in electric car usage in the future and is building more stations to accommodate future needs.

Holiday Airport Shuttles

Clemson Parking and Transportation Services recently began providing free shuttles for travel to and from Clemson University during university recognized holidays. These shuttles provide transportation to and from the Greenville-Spartanburg Airport as well as the Charlotte-Douglas International Airport. These shuttles have saved students over $300,000 in transportation fees in FY16. The success of this program will yield even more savings in the future and has the potential to expand.

New Student Housing Options

Clemson University has undergone significant growth. New housing projects have been built that enable students to live closer to campus, and potentially not have to drive their personal vehicles to get to class. Such housing includes Douthit Hills on the north side of campus and Core Campus near the campus' center. Douthit Hills, which opened in 2018, was built to provide on-campus housing for around 1650 upperclassmen and bridge students at Tri-County Community College. Core Campus, completed at the end of summer 2016, now provides accommodations for 700 honors students and underclassmen. These new on-campus housing options were necessary to help Clemson University keep up with the ever-growing housing demand. These new housing developments also decrease the number of potential commuters, and further reduce the impact of vehicle pollution to the environment.

In addition to the on-campus housing projects, there are also several off-campus housing projects taking shape around Clemson. Campus View is one such project that was completed in 2014. This complex is located in downtown Clemson, within easy walking distance to campus. While students in these apartments often have cars, they do not have to drive them to class every day. UCentre on College, which opened in 2017, is another off-campus apartment building. It houses 418 students and is also located in downtown Clemson. Tenants will have a parking garage to store their vehicles. However, due to the proximity to campus, they will often opt to walk to campus. This will, in turn, reduce the vehicular traffic and increase parking available on campus.

Students' Perspective

A Sightlines survey was completed in 2015. This survey analyzed student, staff, and faculty opinions about carbon emissions and the effectiveness of transportation services offered at Clemson University. The results can be seen in *Figure PT 4*. The auditors noticed that people considered adding more buses to be the most effective path to take. The bus programs on campus have resonated well with students and faculty over the years. The least effective program appeared to be vanpool, as 71% of the population viewed it as either ineffective or very ineffective. This is probably because not many people know about the program, or do not have access to a van. This is an older survey, but these trends should give a general overview of the campus opinion.

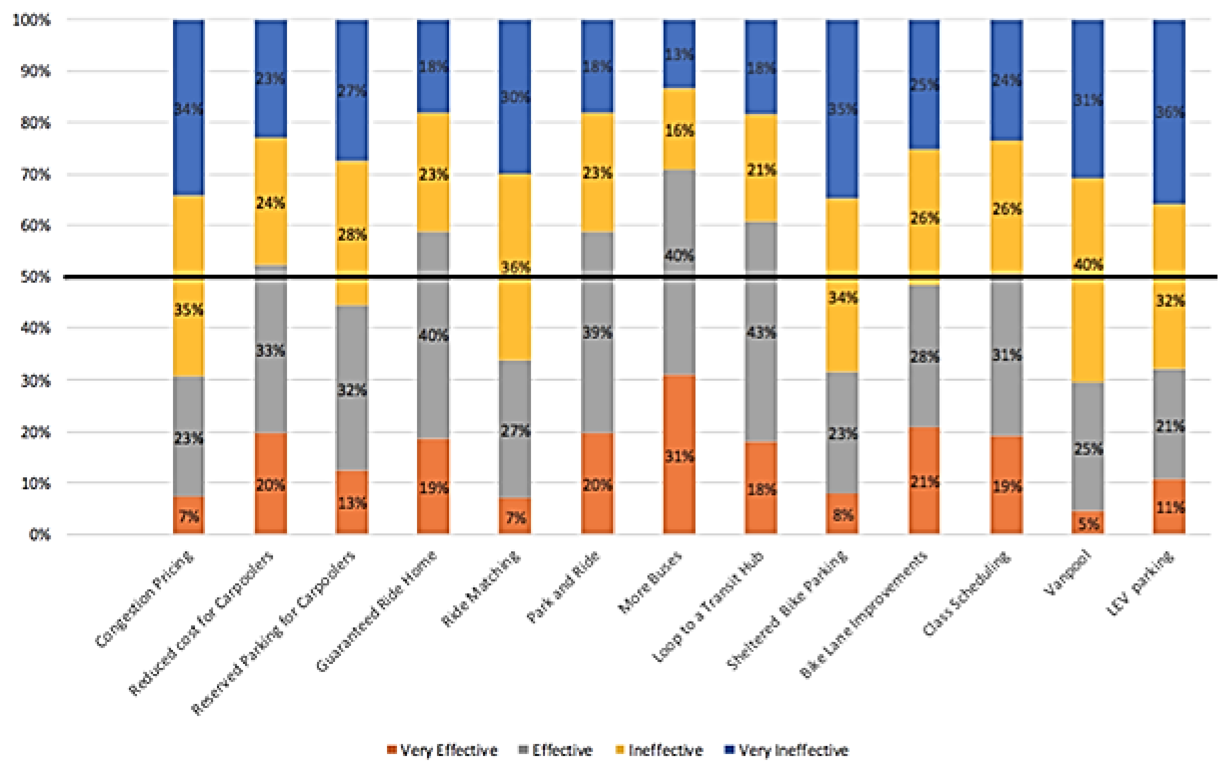

Figure PT 4: Campus Program Effectiveness

One of the major issues with sustainability programs is the amount of awareness among students. It is noted that Parking and Transportation Services utilizes multiple social media accounts and hold events for students to attend. However, several auditors, who are upperclassmen at Clemson, did not know that some of the sustainability programs existed. While it is understood that some of these programs are aimed at freshman students because they live on campus and are more likely to leave their car at home, it is likely that many upperclassmen would utilize these programs if they knew about them. Thus, it is important for Parking and Transportation Services to more effectively market these programs so that more students understand the programs that are in place. This will most likely increase the number of students who utilize these programs, and in turn decrease the number of cars on campus.

It was also noted that many students and faculty have not been willing to use alternative means of transportation to the university. However, this is starting to change, as students and faculty experience difficulty finding parking on campus and see the importance of sustainability for a continuously growing university. One major alternative mode of transportation is the use of shuttles from apartment complexes located close to the university. Clemson does not have an extensive public transportation system like the systems seen in large cities. However, with the CATbus, Tiger Transit, and shuttles from the apartment complexes, the need for students to drive to campus is decreasing. The auditors view this as a very important step to decreasing the number of cars that come to campus every day.

In conclusion, the auditors feel that Parking and Transportation Services has made a tremendous effort to incorporate sustainability into their long-term planning goals. They have effectively implemented programs that help to decrease the vehicular traffic on campus even as the university continues to grow. Parking and Transportation Services has taken a major step towards creating a sustainable transportation program, but there is always room for improvement. It is important for Parking and Transportation Services and CATbus to continue to place sustainability at the forefront of future plans.

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Pesticides and Grounds Management

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Executive Summary

Much of Clemson University's 1400-acre campus is managed by the Landscape Services department. This department applies nitrogen-based fertilizer four times a year to about 15% of the grounds, mostly high visibility areas such as Bowman Field. Insecticides and herbicides are applied on an as-needed basis. Glyphosate, a weed killer, accounts for about 95% of the pesticides used on campus. Landscape Services purchases about 90 gallons of glyphosate a year, and it applies the chemical in a low range of a few gallons a month to a peak of thirty gallons a month, mostly during the peak growth months between May and September. The University has been combatting numerous invasive species in the Hunnicutt Creek watershed by using grazing goats and some herbicides. Over the past 10 years or so, Clemson implemented a successful wildlife contraceptive program to eliminate damage to campus trees caused by the eastern gray squirrel. About 95% of the trees removed from campus in recent years were due to construction. The other 5% were removed as safety precautions. Rather than attempt to replace lost trees on a tree-for-tree basis, the University opts for planting trees that produce a larger canopy. Off the main campus, the University manages the 17,500-acre, financially self-sustaining Clemson Experimental Forest. The Forest produces about 4.5 million board-feet of times annually, but the University strives for sustainability by harvesting just 2.5 million board-feet a year on average.

Introduction

The Pesticides and Grounds Management chapter of the 2019 Clemson University Environmental Audit examines several important land management topics, including the use of chemicals on campus grounds, prescribed grazing as a means of brush management, a recent study on squirrel population management. The prescribed grazing project and the squirrel management study were both initiated several years ago, and this audit provides feedback and results from those projects. The audit also overviews the environmental benefits of Clemson University's experimental forest, and the challenges of its management. The chapter will be concluded with the auditing students' recommendations.

Chemicals

Clemson University's 1400-acre campus is maintained through the hard work of their landscaping services. The primary fertilizer applied on Clemson's campus is a nitrogen-based fertilizer. Thomas Suttles, head of Energy Conservation, said the "total nitrogen levels are in the low to medium range on all discharges, with the athletic fields being in the medium range due to higher maintenance." Four times a year 15% of Clemson's campus is fertilized, typically in high visibility areas such as Bowman field.

Pesticides are applied on an as-needed basis to keep chemical application to a minimal amount. The insecticides used include Zenith 75 WSP and Ground Assault, and herbicides used include Eraser, Eraser A/P, Weeder 65, Tordon 101, Reward, Zenith 75 WSP, Ground Assault, and glyphosate. Glyphosate currently comprises 95% of the pesticides use on campus, and in 2016, the department purchased a total of 90 gallons of glyphosate. According to Fallaw, the amount of glyphosate purchased has stayed consistent for the last decade, and the department follows the product's label recommendations. Glyphosate's active ingredient is glyphosate, a non-selective herbicide. For herbicides, being non-selective means that the chemical will kill most vegetation in the applied area. On campus, glyphosate is, for the most part, strictly used to kill weeds, and usage can reach approximately thirty gallons per month; peak months include those from May to September while the other months average less than four gallons per month. At any given time, the department keeps an inventory ranging from five to thirty gallons, and a new thirty-gallon barrel is purchased when less than five gallons remain. The other previously mentioned pesticides were used for the preparation of the Clemson Experimental Forest.

Invasive Species and Goats

Clemson utilizes both grazing of goats and application of herbicides as methods for removing invasive species, which would otherwise inhibit natural growth. Most of the invasive species found on campus are plants such as Carolina Silverthorn, Kudzu, English Ivy, Chinese Privet, Japanese Honeysuckle, Japanese Stiltgrass, and Mondo Grass. These species are commonly found in the Hunnicutt Creek watershed that runs through the south part of Clemson's campus and the South Carolina Botanical Garden. In this area, 90% of the shrub and herb layer consists of these invasive species. Even though the most common solution is to apply herbicides, it is a laborious task that poses potential hazards to both humans and the environment. Donald L. Hagan stated: "While potentially effective, such a method comes with a high risk of off-target effects due to overspray and chemical volatilization."

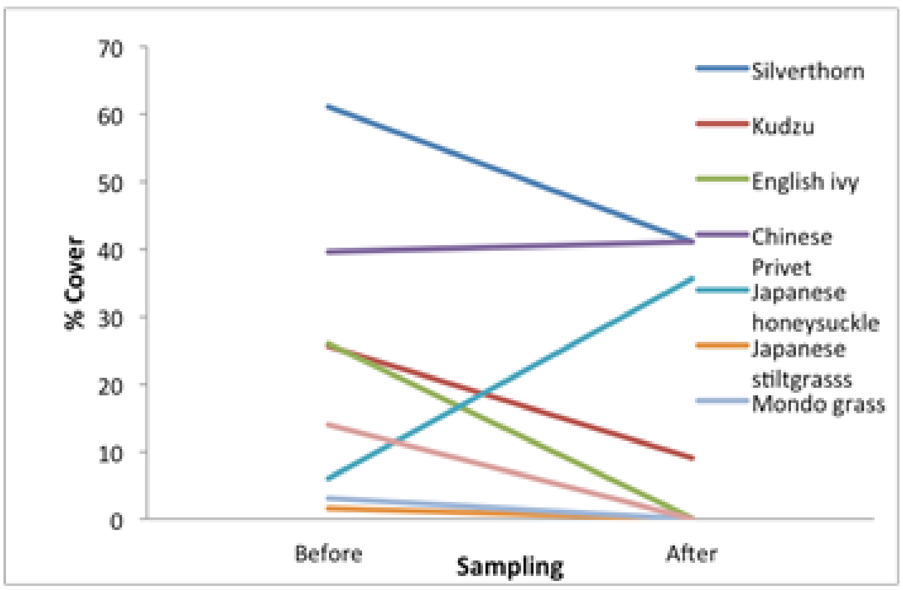

Figure PG 1: Comparison of plant cover before and immediately after goat deployment

Clemson looked to prescribed grazing with goats as a solution to driving back these invasive species. Prescribed grazing utilizes domesticated livestock to accomplish a vegetation management goal, which is typically used to control invasive species. Calvin B. Sawyer and his associates, Dr. Hagan and Jeremy W. Pike, utilized this practice with goats to remove invasive species in the Hunnicutt Creek watershed between August 30 and October 26, 2014. This test evaluated "the effectiveness of prescribed grazing by goats on a 4.7 acre tract" (Sawyer). Over these 56 days, the participating faculty and students found that most of the invasive species were reduced as depicted in *Figure PG 1*. Sawyer speculates that the increase of Japanese Honeysuckle "was due to resprouting from increased exposure to sunlight."

Approaches that are currently used on campus to combat invasive plants were developed based on the results of this test. The first step in the procedure is to allow the goats “to devour the leaves and stems of the plant, clearing out most of the dense foliage and making the area more accessible to humans” (Melvin, 2015). Next, volunteers chop down most of the remaining foliage. Finally, faculty “finished the job by strategically applying herbicide on stumps and other remnants” (Melvin, 2015). The main drawback of prescribed grazing is the risk of water pollution and sediment buildup due to the goats’ waste. However, this slight risk is eclipsed by the more prominent considerations of excessive herbicide use and personnel injuries. This approach of using prescribed grazing and herbicide application continues to prove effective as the amount of invasive species dwindles.

Squirrels

Ten years ago, the population of eastern gray squirrels on the Clemson campus reached excessive levels. An overpopulation of squirrels causes damage to trees and in 2008 it was discovered that over 100 trees had been damaged by squirrels on Clemson property. In order to prevent this damage from continuing, Greg Yarrow, Clemson Wildlife and Fisheries professor and former chair of Clemson’s Wildlife and Fisheries Biology division, initiated a project that studied the effectiveness of wildlife contraceptives as a means of squirrel population control.

The two types of contraceptives considered for the project were GonaCan and Diazacon. The initial choice, GonaCan, is an injected contraceptive that reduces the body’s ability to release reproductive hormones. GonaCan was found to be an effective but challenging solution because of the cost and issues with delivery. As an alternative, the oral bait Diazacon was selected as the contraceptive of choice. Diazacon mimics cholesterol and thus reduces the natural production of cholesterol in a squirrel. Since cholesterol is related to reproductive hormones, a Diazacon side effect inhibits reproductive hormones (“Wildlife Contraceptives,” 2010). The drug was originally given to humans in the 1950s for cholesterol reduction but was discontinued due to the effects on reproduction. It was later found to be useful in managing populations of various birds and mammals such as blackbirds, prairie dogs, and grey squirrels (“Wildlife Contraceptives,” 2010). Diazacon has been found to be both effective and economical for the purposes of the squirrel project at Clemson.

The procedure for the squirrel population control project involved various stages and components. First, the treatment group and a control group were selected by designating a zone of the campus grounds for each group. Next, feeding hoppers had to be specially designed to ensure that only the target species could receive the treatment. The hoppers were redesigned multiple times, and they are currently on their third iteration. Once the hoppers were designed and constructed, they were placed in each of the treatment areas. After the squirrels ate the bait, they were trapped individually to receive blood testing and then released back into their zones. The bait was administered along with rhodamine B dye, which aids in identifying treated squirrels because it becomes visible as a bright pink color in their whiskers under fluorescent light.

In the first year of the study, squirrels were treated every month. After that, treatments were reduced to twice a year in April and November according to their mating seasons.

According to observations, the project was successful due to the safe, humane solution that was applied to sample groups; the project also produced a substantial, but not excessive, reduction in the group populations that received treatment. Observers have noticed fewer squirrels and less tree damage in the treatment areas. These results support the conclusion that the expansion of the project to the entirety of Clemson's campus would produce a similar outcome.

Trees

A selection of trees on campus have been removed and replanted due the degradation of older trees and intensive construction from the past few years. According to the University's Landscaping Services Department, 95% of the trees removed from campus in recent years were construction related and the other 5% were removed for safety precautions. A database that contains the amount, location, species, height, crown cover, and condition of trees was updated in 2018 when new inventory software was introduced. The replanting policy is not based on a tree-for-tree basis, rather the tree canopy is the area of focus. The canopy is affected by the species of the tree planted; trees that produce a larger canopy are planted over trees that produce smaller canopies. Clemson expects that more trees will be planted than removed due to construction.

Experimental Forest

The experimental forest managed by Clemson University comprises 17,500 acres of the Southern Appalachian Foothills. Before being granted to Clemson University, the land had been neglected for decades. Heavy harvesting, erosion from intensive farming, and bombardments from military practice bombings drastically reduced the production of the forest. Clemson began managing the experimental forest in 1939, and through many decades of responsible management, the forest has been restored and is now used for educational, commercial, and research purposes.

The forest consists of eight ecological areas: pine, hardwood, pine-hardwood mix, hardwood upland, bottomland, plantation cove, water, and recreation. Plantation represents the highest portion of the forest with 6,646.1 acres. Hardwood Upland is second with 3,133.9 acres. Pine-hardwood mix, is the third largest area with 2,270.4 acres (*Figure PG 2*).

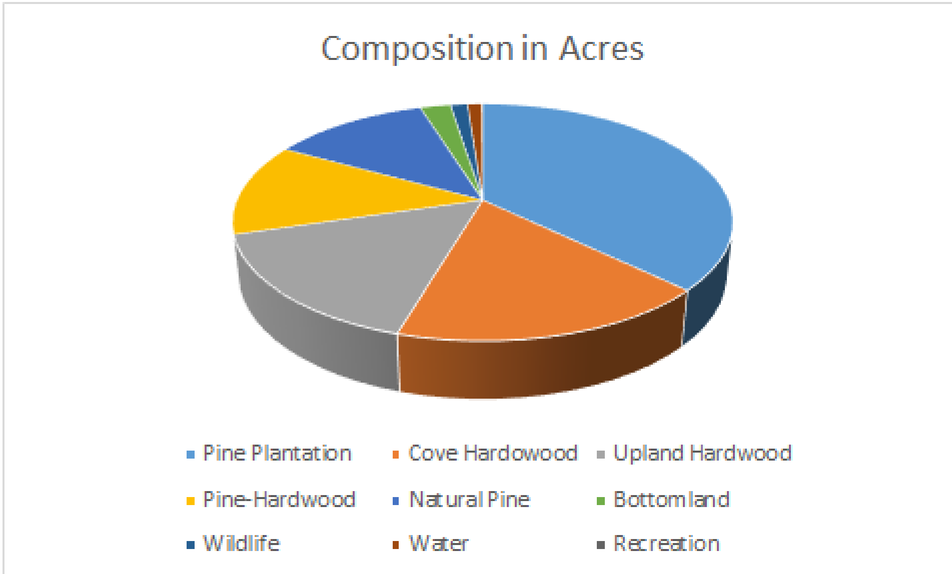

Figure PG 2: Composition of different stand types in the experimental forest by acres

Under the Land Utilization Program, board-feet per acre in the experimental forest increased from 2,225 board-feet per acre to 4,500 board-feet per acre from 1936 to 1958. The Continuous Forest Inventory (CFI) system, established in 1961, has continued with five-year measurement intervals. As of 2011, the board-feet per acre has increased substantially to 7,289 board-feet per acre. This increased forest area has become instrumental in preventing further erosion of the soil, providing adequate habitat, and optimal research/teaching opportunities. The amount of timber harvested in the past few years has decreased due to a fall in the market. The figures below show the amount of timber in cords and board feet harvested from 1667 to 2011 ("Management Planning," 2013).

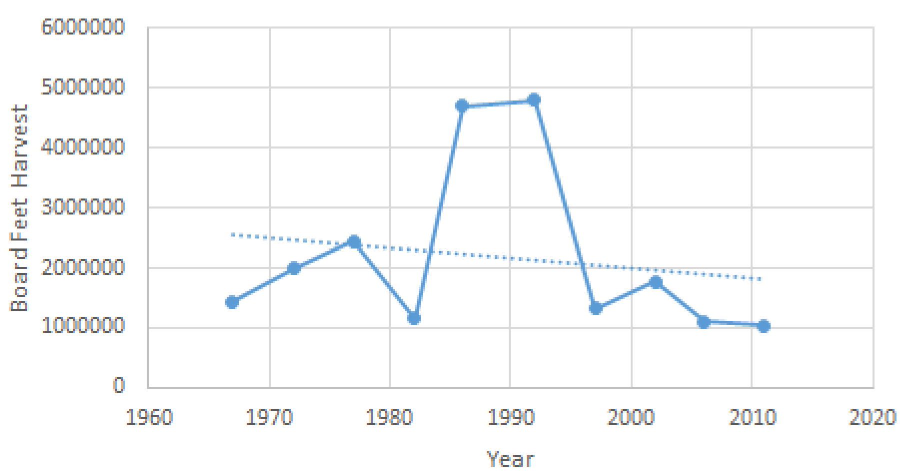

Figure PG 3: Annual board feet of timber harvested

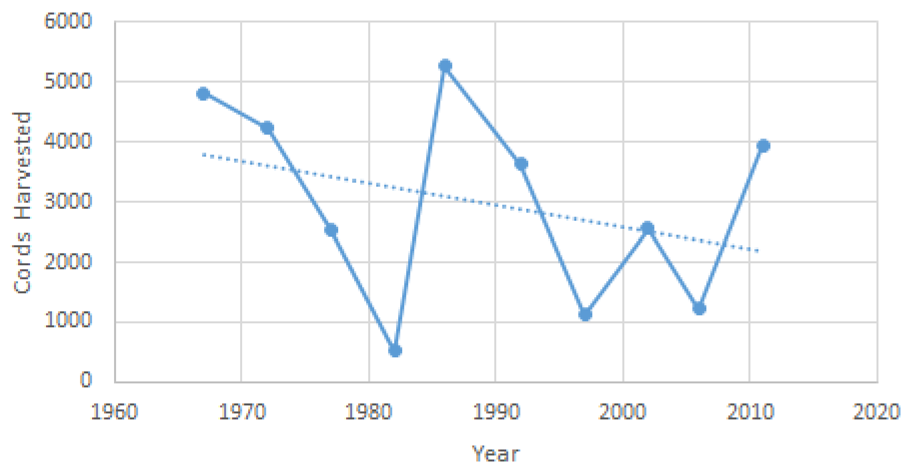

Figure PG 4: Annual cords harvested

Clemson has faced several challenges since taking over management of the forest. The southern pine beetle has been thwarting the growth of pine stands in recent decades. These outbreaks can be detained through cutting and burning portions of the forest that are affected by the beetle. In addition, invasive species from Asia and Europe have taken root in the forest and have become a huge problem. Many of our natural understory species that lie below the canopy have been outcompeted by invasive species such as Chinese Privet, Carolina Silverthorn, Kudzu, Bradford Pear, etc.

The forest is financially self-sustaining. While the Experiment Forest produces approximately 4.5 million board-feet annually, an average of 2 million board-feet are sustainably harvested each year. This annual harvest produces revenue that is the primary funding for salaries, equipment purchases, reforestation expenses, and other land management practices ("Management Planning," 2013).

The Clemson Experimental Forest is certified under the Sustainable Forestry Initiative (SFI). The SFI is forestry's commitment that future generations will have the same abundant and healthy forests that we now enjoy. It is a system of principles, guidelines, and performance measures that integrate the perpetual growing and harvesting of trees with the protection of wildlife, plants, soil, and water. Using sustainable forestry practices also includes recognizing lands that have special ecological, geographic, or historic value and pledging that these places will be managed to protect their unique qualities for the benefit of all citizens.

Students' Perspective

Clemson has made numerous initiatives in recent years to preserve the environment, and the projects mentioned above are manifestations of those initiatives. The goat project and squirrel project are both great ways to improve the campus grounds by the best means available, and the projects have grown through their implementation.

The Landscape Services staff was very helpful in discussing the grounds procedures and current state, and they provided several contacts by which information on specific topics was obtained. The audit team did have difficulty obtaining hard data on several topics, but with continued questioning, some data was able to be obtained. Due to the constant changes around campus in recent years, it is understandable to an extent that the department has not been able to keep the GIS file up to date.

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Russell Alan Hardee, Forest Manager, Clemson Experimental Forest, Clemson Public Service and Agriculture

Calvin Sawyer, Associate Professor, Clemson University Agricultural Sciences Department

Thomas Suttles, Energy Conservation Manager, Clemson University Utility Services

Dave VanDeventer, Recycling Services Manager, Clemson University Facilities

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Procurement

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Executive Summary

The Procurement chapter of the Clemson University Environmental Audit serves as an overview of the Procurement Department and its activities, including data on purchasing software, budgets, vendors, spending activity, and undergraduate student perspectives on the effectiveness of sustainable spending.

This Audit found that the University's top five vendors (Holder Construction Group, Turner Construction Company, Whiting-Turner Contracting Group, Aramark Catering, and DPR Construction) received various degrees of recognition for their sustainability practices; however, these recognitions are not objectively comparable. The Clemson University Procurement Department is responsible for allocating monetary resources to purchase goods and services in a sustainable manner by choosing green vendors whenever possible. This department is also responsible for curating and communicating policies that serve as guidelines for the way Clemson University acquires goods and services. The Procurement Department gives university departments flexibility when making purchases under $2,500 by not requiring approval, but any purchases above that amount must be reviewed and approved by the Procurement Department. The spending caps mentioned in this chapter are the only guidelines set forth for the Procurement Department, meaning efforts towards sustainable purchasing are often up to the integrity of those in the department and are not regulated.

The Procurement Department strives to encourage and facilitate green spending on purchases such as environmentally friendly products, products made with recycled content, low energy appliances, and products made by companies with the mission of sustainability. As Clemson's purchasing moves in a more sustainable direction, it will hopefully encourage vendors to adopt more environmentally sustainable practices to retain their business. Environmentally friendly practices generate good publicity for the university both at the personal and state level and increase students' awareness of their impact on the environment.

Introduction

The Clemson University Procurement Department is responsible for all purchases made with university funds, including the creation and alteration of contracts that are held by the university with outside vendors. The Procurement Department's main method for improving the environmental impact of campus operations is through policy that is preferential towards sustainable suppliers; however, there is currently no method of quantifying the environmental impact of a supplier. Additionally, the green purchasing policy is voluntary, so it's up to individual departments whether or not they choose to keep sustainability in mind when buying many products.

To assess the actions of the Procurement Department, the Environmental Audit will analyze Clemson's public financial records to determine their most significant suppliers. These suppliers will then be evaluated to determine the nature of the environmental impact of Clemson University's Procurement Department.

Policy

Clemson's Procurement Department is responsible for creating and communicating policies that define the way Clemson University acquires goods and services. The cheapest method for acquiring goods is not always the most sustainable method so this requires the Procurement Department to find a balance between being environmentally conscious and cost effective (Szymankiewicz, 1993).

At Clemson University, the Procurement Department oversees thousands of purchases every year, ranging from construction contracts to office supplies to travel expenses. To accommodate this volume, the department allows any purchases under $2,500 to be made without oversight (Nebesky, 2017). Purchases between $2,500 and $1 million must be competitively bid through the Procurement Department and purchases over $1 million must be filed through the South Carolina Materials Management Office ("Welcome to Procurement," 2019).

Environmentally conscious procurement is a topic of emerging relevance; there are few federal and state laws governing the practice, but it is becoming more pertinent to companies. The current sustainable procurement policies, created in 2008, are guidelines rather than laws. These policies include purchasing guidelines for sustainable products and the procedures through which the university can obtain those products and services ("Policies, Procedures and Guidelines," 2019).

Data on Purchases

Clemson University provides public data about their spending habits for all university purchases. Of the companies that receive Clemson's business, many have environmental practices that have received national recognition in the form of awards and public rankings.

TranSpend

Clemson University maintains a website called "TranSpend," Clemson University Transparency Spending, which contains a record of every university purchase beginning in 2014 ("Spending Transparency," 2019). Each entry in the TranSpend system contains the purchase ID number, purchase price, recipient of the funds, date the transaction was made, category of spending, and type of spending within that category.

The spring 2017 auditing team accessed over 20,000 purchase ID's in TranSpend, extracting all available purchase records from 2014 to April 3, 2017. This was done by combining the resulting files into one file and then carefully formatting it for usability using Bash scripts and a program written in C++. The Bash scripts filtered the data by vendor, as well as homogenized the vendor field in the data records. Then a program in Java produced a list of all the vendors on TranSpend along with the net amount paid to each one.

Clemson made 1,011,267 purchases between 2014 and 2017, totaling over $1.45 billion. The median purchase amount was $84.29 and the mean purchase amount was $1,450.85, indicating that a majority of the funds being spent by Clemson are on purchases that are not required to be processed by the Procurement Department. Note that the department only processes purchases of $2,500 or more.

Vendors

There are over 70,000 different vendors listed on the TranSpend spending website. Investigating the environmental practices of each would be beyond the scope of this audit. However, the five largest vendors by purchase amount received over 28% of Clemson's spending in the past four years. Four of the top five vendors are construction or contracting companies, and the other is Aramark as shown in Figure PR 1.

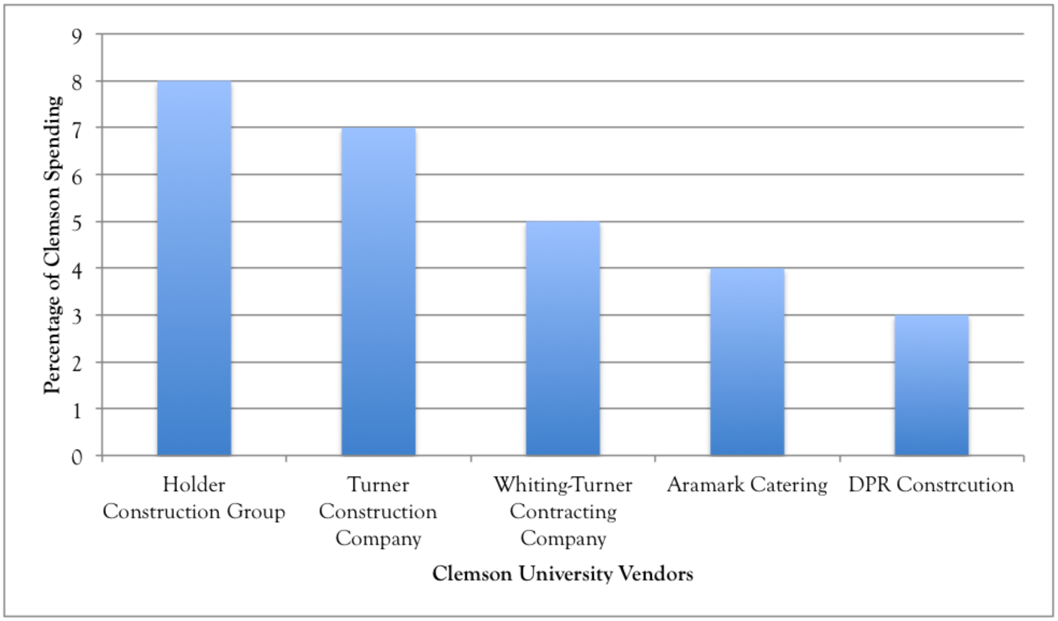

Figure PR 1: Clemson University Largest Vendors by Spending

In fall 2017, Holder Construction Group was the top receiver of funds listed on TranSpend, representing approximately 8.3% of the University's net expenditures ("Spending Transparency," 2019). It garnered the 10th spot on the *Engineering News-Record*'s list of the 2016 Top 100 Green Building Contractors ("The 2016 Top 100"). Holder jumped to the 10th spot in 2016 from the 19th spot in the magazine's 2015 list, evidence that the company was achieving more sustainability in its operations.

In 2017, Turner Construction Company was second from the top in TranSpend and represented approximately 7.4% of net expenditures ("Spending Transparency," 2019). The company was number one on the *Engineering News-Record*'s list of the 2016 Top 100 Green Building Contractors ("The 2016 Top 100"). Turner produces a biennial public report on its own sustainability, and actively seeks out Leadership in Energy and Environmental Design (LEED) accreditation and certification ("Sustainability," 2019). The company asserts that in the past 15 years it has completed more than 1,200 green building projects and diverted three million tons of construction waste from landfills. It also has a goal of reducing the greenhouse gas emissions and water consumption of its onsite construction operations by 50 percent by 2030.

The Whiting-Turner Contracting Company was third from the top in TranSpend in 2017 and represented approximately 5.3% of the net expenditures ("Spending Transparency," 2019). In 2016, this company was 7th on the *Engineering News-Record*'s list of the Top 100 Green Building Contractors ("The 2016 Top 100"). Whiting-Turner has more than 300 professionals "accredited in various third-party sustainability programs and more than 400 projects certified in more than 10 different third-party sustainability certification." Its green programs include LEED, Net zero/zero energy, Living Building Challenge, and Enterprise Green Communities, among others ("Sustainability: Building for the Future," 2019).

Aramark was the fourth largest vendor by spending for Clemson in 2017 and represented approximately 3.9% of the net expenditures ("Spending Transparency," 2019). The company currently has a 15-year contract with Clemson as a food and services provider and claims to have a strong corporate focus on waste minimization and sustainability ("Environmental Sustainability," 2019). Aramark received the 2015 Sustainability Partner Award from Citi ("Aramark Awarded," 2016), and it's listed as a Food Loss and Waste 2030 Champion by the U.S. Environmental Protection Agency ("United States Food Loss," 2019).

In 2017, DPR Construction was ranked 5th in spending on TranSpend and represented approximately 3.1% of the net expenditure ("Spending Transparency," 2019). In 2016, it held the 21st spot on the *Engineering News-Record*'s list of the Top 100 Green Building Contractors ("The 2016 Top 100"). DPR seeks to achieve net-zero energy use in all their office buildings and has built four International Living Future Institute (ILFI) net-zero certified projects ("Sustainable Construction," 2019).

Other Green Vendors

In addition to the top five vendors, who collectively make up 28% of the university's spending, Clemson has employed various other companies with environmentally-focused policies. Most notable of these organizations are Barnes and Noble and RICOH.

Although all the Barnes and Noble services are not available in the Clemson location, the company works to be sustainable in all endeavors. In their food consumption department, they promote reusable travel mugs, sell organic foods, and use ceramic cups and plates. They plan, document, and employ their green building practices, use paperless manuals, and sell recycled notebooks. Travel-wise, they also use fuel-efficient company cars.

RICOH holds a contract with Clemson that will last five years at a minimum. They were awarded this contract through the request for proposal method. In the past Clemson had multiple contracts with different vendors to fulfill their networking and printing needs. Clemson found that only having one company/contract for all their needs with networking and printing has saved them time and resources. Their carbon footprint has decreased due to the consistent support system and by using less non-renewable resources.

Students' Perspective

While the above companies exhibit strong environmental practices, they still only receive 28% of the funds spent at Clemson. The Procurement Department provides an online system called BuyWays which allows faculty and staff to easily purchase supplies from the Procurement Department's recommended vendors. Future audits should still evaluate the data logged in BuyWays and TranSpend in order to the track the financial behavior of Clemson University. However, it is worth noting that TranSpend does not contain information that is pertinent to the ecological impact of Clemson University's spending habits.

The records on TranSpend are not kept permanently. This makes it difficult to analyze changes in spending over long periods of time and makes it more difficult to demonstrate long-term progress towards the goal of environmental friendliness. It is our opinion that TranSpend records should be kept indefinitely. This would not require a large investment of resources and would make it possible to analyze trends in University spending over a long period. To this end, TranSpend could also maintain statistics on the data in its records.

The records on TranSpend do not identify green purchases. This means that data analysis on these records cannot give direct information on green spending. Rather, we must analyze the vendors Clemson chooses to pay. Perhaps TranSpend should add a data field for eco-friendliness, and those filling out purchase records may mark that field as environmentally sustainable if the purchase is either a designated green product or meets a short checklist of requirements.

The Procurement Department has a list of environmental sustainability guidelines for making purchases, but these guidelines are not enforced. Further, it is impossible to enforce such guidelines, as most purchases made at Clemson do not require approval from the Procurement Department. We do not recommend that the University attempt to enforce these guidelines. Rather, we recommend that these guidelines be well advertised to those making purchases, and that Clemson choose their procurement contracts and the suppliers listed in the BuyWays program based on eco-friendliness to make green purchases easier.

As Clemson students, we appreciate the University trying to practice sustainability. Being such a large institution, there are plenty of opportunities to cut corners and choose the cheapest options that may not be as environmentally conscious. As the university continues to grow, sustainability is becoming more necessary than ever. Ensuring that Clemson employs environmentally sustainable vendors is a step in the right direction towards continued sustainability.

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Radioactive Waste

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Executive Summary

Clemson generally experiments with low risk radioactive substances that have little potential to cause harm to the environment. The most commonly used radioactive substances at Clemson are transuranic elements. The main producer of these substances is Innovation Campus and Technology Park, home to many of Clemson's research laboratories. Among these is the Clemson Engineering Technologies Laboratory, where students and researchers explore new usages for materials and the benefits they may introduce. Combined, Clemson's colleges and research centers typically create less than 1,000 pounds of radioactive waste per year. The University's Research Safety Department is responsible for properly handling radioactive waste. Researchers themselves cannot dispose of the waste. There are different forms of radioactive waste, including liquid waste, either aqueous or mixed, and dry waste. Each of the forms of radioactive waste is collected in different amounts and must be handled separately; each poses different challenges to dispose of, but the Research Safety Department properly handles and disposes of them all.

Introduction

Radioactive matter is classified by the emission of radiation, an environmentally hazardous form of energy. Clemson generally experiments with low risk radioactive substances that have little potential to cause harm to the environment. The main producer of radioactive waste at Clemson University is the Innovation Campus and Technology Park, home to many of Clemson's research laboratories. Among these is the Clemson Engineering Technologies Laboratory, where students and researchers explore new usages for materials and the benefits they may introduce. Combined, Clemson's colleges and research centers typically create less than 1,000 pounds of radioactive waste per year.

Clemson's Research Safety Department is responsible for properly handling radioactive waste. Researchers themselves cannot dispose of the waste. There are different forms of radioactive waste, including liquid waste, either aqueous or mixed, and dry waste. Each of the forms of radioactive waste is collected in different amounts and must be handled separately; each poses different challenges to dispose of, but the Research Safety Department properly handles and disposes of them all.

This chapter of the Environmental Audit will outline the sources of radioactive waste production at Clemson. Following that, we will examine the federal, state and university level regulations that guide the radioactive waste treatment and disposal in the *Safety* section. The auditors' recommendations will close this chapter.

Waste Production

All of the radioactive waste produced at Clemson University can be attributed to the university's drive to be on the forefront of innovative research projects. Only a small percentage of Clemson's research groups utilize radioactive material, so the groups that do are highly specialized in their respective fields and focused on groundbreaking analysis and discovery. Clemson University research centers that experiment with radioactive materials are highly regarded for their research in medicine, clean energy, and many other improvements with global applications, so the Research Safety Department does not limit the amount of radioactive waste being produced.

The Environmental Engineering and Earth Sciences (EE&ES) Departments, as well as the Biology and Genetics Departments, are two of several departments that create radioactive waste. Of these two, the Environmental Engineering and Earth Sciences Department produces the majority. Almost all research in EE&ES that utilizes radioisotopes is conducted at the L.G. Rich Laboratory and the Clemson Environmental Technologies Laboratories, which are both part of the Innovation Campus and Technology Park in Anderson, SC (a Clemson Innovation Campus). This site is used by a few graduate student research groups, and also houses the *Radionuclide Waste Disposal: Development of Multi-scale Experimental and Modeling Capabilities* project. It is conducted by a cross-university team and funded by the Department of Energy.

Clemson University is working to improve their disposal of radioactive waste. This is because the research being conducted requires radioactive material, which is necessary for understanding the uses and effects of radioactive particles. For example, the *Radionuclide Waste Disposal* project is devoted to analyzing the effects of radioactive material on the environment and developing a modeling system for the particles and their path in the ecosystem. Other projects use radioactive material as a tool in their research, such as the Genetics Department's use of radioactive isotopes in DNA sequencing and analysis.

As new projects are approved, and old projects are concluded, Clemson University's radioactive waste production fluctuates. There is no steady demand by researchers for any specific radioactive materials, so there is not a steady production of particular types or quantities of radioactive waste. As previously mentioned, Clemson University's possession of a broad scope license allows it to procure and utilize a wide variety of radioactive isotopes. This range encompasses all isotopes that are available on the open market. In total, there are over 1000 known isotopes, around 264 of which are stable, and the remainder are radioactive. The Environmental Engineering and Earth Sciences Department only uses around twenty to thirty at any given time.

These isotopes used at Clemson are not a part of the final product of the research. Since the research is aimed at collecting data, all of the radioactive isotopes used become waste—not only the isotopes, but also anything the isotopes may have come into contact with. In the case of the Environmental Engineering projects, soil and water samples are contaminated with the radioactive material. In every department, though, gloves, paper towels, vials, and other containers become radioactive waste. These are examples of dry waste, which is a category that has the largest opportunity for minimization of waste. Those materials are not directly necessary for obtaining the research data, so it is important to explore ways to reduce this production.

Table RW 1: Radioactive Waste Disposal Shipment on Aug. 19, 2014 (Taken over 15 months)

Shipment 1	
Waste Type	Quantity
Dry	1100 lb
Liquid	0 gal
Mixed (+Toxic waste)	0 gal

Table RW 2: Radioactive Waste Disposal Shipment on Oct. 7, 2015 (Taken over 15 months)

Shipment 2	
Waste Type	Quantity
Dry	613 lb
non-RCRA Scintillation Vials	267 lb
Exempt Scintillation Vials	30 gal
Mixed (+Hazardous waste)	30 gal

The details of the radioactive waste disposal shipments can be seen in *Table RW 1* and *Table RW 2*. These shipments display how Clemson's radioactive waste changes yearly, depending on the projects. The dry waste produced almost doubled from 2014 to 2015. The mixed waste, a combination of radioactive and hazardous waste, remained about the same, but it is a relatively small quantity. It is the most expensive to dispose of so its quantity is always actively minimized.

Safety

Federal Regulations

The U.S. Nuclear Regulatory Commission (NRC) and the South Carolina Department of Health and Environmental Control (DHEC) allow facilities to obtain licenses to use nuclear material within their states; Clemson, however, is independent of the NRC. These licenses are meant to ensure the safety of the individuals in contact with the nuclear material, the safety of the population that may come into contact with the waste material, and the environment. If the regulations put in place are not met, the license is revoked by an NRC officer and all nuclear material will be disposed of.

The NRC's Standards for Protection against Radiation states that a license shall remain valid so long as the "total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year" (§ 20.1301), which keeps potential risk of exposure to a minimal level; this ensures that individuals are not exposed to excessive amounts of radiation that would be harmful to their wellbeing. To protect the environment and the general public, rules on the disposal of nuclear material are made. According to section § 20.2003, licensed material may be discharged into sanitary sewerage if the material is soluble in water, the quantity of the material is not significant compared to the monthly water flow through the sewerage, and the quantity of radioactive material does not exceed approved quantities of hydrogen-3, carbon-14, and all other radioactive materials combined. Obtaining surveys on the radiation levels of individuals in restricted and unrestricted areas is the responsibility of the licensee (§ 20.1302). This means that it is Clemson's responsibility to obtain regular surveys of the radiation levels observed in individuals in contact with radioactive material and surveys on the amounts of waste disposed of (see table RW 3). This policy does not pertain solely to radioactive waste, but to any radioactive material in general.

As stated before, the NRC requires regular surveys be performed. The Radiation Safety Committee (RSC) abides by outlining multiple types of surveys that should be performed. The surveys from the Clemson Radiation Safety Manual are listed in *Table RW 3* below. It shows how surveys ensure the safety of the source users and general population of Clemson.

Table RW 3: Types of surveys performed, their frequency and subject

Type	**Frequency**	**Surveying**
Individual	Every time an individual leaves from working in an area with unsealed radioactive material	Themselves as they leave
"Use Survey"	At the end of the day that sources of radiation are used	The immediate work area
Weekly	Weekly any week that radioactive materials work is conducted	Lab space
Inventory	Intervals not to exceed six months	All radioactive materials possessed. (Quantities, Location, Date, and Individual's name)
Leak Check	Depends on the half-life of the material	Source leaks coming from stored radioactive materials.

State Regulations

DHEC has granted Clemson University a broad radioactive materials license authorizing the use of radioactive materials by approved University personnel. A broad radioactive materials license allows the use of many different radionuclides for a variety of tasks. It is the responsibility of the RSC to govern the use of the radioactive materials to ensure the safety of its students and employees and to ensure that NRC regulations are met.

The RSC and Radiation Safety Officer (RSO) approve Responsible Investigators (RI) to oversee the use of radioactive materials. These RI are legally responsible for the radioactive material in their sections and to oversee the use of all radioactive materials. In order to become a RI or to use any radioactive sources, a safety training classroom course must be completed.

Clemson Regulations

In addition to complying with all state and federal regulations, Clemson University also adheres to its own set of additional requirements. Clemson is dedicated to the safety of every one of its constituents as well as its surrounding community, so it has created these additional regulations in order to provide further insurance of this goal.

Everyone who works with radioactive material and waste at Clemson is required to go to radiation safety training. There are classroom training sessions at the beginning of every spring fall and summer semester. The classroom training sessions consist of lectures on radiation protection and procedures specific to Clemson's Radiation Protection Program. To become an authorized user, a score of 60 or higher is required on the final exam.

As long as the safety measures taught are followed, there is basically no way that anyone on Clemson's campus reaches the 0.1 rem allowed for a person per year. In our interview with Konstantin Povod we inquired what some of the risks associated with the radioactive waste may be. He responded: "Here at Clemson, none. We work with very low activities. If you compare to hospital's waste, [Clemson's waste] is significantly less dangerous." He goes on to explain that here in Clemson only low level radioactive materials are used and that the danger is not with the radioactive dosage. Those working with it are only exposed to about 1 mg or less of radioactive material. Instead it is far more likely that the materials would present a toxic or corrosive hazard. For this, extra safety measures are taken depending on the risk.

Storage and Disposal

Radioactive waste can be dangerous if not stored and disposed of properly. Half-life is an important characteristic of the material and is defined as the time it takes a radioactive substance to lose half of its radioactivity. Radioactive waste is separated into two categories: short half-life and long half-life; a short half-life is anything less than 65 days, and a long half-life is anything longer than 65 days. The rule for disposing radioactive material is that it can be disposed as non-radioactive after it has completed 10 half-lives; therefore, Clemson University holds onto the short half-life substances until they are no longer radioactive, saving money for disposal costs. The long half-life materials are separated immediately to be disposed of by a non-Clemson service.

Additionally, waste is organized by physical and chemical properties into these following categories:

- Dry Active Waste
- Liquid Waste
- Mixed Waste
- Sealed Sources

Dry active waste is made up of normal laboratory waste, such as, paper, plastic, absorbent coverings, towels, empty test tubes and syringes, culture dishes and other glassware. There is no free-standing liquids in dry active waste. Syringes and needles should be wrapped in puncture-proof containers and glass should be wrapped in heavy paper or cardboard before each are discarded into the dry waste cans, which are lined with thick poly bags (Clemson University, 2015).

Mixed waste is a mixture of radioactive and hazardous waste, and can be difficult for Clemson to handle, store, and dispose of. It is important to contact the RSO prior to starting research that creates mixed waste because typical radioactive disposal methods of crushing, compacting, and consolidation may not be compatible with the hazardous waste. Although the mass of mixed waste is less than the liquid or solid waste, it costs significantly more to dispose of.

Sealed Sources is radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal of the radioactive material under the most severe conditions which are likely to be encountered in normal use and handling (Clemson University, 2015).

Responsible investigators (RI) are in charge of projects containing radioactive waste and supervising authorized users while they work with radioactive material (Clemson University, 2015). RIs are responsible for reporting any incidents with the radioactive waste and storing radioactive material in a secure, lockable storage area. All radioactive waste containers are labeled with “Caution- Radioactive Material” or “Caution- Radioactive Waste.” Liquid containers have a positive-fitting cap, which is kept closed to prevent breakage or leakage. If a radioactive waste container is more than ¾ of the way full, it should be removed from the lab and brought to the radioactive waste storage facility. Before containers are removed from the lab they must have the date written on the container (Clemson University, 2015). Clemson stores radioactive waste in the Radioactive Safety Facility located on Lake Drive located near the processing plant.

Figure RW 1: An example of radioactive waste warning signs used at Clemson.

After Clemson's Radioactive Waste Department has accumulated a certain quantity of radioactive waste, it is shipped for disposal within a licensed radioactive waste broker.

Students' Perspective

Although Clemson University's radioactive waste procedures are in accordance with state and federal regulations, there is still room for improvement. Clemson handles a small amount of low-risk radioactive waste. If the radioactive waste department could find ways to make disposing radioactive waste more environmentally friendly, it would go along with the university's mission to reduce its environmental footprint. Since there have been no major spills on campus, we believe the Radioactive Waste Department is handling the waste properly.

During an interview with Brian Powell, the lead investigator of the *Radionuclide Waste Disposal* project, we learned that a large portion of the dry waste produced by Clemson research is not radioactive and could potentially be disposed of with normal waste. If a radioactive substance has any potential to be present on an object, such as a plastic glove that a researcher is wearing, it must be disposed of as radioactive waste. Powell said that these items could be scanned with a handheld device that detects radioactivity.

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Recycling

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Executive Summary

The Recycling Chapter of Clemson University Environmental Audit offers a deeper understanding of the many environmental efforts Clemson University has made since President Emeritus James Barker established the Clemson University Sustainability Commission in 2009. The Recycling Chapter provides various data and statistics from 2006 to 2017 regarding the improvements Clemson University has made by implementing new recycling efforts such as Solid Green, the Gameday Recycling Challenge, and increasing standards for construction and demolition partners.

In the 12-year period ending in 2017, Clemson University's municipal solid waste (MSW) recycling rate grew from 15.2% to 52.5%, an astounding 38% increase. On average, Clemson brings in about $70,000 to $80,000 annually from recycling rebates. Though the South Carolina Solid Waste Policy and Management Act of 1991 requires all institutions to have a recycling rate of 25-35%, Clemson University has met this benchmark every year since 2009. Additionally, Clemson University now requires all contractors to recycle a minimum of 75% of waste on all construction projects. In the ten-year stretch ending in 2017, there has been a 30% increase in Clemson's total waste stream recycling rate, with a maximum rate of 90% recycled in 2015. The total waste stream recycling rate includes construction and demolition.

Clemson University is making an effort to reduce the amount of landfill waste they produce due to the high rising costs of landfill fees and other costs associated with hauling debris to the landfill. Landfill fees were around $30 per ton in 2017, and the University averages about 3,500 tons a year. That amounts to over $100,000 a year, and that number does not account for related costs of hauling the waste to a landfill. By decreasing the amount of waste taken to landfills, and instead diverting recyclable material in the waste stream from landfills, Clemson University hopes to steadily lower their annual landfill expenses and reduce their overall environmental impact both on campus and in the community.

As Clemson University continues to expand and implement new construction projects such as Douthit Hills, the College of Business, and the new IPTAY Center, recycling rates will continue to increase due to the new recycling initiatives put into place with construction and demolition partners. Moreover, as student recycling initiatives continue to grow, more and more students will be involved in the larger goal to make Clemson University a sustainable campus.

Introduction

Because Clemson University continues to grow in both size and scope, it is integral for all organizations to understand their own environmental impact and what actions they can take to reduce the amount of waste they produce and improve the environment at Clemson University.

In the 12-year period ending in 2017, Clemson University's municipal solid waste (MSW) recycling rate grew from 15.2% to 52.5%, an astounding 38% increase, exceeding the 25-35% annual recycling percentage required by the South Carolina Solid Waste Policy and Management Act of 1991. This significant increase is primarily due to the food waste recycling initiatives in the dining facilities on campus, as well as the gameday recycling initiatives during the football season. This percentage is expected to increase even more in the coming years as programs expand and new initiatives develop.

This chapter will interpret the data available about Clemson University's solid waste management and the process's budgetary implications. It will also analyze in depth the recycling efforts Clemson has introduced, and provide suggestions that student auditors have generated to enhance Clemson's reputation as a sustainable campus.

Data and Statistics

The overall MSW recycling rate at Clemson University has increased steadily over the years. Since Clemson University is a state institution, it is governed by the South Carolina Solid Waste Policy and Management Act of 1991. This law requires all institutions to have a recycling rate of 25-35%, and Clemson University has met this benchmark every year since 2009. While this percentage does not account for construction and demolition waste, it does account for yard waste. Currently, Clemson University almost doubles the recycling rate required by law and recycles 100% of its yard waste through mulching. *Figure RC 1* displays the MSW recycling rate for each academic year over the past decade.

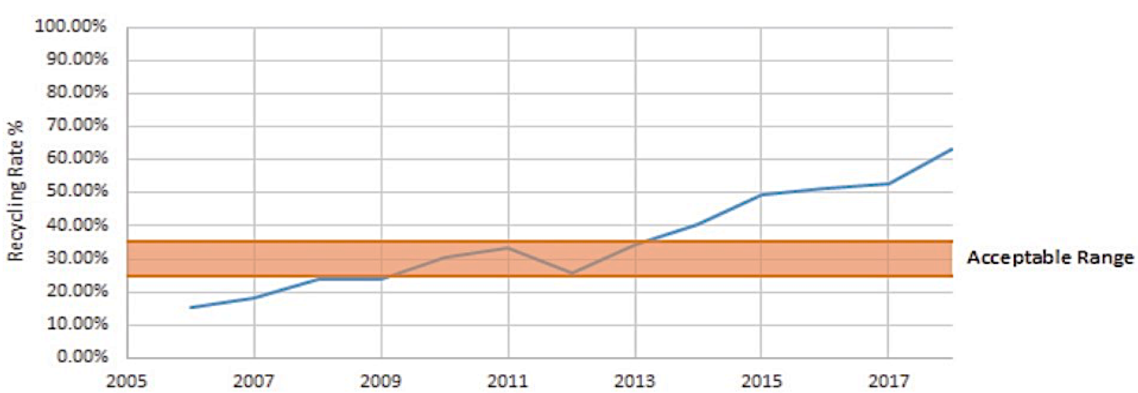

Figure RC 1: Clemson University MSW Recycling Rate

Even factoring in construction and demolition, the Clemson University recycling rate has steadily improved, as depicted in *Figure RC 2*. In the last 10 years, there has been a 30% increase in Clemson University's total waste stream recycling rate, with a maximum rate of 90% recycled in 2015. This amount fluctuates due to the amount of construction on campus, but the university still holds the construction companies they hire to a higher standard. Clemson University now requires all contractors to recycle a minimum of 75% of waste on all construction projects.

Figure RC 2: Clemson University total waste stream recycling rates by year including construction and demolition

The construction that took place in 2015 caused the total waste stream recycling rate to climb to a staggering 34,313 tons, compared to about 4,180 tons in the previous year. Similarly, in 2010, the total waste stream jumped to about 7,859 tons compared to 1,552 tons in the previous year, largely due to construction and demolition (C&D) recycling. These uncommon, large amounts of recycled waste skew the data for the Total Waste Stream over the last 10 years, as depicted in *Figure RC 3*.

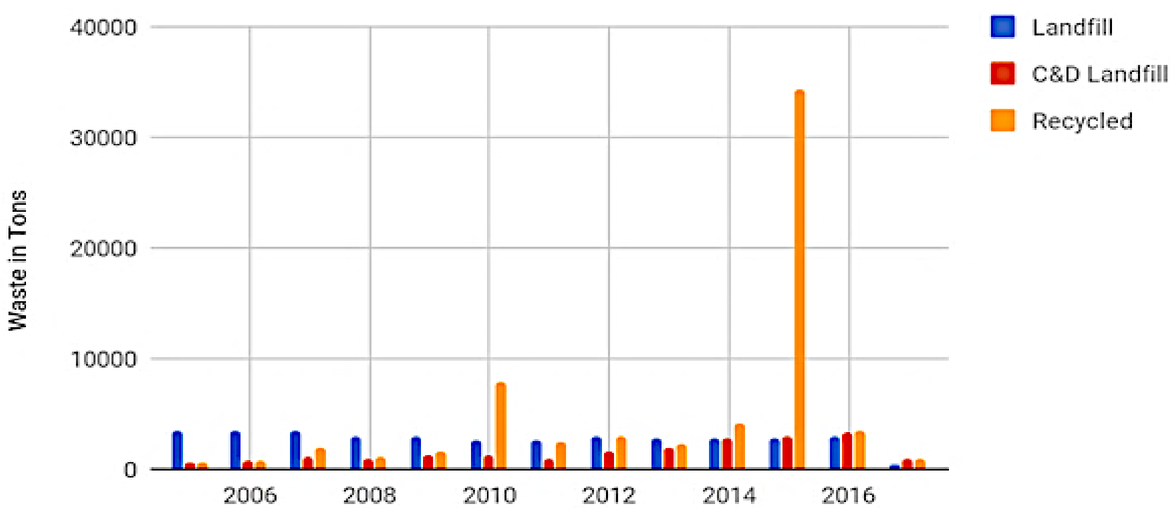

Figure RC 3: Breakdown of total waste stream history by year

Clemson University's Total Waste Stream history consists of three different parts: Recycled, MSW Landfill, and Construction and Demolition (C&D) Landfill. This breakdown of the waste stream, depicted in *Figure RC 4*, reveals that the majority of Clemson University's waste is recycled when considering this one year.

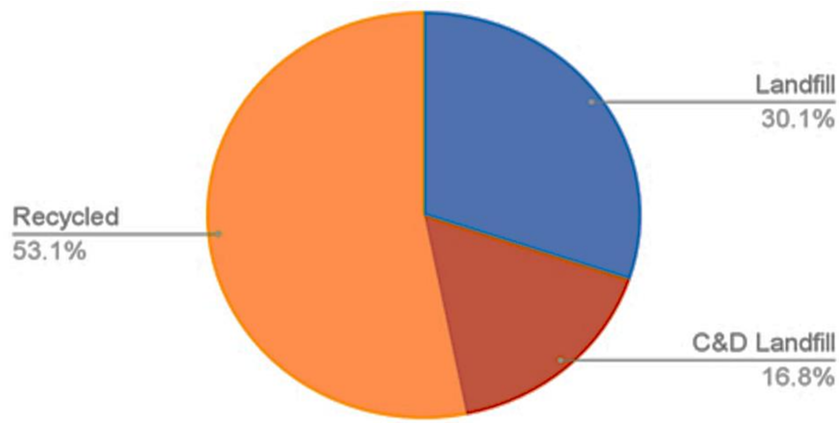

Figure RC 4: Total waste stream history (2016 - 2017)Budgetary Information

The steady decline in the cost of solid waste on Clemson University's campus, as seen below in *Figure RC 5,* is a subsequent result of the increased recycling rates. Implementing more recycling programs into Clemson University's existing initiatives will continue to decrease these costs. The budget for the waste stream falls under the Custodial Services budget of the university, and it is one of the larger expenses.

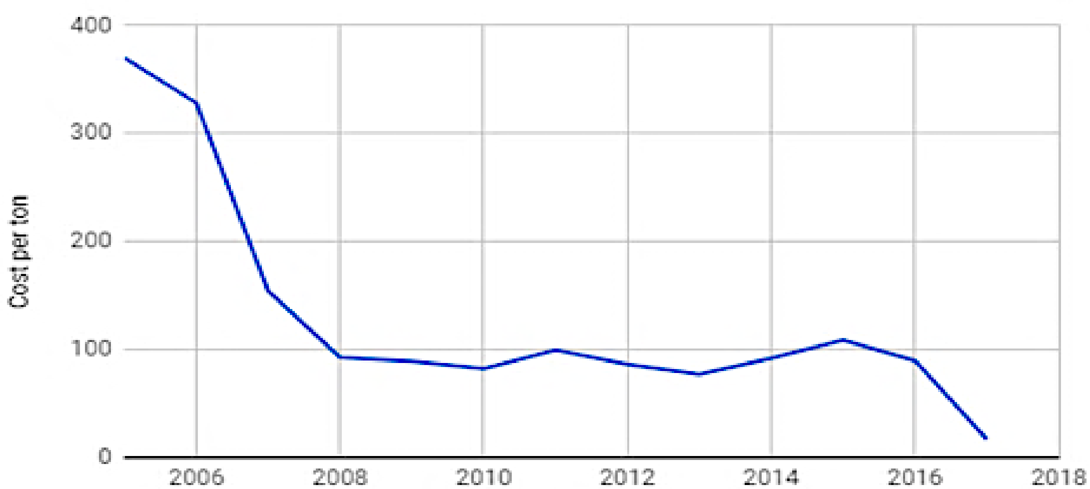

Figure RC 5: Cost per ton of solid waste

Recycling has the potential to save Clemson University an incredible amount of money. *Figure RC 6* displays the increasing recycling amount and declining landfill waste. By looking at the graph you can infer that higher amounts of solid waste mean higher costs. Therefore, less solid waste through an increase in recycling means lower costs. Hauling waste off to the landfill is an expensive process that costs Clemson University over a quarter of a million dollars each year. Landfill fees in 2017 clocked in at around $30 a ton, and over the past ten-year period ending in 2017, the university averaged upwards of 3500 tons a year. In addition to the cost per ton in landfill fees, there are hauling fees and other expenses that have to be paid in order to dispose of the university's waste. These costs greatly increase the cost per ton of waste. For example, the 2016 cost per ton averaged out to be $130.82 (VanDeventer, 2017). By contrast, it only costs Clemson University $89.64 per ton to recycle, which is about a 46% savings per ton.

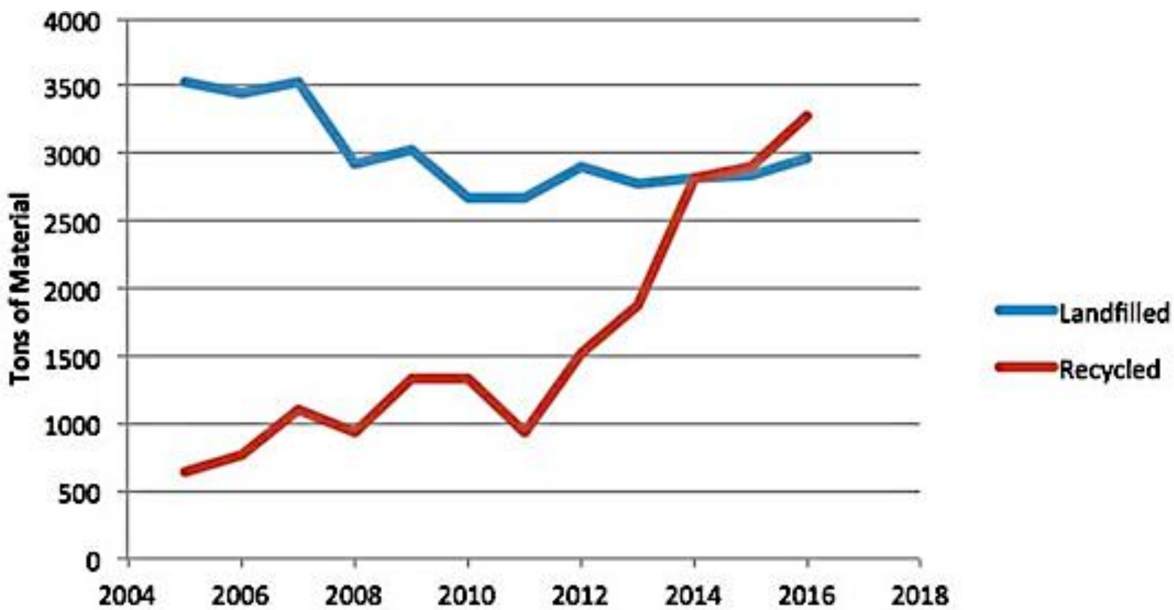

Figure RC 6: MSW recycling and landfill amounts in tons

In addition to saving the university money by reducing the amount of landfill waste, recycling can bring in additional revenue. Since part of the recycling revenue comes from plastics such as PET (polyethylene terephthalate) and PP (polypropylene), the cost of oil and fossil fuels dictate the selling rate of recycled materials. Additionally, the cost of transportation and running the machinery to recycle these products is factored into the total revenue, though these costs are minor, and these are also dictated by the price of fossil fuels. However, the majority of the recycling rebates come from paper and cardboard, which does not fluctuate with the petroleum market. On average, Clemson University brings in about $70,000 to $80,000 annually from recycling rebates.

Recycling Programs at Clemson

Clemson University's recycling program was first established in 1990. Since it was established in 1990, the recycling program has both increased the number of recyclable products as well as implemented various waste management strategies. A key component to the increase in recycling rates can be attributed to an increase in student awareness, along with improvements made at Clemson's Kite Hill Recycling Center. Kite Hill is considered a Materials Recovery Facility, or a facility that receives, separates, and prepares recyclable materials for other facilities. The Kite Hill Recycling Center is instrumental in establishing Clemson's reputation as one of the top recycling universities in South Carolina by helping increase overall recycling rates.

The cornerstone behind Clemson University's sustainability effort is the movement known as Solid Green. Solid Green, whose logo is illustrated below in *Figure RC 7*, is the sustainability brand for the university, which helps to identify sustainable practices such as energy, waste diversion, healthy campus, water, and social issues. On October 11, 2017, Clemson University held an annual Solid Green day event to raise awareness about littering, recycling, and other environmental issues. The day was a joint effort between students and staff at the university to join together and pick up trash and assist with the recycling process. Those who participate receive a free T-shirt or other incentives to help motivate them to participate and recycle as much as they can (Sikes, 2017).

Figure RC 7: Clemson University's logo for Solid Green

Clemson University has also begun participating in what is known as the Gameday Recycling Challenge. The Challenge requires a college or university to choose one home game of the season and attempt to collect as much recyclable waste from that day as they can. Football gamedays account for about 10% of the university's waste for the year. The potential for waste is huge; however, in 2014 Clemson University surpassed all expectations by winning the Gameday Recycling Challenge during our home game against our in-state rival, the University of South Carolina, and recycling almost 30 tons as seen below in *Figure RC 8* (Foley, 2015). By winning this challenge, Clemson beat 450 other colleges and universities across the nation, which is extremely impressive since we were competing against some universities nearly double our size.

Figure RC 8: Materials recycled on game day weighing up to 30 tons

One of the newest programs at Clemson University, implemented in 2011, is the compost program. It has been revolutionary in the impact on sustainability. Dave VanDeventer, Recycling Manager, described the early program as a learning experience when the university outgrew their first compost machine in two years by 2013. With innovation being a driving force for the university, a specialized manager was brought in to centralize the operation and introduce the university to three different ways of making compost. One of those ways is known as forced aeration, where the air is blown through a sedentary pile of compost. This way of preparing compost is more efficient than other methods, which can take almost two months because this one only takes two-to-three weeks. By composting on campus, food and dining hall waste is diverted from landfills and is being used in these composting facilities. With expanded methods and machinery, Clemson University now has the ability to produce greater amounts of compost than in earlier years, and this is essential to revitalizing the farmlands and endangered areas around the University.

Ultimately, Clemson University has a number of recycling programs that have benefited the campus in numerous ways. The programs have not only helped the environment but have also brought the Clemson community closer together. Additionally, new recycling initiatives have helped raise the revenues of Clemson University, which, in turn, has also increased revenue for the City of Clemson. Clemson University has revitalized their surroundings by being more involved in developing solutions to propel them towards their goal of sustainability.

Students' Perspective

Although Clemson University is technically far exceeding the 25-35% MSW recycling rate required by the state, this is in part because the state allows institutions to include yard waste recycling in this figure. Clemson's yard waste makes up about a third of our current 52.5% MSW recycling rate. Therefore, all other MSW recycling such as dining hall food waste, cardboard waste, and student and faculty waste like bottles and cans, makes up about two thirds of this rate. While recycling yard waste is beneficial for the campus and allows Clemson to exceed state requirements, there are still more actions that student and faculty members can take on campus each day to reduce our overall landfill waste.

One recommendation would be to not only increase student awareness, but also student participation in programs like Solid Green and the Game Day Challenge. The popularity of "going green" has grown over the past decade, and more students are taking part in Clemson's sustainability initiatives. However, greater student involvement would definitely increase the recycling rate on campus and significantly reduce our landfill waste. To get more students involved, we ought to implement strategies such as various social media campaigns or even email blasts. Additionally, Clemson University could host end-of-the-semester "recycling parties" where students could turn in all of their used papers and notebooks from the semester in exchange for a coupon or treat. Likewise, teaming up with nationwide movements such as RecycleMania, which already partners with over 500 universities and colleges across the United States and Canada to decrease the amount of waste on college campuses and educate people on the importance of recycling (Sikes, 2017), could also increase recycling rates on campus. Though Clemson University is certainly making excellent strides toward their goal of becoming a more sustainable campus, increasing student and faculty participation in various recycling initiative will surely allow them to exceed all expectations.

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Solid Waste

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Executive Summary

Since the 2013 Environmental Audit, Clemson University increased its total solid waste from 4,427 tons in the 2012-2013 academic year to 6,238 tons in the 2016-2017 academic year. The growth in solid waste is attributed to a larger student body, but it is mitigated by an increase in recycling. From 2006 to 2017, the student body increased from 17,309 to 23,406 people, and recycling rates of municipal solid waste (MSW) increased from 15.4% to 52.4%. This is due to many green efforts across campus, such as recycling programs both in every building and during football games.

Construction and demolition waste has maintained a relatively constant rate, except for a spike in the 2015-2016 year due to the construction of Core Campus and renovation of Littlejohn Coliseum. Recycling costs have only marginally increased from $86.32 per ton in 2012-2013 to $89.66 per ton in 2016-2017, while the cost for landfilling waste has drastically increased from $0.39 to $30 per ton. This financial incentive has also made it easier for the campus to stay green. According to the state requirement defined by the South Carolina Department of Health and Environmental Control (DHEC), the required MSW recycling rate is 25%-35%, but Clemson has exceeded that number, recycling over 52.4% in 2017. Overall, Clemson has made great strides in dealing with solid waste from a green perspective.

Introduction

Clemson's Recycling and Custodial department leads the efforts to manage the solid waste produced on campus. This management program focuses on many different areas including recycling solid waste, budgetary information, disposal methods of waste, and updated laws and regulations. The Solid Waste Chapter of the 2019 Environmental Audit will provide an overview of these areas.

The *Main Data* section we will look at the municipal solid waste and construction and demolition waste figures and analyze some recycling data. The *Solid Waste Budget* section of this report provides information about the amount of money that the department is allotted to manage the total waste stream (TWS). It also addresses the cost of waste management practices over the past decade. The *Laws and Regulations* section is provided as reference for definitions of solid waste as set by the State of South Carolina. Lastly, the *Plans for Improvement* and *Students' Perspective* sections offer ideas for how solid waste may be managed in the future.

Main Data

Municipal Solid Waste

The production of MSW can best be shown through examining total tonnage (see *Figure SW 1).* The number of students attending Clemson has grown from 17,309 to 23,406 in the past 12 years. The amount of MSW produced has increased along with the rising population. In 2006, the TWS was 4175.2 tons, a far smaller number than the 6238.1 tons produced in 2017. According to the South Carolina Department of Health and Environmental Control, the state defines MSW as the combined residential, commercial, institutional, non-profit and industrial packaging and office waste generated. This includes paper, cans, bottles, food scraps, yard trimmings, packaging and other items which should be recycled ("Regulation 61-107.19," 2008). MSW is gathered by Clemson University custodial staff, taken to the Pendleton Transfer Station, which is operated by Waste Management, and then transported to a landfill in Georgia. *Figure SW 1* shows the total MSW stream in tons from 2006 to 2017 including the weight from yard waste.

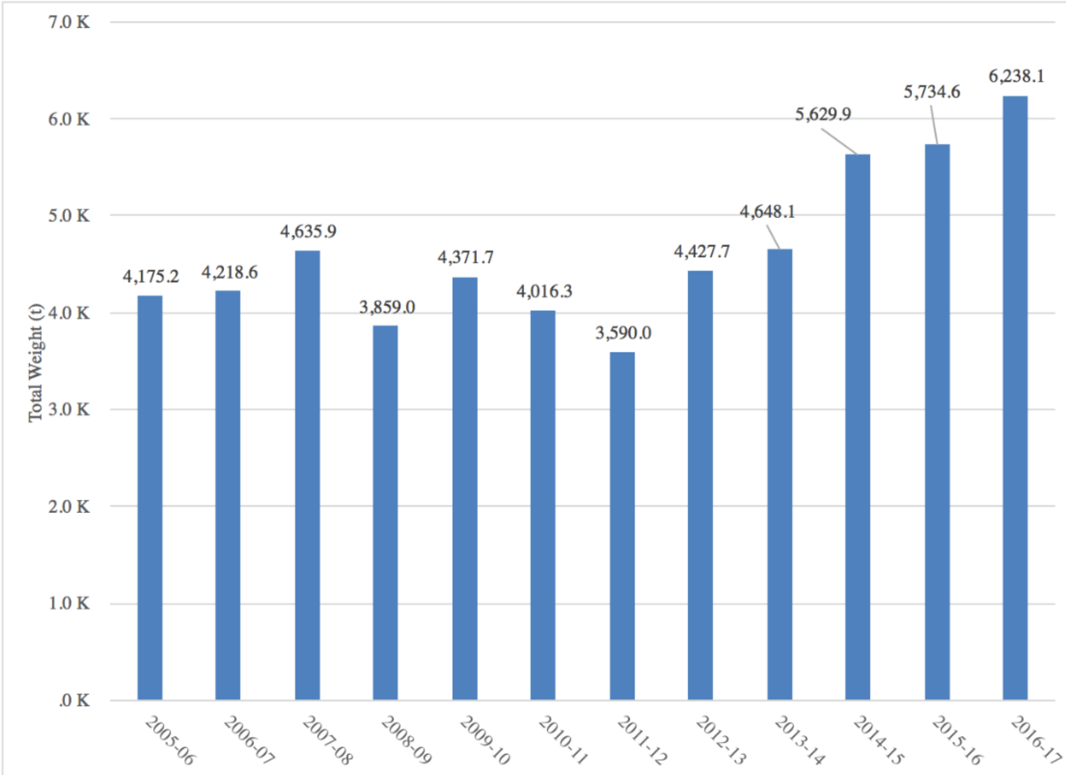

Figure SW 1: Clemson University municipal solid waste stream (tons) including yard waste between 2006 and 2017)

Construction and Demolition Waste

As the enrollment of Clemson continues to grow, more buildings are required to meet the needs of the student body. As a result, there have been numerous construction projects during the last few years. The waste produced from construction projects is its own category of solid waste, referred to as Construction and Demolition Waste. C&D waste is defined as discarded solid wastes resulting from construction, remodeling, repair and demolition of structures, road building, and land-clearing. The wastes include, but not limited to, bricks, concrete, and other masonry materials, soil, rock, lumber, road spoils, paving material, and tree and brush stumps ("Regulation 61-107.19," 2008). C&D waste is part of the Total Waste Stream, and it can have a large impact on that value. The amount of C&D waste can experience vast fluctuations from year to year depending on the amount of construction undertaken. For example, in 2015-2016 it was a staggering 37,531.2 tons due to the renovation of Littlejohn Coliseum and construction of Core Campus. Construction and Demolition waste is handled by S.H. Carter Development, which is required to recycle at least 75% of the C&D waste that is produced. Since C&D waste is included in the operation fee for the construction program, it is not part of the solid waste management of Clemson University. *Figure SW2* highlights the TWS for Clemson University when factoring in C&D waste.

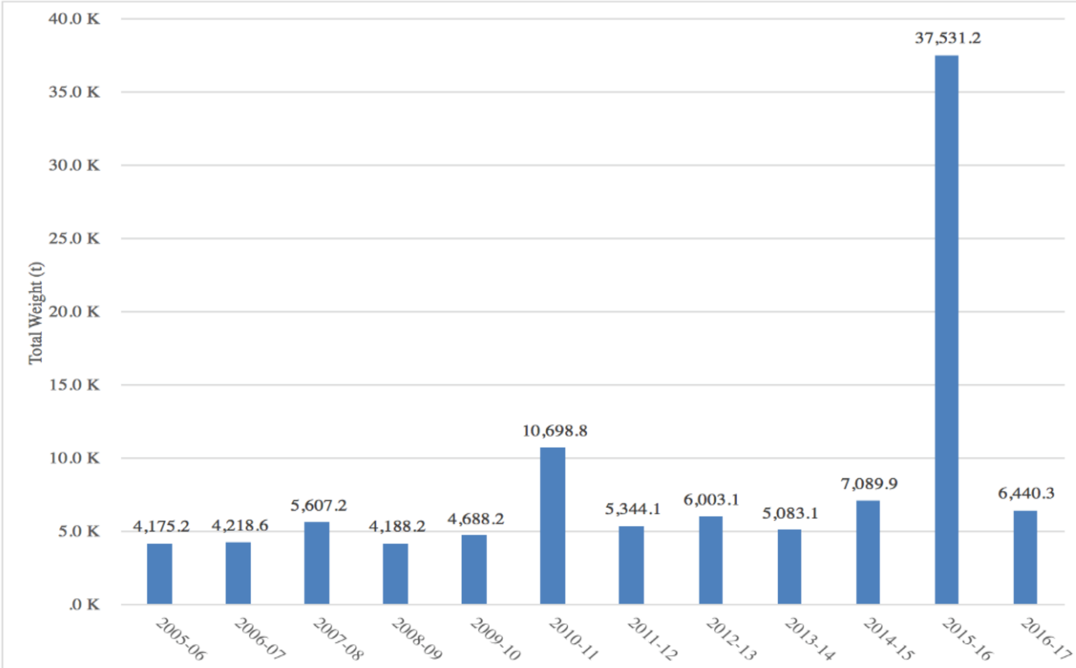

Figure SW 2: Clemson University total waste stream including C&D waste from 2006-2017

Recycling

Recycling is a huge component of managing MSW. In ten years, Clemson University has made large strides in solid waste management. Clemson University has increased the percentage of municipal solid waste that is recycled each year. From 2005-2006, Clemson University recycled 15.4% of the municipal solid waste stream, excluding C&D, yet in 2016-2017 the recycling percentage increased to 52.4% (see *Figure SW 3).* According to the state requirement defined by SC-DHEC, the required MSW recycling rate is 25%-35%, which has been surpassed by Clemson University. *Figure SW 3* and *Table SW 1* outline the percentage of MSW that has been recycled by the school.

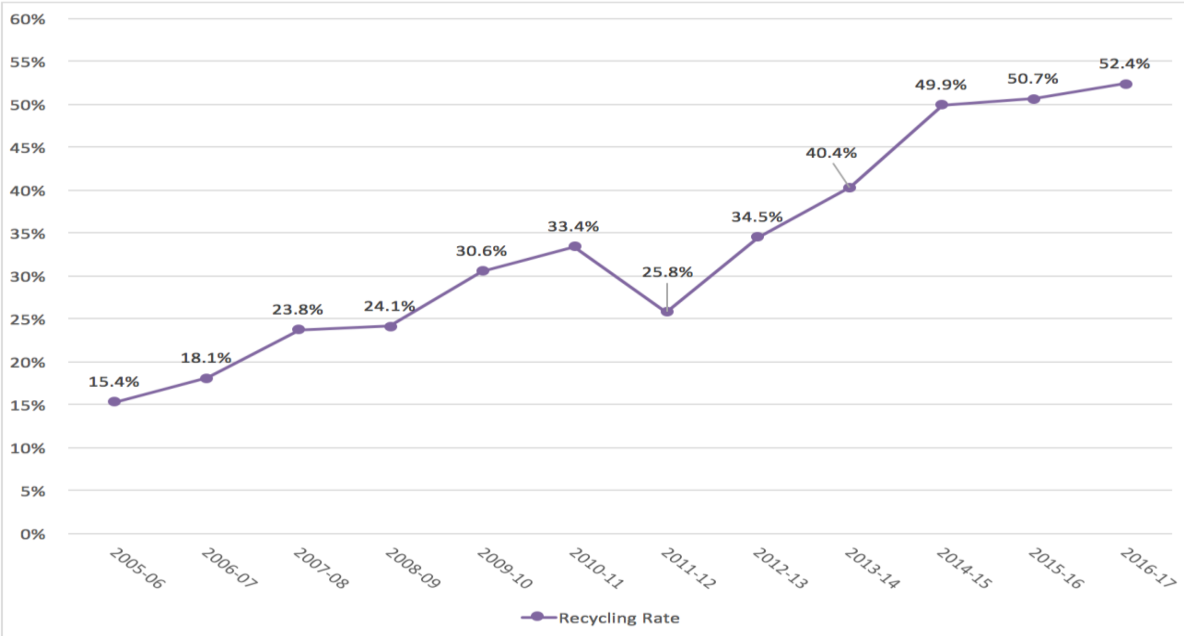

Figure SW 3: Clemson University municipal solid waste recycling rate between 2006-2017, excluding &D waste

Table SW1: Clemson University Total Waste Stream History (Including C&D waste)

	Tons				Percent
	Landfilled	C&D Landfill	Recycled	Total	Recycling Rate
2005-06	3,534.10	N/A	641.1	4,175.20	15.40%
2006-07	3,455.50	N/A	763.1	4,218.60	18.10%
2007-08	3,534.60	81.6	1,991.00	5,607.20	35.50%
2008-09	2,927.00	95	1,166.20	4,188.20	27.80%
2009-10	3,035.60	100.1	1,552.60	4,688.20	33.10%
2010-11	2,674.80	165.3	7,858.70	10,698.80	73.50%
2011-12	2,663.50	289.5	2,391.10	5,344.10	44.70%
2012-13	2,899.70	129.9	2,973.50	6,003.10	49.50%
2013-14	2,772.40	84.24	2,226.50	5,083.10	43.80%
2014-15	2,820.10	89.97	4,179.80	7,089.90	59.00%
2015-16	2,829.70	388.75	34,312.80	37,531.20	91.40%
2016-17	2,968.70	56.5	3,415.10	6,440.30	53.00%
2017-18	387.6	17.04	894	1,298.60	68.80%

One of the primary sources of solid waste on Clemson's campus is Athletics, specifically football games. As defending national champions, Clemson draws over 81,000 people on game-days, making it equivalent to the third largest city in South Carolina. With this many people, a large amount of MSW is produced; as such, game-days are a major area of focus for the Recycling and Custodial department. There has been a steady trend of more MSW recycled and less landfilled *(see Table SW2).* The game-day recycling rate has increased almost every year, from 20% in 2011 to 52% in 2016. This is a major factor as to why Clemson University's overall recycling rate has increased. There was an anomaly in 2015 due to torrential rains for some of the games, which caused the MSW to be too wet to recycle. It was rejected by the contractor and subsequently landfilled. *Table SW2* gives a brief summary of trends in MSW management for game-days at Clemson, and *Table SW3* provides a more in-depth study of each game on a yearly basis.

Table SW 2: Annual Game-day Totals of MSW Recycled and Landfilled (2011-2016)

Year	MSW recycled (lbs)	MSW landfilled (tons)	Recycling rate
2011	92,780	184.2	20%
2012	111,640	181.34	24%
2013	123,604	244.76	20%
2014	214,974	145.79	42%
2015	237,076	229.02	34%
2016	315,143	147.75	52%

Table SW 3: Game Day Totals between 2011-2015

2011	Recycled (lbs)	% Rate	Landfilled (Tons)	Total Tons
Troy	10,760	17%	27.13	33
Wofford	11,680	22%	20.16	26
Auburn	15,620	21%	29.16	37
Florida State	17,000	18%	37.52	46
Boston College- HC	14,720	22%	25.66	33
UNC	10,120	19%	22.29	27
Wake Forest	12,880	22%	22.28	29
Season Total	92,780	20%	184.2	231

2012	Recycled (lbs)	% Rate	Landfilled / Tons	Total Tons
Ball State	10,580	19%	22	27
Furman	12,860	22%	23.1	30
Ga. Tech	18,930	24%	29.78	39
V. Tech	18,690	29%	22.67	32
Maryland- HC	12,780	21%	23.42	30
NC State	13,060	25%	19.9	26
USC	24,740	23%	40.47	53
Season Total	111,640	24%	181.34	237

2013	Recycled (lbs)	% Rate	Landfilled / Tons	Total Tons
Georgia	19,890	11%	80.87	91
SC State	7,062	10%	31.53	35
Wake Forest - HC	21,675	28%	28.05	39
Boston College*	6,420	12%	24.26	27
Florida State	30,892	25%	47.44	63
Ga. Tech	11,474	36%	10.04	16
Citadel	26,191	37%	22.57	36
Season Total	123,604	20%	244.76	307

Note: * 2 - 30 yd. loads of recycling went to the landfill

2014	Recycled (lbs)	% Rate	Landfilled / Tons	Total Tons
SC State	42,750	63%	12.33	34
UNC	17,755	44%	11.52	20
NC State	18,397	28%	23.31	33
Louisville	23,709	25%	36.35	48
Syracuse	29,080	32%	31.52	46
Ga. State	22,559	48%	12.01	23
USC	60,724	62%	18.75	49
Season Total	214,974	42%	145.79	253

2015	Recycled (lbs)	% Rate	Landfilled / Tons	Total Tons
Wofford	33,478	38%	27.08	44
App St	31,218	36%	27.23	43
*Notre Dame	10,591	9%	55.73	61
*Ga Tech	10,951	10%	46.94	52
Boston College - HC	37,686	37%	31.41	50
Florida St.	68,897	80%	8.62	43
Wake Forest	44,255	41%	32.01	54
Season Total	237,076	34%	229.02	348

Note: *waste material sent off to be sorted by contractor rejected because of wet material from torrential rains both on 10/3 and 10/10 weekends and material was landfilled.

Solid Waste Budget

The budget for solid waste is comprised of landfill fees and hauling (pulling) fees. Hauling fees includes the fees for the transportation of both landfilled and recycled solid waste. These costs have varied on a yearly basis. For example, in the decade ending in 2017, the average landfill fee increased from $0.39/ton to $30/ton, while the cost per tonnage for recycling began consistently decreasing. The differing trends have resulted in a relatively stable overall cost. The trend of the overall cost (see *Table SW4)* includes the total expenditures of landfill fees and hauling fees from 2013 to 2017 for MSW only. The hauling fees have increased from $200,428.59 in 2013 to $207,624.62 in 2017, which is a fairly minimal change.

Table SW 4. Total Landfill Fees and Total Hauling Fees (2013-2017)

(Does not include C&D, but does include yard waste)

	Landfill Fees (Waste Management Inc.)	Hauling Fees (Republic Inc.)
2012-13	$86,991.00	$200,428.59
2013-14	$83,171.40	$195,545.30
2014-15	$84,602.40	$198,135.81
2015-16	$84,890.70	$214,521.61
2016-17	$89,061.60	$207,624.62

Currently, Clemson University's Custodial, Recycling, and Solid Waste Department receives $400,000 yearly for solid waste management. The solid waste generated by Clemson University is collected by contractors Republic Inc. for hauling (pulling) and Waste Management Inc. for landfill. It should be noted that the University has a revenue contract for the sale of recycling commodities (paper, bottles, cans and cardboard) with American Recycling of Western North Carolina. In addition to the trash containers collected by Republic Inc., Clemson University has costs for collecting the trash in academic buildings, dorms, and dining halls. This cost is $1.23 per cubic yard (Jones, 2017).

Figure SW4 provides details of the cost per ton spent on recycling from 2006 to 2017. Over the years, the cost for recycling has been decreasing, which has offset the increase of the landfill cost.

Figure SW 4: Municipal Solid Waste Recycling Cost Per Tonnage (2006-2017)

(Excluding C&D waste but does include yard waste)

Figure SW5 shows the total expenditure for recycling. From 2006 to 2017 the money spent on recycling has increased because of the growth in total recycled waste. Since more solid waste has been recycled instead of going to landfill over this time period, the overall cost of waste management has remained constant.

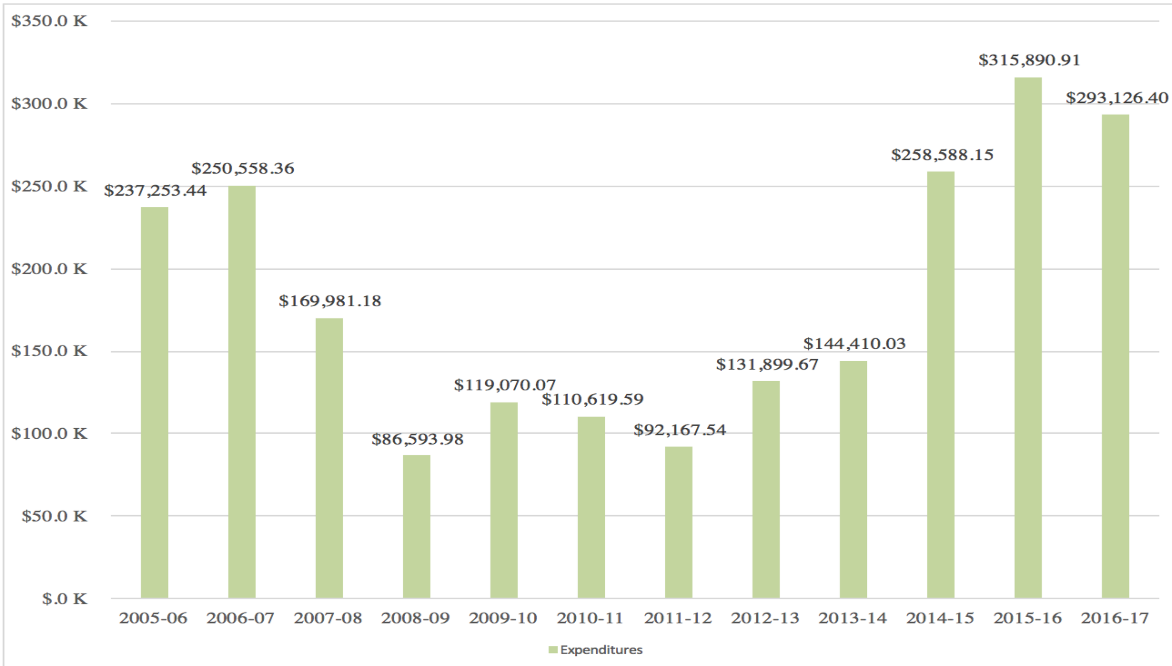

Figure SW 5: Municipal solid waste recycling expenditure annual total (2006-2017)

(Does not include C&D waste but includes yard waste)

Laws and Regulations

Clemson University must follow federal and state regulations for its solid waste management programs. The Resource Conservation and Recovery Act (RCRA) of 1976 developed guidelines for solid waste disposal and gave the U.S. Environmental Protection Agency direct control over setting standards for disposal and management of solid waste by facilities. According to the RCRA, "The State plan shall address all solid waste in the State that possess potential adverse effects on health or the environment or provides opportunity for resource conservation or resource recovery." This determined that the individual states set regulations on their own solid waste management. In South Carolina, solid waste is defined and regulated by the South Carolina Solid Waste Policy and Management Act of 1991. Clemson University defines solid waste through its Office of Research website as follows: "A solid waste is any solid, semi-solid, liquid or contained gaseous material that is discarded or considered 'inherently waste-like'" ("General," 2019).

Plans for Improvement

There are several initiatives that Clemson University has put into place to increase the amount of recycling on campus. In 2015, Clemson University started transitioning the President's Picnic to a zero-waste event. This is part of Clemson's ongoing efforts to get students to recycle more by increasing education and awareness. Clemson University believes that existing recycling efforts can be improved.

These initiatives have strengthened Clemson University's recycling program; however, there are several areas that have room for improvement. One of the biggest areas Thomas Jones, Director of Recycling and Custodial Services, is focused on is improving the environmental friendliness of solid waste disposal on campus. Garbage dumpsters are a major concern as they can cause seepage and leak hazardous materials into the environment. Jones believes that the number of dumpsters on campus can be reduced drastically to minimize spending on disposal. The design of the dumpsters could be improved by providing a drain underneath to catch hazardous leaks and enclose the dumpster in a protected area. There are also two departments that contribute greatly to the production of solid waste on campus: housing and dining at 24% and 28%, respectively. The dining department has made significant progress on composting more food waste in recent years; however, Clemson believes that education and training will result in better management of MSW for these departments in the future (Jones, 2017).

Students' Perspective

As Clemson University students, we have recognized several improvements that the Solid Waste Department and other departments can make with managing their disposal of solid waste. We have firsthand experience living on campus, allowing us to envision changes that can be made to reduce the amount of solid waste going to landfill. A significant modification that can be made is increasing the size of the small plastic recycling containers that are placed in the dorms of on-campus housing. The current plastic containers are too small to hold any reasonable amount of recyclable material and fill up too quickly. To provide a reference for the bin sizes, the bins are only able to hold about four crushed two-liter soda bottles. Students are most likely not going to empty the container when it reaches maximum capacity, and much of the recyclable material subsequently will be thrown into the trash. Larger recycling bins allow for more trash to be held, keeping more waste in the recycling stream.

One of the most concerning figures discovered during the audit was the amount of solid waste the dining department produces in comparison to all other departments. The dining hall accounts for 28% of all of Clemson's solid waste. This percentage is unsettling because most of the dining halls' waste should be recyclable or compostable as most food containers are made with plastic, metal, or cardboard. Clemson would benefit from increase training and awareness of the staff regarding recycling, which could potentially lower the dining department's impact on the environment. Clemson should encourage Aramark, the contractor managing and supplying the dining halls, to take more steps to improve recycling rates in dining halls.

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Stormwater

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Clemson University qualified as a Municipal Separate Storm System in the fall of 2015. This allows the University to discharge stormwater into Lake Hartwell and avoid any onerous restrictions or costly fines and alternatives. In order to do this safely and not violate regulations, the university must continuously test the lake for pollutants to ensure its levels are acceptable and do not cause harmful contamination. This chapter discusses the different ways stormwater is maintained in order to keep up Clemson's recognition as a Center of Excellence in Watershed Management. There are a series of tests, coliform being the most important, that are used to regulate and monitor the stormwater system for proper functioning. Robert McCrary, Environmental Compliance Officer for stormwater management, worked with this audit in order to map out the process and create a series of figures for its visualization. The chapter discusses the major flaws of the system—short staffing and Clemson's rapidly expanding campus—and presents a series of ways to help in the efforts to keep the stormwater at appropriate levels. These are concepts such as educating incoming freshman along with employing students, depending on the specialties of their major, to help. This could also be beneficial for the students in giving them real world experience. This is important because any violation of the regulations could cause the University to lose its current status. Not only will this present a costly problem, but also give the University a bad reputation for environmental awareness, which could turn away potential investors and students.

Introduction

Clemson University was placed under the Municipal Separate Storm Sewer System (MS4) in October of 2015. This required Clemson to obtain a permit from the Environmental Protection Agency (EPA) in order to discharge stormwater into Lake Hartwell. Under EPA regulations, the system requires annual testing for pollutants and documentation to prove that the water is being discharged properly into public water.

In the case of the University, the lake is within acceptable levels of pollution. Preparation for Clemson's small MS4 began in July 2013, before the 2015 deadline, in order to get a head start on the changes that had to be made. In order to be prepared, Clemson conformed with the MS4 regulations set forth by the EPA and the South Carolina Department of Health and Environmental Control (DHEC). The efforts to keep the levels of bacteria and other contaminants low have allowed Clemson to continue to be recognized as a Center of Excellence in Watershed Management by both EPA Region 4 and DHEC (Marraccini, 2013). Additionally, the testing records show that Clemson has been able to keep pollutants to a minimum with occasional increases due to seasonal rain events and minor problems with the system.

This chapter of the Environmental Audit will describe the municipal separate storm sewer system and the stormwater testing methods. The preventive measures and the monitoring will be discussed before the auditing students' recommendations are rolled out. .

Municipal Separate Storm Sewer System (MS4)

The Municipal Separate Storm Sewer System is defined by the EPA as a system that discharges municipal stormwater into waters of the United States that is not a combined sewer system and not part of a sewage treatment plant (Maraccini, 2014). Clemson University was able to become a small MS4 based on its inclusion in the Greenville urbanized area in the 2010 U.S. Census (Department of Health and Environmental Control, 2016). A small MS4 is a program that was not previously covered under the National Pollutant Discharge Elimination System (NPDES) stormwater program. The vast majority of Clemson's stormwater is funneled equally into Hunnicutt Creek and the Seneca River Basin and all the water eventually ends up in the Old Seneca River bed where the Corps of Engineers pumps the water into Lake Hartwell (Clemson Public Service and Agriculture, 2017). The greatest volume of water runs underneath the football stadium and exits underneath the Indoor Practice Facility into the basin. Because the water is discharged directly into local water bodies, a permit from the NPDES requires the permittee to develop a stormwater management plan to limit the pollutants in the water. According to DHEC, an entity under MS4 must have public education and outreach on stormwater, discharge elimination and detection, construction site runoff control, and a pollution prevention plan all incorporated into a stormwater management plan (Department of Health and Environmental Control, 2016). Also, if stormwater is being released into a body of water, there is a maximum daily amount that can be released that must be within acceptable water quality standards. Stormwater is monitored by a number of individuals and organizations. These include Robert McCrary, an environmental compliance officer at Clemson University; and the Carolina Clear Group, a Clemson extension service that educates and involves people in waterway protection and pollution prevention.

Testing

Since the stormwater is not treated before it enters Lake Hartwell, keeping the levels of pollution in the stormwater as low as possible is a priority. Currently, testing the stormwater pollutant level is done bimonthly at each of 13 test sites for a number of contaminants, including E. coli, oil and grease residue, chemical oxygen demand (COD), phosphorous, pH, ammonia, nitrate, and residual chlorine. Each site is a location where stormwater runoff is gathered and funneled through the stormwater system into one main line. The final destination in the system is the pump station next to the lake. Here the stormwater is released into Lake Hartwell. The data from each of the test sites was recorded and sent to the EPA one year after being under MS4. This was done to maintain accountability, should the EPA choose to audit the program. Testing bimonthly is needed to ensure that our campus is meeting the standards and that the water being pumped into the lake has a safe level of pollutants for humans and wildlife. The tests look for spikes or dangerous levels of any of the contaminants that are tested for.

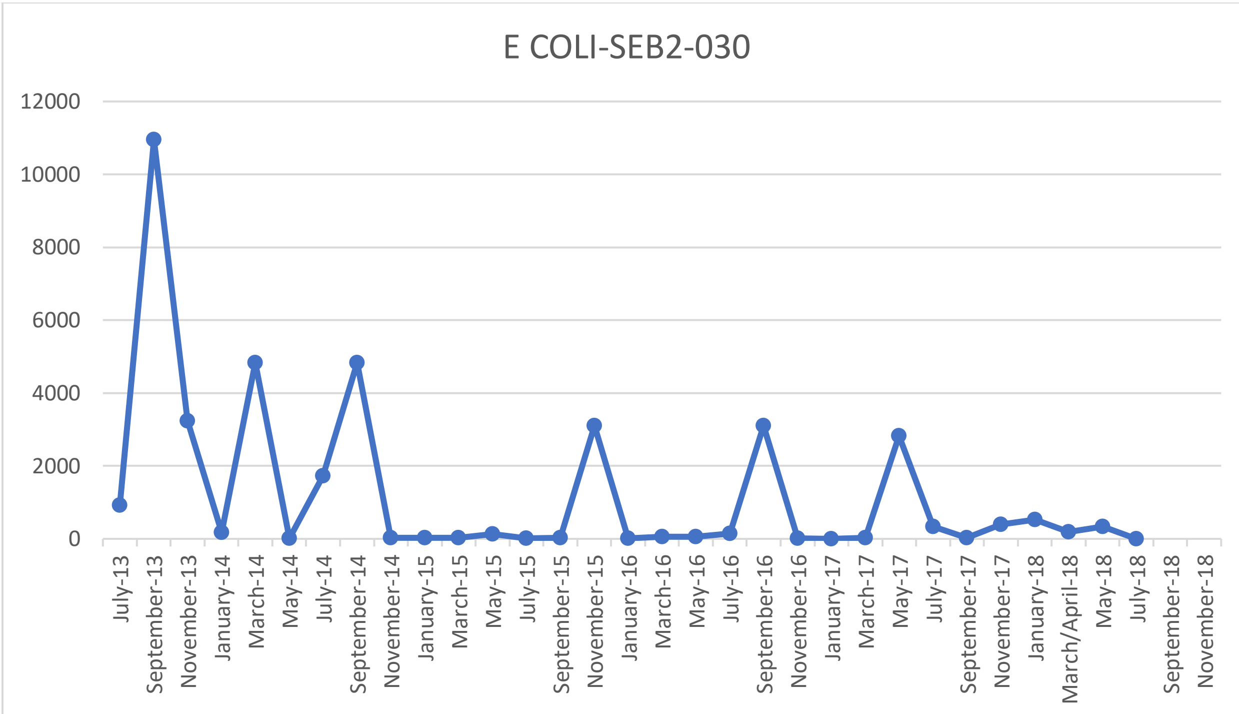

Figure ST 1: Level of E. coli present in stormwater at test site SEB2-030 from July of 2013 to July of 2018. Each site is tested every 2 months; it is measured as E. coli per 100mL.

E. coli, formally *Escherichia coli*, is one of many microbial contaminants found in water (Ela and Masters, 2009). In an ideal world, water would be tested for all of the dangerous pathogenic microorganisms that are of concern in water; however, these tests are generally too difficult or too costly and time consuming to perform for general purposes. A simpler alternative to this is to test the water for evidence of fecal contamination which houses many kinds of pathogens. In such a test, a coliform bacterium is used such as E. coli. The coliform bacteria is found in high concentrations in untreated wastewater and E. coli is also excreted in high concentrations from feces. In this case, E. coli acts as an indicator which can detect direct fecal contamination or wastewater contamination in the water stormwater system (Ela and Masters, 2009).

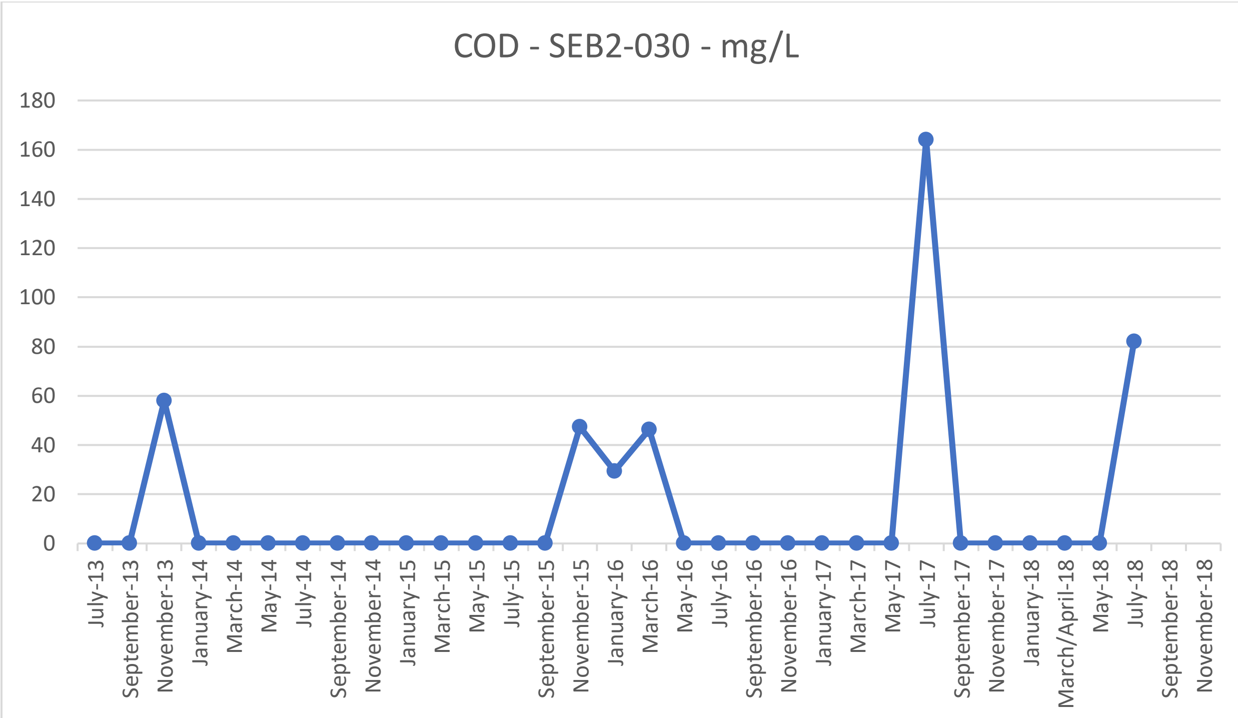

Figure ST 2: Level of COD or chemical oxygen demand present in stormwater at test site SEC6-084 from July of 2013 to July of 2018, each site is tested every 2 months. It is measured as milligrams of oxygen demanded per liter of water (mg/L).

This test is a measure of the amount of oxygen-demanding materials in the water. One source of COD is from microorganisms in the water. Whenever any sort of biodegradable waste product is released into a body of water, microorganisms will feed on the waste and break it down. When this reaction takes place in an environment with insufficient oxygen, dangerous and unstable byproducts can be formed in the water such as hydrogen sulfide, ammonia, and methane (Ela and Masters, 2009). Other than these byproducts, another major danger of too much oxygen-demand in water is the reduction of the amount of dissolved oxygen in the water. As the amount of dissolved oxygen in a body of water is reduced, the local organisms in the water are starved for oxygen. Once the dissolved oxygen reaches a certain point, organisms in the water will evacuate or die. This will severely impact the ecosystem of the body of water in a negative way. This test for COD will allow the university to discover any dangerously high levels of COD and determine if action needs to be taken.

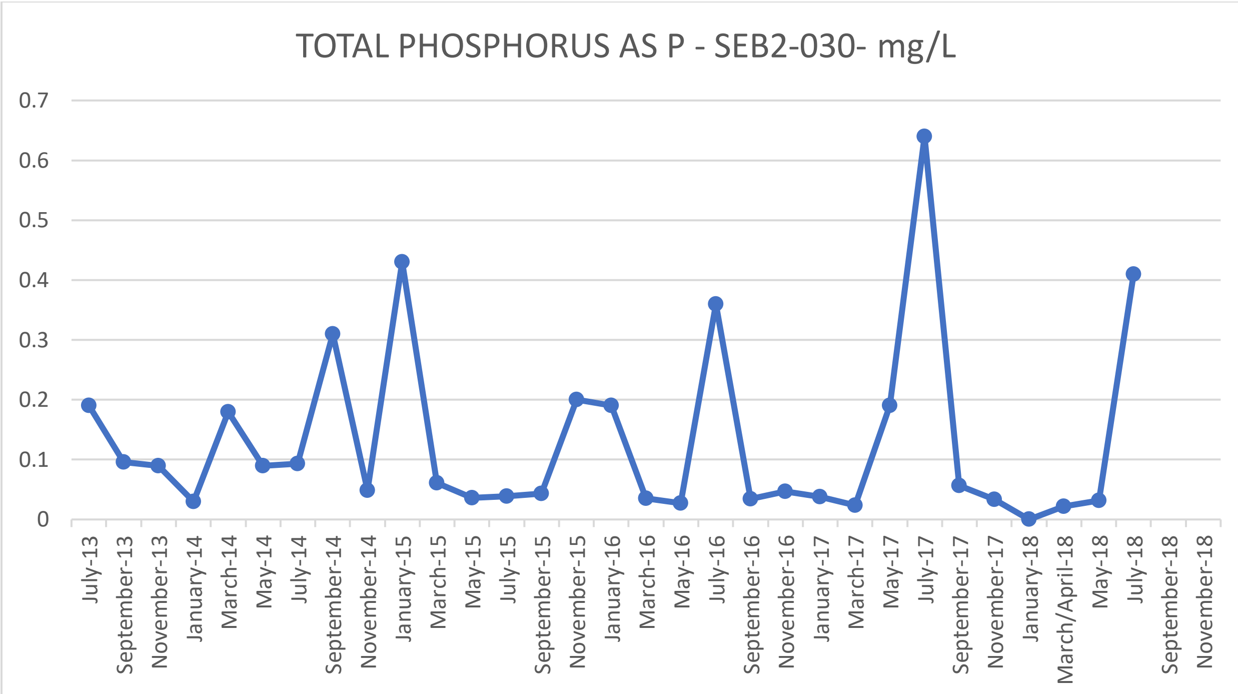

Figure ST 3: Level of phosphorus present in stormwater at test site SEB2-030 from July of 2013 to July of 2018. Each site is tested every 2 months. It is measured as milligrams of phosphorous per liter of water mg/L.

One of the major threats of phosphorus in water is that phosphorus can act as a nutrient to organisms in the water (Ela and Masters, 2009). In this context, nutrients are chemicals that are essential to the growth of these organisms. This process is known as eutrophication and is especially dangerous for lakes such as Lake Hartwell. Although this doesn't sound harmful, when in sufficient concentration nutrients can be act as pollutants to the water. When nutrient concentration is at high levels, this can cause a spike of growth in aquatic plants such as algae. When the mass amount of algae dies and decomposes, they will remove large amounts of oxygen from the water. This can cause a problem similar to that of COD such as organisms dying due to lack of oxygen.

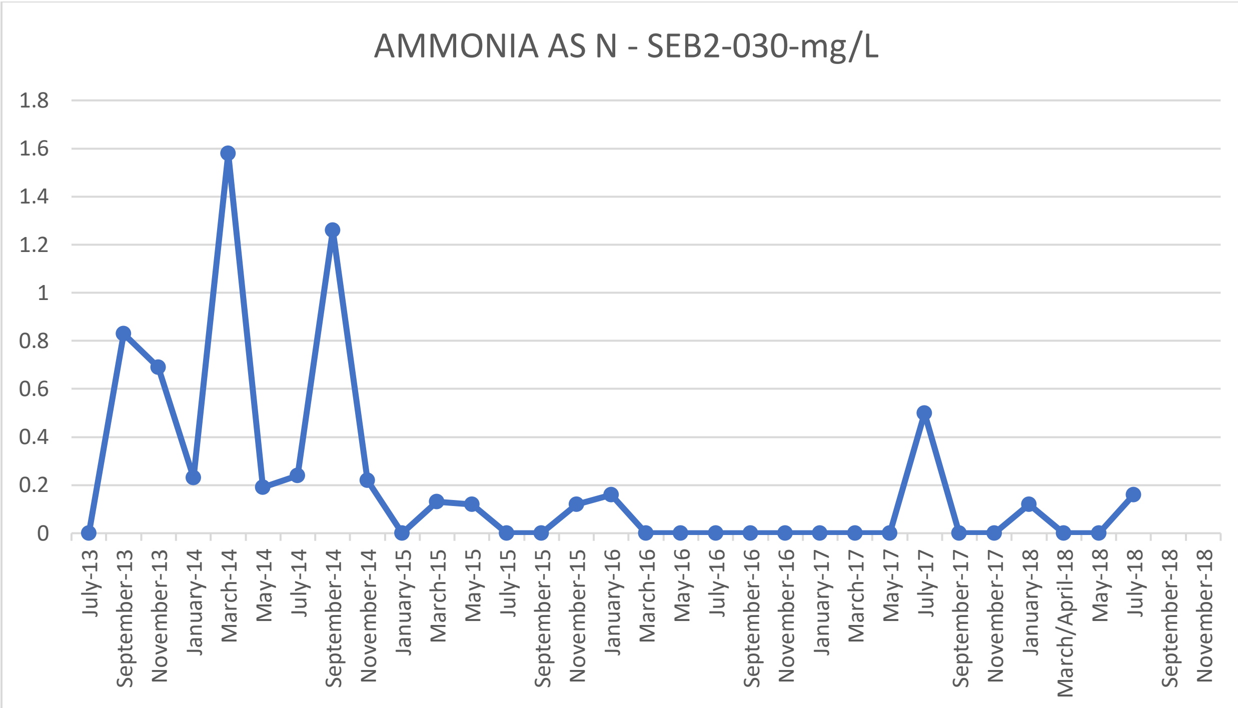

Figure ST 4: Level of ammonia present in stormwater at test site SEC6-084 (one of the 13 sites that is tested) from July of 2013 to July of 2018. Each site is tested every 2 months. It is measured as milligrams of ammonia per liter of water (mg/L).

Ammonia is a form of nitrogen and it is toxic to aquatic life in concentrations from 0.53 to 22.8 (mg/L), so it is very important to monitor levels of this substance that will enter waterways. Lower levels of ammonia can also physically stress aquatic life. The sources of ammonia can be from agricultural fertilizers, improper disposal of household chemicals, atmospheric deposition, and industrial sources (Oram, 2014).

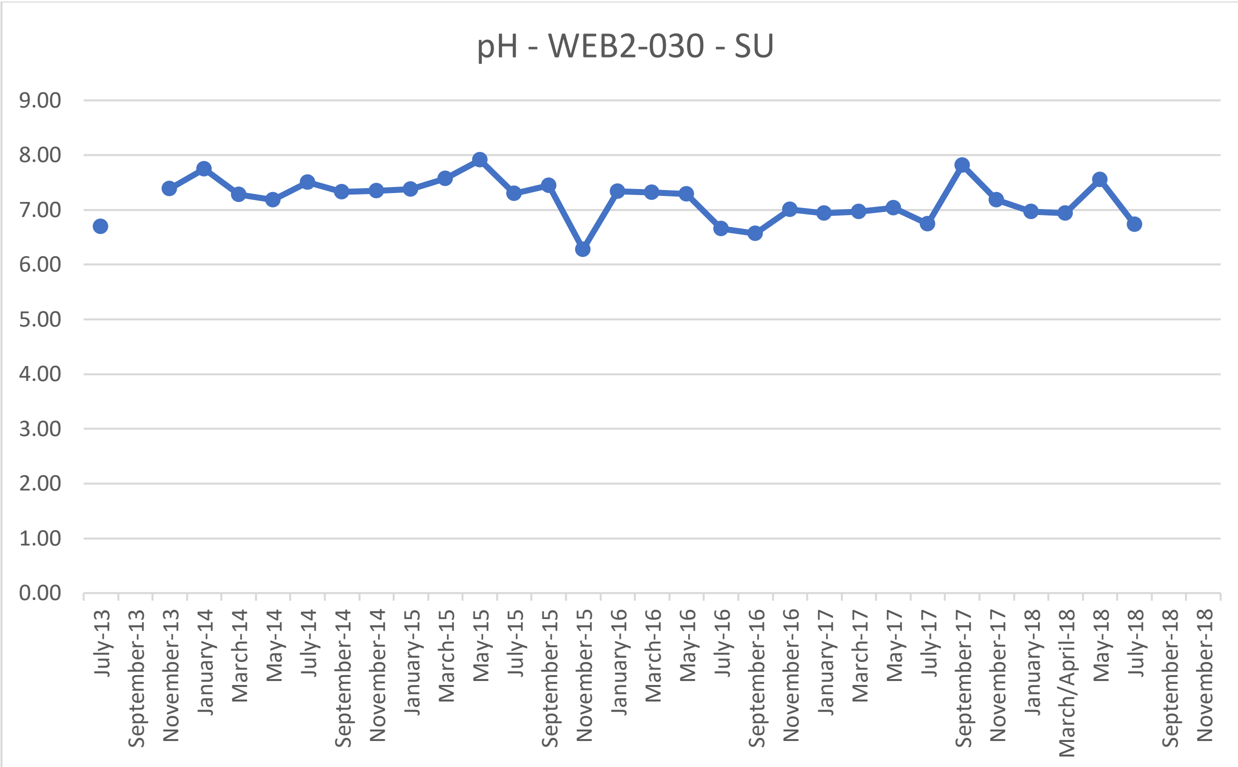

Figure ST 5: pH present in stormwater at test site SED1-010 (one of the 13 sites that is tested by Robert McCrary) from July of 2013 to July of 2018. Each site is tested every 2 months. It is measured as the concentration of hydrogen ions in water.

A low pH is an indicator of acidity. Although all rain has a small amount of acidity, rain in many areas can be described as acid rain, meaning that it has even more acidity that regular rain. When acid rain falls over bodies of water it can make the body of water acidic as well. This acidity can cause damage to structures in the body of water such as piers, docks, and bridge abutments. Not only this, but when plants absorb acidic water it can cause harm to the plant and negatively impact the ecosystem. Aquatic organisms can also be damaged by acidic water (Ela and Masters, 2009). If the pH drops too low, organisms can die. Not only can low pH directly harm organisms, but dangerous materials such as mercury which are normally insoluble can begin to dissolve into acidic water and cause even more damage. The pH is tested to ensure that organisms are safe and to prevent significant corrosion.

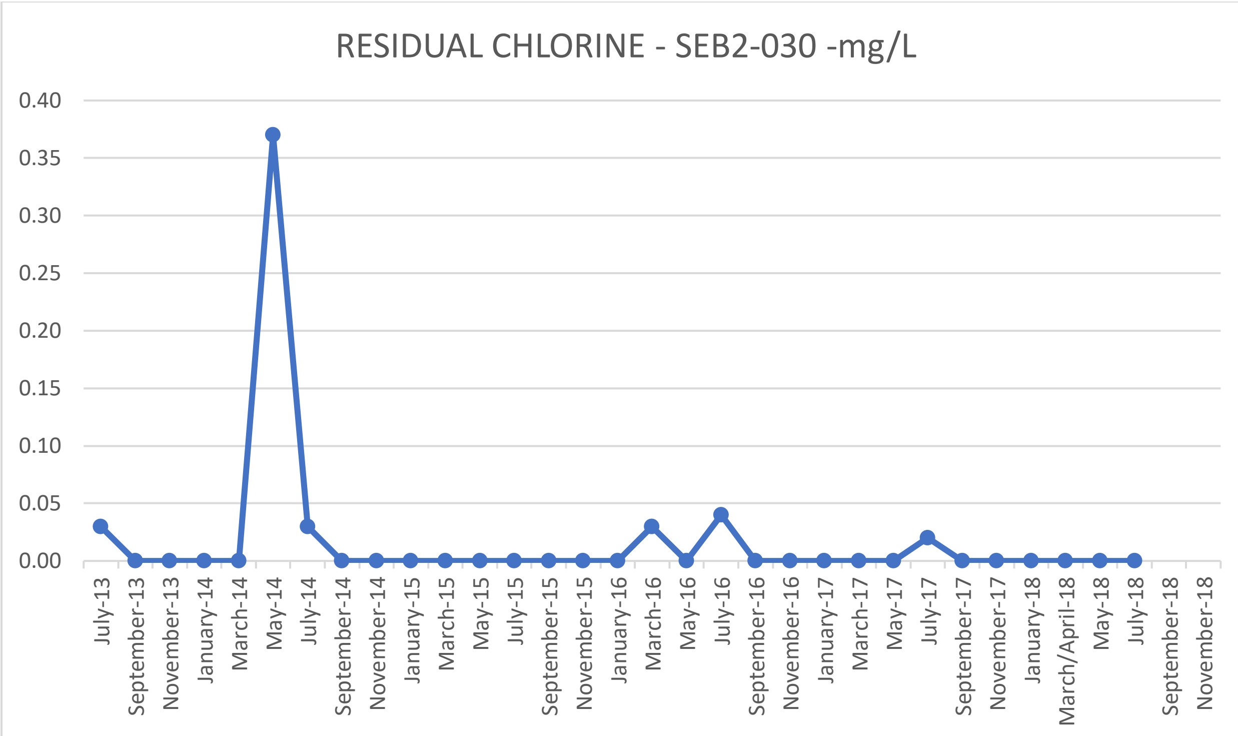

Figure ST 6: Level of residual chlorine present in stormwater at the pump station test site from July 2013 to July 2018. Each site is tested every 3 months. It is measured as the concentration of chlorine in water.

The primary form of water treatment is disinfection. Two forms of disinfection are generally used. Primary disinfection is used to treat the water while at the treatment plant and residual disinfection is used to keep the water clean while it is transported. Chlorine is one of the most common disinfectants used because it can be used as both primary and secondary disinfectant and also because it is effective and cheap. However, there is a risk involved in using chlorine. Chlorine use can create halogenated disinfection byproducts by chlorine combining with natural organic substances in the water. These byproducts can be carcinogenic and cause major harm to organisms (Ela and Masters, 2009). Chlorine can also corrode a large number of materials. Chlorine is tested to ensure that there is not a significant chance of corrosion of halogenated disinfectant byproducts.

Preventative Measures

While the testing and monitoring programs play a major role in keeping the program in compliance, there are a number of other ways to control what goes into the stormwater system. A major factor in keeping the pollution at a minimal level is constantly checking to see if there are any strong spills of contaminants, which allows for a quick response and solution. Each site is tested every 2 months and is measured as mg/L.

Spikes, such as those in these figures, show what toxin or bacteria is high so that the source of the toxin can be identified, located, and then fixed. For example, a spike in colony-forming bacteria such as E. coli would suggest a sewage leak. The pumping stations location would provide insight into where to look for the leak as well. Problems can come from sewage leaks, construction, chemical spills, and various types of containers leaking. Without continuous monitoring, these problems can go unseen and negatively affect the stormwater pumped into the lake. Another form of monitoring currently being used is dye testing. McCrary has tested every drain on campus by dropping dye into drains to make sure that the pipes do not have any misconnections, such as sewer water going into stormwater and vice versa. There can be serious consequences from a break in a pipe where raw wastewater can seep out of a cracked or broken pipe and make its way into the stormwater system. The dye tests allow McCrary to locate any problems and quickly fix them.

The Spill, Prevention, Control, and Countermeasure (SPCC) program requires that all oil-like substances are kept out of storm drains by being contained in double walled containers and relocating them far away from any drains. Some drains are fitted with a special shutoff valve. If the valve detects oil, it automatically shuts itself and closes off the drain. Additionally, old dumpsters are replaced in order to ensure that water contaminated with garbage does not flow into the drains. All dumpsters have a sign on them with a phone number so that a leaky dumpster can be reported for inspection and replacement. Athletics programs also contribute to minimizing pollution by placing portable restrooms on dirt or on asphalt with absorbent socks around the storm drain. There are two main solutions when dealing with cars and parking lots affecting stormwater. When rain falls onto an asphalt parking lot, all of the fluids that leak from cars sit on top of the asphalt and wash into the stormwater system. By building lots from gravel, the leaked fluids can enter the ground and disperse slowly, rather than accumulate in mass quantities in the system. Secondly, asphalt parking lots are being built with retention ponds near them so that runoff flows from the parking lot to the pond. This helps keep oil, gas, and other chemicals out of the stormwater system. The runoff flows into the retention pond, which acts as a slow, natural filter that disperses the harmful material out over time. These methods ensure compliance while keeping oil out of the water. For the future, the department plans to continue to fix problem drains and add personnel to deal with the increasing workload (McCrary).

Monitoring

Dry weather flows, which occur when there is no rainfall, are monitored to insure that the water flow is coming from safe sources. An example of a safe source would be the condensation from air conditioners, as opposed to a dangerous leak from another source. McCrary walks Hunnicutt Creek once a year checking each outfall (an area where stormwater is entering the creek) and also checks the more eroded outfalls once a year. At the outfalls, McCrary is checking for where contaminants could potentially be entering the creek.

Even though many precautions are taken to ensure the water is safe for the environment, it is impossible to keep the water entirely free from contaminants. This is because all mammals possess bacteria such as E. Coli and coliform. Hearing about these bacteria in water often scares the public, but the levels are not alarming; bacteria are impossible to completely eliminate in an open system

Students' Perspective

As the average person is not informed of what is involved in a stormwater system, keeping the system clean is not typically on the mind. Therefore, by educating about what stormwater is and how to keep the system as clean as possible, students at Clemson could greatly contribute to protecting the stormwater system. Students are able to directly participate in the stormwater program in the classroom and lab settings, such as in the Agriculture programs. These students take classes about watershed management and are required to create management plans for the specific areas within the process, but do not get to implement the plans. Including students in the actual process of management provides hands-on experiences that are incredibly desirable in the workforce. Civil engineering students could also be involved with the planning aspects in combination with management implementation. The level of awareness on campus about stormwater is also incredibly low. There are programs and literature in place to educate about water consumption, electricity use, trash, and recycling, yet nothing involving stormwater. Communication majors could be used to quickly solve and manage the lack of awareness on campus. Clemson could also teach incoming freshman and transfer students at orientation or in the mandatory CU1000 course about how stormwater is handled. It is important to understand as the campus grows, more green spaces are lost; this is detrimental to the proper drainage of stormwater. Although the system has increasingly become better, it is starting to level out in its improvement because of the rapid growth of the campus. Students should be informed of this as well as given some examples of how the stormwater becomes polluted. Finally, the phone number for the stormwater management should be posted and easily accessible; the department encourages students to report any suspicious drainage that they see as it can all make a difference for the stormwater treatment.

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Wastewater Treatment

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The Clemson University Wastewater Treatment Plant (CUWWTP) monitors chemical levels while treating the wastewater produced by the university's main campus. CUWWTP works within the regulations and houses an efficient internal water system, running no higher than 50% capacity, to clean water prior to its release into Lake Hartwell. Current plans project the plant to enable cleaning 1.8 million gallons per day and run 50% capacity in the year 2028. In order to clean the wastewater, CUWWTP monitors the biochemical oxygen demand (BOD), pH, phosphorous, and nitrogen levels of the water. With the ever-growing population of Clemson's campus, CUWWTP's budget has been increasing over past years. Facility modifications are necessary, as with most operations, in order to make improvements and meet the changing demands that Clemson University is experiencing. The CUWWTP's operators have asked for flow measuring devices to improve the wastewater treatment process. During large events and rainstorms in Clemson the CUWWTP begins to run at peak from the lack of flow equalization capabilities. CUWWTP equipment is approaching the end of its functional lifespan.

Introduction

The Clean Water Act of 1972 mandated by the federal government requires the removal of human excrements, soaps, debris, and various chemicals from wastewater used by homes, industries, and businesses into clean water before being released back into the environment. Failure to do so has harmful consequences and can have catastrophic impacts on the wildlife populations and the environment.

Clemson University has its own internal water system that treats the wastewater before releasing it into Lake Hartwell. As of April 4, 2017, Clemson University's Wastewater Treatment Plant (CUWWTP) is implementing a process master plan to increase and improve the efficiency of wastewater treatment as Clemson University grows in popularity and population. The scope of the master plan includes the following: review and update current wastewater flow and loading projections; evaluate existing facilities and review their historical operating data; analyze equipment operations; perform process modeling to optimize CUWWTP operations; and develop a capital improvement plan. As of April 2019, CUWWTP is in compliance with the Clean Water Act of 1972. Also, the staffing and overhead expense budget set by CUWWTP has remained consistent, but with the increasing population of Clemson University, the capital renewal and recovery expenses have grown exponentially within the past few years.

This chapter of the Environmental Audit will examine the biochemical oxygen, nitrogen, pH, and phosphorus components of wastewater. The chapter will also overview Clemson University's waste water treatment plan and the associated budget. Then we will elaborate on the improvements that

Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a system measurement of pollutants in water. BOD is necessary for organisms to break down organic materials. Dissolved oxygen (DO) is the amount of oxygen found within a source of water. For large bodies of water, such as Lake Hartwell, the BOD levels sit below the levels of DO present so that organisms do not overpopulate the lake. However, if the effluent flow from the water treatment facility contains a significant amount of chemical waste BOD levels increase. CUWWTP's primary chemical waste contaminant is nitrogen in the form of TKN (nitrates and ammonia). TKN is a nitrogen fertilizer that can drastically increase the number of microbes present in the water, thus causing BOD levels to increase and the DO levels to decrease faster than the oxygen level of the water can naturally replenish. The area impacted by this reversal of DO/BOD levels is known as a "dead zone."

The impact on the dead zone is reversible due to anaerobic microbes that break down chemicals, causing oxygen to be released back into the water and dissolved. This allows for the DO and BOD levels to return to equilibrium. CUWWTP uses sequencing batch reactors (SBR) to monitor the levels of DO/BOD. The wastewater enters the SBR and blowers pump oxygen into the water increasing the DO, allowing the aerobic microbes to break down the TKN.

Clemson University abides by the National Pollution and Discharge Elimination System (NPDES) guidelines for the effluent flow of wastewater. Currently, the NPDES states that the effluent flow of wastewater has to have a 5-day BOD (BOD5) level below a range of 450/675 lbs (30/45 mg/L) on a weekly/monthly basis. Since October of 2006, there have only been two instances where BOD levels exceeded the limits set by NPDES. The first was on March 3rd, 2010 when BOD levels reached 34 mg/L and the second was on November 10th, 2010 when BOD reached 66 mg/L (Figure WT 1). For DO at CUWWTP the minimum concentration needed is 5 mg/L, the only instance since 2006 where DO levels have fallen below the required consistency was on December 26th, 2008 where DO levels were 4.80 mg/L.

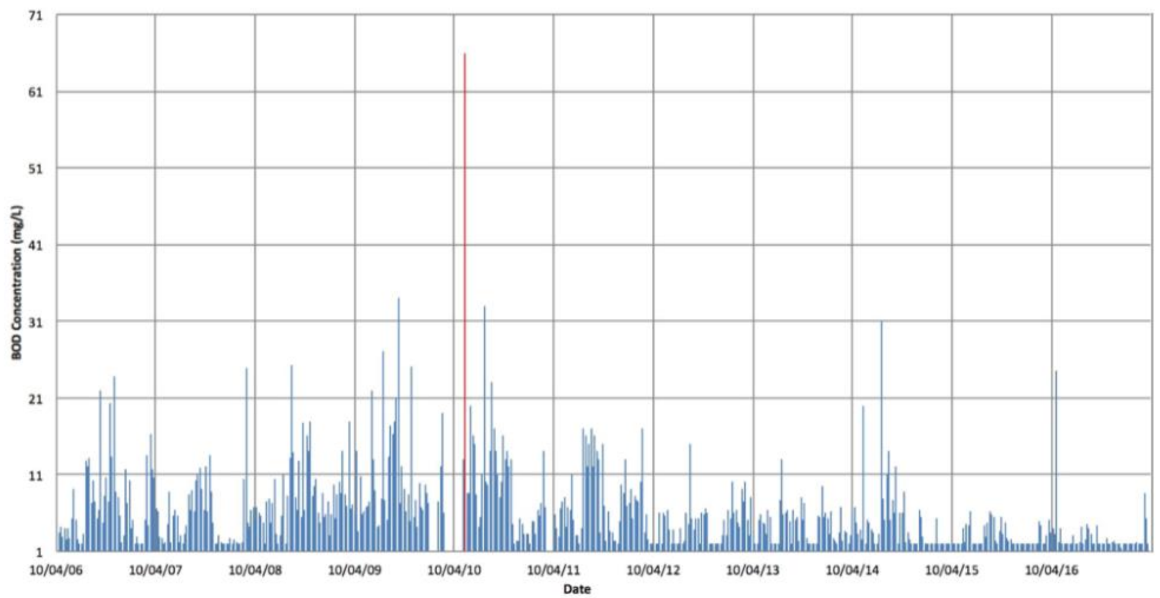

Figure WT 1: Clemson's Body Oxygen Demand Concentrations from 2006 to 2016

Nitrogen

Nitrogen is vital to aquatic plant and animal life. Nitrogen comes from a variety of sources, including human and animal waste (septic systems), crop residue, and fertilizers (Copeland, 2017). However, excess nitrogen can lead to algae blooms that can deteriorate water conditions. The EPA lists an acceptable nitrogen concentration for a body of water to between 2 mg/L and 6 mg/L. This range is not listed on the NPDES permit and is not a requirement for the effluent flow of the CUWWTP. While a total maximum daily load (TMDL) is not set for nitrogen in Lake Hartwell, there is still monitoring of the concentration of nitrogen in the water. Large bodies of water, such as Lake Hartwell, are normally not affected by abnormalities of effluent nitrogen concentration as the overall consistency dilutes once it enters the body of water. Clemson CUWWTP takes nitrogen into account when renews its NPDES permit every five years. Moreover, there are evaluations done by the South Carolina Department of Health and Environmental Control (DHEC) on plant's impacts on the lake. One example is setting a TMDL to maintain water quality standards so nitrogen is not an issue for Lake Hartwell or the plant. The plant's historical data indicates nitrogen concentrations are not harming the environment (Figure WT 2).

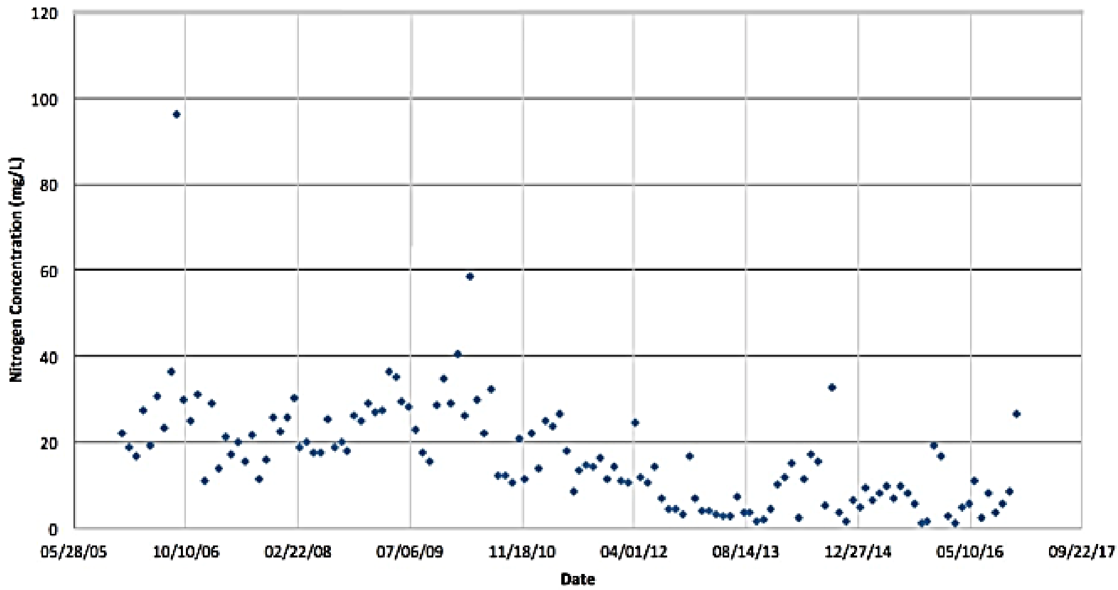

Figure WT 2: Nitrogen Concentrations from 2005 to 2017

Wastewater pH Levels

ThepH levels present in wastewater is a vital component that needs to be analyzed because the water has to be redistributed into Lake Hartwell. For CUWWTP, the influent water is both treated and dispersed into Lake Hartwell. Adequately addressing the effluent water for organisms, animals, and humans to safely use Lake Hartwell is essential. When testing wastewater, it is essential to get a range of pH present in the water to know the proper treatment method to use. Clemson's CUWWTP maintains the pH level needed because it is essential for the effluent water to be able to go back in the lake. Furthermore, the type and amount of chemicals used in the treatment must be monitored. Based on the pH level found in wastewater, acidic or basic compounds are used in the procedure to achieve a pH level from 6.5 to 8.0 (Kirby & Garrison, 2017). Clemson's CUWWTP primarily uses lime and alum in different amounts to adjust pH in the wastewater. If the water's acid levels are too low, aeration and phosphorus are used as the main acid producers make the pH of the wastewater more neutral. The neutralization of the pH also plays a role in the removal of toxic metals. The chemicals added into the sequencing batch reactors

(SBR) cause toxic metals to bond together, so that over time they will settle to the bottom and can be removed. After the central metal separation, a filter press flushes out leftover residue in the water. The specific filter press used in Clemson's CUWWTP is called a rotary press tool; it removes about 98% of the solid material (Master Plan, 2017, p. 42).

The pH level is a component that must be examined and handled at each part of the wastewater treatment process. One of the most critical areas pH is measured and adjusted is during the disinfection stage. Chlorine is used during this stage to sanitize or disinfect the wastewater. At this point, the pH has to be monitored to achieve the desired results. "The major factors that need to be taken into consideration when evaluating the performance of chemical disinfectants are contact time, the efficiency of mixing, concentration of chemicals used, residual remaining, pH and the concentration of interfering substances which may reduce the effectiveness of the disinfectant" (Naidoo & Olaniran, 2013, p. 257). By not adequately maintaining the pH levels, bacteria such as Salmonella can develop in the effluent water and end up in public areas. Even after treating the wastewater, some studies have shown Salmonella to survive and contaminate the resulting water from process (Naidoo & Olaniran, 2013, p. 262).

Clemson's CUWWTP maintains specific pH level in different parts of the wastewater treatment process to prevent issues stemming from too high or low pH levels. The SBRs maintain an approximate pH level of 7.0 while aerobic digesters preserve a range of pH between 7.0 and 7.5 (Master Plan, 2017, p. 42). The annual average pH of the effluent water was found to be 6.55. The maximum monthly average was observed in September 2015 and was found to have a pH of 6.81. On September 7th, 2015, the peak daily average of pH was 7.3 (Master Plan, 2017, p. 108). This data reaffirms the pH levels of CUWWTP falls within the ranges of 6.5 and 8.0.

Phosphorus Concentration

The phosphorus concentration of effluent is a crucial variable that can have huge impacts on the environment. Phosphorus "is an essential element for plant life, but when there is too much of it in water, it can speed up eutrophication (a reduction in DO in water bodies caused by an increase of mineral and organic nutrients) of rivers and lakes" (Kirby & Garrison, 2017). Therefore, it is essential for Clemson University to release some phosphorus into the surrounding environment because too little phosphorus can reduce the nutrients available to biological life. Also, too much phosphorus in the effluent causes eutrophication by providing organisms with excessive nutrients. The excess nutrients can lead to extreme natural population growths, such as algal blooms, which reduces the amount of DO and increases the BOD. As mentioned previously, a higher phosphorus concentration also causes the pH of the water to become more basic. Clemson began monitoring and treating for phosphorus concentrations within the past ten years.

Over the past ten years, Clemson has maintained the phosphorus concentration limits required and has taken initiatives to ensure standards. According to an internal audit performed by Black and Veatch, the average phosphorus concentration of Clemson's influent from July 2015 to

August 2016 was 6 mg/L (Master Plan, 2017, p. 31). Clemson's wastewater plant is required by NPDES Permit No. SC0034843 to reduce the influent phosphorus concentration to an average of 1.64 mg/L per month (Master Plan, 2017, p. 31). Once the wastewater enters the facility, the material is pumped into a primary clarifier followed by going into a sequencing batch reactor (SBR) where alum (aluminum sulfate) is dosed to facilitate chemical phosphorus removal. On January 12, 2017, Black and Veatch analyzed the CUWWTP to test for phosphorus concentration among other pollutants collecting samples every two hours before the effluent reached the SBR and immediately after the effluent exited the SBR. Analysis of each sample concluded that the initial phosphorus concentration reaches a peak of approximately 6 mg/L around 3 p.m. and steadies out at about 3.5 mg/L during the rest of the day (Master Plan, 2017, p. 39).

Knowing the phosphorus concentration entering the plant is important because this determines the deposit of alum in the SBR. Currently, the plant does not have an automatic, continuous monitoring system for entering phosphorus concentrations. Therefore, the SBRs are overdosed with alum to ensure the maintenance of phosphorus concentration. In general, the following equation is used to describe alum reacting with phosphorus in wastewater:

Al3+ + Hn(PO4)3-n AlPO4 + Hn+

In situations where the effluent exceeds 1.64mg/L, alum doses will be increased throughout the month to ensure the monthly average is below or equal to 1.64 mg/L. According to Matthew Garrison, the plant manager, initiatives are being made to purchase a phosphorus analyzer that would be able to dose the SBRs with the correct amount of alum to maintain less than 1 mg/L phosphorus concentration. This analyzer would save money on alum and energy, and it would be more reliable than current operations.

CUWWTP Processes

CUWWTP treats wastewater generated at the facilities on Clemson University's main campus. The diagram at the end of this section gives a brief explanation with the addition of pictures to help explain the processes that happen during wastewater treatment. The following text provides a further in-depth description of each of the methods within the diagram.

The wastewater treatment process begins when the wastewater enters the headworks through a common 30-inch line (Master Plan, 2017, p. 27). The wastewater comes to the headworks through gravity in place of a pump. The headworks are responsible for scanning the water for large pieces of debris such as plastics, pieces of wood, and other trash. A banded screen removes these, then the garbage is taken to a landfill for disposal. From here, a grit chamber processes the water. The grit chamber is responsible for removing inorganic particles by allowing such particles to settle at the bottom of the tank while the rest pumps through the influent pump station. Grit removal is essential because the grit can damage pumps used in later stages of wastewater treatment as well as accumulate in sludge digesters. Once the removal of large pieces of trash and grit has taken place, there is a discharge of wastewater into the pump station where three submersible pumps filter the wastewater into a flow splitter which then distributes the water into the two primary clarifiers through a 16-inch force main (Master Plan, 2017, p. 27). Force mains are pipes that carry wastewater under pressure from the discharge side of a pump. These pumps are equipped with variable frequency drives (VFDs) and can pump 2,380 gallons per minute (GPM) (Master Plan, 2017, p. 27). The primary clarifiers mainly receive wastewater from the three submersible pumps, but they also receive additional wastewater from the underflow of SBRs, the wastewater produced by the secondary clarifiers, and the wastewater generated by the four sludge presses. This wastewater goes back through the primary clarifiers to remove additional sludge and to chemically treat the water. The primary clarifiers' main job is sludge removal. The clarifiers work by allowing mud to settle on the bottom of the tank where scraper blades move the sludge into the primary sludge pumps. The sludge then goes through two digesters before being pressed. The water removed from the pressing of the mud goes back into the primary clarifiers. Then there is a disposal of the sludge.

Once the wastewater goes through the primary clarifiers, it then goes into one of the two SBRs utilizing a 20-inch line (Master Plan, 2017, p. 27). Pneumatic-actuated butterfly valves control the wastewater flow into the SBRs to align it with the alternating SBR fill cycles. The filling stage of the SBR is called the "anoxic stage." Once filling the SBR, air from the SBR blowers is diffused through the bottom of the tank allowing for aeration and nitrogen removal. This process allows for any solids to settle and be pumped back into the primary clarifier to maintain the specified solids retention time (SRT) through sludge pumps. In this stage, alum and liquid lime are tapped into the SBRs as needed to treat the water to reduce phosphorus levels and stabilize the pH.

Wastewater is first pumped into primary clarifiers located at an equalization basin; from there the wastewater then flows into a secondary clarifier through a 25-inch effluent piping (Master Plan, 2017, p. 28). Similar to the primary clarifiers, the secondary clarifiers' main job is the removal of any remaining solids within the wastewater. These remaining solids are often organic growths which were created in the earlier wastewater treatment processes. Any solids that settle to the bottom of the secondary clarifiers are pumped back into the primary clarifiers to be removed and disposed of with the sludge — discharging the water in the secondary clarifiers into the chlorine contact basin. In this basin, there is a dispersion of chlorine gas by a chlorinator located at the entrance of the contact basin which is necessary as one of the final stages because it sterilizes the water. The water, now having been treated with chlorine, goes into a post-aeration basin. This basin uses sulfur dioxide to remove the excess chlorine so that the water can be safely deposited back into Lake Hartwell without harming the lake's ecosystem. The final stage before discharging the water into the lake is that the water needs to be re-aerated. Re-airation is done by a diffused air aeration system just before the discharge of water into the lake through a 24-inch outfall pipe (Master Plan, 2017, p. 28).

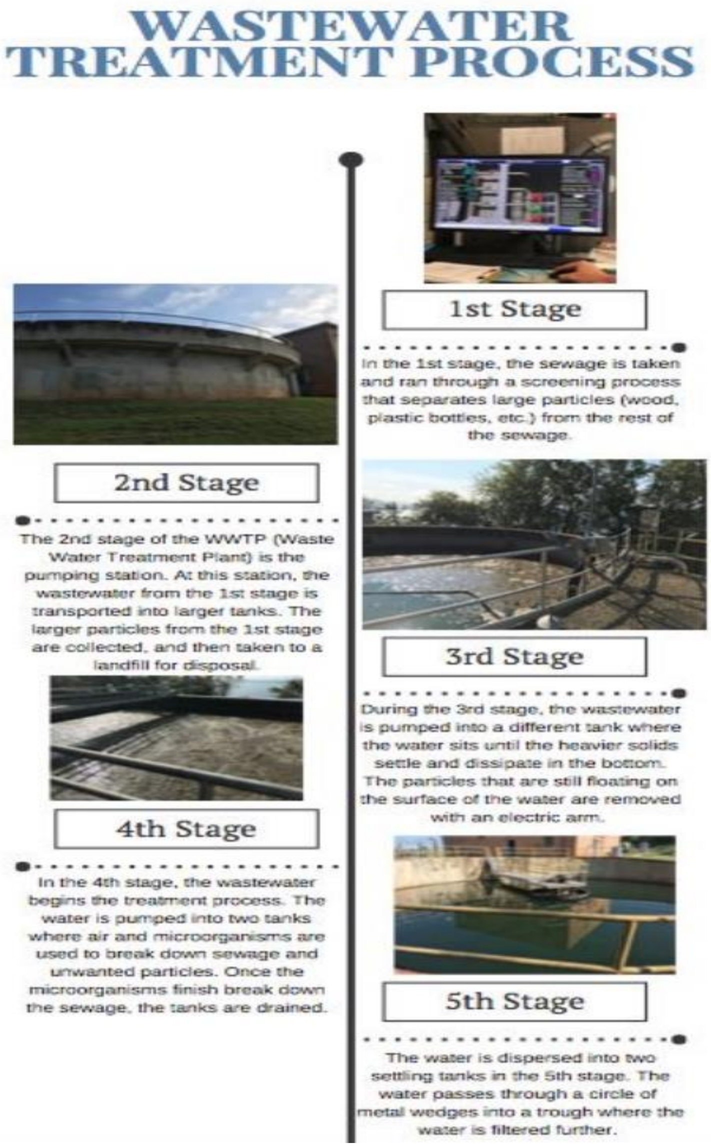

Figure WT 3: Wastewater Treatment Pictograph of Treatment Process

Budget

The total budget for wastewater has increased relatively steadily over the years (Figure WT 4). The significant areas of growth are in capital renewal/recovery and operations and maintenance (O&M) and supply expenses. The largest area of growth is in capital renewal/recovery expenses which have grown from $82,000 in the fiscal year 2011 to 440,000 by the fiscal year 2019, a 537% increase. Following this is the growth by O&M and supply expenses which have grown from $370,000 in the fiscal year 2011 to $638,000 by the fiscal year 2019, a 172% growth. These increases are due to the growth in student population over the years. The remaining two areas, staffing and overhead expenses, and utility expenses, have remained consistent with little to no expense growth over the past few years.

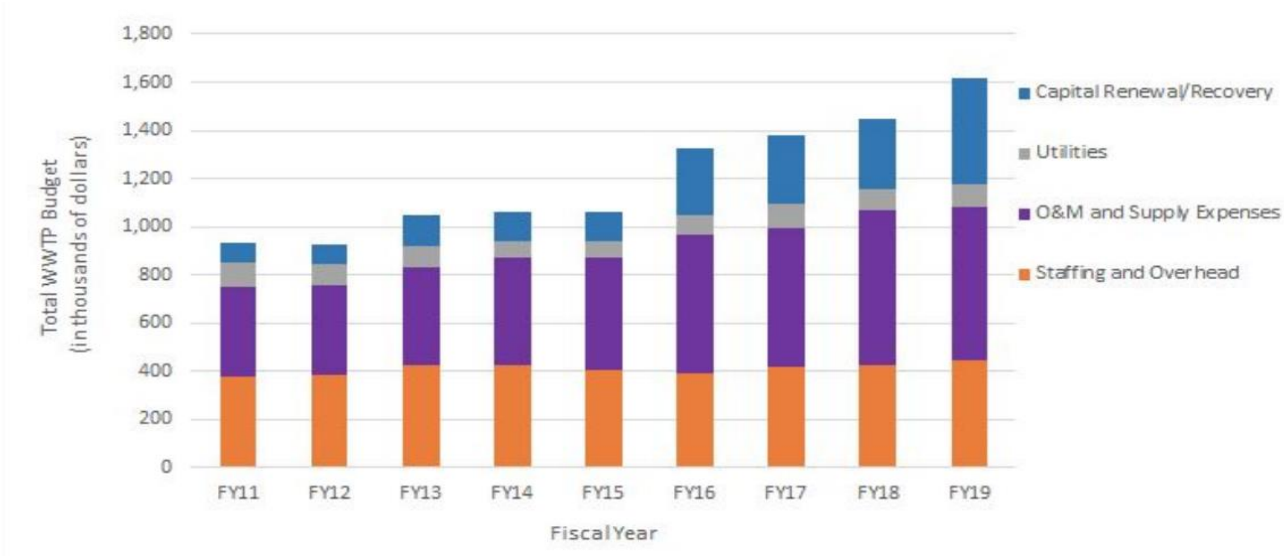

Figure WT 4: Budgetary Information from 2011 to 2019

The total budget issued for the 2017 fiscal year was $1,383,000. Staffing and overhead were allocated $421,000, O&M and supply expenses $571,000, utilities $104,000, and capital renewal/recover $287,000. Above, Figure WT 4 shows budgetary information for the past six years as well as information for the next two years.

Improvements

As with any facility, Clemson's wastewater treatment facility needs modifications to keep up with the changing times. Clemson University is evolving, and the CUWWTP has to develop and grow, as well. The recommended improvements and upgrades were consulted on with Clemson University personnel and the CUWWTP operators (Master Plan, 2017, p. 71). The University's

CUWWTP is not concerned with growing in capacity because the wastewater average daily flow does not exceed their plant's resources (Master Plan, 2017, p. 71). The CUWWTP is efficient. With the current population size at Clemson University, the plant will continue to be productive for many years to come. To begin thinking about improvements and updates, the existing CUWWTP was evaluated to see what were the incomplete modifications and how pressing each concern is as well — categorizing each problem into two sections: short-term projects and long-term projects. The short-term changes include the following: automation and remote monitoring, flow equalization, and process redundancy (Master Plan, 2017, p. 71). The long-term projects include upgrades within two departments of the biological treatment process and the disinfection system (Master Plan, 2017, p. 71). This section does not mention all of the modifications and updates; however, the ones that are named go into detail. The budget, along with the future impacts on the plant, determine which projects are considered short-term and long-term. The costs for the short and long-term plans are estimates drawn from engineering designs. The prices for materials and equipment are from equipment manufacturers, historical bidding, and cost estimating data from similar Black & Veatch projects (Master Plan, 2017, p. 71).

Automation and remote monitoring projects are in the short-term projects category because these two projects can help the CUWWTP be successful now. The long-term plans are essential, but because of funding constraints, these projects can be postponed until the near future or spread out between different projects. The short-term projects will improve operator monitoring and control capabilities for the existing equipment and systems at the facility (Master Plan, 2017, p. 72).

Updated Flow Measuring Devices

The CUWWTP's operators asked for flow measuring devices to improve the wastewater treatment process. Currently, the flow measuring device only monitors and measures the water going upstream towards the Parshall flume at the headworks. The new flow measuring device will be a 16-inch electromagnetic flow meter. The new meter will be installed at the pump station or beside the primary clarifiers at the plant. This update is considered a short-term project because the plant does not have a flow measuring device at the secondary clarifier on the recirculation pipes. With the equipment the plant's facility has now, the operators cannot monitor the water moving upstream at the primary clarifiers and the recirculation pipes at the secondary clarifiers. The two cannot be measured simultaneously to get a combined rate. This short-term project will include an 8-inch electromagnetic flow meter along with the 16-inch electromagnetic flow meter (Master Plan, 2017, p. 73).

Improved Flow Equalization Products

When the University has an event with a lot of people in attendance or a massive rainstorm, the influent flows at the CUWWTP peak, for the wastewater facility does not have flow equalization capabilities near the SBRs going upstream (Master Plan, 2017, p. 74). Therefore, the influent flows caused by home football games and other events can create challenges for the operators at the

CUWWTP (Master Plan, 2017, p. 74). The problem is keeping the SBRs operation running while attending to the fill and decant cycles. Improvements to the flow equalization project are essential for large or rainy events, but the improved project will also allow the plant to upgrade the SBRS in the future without interrupting other operations (Master Plan, 2017, p. 74). The CUWWTP has a post-equalization basin downstream, but it is not efficient when these flow peaks occur. The inadequacy of the equipment and process can cause issues. When the water goes through the disinfection stage in the chlorine contact basin, the contact time may be insufficient. There are three solutions to solve this problem: installing a new equalization basin, improving the SBR influent pipes, and modifying the SBR decant pipes. The new equalization basin will "fill from a bypass line installed on the existing influent force main" (Master Plan, 2017, p. 74). One option is to build the basin through a new drain line to the recycle wet-well. The basin will re-circulate to the primary clarifiers using the CUWWTP's existing recycle pumps (Master Plan, 2017, p. 75). The second option is to build a new pumping capacity "to pump the equalized flow volume to the primary clarifiers or directly to the SBRs" (Master Plan, 2017, p. 75).

Since the CUWWTP operates below its capacity, the operators believe a partial flow equalization is possible, which will use existing pipes and tanks as optional flow equalization in case of a massive rainstorm or a big event on campus (Master Plan, 2017, p. 75). This second option will improve the SBR influent pipes. By filling the primary clarifiers when the influent flow surpasses a certain point this will reduce and eventually eliminate the recycling of treated sewage from the secondary clarifiers (Master Plan, 2017, p. 75). This alternative to the new equalization basin is more cost effective, as well. The new equalization basin is estimated to cost $4.5 million while doing a partial flow equalization will cost $460,000 (Master Plan, 2017, p. 77). The later project also has more flexibility such as using the primary clarifiers for the following roles: flow equalization or primary clarification. Moreover, the improvements on the SBR influent piping are minor (Master Plan, 2017, p. 75). The last improvement option is to update the SBR decant pipes. This option is the most cost-friendly choice. It will cost an estimated $103,000 compared to the other two options. This plan includes replacing the four existing butterfly valves on the exterior decant pipes with the new electric-actuated valves, which are more efficient than the manually operated valves the plant is currently working with. The electric plugs are now standard and come in the equipment packages from Fluidyne SBR systems. The project can be completed by itself or can be added onto one of the SBR upgrades (Master Plan, 2017, p. 77). Each improvement option has its benefits but updating and improving the flow equalization will help the CUWWTP become more efficient when faced with massive rain storms or events like the Tigers' home games.

Process Improvements

As with any facility, the CUWWTP's equipment is "approaching the end of its useful life" (Master Plan, 2017, p. 78). In the late 1980s, the introduction of SBRs into the plant and the aeration manifolds and conventional structures are original to the CUWWTP. After the flow equalization project, equipment will begin to be phased out with new, updated material. Since one of the SBRs will be taken out of ser for extended periods, the majority of the work will take place in the summer when the average daily flow is lower (Master Plan, 2017, p. 78). The CUWWTP is considering four different options for the SBRs. The refurbishing or replacement of SBRs one at a time. The SBRs are not the only pieces of equipment that need to be updated. The secondary clarifiers are as old as the plant itself, and the material for the clarifiers is close to 50 years old. Clarifier replacement could be phased out like the SBRs will most likely be, but there is a cost advantage to buying both clarifiers at the same time (Master Plan, 2017, p. 80). The CUWWTP is aware they will have to begin replacing equipment with updated models as time comes. Moreover, not restoring the material soon does not allow the facility to grow and continue improving.

Students' Perspective

While researching wastewater, touring the facilities, and interviewing important figures at Clemson University's Facilities, the wastewater treatment team was impressed by Clemson's initiatives. The CUWWTP is constantly growing and evolving to meet the needs of the University. The faculty and administrators have been willing to help at each stage of this process. The information the team received from Clemson University's Facilities and CUWWTP is detailed and answers the majority of the questions a reader may have about the plant and its processes. Also, outside sources such as the EPA provides ample background information on the topic. The wastewater treatment facility should be recognized more, and there should be a course or a seminar each student should take to learn about the wastewater treatment process. The wastewater treatment Audit team thinks Clemson University should allow a section of a CU1000 course to cover environmental concerns and our impact on Lake Hartwell. Clemson University is trying to reduce its ecological footprint, but the administrators and faculty can only do so much. It is their job and the students' job to be better stewards to the environment. The University should continue to pursue low-flow fixtures in future capital projects such as the new business school building. Therefore, these initiatives may keep the University from making these improvements later on while maintaining water demands within the CUWWTP's capacity.

Sources

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Scott Banks, Associate Director of Utility Services, Clemson University

Matthew Garrison, Wastewater Treatment Plant Manager, Clemson University.

Harry Kirby, Environmental Compliance Engineer, Clemson University Utility Services

Tony Putnam, Director of Utility Services, Clemson University

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Water Usage

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Executive Summary

The Water Use chapter of the Environmental Audit documents the uses of water between 2006 and 2017. Additionally, future initiatives to decrease water waste are described in detail.

Due to the recurring issue of minor droughts, Clemson began researching water sustainability in hopes to curb and eventually correct the issue in the future. Clemson was awarded a one-million-dollar grant from the U.S. Environmental Protection Agency (EPA) in order to fund research pertaining to extreme weather conditions and the effect of climate change on drought severity and frequency of wildfires and flooding, etc. In February of 2017, Ashok Mishra, an assistant professor of Civil Engineering at Clemson, announced that he is building a new computer model that will incorporate more factors than what current drought forecasters use. This model will be able to predict drought effects as soon as six months before they are felt.

New construction has been keeping water usage in mind. The Kite Hill water tank, completed in 2018, is the newest construction effort. The tank can hold up to two days' worth of water to sustain the campus, as opposed the original tank that could only hold eight hours' worth. It also serves as a long-term solution for the backup pressurization and capacity for a licensed distribution system. This would more easily supply water to campus and help keep up with the campus population. Additionally, the new housing buildings are to be fit with water saving appliances in the resident bathrooms. These appliances use less water, minimizing water waste.

One thing that Clemson University does not yet implement is recycling water, according to Tony Putnam, Director of Clemson Utilities. Greywater from bathroom sinks, drains, and clothes washing machines can be recycled. Research shows that successful systems can meet up to 50% of a property's water needs. These practices offer both energy and financial savings.

Introduction

Like most natural resources, water supply is limited. With the increasing population of Clemson University, water usage is a growing concern. Because of this, it is imperative to inform students and faculty of campus water use and disposal, and work to better conserve this resource.

A major issue on campus includes the dramatic increase in costs due to excess water use. For example, to produce 1 million gallons of clean drinking water, it costs over $95 (Putnam, 2016). Once the clean drinking water has been used, it costs approximately $370 to distribute it as waste water back into Lake Hartwell. That means for approximately one million gallons of water, it costs around $465 to produce and recycle it (Putnam, 2016). Additionally, there is a large energy cost associated with both pumping water and treating it. Therefore, using excess water not only cuts into the amount of useable water available, but it also creates excess costs and consumes additional energy.

As both the student and faculty populations have increased over the past ten years, so has the water usage. Our team has collected data from the past ten years to compare Clemson's water usage to the population increase, as well as financial and energy costs. In addition, we also researched the following topics contributing to water use: the water tank on Kite Hill, water usage and rainfall in the city of Clemson, the effects of the last drought, and the increased water usage in housing and dining.

With this audit, the Water Usage department at Clemson University can analyze the data and adjust as needed. Additionally, this audit informs Clemson University employees and students about the excess amount of water they are consuming, as well as methods they can practice limiting their water usage. Our hope is that people will practice conservation methods and help reduce the excess amount of water used.

Population Increase

Clemson University's population is increasing at a steady rate. The student population has increased annually by about 500; the staff is also expected to increase at a consistent annual rate in the future. Major factors contribute to the use of water on Clemson's campus: residential student population; transient student population; faculty and staff; dining facilities; boiler plant and chilled water plant during heating season; research facilities; 2-hour fire flow reserve; and miscellaneous usage. *Figure WU 1* gives an estimate of the essential water use during the cooling season. The numbers given are based on the 2012 fiscal year. The essential water use in the Cooling Season is 547,300 gpd (Putnam, 2016).

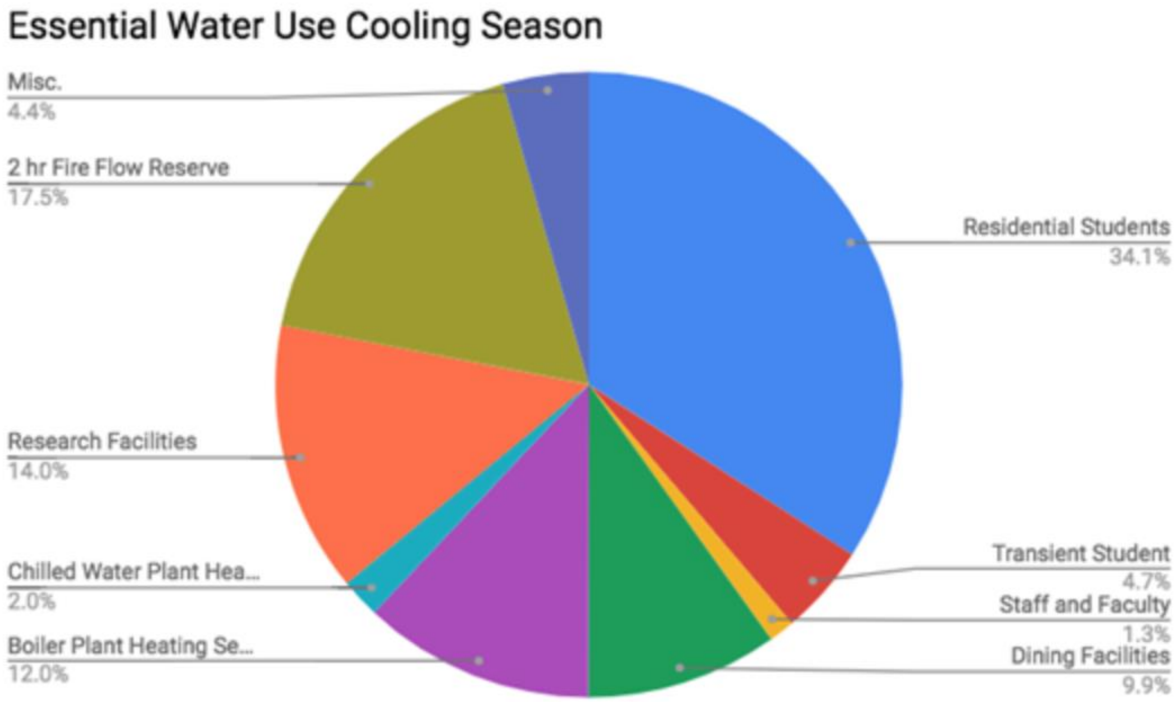

Figure WU 1: Essential water use during cooling season FY2016

As previously mentioned, the housing projects are increasing on campus due to the growing student population. Water consumption in areas such as housing and dining will likely increase in the coming years. With the new addition of Core Campus, the business school and further expansion of on-campus housing, we can expect a significant increase in the water consumption at Clemson University. Dormitory occupancy gives a more accurate representation of the water usage of housing, while not representing the overall water use on campus. The best perspective on water usage across campus can be determined by total student enrollment at Clemson.

Projections indicate that the student population will be nearing 25,000 by the year 2020 ("Clemson Interactive Factbook," 2019). As the population on campus increases, the amount of water used will increase as well. With the population and water usage both increasing, efforts need to be made to curb or reverse the amount of waste water produced.

In *Figure WU 2*, the amount of water consumption is, on average, decreasing each year, but the amount of waste water is remaining more constant (Putnam, 2016). For scale, the student population is in hundreds of students and the water is in millions of gallons. This chart illustrates things currently being done to decrease the amount of water used on campus. Even as the student population has steadily grown, changes have been made to decrease water usage. An example of one of these changes is a new and more efficient flushing mechanisms for toilets.

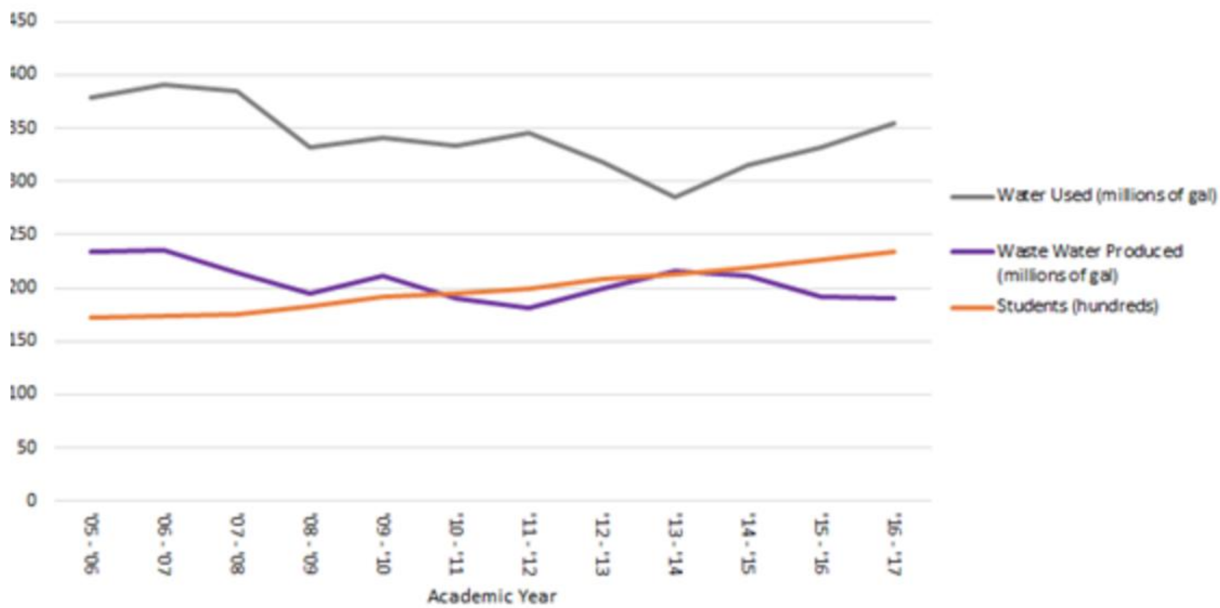

Figure WU 2: Water use v. student population at Clemson University

Energy Cost

A substantial amount of energy is used to transport one million gallons of clean drinking to and throughout Clemson University's campus. This water is obtained from the Anderson Regional Joint Water plant located in Anderson, South Carolina. It is pumped along a pipeline to the Kite Hill Water Tower where it is stored until it is ready to be used. After water has been used, wastewater must be treated before it can be recycled into the surrounding environment. This recycling process requires three times as much energy as producing water does. The wastewater is sent to a gravity drain sanitary sewer collection system which drains to Calhoun Bottoms. There the screening pump station pretreats the wastewater, which is then pumped to the university's wastewater treatment plant located near Lake Hartwell's diversion dam.

Inefficient consumption of water not only depletes the amount of useable water available, but it also effectively wastes energy and raises energy-related costs. It requires about 1187.5 kilowatt-hours (4275 megajoules) of energy to produce one million gallons of useable water (Putnam, 2016). A kilowatt-hour (kWhr) is the unit most commonly used for billing energy.

Wastewater alone during the 2014-2015 year added up to over 200 million gallons. The energy required to treat wastewater is about 4625 kWhr (over 16,000 megajoules) of energy per one million gallons, which is about four times more energy than what is required to initially prepare water for first use.

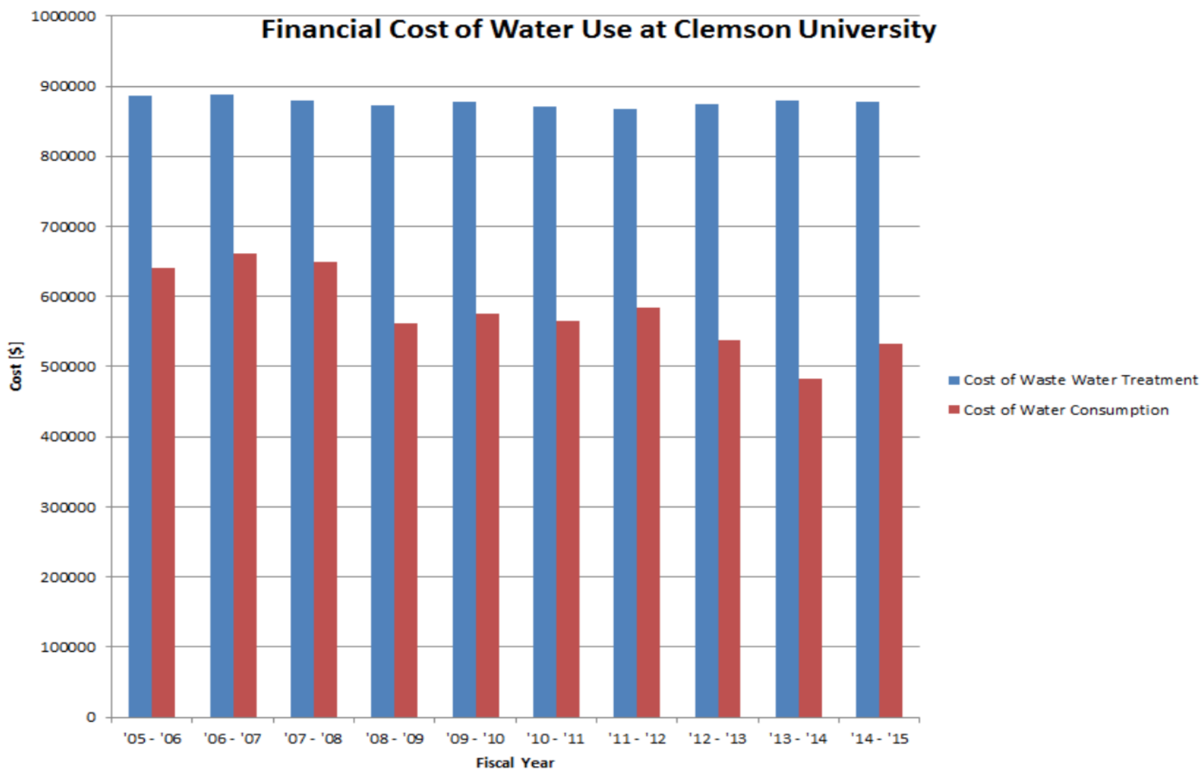

Figure WU 3: Financial cost of water use at Clemson University- 2006-2015

Figure WU 3 shows the yearly expenses from water use and waste water treatment at Clemson University. The cost of water usage is less than the cost to treat wastewater; the average cost per year for water use is $643,147 and the average cost of wastewater treatment is $974,741. Both costs have decreased since 2005, showing signs of improvement when considering the population growth on campus. The data depicts the expense of treating wastewater, and the amount of wastewater treated is less than the amount of water consumed (*Figure WU 2*). This is because for each million gallons of water, it is almost three times more expensive to treat wastewater than it is to produce drinking water. It is worth noting that the main contributor to the cost of treating wastewater at Clemson University is the operating cost of the wastewater treatment plant. The wastewater treatment plant has a standard operating cost of about $800,000, and that is independent of the amount of wastewater being treated.

As a top ranked public university, Clemson must maintain a level of sustainability to reflect the growing awareness of energy consumption. To achieve this, Clemson has implemented a goal to decrease its energy consumption by 20% by the year 2020 (“Energy Awareness,” 2019). Due to the high-energy costs to clean and produce a usable water supply, decreasing water consumption is necessary to achieve this goal. Clemson must come up with new ways to reduce its water consumption and see how past plans have positively affected the water consumption.

Irrigation

Clemson prides itself on a prestigious agricultural program. Keeping up with the demands of this program requires utilizing a large amount of water. Clemson University Facilities has been distinguishing how much of the overall water use is a campus contribution. This is tracked by the outdoor water meter locations throughout campus. In *Figure WU 4*, it shows the total water usage in gallons each month from July 2014 to June 2015.

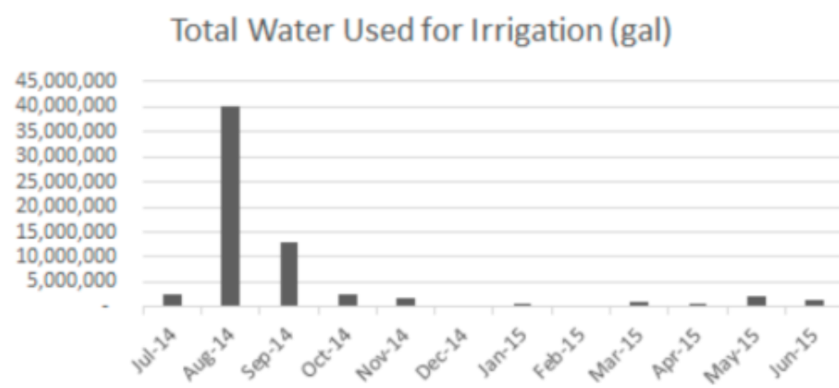

Figure WU 4*:* Total water used for irrigation July 2014-June 2015

The graph indicates that in August 2014 a tremendous portion of the irrigation water was used. An investigation found that the biggest contributors to August's high irrigation usage were the meters near McFadden and Calhoun Mansion, and there were no recorded major water leaks (Putnam, 2016). Initially, staff thought the huge jump was due to rainfall, but this was not the case. According to rainfall data, the highest recorded rainfall for 2014 was August 10th, although measured rainfall significantly decreased later in the month ("Weather History Clemson," 2014). Other contributions to increased irrigation are vast amounts of landscaping in these areas. Preparing for the upcoming football, soccer, golf, baseball, and track and field seasons, Clemson University Facilities most likely increased irrigation in these areas in August due to the warmer weather. Furthermore, the landscaping near Calhoun Mansion most likely contributed to this higher water consumption.

Over other months, irrigation was consistent. As expected, it decreased significantly during the winter months when less landscaping maintenance is needed. Once temperatures begin to rise at the start of spring, irrigation increases again in order to prepare for new plant growth.

The cost per month for this landscaping is shown in the following graph (*Figure WU 5*). Again, August contributes to a huge financial cost, but this is due to the reasons previously explained. The total cost for irrigation from July 2014 through June 2015 was $133,392.50.

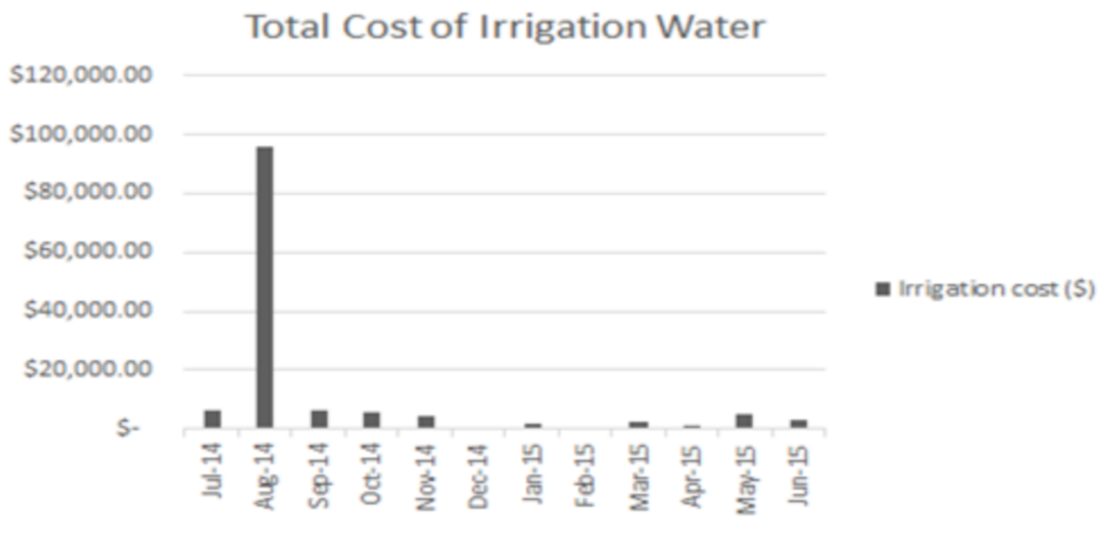

Figure WU 5: Total cost of irrigation July 2014-June 2015

Rain Water in Clemson, SC

Rainfall was relatively constant in the city of Clemson from 2007 to 2016 ("Climate Clemson," 2019). Levels are higher from January to September and lower from October to December (*Figure WU 6*). Levels were lower in drought years 2008, 2009, 2012, and 2016

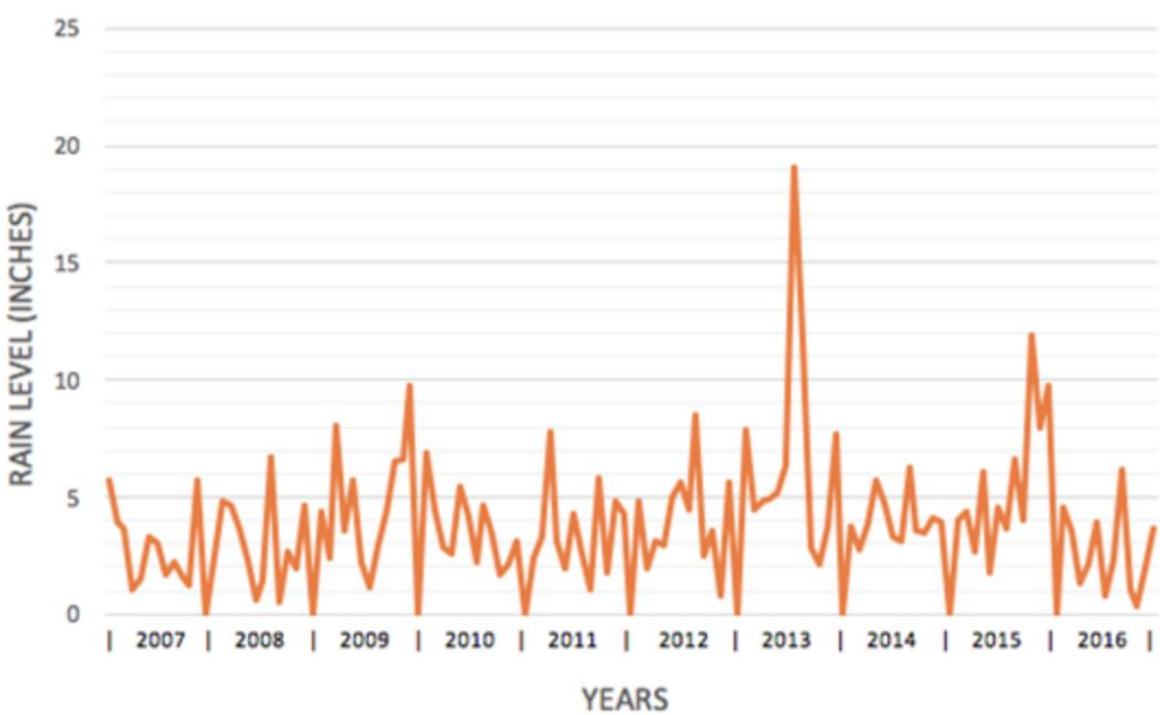

Figure WU 6: Rainfall for Clemson, SC 2007 to 2016

Drought Impact

Droughts have been a recurring issue in Clemson and surrounding Pickens County area. Clemson has faced problems such as low energy production, low water supplies, and higher water costs, all because of droughts. Each month, South Carolina's Drought Response Committee comes together to discuss the state's drought status. There are five levels of drought, which are as follows: normal (D0), incipient (D1), moderate (D2), severe (D3), extreme (D4). *Figure WU 7* shows the drought severity and coverage index (DSCI) for Pickens County. DSCI is an experimental method for converting drought levels from the U.S. Drought Monitor map to a single value for an area ("United States Drought Monitor," 2019). The equation for this method is presented below.

$$1(D0) + 2(D1) + 3(D2) + 4(D3) + 5(D4) = DSCI$$

The drought levels are represented by the percentage of the cumulative land area that is under that particular drought level.

Since March 2007, the Pickens County area has rarely been at a normal drought level. From May 2007 to September 2009, Pickens County was receiving maximum DSCI values (*Figure WU 7*). At that time, Clemson began facing issues with receiving adequate energy production out of Hartwell Dam. The dam's management began reducing the flow of water from upwards of 4200 cubic feet per second down to 3100 ("Hartwell Dam," 2019). Although the drought was still in occurrence, in February of 2009, the flows were raised back to 3600 cubic feet per second to prevent environmental damage and to continue to provide energy to the communities ("Savannah District," 2019). Occurrences such as this are still taking place as the DSCI values, just within the beginning of 2017, are reaching maximums again.

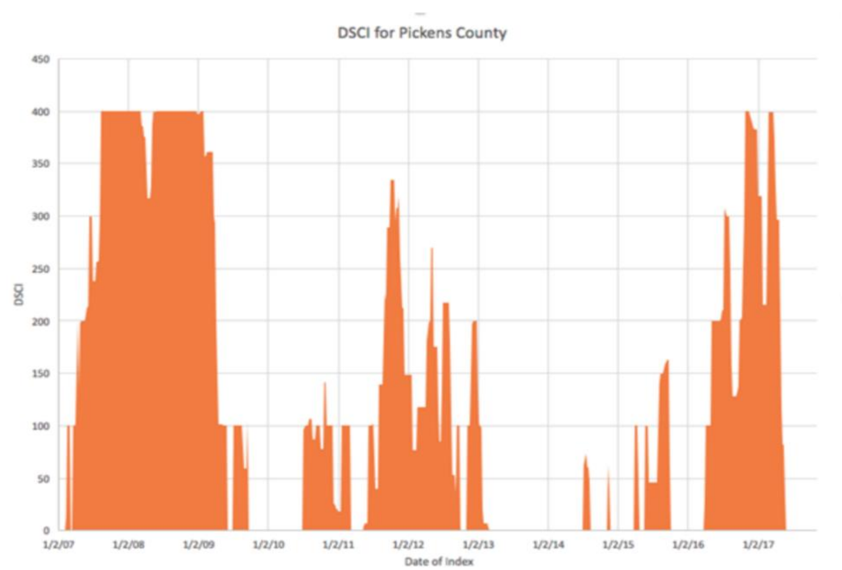

Figure WU 7: DSCI for Pickens County ("Data," 2019)

One of the main problems Clemson has faced during these drought seasons is that the amount of water used stayed the same, or even increased. For example, the irrigation section refers to a large portion of the irrigation water being used in August of 2014 due to the drought occurring at the time. In *Figure WU 7*, there is a small spike in the DSCI levels around August of 2014 and that was only a minor drought status. Due to this recurring issue, Clemson began researching water sustainability in hopes to curb and eventually correct the issue in the future. In November of 2015, Clemson was awarded a one-million-dollar grant from the Environmental Protection Agency (EPA) in order to fund research pertaining to extreme weather conditions and the effect of climate change on drought severity and frequency of wildfires and flooding, etc. Also, in February of 2017, Ashok Mishra, an assistant professor of Civil Engineering at Clemson, announced that he is building a new computer model that will incorporate more factors than what current drought forecasters use to help predict drought effects for as long as six months before they are felt (Alongi, 2017).

Installation of the Water Tank on Kite Hill

The Kite Hill water tank project was a major asset to Clemson University's campus in 2018. The project was in partnership with The Anderson Regional Joint Water System (ARJWS), the regional water utility provider, and Clemson Uversity Facilities. The main purpose of this project was to keep up with Clemson's available water demands for the rapidly expanding community. By law, the state of South Carolina requires mid-size communities, such as Clemson, to have a water tank that can sustain the community for two hours during peak usage with an additional supply for fire protection, or sustain the community for a half day at maximum usage. However, the University Facilities went above and beyond when developing this project and built a water tank that can sustain the campus for two whole days in the event of an emergency. The new water tank replaces both the Clemson House water tank and Kite Hill water tank.

The main initiative for replacing the old Kite Hill water tank was because of its outdated standpipe structure built in 1958; it could not withstand the demands of the steadily growing campus population. Its structure limited it to only 150,000 useable gallons. The new water tank can hold up to one million gallons of water, consolidating as well as increasing the amount of useable water for the Clemson community.

The new Kite Hill water tank carries with it many benefits. As mentioned above, the tank can hold up to two days' of water to sustain campus in the event of a major water crisis, such as a pipe burst. It also serves as a long-term solution for the backup pressurization and capacity for a licensed distribution system. Because the new tank is larger in volume, there will be improved pressure to buffer the water transmissions and pumping systems that are operated by ARJSW. This will allow ARJSW to pump water at lower costs during off-peak hours, which can help control water rates. With this new investment on campus, University Facilities hopes to encourage growth and cut down on waste.

Students' Perspective

With the growing population of Clemson University, the increase in the amount of water usage has increased dramatically resulting in an increase in water costs. Clemson University has attempted to improve this problem by implementing methods for water conservation in the new buildings that are being built around campus. An example of this is the dual flush toilets and the low flow shower heads that the university has installed in the new dormitories. The dual flush toilet is equipped with a single handle that can be pulled, pushed, or twisted in a variety of ways to use a lower amount of water for liquid waste than for solid waste ("Dual Flush Toilets," 2019). These toilets help reduce water usage and treatment. The primary purpose of this initiative was to increase conservation efforts in hopes that the amount of water usage would decrease. However, in the years to come Clemson's water usage is expected to increase. Our suggestion to lessen this problem is to make students and staff more aware of ways they can conserve water. Also, with this audit the Utilities staff on campus can investigate other possible changes.

Another approach to consider is recycling water, something the University doesn't do (Putnam, 2016). According to the EPA, water recycling is "reusing treated wastewater for beneficial purposes such as agricultural and landscape irrigation, industrial processes, toilet flushing, and replenishing a groundwater basin" ("Water Recycling and Reuse: The Environmental Benefits," 1998). Specifically, graywater is reusable water from bathroom sinks, drains and clothes washing equipment. These practices can offer both energy and financial savings. Successful greywater systems can meet up to 50% of a property's water needs. Other universities in the United States have already implemented water recycling practices. Pepperdine University has recycled wastewater for more than 40 years ("Center for Sustainability: Water," 2019). The new recycled water is used for 99% of irrigation and reclaimed water is stored in two lakes on campus. Furthermore, Pepperdine has implemented an irrigation monitoring program to further conserve water. Stanford University also implements water recycling by using local creeks, dams, and lakes' supply of non-potable water for irrigation on its campus ("Strides in Water," 2016). Furthermore, Stanford has developed a recycled water system that uses recycled water for toilet and urinal flushing. The implementation of these policies is projected to significantly reduce domestic water use in the new academic buildings.

Since recycling water, or using gray water, reduces energy and financial costs, our group suggests that Clemson University devote further research to this area. Looking into policies implemented by other universities like Pepperdine and Stanford and how those methods impacted the energy use and financial cost will answer questions as to the feasibility and effectiveness of such a program.

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Workplace Safety

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Executive Summary

The Workplace Safety chapter highlights the key workplace safety findings of Clemson University's Environmental Audit. The Workplace Safety chapter focuses on trends of injury data and changes in safety policies on campus between 2010 and 2016. This chapter is important in understanding the effort and progress Clemson University has made in creating a safe environment for its staff, students, and guests.

As time and technology have advanced, workplace practices have changed. In 2006, the total number of injuries among faculty and staff was 254 compared to 192 in 2013 ("Workplace Safety," 2013). This 24% decrease can be accredited to the efforts of the University to make the workplace as safe as possible. Since the 2013 Environmental Audit, the Department of Environmental Health and Safety and the Department of Risk Management have strived to decrease the injuries on campus by identifying safety hazards and increasing their level of involvement. These departments have implemented programs such as the Asbestos Abatement Program and the Safe Tiger Program to target specific causes of injury. The data collected shows their efforts have been successful in decreasing incident rates since 2013, reaching 2.6%, which is a considerable decline from the 4.1% in 2013. To make sure that incident rates continue to decline, the main causes of injury must be addressed: falls/slips, sprains/strains, and cuts/scrapes. These incident rates can continue to fall if the University recognizes the trends in workplace injury and illness.

Introduction

It is imperative that Clemson University keep its campus as safe as possible for its students, employees, and visitors. Workplace safety ranges from the prevention of physical injuries such as scrapes, to the improvement of air quality such as smoking prevention. In addition, Clemson has many regulations, manuals, and certifications to help the faculty, staff, and student body do their part in keeping the campus safe for themselves and others.

The purpose of the Workplace Safety chapter is to present data on general safety topics on Clemson University's campus. This chapter objectively summarizes the data collected and explains the University's trends in improving safety. Topics this chapter covers include regulations, injury, permits/certifications, fire safety, indoor air quality and aerosols, tobacco policy, cleaning supplies, lead management, ergonomics, radon testing.

Regulations

Clemson University is a state-owned public institution and therefore must adhere to regulations concerning health and safety, as well as environmental regulations. Many agencies ensure that Clemson complies with all regulations, including:

- The South Carolina Department of Health and Environmental Control (DHEC);
- The Nuclear Regulatory Commission (NRC), which deals with all regulations concerning nuclear power safety, including the controlled production of it, as well as civilian use of nuclear power;
- The South Carolina Department of Labor, Licensing, and Regulation, which oversees all regulations of the Occupational Safety and Health Administration (OSHA).

The Environmental Health and Safety Department is supportive of inspections and will willingly provide any and all information that might help the inspecting agencies. Departments found in violation must pay all issued fines.

Injury Data

Workplace safety is not only important to Clemson University, but also the government of the United States. The government tasks the U.S. Department of Labor with recording reported workplace incidents and determining trends. The Risk Management Department at Clemson University has similar duties in maintaining injury and worker's compensation data.

The Bureau of Labor Statistics is a sector of the U.S. Department of Labor with duties to collect labor statistics and release reports for the public. Their news release from October 27, 2016 summarized the incident rates per 100 full-time employees from the year 2011 to 2015 ("Employer-Reported," 2016). *Figure WS 1* shows that the incident rates per 100 full-time employees has been steadily decreasing since 2011. In 2011, the private industry saw 3.8 incidents per 100 full-time workers. This rate decreased to 3.3 incidents per 100 full-time workers by 2015, when approximately 2.9 million injuries and illnesses were reported in the private industry. The year 2016 also comprised 2.9 million injuries and illnesses, including 22,000 from colleges, universities, and professional schools.

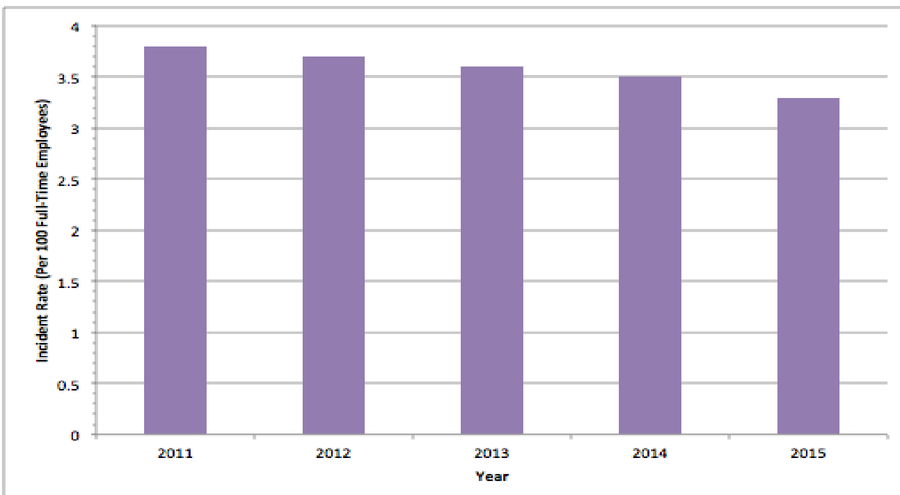

Figure WS 1: Nonfatal Private Industry Incident Rates from 2011 to 2015 of Companies with More than 1,000 Employees

Much like the United States government, Clemson University is working to decrease its incident rates. Comparing the incident rates of private industry in the U.S. to incident rates of the University is an adequate gauge of how well Clemson's incident lowering techniques are working. *Figure WS 2* draws a comparison between the country's statistics and that of Clemson University by depicting the incident rates in the same format. Since 2013, Clemson University's incident rate per 100 employees has decreased, but the change in incident rate is more variable than that of U.S. private industry. Between the years 2013 and 2014, the U.S. incident rate decreased by 0.1 incidents per 100 employees while the University's incident rate decreased by almost 1 incident per 100 employees ("Employer-Reported," 2016). However, between 2014 and 2015 the U.S. incident rate decreased by 0.2 and the University incident rate decreased by only 0.1. Even with variation, it is clear that Clemson University's incident rates per 100 employees has seen a trend of decreasing numbers.

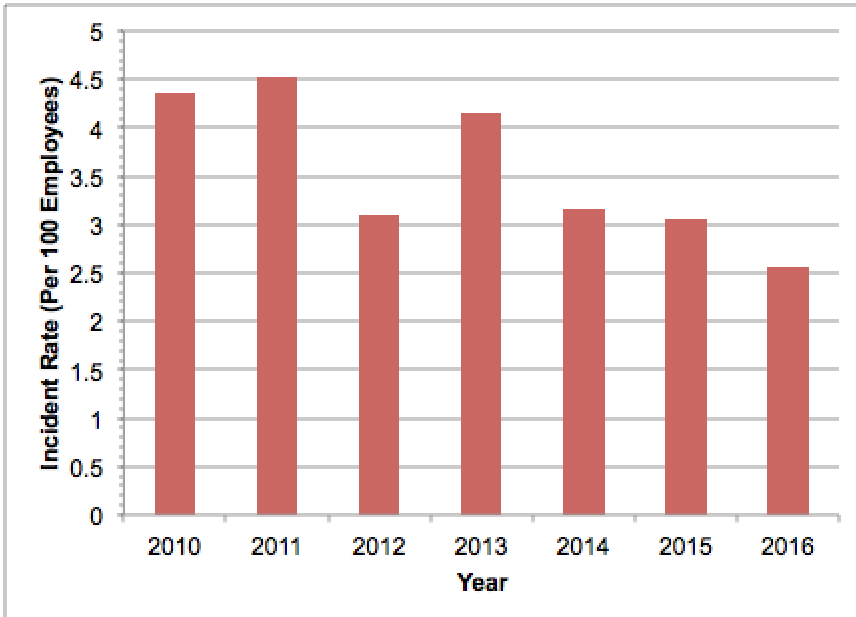

Figure WS 2: Clemson University Incident Rates from 2010 to 2016

Table WS 1 separates each incident into categories used by the Bureau of Labor Statistics. By looking at each category per year, assumptions can be made about whether or not the incidents were connected in some way. The year 2011 had the highest incident rate per 100 employees. In 2011 there was an abnormally high number of burns/scalds/chemical exposures. This can be explained by a series of incidents that were connected to one another (Rice). Linda Rice showed that this high number can be explained by a team of workers spraying silica to clean a building when they were exposed to potentially harmful chemicals. The entire team had to be treated for exposure, increasing the number incidents in the exposure category. *Table WS 1* below depicts the numbers for each category per year from 2010 to 2016.

Table WS 1: Accidents and Injuries among Clemson Faculty and Staff 2010-2016

Type of Injury	2010	2011	2012	2013	2014	2015	2016
Fall/Trip/Slip	34	40	26	25	34	31	25
Sprain/Strain/ Fracture	54	45	57	67	50	32	36
Cut/ Scrape/Puncture	26	30	26	52	43	23	23
Transportation	4	1	2	10	2	3	9
Struck by Object	14	9	5	4	5	15	3

Struck Against Object	16	5	3	1	0	0	0
Burns/Scalds/ Chemical Burns/Exposures	12	27	7	11	5	21	5
Caught In Machinery	7	1	2	0	7	0	0
Inhalation	11	0	1	3	3	1	12
Animal/Insect	4	9	6	3	1	8	6
Allergy	1	6	0	1	1	8	7
Repetitive Motion	5	0	2	7	4	0	0
Other	0	16	1	8	0	13	8
Total	188	189	138	192	155	155	134

The Bureau of Labor Statistics defines the main categories of workplace injury, which was the basis of the data collected at Clemson. Among all of the categories listed, the three largest categories of injury were Fall/Trip/Slip, Sprain/Strain/Fracture, and Cut/Scrape/Puncture. All of the University recorded workplace incident data for 2010 – 2016 can be viewed in *Table WS 1* (Newberry).

Figure WS 3 illustrates the three most prevalent categories of injuries for 2010-2016.

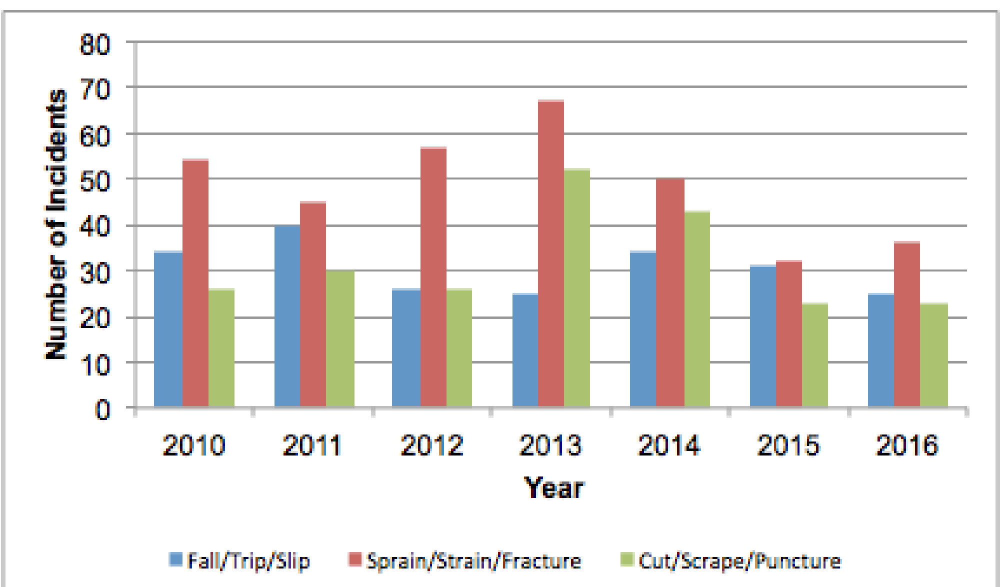

Figure WS 3: Accident and Injury Trends from 2010-2016

Every year from 2010–2016, the Sprains/Strains/Fractures category has the highest number of incidents. Many of these injuries are from high repetitive motions, and the risk of injury can be reduced by workplace ergonomics. Clemson's Risk Management department is currently aware of the effects of ergonomics on workplace injuries and are making strides to prevent the problem (Rice).

The Risk Management Department at Clemson University is tasked with thoroughly documenting reported injuries. These records allow for graphics and trends to be created and analyzed. Through analysis of this data, new policies can be implemented in an effort to prevent future injuries. To better the safety on campus it is the responsibility of all faculty, students, and individuals to report incidents.

One initiative program the Risk Management Department has implemented is the Safe Tiger Program ("Safe Tiger Program"). This program enters the name of each person who reports a safety hazard to a drawing for a coffee mug every two weeks. The Risk Management department still encourages reporting of safety hazards on campus in order to maintain accurate record keeping.

The following sections display how the university is working to mitigate hazards to promote a safe environment for everyone on campus. Data on incidents show fluctuations in incidents over time, but injuries are still occurring. Because injuries still occur, work will always need to be done to reduce the number and severity of injuries. Some areas where injury prevention is focused are indoor air quality and ergonomics. Moreover, various manuals and policies are discussed in order to explain what the University is doing to prevent injury and what options are available to injured faculty, staff, and students.

Permits and Certifications

Clemson University's Confined Space Manual

The purpose of Clemson University's Confined Space Manual is to implement permit-required confined space safety ("Confined Space Manual," 2011). By archiving safe interactions with confined spaces, the university strives to meet all government regulations on the subject. This manual incorporates all the federal Occupational Safety and Health Agency standards on Permit-Required Confined Space. Supervisors are required to have employees trained to enter confined spaces, and to have them gain proper authorization.

Clemson University's Hazardous Waste Management Manual

Most recently revised in February 2015, the Hazardous Waste Management Manual outlines the proper procedures for managing hazardous waste (HW) at Clemson University's main campus. ("Clemson University Hazardous Waste," 2015). Essentially, this manual is a "how-to" guide that shall be followed by all Clemson employees, students, and subcontractor personnel employed by the University. All procedures in this manual are compliant with the regulatory requirements contained in Title 40 of the Code of Federal Regulations part 262 located in The Resource Conservation and Recovery Act of 1976 (RCRA). The South Carolina Hazardous Waste Management applies to the storage, treatment, transportation, and disposal of wastes on Clemson University's main campus. The University is currently classified as "Large Quantity Generator," and being a Large Quantity Generator of hazardous waste it prohibits Clemson personnel from performing certain actions such as treating hazardous waste, transporting hazardous waste away from the main campus, and negligent or otherwise unlawful waste disposal ("Clemson University Hazardous Waste," 2015).

Spill Prevention Control and Countermeasure Plan (SPCC)

The SPCC was created in accordance with 40 CFR 112.4 and employs a number system for onshore non-transportation facilities. This plan contains a list of all drums, containers, and tanks that could potentially lead to one of the harmful spills identified in this plan. The emergency procedures/spill prevention section in this plan provides steps on what one should do if they find a release of oil or hazardous substance on the main campus. Numerous amounts of contacts are also listed in this plan, from emergency to other report agencies ("Clemson University Spill Prevention," 2011).

Radiation Safety Manual

Clemson University was granted the ability to use radioactive materials by the S.C. Department of Health and Environmental Control under Radioactive Materials Regulation 61-63 Title-A. Radioactive materials support a variety of biotechnical research and teaching activities at the University. This manual offers rules and procedures also mentioned in the Radiation Protection Program. The requirements and guidelines mentioned in the manual are intended to help the end user of radioactive materials and help Clemson University meet the regulatory compliance commitments relative to the authorization and possession of radioactive materials ("Clemson University Radiation Safety," 2011).

Fire Safety

Clemson University prioritizes safety amongst its students, faculty, and staff. Because of this priority, the University has many departments to ensure fire safety on campus. Fire Chief William Daniel acknowledges these departments by saying, "Fire Safety is not just the responsibility of the Fire Department, and our campus is lucky to have a good Planning and Codes Department to assure new construction and renovation projects are constructed in compliance with the adopted Building and Fire Codes along with our department's Research Safety Group that assures lab safety and safe chemical handling practices, so fire is prevented and waste is properly disposed."

As stated above, Clemson takes many precautions to provide a safe environment for learning and growing. These precautions vary from employee training to a well-funded, well-staffed fire department watching over Clemson's campus. Not only do these precautions protect Clemson University, but they also protect the city of Clemson. Clemson University Fire Department and Medical Emergency Services practices fire suppression spanning from the main campus to the city of Clemson and Lake Hartwell ("Fire and Medical Emergency Services," 2019).

The Fire and EMS department divides employees into four categories: full-time, student, volunteer, and special event EMT ("Fire and Medical Emergency Services," 2019). Of these employees, seven to fifteen are on duty at once, depending on the projected need (Daniel). Moreover, the department is backed by a fleet of vehicles that give them the mobility they need to keep Clemson safe from fire hazards. Their fleet consists of three fire engines, two John Deere gators, two ladders, and three medical vehicles. The department also has special rescue teams to handle particular situations, such as water surface rescue, water subsurface rescue, vehicle/mechanical rescue, confined space rescue, vertical rescue, and trench rescue. These various specialties and levels of expertise allow Fire and EMS to deal with many different types of situations in an efficient, timely manner.

Fire and EMS also has an active role in the resident communities on campus. Their Fire Safety System requires all residential areas to be equipped with electronically monitored sprinklers and fire extinguishers ("Fire and Medical Emergency Services," 2019). They also require one or two mandatory fire drills in each school year and provide fire safety training for all resident assistants ("Annual Security and Fire," 2018). By the end of training, resident assistants know how to call CUFD, inspect fire equipment, and use a fire extinguisher. Full time employees and graduate staff undergo similar training by Fire and EMS.

Lastly, Clemson University Fire and EMS make a conscious effort to record accurate statistics on fire incidents at Clemson ("Annual Security and Fire," 2018). They also have recently implemented the Clemson University Fire Protection Five-Year Future Upgrade Matrix. This matrix is a list of all residence halls on Clemson's campus as well as features that will be added to protect its residents from fire. This plan, along with the staff and resources listed above, provide the City of Clemson and Clemson University with the support needed to prevent and neutralize fire hazards.

Indoor Air Quality and Aerosols

It is important for all buildings on campus to have proper ventilation ("Laboratory Safety," 2019). Since the 2013 Environmental Audit, 76 of the campus's 85 buildings have developed a proper ventilation system. Proper ventilation not only enables healthy respiration, but it also filters out hazards such as airborne illnesses, aerosols, and chemicals, ensuring they do not spread within the building and cause further problems.

In order for the department to understand indoor air quality issues pertinent to the Clemson community, a questionnaire is available on Clemson's environmental safety website. This questionnaire is a four-page document asking for details such as what symptoms are occurring, where in the building they come about, and how long these issues have been persisting.

Air particles spawning from things such as asbestos and lead paint have a negative effect on indoor air quality because of the toxins that they can potentially hold. With regards to asbestos, Clemson has an asbestos awareness program for employees as well as an asbestos removal program. These programs strive to remove asbestos from campus buildings and make employees aware of the hazards caused by asbestos, respectively. Unfortunately, while employees can identify where asbestos is and can remove it without essentially tearing down every building and rebuilding with expensive, high quality materials, asbestos cannot be removed completely (Newberry). The budget on the Asbestos Abatement Program has stayed steady at around $80,000.00 since its first full year of data from 2015.

One of the larger issues that Clemson faces is the process that must be taken when one of its ventilation units breaks down, which often occurs without warning. This repair process tends to be slow because of the number of steps that must be taken: developing a blueprint to replace the unit, determining a budget, proposing the budget, receiving budget confirmation, and finally carrying out the process (Newberry).

Proper ventilation has its own regulations specifically within laboratories due to all of the chemicals that are used; these chemicals produce additional aerosols. Laboratories usually require exhausts as added ventilation. These exhausts, while handled by the departments themselves, do need the approval of the Environmental Health and Safety department before installment. If a hood does not work, it is required not only that it be fixed immediately, but also that the procedures within the lab stop immediately. Additional ventilation is also sometimes needed depending on what properties are being used in the lab, such as acids or radioactive material ("Laboratory Safety," 2019).

Tobacco Policy

Clemson University's Tobacco Policy states: "Clemson University is a tobacco-free institution. No smoking or other use of Tobacco Products is permitted on University Property. This policy is intended to discourage tobacco use and includes a ban on selling, free sampling or littering of any and all Tobacco Products on University Property."

This policy went into effect on January 1, 2016. The purpose of this policy is to promote a healthy and fire safe campus for both residents and visitors ("Clemson University Tobacco-Free Campus"). The policy extends to cigarettes, chewing tobacco, smokeless tobacco, electronic cigarettes, and other forms of tobacco defined on the university website.

Clemson University Fire Chief William Daniel claims the number smoking and vaping complaints has increased since the University implemented this policy. He believes this is due to more people reporting violators as a result of the policy's publication. He also states that an effect of this policy has been more mulch fires around campus from carelessly discarded cigarettes. These mulch fires have become more common because all ash bins have been removed from campus. Those still smoking on campus discard their cigarettes improperly. Chief Daniel also speculates that passing drivers discard cigarette butts onto mulch-lined medians while driving through campus.

Creating a tobacco-free campus has produced negative consequences, but the policy prevents secondhand smoke pollution and promotes general welfare on campus. Additionally, resources at Redfern Health Center website provide smokers with facts on tobacco use and tools to help quit tobacco use ("Tobacco," 2019).

Cleaning Supplies

Creating a clean environment is essential for maintaining a safe and healthy campus. This task falls primarily on the shoulders of Clemson University's custodial department. They are not only tasked with keeping our campus clean, but also using the proper products to do so. These products must not only be safe for the health of Clemson faculty, staff, students, and visitors, but also safe for the environment ("Custodial Customer Service Guide," 2019).

Clemson contracts with GCA Services group for cleaning services. Together, they ensure that healthy, environmentally friendly products are used on campus. These products must be Green Seal Certified so that they comply with the University's sustainability initiative (Miller). Moreover, many buildings on campus carry Leadership in Energy and Environmental Design, or LEED, Certifications, which requires supplies and procedures to be eco-friendly ("Impact of Buildings," 2019). Clemson University also trains its custodial staff to practice "green" cleaning procedures. New staff members work with a designated trainer for the first two weeks of employment (Miller). This training covers all custodial essentials, including chemical descriptions and green cleaning procedures. From staff to products, Clemson University strives to keep its campus clean and green.

Lead Management

Lead is a naturally-occurring heavy metal. While it is generally non-reactive, it is extremely toxic to exposed individuals. Lead poses the largest risk when it is found in deteriorating paint ("Lead Toxicity," 2017).

Lead is found in many common household chemicals, but it can also be found in soil, air, and water. Lead can enter the body through inhalation, ingestion, and even absorption. Lead can cause a wide variety of issues, from learning disabilities to pregnancy complications to even death

("Learn about Lead," 2018). Clemson University follows the federal Occupational Health and Safety Administration (OSHA) standards when regulating exposure to lead. The Lead Management Program assists in training employees working with materials containing lead. The program also allows for surveillance for the employees exposed to levels of lead above the action level.

Clemson University's Department of Environment Health and Safety is responsible for conducting all inspections to ensure compliance with the standards and regulations of OSHA as well as the South Carolina Department of Health and Environmental Control (DHEC). The procedures for handling lead exposure are summarized below and can be found in their entirety within the "Clemson University Worker Exposure Lead Management Program" manual (2011). As stated in Clemson's 2013 Environmental Audit, "the Permissible Exposure Limit (PEL) set by OSHA is 50 micrograms of lead per cubic meter of air during an eight-hour time period. The amount of lead present is monitored initially in the workplace and if the initial level is found to be above 30 micrograms of lead per cubic meter, then an air-monitoring program must be implemented" ("Workplace Safety"). OSHA also regulates worker protection, medical treatment, and worker training when dealing with lead ("Lead in Construction," 2004). The regulations pertaining to lead have not changed since the last Environmental Audit was published in 2013:

Worker Protection

- Respirators are often used to supplement engineering controls and work practices to reduce worker lead exposures. Skin exposure should also be limited.
- A shower should be taken before and after working with lead to limit any possible exposure.
- Anyone not properly protected should be as far away from the site as possible if the worker is directly working with the lead.
- Extra precautions must be taken if there is an excess of PEL level.

Medical Treatment

- Surveillance: When an employee's airborne exposure is at or above the AL for more than 30 days in one year, the employee must immediately seek medical consultation ("Lead in Construction").
- Examination: If deemed necessary, the employee will be examined through physical exams for blood lead levels, lung function, and many other aspects affected by lead exposure.
- Medical Removal Program: If necessary, the employer must provide up to 18 months of medical removal protection benefits until the employee's blood lead level has decreased to below the PEL.

Worker Training

- OSHA's website has information on their training and general regulations.

Ergonomics

Ergonomics is the study of how efficiently people work within their environment. In the United States, ergonomics is largely regulated by OSHA. Research on ergonomics at Clemson is conducted by the Human Factors Institute, a committee comprised mostly of psychology professors and students. The main focus of the committee's research is seeing how humans interact with technology. The committee has been rated as a "gold chapter" by the Humans Factors and Ergonomics Society over the past six years.

Clemson's Center for Health Facilities Design and Testing offers a toolkit for conducting an ergonomic assessment ("Ergonomic Assessment," 2019). In the Clemson University 2006 Environmental Audit, Clemson University Professor Emeritus and colleagues detailed what takes place in an ergonomic review: "In an ergonomic review, several workstation characteristics are taken into account. PC displays, keyboards, desk height, chairs, and light reflection are all critiqued. Several different actions may be taken when a problem is found. Engineering controls involve a general redesign of the workstation. Work practice controls include education about the work practice, and administrative controls are aimed at reducing the amount of repetition or work that is causing the problem. In other cases, personal protective equipment might also be used. This is equipment designed to reduce ergonomic injuries and includes items such as braces and padding."

Radon Testing

Radon is a radioactive gas that almost completely evades the senses due to it being colorless, tasteless, and odorless. While radon has a short half-life, it is a naturally occurring element that is almost always being regenerated. Since radon has a very high density, it often accumulates in low areas like crawl spaces and basements. Foundation openings, like cracks and holes, allow radon to enter buildings ("Radon Fact Sheet," 2008). There is a clear link between the inhalation of radon and lung cancer. In fact, radon is the leading cause of lung cancer among non-smokers and is second only to cigarettes in causing lung cancer among smokers ("Radon," 2018).

Radon can cause serious issues to indoor air quality, an important facet of workplace safety at Clemson University. Radon levels were measured in building at Clemson until 2006. Measuring for radon was deemed unnecessary after 2006 due to the test results of previous years and Clemson's low geographical risk.

Students’ Perspective

Clemson University has committed resources to making its students, faculty, and staff aware of safety risks throughout campus. The University has many manuals and programs that allow the public to find safety information on demand. These manuals are easily found online, and they range in subject from indoor air quality to campus general safety. The manuals describe how to prevent certain accidents as well as what to do when an accident occurs.

The data indicates that the number of injuries within the workplace has decreased over time, which continues the trend shown in the previous audit. However, many accidents still occur on Clemson’s campus, and the most frequently occurring accidents are the same each year. These frequent accidents indicate that improvements can still be made with regards to safety and risk management. By talking to experts in the field of Safety and Risk Management on campus, the auditors believe that most, if not all, accidents are preventable.

Clemson University does a thorough job in promoting fire safety on campus. Clemson Fire Department and Medical Emergency Services provide many methods of fire prevention and suppression. They also support fire awareness on campus by training residential and educational staff and offering training to others on campus. Clemson has also changed its smoking policy to adapt with time and new sustainability initiatives. This policy has reduced smoking on campus, but the removal of public ash bins has caused an increase in the occurrence of mulch fires (Daniel). Assuming some people on campus refuse to stop smoking, these mulch fires can only be prevented by treating the ground to be prepared for ashes. Chief Daniel explained that most of these mulch fires occur along mulch-lined medians. The auditors suggest removing mulch from the medians so that there would be no mulch to catch fire.

Clemson has little information on how it handles ergonomics. While there is an ergonomics society on campus, specific details about the data they had compiled weren’t present on their website. Most of the information provided on ergonomics was from the 2013 Audit, which itself mentioned the 2009 Audit multiple times with regards to ergonomic regulations. The auditors suggest better documentation of ergonomic initiatives, including how workplaces are accommodated for each individual employee experiencing ergonomically related injuries and how much those accommodations cost.

Finally, the auditors suggest more detailed and organized record keeping for all affiliated departments. Creating a uniform format for records would hasten the process of data analysis and allow this analysis to be performed more often. Funding the Risk Management Department for more Safe Tiger mugs would also encourage incident reporting on campus and make records more accurate. This funding would allow students, faculty, and staff to be more involved in making Clemson University safe.

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