Meadowcreek Stormwater and Erosion Renovation The Effects of Climate Change and Golf Course Unsustainability on the Environment

A Thesis Prospectus In STS 4500 Presented to The Faculty of the School of Engineering and Applied Science University of Virginia In Partial Fulfillment of the Requirements for the Degree Bachelor of Science in Civil Engineering

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Current Thoughts on Paper: In 4500, I got a good stard on the research process. However, many points in the paper could use elaboration, such as the use of aguntic vegetation to improve water quality. With the added word count in the thesis, I'm looking forward to furthering my discussion on the same topic.

location Introduction

Meadowcreek Golf Course is a public course local to the community of Charlottesville Virginia. The 155-acre course borders the Rivanna River and partially occupies the floodplain of the river. The Rivanna River is where most stormwater in the vicinity of Meadowcreek Golf Course drains. Due to the quantity of stormwater that passes over the site, special care must be & reason taken to prevent erosion and water quality issues. Fertilization practices for the grass on the course directly introduce nitrogen into any runoff, which can damage river ecosystems. Currently, Meadow Creek runs across the course through a series of three recreational ponds. These ponds were created as obstacles for the course, not to manage stormwater. Meadow Creek connects to the Rivanna River through a pipe that runs under the 17th hole, just prior to the green. The outlet of this pipe cannot be found in the river, and it is suspected that the pipe may have Sproblem collapsed. Instead, the water now runs over the hole, causing erosion and water quality issues. Specifically, during flood events, the whole 17th hole becomes submerged in water. There is also ρ roble M ξ a deep head cut that has been formed just before the green, in the area where the pipe should come out. Due to the flooding from Hurricane Helene alone (Figure 3, Appendix), the head cut advanced another five to seven feet onto the course (Figure 1). While there are general erosion issues on the site, this head cut poses an active fall risk to any golfer nearing the green from the front left side and the area is currently roped off (Figure 1).



Figure 1: Progression of Headcut Over Time

topic

Many people have grown up hearing that climate change will be one of the main things that future generations will have to deal with. The fact is climate change is here now. Its effects can be seen today in sea level rise, storm severity, and higher temperatures. The question is no longer how we can prevent it but is how we can transition our living areas away from affected areas (Palmer, 2024). During major flood events, inland rivers end up carrying most of the stormwater that is dropped overland. While riverbank erosion and fluvial morphing are two things that occur naturally, the increased frequency and severity of flood events, due to climate change, have led to more damage to inland rivers. For thousands of years, humans have lived along rivers, for various reasons. Today, it is no different. The damage being sustained by inland rivers is a direct hit to society, because these rivers provide drainage, irrigation, drinking water, recreation, and food. If the problem is not mitigated, many people could suffer.

With the golf course being in the floodplain of the Rivanna River, which carries most of the stormwater load during major flooding events in Charlottesville, it is directly affected by climate change. As climate change progresses, stricter measures must be taken to address the damages. Golf courses take up extensive green space and are rarely designed with stormwater management in mind. Better understanding the effects of climate change on flooding events and inland river health can aid in the solution formulation process for the stormwater management problem that is currently being faced by Meadowcreek Golf Course.

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Technical Overview

The stormwater management problem at Meadowcreek Golf Course can be broken down into two main issues. First, the erosion at the head cut on the 17th hole is encroaching on and threatening to undermine the green. Second, the haphazard runoff path currently absorbs nitrogen 3 (10) Leven and other chemicals from the fertilizer on the course and deposits them in the river and ponds on site. Both issues can be solved if the course is reengineered to handle the quantity of stormwater produced during major flood events.

A head cut is formed when water is draining from a higher surface to a lower surface over a ledge. In this case, the water drains from the course playing surface to the river below, over a riverbank that is about 15 feet high on average. For a head cut to form, the softer layer of soil closer to the bottom of the riverbank erodes due to the falling water. Over time, this forms a cavity. When the cavity gets large enough, the upper, harder portions of soil collapse, like when digging a hole in the beach that extends below the waterline that invariably starts to collapse the deeper it gets. With a head cut, each collapse exposes more soft soil to erode at the bottom and the process continues until the head cut becomes a new tributary to the river.



Figure 2: Headcut Migration Process

In this case, the golf course does not want a new river tributary forming across the 17th hole, so the stormwater must be managed in a way that prevents it from running straight across

the hole and over the riverbank. Previously, the pipe under the 17th hole took care of the water. However, now the outlet of the pipe that should be draining into the river cannot be found. There are no plans showing the location of the pipe, since it was laid so long ago. No one knows if it runs straight under the hole or if there are turns. It is also not clear whether the mouth of the pipe was clogged by a riverbank collapse or if the concrete pipe collapsed somewhere along its span. The first step to get to the bottom of this issue is to run a video probe down the pipe to see where the collapse or clog is. If the pipe is clogged, a simple cleaning may fix the whole situation. If the pipe has collapsed, the solution is to either patch it or to excavate the whole run and let the creek run across the hole. This choice will depend on how deep the pipe is and what the City of Charlottesville wants done, as it is a public course.

problem

The fertilizer issue has contributed to harmful algal blooms that have destroyed ecosystems in the ponds and harmed those in the river. The resolution of the pipe situation will alleviate most of fertilizer runoff problem. However, redesign of the ponds may also be necessary. The ponds could serve to help manage not only the stormwater quantity, but also its quality. Deeper and larger ponds would allow the water to be treated naturally. Also, depending on the results of water nutrient tests, strategic planting of special underwater vegetation could help naturally break down contaminants.

STS Overview

The question the science technology and society portion of this report will seek to answer is: what is the combined effect of golf courses and climate change on the environment? Much research has been done on the effects of climate change on coastal cities, through sea level rise. However, the reality is that climate change is here and part of that means the flooding events will only continue become worse. The worsening major flooding events have a large impact on inland

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reasoning

streams, which arguably leads to a larger affected population than is affected by sea level rise (Dey and Mandal, 2022). Due to that fact that golf is primarily played by the rich and powerful, the negative environmental effects of golf courses, including fertilizer runoff, hydrologic pollution, and extensive urban land use, have largely been swept under the rug (Millington and Wilson, 2016). With the reality of climate change and the prominence of golf today, it is worth looking at the combined effect of the two.

Climate change does not and will not affect everyone the same. Poorer regions of the world will be less equipped to handle the dangers caused by climate change. These include increasingly hazardous wet-bulb temperatures, coastal flooding, declining air quality, and declining water quality. Research by Cruz and Rossi-Hansberg controls for the varying degrees each region in the world will experience global warming, based on proximity to the equator, and projects how each region will be affected economically (2023). They looked at the effects of climate change on local productivity, amenities, and migration patterns. Another metric they used to analyze this problem was welfare loss, which is an economic term referring to when the efficient market quantity, determined by a fair market process, is not able to be supplied. Cruz and Rossi-Hansberg state that the poorer regions of the world, like Sub-Saharan Africa and South East Asia, will be affected most by climate change. Based on their model, by 2200 the welfare loss will be 10% in these areas, which will drastically effect life span and quality of life for locals. Through this research, extra resources can be allocated to these at-risk regions before the fallout from climate change progresses past the point of no return. A proactive approach can save lives and lessen the detrimental environmental consequences.

Golf courses are among the most densely fertilized areas, because the greener the course, the higher the allure to prospective customers. Because of this, golf courses notoriously deposit

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large quantities of fertilizer chemicals into local waterways. Stormwater best management practices are also largely ignored by golf courses, because they are expensive and cut into course profits. Poor stormwater management does not tangibly affect a golf course unless a major flood event closes the course, so steps are not often taken to improve golf course stormwater *n*Solutions management infrastructure. There are many green infrastructure methods for stormwater quality management that a study by Burgis investigates, including passive irrigation technology, retention ponds, and permeable pavers (2020). These methods help control volume and quality of runoff and support the course and surrounding community health. Agricultural, and in this case, recreational fertilizers are projected to have major impact on the environment in the future (Crosson and Brubaker, 2016). High levels of nitrogen, the active ingredient in most fertilizers, can lead to algal blooms. Algal blooms destroy aqueous ecosystems and can allow proliferation of dangerous bacteria in drinking water. Hudnell details the deadly effects of cyanobacteria blooms in domestic waterways (2008). Reports of cyanobacteria poisonings go back to the late 1800s. Symptoms can include stomach and intestinal issues, trouble breathing, allergic responses, skin irritation, liver damage, and neurotoxic responses. Some studies have even linked > historia long-term low-level cyanobacteria bacteria exposure to liver cancer and digestive-system cancer. Analysis

This science technology and society report will analyze the historical trends in climate change, inland river health, major flood events, fertilizer runoff, and golf course sustainability to better equip the current and future generations. Empirical data on erosion progression and water quality will be collected from Meadowcreek Golf Course and analyzed in a case study. Finally, multiple green infrastructure stormwater management methods will be compared, and a plan will be formulated for the situation at Meadowcreek Golf Course. Results from this study can be extrapolated to help solve the same issues on and around other golf courses worldwide.

Conclusion

The technical portion of this report will detail the solution to the erosion and water quality problems that are currently present at Meadowcreek Golf Course. Further research could follow the results of this solution to better inform similar future projects. The science, technology, and society section of the report will provide an analysis on the combined effects of climate change and golf course sustainability issues on the environment, through an amalgamation of current research and data drawn from the Meadowcreek Golf Course case study. These results will illuminate the best path forward for golf course sustainability in the face of climate change. Climate change promises to be one of the largest challenges humanity will encounter in the next 100 years. This research will help facilitate a proactive approach to respond to climate change, through optimizing the design of one largely untouched fraction of domestic

land – golf courses.

> topic

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Appendix



Figure 1: Progression of Headcut Over Time



Figure 2: Headcut Migration Process



Figure 3: Site Flooding in the Wake of Hurricane Helene