Meadow Creek Golf Course Drainage Improvements
(Technical Topic)

A Site-Specific Analysis of Golf Course Impact within Charlottesville, VA
(STS Topic)

A Thesis Project Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree
Bachelor of Science, School of Engineering

Brett Bober

Fall, 2024

Technical Project Team Members: Jesse Cousins, Marshall Epperson, Joseph Holland, Samuel Lauer, & Juliana Portugal

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.

Signature _____

Approved _____ Date _____
William Davis, Assistant Professor of STS, Department of Engineering and Society

Approved _____ Date _____
Teresa B. Culver, Associate Professor, Department of Civil and Environmental Engineering

Introduction

As our society continues to develop infrastructure and climate change continues its rise, stormwater management becomes an increasingly important practice that must be adjusted to match the novelty of this time (EPA, 2024, p.1). With more impervious surfaces created from the implementation of new roadways, structures, and other concrete or asphalt areas, water often becomes runoff rather than filtering into the soil, which can cause flooding and other hazards (University of Nebraska, 2014, p.1). A rise in global temperature, along with its corresponding weather, will also make many areas prone to extreme weather events, exacerbating the issue of runoff (EPA, 2024, p.1). In addition to water quantity concerns, water quality will also become an integral focus. With more runoff, more nitrogen and phosphorus will be carried with water flow which will act as pollutants to nearby waterways (Chesapeake Bay Foundation, n.d). While this phenomenon will be occurring all across the world, case studies such as one conducted in Boston, MA already corroborate these trends; simulations using stormwater management software indicated that climate change will increase the susceptibility of runoff to impervious coverage, precipitation, and intensity of weather events (Pyke, 2011, p.166). Managing stormwater appropriately is paramount to avoiding these water quantity and quality issues, and as global changes occur, these strategies must often adapt to fit new needs.

In the case of Meadow Creek in Charlottesville, prior practices of stormwater management are no longer fulfilling the needs of the 17th hole of a golf course. Recent weather events have been overwhelming the existing pipe system, causing flooding and the inability to play the back nine holes of the course. Like in many other developed areas, the use of fertilizers also poses the potential for increased nitrogen and phosphorus loads in the Rivanna River, which directly borders the location of this hole. With both enjoyment and the environment being

threatened, this capstone team – with the help of environmental consulting firm Hazen & Sawyer – plans to address the stormwater concerns of the hole by introducing a new management system. Beyond reconfiguring the existing system, a broader questioning of the intent behind these alterations is also required: is a golf course the most efficient land use for supporting the Charlottesville community?

Technical Topic

Patterns of global warming overcoming current stormwater management practices are already present in Charlottesville. At Meadow Creek, a series of detention ponds exist primarily for water storage and act to buffer peak discharge rates of more extreme weather events (UVA, n.d., p.4). These ponds are connected in series, and then a pipe channels water from the last pond to the Rivanna River as a discharge point. With changes in runoff, this pipe is no longer able to withstand the quantity of water flowing through, leading to flooding of the course. Previously implemented pipe networks such as this one are often designed to accommodate smaller events and less precipitation, and as climate change increases the intensity of such events, pipes may need to be upsized or replaced altogether (Moore, 2016, p.499). Recent footage of the pipe from October also showed that it was clogged with debris, which may have resulted in its failure. Underground systems like these pipe networks are often difficult to maintain for this reason, as a combination of limited access points and the accumulation of sediment can result in a decrease in functionality (EPA, 2001, p.3). Considering these various modes of failure, transitioning the stormwater management plan from a pipe network to a more modern solution is an appropriate decision for this site.

The golf course at Meadow Creek is facing issues of flooding and nutrient pollution, meaning that the desired solution must accommodate improvements in water quantity and

quality. The Virginia Stormwater Management Handbook, produced by Virginia's Department of Environmental Quality (2024), provides a lengthy yet not comprehensive list of approved procedures for stormwater that addresses both matters. In Chapter 8.3, post-construction procedures are discussed and can be sorted into four categories: basins, conveyance, filtration/infiltration, and support. Conveyance systems offer the most promise as they are able to manage water over relatively steep grades, and they are able to infiltrate water more effectively, which will reduce the concentration of pollutants entering the Rivanna. In comparison to the previous pipe network, a conveyance system will also offer more opportunities for maintenance due to its above-ground design (Virginia Stormwater Management Handbook, 2024, p.1018).

Besides the specifics of the system, the solution must also meet the functional needs of golf. Traditional best management practices, or BMPs, such as basins or river daylighting are common practice for UVA and other Charlottesville sites (UVA, n.d., p.4), but such solutions may be impractical for the hole; the best solution will address water concerns while also staying in line with the aesthetics and game. Acknowledging not only these physical constraints but also the societal ones is integral to design. Namely, a case study of 20 stormwater systems across Northern Europe showed that the most successful solutions are ones that are site-specific, and that without accounting for social aspects, the solution often becomes undesirable (Backhaus & Fryd, 2013, p.61-62). A common solution regarding golf courses is to design stormwater systems into the play of their course, resulting in many ponds and ditches that also serve the purpose of water storage (West Virginia Golf Course Superintendents Association, n.d., p.9). Because of this, management solutions that could resemble water hazards or ones that will be otherwise unnoticed are preferable for the given site.

Considering conveyance systems that will fit the aesthetics and functionality of the course, regenerative stormwater conveyance is a solution this capstone team plans to investigate. Site visits will be conducted to determine if the characteristics of the site are feasible to withstand such a system. If the site constraints, budget, and timeline are all favorable, a regenerative stormwater conveyance system would be ideal to reduce the flooding and nutrient pollution occurring at Meadow Creek.

STS Topic

Along with the development of infrastructure and climate change creating new trends across the world, the city of Charlottesville faces additional social and environmental issues that can be examined through a local lens. From housing crises to a lack of accessibility, Charlottesville, like many other cities, has many social matters that warrant direct focus and financial support (Higgins, 2024, p.1). With all of these hot-topic discussions, one should ask the question – why was a golf course chosen to be the next recipient of funding?

The nature of golf courses has been debated from the very beginning of their implementation. Though many groups are in disagreement of the utility of these courses, one agreement is clear: golf course management is inherently localized, and the resources and efforts that go into its maintenance can drastically change the impacts of the course on the surrounding community (Salgot and Tapias, 2006, p.221). From an environmental perspective, poorly managed golf courses are prone to depreciate nearby water bodies due to excessive water use and cause nutrient pollution through fertilizers (Wheeler & Nauright, 2006, p.431-432). If managed properly, they can serve as wildlife protection areas for threatened and endangered species, adding ecological value to the area (Salgot and Tapias, 2006, p.219). Socially, the accessibility of a public golf course is attractive in providing many groups an opportunity for relaxation and

leisure that is not easily affordable, but the high initial investments of golf makes the courses a large waste of space to many who are still unable to afford it (Onyango, 2024, p.2). With these contradictory impacts, it would be incredibly valuable to research the impact of this specific course and the reasons why this project was chosen for improvement.

For the STS research component, two main strategies will be highlighted: research on the environmental impacts on the Meadow Creek golf course, and a stakeholder analysis to provide a better understanding of the social impacts of this project. Firstly, data collected through the technical portion of this capstone project will aid in determining some of the environmental impact of the course. Water quality calculations regarding phosphorus and nitrogen pollutants will be calculated to decide if the overall impact to the Rivanna River is substantial, and sediment tests will also be conducted to assess suspended solids pollution. Evaluating this environmental impact is not only essential for the preservation of biotic components in water and soil (Petrosillo, 2019, p.2218), but also for the protection of human health. Countless groundwater contamination cases, such as a chlordane outbreak in Cape Cod, show pesticides above permitted allowance, causing risks to human health (Miles, 1992, p.179-185). Additionally, trends like these are disproportionately highlighted in historically marginalized communities, as seen in Florida with communities of higher Hispanic and nonwhite populations experiencing more severe frequencies of waterborne diseases (Kamanmalek, 2023, p.4). Because the Virginia DEQ's environmental justice mapper (EJScreen+) indicates the surrounding area of Meadow Creek to consist of 67% people of color compared to the state average of 37%, these environmental impacts are even more relevant. Overall, these findings will provide insight into the effect of the golf course on its surrounding environment.

Once a general idea of the environmental practicability of the golf course is obtained, the theory of the Social Construction of Technology (SCOT) will be applied. Taking all involved stakeholders into account is often a successful way in determining the key influences behind technologies and decisions, and it may lead to visible gaps where it is clear some groups are not involved in decisions that impact them (Klein and Kleinman, 2002, p.30). In fact, research specifically shows that communities surrounding golf courses are regularly left out of conversations regarding development and construction of the course (Wheeler & Nauright, 2006, p.434). Non-experts can add tremendous value to the development of technology as well; their voices deserve to be a main focus in a conversation of potential redevelopment of land use, and understanding their perspectives, previous life experiences, and knowledge are relevant factors in making such a decision (Star, 1999, p.380). Interviews may be done with neighbors of the course to determine their emotions regarding the utility of the area. Sample interview questions will be based on the methodology of a healthcare survey in which participants were asked their opinion of the value of the service and its current state, which yielded promising results and can be directly applied to the consideration of the golf course (Nguyen, 2014, p.61). Often, the main fault in environmental stakeholder analyses is a lack of transparency and disclosure about the methodology and application of findings, so strong efforts will be made to connect neighbors to this process as much as possible (Bendtsten, 2021, p.8). This two-fold approach aims to close the gap in knowledge regarding the social and environmental implications of this golf course, which will hopefully lead to an appreciated land use for the majority rather than the minority.

Conclusion

This capstone project altogether intends to better the Charlottesville community. Through the technical portion of this project, small-scale yet important issues caused by the flooding and

nutrient pollution of the Meadow Creek golf course's 17th hole will be improved through a stormwater management solution, likely a regenerative stormwater conveyance system. Modifications to the existing system only become more necessary as global warming progresses, making these changes relevant to the success of the course. By focusing on the stakeholders involved and diving deeper into the impacts of this golf course, this project will also address the question of whether this success is beneficial to the surrounding environment and people, or if it is simply a short-term fix for the functionality of the course. Stormwater management and the ethicality of implementing such a solution will provide Charlottesville with a greater quality of life.

References

Backhaus, A., & Fryd, O. (2013). The aesthetic performance of urban landscape-based stormwater management systems: a review of twenty projects in Northern Europe. *Journal of Landscape Architecture*, *8*(2), 52–63. https://doi.org/10.1080/18626033.2013.864130

Bendtsen, E. B., Clausen, L. P., & Hansen, S. F. (2021). A review of the state-of-the-art for stakeholder analysis with regard to environmental management and regulation. *Journal of Environmental Management*, *279*, 1–9. https://doi.org/10.1016/j.jenvman.2020.111773

Chesapeake Bay Foundation. (n.d.). *Runoff Pollution*. Chesapeake Bay Foundation. https://www.cbf.org

Environmental Protection Agency. (2001, September). *Storm Water Technology Fact Sheet*. EPA. https://nepis.epa.gov/

Environmental Protection Agency. (2024). *Climate Adaptation and Stormwater Runoff*. Climate Change Adaptation Resource Center (ARC-X). https://www.epa.gov

Higgins, J. (2024, February 13). *What is the most pressing human rights issue facing Charlottesville?* Charlottesville Tomorrow. https://www.cvilletomorrow.org

Kamanmalek, S., Alamdari, N., Blunt, B., & Hammond, D. (2023). The Role of Stormwater Best Management Practices in Controlling Waterborne Diseases Across Florida with Special Attention to Environmental Justice. *Research Square*, *1*, 1–13. https://doi.org/10.21203/rs.3.rs-2596157/v1

Klein, H. K., & Kleinman, D. L. (2002). The Social Construction of Technology: Structural Considerations. *Science, Technology, & Human Values, 27*(1), 28–52. https://doi.org/10.1177/016224390202700102

Miles, C. J., Leong, G., & Dollar, S. (1992). Pesticides in marine sediments associated with golf course runoff. *Bulletin of Environmental Contamination and Toxicology*, *49*(2), 179–185. https://doi.org/10.1007/bf00191752

Moore, T. L., Gulliver, J. S., Stack, L., & Simpson, M. H. (2016). Stormwater management and climate change: vulnerability and capacity for adaptation in urban and suburban contexts. *Climatic Change*, *138*(3–4), 491–504. https://doi.org/10.1007/s10584-016-1766-2

Nebraska Extension Publications. (2014). *Stormwater Management: What Stormwater Management Is and Why It Is Important*. NebGuide. https://extensionpubs.unl.edu/

Nguyen, O. K., Chan, C. V., Makam, A., Stieglitz, H., & Amarasingham, R. (2014). Envisioning a Social-Health Information Exchange as a Platform to Support a Patient-Centered Medical Neighborhood: A Feasibility Study. *Journal of General Internal Medicine*, *30*(1), 60–67. https://doi.org/10.1007/s11606-014-2969-8

Onyango, K. (2024, April 1). *Pay to Play: Participation Barriers in Golf*. The Phoenix News. https://www.thephoenixnews.com/posts/pay-to-play-participation-barriers-in-golf

Petrosillo, I., Valente, D., Pasimeni, M. R., Aretano, R., Semeraro, T., & Zurlini, G. (2019). Can a golf course support biodiversity and ecosystem services? The landscape context matter. *Landscape Ecology*, *34*(10), 2213–2228. https://doi.org/10.1007/s10980-019-00885-w

Pyke, C., Warren, M. P., Johnson, T., LaGro, J., Scharfenberg, J., Groth, P., Freed, R., Schroeer, W., & Main, E. (2011). Assessment of low impact development for managing stormwater with changing precipitation due to climate change. *Landscape and Urban Planning*, *103*(2), 166–173. https://doi.org/10.1016/j.landurbplan.2011.07.006

Rector and Visitors of the University of Virginia. (n.d.). *Stormwater best management practices*. Environmental Resources. https://pollutionprevention.virginia.edu/stormwater-mgmt/best-practices/

Salgot, M., & Tapias, J. C. (2006). Golf courses: Environmental impacts. *Tourism and Hospitality Research, 6*(3), 218–226. https://doi.org/10.1057/palgrave.thr.6050016

Star, S. L. (1999). The Ethnography of Infrastructure. *American Behavioral Scientist*, *43*(2), 377–391. https://doi.org/10.7551/mitpress/10113.003.0030

Surface Water Management. West Virginia Golf Course Superintendents Association. (n.d.). https://wvgcsa.org/surface-water-management/

Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, Virginia Stormwater Management Handbook (2024).

Wheeler, K., & Nauright, J. (2006). A Global Perspective on the Environmental Impact of Golf. *Sport in Society*, *9*(3), 427–443. https://doi.org/10.1080/17430430600673449