Prospectus

Meadow Creek Water Quality Management Plan
(Technical Topic)

Technological Politics and the Inequitable Distribution of Green Stormwater Infrastructure Technologies
(STS Topic)

By

Lindsey Stegenga

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Technical Project Team Members: Emma Stephens, Caroline Marquis, Zavier Richards

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.

Signed: ____

Approved: _____________________________________ Date _______________________
Ben Laugelli, Department of Engineering and Society

Approved: _____________________________________ Date _______________________
Teresa Culver, Department of Engineering Systems and Environment

Introduction

Healthy waterways are essential elements of healthy environments. They are important habitats for wildlife, protect biodiversity, maintain productive ecosystems, and provide aesthetic outdoor spaces for recreational activities (Judith Nitsch Engineering, Inc., 2002). Meadow Creek is a waterway that flows through the northern part of Charlottesville and outfalls into the Rivanna River, which then flows down to the James River and eventually into the Chesapeake Bay. Because many parts of the Chesapeake Bay contain excess phosphorus, nitrogen, and sediment, laws have been put in place to curb the amount of pollutants that can enter its waterways (US EPA, 2013). Meadow Creek underwent a stream restoration project in 2012 that was necessary due to excessive sedimentation caused by stream bank erosion (The Nature Conservancy, 2013). However, the improvements of this restoration project will not remain indefinitely as new developments add runoff to the watershed. The broad, overarching goal of this project is to improve the water quality of Meadow Creek and reduce excessive runoff throughout the Meadow Creek watershed in order to provide a safer, healthier environment for the local community.

To address this problem, I am designing a watershed management plan that will identify "hotspots" within the watershed where stormwater Best Management Practices (BMPs) should be implemented to have maximum benefit on improving water quality by reducing runoff volume and removing nutrients. BMPs include technologies such as green roofs, bioretention basins, rain gardens, permeable pavements, and rainwater harvesting, among others. These technologies are also referred to as green stormwater infrastructure, as opposed to gray stormwater infrastructure which encompasses traditional systems made of concrete gutters, drains, and pipes that discharge untreated runoff into local waterways (US EPA, 2015).

However, the technical aspects of this project alone are not enough to achieve the overarching goal of creating a healthier, safer environment for the Meadow Creek watershed. This is because there are also social and economic aspects to the problem. BMP technologies have political implications as they typically benefit already privileged communities over disadvantaged communities due to where they are implemented, such as the University of Virginia Grounds and the Shops at Stonefield within the Meadow Creek watershed. Studies of urban areas have shown green infrastructure is not distributed equally, driven in part by market forces (Mandarano & Meenar, 2017). I will be exploring these political implications and power relations through Langdon Winner's theory of technological politics. If the political aspects of green infrastructure are ignored, disadvantaged communities in Charlottesville will not see the benefits that the more privileged communities will, including reduced flooding, improved air quality, and improved neighborhood aesthetics (Center for Neighborhood Technology, 2011).

In order to achieve the overall goal of improving the water quality throughout the Meadow Creek watershed and creating a healthier community, both the technical and social factors must be considered. If only some members of the Charlottesville community receive the benefits of these green infrastructure technologies, then the goal has not been met. In this paper I will expand upon why this technical project is necessary and propose a path to a solution that takes both the technological and social factors into account.

Technical Problem

After the Meadow Creek stream restoration in 2012, a report was created specifying the estimated benefits of the restoration, which included significant reductions in total sediment loading, phosphorus, and nitrogen. The report mentioned that channel geometry may change over time due to erosion and flooding events and therefore the estimated reductions may change as well (Cho & Graham, 2014). As the Charlottesville area sees more economic development and growth, the watershed can expect more impervious areas, such as buildings and parking lots, which lead to higher amounts of runoff and pollutants. If water quality is not treated more systematically throughout the watershed, the benefits of the restoration might be limited in the future as greater levels of sediment and nutrients flow into Meadow Creek.

Typically, new stormwater management infrastructure that reduces runoff quantity and improves runoff water quality is built when a new site is developed or redevelopment of an existing site is proposed. Engineering firms tasked with stormwater management design complete the Virginia Department of Environmental Quality's spreadsheet, known as the Virginia Runoff Reduction Method (VRRM) spreadsheet, to determine the treatment volume and total phosphorus load reduction required for their site. The water quality must be improved to meet the Virginia maximum of 0.41 lb/acre/year of phosphorus. To meet this goal, a BMP or series of BMPs can be designed which will remove nutrients from the runoff and potentially decrease the amount of runoff through infiltration as well (VA DEQ, 2016).

This current methodology of green infrastructure implementation is flawed because the technologies are distributed unequally throughout the Meadow Creek watershed, as can be seen on the city's online CityGreen map (City of Charlottesville, 2020), which means there are many areas that are not treated. By considering the implementation of BMPs on a watershed scale through a multi-objective analysis instead of considering implementation only in new development projects on a site to site basis, the watershed health can be improved as a whole.

There are multiple factors that will be considered in our watershed management plan from a technical perspective. The first factor considered will be the locations of "hotspots," which are areas that experience the greatest levels of pollutant loading. These hotspots can be identified by areas with large amounts of impervious surfaces and therefore excessive surface runoff, including industrial and commercial land uses, or areas that generate high quantities of nutrients, like athletic fields treated with lots of fertilizer (Wang et al., 2017). Another criterion to consider will be areas that are not already being treated by a BMP or located directly downstream of an existing BMP. The city of Charlottesville has an interactive map online pinpointing the locations of all publicly and privately owned green stormwater infrastructure that we can reference in this process. Albemarle County also has an online GIS layer that shows their stormwater facilities which we can reference as well. Additionally, we would like to factor in other indicators of ecological health using data on dissolved oxygen levels and conductivity collected by our team in the field at various locations along Meadow Creek. In hopes of addressing the broader goal of improving the health of all residents of the watershed, we will be factoring demographic data into the selection of hotspots as well. The importance of this will be discussed in the following section. To support the claim that this Meadow Creek watershed management plan should be implemented, we will look into developing an analysis of the immediate benefits and long-term resilience of our proposed plan.

STS Problem

As previously stated, BMPs are typically constructed with new development or redevelopment projects, which are projects in locations where developers believe they will get the highest return on investment (Mandarano & Meenar, 2017). This tends to exclude low-income and disadvantaged neighborhoods. A notable example of BMP placement within the Meadow Creek watershed is the Shops at Stonefield which has 42 tree box filters as well as bioretention, underground detention, and hydrodynamic separators (Albemarle County, 2020). Most engineering professionals in the private sector, including a local Charlottesville stormwater engineer I spoke with, do not consider the role of social factors in the placement of these green infrastructure technologies. Their priority is meeting the nutrient load reduction requirements on the site that their clients have already selected and asked them to design for. What many professionals and developers fail to consider is that viewing BMP technologies in Meadow Creek as purely technical objects keeps people in disadvantaged communities from receiving the benefits of these technologies, and puts already marginalized communities at a further disadvantage. By considering the fact that power relations between communities plays a role, the benefits of these technologies such as improved air and water quality, aesthetics, community cohesion, and opportunities for public education can be enjoyed by communities that need them the most. To resolve this problem of understanding, I propose that BMP technologies must be seen as political objects by all stakeholders in the Meadow Creek watershed improvement and BMP implementation processes.

To explore the current power relations related to the implementation of green stormwater infrastructure in the Meadow Creek watershed I will use Langdon Winner's theory of technological politics. In this theory, "politics" refers to power and authority between human groups and activities that these groups participate in. Winner claims that technologies have the ability to privilege some groups while marginalizing others, which affects power relations within society (Winner, 1980). Green infrastructure technologies were not meant to enhance the natural environments of some communities over others, but it creates a separation between those in the Meadow Creek watershed who have knowledge, power, influence, and capacity and those who do not. People who have high levels of capacity and awareness of these technologies can more easily obtain and maintain green stormwater infrastructure, while people who have less resources and have never heard of these technologies cannot (Leisnham et al., 2017).

To analyze the role that political aspects and power dynamics play in the local Meadow Creek watershed, I will perform an analysis of demographic data from census block groups in a geographic information software, ArcGIS Pro. Following the process laid out in a study by Mandarano and Meenar, maps will be generated showing the prevalence of different context variables in each census block group such as race, ethnicity, income, poverty rate, vacancy rates, and number of single parent households. After creating each separate map, a composite map will be made showing which block groups contain the highest numbers of each of these groups that can signify the presence of a disadvantaged community. Using data from the city's green infrastructure map, CityGreen, and the county's stormwater facilities GIS layer, locations of existing green stormwater infrastructure on private and public property can be identified. Then they will be overlaid onto a map containing the results of the census block group analysis to show local policy makers and engineers that green infrastructure is inequitably distributed in the Meadow Creek watershed.

Conclusion

The technical project will deliver a map showing the proposed locations for BMP implementation within the Meadow Creek watershed based on the hotspot analysis. This environmental analysis will include pollutant loading and ecological health information obtained from prior research studies and data we collect in the field at various locations along Meadow Creek. For each hotspot location chosen, a BMP type will be selected and then designed to a certain extent, which will be determined after the number of facilities is finalized. The STS research paper will deliver a comprehensive understanding of how the implementation of green stormwater infrastructure has unintended consequences, privileging wealthier communities over others, using the theory of technological politics. Local policymakers and engineers can be informed by these results and incorporate this knowledge into future project planning and policies. The results of both of these projects will address the broader socio-technical problem of improving water quality and providing social benefits of green stormwater infrastructure technologies for all residents of the Meadow Creek watershed, not just the people in already privileged areas. Hopefully some of the technologies designed in the technical project can be implemented in priority areas and will work to create cleaner waterways, cleaner air, and safer neighborhoods for all.

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