Executive Summary

Impacts of Rainfall Distributions and Land Cover on the Effectiveness of Stormwater Best Management Practices

By

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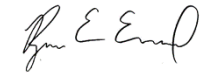

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Anthropogenic climate change and other human impacts on landscapes necessitate human interventions such as the implementation of stormwater best management practices and ecosystem restoration. To combat pollution entering our waterways and to decrease the frequency of severe flooding, stormwater best management practices (BMPs) are often implemented. Key examples come from Clarksburg, MD, an urbanizing area outside of Washington, DC. Previous studies of the area explore how different BMP implementation techniques (grey vs. green infrastructure) impact stream health, estimated using benthic community indicators like benthic index of biotic integrity (IBI), percent EPT, and taxa richness. Taxa richness is a measure of the number of different taxa present, while EPT looks at the percent of individuals from sensitive taxa including Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies) relative to all benthic macroinvertebrate individuals (Reif, 2002 & Haney, 2013). On the other hand, IBI is a metric created by the Maryland Department of Natural Resources and is a combination of 9 metrics: total number of taxa, number of EPT taxa, number of Ephemeroptera taxa, number of Diptera taxa, percent Ephemeroptera, percent Tanytarsini, number of intolerant taxa, percent tolerant individuals, and percent collectors (MDNR, 2007). Findings from other Clarksburg studies resulted in a critical research question: why are two sub catchments of similar size, bmp implementation techniques, and land cover resulting in different benthic variable outcomes?

This study analyzed two sub catchments, TR-104 and TR-109, by considering BMP placement in regard to drainage area composition, sub catchment land cover types and amounts treated by BMPs, and the storage capacity of each catchment and how it is impacted by different storm intensities and distributions. To do this, for both catchments, all BMPs had their drainage areas delineated using a 10m digital elevation model. Land cover maps were also created for the

years 2010 to 2019 using Planet RapidEye Orthorectified imagery and supervised maximum likelihood classification in ArcGIS (Esri Inc, 2020 & Planet Team, 2017). The different classifications included impervious, barren (fallowed agricultural land and construction areas), grass (grasses and active agriculture), and forest. he drainage areas were overlayed by the land cover to create a dataset that contained how much of each land cover was treated by a given BMP, and each BMP's storage capacity if applicable. This information was then summarized for the sub catchments to include each land cover's area treated, area untreated, and percent of that land cover treated. A model was also created using BMP drainage areas and storage information to simulate storage availability throughout a rainfall event. Eight different scenarios were tested using rainfall data from a typical (mean daily rainfall amount) and extreme (maximum daily rainfall amount) event across a range of climate conditions represented by recent historical climates of Clarksburg, MD and three other cities: Dallas, TX, Seattle, WA, and Los Angeles, CA. Storage throughout an event was modeled using the drainage area and land cover composition to calculate runoff entering each BMP. Relationships were tested between the land cover variables, total storage capacity, and benthic variables. BMPs were also evaluated to see if they were under- or over-utilized during storm events in the model. Lastly, an optimization model was created to find areas that would make good candidates for BMP placement. This was done by examining flow accumulation values, locations where BMPs already existed, and places with untreated impervious and barren cover.

The results of this study showed weak relationships between benthic indicator variables and the land cover variables at both sub catchments. TR-104 had a positive relationship between storage and IBI, while TR-109 had a negative relationship. One possible reason for the weak relationships was exemplified in the results of the rainfall scenarios. For a typical event, TR-109 had more BMPs that were overwhelmed and more underused compared to TR-104. This could

signify that the drainage composition and BMP treatment area are only part of what makes a BMP effective. Therefore, they may not be a great indicator on their own for BMP effectiveness if BMPs are not being used in a way they were designed for. Especially if the problem is under-sizing, which means that although that area is "covered" by a BMP it may not be treated throughout entirety of a storm event. When this happens not all runoff in that area is being treated before reaching the stream. Other reasons for not seeing strong relationships could be the limited amount of data post-construction, as well as the fact that ecosystems take time to recover. The BMP optimization model resulted in many suitable spots for both TR-104 and TR-109. If BMPs were to be implemented in these locations, the percent of impervious cover treated would increase from 33% to 56% at TR-104 and from 51% to 53% at TR-109.

Overall, the results of this study can be used to identify shortcomings in the arrangement of current BMP infrastructure in Clarksburg, MD. Local resource managers can use this information to decide future BMP placement and consider sizing for both typical and extreme events. This will mitigate the effect of urbanization on stream health, in addition to benefiting humans by decreasing stream flashiness and therefore instances of flood events. The methods used in this study can help evaluate both the individual and catchment wide effectiveness of BMPs and BMP systems. This study also offers ideas for future research in the area to better understand what makes a BMP effective. One possible idea is to monitor the water quality incoming and outgoing from BMPs to identify the problem in each individual drainage area and accordingly specialize BMP implementation to address the issue. This is important because although benthic variable outcomes tell us there is a problem, it does not necessarily tell us what is behind it. Hopefully this information can be used to direct future studies and to optimize BMP implementation.