Managing Urban Stream Sedimentation

Accotink Creek, Virginia

Hannah Somers, Vermont Law School
7/30/2016

ABSTRACT: Accotink Creek is a 52 mile stream located in northern Virginia. Due to its high level of development and impervious cover it is classified as an urban stream. Currently, a sediment Total Maximum Daily Load (TMDL) is being developed for the stream and its major tributary, Long Branch, with the goal of reducing streambank erosion and stream widening with a hope to restore the benthic community. I suggest that adequate management of Accotink Creek and Long Branch will require a highly planned, prioritized, and watershed-scale two-step approach. First, impervious surface cover in the watershed must be reduced and infiltration rates increased using a system of Low Impact Developments (LID). Second, riparian buffer and stream restoration will be necessary due to high levels of stream degradation, but must only be included once stormwater flow has been reduced to a point at which the restoration measures will be successful. Restoration practices, while they should be implemented only after LID practices are adequate, must be included in initial planning to ensure a watershed approach. This paper will assist in determining the initial considerations in determining the most effective sedimentation management plan for Accotink Creek and Long Branch.

TABLE OF CONTENTS

ACRONYMS

BMP	Best Management Practice
CWA	Federal Water Pollution Control Act ("Clean Water Act")
EPA	United States Environmental Protection Agency
ISC	Impervious Surface Cover
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollution Discharge Elimination System
TMDL	Total Maximum Daily Load
VA DEQ	Virginia Department of Environmental Quality
VSCI	Virginia Stream Condition Index
VSMP	Virginia Stormwater Management Program
WIP	Watershed Implementation Plan

Managing Urban Stream Sedimentation
Accotink Creek, Virginia Case Study

1. Introduction

Section 303(d) of the Federal Clean Water Act (CWA) requires states to develop Total Maximum Daily Loads (TMDLs), which describe the maximum amount of a pollutant a waterbody can receive, for any waterbodies that are found to be impaired.[1] The Virginia Department of Environmental Quality (VA DEQ) uses monitoring of benthic macroinvertebrate communities to ensure that water quality standards are met in Virginia streams.[2] The monitoring is then quantified using the Virginia Stream Condition Index (VSCI) which ranges from 0-100. DEQ has set 60 as the threshold for indicating impairment. Accotink Creek's VSCI scores for the Upper Accotink, Lower Accotink, and Long Branch tributary range from 21.2 to 38.9; well below the set threshold of impairment.[3]

The U.S. Environmental Protection Agency (EPA) in conjunction with the VA DEQ developed a TMDL for Accotink Creek in 2012. The TMDL aimed to use hydrologic flow modeling as a proxy for the amount of sedimentation occurring in the creek. The models were then used to determine the amount of sediment loading and therefore the amount of sediment reduction required in accordance with the Chesapeake Bay TMDL[4] and Virginia's Watershed Implementation Plans (WIPs)[5]. In *Virginia Department of Transportation v. EPA*, the district

---

[1] 33 USC 1313(d). Clean Water Act Section 303(d). "Water quality standards and implementation plans". Link.
[2] Virginia Department of Environmental Quality. Interstate Commission on the Potomac River Basin. *Stressor Analysis Report for the Benthic Macroinvertebrate Impairments in the Accotink Creek Watershed, Fairfax County, Virginia.* September 29, 2015. p.1-4. Link.
[3] Id. p.1-6.
[44] The Chesapeake Bay TMDL was developed on December 29, 2010 and provides a pollution loading reduction requirement for states in the Bay region in order to restore Bay health. These states include Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the District of Columbia. (US Environmental Protection Agency. "Chesapeake Bay TMDL Fact Sheet.". September 30, 2015. Link.)
[5] Watershed Implementation Plans (WIPs) are implemented by each state included in the Chesapeake Bay TMDL (see Footnote 4) to provide more detailed information on how to meet Bay TMDL goals by 2025. There are three

court remanded the TMDL for Accotink Creek.[6] The court applied the findings in *Chevron v. Natural Resources Defense Council*, stating that the utilization of proxy TMDLs violates authority granted to the EPA and VA DEQ under the CWA.[7] Water flow is not a "pollutant" according to the plain text of CWA Section 502(6) and therefore cannot be used to determine loading.[8]

Currently, new TMDLs for Accotink Creek and Long Branch are in the development stages. To begin the process, an analysis was conducted to determine the stressors causing biological impairments in both waterways. The stressor analysis identified four major stressors to the benthic environment – sediment, chloride, hydromodification[9], and habitat modifications.[10] To comply with the court's order, TMDLs need to be developed for both sediment and chloride. For hydromodification and habitat modifications alternative approaches may be used for mitigation. For the purposes of this paper, sediment management will be the focus.

Accotink Creek faces a unique management challenge due to the urbanization of its watershed. Increased impervious surface cover has led to a decrease in infiltration capacity of the soils, and therefore increased levels of urban stormwater runoff.[11] Increased runoff, increases flow velocity in the stream channel and causes high levels of streambank erosion and channel widening. The challenge of managing sedimentation in Accotink Creek, then, comes down to determining what is the most effective way to implement controls that will reduce impervious

---

phases, Phase I WIP, Phase II WIP, and Phase III WIP. Phase III WIP will begin in 2017. (US Environmental Protection Agency. "Chesapeake Bay Watershed Implementation Plans". July 27, 2016. Link.)

[6] Va. DOT v. United States EPA, 2013 U.S. Dist. LEXIS 981, 43 ELR 20002, 2013 WL 53741 (E.D. Va. 2013)

[7] Chevron U.S.A. Inc. v. Natural Resources Defense Council, Inc., 1983 U.S. LEXIS 2061, 464 U.S. 927, 104 S. Ct. 329, 104 S. Ct. 330, 78 L. Ed. 2d 300, 52 U.S.L.W. 3341 (U.S. 1983)

[8] 33 USC 1362(6). Clean Water Act Section 502(6). "Definitions". Link.

[9] Hydromodification means any change to the natural stream channel and includes activities such as channelization, channel modification, dams, and streambank or shoreline erosion. (US Environmental Protection Agency. "Nonpoint Source: Hydromodification and Habitat Alteration". October 31, 2015. Link.)

[10] Virginia Department of Environmental Quality. Interstate Commission on the Potomac River Basin. *Stressor Analysis Report for the Benthic Macroinvertebrate Impairments in the Accotink Creek Watershed, Fairfax County, Virginia.* September 29, 2015. p.1-4. Link.

[11] Id. p.335

cover and stormwater runoff. A sedimentation management plan to implement the future sediment TMDLs for Accotink Creek and Long Branch will require prioritizing implementation sites (Section 2.1), planning on a watershed scale (Section 2.2), and implementing management practices using a two-step approach. First, a plan for Low Impact Development (LID) implementation that reduces impervious surface cover in the watershed and therefore reduces stormwater flow reaching the channel is required (Section 3.1). Second, a commitment to implementing stream channel (Section 3.2) and buffer restoration (Section 3.3) will be necessary, but only after the urban stormwater flow levels have been reduced[12] in order to allow the restoration to be successful. Restoration will need to be included in the initial planning steps and should connect hydrologically to the LID practices in the watershed.

1.1 Watershed Characterization

Accotink Creek is a 52 mile stream located in northern Virginia. [13] The creek's watershed has an area of 51.1 square miles with jurisdiction split amongst Fairfax County (77%), the City of Fairfax (11%), the Fort Belvoir Military Reservation (8%), and the Town of Vienna (4%). The creek joins Daniels Run Tributary, Bear Branch and Long Branch tributaries before finally reaching Gunston Cove and the Potomac River.[14] The Creek watershed is characterized as urban

[12] Level of flow reduction necessary to implement successful stream channel and buffer restoration is variable and will require additional research. Data from the Knife River Restoration Project in Lake County, Minnesota suggests states that stream flow had increased 25-33% and therefore a similar percentage of flow reduction was necessary for restoration practices to be successfully implemented. (Healthy Lakes Healthy Rivers. "River Restoration in Minnesota Repairs Stream Banks, Reduces Sediment Load". March 22, 2016. Link.)

[13] Fairfax County Stormwater Planning Division. DPWES. *Fairfax County Stream Protection Strategy*. "Chapter 3: Accotink Creek Watershed Summary". p.3-73. Link.

[14] Id.

with 87% commercial, industrial, transportation, or residential lots less than two acres with 29% of the watershed covered by impervious surface.[15]

Three hydrogeomorphic regions are found in the watershed including Piedmont, Coastal Plain Uplands, and Coastal Plain Lowlands.[16] The Upper Accotink and Long Branch reaches fall completely within the Piedmont region. The Low Accotink reach falls 44% within the Piedmont, 50% in the uplands of the Coastal Plain, and the remaining 6% in the Coastal Plain Lowlands. Hydrogeomorphic classification determines the rate of groundwater discharge to the stream and is therefore important in determining the rate of flow traveling from the groundwater to the stream channel.[17] It is also worth noting in regard to flow and sedimentation control that 69.9% of Long Branch watershed, 38.3% of the Lower Accotink watershed, and 52.0% of the Upper Accotink watershed contains soils characterized by slow infiltration rates.[18]

2. Planning Considerations

Urbanization of the Accotink watershed has caused increased stormwater flow and therefore increased streambank erosion which is threatening the benthic community in both Accotink Creek and Long Branch. After the new sediment TMDLs are development for each reach, a management plan will need to be developed to determine the most effective way to meet TMDL goals and begin to restore the waterways to meet water quality standards. Before specific implementation practices can be determined, it is important to decide which sites throughout the

---

[15] Virginia Department of Environmental Quality. Interstate Commission on the Potomac River Basin. *Stressor Analysis Report for the Benthic Macroinvertebrate Impairments in the Accotink Creek Watershed, Fairfax County, Virginia.* September 29, 2015. p.ES-1. Link.
[16] Id. p.2-4
[17] National Geographic Society. "Hydrogeomorphic regions". Link.
[18] Virginia Department of Environmental Quality. Interstate Commission on the Potomac River Basin. *Stressor Analysis Report for the Benthic Macroinvertebrate Impairments in the Accotink Creek Watershed, Fairfax County, Virginia.* September 29, 2015. p.2-7. Link.

watershed should be given priority and how to implement practices on an interconnected, comprehensive, watershed-scale.

2.1 Site Prioritization

Adequate implementation of sediment management practices will first require a prioritization of implementation sites based on reach, land use type, and restoration potential. First, a prioritization amongst the Upper Accotink, Lower Accotink, and Long Branch reaches will be required. Because Lake Accotink segments Accotink Creek and therefore likely captures most of the sediment from the Upper Accotink and Long Branch it is important to consider which segment may be more suitable for implementing sediment management practices.

Second, landuse types throughout the Accotink Creek watershed should also be examined for prioritization. Residential landuse makes up 66.1%, 59.6%, and 76.7% of the Upper Accotink, Lower Accotink, and Long Branch watersheds respectively.[19] Therefore, residential land already makes up a large portion of the affected watershed and should be considered when prioritizing where to implement sedimentation management practices. Additionally, there is generally a high percentage of impervious cover in residential areas. For example, each of the 13 residential areas assessed in the Long Branch Central reach watershed contained 55-70% impervious cover.[20] High percentage of residential land use in the Accotink watershed paired with high levels of impervious cover in many of those residential areas presents a sediment management opportunity. If management practice implementation can be focused on residential areas, especially where impervious cover is high, and practices were found to be effective, 66.1%-76.7% of the watershed would be managed, leaving a small percentage left to control.

---

[19] Virginia Department of Environmental Quality. Interstate Commission on the Potomac River Basin. *Stressor Analysis Report for the Benthic Macroinvertebrate Impairments in the Accotink Creek Watershed, Fairfax County, Virginia.* September 29, 2015. P.2-14. Link.

[20] Fairfax County Department of Public Works and Environmental Services. “Watershed Workbook”. Accotink Creek Watershed Management Plan DRAFT. October 2008. p.2-18. Link.

Another way to consider prioritizing sedimentation control practices is by looking at stream channel and buffer restoration potential. To adequately control sedimentation in the Accotink watershed, LID practices must be implemented adequately in order to reduce flow to a level suitable for stream channel and buffer restoration.[21] It would be helpful to consider which reaches have the highest restoration potential and to begin there for the highest chance of restoration success. Additional research will most likely be necessary before actual implementation, but there is current data available on restoration potential that could help to narrow down site choices. Fairfax County Department of Public Works and Environmental Services produced a Watershed Workbook in October of 2008 that outlines the restoration potential for different segments of Accotink Creek and Long Branch (see Appendix). For example, the segment labeled Long Branch North has only 6% moderate restoration potential for stream buffers. A reach of Accotink Creek referred to as Mainstem 1, in contrast, has high erosion restoration potential and stable stream buffers. The watershed of reaches with higher restoration potential should be targeted as priority implementation sites in order to ensure that once LID practices are implemented and successful, the reach itself has a high probability of restoration.

Determining where in the Accotink watershed to prioritize LID practices and long-term restoration efforts is important in ensuring a sedimentation management plan that is both cost and time effective. Once sites are prioritized, specific practices and timelines can be determined.

[21] See Footnote #11.

2.2 Watershed-Scale Implementation

Adequate implementation of sedimentation control practices to meet future TMDL goals in the Accotink watershed, in addition to site prioritization, will require comprehensive and watershed-scale planning. Considerations will have to be made both in the interconnection of individual LID practices and also in the planning of future restoration projects that are hydrologically connected to those LID practices. The goal is to ensure that the largest percentage of the watershed is under stormwater and sedimentation management as possible and that LID practices are reducing the flow levels reaching future restoration sites in order to ensure longevity of restoration projects.

A planning model called the "treatment train" is often used to ensure that implemented practices connect hydrologically. For example, a rain garden may be placed within a residential area, which then may convey water to an infiltration basin or constructed wetland, which would then convey water to a restored stream. A "treatment train" requires a large amount of initial planning and investment and therefore may be difficult to implement.[22] Whether or not the management plan for Accotink watershed sedimentation follows strictly the "train" model, LID practice connection to future stream restoration projects will be necessary. The extent to which the Creek and Long Branch have been altered will require a comprehensive plan which will employ management practices that will convey stormwater flow to a stream reach which can then be adequately restored.

[22] Wong, Tony H.F. Tim D. Fletcher. "Modelling Urban Stormwater Treatment – A Unified Approach". *Ecological Engineering.* August 2006. Section 1. Link.

3. Suggested Management Practices

Adequate management of sedimentation in Accotink Creek is going to require a focused, watershed-scale approach that maintains the natural ecological structure and function of receiving water bodies.[23] The urbanization of the stream has effectively turned Accotink from a functioning ecosystem to an efficient gutter. [24] Conventional stormwater controls have been found to only exacerbate this problem, failing to mitigate streambank erosion and sedimentation. A combination of focused LID practices and carefully-planned stream bank and channel restoration at hydrologically at strategic locations will be necessary.

To understand why LID practices do work, it is important to examine how conventional stormwater management has failed. Conventional stormwater management practices, also known as grey infrastructure, have exacerbated the effects of urbanization and have led to increased streambank erosion. These practices include pipes, drains, curbs, tanks, etc. which essentially work to convey stormwater runoff and discharge into streams and rivers as quickly as possible in order to reduce potential damage caused by urban flooding.[25] The effect of urbanization on streams acts similarly by increasing the loading of water and nutrients while simplifying the stream channel. Conventional stormwater management practices, in an effort to control stormwater runoff, have actually aided in the simplification of channel substrate, the alteration of bank structure, and the reduction of woody materials used for habitat.

Traditional management methods focused initially on conveying flow to the stream channel. Unfortunately, this process has become problematic for benthic organisms as increased

[23] Wong, Tony H.F. Tim D. Fletcher. "Modelling Urban Stormwater Treatment – A Unified Approach". *Ecological Engineering.* August 2006. Section 1. Link.
[24] Bernhardt, Emily S. and M.A. Palmer. "Restoring streams in an urbanizing world". *Freshwater Biology* (2007). p.738. Link.
[25] A.H. Roy, S.J. Wenger, T.D. Fletcher, C.J. Walsh, A.R. Ladson, W.D. Shuster, H.W. Thurston, R.R. Brown. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States". *Springer : Environmental Management*. (2008). p.346. Link.

flow causes streambank erosion which fluxes excess sediment into the stream channel and alters habitat, negatively affecting the ecosystem. Thankfully, the Clean Water Act (CWA) of 1972 began to show a shift in the way US waters were managed.[26] Then in 1987, the National Pollution Discharge Elimination System (NPDES) stormwater program brought change once again in the form of a permitting structure, allowing oversight and the development of a system of best management practices (BMPs).[27] The development of new implementation options created room for transition away from grey infrastructure and towards green infrastructure, or low impact development (LID).

3.1 Low Impact Development (LID)

LID was first implemented in Maryland in 1999 as a way to mitigate the effects of urbanization and impervious surface coverage on streams in Prince George's County.[28] Practices can include a variety of techniques but common practices include vegetated swales, wetlands, ponds, sedimentation basins, and infiltration systems, green roofs, and permeable pavements.[29] Since its development, many LID practices have been implemented with the focus of "preserving as much as the site in an undisturbed condition, and where disturbance is necessary, reduces the impact to the soils, vegetation, and aquatic systems".[30] In contrast, conventional stormwater treatment typically only mitigates peak flow conditions, while LID practices work to also maintain the pre-development runoff volume.[31] Successful management of sedimentation in the

---

[26] A.H. Roy, S.J. Wenger, T.D. Fletcher, C.J. Walsh, A.R. Ladson, W.D. Shuster, H.W. Thurston, R.R. Brown. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States". *Springer : Environmental Management*. (2008). p.346. Link.
[27] Id.
[28] Id.
[29] Wong, Tony H.F. Tim D. Fletcher. "Modelling Urban Stormwater Treatment – A Unified Approach". *Ecological Engineering.* August 2006. Section 1. Link.
[30] A.H. Roy, S.J. Wenger, T.D. Fletcher, C.J. Walsh, A.R. Ladson, W.D. Shuster, H.W. Thurston, R.R. Brown. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States". *Springer : Environmental Management*. (2008). p.352. Link.
[31] Id.

Accotink Creek basin must involve Low Impact Development (LID) implementation measures that offset the high levels of imperviousness and stormwater runoff in the basin.

Accotink Creek faces a unique challenge due to the urbanization of its watershed. Increased impervious surface coverage leads to a decrease in infiltration capacity of the soils, and therefore increased levels of urban stormwater runoff.[32] As the percent impervious surface cover (ISC) increases to 10-20%, runoff increase twofold, at ISC of 35-50%, runoff increases threefold, and as ISC increases to 75-100%, runoff increase threefold.[33] Currently, all segments of the Accotink Creek watershed, with the exception of the central Long Branch tributary, contain greater than 25% ISC.[34] Stormwater runoff from areas with high percentages of impervious surfaces is the main contributor to the degradation of urban streams.[35] In the case of Accotink Creek, the major stressor is urban stormwater runoff then causes increased quantity and velocity of water within the stream channel, causing abnormal levels of stream bank erosion and sedimentation.

3.1.1 Benefits to Accotink Watershed

Sedimentation is most efficiently controlled using practices that increase infiltration. For example, infiltration practices such as infiltration basins and porous pavement remove sediment at a 90% pollutant removal efficiency; and filtering practices such as swales and bioretention facilities remove sediment at a 85% pollutant removal efficiency.[36] The key is increasing the percentage of pervious surface and decreasing the amount of stormwater flow reaching the

---

[32] A.H. Roy, S.J. Wenger, T.D. Fletcher, C.J. Walsh, A.R. Ladson, W.D. Shuster, H.W. Thurston, R.R. Brown. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States". *Springer : Environmental Management*. (2008). p.335. Link.
[33] Id.
[34] Fairfax County Stormwater Planning Division. DPWES. *Fairfax County Stream Protection Strategy*. "Chapter 3: Accotink Creek Watershed Summary". p.3-73. Link.
[35] A.H. Roy, S.J. Wenger, T.D. Fletcher, C.J. Walsh, A.R. Ladson, W.D. Shuster, H.W. Thurston, R.R. Brown. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States". *Springer : Environmental Management*. (2008). p.344. Link.
[36] Chesapeake Bay Program. "Best Management Practices for Sediment Control and Water Clarity Enhancement". October 2006. p.32. Link.

channel. The LID approach has been found to result in "increased retention of stormwater and pollutants on site, mimicking pre-development hydrologic function".[37] Additionally important especially in the Accotink Creek watershed where there is a combination of old and new developments, LID practices can be applied equally well to new development, urban retrofits, and redevelopment or revitalization programs.[38]

In addition to lowered costs for the intended benefits of LID practices, there are also environmental and social benefits that could be factored into a cost-benefit analysis. For example, LID practices can increase the urban forest, reduce the urban heat island, improve air quality, reduce thermal stream pollution, enhance the appearance of a community, and provide a stronger sense of place.[39]

For these reasons, Low Impact Development (LID) practices which increase pervious surface coverage and encourage infiltration is a necessary first step in decreasing the streambank erosion and sedimentation occurring in Accotink Creek and Long Branch. Though there are many stormwater practices available, LID practices will provide for long-term improvements to the watershed that will allow for successful stream and riparian restoration efforts in the future.

3.1.2 Considerations for Implementation

While practices are very efficient at mitigating sedimentation, a few considerations should be made before implementation. These potential challenges include costs and and long-term maintenance.

Case studies show at least a 25-30% reduction in costs associated with site development, stormwater fees, and maintenance for residential developments that use LID techniques. LID

[37] Chesapeake Bay Program. "Best Management Practices for Sediment Control and Water Clarity Enhancement". October 2006. p.32. Link.
[38] Id.
[39] "Introduction to LID". Link.

practices generally have lower lifetime costs than conventional practices as well. In 2010, New York City released a green infrastructure plan outlining options for LID practices to help reduce combined sewer overflows and protect water quality.[40] The study then compared the green strategy with a grey infrastructure strategy aimed to achieve the same goals. In total the green strategy was found to reduce CSO volumes by 2 billion gallons more and cost $1.5 billion less than the grey strategy.[41] A case study from Seattle, WA also showed that LID practices would be effective in areas of urban development. The Seattle study showed that just by reducing impervious surface by 11% using LID practices, stormwater leaving the street declined by 99 percent and total suspended solids was reduced by 84%.[42] The variability of LID practices and the potential for hybrid systems also presents the issue of adequate cost-analysis in the planning stages. Two resources to explore when modeling the costs are *Best Management Practices and LID Whole Life Cost Models* and *Green Values Calculator*. *Best Management Practices and LID Whole Life Cost Models* is a spreadsheet of tools that can be used to help identify whole life costs of stormwater management practices through a combination of capital costs and ongoing maintenance costs.[43] The *Green Values Calculator* is a tool used to quickly compare the costs and benefits of different types of LID practices and those of conventional stormwater practices.[44]

Generally, LID practices are able to address stormwater runoff through small, cost-effective landscape features located at the lot level.[45] A large part of LID effectiveness is maintaining long-term maintenance and proper function. Unlike conventional practices, this can

[40] United States Environmental Protection Agency. Office of Wetlands, Oceans, and Watersheds. "Maintenance of Low Impact Development". December 2012. Link.
[41] Id.
[42] United States Environmental Protection Agency. Office of Wetlands, Oceans, and Watersheds. "Effectiveness of Low Impact Development". October 2012. Link.
[43] Water Environment and Reuse Foundation. "Best Management Practices and LID Whole Life Cost Models". Link.
[44] Green Values. "National Stormwater Management Calculator". Link.
[45] "Introduction to LID". Link.

be done with LID practices such as rain gardens or bioretention ponds which add an appealing addition for the community. This appeal combined with educational efforts about the purpose and proper maintenance of the facility can allow for a sense of ownership within the community and therefore adequate community maintenance. Additionally, although community maintenance may take initial education efforts, it has the potential to reduce strain on local government manpower.

3.2 Stream Channel Restoration

Accotink Creek and Long Branch are experiencing severe streambank erosion and channel widening. This requires that any mitigation of sedimentation not only requires a holistic approach to LID practice implementation, but also a long-term commitment to implementing in-stream and riparian reconstruction once the level of flow has been adequately reduced. Stream restoration is a term used to cover a "broad range of actions and measures designed to enable stream corridors to recover dynamic equilibrium and function at a self-sustaining level".[46] Restoration practices could include a variety of practices including bank protection, grade control, flow deflection and concentration, and bank stabilization.[47]

In developed urban catchments, "the majority of sediment leaving the catchment comes from within channel erosion as opposed to hillslope erosion".[48] As urban streams widen at an unnatural rate, the ratio between pools and riffles tends to remain constant, therefore the spacing between these natural structures becomes greater and creates unnatural habitat conditions.[49] Pool habitats can also be significantly affected as excess sediment is deposited, filling pools and

---

[46] Chesapeake Bay Program. "Best Management Practices for Sediment Control and Water Clarity Enhancement". October 2006. p.14. Link.
[47] Id. p.17
[48] A.H. Roy, S.J. Wenger, T.D. Fletcher, C.J. Walsh, A.R. Ladson, W.D. Shuster, H.W. Thurston, R.R. Brown. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States". *Springer : Environmental Management*. (2008). p.340. Link.
[49] Id.

harming invertebrate communities.[50] Additionally, "less fine sediment, increased coarse sand fractions, and decreased gravel classes" have been observed in urban stream channels with bank erosion.[51]

3.2.1 Benefits to Accotink Watershed

90% of the channels in the Accotink Creek watershed are characterized as a Type III stream channel, meaning degradation has led to overly steep banks, common bank failure, and extreme bank erosion.[52] The watershed "contains extensive areas of unstable habitat, with sloughed and eroded banks, large unstable sediment bars and numerous fallen trees and logjams".[53] Erosion of the streambank creates a widening effect that can damage the natural pools and riffles as well as the natural substrate of the channel.[54]

The effects of urbanization, high percentages of imperviousness, and stormwater runoff have the unique effect of actively widening and degrading the benthic community in Accotink Creek and Long Branch. According to a DEQ assessment done in 2000, bank stability was assessed as marginal or poor in all but one of the sixteen habitat assessments throughout the watershed.[55] Because of stream widening, LID practice implementation may not be enough to restore the Accotink Creek stream ecosystem.

With long-term planning that includes large scale in-stream and riparian restoration practices, the LID practice implementation alone may not be sufficient to recover the stream

---

[50] Paul, Michael J. and J.L. Meyer. "Streams in the Urban Landscape". *Annual Review of Ecology and Systematics*. Vol.32 (2001). p.350. Link.
[51] Id. p.340
[52] Fairfax County Department of Public Works and Environmental Services. "Watershed Workbook". Accotink Creek Watershed Management Plan DRAFT. October 2008. p.1-16. Link.
[53] Id. p.3-75
[54] Virginia Department of Environmental Quality. Interstate Commission on the Potomac River Basin. *Stressor Analysis Report for the Benthic Macroinvertebrate Impairments in the Accotink Creek Watershed, Fairfax County, Virginia.* September 29, 2015. p.ES-8. Link.
[55] Virginia Department of Environmental Quality. Interstate Commission on the Potomac River Basin. *Stressor Analysis Report for the Benthic Macroinvertebrate Impairments in the Accotink Creek Watershed, Fairfax County, Virginia.* September 29, 2015. pES-7. Link.

ecosystem. This would be the case if components of the original system have been lost due to abnormal water flow levels. Because of the major changes to the channel of Accotink Creek and its tributaries this is likely the case. Therefore, stream restoration practice options must be assessed and included in initial implementation planning to ensure that after LID practices are implemented and found to be successful, the stream itself will be restored in a cohesive fashion.

3.2.2 Considerations for Implementation

Generally, restoration efforts within the stream channel or within the riparian vegetation are unlikely to substantially improve instream ecological conditions because these practices do not match the scale of the degrading process.[56] The same would be true for implementation practices in the Accotink Creek watershed because of high levels of impervious cover and the large quantity of flow reaching the stream channel. Therefore, volume of stormwater runoff from impervious surface in the watershed must be controlled first before stream restoration can occur successfully.

Stream restoration may not be feasible in all circumstances, it may not even be effective without adequate LID controls outside of the streams, but they need to be considered, included in the holistic approach when installing LID controls, and should be implemented down the road once the LID controls are shown to be working properly.

Cost of stream restoration projects is also a very important consideration but vary widely. According to data from Montgomery, Baltimore, and Prince Georges Counties, Maryland, costs per linear foot range from $13-$700 depending on the project.[57] Larger projects tend to have lower costs per linear, and therefore while costs are variable, data suggests that higher levels of

[56] Walsh, Christopher J.; T.D. Fletcher; A.R. Ladson. “Stream restoration in urban catchments through redesigning stormwater systems: looking to the catchment to save the stream”. *North American Benthological Society*. (2005). p.690. Link.

[57] Chesapeake Bay Program. “Best Management Practices for Sediment Control and Water Clarity Enhancement”. October 2006. p.19. Link.

initial planning and organization that would make larger projects possible should be considered.[58]

3.3 Stream Buffer Restoration

To ensure that any stream channel restoration in the Accotink Creek watershed is successful in restoring the benthic community and reducing streambank sedimentation and destabilization, the restoration of buffers must also be considered. A riparian buffer is an "area of trees, shrubs, grasses or other a vegetation that is (i) at least 35 feet wide, (ii) adjacent to a body of water, and (iii) managed to maintain the integrity of stream channels and shorelines".[59]

3.3.1 Benefits to Accotink Watershed

Buffers can serve many water quality purposes including promoting infiltration, groundwater recharge, and moderating peak flows. The roots of mature buffers can also help to stabilize streambanks and prevent further streambank erosion. The Chesapeake Bay Program credits urban riparian forest buffers with an average sediment reduction efficiency of 50% for forest buffers, but sediment reduction efficiency have not yet been established for grass buffers.[60]

3.3.2 Considerations for Implementation

Unfortunately, in many urban areas there is a lack of available space to implement osubstantial riparian buffers. Additionally, although buffers can be up to 50-85% efficient at sediment reduction, this sediment is often removed from stormwater flow itself and therefore buffers may not be as successful in controlling in the Accotink Creek watershed where sedimentation occurs mainly from streambank erosion.

---

[58] Chesapeake Bay Program. "Best Management Practices for Sediment Control and Water Clarity Enhancement". October 2006. p.19. Link.
[59] Id. p.8
[60] Id. p.8

The costs of implementing riparian buffers, similar to stream restoration projects, are also extremely variable. For 435 bare root seedlings per acre, the cost range is listed as $1529-$2060, including maintenance.[61] Many other costs can also be involved though, especially if other materials for bank stabilization ate involved. Funding and implementation are also of concern because maintenance of riparian buffers requires the ability to provide adequate outreach and technical assistance to landowners, and the costs largely go beyond traditional cost share and incentive programs, especially in urban areas. For example, the Conservation Reserve Enhancement Program (CREP), a major source of funding for riparian buffers, is largely aimed at agricultural practices and agricultural lands make up a very small percentage of the Accotink Creek watershed.[62]

Riparian buffers are very effective at mitigating peak flows and stabilizing stream banks and therefore will be necessary in the Accotink Creek watershed in order to restore benthic health. Unfortunately, of the current infrastructure in the watershed the most significant problems included 50 deficient buffers.[63] If buffers are not managed properly, they become very ineffective and therefore may not be the most cost effective options to controlling sedimentation in the watershed. Therefore, I believe they will be most effective when constructed in conjunction with stream restoration projects in order to consolidate maintenance efforts.

[61] Chesapeake Bay Program. "Best Management Practices for Sediment Control and Water Clarity Enhancement". October 2006. p.10. Link.
[62] Id. p.12
[63] Fairfax County Department of Public Works and Environmental Services. "Watershed Workbook". Accotink Creek Watershed Management Plan DRAFT. October 2008. Link.

4. Other Considerations

Site prioritization, comprehensive watershed-scale planning, and an interconnected implementation plan first involving LID practices to ensure for future success of restoration practices are all crucial aspects of successfully managing sedimentation in Accotink Creek and Long Branch watersheds. Other factors I will touch on briefly but deserve more in depth consideration include: encouraging community education and involvement, and expanding monitoring practices.

4.1 Community Education & Involvement

Community education and involvement is beneficial to sedimentation management in the Accotink Creek watershed in many ways. First, education about the harms of sedimentation to the benthic community and general health of local streams can help to gain support for the implementation of management practices. Second, members of the community could be helpful in implementing practices or monitoring stream health in a way that government agencies may not be able to due to funding or manpower restrictions. Local governments offer programs such as Adopt-A-Stream and citizen monitoring that would be beneficial to pursue. Finally, some practices may fall on or near private property and rely on the community to take ownership of and maintain. For all of these reasons, education and community involvement is an important part of any stream management plan and could be especially useful in the case of sedimentation management in the Accotink watershed.

4.2 Monitoring for Effectiveness

Monitoring is crucial to the success of the Accotink Creek watershed management plan for two reasons. First, in order to ensure that stream channel and buffer restoration can begin and function successfully, monitoring of the effectiveness of the implemented LID practices is necessary. After LID practices are implemented, factors such as infiltration rates, reduction of peak flow levels, and connectivity to desired reaches will be necessary to determine when conditions have been restored to a level that can maintain restoration activities. Second, monitoring of both LID practices and restoration practices will be necessary for record keeping purposes. For example, currently there is very little data on reduction of sedimentation from streambank erosion sources specifically and additional data will be helpful in ensuring that future TMDL requirements are met.

5. Conclusion

The effort to abate the degradation of urban stormwater runoff and streambank erosion in Accotink Creek and Long Branch must be as comprehensive and integrated as the process of degradation.[64] Prioritization of restoration must be based on reach, land use type, and restoration potential to determine most effective implementation sites. Then, planning considerations should be determined on a watershed-scale and based in the idea of a "treatment train" management model that will help management practices connect hydrologically from the watershed to the stream channel. Specific management practice implementation should include a two-step approach. First, a plan for Low Impact Development (LID) practice implementation that reduces impervious cover and, second, a commitment to stream channel and buffer restoration to restore Accotink Creek and Long Branch health.

This paper provides an overview on how to begin to develop an effective sediment management plan to meet future TMDL requirements for Accotink Creek and Long Branch based on the above recommendations, but future research will be needed to fully develop additional considerations for implementation. These considerations include determining

[64] file:///C:/Users/Login/Downloads/MikalsenT-89.pdf In discussion section

jurisdiction for implementation, legal authority for implementation, and how to best address retrofitting current developments in the watershed. First, it should be determined which of the localities involved - Fairfax County, the City of Fairfax, Fort Belvoir Military Reservation, or the Town of Vienna - will implement which components of the management plan. This distinction is important because it is relevant to determine local legal authority and funding sources.

Second, the legal authority for each of these jurisdictions to implement management practices should also be more fully explored. The federal legal authority is founded in federal, state, and local laws. Exploration will be required for a number of topics including: the authorities given through the CWA Section 303(d) which establishes authority for TMDL development[65], state WIPs that give states the authority to implement TMDL goals[66], and stormwater management authority given under the Virginia Stormwater Management Program (VSMP)[67] to localities through Municipal Separate Storm Sewer System (MS4) permits[68]. Each locality has local ordinances that should be explored as well.

Third, a more in depth consideration on how to retrofit[69] current developments is necessary to implement a sediment management plan for the Accotink watershed. This is important because often retrofitting facilities can become more costly then creating facilities during the process of new development. It is also important to consider within a long-term management plan because facilities may need to have the ability to be retrofit for increased capacity as the watershed continues to develop. All of the above considerations should be explored further in

---

[65] USC 1313(d). Clean Water Act Section 303(d). "Water quality standards and implementation plans". Link.

[66] Watershed Implementation Plans (WIPs) are implemented by each state included in the Chesapeake Bay TMDL (see Footnote 4) to provide more detailed information on how to meet Bay TMDL goals by 2025. There are three phases, Phase I WIP, Phase II WIP, and Phase III WIP. Phase III WIP will begin in 2017. (US Environmental Protection Agency. "Chesapeake Bay Watershed Implementation Plans". July 27, 2016. Link.)

[67] Virginia Department of Environmental Quality. "Stormwater Management". Link.

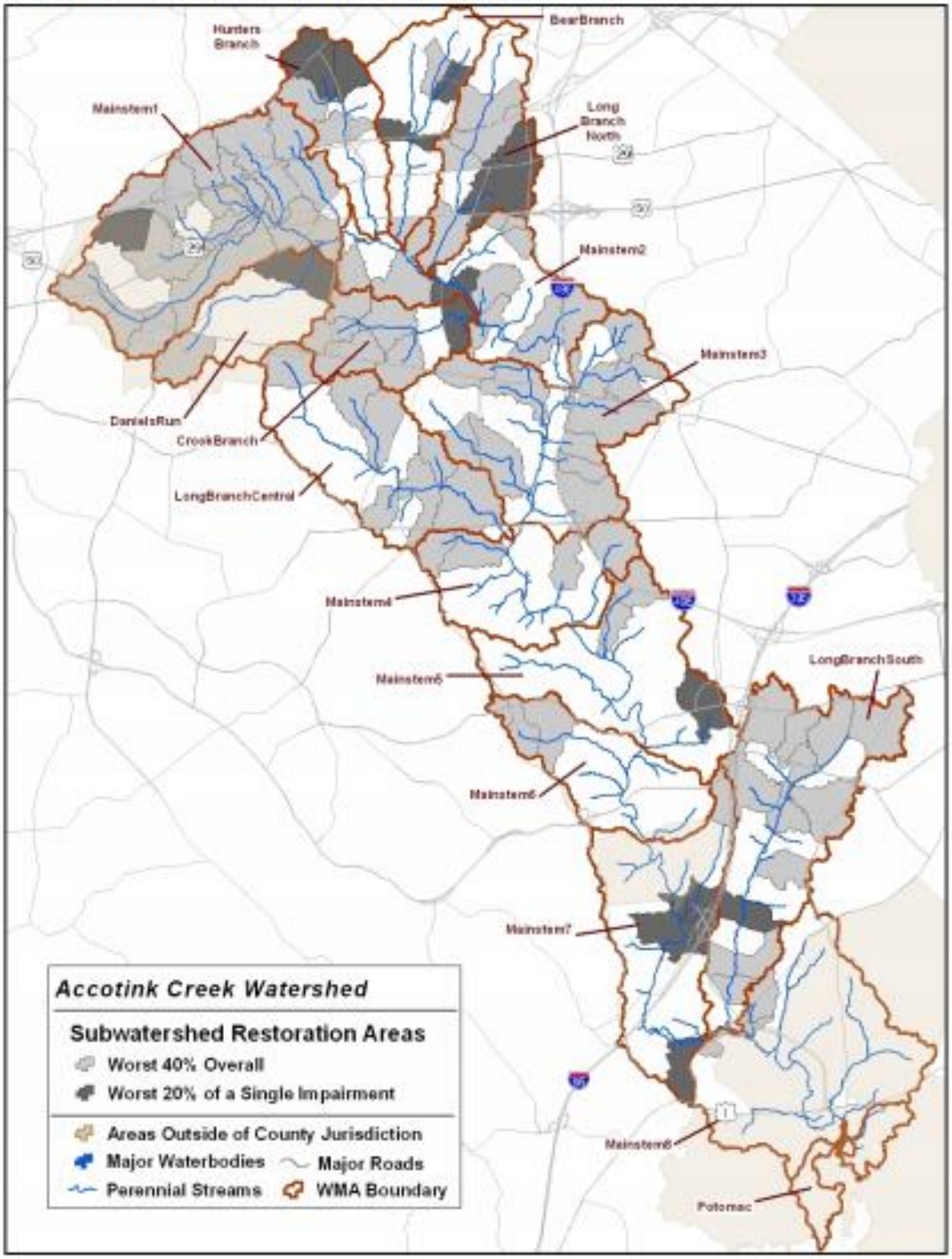
[68] Virginia Department of Environmental Quality. "Municipal Separate Storm Sewer System (MS4) Permits". Link.

[69] Retrofitting is the process by which new stormwater management practices can be installed in older developments where no stormwater controls were previously in place or where the current controls are inadequate. (Chesapeake Stormwater Network. "Stormwater retrofits". Link.)

additional research and combined with the findings in this paper to develop an effective sediment management plan for Accotink Creek and Long Branch.

6. Appendix [70]

Map 4-1: Priority Subwatershed Restoration Areas



[70] Fairfax County. Accotink Creek Watershed Management Plan : Chapter 4. "Summary of Watershed Restoration Strategies". p.4-3. Link.