The Borough of Northumberland, Pennsylvania

Liberty Hollow Run Green Infrastructure Study

Planning Level Report:

A Planning & Conceptual Level Document for the Implementation of Green Infrastructure Practices

HAZEN AND SAWYER
Environmental Engineers & Scientists

Funded by The Chesapeake Bay Trust

Liberty Hollow Run

Green Infrastructure Study

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Section 1.0 Executive Summary-

Liberty Hollow has seen flooding, stream bank erosion, and most recently a storm water pipe collapse. Development of the area above Liberty Hollow Park has occurred over the past several decades. The development has turned once wooded and then farmed permeable land into rooftops, gutters, paved driveways and impervious streets. Associated with this development is an inevitable increase in stormwater runoff, as the rainfall now has less vegetation to use or slow it from running down the hill into Liberty Hollow, the Susquehanna River and beyond. The increased runoff, as measured by volume and intensity, is a culprit in many downstream issues. The Chesapeake Bay Trust recognizes these issues as causing degradation of the Chesapeake Bay and realizes the problems exemplified by the Borough of Northumberland are not unique.

When the land was developed in decades past, removing stormwater as quickly as possible was the intended solution. Now that the cumulative effects of this degradation are clear and a direct result of past development methodologies, the Chesapeake Bay Trust is promoting green infrastructure through its grant program in order to start the reversal of these harmful practices.

Green infrastructure is a term used to describe practices which serve to revert the effects of development, and allow for more natural processes to take place. Infiltration, evapotranspiration, recycling/reuse, and interception are among the practices which green infrastructure uses to achieve its purpose. With the awarded grant, the Borough contracted with Hazen and Sawyer to conduct a study, consistent with the requirements of the grant program, to evaluate opportunities to install green infrastructure in the Liberty Hollow Watershed. The study was designed to benefit the property owners, the neighborhood, the Borough's assets (park, stream, pipes, & pool), and ultimately the water quality of the Susquehanna River and the Chesapeake Bay.

The results of the study are contained within this report. A watershed plan has been developed for Liberty Hollow, including projects and programs which can ultimately be applied across the entire Borough. Educating and involving the property owners is a key ingredient in achieving successful implementation of green infrastructure. With an already developed neighborhood, there are limited opportunities to install structural features (Section 3.0). It is at this juncture, that public support becomes crucial, and becomes a major driver towards achieving watershed goals, as additional programs and concepts (Section 4.0) can be employed.

The alternatives analysis conducted revealed over $800,000 worth of improvements that would ultimately benefit the stream corridor and its subsequent watersheds. However, a select list is noted within the report to identify which practices will achieve the most economically, environmentally, and socially productive results. A summary of the proposed recommendations are below. Costs and detailed descriptions of what each of the suggested actions below entails are provided in the report:

- Rain barrel subsidation program ($15k)
- Tree planting Program ($15k)
- Perform Complete Design of BMP features ($111k)
- Implement & Maintain BMP features ($360k)
- Potentially Monitor BMP features ($18k)

There is a list of structural projects recommended in Section 7.0 (Conclusion), which would prove beneficial to the stakeholders in this effort, in addition to the programmatic approaches listed above. Therefore, we recommend that the Borough applies for a second round of funding through the Chesapeake Bay Trust, which is due on February 14th, 2014 for the maximum amounts allowable for design and construction services. The 2014 CBT applicants are eligible for both design (up to $50,000 over 1 year) and construction/implementation (up to $250,000 over 3 years).

Section 2.0 Background-

Liberty Hollow Run is a stream basin situated partially within Liberty Hollow Park in the Borough of Northumberland, PA. The watershed headwaters begin in a developed suburban neighborhood situated upstream from Liberty Hollow Park. The stream subsequently flows through Liberty Hollow Park, is piped through CMPs and older stone tunnels, and returns to the surface for several blocks, before ultimately reaching the Susquehanna River's North Branch. From the 170-acre drainage basin, approximately 116 acres contribute to the stream at the culvert entrance behind Northumberland's Liberty Splashland Community Pool, which is a noted problem area. Approximately 76 of the 116 acres above the culvert are developed, which has led to increased wet weather runoff volumes and velocities that are causing detrimental effects downstream. Furthermore, residents of the developed headwaters area, report that a significant percentage of the soils are clay and shale; contributing to the run off. The Liberty Hollow area has experienced flood damage as the stream flows have overtopped the banks near Liberty Splashland, and polluted the pool on several occasions. Stream scouring and bank erosion is evident as vegetation, and aquatic and biological life are not abundant within the stream. The stream culvert collapsed within 200 feet of the entrance, prior to a change in direction of flow. Though it is uncertain at this time exactly what caused the collapse, the issue has caused attention to be drawn to the eye-sore (the pipe collapse) and hazard to the public. In addition to the localized effects witnessed in Liberty Hollow and the Borough of Northumberland, watershed-wide development may be causing degradation to the Susquehanna River and ultimately the Chesapeake Bay. Studies show that sediment pollution, erosion, increased water temperature, and decreased aquatic and biological life ultimately take hard tolls on the economies and beauty tied to the Bay as we know it.

In May of 2013, the Borough was awarded a grant by the Chesapeake Bay Trust to perform a study to propose alternatives to mitigate the issues mentioned above. The Borough entered into a contract with Hazen and Sawyer, P.C. to complete this project. In order for the funds to be awarded, Hazen and Sawyer was tasked with the following project goals:

Through the use of green infrastructure:

1) Educate the community about the benefits of green infrastructure and surface water protection
2) Improve Water Quality in Liberty Hollow Run, the Susquehanna River, and ultimately the Chesapeake Bay Watershed
3) Reduce the velocities and volumes of water impacting downstream storm drainage systems (reducing impervious area, preventing erosion, providing flood mitigation)
4) Create Green Jobs and Green Streets

Green infrastructure, if properly implemented, can address each of these goals, as well as provide ancillary benefits such as: improved aesthetics, increased property values, reduced temperatures, re-charged groundwater and streams, and decreases in sewer overflows or plant bypasses. Additionally, green infrastructure implementation can be spread out over time. For reference, a map of the drainage basin area is provided on the following page as Figure 1.

Liberty Hollow Run Green Infrastructure Study

Liberty Hollow Run Drainage Area - March 2013

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Environmental Engineers & Scientists

This technical report contains:

- The analysis of alternatives which could improve (reduce) the stormwater runoff and pollutant load
- A description of the applicable alternatives
- Construction costs based on approximate BMP cost estimating tools (Note: detailed itemized construction costs are not included)
- Conceptual level layout and details of the preferred green alternatives
- Potential funding mechanisms and opportunities
- A summary of community involvement/outreach activities and opportunities
- And, a comprehensive planning summary for implementation of watershed management using green infrastructure

The neighborhood which contributes the majority of runoff to Liberty Hollow Run appears to have been developed with the mentality that stormwater should be removed as quickly as possible. This was common for most developments well into the 1990's. That design approach is now known to have adverse environmental effects. For example, in the neighborhood above Liberty Hollow Run, storm inlets and pipes convey wet weather runoff directly to nearby channels which contribute to Liberty Hollow Run. When the land was developed, tree coverage was minimized and the amount of impervious surfaces (rooftops, roads, driveways) was increased. This development approach can lead to increased runoff, causing stream erosion and water quality impacts. Figure 2 depicts how this process happens:

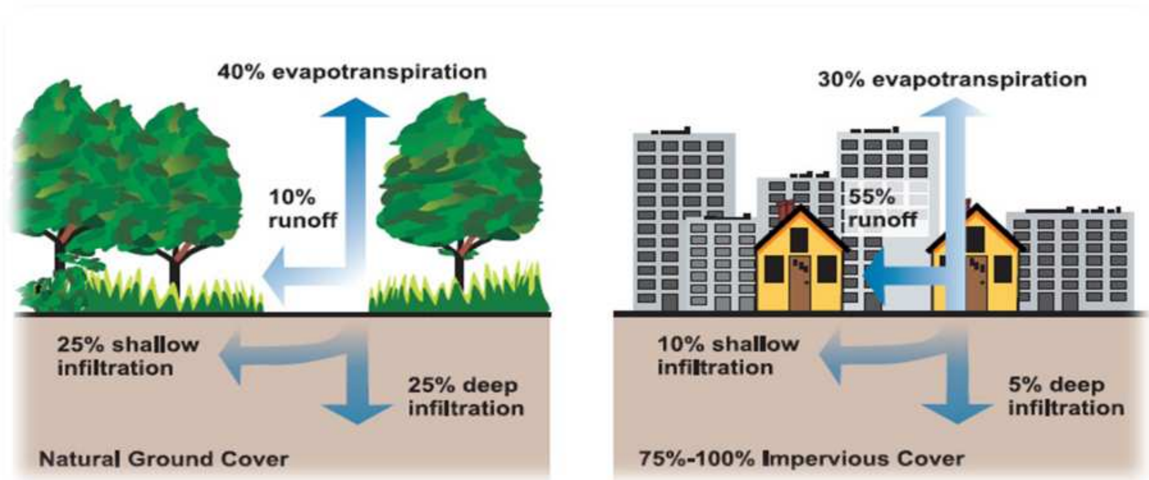


Figure 2: Development Increases Runoff

*Percentages shown do not necessarily reflect specific project circumstances

Green infrastructure applies concepts through the use of both structural and non-structural techniques to reduce the volume and rate at which stormwater leaves a site, street, a neighborhood, and even a watershed. The techniques used are often referred to as Best Management Practices, or BMPs and can begin to reverse the impacts of the increase in stormwater runoff illustrated above. The Liberty Hollow drainage area was not developed with these concepts in mind. Therefore the existing topography, houses, buildings, pavements, and existing utilities inevitably create challenges to implementing green infrastructure concepts. However, knowledge of the particular practices almost always allows for compromise and successful results.

Section 3.0 Alternatives Analysis:

3.1 Public Outreach

The first step of the alternatives analysis included Hazen and Sawyer seeking the input from watershed residents and conducting preliminary fact finding. Not only did the meeting serve as an excellent opportunity to share our approach with the citizens and thereby stakeholders, but the meeting allowed those in attendance to point out additional issues that were only evident to someone who witnessed these storm events in person.

Public Meeting #1

The first public meetings took place on October 23rd, 2013 in the Borough's 2nd Street Municipal and Community Center located at 175 Orange Street, Northumberland, PA 17857. A total of 12 attendees were present at the first meeting. The attendance list, meeting minutes, and PowerPoint presentation are attached as Appendix A of this report. Hazen and Sawyer opened up the meeting with a PowerPoint explaining the project background, the issues at hand, potential solutions, and a map of the preliminary analysis and field survey results. Subsequently, the floor was opened up to the public who asked questions, expressed concerns, and provided valuable feedback. This feedback helped direct the project and allowed Hazen and Sawyer to focus on appropriate preliminary engineering solutions, ultimately resulting in conceptual design.

Public Meeting #2

The second public meeting took place on January 27, 2014 at the 2nd Street Municipal and Community Center and included 25 attendees. This excellent turnout was prompted by a public outreach effort that included over 250 mailers in the neighborhood within Liberty Hollow and a newspaper article in Sunbury's *The Daily Item*, publicizing the meeting and noting the issues at hand. Concerned and supportive citizens engaged in an informative dialogue which allowed the public to better understand the issues and proposed solutions, as well as provide valuable feedback concerning problem areas in the drainage watershed. Attendees agreed that a pronged approach should be taken to handle these issues, including structural BMPs (bioretention, pervious pavement), community programs (subsidized rain barrels, a tree planting program, and additional instructional programs), and potentially a blue or green roof at the community pool dependent on further analysis. Of note was an important discussion that the wet weather issues the Borough faces will not disappear overnight, but that a watershed-wide effort will be the best way to approach the problems and address one "drop" at time. Appendix B includes the details from the second public meeting.

Project Sign

Within the project Budget, money has been set aside for the creation of a community sign and public education opportunity location. The sign is to be located at a frequently traveled and highly visible site that will both catch the eye and hold the interest of the public. Included on the sign will be a summary of the project background, goals, benefits of installed practices, and potentially a list of other ways that citizens can help mitigate the issues harming the Liberty Hollow Stream Corridor. Potential locations include the head of a trail path, directly adjacent to an installed BMP, or at the Liberty Splashland Parking Lot. Any parking lot or property improvements made at Liberty Splashland, or to the stream bank and culvert behind the pool would provide a great opportunity for the sign, especially if the construction achieves the end result of improved water quality.

In addition to signage, the Borough can efficiently and inexpensively spread knowledge of the green infrastructure practices commonly implemented in programmatic ways by holding informative seminars. See Section 4.0 for other ways that the Borough can engage the public and have success at the individual home owner and neighborhood levels, such as tree planting, rain barrel, rain garden, and downspout disconnect programs. The Borough will also partner with a local non-profit organization, 17857.org, to include "how to" articles in their quarterly newsletter.

3.2 Conceptual Layout

Installing green infrastructure above the point where the stream enters the culvert will have more obvious benefits as opposed to BMPs below the point of entrance into the culvert. This is not to say that future green infrastructure projects in the lower portion of the watershed would not benefit Liberty Hollow Run and the overall Susquehanna River and Chesapeake Bay watersheds. It reflects that these improvements alone are unlikely to resolve issues above the culvert entrance.

> *Special Topic*: Existing Public ROW versus Private Property
>
> Assuming that the borough will ultimately be responsible for the maintenance of the structures to be installed, opportunities that are built within existing Right-Of-Way were considered and prioritized. This avoids property acquisition scenarios which can drive costs upward, and create negative first impressions. Building within the Right-Of-Way allows for Borough maintained practices, rather than relying on the property owner to maintain the practice. Motivated homeowners are encouraged, if they are willing to alter their property slightly, to approach the Borough and work together to implement GI stormwater solutions. For example, if a homeowner wishes to install and maintain a rain garden, bioretention, or pervious pavement practice on his or her property, the Borough may be able to provide design assistance and general maintenance guidance. In the event that a citizen wishes to help the cause of reducing stormwater runoff, but is not up to the challenge of maintaining a practice, it may be worthwhile to discuss the process of the property owner donating an easement to the Borough. This would allow Borough maintenance personnel to access and maintain the practice on private property, without acquiring the land. See section 5.0 regarding maintenance.

In order to evaluate the benefit of implementing BMPs in the Liberty Hollow Drainage Area, Hazen and Sawyer conducted a conceptual analysis of the watershed using topographic maps, aerial photography, a hydrologic and hydraulic modeling program, and existing (post-development) stormwater drawings. The locations of key catch basins inlets and cumulative drainage sub-basins were assessed to categorize which areas combine to create the highest storm water runoff peak flows and volumes. Table 1 provides an overview of the screening of these different techniques, specifically for the Library Hollow project.

Table 1 - BMP Applicability

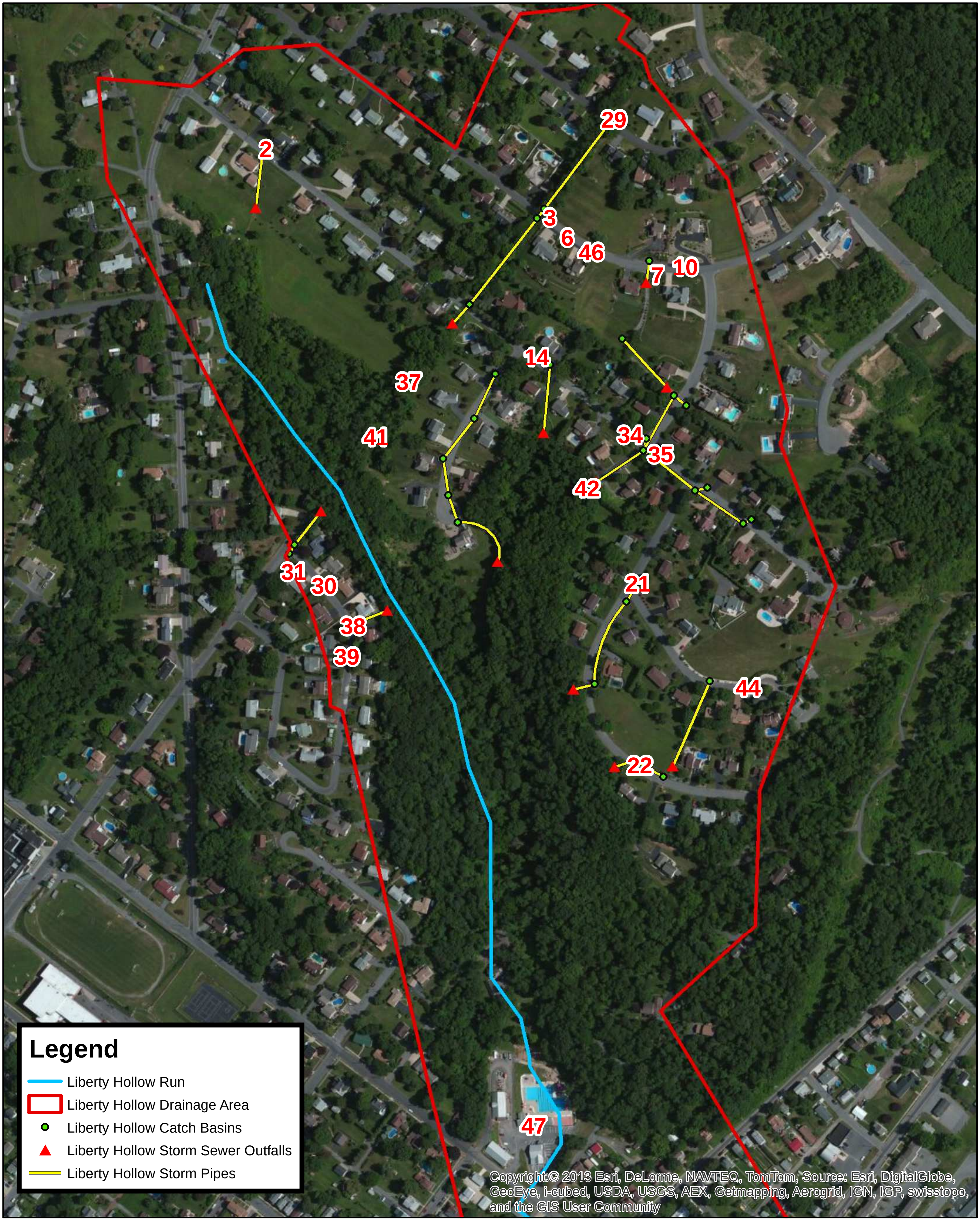
Practices	Applicability
ROW Bioswale and Planter Boxes	**High** - Plenty of opportunities exist within the ROW for implementation of these practices which provide peak flow reduction, limited volume reduction, infiltration, and pollutant filtration. They may be constructed with an underdrain connecting to the existing storm sewer system. Since the soils in the area are typically type C soils, underdrains are advised.
Dry/Wet Detention Pond or Constructed Wetland	**Low** – A detention pond requires a larger area of land relative to other BMPs. Limited un-developed land is available in the drainage area. Feasibility is limited further by steep slopes, woodland coverage, private property restrictions, and close proximity to stream corridors. Earthwork calculations and hydrologic and hydraulic modeling revealed that only one small opportunity may exist to construct such a feature. Additionally, with regard to project goals, a wet pond is more appropriate than a dry basin in that it provides additional water quality benefits that a dry detention pond does not. However, wet ponds provide less volume/peak rate reduction when compared to a same-sized dry basin due to the constant wet pond volume that is occupied.
Green Roofs and Blue Roofs	**Medium** - Given the purely residential development that has occurred, this type of BMP requires acceptance primarily by the individual homeowners that populate the area. Therefore, wide application of green and blue roofs is challenging. In this regard, while potentially less effective, rain barrels are a BMP that is more likely to be installed and maintained by individual homeowners due to the immense cost differences between the two practices. However, should the borough be looking to replace any Borough owned buildings or rooftops, then the cost of installing a blue or green roof is immensely subsidized by the fact that construction would be taking place regardless of the green design aspects and related costs. The Borough also has direct ownership of these "community" buildings and would not have to acquire property or easements to install and maintain the features. Please see section 3.2.4 for more details.
Pervious Pavement	**High/Medium**- The drainage area has a few excellent opportunities for pervious pavement where flatter impervious areas drain to locations where the practice could be installed. Furthermore, the style of development allows for increased opportunity because the wider roadways and large cul-de-sacs have additional pavement areas that are suited for the application. Unfortunately the drainage area does exhibit several streets that are sloped at more than 5%, which would otherwise be great candidates for pervious pavement. Generally slopes up to 5% percent can handle pervious pavement, however, baffles may need to be installed to maximize storage along the length of the practice[2]. Furthermore, in the case of this particular drainage area, type C soils will likely call for the installation of an underdrain to promote drainage through the practice.
Infiltration trench	**Low**- Limited infiltration trench opportunities exist within the drainage area. For the most part, the existing site conditions provide opportunities where existing drainage patterns already bring stormwater to locations which are ideal for other opportunities, most notably, ROW Bioswales.

Tree Planting	**Medium** – Tree planting programs have proven beneficial on multiple levels, and there is ample open space in the headwater neighborhood. Medium sized trees can capture in the range of 50 to 65 gallons from each storm that is at least ¼" of total rainfall, and around 2,380 gallons annually on an individual basis[3]. Note: The provided values are subject to location and tree type. Ultimately, trees are an inexpensive approach to stormwater management that promote neighborhood beautification.
Rain Barrels	**Medium** – Each home has opportunities to install and use rain barrels. Typically these range in size from 55 to 90 gallons and generally cost between $50 -$300 uninstalled. However, do-it-yourself rain barrels are made for around $30 dollars[4]. The average rainfall event is approximately 0.25 inches of rainfall or less. A 150 gallon rain barrel withholds rainfall from a 1000 sq.ft. roof from the storm system for the average storm (assuming that the property owner uses the stored runoff from the previous storm event).
Downspout Disconnection	**Medium** – A majority of homes in Upper Liberty Hollow have connected downspouts. Downspouts which connect to the storm sewer or roadways exacerbate the issues by quickly routing rooftop rainfall to the stream. Re-routing these flows to a rain barrel, a rain garden, or even simply a grassy area can have positive impacts downstream. In a sense, this technique mitigates the effects of the impervious area that rooftops represent. Unfortunately, BMP success is typically dependent on homeowners' implementation and where the flows are re-routed on a case-by-case basis.
Rain Gardens	**Medium** – Flooding mitigation, peak flow reduction, and high pollutant/sediment removal rates make rain gardens an excellent option for this project. The key challenge is finding the space to implement this technique within the Right-Of-Way. On an individual homeowner basis, this is a great option in combination with downspout disconnection. Ultimately, the same concepts as in bioretention are implemented. Soils in the area somewhat limit the ability of these practices due to limited infiltration potential. For this reason, underdrains or properly designed overflow structures are required based upon site specific soil testing.

The areas with the highest peak flows and velocities were targeted as the top priority. After mapping the storm drainage service area and understanding which sub-basins generate the largest flows, a field survey was conducted to both verify the configuration of the storm system, the topography, the location of catch basins, and to identify additional opportunities that are hard to reveal through office review of data. Over 40 practices were identified through the 2 phases of the survey, during which time some features were eliminated from consideration given specific site constraints. The priority of the alternatives was assigned by our team. Figure 3 (Map of Alternatives) and Table 6 (Alternatives Rank & Cost) reveal the alternatives resulting from the studies.

In order to analyze the drainage area, Hazen and Sawyer utilized a software called PCSWMM. This is a planning tool developed by the EPA (known as SWMM 5.0) combined with a GIS user-interface developed by CHI Software. It has the ability to model Hydraulic and Hydrologic simulations to predict flow scenarios given many variables. H&S developed the model based upon common theoretical engineering information as well as a set of databases including USGS soil survey information, Elevations from Google Earth, PASDA topographic datasets, and storm sewer network information from available drawings. Within the software, the Runoff Curve Number Infiltration Method was used, as suggested in PADEP's "Pennsylvania Stormwater Best Management Practices Manual" as 1 of 3 most commonly used methods. EPA's SWMM 5.0 is then able to calculate runoff by dynamically subtracting infiltration from the total rainfall from each sub-basin, resulting in a flow which can then be calculated/routed using Manning's equation through the storm sewer pipe network. This was the methodology used to determine existing and proposed flows entering Liberty Hollow Run's streams from several sub-basins in the neighborhood above the park.

Design Guidelines for ROW Bioswales, Pervious Pavement, and Wet Ponds are located in Appendix D, and can be found in the PA Stormwater BMP Manual[5]. The manual contains additional detail for site evaluation, soil testing protocol, and plant selection among many other related BMPs and topics.



Liberty Hollow Run Green Infrastructure Study

Alternatives - April 2014

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3.2.1 Soils

Model Infiltration was based on the assumption that soils are type C soils. This is a conservative estimate of soil type as some soils in the practice areas are type B soils. Though the impression of the soils which was gathered from those in attendance at public meeting #1 is that they are quite impermeable (mostly clay), the NRCS site soil survey reveals that most soil in the practice areas are shaly and silty loams. Figure 4 (Soils Map) displays the results of the survey and Table 2 (Soils List) below gives the soils names (Full soil descriptions can be found in Appendix C). The NRCS analysis is being used as a planning level tool to fuel the model with a necessary assumption for conceptual design purposes only. Full design requires that proper soil infiltration testing is performed in accordance with the Pennsylvania Stormwater Best Management Practices Manual, Appendix C. If swelling potential or low permeability is found to be present through soil testing, an underdrain and impermeable barrier should be used to line the practice. According to the NRCS survey, the site soils have low swelling potential.

Table 2 – Soils List

Map Symbol	Name	Hydrologic Soil Group
BkB	Berks Shaly Silt Loam 3-8% slopes	C
HtB	Hartleton Channery Silt Loam 3-8% slopes	B
HtC	Hartleton Channery Silt Loam 8-15% slopes	B
HtD	Hartleton Channery Silt Loam 15-25% slopes	B
BeB	Bedington Silt Loam 3-8% Slopes	B
BkD	Berks Shaly Silt Loam 15-25% slopes	C
BkC	Berks Shaly Silt Loam 8-15% slopes	C
WkE	Weikert & Klinesville Channery Silt Loam Steep Slopes	C/D
WeD	Weikert Shaly Silt Loam 15-25% Slopes	C/D
WsB	Wheeling Soils 3-8% Slopes	B

Liberty Hollow Run Green Infrastructure Study

Liberty Hollow Run Soil Types - March 2013

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3.2.2 Pervious Pavement Opportunities

To understand the benefit of installing pervious pavement, the practices were sized in attempts to contain and infiltrate the Water Quality Volume (WQv). The WQv is typically recognized as the runoff resulting from a 1" rainfall event, which is typically considered the amount to be captured to protect the water quality integrity of downstream waterways. However, due to site constraints like topography, development, and utilities this goal can't be achieved uniformly across the watershed for all practices.

For conceptual design purposes, no surface storage was used because the opportunities for pervious pavement are on the roadway. Below is a list of the pervious pavement and design storage sizes. It should be noted, that given the type C soils expected in the watershed, an underdrain may be necessary. For this reason, pervious pavement is considered to be a more acceptable and cost-efficient alternative in those areas which are flat and directly adjacent to the existing storm sewer network for ease of connection. Table 3 is a list of the obvious pervious pavement opportunities:

To size the Pervious Pavement Opportunities:

1) Area of the practice was selected using GIS during the office and field review period
2) Area (sq. ft.) x 2 foot bed depth (ft) x 0.4 bed void space = Storage Volume (cu. Ft.)
3) Underdrains to be design/installed pending the results of a site specific soil investigations during the design process.
4) See appendix D for full design guidelines.

Table 3 – Pervious Pavement Opportunities

Name	Priority for Implementation (3 being most beneficial)	Storage Volume	Location
BMP-38	3	726 ft^3	Elliott Drive - Catch Basin 19
BMP-39	3	776 ft^3	Elliott Drive – Catch Basin 20
BMP-30	2	1270 ft^3	Elliott Drive – Catch Basin 66
BMP-31	2	828 ft^3	Elliott Drive – Catch Basin 21
BMP-6	2	880 ft^3	Jefferson Street – Catch Basin 32
BMP-7	2	349 ft^3	Jefferson Street – Catch Basin 36
BMP-44	2	1348 ft^3	Honey Locust Lane – Catch Basin 25
BMP-46	2	719 ft^3	Jefferson Street – Catch Basin 32
BMP-43	1	888 ft^3	Jefferson Street – Catch Basin 36
BMP-10	1	787 ft^3	Jefferson Street – Catch Basin 34

3.2.3 Bioretention Opportunities

In order to associate conceptual level benefits to the identified bioretention opportunities that were realized in the watershed, a surface storage depth of 1 foot was assumed in addition to 3 feet of media and stone bed with a cumulative 0.33 void space. This results in an approximate storage space of about 1 feet beneath the practice's surface. Full design will require adjustment of these assumptions as more is learned about the soils and their infiltration capacity. Likewise, ROW bioswales and bioretention opportunities were selected and prioritized with the existing infrastructure in mind. Underdrains may be required to facilitate proper dewatering of the facility so that it can empty, based on a general assumption of hydrologic soil type C, within 72 hours. Below is Table 4, identifying the bioretention practices expected to have the most benefit should the Borough choose to implement them:

To size the bioretention Opportunities:

1) Area of the practice was selected using GIS during the office and field review period
2) Area (sq. ft.) x ((3 foot bed depth (ft) x 0.33 bed void space) + 1 foot surface storage) = Storage Volume (cu. Ft.)
3) Underdrains to be design/installed pending the results of a site specific soil investigations during the design process.
4) See appendix D for full design guidelines.

Table 4 - Bioretention Opportunities

Name	Priority for Implementation (0 being low 3 being Highest)	Storage Volume	Location
BMP-2	3	800 ft^3	Susquehanna Road – Catch Basin 45
BMP-3	3	3802 ft^3	Jefferson Street – Catch Basin 33
BMP-14	3	1404 ft^3	Susquehanna Road – Catch Basin 64
BMP-21	3	1824 ft^3	Honey Locust Lane – Catch Basin 27
BMP-22	3	3406 ft^3	Wild Cherry Lane – Catch Basin 23
BMP-27	3	550 ft^3	Susquehanna Road – Catch Basin 28
BMP-29	3	2736 ft^3	Lincoln Street – Catch Basin 63
BMP-34	3	786 ft^3	Susquehanna Road – Catch Basin 39
BMP-35	3	1050 ft^3	Susquehanna Road – Catch Basin 37

3.2.4 Blue or Green Roof at Liberty Splashland

As is often the case when it comes to funding green infrastructure projects, it makes sense for municipalities to "piggy-back" planned infrastructure update projects when considering the timing of installing green infrastructure. This is especially true for planned retro-fitting opportunities such as roof replacement or street paving. Any time that existing asphalt is torn up, ground is displaced to access a utility line, or a roof needs replaced, there is an opportunity to evaluate green infrastructure costs savings. By partnering green infrastructure construction and installation with other necessary construction activities, the Borough can avoid bearing some of the construction costs which would be required if GI were to be installed alone. For example, should the Borough choose to replace the roof of the bath house at Liberty Splashland, the existing roof must be removed regardless of green infrastructure installation. If a blue or green roof were desired, the Borough could use the opportunity to plan and have a structural analysis performed or incorporated into the design of the new roof, which would consider and support the additional weight load of a BMP rooftop.

Knowing the Borough has control of the Liberty Splashland property, there would be no property or maintenance acquisition issues to install or maintain a blue or green roof. For reference, blue roofs are intended to store rainwater, and allow for a slow release over time rather than a flashy peak flow from the rooftop during storm events. Blue roofs also allow for some level of evaporation, but rely mostly on an orifice to release flows more slowly than a traditional rooftop. Green roofs, while typically heavier, require more maintenance and provide similar environmental benefits. Technically speaking, a green roof would be more environmentally conscious by providing a decreased "carbon footprint". Though a green roof may prove to be a valid alternative, a blue roof is considered more heavily in this preliminary stage due to its potentially lighter framework. This text section does not rule out a green roof, but simply provides conceptual level design calculations for what is anticipated to be the preferred alternative. Green roof calculations will provide similar values in terms of peak and total volume flow reductions.

The picture below maps out one of many potential environmentally friendly roofing options. A preliminary design layout for a blue roof is provided in the photo on the right side of figure 5, below. The maintenance garage was not included in the analysis that follows, but it too would suffice as a potential blue or green roof candidate.

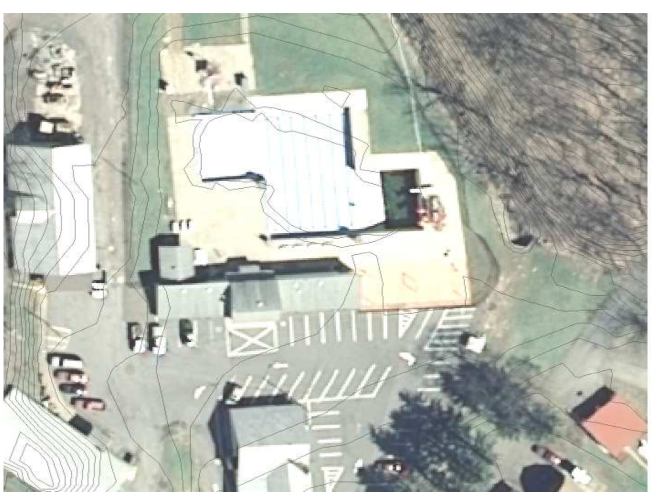

Figure 5 – Conceptual Blue Roof Layout

A common method for installing blue or green roofs, is to use a tray system. Trays are purchased as shown below, and therefore require little start up maintenance as vegetation is already established, or the tray is simply filled with a gravel to provide support against potential uplift forces. By using the tray system, future roof maintenance becomes much less of a concern versus a technology that actually uses the roof structure surface itself to act as the BMP. If roofing sections need replace in the future, the tray system could be disassembled relatively quickly.

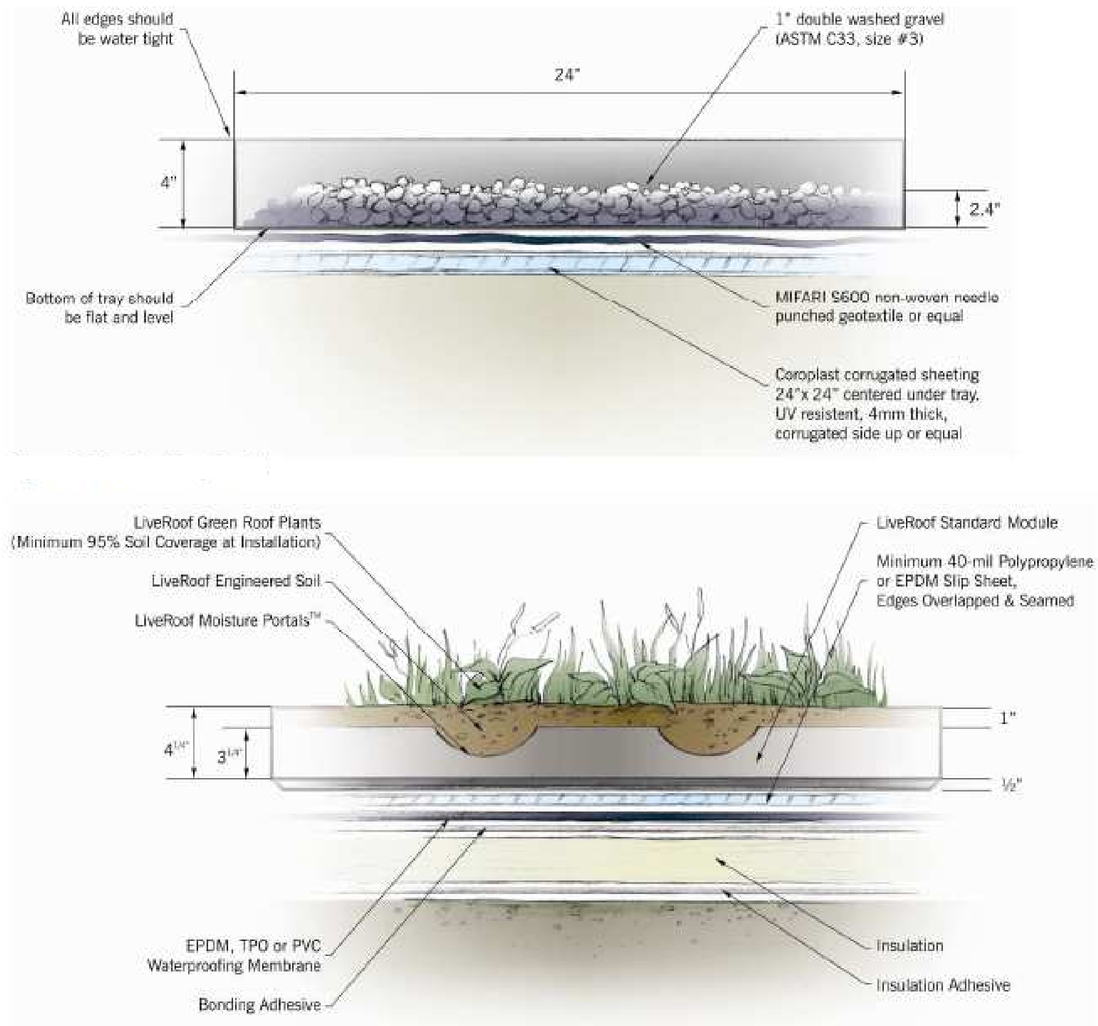

Figure 6 – Blue and Green Roof Trays

To size the blue roof opportunity:

1) Area of the practice was selected using GIS during the office and field review period
2) With 2ft x 2ft trays in double rows of 9, with 2 to 3 feet between double rows for maintenance access purposes, the rooftop of the existing bathouse would fit somewhere near 360 trays. This equates to a total surface area of 1440 sq. ft.

Volume Reduction:

The current volume leaving the roof of the bathouse from a 1" storm is approximately:

Existing Roof Volume= 3102 sq. ft. of total roofspace x 1" of rainfall x 1/12 x 7.48 gal/cu.ft. = 1933.6 gallons

The installation of a blue roof for the layout proposed in figure 5 would remove or delay 46.4% of the runoff from the bathouse given a 1" rainfall event.

Proposed Tray Layout Volume = 1440 sq. ft. x 1" of rainfall x 1/12 ft x 7.48 gal/cu.ft. = 897.6 gallons removed or slowed.

Rate Reduction:

The blue roof portion of the roof reduces the peak runoff by storing the stormwater in the trays and releasing the flow slowly over time. The peak flow rate from each tray is approximately 0.0001 cfs, when the tray is full (3 inches of ponded water), and progressively decreases as the tray is emptying due to less pressure forcing the water out through the filter fabric. Considering a Type II SCS 1-year storm, with a peak intensity of 2.8 in/hr:

360 trays x 0.0001 cfs/tray = 0.036 cfs from all the trays combined, compared to

360 trays x 4 sf/tray x 1 acre/43,560 sf x 2.8 in/hr x 1 (runoff coefficient) = 0.09256 cfs

The peak reduction for the area covered by the trays is, therefore, approximately 61.1% less than the existing rooftop runoff peak flow. The trays are capable of storing up to 3 inches of water, and therefore can mitigate much more than just the 1" storm. Total storage volume given the proposed layout in figure 5 is approximately:

360 trays x 2ft x 2ft x 3in x 1'/12" x 7.48 gal/cu. ft. = 2692.8 gallons

Cost:

Typical vegetated roofs range in cost from $5 to $50 per square foot[11]. This cost ranges greatly in large part due to the structural analysis and potentially more intense structural support system that needs installed based upon site specific conditions. Retrofitting an existing roof can cause costs to shift as well, versus building a new roof from scratch. Though the values range greatly, Hazen and Sawyer has completed projects which confirm this range. It should be noted, that a preliminary structural analysis of the existing roof and truss system would first have to be performed to better understand feasibility and total project costs. For the purposes of this report, a planning level cost is provided in table 6 based upon the anticipated practice coverage.

3.2.5 Low Priority Opportunities

Beyond the obvious applications listed above for pervious pavement, bioretention, and a possible blue or green roof, there are a few other low priority solutions that may be applicable in Liberty Hollow. The wet pond alternative, in particular, is what remains from the idea proposed at the first public meeting; A dry detention basin. Steep and wooded slopes, environmental concerns, earthwork requirements, safety risks, and more intense maintenance practices associated with the option of having a larger basin in the woods drive its cost up, and its likeability down. Furthermore, the quantity and quality results generated suggest that a similar amount of benefit can be achieved by implementing decentralized features such as pervious pavement and bioretention practices across the neighborhood. Table 5 lists the low priority opportunities. In addition to the opportunities listed, some form of stream stability reinforcement around the culvert is recommended. This would also provide protection against erosion, and potentially be able to provide some energy dissipation prior to flows entering the culvert. This concept was not included in the modeling analysis as it would have little negligible effects on the quantity results. Grade control structures and toe protection, if built, would provide necessary improvements and future protection to the stream banks.

Table 5 - Low priority Opportunities

Name	Priority for Implementation (0 being low)	Storage Volume	Location	BMP Notes
BMP-37	1	0 ft^3	Susquehanna Road – Catch Basin 45	Channel Stabilization- Erosion control construction rock installation to prevent channel erosion
BMP-42	1	~4,000 ft^3	End of Buchanan Ave. (extension)	Stilling Basin- typically these structures provide velocity reduction to aid in protecting against channel erosion. They can serve as sediment traps, improving water quality, but are not typically designed to provide storage. This is an end of pipe BMP. Its small size allows for implementation even though steep slopes exist downstream.
BMP-41	1	~38,000 ft^3	In the woods, behind homes along the end of the west side of Empress Tree Lane	Wet Pond- designed to provide water quality benefit and some water quantity benefit. Site constraints as listed above limit the potential of this BMP, and likewise costs are driven up. It is a low priority BMP due to these factors. BMP-37 would lead to this feature if they were both implemented. Then, BMP-41 would have a rock spillway overflow to the existing stream.

3.3 Planning Level Cost Estimates

Table 6 lists the alternatives with a priority ranking in the third column. Rankings range from 1 to 3, with 3 being the end of the scale that provides the most benefit. Quantitative benefit per dollar spent, obvious environmental impacts, as well as safety and risks associated with the construction and maintenance of the listed BMPs were all weighed subjectively by our team to form the recommendations below. Construction cost estimates were developed using information available through PA DCNR. Additionally, for the wet pond and stilling basin, Hazen and Sawyer used construction index costs and performed a slightly more in depth preliminary costing analysis due to the complexities expected during construction for those two features.

Table 6 – Alternatives Ranking & Cost

ID #	Type of Practice	Priority	Planning Level Cost Estimate (Design & Construction)
3	bioretention	3	$64,650
29	bioretention	3	$46,500
34	bioretention	3	$13,350
35	bioretention	3	$17,850
21	bioretention	3	$31,000
22	bioretention	3	$57,900
38	pervious pavement	3	$10,900
39	pervious pavement	3	$11,650
2	bioretention	3	$13,600
14	bioretention	3	$23,900
7	pervious pavement	2	$5,250
44	pervious pavement	2	$20,200
46	pervious pavement	2	$10,800
30	pervious pavement	2	$19,050
31	pervious pavement	2	$12,400
6	pervious pavement	2	$13,200
47	Blue/Green Roof	2	$72,000
43	pervious pavement	1	$13,300
41	Wet Pond	1	$410,000
42	Stilling Basin	1	$20,000
10	pervious pavement	1	$11,800
37	Stabilized Channel	1	$8,000

In order to weigh the closely matched alternatives of bioretention and pervious pavement, a cost comparison was conducted with model results from the 1” storm (or the WQv Rainfall Event). The sampled BMPs are shown in Table 7, along with the resulting construction cost estimates. As displayed, Bioretention offers slightly less cost to runoff removed, on average. This is not to say that through detailed design, this order could not be reversed on select cases. With these results in mind, bioretention was weighted more heavily as a priority for implementation than pervious pavement. However, previous engineering efforts and current public outreach efforts have identified two respective catch basins associated to the two highly weighted pervious pavement opportunities as a problem area. Therefore, table 6 includes two (2) "priority 3" examples of pervious pavement. Additionally, these locations on Elliott Drive are located in low sloped sections of the road, allowing the pervious pavement to function more appropriately. Ranking lower in the table are those opportunities which are potentially rewarding options, but highly susceptible to cost increases due to their vulnerable locations, O & M, overall capital costs, potential permitting issues, and environmental impact.

Table 7 – Pervious Pavement Vs. Bioretention Cost Metrics

Pervious Pavement Cost Benefit			**Total Volume**			**Peak Flow**		
GIVEN a WQv Storm Event	**Sq. Ft. of Pervious Pavement**	**Cost @ 15/sq.ft.**	**Existing Conditions (MG)**	**Alternatives Applied (MG)**	**$/gal removed**	**Existing Conditions (MGD)**	**Alternatives Applied (MGD)**	**CFS Removed/ $10000**
BMP-30 & BMP-31	3131	46965	0.021	0.004	2.76	0.88	0.02	0.183115
BMP-44	2013	30195	0.016	0.005	2.75	0.47	0.03	0.145719
BMP-38 & BMP-39	2243	33645	0.009	0	3.74	0.39	0	0.115916
				Average	**3.08**			**0.148250**
Bioretention Cost Benefit			**Total Volume**			**Peak Flow**		
GIVEN a WQv Storm Event	**Sq. Ft. of Pervious Pavement**	**Cost @ 17/sq.ft.**	**Existing Conditions (MG)**	**Alternatives Applied (MG)**	**$/gal removed**	**Existing Conditions (MGD)**	**Alternatives Applied (MGD)**	**CFS Removed/ $10000**
BMP-2	400	6800	0.059	0.053	1.13	1.9	1.86	0.058824
BMP-14	702	11934	0.027	0.016	1.08	0.88	0.25	0.527903
BMP-29	1368	23256	0.035	0.014	1.11	1.14	0.13	0.434297
				Average	**1.11**			**0.340341**

3.4 Anticipated Watershed-Wide Benefits

Table 8 reveals results from a more comprehensive perspective in terms of over-all predicted watershed benefit. BMPs were modeled using PCSWMM, a dynamic engineering Hydraulic and Hydrologic Routing Model, for several different scenarios as described in the table below. Different rainfall events, and BMP implementation configurations were analyzed. Of note again is the "WQv" storm, which is a common term in wet weather management. It is expected that by capturing or detaining this volume of rainfall runoff, equivalent to the runoff of a 1" rainfall storm, that the employed practice is providing adequate benefit to preserve the water quality of the downstream water path with respect to the area from which the runoff is detained. Often times, capturing the water quality volume is a goal when implementing green infrastructure. This is the case with Liberty Hollow, and many other watersheds which are being retrofitted with green infrastructure, due to space and site constraints.

The results presented in Table 8 are based on an assumption that each BMP has available capacity to intercept additional runoff. In other words, the results assume that the storm event occurs after a dry period during which the BMP has exfiltrated stored runoff to the surrounding soils, and rain barrels have been emptied by the property owner, etc. The reductions of runoff volumes and peak discharges will be less if the BMPs are not dry.

Analysis of large flood events such as the 10-year and 25-year storm events is not included. The large events can be critical to the design of the Liberty Hollow culvert, but are not crucial to the conceptual level recommendations associated with this report because there is not available space to implement practices which would handle such large and infrequent events. This is because it is unlikely to achieve the capture of a storm larger than the 1 year storm in Liberty Hollow due to existing development of houses and roadways, space constraints, topography, and soil types. Percent reductions of peak discharge and runoff volume for larger storm events is expected to be less than the values presented for the 1-inch and 1-year storm events.

Table 8 - Watershed Results

Results Summary						
Storm & Scenario	Existing Conditions		W/ Alternatives Modeled		% Reduction	
	Peak Flow (cfs)	Total Flow (MG)	Peak Flow (cfs)	Total Flow (MG)	Peak Flow (cfs)	Total Flow (MG)
1in. (WQv) - All Conceptual Alternatives	27.21	0.758	17.53	0.467	35.6	38.4
2.34in. (1 Year storm) - All Conceptual Alternatives	93.53	3.283	74.25	2.637	20.6	19.7
1in. (WQv) - Pervious Pavement & Bioretention Only	27.21	0.758	19.27	0.588	29.2	22.4
2.34in. (1 Year storm) -Pervious Pavement & Bioretention Only	93.53	3.283	89.94	3.115	3.8	5.1
1in. (WQv) - Alternatives BMP-41 & BMP-42 Only	27.21	0.758	22.43	0.583	17.6	23.1
2.34in. (1 Year storm) - Alternatives BMP-41 & BMP-42 Only	93.53	3.283	78.19	2.943	16.4	10.4

Water quality benefits by type of practice are estimated for the individual practices in the Pennsylvania Stormwater Best Management Practices Manual[5,6,7]. The results for the recommended alternatives are presented in Table 9. These are approximate values, and it should be noted that site specific conditions can cause these numbers to fluctuate from the typical values listed.

Table 9 – Typical Water Quality Benefits by BMP

Type of Alternative	Pollutant	Typical % Removal
Bioretention	Total Suspended Solids Total Phosphorus Total Nitrogen	85 85 30
Pervious Pavement	Total Suspended Solids Total Phosphorus NO_3	85 85 30
Wet Pond	Total Suspended Solids Total Phosphorus NO_3	70 60 30

4.0 Alternative Community Approaches and Additional Opportunities

4.1 Rain Barrel Analysis

Typical Rain Barrel Installation

Rain Barrel programs have had success across the country and provide rainwater harvesting opportunities for those who garden. Though the typical 50-90 gallon rain barrel will not contain an average 1” storm event, they do still provide a positive impact. Plotted out below are benefit curves should the Borough implement a Rain Barrel program. This technique can be paired with a rain garden or by simply re-routing flows in excess of the barrel(s) volume onto a lawn such that it flows away from the house rather than directly back into a pipe or drain. According to a GIS desktop survey, approximately 132 rooftops contribute flows to Liberty Hollow, and the survey was performed assuming that each home would implement one 90 gallon rain barrel. The results presented in Table 10 assume that property owner has emptied that rain barrel between storm events. The assumption that each rain barrel is emptied may be more valid during dry periods such as summer. The numbers below represent percent reductions only from the rooftop areas, and not the entire area of the watershed.

Table 10 – Rain Barrel Implementation

Rainfall (in)	Roof Runoff Volume*	Percent Captured- 50% Implementation of 90 Gallon Rain Barrels	Percent Captured- 100% Implementation of 90 Gallon Rain Barrels
0.1"	1650 ft3	48.1%	96.3%
0.25"	4125 ft3	19.3%	38.5%
1"	16500 ft3	4.8%	9.6%
2.34"	38610 ft3	2.1%	4.1%

*Calculating 1500 SQFT/roof x 132 Homes x Rain"/12

Though the rooftops do not account for the total amount of runoff from the neighborhood, the table shows just how effective rain barrels can be for smaller storms up to the 1” Rainfall Storm (which is usually considered for treatment of the Water Quality Volume when designing stormwater infrastructure). Historical rainfall patterns show that, typically, the 1” rainfall event is greater than 90% of all 24 hour storms that occur on an annual basis[8]. Additionally, rain barrels are an alternative which can be implemented Borough-wide. It is an easy installation at the individual home owner level, and costs are typically quite feasible ranging from $70-$300 for a ready-to-go rain barrel depending upon size and style. Municipalities can also develop a program to incentivize the homeowners by sharing the costs and providing even less expensive barrels by subsidizing costs and holding installation workshops.

4.2 Downspout Disconnection

The use of rain barrels can be coupled with an equally, if not more, effective technique of stormwater mitigation known as downspout disconnection. Whether a rain barrel is installed or not is irrelevant, because the disconnection simply consists of cutting the roof leader pipe prior to its dive below ground where it would normally tie in to the storm, combined, or sanitary sewer system. The flows are re-routed via some flow diversion device, or splash pad, toward a lawn or wooded area away from the home (or any structure with a basement). If a rain barrel is installed, the overflow is routed away from the home in a similar manner, rather than dumping back into the existing draining system. Understanding exactly which homes are connected to the storm sewer system, sanitary sewer system, or those which are routed through drains to the roadway requires analysis beyond the scope of this project. Many municipalities adopt smoke or dye testing programs to better understand how homes in their neighborhoods are connected. However, it is very clear that a majority of the homes in the focus neighborhood are currently connected in one way or another, which can be noted from the field survey alone. The table below shows potential benefits that could be achieved assuming that all roof leaders are currently tied into the storm system either by roadway or subsurface piping connections. Since homes with disconnected downspouts are not accounted for, the table below should only be used to judge the sensitivity of implementing the technique. Unlike the rain barrel table above, the exercise for downspout disconnection considers all flows reaching Liberty Hollow from the upper neighborhood, not solely the rooftop flows.

Table 11 – Downspout Disconnection Results

Rainfall	Metric	Connected Downspouts	50% Disconnection	100% Disconnection
1" WQ Volume Event	Cumulative Peak Flows (CFS)	27.21	23.22	19.23
	% Reduction		14.7%	29.3%
	Total volume (MG)	0.758	0.684	0.61
	% Reduction		9.8%	19.5%
2.34" 1 year storm	Cumulative Peak Flows (CFS)	95.53	87.48	80.97
	% Reduction		8.4%	15.2%
	Total volume (MG)	3.283	3.166	3.046
	% Reduction		3.6%	7.2%


Splash block

Cumulative peak flow values were calculated using the EPA SWMM Model that was built as a tool to better understand the flows reaching the Liberty Hollow Culvert. The Cumulative Peak Flow value is simply a sum of the storm outfall modeled as part of this analysis. The cumulative peak flow is strictly an artificial value to gauge BMP implementation.

The exercise suggests that there is significant benefit to be gained by this relatively inexpensive technique of disconnecting downspouts. Splash blocks are easy to implement and can be purchased for under $10 each, or rain barrels could be installed with overflows routing to the yard rather than a sewer drain or curb line. Downspout disconnection can be promoted at rain garden workshops to inform the public about proper construction methods and costs. This type of workshop could be paired with information about implementing rain barrels as well.

4.3 Tree Planting Program

Hazen and Sawyer performed a conceptual GIS analysis to examine the potential for tree planting locations available along the ROW. The analysis indicates that if the borough were to support a tree planting program, approximately 70 medium sized trees could be planted along roadways to intercept rainfall. Not only do trees absorb and uptake water, but they provide a distraction from rain falling directly onto an impervious surface. Ultimately this has the effect of both reducing and attenuating wet weather, especially during the more frequent smaller storms. Additionally, the Chesapeake Bay Trust states its support for this BMP in its grant application.

For analysis sake, a medium tree was considered to have a 32 foot diameter canopy, covering approximately 800 square feet. Assuming 70 additional trees are planted and 45 gallons of interception by the average medium sized tree, this equates to 3,150 gallons of rainfall intercepted from Liberty Hollow for each storm consisting of a 1/4" of Rainfall or more, according to the Center for Urban Forest Research[3]. That amount of storage translates into 421 ft^3 for each event, which can be used to compare against the structural alternatives proposed. Heritage River Birch Trees have a current market value of approximately $25 per tree. Implementing a tree program of 70 midsized trees would cost approximately $1,750, discounting the cost of planting. In addition to intercepting rainfall from pervious coverage and slowing stormwater runoff, trees also provide ancillary benefits such as:

- Producing oxygen
- Cleaning soil
- Controlling noise pollution
- Cleaning the air
- Creating shade and cooling
- Breaking winds during the winter (decreasing heating bills)
- Fighting soil erosion
- Increasing property value

4.4 Liberty Splashland Parking Lot

The Liberty Splashland parking lot does not runoff to Liberty Hollow upstream of the culvert entrance behind the pool. However, green infrastructure opportunities can be implemented within the Liberty Splashland property to control site runoff which does eventually make its way through drains to the culverted stream, and likewise, the Susquehanna River. Green infrastructure on the Splashland site will still have a positive effect and align with the goals of the Chesapeake Bay Trust. Ultimately, the location and frequent traffic through the Splashland creates an ideal public education opportunity if future GI projects are to be installed in Liberty Hollow. Pervious pavement is an obvious option, but bioretention opportunities could be examined as well based upon the site layout.

4.5 Existing Structure Functionality

The existing stormwater detention facility that existing between 460 Susquehanna Road and 427 Jefferson Street appears to be well maintained. Without seeing the design details, it is impossible to know for what level of control the basin and outlet structure has been designed. It is possible that scrutiny of the outlet structure may provide an opportunity to release water more slowly through a smaller orifice or by adjusting outlet invert elevations to promote more infiltration. Furthermore, the structure appears to act as a dry detention basin. If the pond were to be converted to a wetland or wet pond type feature, it may be able to provide additional water quantity & quality benefits through infiltration and biofiltration by plants.

4.6 Empress Tree Lane Street Runoff

The property at the end of Empress Tree Lane (Southeast of the Cul De Sac) is unfortunately located in a low area that received quite a bit of surface runoff in addition to a shallow catch basin surfacing in the driveway. Unfortunately, the slope and space constraints along the Right-Of-Way of the street prohibit the cost effectiveness of alternatives being implemented. However, there is a property just to the West, which appears to be partially developed with no dwelling unit. Acquisition rights are a barrier to using this property as a location for BMP installation, however, it is close in proximity to the stream and could potentially serve as a small bioretention/stilling basin area if the storm sewer were to be re-routed. Re-routing the storm sewer system, and potentially dealing with permitting issues given the proximity to the stream would also drive up the cost of such a project. Lastly, the partially developed property should, at the very least, be inspected for bare soils and stabilized with vegetation. Runoff from a bare soil pile would contain high sediment content and has direct access to the stream, leading to degradation. If the Borough were interested in acquiring this property, and the owner were willing to part at a reasonable cost, the location may influence the opportunity for additional BMPs, or relocation and improved priority/rating of BMPs proposed in this report.

5.0 Operation & Maintenance

One of the goals of the Chesapeake Bay Trust is to fund projects which promote green jobs. Not only would the alternatives require design and construction labor, but also require annual maintenance programs to be implemented and executed by trained personnel. Below are basic maintenance guidelines & planning level costing assumptions associated specifically with maintenance activity. The following information is summarized from PA DCNR's website[11].

Table 12 – Operation and Maintenance

Practice	Maintenance Required	Cost (Annual)
Pervious Pavement	Street Vacuum to remove clogged sediment	$500 per year for a half acre parking lot. EPA estimates a more conservative value of 4% of the design & installation cost as annual maintenance.
Bioretention	Mulching, upkeep of plants, and replacement of media every few years.	Costs similar to regular landscaping. Planter boxes, similar in concept, have maintenance costs of about 1$/Sq.Ft. per year.
Wet Pond	Inspection 4 times per year for watering weeding mulching and replanting until the pond is well established. Efforts will decrease over time, however, sediment must be removed every 5 to 10 years. Maintenance plans should be included with full design.	PA DEP estimates wet pond maintenance costs in the neighborhood of 3% to 5% of capital costs.
Blue Roof	Remove debris from trays, check for cracks in trays, check for deterioration of filter fabric	Equal to or less than Green Roof maintenance costs.
Green Roof	Hand weeding, chemical weed management, planting in bare spots, irrigating	Up to $1.25/sq.ft.

Pervious pavement will eventually require vacuuming to extract any clogging and dried sediment that builds up within the pavement pores and cracks. Often times, municipalities which invest in pervious pavement, or are at least responsible for its maintenance, purchase a walking vacuum for smaller areas. If the BMP areas are relatively easily accessible, utility sewer trucks with vacuum which are owned for other sewer cleaning issues can potentially be used/retrofitted for pervious pavement clean out.

Bioretention maintenance will consist of a higher front end effort to establish vegetation. Activities will initially consist of watering plants, maintaining a stable layer of erosion control mulching, and possibly providing tie stakes for certain plants. After the practice has stabilized, routine maintenance should be performed to ensure proper functionality to remove foreign objects, leaves, or branches that may prohibit draining. When un-acceptable back-ups or bypassing of the practice occurs, maintenance personnel may have to perform a clean out of the underdrain, if one is installed. Additionally, depending on the type of components within the storage bed, some replacement of mulch, media, and storage stone may be required to ensure proper functionality.

Maintenance plans for wet ponds tend to be a bit more detailed, especially until the pond reaches its intended growth stage and begins functioning as designed. This is the type of feature which should be checked often with wet weather events to ensure proper functionality. It should also be checked after events to verify proper draining time and embankment appearance and performance. Prior to complete establishment, mulching, seeding, and staking may be required more frequently. Ultimately, the performance of the outlet structure must be maintained and kept free of any unwanted debris. Depending on how well the pond is able to do one of its intended jobs, to settle out sediment, the bottom will have to be dredged of built up sediment every few years. This is another reason why accessibility plays into the capital and maintenance costs of such a structure.

Blue roofs opportunities need maintenance on an ongoing basis to ensure that clogging within the trays does not occur. Careful oversight during construction ensures that proper ballast materials reduces the amount of potential clogging. During the first month after installation, review of the site needs to be conducted on a weekly basis to check for clogging and displacement, with washing of the tray materials to be conducted as necessary. After the first month, any debris associated with construction should be alleviated, so monthly investigations can be conducted to check for clogging. During the site reviews, checking for cracks in trays and degradation of filter fabric would be necessary. Clogging materials require washing. Replacement of the trays and filter fabric may be required over time, though is not expected during the first few years.

Green roofs require the most maintenance during the first 2-3 years, while the vegetation gets established. The tray system has an advantage of pre-established vegetation, but suitability to the site is never a certainty; problems that may develop include: wind erosion, bare spots, infestations of annual weeds that can choke out beneficial cover plants, and nutrient deficiencies. After the first couple years, the green roofs require minimal maintenance as vegetation adjusts to the roof.

For both types of roofing alternatives, assuming proper maintenance is performed, the useful life of the green infrastructure is expected to outlast the life of the roof membrane, in excess of 30 years. The advantage of the tray system is that it can be moved to accommodate repairs to the roof as needed, and individual trays can be replaced if problems arise, without a wholesale replacement of the system overall.

Section 6.0 Funding Mechanisms

As communities across the country begin to realize the benefits of green infrastructure, government backed funding continues to grow through increased grant opportunities from the national level to the local level. As more data is collected, trends also continue to show that when planned and implemented properly, green infrastructure is often a more cost effective approach than traditional gray stormwater management alternatives. The newest U.S. E.P.A. Green Infrastructure Strategic Agenda[12] was released in October, 2013. Objective 4 of 5 focuses on funding of green infrastructure. The Agency recognizes that it must:

- Leverage the Clean Water Act State Revolving Funds to fund green infrastructure projects
- Identify opportunities to reduce GI costs
- Promote stormwater utilities as a sustainable funding source

All three of which support the agency consistent efforts to push green infrastructure into our nations developed watersheds.

A funding opportunities scan was performed as part of this project to promote implementation. Funding opportunities must be monitored periodically as the application processes for each opportunity is usually different from the next. It should be noted that the information provided below is from a snapshot in time prior to the submittal of this report, and that the material provided by the funding sources is in many cases time sensitive. Therefore, it is important for an effort to be made to re-visit the sites below every one to three months. The following funding sources are recognized as potential funding mechanisms by which the borough could attempt to obtain to fund the alternatives resulting from this planning level report:

1. Chesapeake Bay Trust- Chesapeake Bay 2013 Green Streets- Green Jobs- Green Towns Grant Application- This is the Borough's most likely source of funding due to the grant process which it is already a part of. Assistance in this program is available for innovative green street project planning, design, and implementation ($50k for planning or design, and up to $250k for construction). The strongest proposals will incorporate innovative low impact development/green infrastructure best management practices and demonstrate cost-effectiveness of such practices. An example of a cost-effective project is one that treats at least an inch of runoff and costs less than $60,000 per a one acre drainage area in an urbanized watershed. Leveraging ongoing or planning, design, and construction activities and private capital will be a theme: the strongest proposals will describe projects pursued in concert with existing street re-design and/or repair projects. The Chesapeake Bay Trust offers other opportunities throughout the year, such as grants for additional education purposes such as school field trips to educate students about the environmental issues facing the Bay. These additional opportunities are able to be monitored through the website listed below.

   Up to $250,000 can be awarded to applicants in this year's round of grants for implementation projects.
   See: http://www.cbtrust.org for more information.
   Deadline: February 14, 5:00 PM 2014

2. National Fish and Wildlife Foundation- Applicable Grant monies have been available the past years through the NFWF. Two to keep on radar for the Borough are “Chesapeake Bay Small Watershed Grants 2013” and “Chesapeake Bay Innovative Nutrient and Sediment Reduction 2013”. These were both released in 2013, but no information has been released yet for the 2014 round of funding. These grants are also considered to be under the “Chesapeake Bay Stewardship Fund”.

   Small Watershed Grants were awarded from $20,000 to $200,000 in 2013 with a 25% match. Innovative Nutrient and Sediment Reduction Grants were awarded from $200,000 to $750,000 with a 1:1 match in 2013. According to the NFWF website, Congress mandates that each federal dollar NFWF awards is leveraged with a non-federal dollar or equivalent goods and services. NFWF refers to these contributions as "matching contributions." As a policy, NFWF seeks to achieve at least a 2:1 return on its project portfolio -- $2 raised in matching contributions to every federal dollar awarded. To be eligible, matching contributions must be:

   - Non-federal in origin (federally appropriated or managed funds are ineligible; e.g., Pittman-Robertson, Dingell-Johnson, Intermodal Surface Transportation Efficiency Act);
   - Raised and dedicated specifically for the project;
   - Spent between the project start and end dates designated in the grant application;
   - Voluntary in nature (mitigation, restitution, or other permit or court-ordered settlements are ineligible); and
   - Applied only to the NFWF grant and not to any other federal matching programs.

   See: http://www.nfwf.org/ for more information.
   U.S. E.P.A. notes that the deadline is usually early May

3. Wells Fargo & National Fish and Wildlife Foundation – The planned alternatives would achieve 3 of the 5 possible goals set forth by this grant: (3) restoring and managing natural habitat, species and ecosystems that are important to community livelihoods; (4) facilitating investments in green infrastructure, renewable energy and energy efficiency; and (5) encouraging broad-based citizen participation in project implementation. This is a 5 year initiative beginning in 2012, releasing $3 million per year.

   Typical award amounts are $25,000 to $100,000 with a 1:1 match. The same “match” requirements apply from funding opportunity number 2.

   See: http://www.nfwf.org/ for more information.
   Deadline: Typically December

4. The STAR Program through U.S. E.P.A. – The third goal applies to the issues in Northumberland as it reads: “(3) Safe and Sustainable Water Resources: Sustainable Chesapeake: A Community-Based Approach to Stormwater Management Using Green Infrastructure; Performance and Effectiveness of Green Infrastructure Stormwater Management Approaches in the Urban Context: A Philadelphia Case Study; High Priority Water Quality and Availability Research.” 2014

allocations will be somewhere near $61 million dollars. No cost sharing was required for this grant program in 2013. It could be expected that the same or similar circumstances would apply for the current year.

Typical low amount awarded is $250,000
See: http://www.epa.gov/ncer/ for more information.
Deadline: Varies

5. Environmental Education Grants Program through PA DEP- The Environmental Education Grants Program (EE Grant Program) was developed to support and strengthen environmental education in Pennsylvania. These grants can be applied for by municipalities, conservation districts, or even schools. Such a program could be used to educate people or students about the benefits of installing rain barrels or what other BMPs can do for the watershed, and how what Northumberland does can translate into benefit for the Chesapeake Bay on a larger scale. This grant opportunity has closed for the current year, but should be considered for the coming year.

   Typical award amount: $4,500
   http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?%2fGrants%2fGrantLoans
   Deadline: January 2014

6. Growing Greener Watershed Protection Grants through PA DEP- The Growing Greener Watershed Grants provides nearly $547 million in funding to clean up non-point sources of pollution throughout Pennsylvania. Examples of projects include acid mine drainage abatement, mine cleanup efforts, abandoned oil and gas well plugging and local watershed-based conservation projects. The grants were established by the Environmental Stewardship and Watershed Protection Act. Municipalities, authorities, conservation districts, or other watershed protection entities may apply.

   Typical award amount: $95,000
   A 15% match is required. Match contributions cannot include other DEP funding sources, DEP County Environmental Initiative funding or DEP in-kind services, including laboratory analysis.
   See more information at:
   http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?%2fGrants%2fGrantLoans
   Deadline: Summer 2014

7. Nonpoint Source Implementation Program Grants (Section 319) through PA DEP- This grant program provides funding to assist in implementing Pennsylvania's Nonpoint Source Management Program. This includes funding for abandoned mine drainage, agricultural and urban run-off, and natural channel design/streambank stabilization projects. Counties,

municipalities, authorities, school districts, nonprofits, conservation districts and watershed groups are eligible to apply.

Typical award amount: $200,000
There is no match requirement for this grant program, however, proven match availability may improve the chance of being awarded grant monies.
http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?%2fGrants%2fGrantLoans
Deadline: Summer 2014

8. Nonpoint Source Pollution Educational Mini-Grants (PACD) through PA DEP- The Nonpoint Source Educational Mini-Grants were created for the purpose of informing and educating people about the causes, consequences and clean-up of nonpoint source water pollution. Only conservation districts are able to apply for these grants, however, Northumberland offering to hold the meeting at their venue could result in an appropriate turn-out by Northumberland guests of interest.

   Typical award amount: $2,000
   http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?%2fGrants%2fGrantLoans
   Deadline: March

9. Watershed Education Grants through PA DEP- Through the Water Resources Education Network (WREN) Project, the League of Women Voters of Pennsylvania Citizen Education Fund accepts proposals for watershed education projects sponsored by community based partnerships that educate, build awareness, and promote water-sustaining public policies and/or behavior change. Projects should be designed to encourage individual or collective action that will protect and improve local water resources. Counties, municipalities, authorities, school districts, nonprofits, conservation districts and other entities are eligible to apply.

   Typical award amount: $4,500
   http://www.depreportingservices.state.pa.us/ReportServer/Pages/ReportViewer.aspx?%2fGrants%2fGrantLoans
   Deadline: March

10. **Rivers Conservation Program through PA DCNR (C2P2) -** Due to limited funding during this fiscal year, River Conservation grants are available to municipal entities only. Non-profit organizations are encouraged to partner with a municipal entity to develop and execute this type of project. The purpose of this funding is to develop or implement watershed/river-corridor conservation plans. Priority is given to projects that implement plan recommendations in watersheds that are recorded on the Pennsylvania Rivers Registry. The Susquehanna River is on the Pennsylvania Rivers Registry.

A 50% Match is required, and though the application period is currently closed, it should be checked for re-opening periodically. In 2013, the application period was open from January 15th to April 16th, 2014.
Several other grant opportunities including Trail and Public Education opportunities can be monitored at:
https://www.grants.dcnr.state.pa.us/LearnMore.aspx?GrantProgramId=73

11. The Commonwealth Financing Authority (CFA) and Act 13 funds- There are several programs that could apply to the efforts discussed within this report. Thought at the time of this report they are closed, the website should be re-visited in the coming months to look for monies being revealed through, most notably, the:
    Watershed Restoration Protection Program - Projects which involve the construction, improvement, expansion, repair, maintenance or rehabilitation of new or existing watershed protection Best Management Practices (BMPs).

    $300,000 is the maximum award.
    H2O PA requires a 50% match, and may come from other sources including PennVest.
    The Flood Mitigation Program requires 15% match, and Match will be evaluated based on the benefit to the project and may include cash or in-kind services.

    The programs that may be applicable to the Borough include: Greenways, Trails, & Recreation Program, Flood Mitigation Program, and H2O PA - Water Supply, Sanitary Sewer and Storm Water Projects Program. These additional programs along with the WRPP can be monitored at:
    http://newpa.com/find-and-apply-for-funding/commonwealth-financing-authority

12. Pennsylvania Department of Community and Economic Development- No current applicable programs, other than those listed above to which this department is already tied. This department should continue to be monitored.

13. Several other funding options are available through Private funding entities who seek to better the environment through their efforts. The following website should be checked periodically for applicable grant donors specifically within the Susquehanna River Corridor:
    http://www.susquehannagreenway.org/project-funding

    Additional local funding foundations may be sources for additional Grant funding, or to assist with a match. They include the S. Luther Savidge Charitable Trust, the Degenstein Foundation, among others.

Section 7.0 Conclusions

The desktop review and field-level analysis revealed a variety of opportunities to mitigate negative downstream impacts that threaten the integrity of Liberty Hollow and aid in the degradation of the Susquehanna River and Chesapeake Bay. The practices identified in Section 3 of this report serve as a framework, or better as a plan of action for the Borough of Northumberland. The alternatives analysis has allowed the development of a Green Infrastructure Watershed plan for Liberty Hollow. Should the Borough secure funding, the preferred alternative would be a combination of both structural BMPs and programmatic solutions. The BMPs listed in table 6 and again below are in the order which they should be implemented to achieve maximum benefit to Liberty Hollow per dollar spent. As the Borough secures funding, it is recommended that an implementation schedule as follows would be follow to install all priority 2 and 3 BMPs.

Table 13 - Recommended BMPs

ID #	Type of Practice	Priority	Planning Level Cost Estimate (Design & Construction)
3	bioretention	3	$64,650
29	bioretention	3	$46,500
34	bioretention	3	$13,350
35	bioretention	3	$17,850
21	bioretention	3	$31,000
22	bioretention	3	$57,900
38	pervious pavement	3	$10,900
39	pervious pavement	3	$11,650
2	bioretention	3	$13,600
14	bioretention	3	$23,900
7	pervious pavement	2	$5,250
44	pervious pavement	2	$20,200
46	pervious pavement	2	$10,800
30	pervious pavement	2	$19,050
31	pervious pavement	2	$12,400
6	pervious pavement	2	$13,200
47	Blue/Green Roof	2	$72,000
TOTAL			***$444,200***

Table 14 -Recommended Design, Construction, & Implementation Cost Breakdown

Item	Type	Cost
Design	Contractual	$111,000
Structural BMPs	Contractual	$333,200
Subtotal		*$444,200*
Rain Barrel and Community Alternatives Program	Supplies	$15,000
Tree Canopy Planting Program	Supplies	$15,000
1st Year's Maintenance	Personnel	$26,600
Recommended Total		***$501,000***
Optional: BMP Monitoring	Supplies & Personnel	$18,000

The following recommendations are in line with those objectives outlined by the Chesapeake Bay Trust that would provide maximum benefit to Liberty Hollow and downstream watersheds.

Seek Funds to implement programmatic & community wide alternatives:

1. Rain barrel subsidization program- Seek funds to establish an inventory of rain barrels and sell to Borough Citizens at a reduced cost. This effort could be coupled with inexpensive barrels sourced from a local food industry. Downspout disconnect workshop(s) - These could be 2 to 4 hour long workshops held at the community center to educate the public on do-it-yourself construction methods for rain barrel and downspout disconnection. Initial start-up funds of $15,000 would be used to establish an inventory, for Borough Staff to publicize workshops, provide instruction about implementation, and offset salary costs.
2. Tree planting & tree canopy planting program – Use awarded funds to purchase trees and work with the existing Northumberland Borough Shade Tree Commission to educate citizens about the benefit of tree planting, and to gather volunteers to assist with planting and watering efforts. A startup program of $15,000 would be used to establish an inventory of appropriate trees and provide guidance on planting locations and care.

Seek funds for design and implementation of preferred structural alternatives as presented:

1. Seek $111,000, for design fees required for the recommended structural BMPs. This could be applied to any combination of the structural BMPS. $50,000 is the maximum amount awarded for design through the Chesapeake Bay Trust. Other funding mechanisms would be required to fund the remaining anticipated design fees.
2. Seek $359,800 in funding for structural alternatives listed as type 3 and 2 priorities. These can be implemented individually or in groups over time as funding is obtained. Note that first year maintenance is included in the estimated cost. The Borough should continuously evaluate the preferred list of alternatives as additional infrastructure replacement projects occur as necessary. This recommended list includes bioretention, pervious pavement, and one blue roof opportunity as show above in the section.
3. Seek approximately $18,000 to set up and implement a BMP monitoring program to sample water quality and calculate flow reduction for the structural BMPs. The Borough could work with PADEP to gain nutrient removal credits, which would ultimately compensate to the WWTP effluent limitations which the Borough is currently

attempting to overcome. Order of magnitude concerning removal to be expected due to the planned projects is likely on the level of 10 to 100 Lbs per year of nitrogen and phosphorus respectively, if all projects are implemented. This endeavor should only be undertaken should the Borough see a long term economic benefit.

The conceptual level BMPs provided through the analysis contained within this report would be fine-tuned during complete design as more information is gained about the soils, level of interest of the public, and the actual right-of-way distances are measured out to finalize BMP sizes. In addition to the structural alternatives, it is recommended that the borough develop a program to educate its citizens on ways to mitigate the issues at the individual property level. Subsidizing installations and capital costs, and holding educational workshops are the keys to this involvement. Ultimately, by keeping the public engaged at a high level, more positive relationships are formed and better success can be had watershed wide.

In choosing a sign location, the borough should consider installation at the most heavily traveled or publicized site. As mentioned in previous report sections, Liberty Splashland lends itself to this type of traffic, however, the sign would make more sense in this location if a mitigation project is funded to repair the collapsed culvert, provide streambank erosion protection, or install a structural BMP such as a blue roof, bioretention, or pervious pavement. These visible opportunities could then be pointed out within the context of the sign, in addition to references to the practices which are planned for the neighborhood above Liberty Hollow Park. Alternatively, or potentially in addition to a sign at the pool, any trail to be developed through Liberty Hollow Park would serve as another viable sign location. As additional opportunities present themselves for these projects, green infrastructure implementation adjustments can also be considered. Sign location will likely depend on which project funding presents itself first and most prominently in addition to the amount of visitors it will receive.

The proposed recommendations allow the borough to do as much as it can with any funds that are made available. A major benefit of choosing a decentralized green infrastructure watershed plan approach, is that monies can be spent in increments. This allows re-prioritization of un-built alternatives in the event that details surface which impact the prioritization of the remaining unbuilt structures. It also allows re-prioritization of the alternatives once a handful of the practices are implemented, to avoid spending money where it is not truly needed. Monitoring should be done before and after construction if the Borough intends to apply for nutrient removal credits through the use of green stormwater practices. The alternatives recommended are beneficial to the Chesapeake Bay's water quality struggles, and would likewise be beneficial to the Susquehanna River. They are specifically geared to mitigate issues seen near the entrance of Liberty Hollow Run to the Culvert adjacent to the Liberty Splashland property and still provide benefits to the Bay downstream. The Borough should continue to evaluate opportunities in the lower portion of the drainage basin should more monies become available beyond the alternatives recommended within this report. Additionally, similar concepts should be considered, throughout the Borough, any time that construction will be taking place. It is easier and more cost effective to install practices if the ground is already planned to be disturbed, rather than bringing in equipment and tearing up pavement or yards solely for GI. Implementing the recommended alternatives would call for construction jobs and ultimately maintenance work that the borough would be responsible for. Installed and well maintained BMPs will benefit the homeowners in the Liberty Hollow Neighborhood, the Liberty Hollow Stream Corridor and Park, and water quality in the Susquehanna River and Chesapeake Bay downstream.

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