TOWSON HIGH SCHOOL

Flood Management of Herring Run

A Comprehensive Approach

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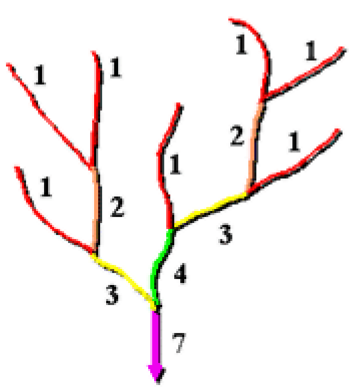
This document examines the best methods to manage the flooding of Herring Run where it intersects Stevenson Lane.

Introduction

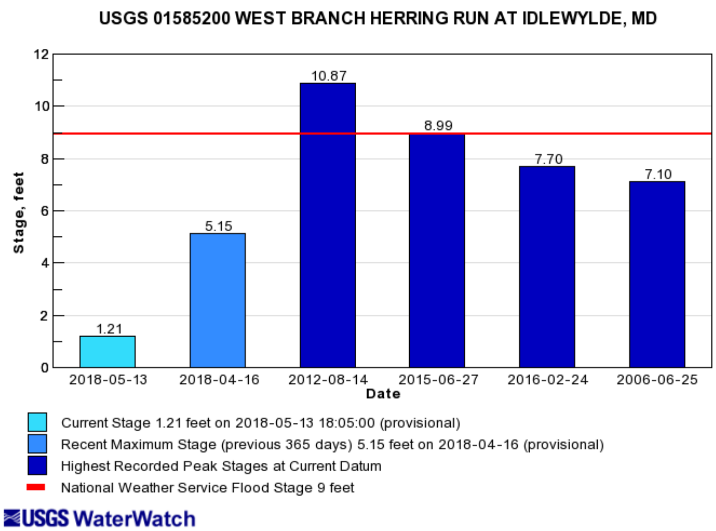
There is a vacant lot where two level one stream tributaries of Herring Run meet at Stevenson Lane near the Maryland Country Club and Worthington Road in Towson, Maryland. During rainstorms, the stream cannot handle the incoming flow of water from both sources and has a history of flooding. The larger of these two tributaries is known as Towson Run and when it combines with the smaller tributary it forms the East Branch Herring Run. Once the two branches meet, they enter a narrow culvert under the Maryland Country Club and Stevenson Lane where the flow of water is too much to handle for such a narrow path, so backups occur. The area became heavily eroded and the houses on the land frequently flooded. Baltimore County bought the land by this floodplain in 2016 and tore down the six houses that were there. Blue Water Baltimore has received a $115,571 grant from the Chesapeake Bay Trust's Watershed Assistance Two-Year Milestone Support grant program to study turning this vacant lot into a six-bridge trail/park to connect neighborhood parks and other landmarks in Eastern Towson and to restore the tributary and expand the floodplain. The trust gives grants to local government officials, and nonprofits to promote engagement in restoring the Chesapeake Bay or other waterways around the area. Nothing can be built until the flooding is controlled so the community has an opportunity to influence the management practices used to control the high levels of erosion, runoff, and pollution from the frequent flooding. We have an estimated budget of approximately $300,000, out of the total estimated $650,000 to restore a 2 mile stretch of Herring Run, to build and implement the management practices to mitigate and reduce the impact of flooding on the plot. In order to do so, we will implement a riparian buffer zone, rain gardens, permeable pavers, and dry ponds, which will ultimately reduce flooding considerably and help restore stream health.

*see captions of pictures for further information on the situation on the plot.



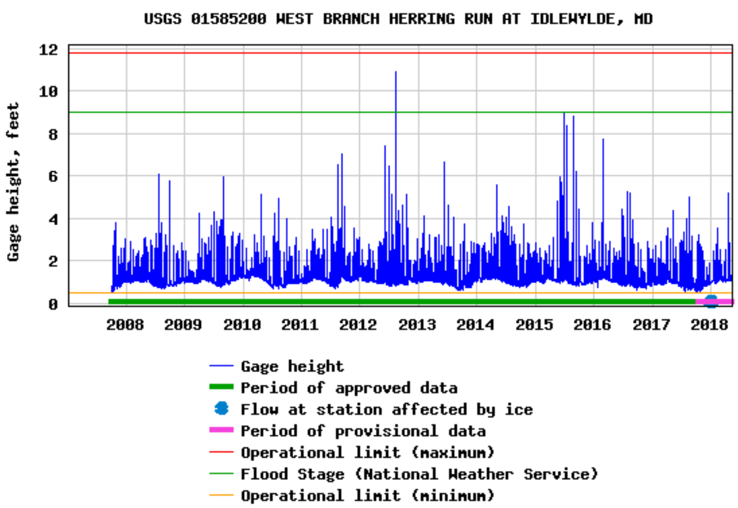
On the site, two first order streams combine to form a second order stream. This causes flooding as the second order stream is narrower than the sum of its parts so the rush of storm water is too much for it to handle.

Diagram Courtesy of ArcGis



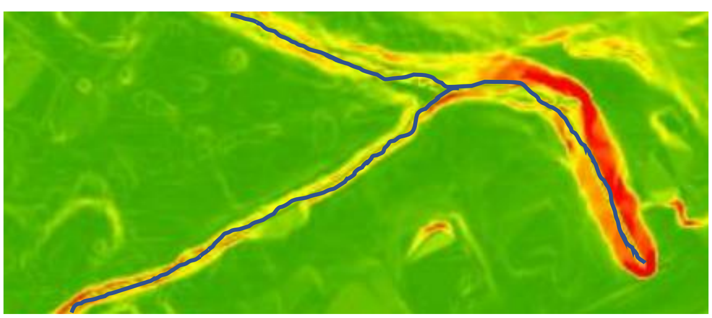
This USGS Water Watch graph indicates that Herring Run has a National Weather Service Flood Stage at nine feet; however this a different area of herring run, but is relatively close

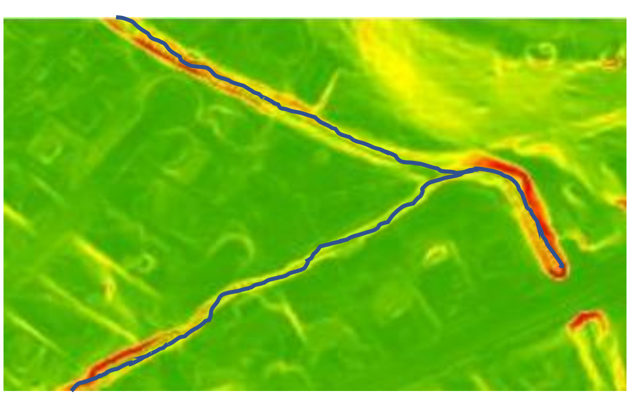
Courtesy of USGS



This hydrograph shows that with storms, the gage height often jumps and reaches over four feet several times a year. This is higher than the banks at some points along the river, especially along the plot.

Courtesy of USGS



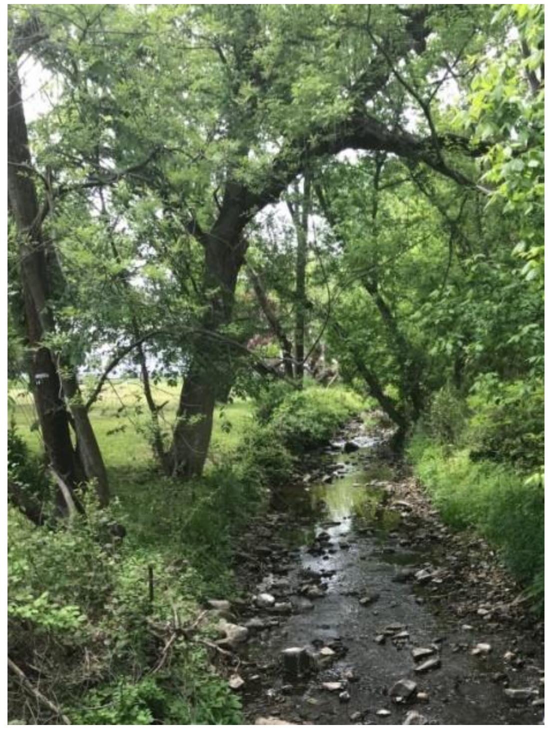


This is a topography map that shows there is a very steep slope towards the banks of the river, indicative of erosion. Surrounding the river are residential plots.

The lower map is zoomed out more.

The blue line was drawn in to show the two branches of Herring Run.

Provided by Maryland Topography Viewer.

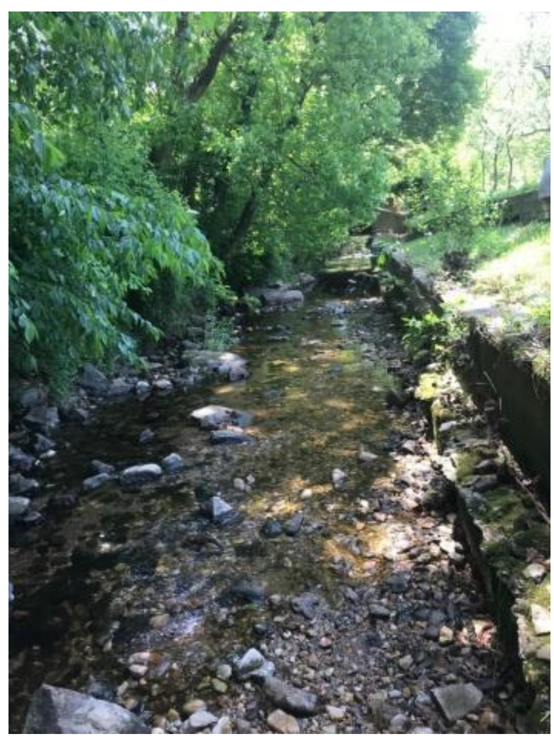


Top right: Smaller branch of Herring Run with near vertical banks indicative of harsh erosion. It is about 33 inches wide.

Top left: Larger branch of Herring Run with a variety of bank sizes and a healthier bank system. It is about 148 inches wide.

Bottom Left: Smaller Branch heading towards larger branch.

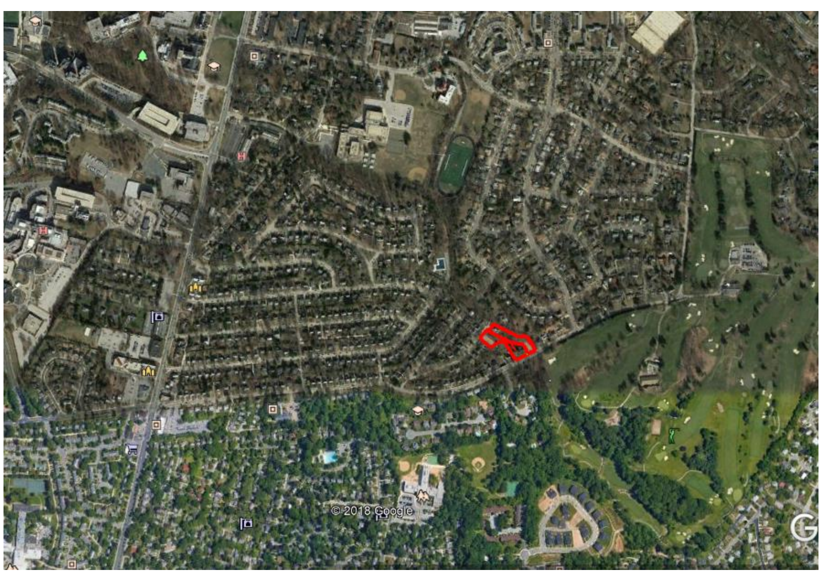
Bottom Right: The combined branches heading toward Stevenson Lane. It is about 145 inches wide.



On the left is the half of the plot closest to Worthington Road and on the right is the half of the plot closest to Stevenson Lane.

Towards the bridge at Stevenson Lane, two man-made bank vertical walls exist that have a combined height of 68 inches. These walls would help to address flooding in this tiny section, but does not help to control it right before. This bank height difference is part of the reason flooding is so prevalent.

These pictures of the same area of the stream are located after the two different branches have met. There is a shallow bank that then turns into a steep grass bank that is undercut with vegetation hanging over it. This wall has a height of about 4 feet when measured vertically from the river. The hydrograph above shows that the stream often reaches above this point, the reason why there is widespread flooding here. The undercut bank is indicative of erosion and its removal from the stream itself means that the erosion occurred under raised water levels or flooding conditions.



In this area, Herring Run has a catchment area of 126 acres. 96% of this is for urban land use which often includes very impervious land uses. As a result, there is a lot of runoff that can better enter the stream, making flooding worse during storms. Our plot is shown in red. This runoff is not filtered by vegetation much and as a result the stream quality is not very good. In fact there are almost no sensitive benthic macroinvertebrates present, which would indicate good stream health.

Proposal

Establishment of Riparian Buffer Zone

Riparian Buffer Zones

Riparian buffer zones are the areas of vegetation surrounding streams. This vegetation is needed for a variety of ecosystem process. The vegetation in these zones helps filter out pollutants like nitrates and phosphates as well as slow the flow of water. As a result, less runoff enters the stream directly, rather sinking into the ground where it will eventually travel into the stream. Water that does enter the stream will be significantly slowed so it does not contribute to erosion and flooding as drastically. Furthermore, the less runoff that enters the stream the less water that contributes to flooding, the primary problem seen on the focus area of this project.

In Herring Run

Directly surrounding both branches of Herring Run on the plot should be a 75-foot riparian buffer zone. This width is needed to ensure that the water is slowed and filtered enough so that runoff is significantly reduced and pollutants from the surrounding residential and commercial land uses are mitigated to a better effect. The 75-foot Riparian buffer zone would surround each branch of Herring Run found on the site. These zones would intersect as well. Three zones must be established as a part of this riparian buffer. Throughout the riparian buffer zone and entire project would be native plants only. Exotic plants have already found themselves along the stream and can threaten native species better suited to uphold the integrity of the stream. Japanese Honeysuckle, Japanese Stilt grass, and Multiflora Rose have all been introduced through human activities along the stream and it is important that this does not continue.

Zone 1

Located next to the stream, zone 1 would have a width of 20 feet. Zone 1 would consist primarily of trees and surrounding grasses. This vegetation would be native to Maryland, have fast growing roots, and be tolerant or favorable of wet conditions and flooding. Immediately next to the river would be 5 feet of shrubs. These shrubs would be allowed to grow throughout the year. This few feet of smaller vegetation would be followed by deciduous trees that meet the prior criteria. The slight removal of trees from the river would ensure the roots do not grow into the river and establish themselves above the banks of the river. The trees would create a dense canopy. This would slow rainfall and provide temperature control for the stream.

Courtesy of http://www.extension.umn.edu/environment/agroforestry/riparian-forest-buffers-series/design-of-riparian-forest-buffers/#three-zone.

As a result of this shade, the aforementioned shrubs would need to be shade tolerant. The trees should be spaced about 10 feet apart. A variety of forbs could be planted in every single zone.

Qualifying shrubs: Dwarf Azalea, Highbush Blueberry, Black Huckleberry, Possumhaw

Qualifying Trees: Red Maple, Silver Maple, Sweet Gum, Black Willow, Green Ash, Common Hackberry, Bald Cypress, Pin Oak, River Birch, American Elm

Qualifying Forbs: Hairy White Oldfield Aster, Narrowleaf Evening Primrose

<u>Zone 2</u>

This layer would be adjacent to zone 1 and would be 30 feet wide. This layer would have smaller deciduous trees, spaced less densely than the trees in zone 1, about 12 feet apart. This would provide for a larger variety of shrubs, bushes, sedges, forbs, and grasses to occupy the understory, that don't have to be as shade tolerant. The shrubs should be placed at about 3 feet apart. All of these plants should continue to be wet and flood tolerant.

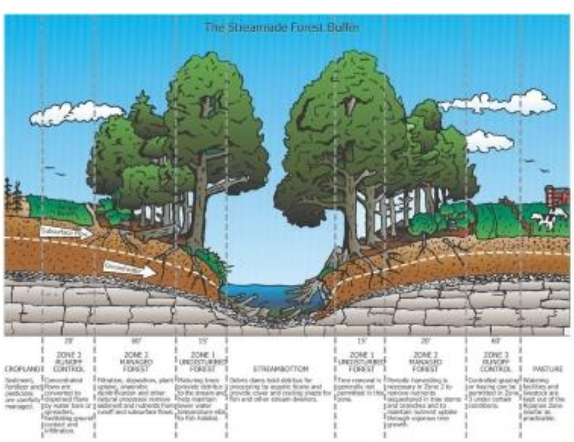
Qualifying trees: Red Maple, Silver Maple, Sweet Gum, Black Willow, Green Ash, Common Hackberry, Bald Cypress, Pin Oak, River Birch, American Elm

Qualifying shrubs: Dwarf Azalea, Highbush Blueberry, Black Huckleberry, Possumhaw, Bushy St. Johnsworth, Allegheny Blackberry, American Hazelnut, Common Buttonbush

Qualifying Grasses, sedges, and forbs: Red Fescue (grass), Narrowleaf Blue-eyed Grass (grass), Tussock Sedge (sedge), Blue Wood Sedge (sedge)

<u>Zone 3</u>

This zone would be 20-25 feet deep and would primarily consist of grasses and sedges. These grasses and sedges again should be wet tolerant and those closest to the tree layers should be shade tolerant; to provide for lots of water absorption and runoff filtration before entering the stream.



Courtesy of https://www.dec.ny.gov/chemical/106345.html

As the grasses travel further away from the tree layers they need not be as shade tolerant. The presence of these grasses would allow for extra root penetration and thus a higher capacity for flood water capture and also further slow runoff and floodwaters. This would slow the process of the stream flooding, allowing for seepage time. The last ten feet of zone 3 would merge with the rain garden. This means that section of the rain garden would comply with what was laid out previously for this zone.

Qualifying Vegetation: Blue Sedge, Bloodroot, Cinnamon Fern, Butterfly Milkweed, Tall Fescue

Justification

Restoration Program in Santa Cruz: Until the 20th century the Santa Cruz River contained a very diverse and large riparian ecosystem. But as time progressed and the area's population grew, there was a much higher demand for water that needed to be filled. So this water was taken from the Santa Cruz and this cause the sustained surface flow of the river to go down in large numbers. This had a profound effect on the riparian buffer by destroying more than 95% of riparian areas. The whole ecosystem was destroyed and they decided they need to restore the river. Part of the restoration plan was to rebuild the riparian buffer zones by the river by planting over 10,000 tress and cacti. It was then reported after the restoration plan that the restoration of the riparian buffer zones further stabilized the banks of the river, floodway, and floodplain. Not to mention the great benefits it contributed to the surrounding ecosystem by providing a more vibrant riparian area and allowing for the reintroduction of plants and animals that were lost due to the cease of sustained river flow. In this case the riparian buffers played a major role in restoring the river.

Reported Benefits and Effectiveness by the University of Vermont: "The most important function of these zones is to act as a filter for water flowing into the water source, and studies show that they greatly reduce water pollution. The vegetation and soil absorb runoff water that is often laden with pollutants, sediments and nutrients that are harmful to the water supply, especially if the buffer zone is over 30 feet wide. The absorption of runoff water has other benefits: it recharges the ground water supply, and can regulate water flow in rivers and therefore reduce and prevent flooding. Having vegetation immediately adjacent to a water source also helps control erosion, as the roots of the plants help hold soil in place. Zones of land adjacent to water sources are often flourishing wildlife habitats, with many species depending on them for survival.2 Buffer zones could also theoretically reduce the amount of public spending on storm water management and pollution removal."

Riparian Buffer Functions: reducing erosion, filtering sediment, filtering pollution, providing shade to moderate water temperatures, providing habitat and increasing biodiversity, and storing water and reducing flooding.

Reduction of Flooding and Recharging of Groundwater: One large benefit of riparian buffers is that they are very effective at absorbing rain water which allows for the ground water supplies to recharge and for storm runoff to be released at a slower speed. Since it absorbs rainwater, after a large rain event where there would be intense flooding. The riparian buffers help to significantly reduce the intensity and frequency of the flooding after rain events. This is very beneficial for the Towson Run since flooding is a large problem. One more added benefit is that in the case there was a dry period, the riparian buffers helps to increase the water flow significantly by being able to store groundwater.

Reducing Erosion: The roots of a riparian buffer, which include herbaceous and woody plants, help to give strength to the surrounding stream bank by going into the topsoil while also going into the stream bank's weathered bedrock to hold together sediment. This greatly helps with the stream banks cohesiveness and makes it more difficult for large amount of water to erode stream bank soil because the roots help keep it together.

Filter Sediments: When riparian buffers are introduced they greatly help filter sediment from storm water runoff. This helps reduce the overall amount of sediment in the stream. When trees are put close to the stream they create barriers which greatly help slow the water flow and this allows the sediments to settled and be filtered by the riparian plants. For example in Blacksburg, VA, 9.1m and 4.6 m wide orchard grass buffers were placed in shallow, uniform streamflow, and they removed on average 84% and 70% of incoming suspended solids. Suspended solids are indicators of the amount of sediment in the stream so when there are less suspended solids the stream has less sediment and is healthier. So based on this case you can see that riparian buffers help filter out the sediments from the stream very effectively

Provision of Habitat: Riparian areas help significantly in providing a habitat for aquatic and terrestrial organisms. These animals play a large role in keeping the stream healthy which is also why riparian buffers play a large role in maintaining stream quality indirectly. In aquatic habitats the large woody debris that are created by riparian areas are essential in maintaining all of the aquatic organisms that reside in the stream. The organic matter that is from the trees such as leaves, twigs, and logs are an essential food source for aquatic macroinvertebrates. These macroinvertebrates can directly consume the wood or consume the biofilms that are formed on the organic matter. They also use the woody debris as a habitat to hide from predators. This debris can also provide a site for macroinvertebrates to lay their eggs on to or emerge into adults. The riparian buffers play a large role in maintaining the bottom habitat of the stream. Most of the ecological activity in an aquatic ecosystem takes place on inorganic and organic materials on the bottom of the streams. This matter from the riparian buffer ultimately expands the bottom habitat area and allows for more biological activity which can lead to an increase of biodiversity.

Removal of Pollution by Vegetation: Pollutants such as metals, nutrients, and other chemicals that are deposited into the stream via runoff can all be removed by the vegetation in riparian areas because of plant uptake and it facilitates the bacterial degradation of the pollutants. Narrow buffers are generally useful for removing sediments while wide buffers are very effective at nutrient removal from the stream. In northern Baltimore County, MD, the Minebank Run cut through a few urban areas with lots of impervious surfaces. The heavy volumes of rainfall running off these impervious surfaces has allowed for more pollutants to be carried and placed into the Minebank Run. Part of the restoration effort was to widen the riparian buffer by planting over 3000 trees and shrubs. This prevented up to 50,000 pounds of sediment from running off into the stream and had reduced the nitrogen levels of the stream by almost 50% which is very effective if you are trying to reduce nitrogen levels.

Rain Garden

Rain Gardens

Rain gardens are slightly sunken areas that are filled with a variety of vegetation that efficiently soak up water. The depression in these areas allow for water to be collected from flooding events and runoff and then slowly be absorbed into the ground while pollutants are removed.

In Herring Run

The rain garden would begin at the last ten feet of the riparian buffer zone and would then proceed to extend another 20 feet. The rain garden would have a 6 foot path going through the middle of it. This would divide the rain garden into two 12 foot segments. For this reason the path would not go into the designated riparian buffer zone. The 12 foot half partway in the buffer zone would have vegetation that coincides with the vegetation laid out for zone 3 of the riparian buffer zone. The other half would have a wider variety of vegetation.

Courtesy of http://proscapesllc.com/the-rain-garden-is-one-of-the-more-popular-landscape-ideas/

Specifications

The ponding depth of the rain garden would be 1 foot. The slope needs be 3 to 1 so the sloping distance would be 3 feet on each side. This leaves 6 feet of the rain's width garden to be at the ponding depth. This means that for every foot in length of the rain garden 9 cubic feet of water would be stored. This applies to only one half, so when accounting for both, 18 cubic feet of water would be stored per foot in length. The whole length of the rain garden would be about 400 feet so about7,200 cubic feet of flood water could be retained by the pond.

Vegetation

Shrubs: Arrowwood Shrub, Silky Dogwood Shrub

Perennials: Cinnamon Fern, Cardinal Flower, Bloodroot, Blue Sedge, Christmas Fern

Soil Below and Mulch

If the soil is evaluated to lack significant porosity, extra measures may need to be taken to ensure percolation. Firstly, on the site dig an 18 inch deep whole with a 12 inch diameter, as recommended by Blue Water Baltimore. Then fill it completely. Wait an hour or two and fill it again. Do this 2 more times. Then wait to see how long it takes to completely empty. If it takes less than 24 hours only 3 extra inches lower than the ponding depth. This would be filled with mulch. If it takes more than 24 hours 15 extra inches need to be dug. The top 3 again will be mulch while the bottom 12 should be a combination of gravel, sand, and clay. This would add expense, but also ensure maximum flood protection.

Justification:

Flood Prevention Effectiveness: Rain gardens are very effective at mitigating the effects of flooding because they heavily reduce the amount of water by allowing the water to effectively percolate and infiltrate into the groundwater storage. Rain garden designs usually include removing 6 to 12 inches of soil then altering it with tillage, compost, and sand. This design allows it to absorb 30% more water than any conventional lawn which is extremely effective considering they both take up the same space but one allows for more infiltration

Pollution Removal: In terms of removing pollution from storm water runoff, rain gardens are one of the most effective practices for removing pollutants. They remove up to 90% of nitrogen and chemicals from the water they absorb and up to 80% of sediments. This would significantly help reduce pollution in nearby water sources such as streams by effectively removing large amount of pollutants from storm water runoff that is likely to occur after rain events. Considering 70% of all water pollution is caused by storm water runoff, rain gardens would have a profound effect on the nearby water source as they would remove most of the pollutants from this runoff and the runoff is the main source of the pollution.

Courtesy of https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates

Maintenance: One of the most beneficial things about maintaining a rain garden is the native vegetation so 1 year after the rain garden is incorporated there is no need for fertilizer. Once all the plants are in place after one year there is a very small amount of maintenance needed and the rain garden can just run by itself

Pathway

As already mentioned the pathway would be six feet wide and would travel in between the two halves of the rain gardens, dividing the gardens into two twelve-foot sections. The pathway would travel from Worthington Road to Stevenson Lane and would be removed from the larger branch of Herring Run by 77 feet. The Path would however divide the riparian buffer zone for the smaller branch of Herring Run and would be removed from the larger branch of Herring Run by 77 feet. The Path would however divide the riparian buffer zone for the smaller branch of herring run. It is best that the pathway be fit in between the rain garden as permeable pavers best drain floodwaters when surrounded by a bio swale structures. This pathway would ensure that the whole plot can be traveled by visitors to the park, making it more attractive to the public. These pavers can last up to 30 years making it a sustainable solution as well.

Courtesy of http://extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/master-gardeners/Howardcounty/Baywise/PermeablePavingHowardCountyMasterGardeners10_5_11%20Final.pdf

Justification

Runoff Prevention Effectiveness: One major benefit of permeable pavers is that they take the role of the urban impervious surfaces while also allowing the water to infiltrate into the ground. This significantly reduces the runoff volumes during storm events because most of the rain will land on the impervious surfaces so if they were replaced with concrete permeable pavers, very large amounts of storm water runoff would get discharged into groundwater before it has a chance to get to the storm water system which helps prevent overflowing of these storm water systems and nearby water sources. By removing large amounts of runoff before it can be dealt with by other storm water management practices, which reduces the need for them, time and money can be saved.

Pollutant Removal: One benefit of these permeable pavers is that they can reduce the concentrations of certain pollutants via 3 methods. Physically by storing the pollutants within the pavement or soil, chemically by allowing bacteria to break down and utilize certain pollutants, or biologically when plants grow in the middle of some pavers they can trap and store pollutants.

Winter Benefits: One big problem with the Towson Run is that during the winter large amounts of salt is needed to prevent the road from icing over. When it rain all this salt is deposited into the Towson Run which can heavily change aspects of the stream. Permeable pavers require 0 to 20% less salt applied compared to regular asphalt. This would significantly reduce the amount of salt that is deposited to the nearby water source. Also air can be trapped within the pavement and this air can store heat and later release it to the surface of the pavement during snow events which helps to melt and thaw the ice on the road nearby, which makes the roads much safer and reduces the need for lots of salt.

Dry Pond Installation

There would be two dry ponds located at the site one in the upper left corner and one in the lower left corner. The lower left corner dry pond would be larger with dimensions of about 100 by 50 feet and 50 by 50 feet in the upper left corner. Both these ponds would have a 3 to 1 slope that would result in a 5 foot depth. In total there would be a volume of about 24,000 cubic feet. When water thusly floods from the river 24,000 cubic feet could be stored and both the area towards the Wiltondale neighborhood and Stoneleigh neighborhood would be protected by the dry ponds. These dry ponds would have a drainage pipe very close to the bottom of the pond allowing for slow release of the water back into the stream. Perhaps several inches of water would be left in the pond in order to sustain a marshy ecosystem within it, allowing for vegetative filter strips. The drainage pipe would release water back to the stream over several days to lower flooding ability. The ponds would also help stop flooding in the first place by holding vast amounts of runoff before they enter the stream.

Plants: Marshy plants, can live in wet and drier conditions. Native to Maryland

Shrubs: Brook-side Alder, Red-osier Dogwood, Common Winterberry, Sweetbay Magnolia

Sedges and Rushes: Fringed Sedge, Bladder Sedge, Shallow Sedge, Upright Sedge, Fox Sedge, Three-way Sedge, Blunt Spikerush, Soft Rush, Three-square Bulrush, Green Bulrush, Wool-grass, Soft-stem Bulrush

SAV: Sweetflag, Broad-leaf Water-plantain, Common Marsh-marigold, Broad Water-weed, Swamp Rosemallow, Blueflag, Golden Club, Arrow Arum, Pickerel Weed, Broad-leaf Arrow-head, Lizard's Tail, Narrow-leaf Cattail, Broad-leaf Cattail, Wild Celery

Wildflowers and Grasses: Swamp Milkweed, Swamp Aster, White Turtlehead, Spotted Water-hemlock, Canada Manna Grass, Fowl Manna Grass, Rice Cutgrass, Allegheny Monkey-flower, Swamp Saxifrage, Prairie Cordgrass

Ferns: Royal Fern, Virginia Chainfern

Justification:

Storm Water Runoff Mitigation: One great thing detention basins can do is slow and prevent the overflow of storm water runoff. They're designed to capture water during rain events to lessen the severity the runoff has on the ecosystem. They are not permanent pools of water and they are made to dry out after a certain period of time and retain water only after rain events. If there was to be a very large storm event, these dry detention ponds would be very effective at preventing over flow because they act as a temporary storage for the water and as more water is collected the flow goes down and is controlled which helps significantly prevent the catastrophic effects of overflowing storm water runoff

Pollutant Removal: In addition to slowing storm water runoff, dry detention ponds are also fairly effective at removing pollutants from the water that is caught inside the depressed area. This is because the water is drained from the ponds and this allows the native vegetation within the ponds to absorb the nutrients and pollutants from the storm runoff water and studies have shown that this significantly reduces the amount of pollutants in the nearby water source.

Additional Uses: In between rain events, detention basins are typically dry and contain little water. This allows the space to be used as a recreation field for sports, etc. and provides more green space for the area as a whole while also being used as a storm water runoff management practice which makes it very efficient and effective at helping nearby bodies of water

Courtesy of https://stormwater.pca.state.mn.us/index.php?title=File:Vegetated_filter_strip_4.png

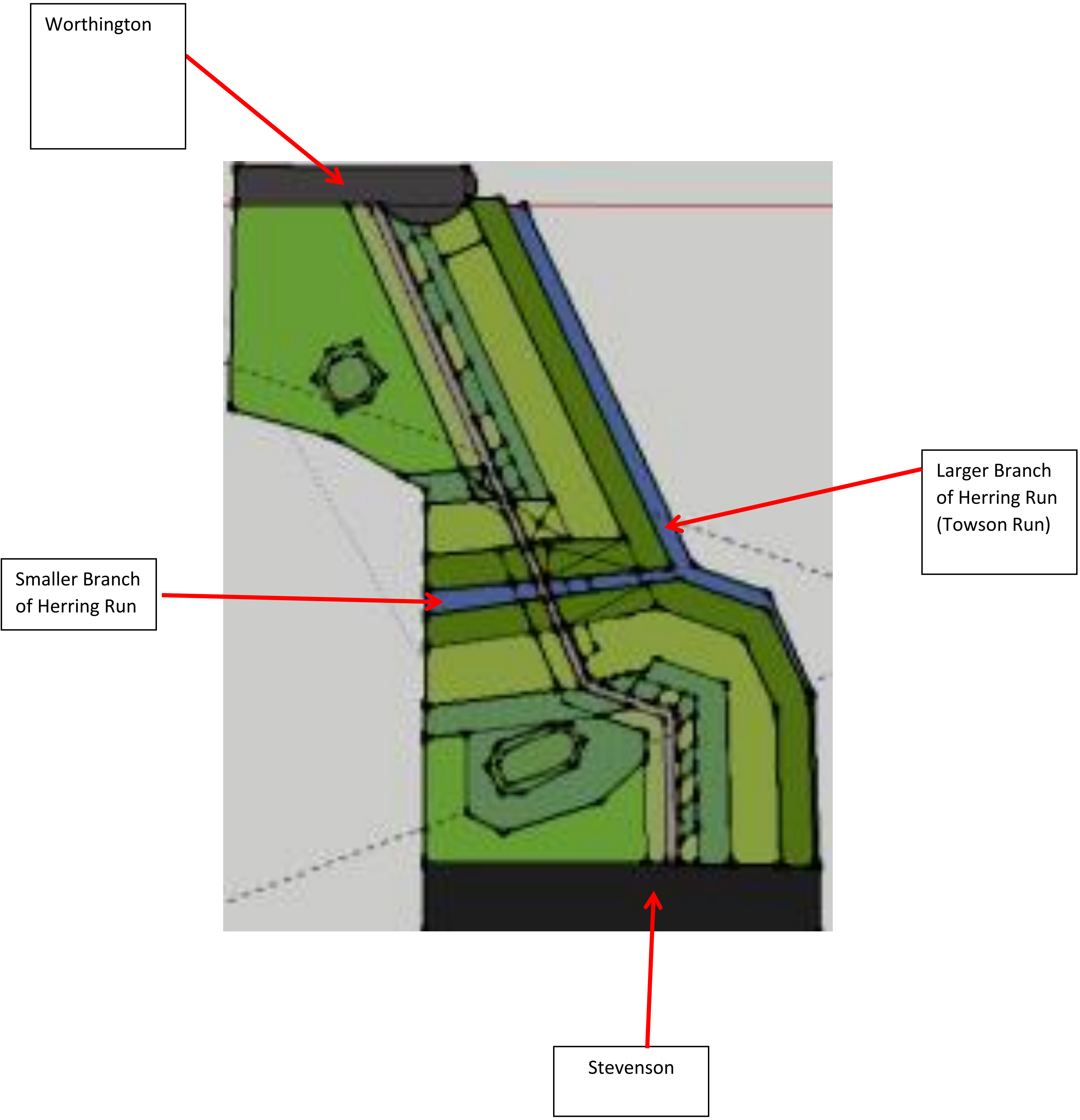
Maintenance: One of the most important things about a retention pond in ensuring that it is working to its fullest potential is maintenance. Routine maintenance like debris removal and mowing needs to be done on a frequent basis so the detention pond is not defective. There are also non-routine maintenances that need to be done on an annual basis like sediment removal and slope stabilization. Since the detention pond that we will incorporate will be near an established neighborhood and not near a large commercial district, there will be less needs for routine maintenances but if there is a frequent deposit of trash then more maintenances will be needed to make sure the outlet for the detention pond is not clogged. There will likely need to be an identification of who will control the routine maintenance, non-routine maintenance, and inspections to ensure that the detention basin is maintained properly.

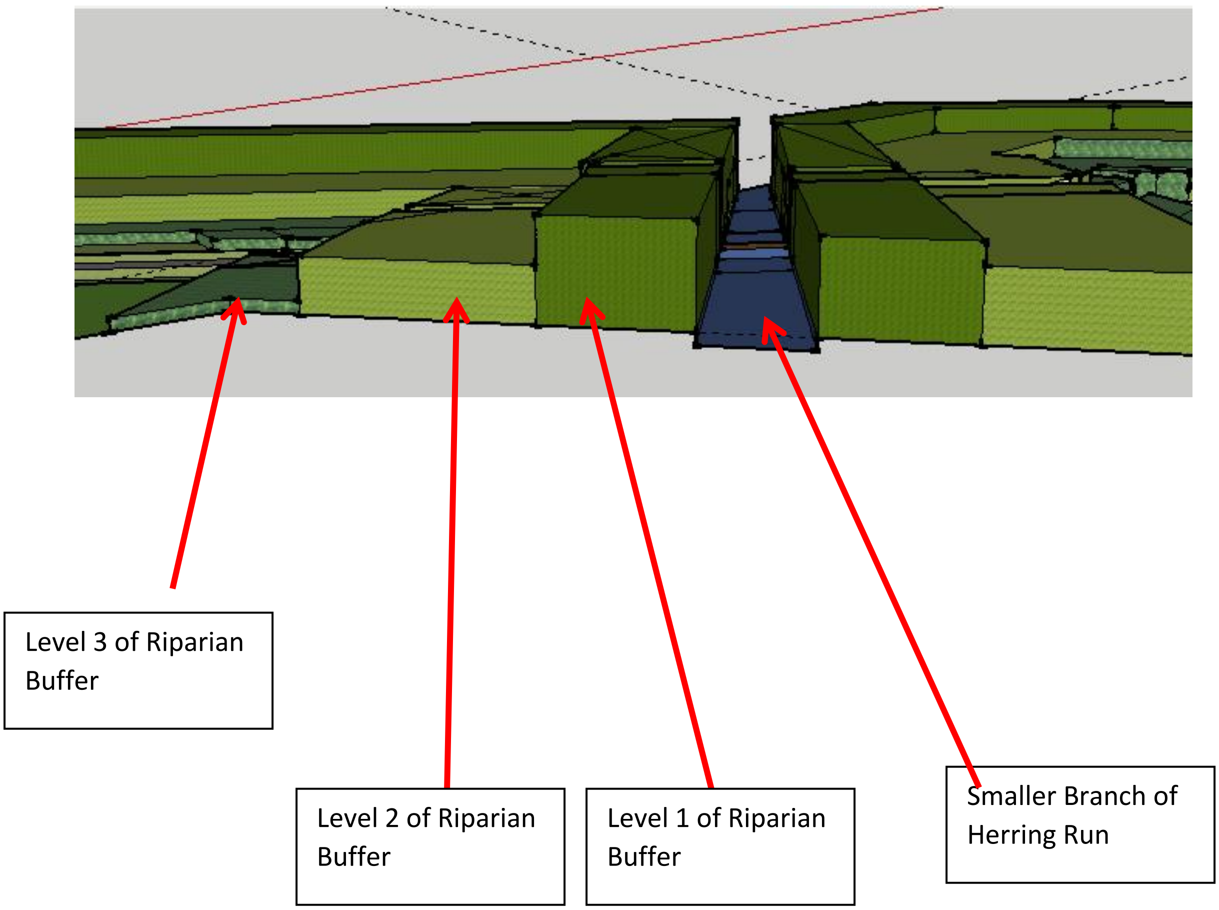
Park

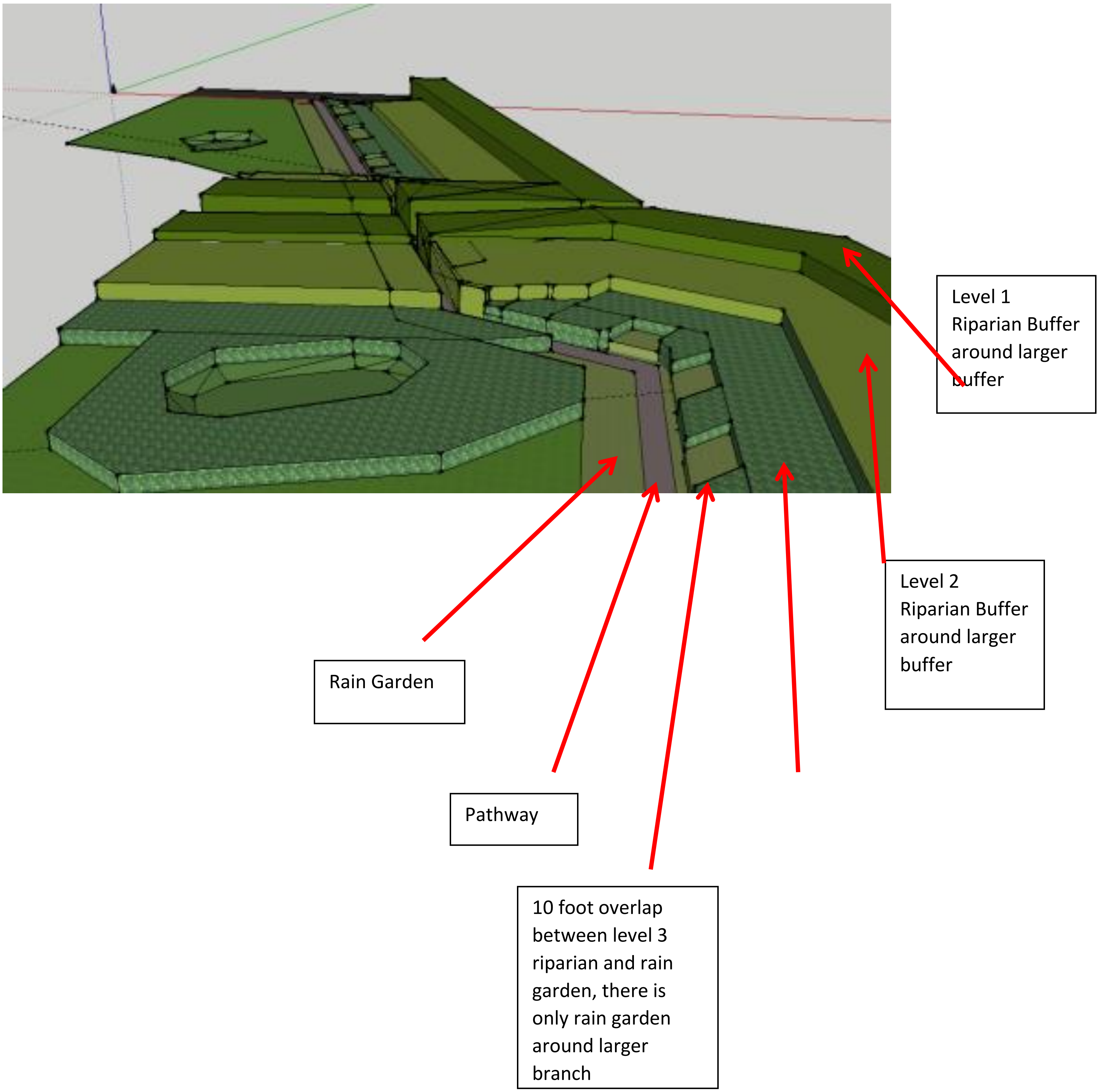
In the upper left hand corner of the plot a grassy park would be introduced. This park would be manicured to keep the grass at low enough heights for human activity. There would benches and other possible human attractions. This grassy park would surround the dry pond located in the upper left corner of the plot. For this reason it would be wise to implement a fence around the dry pond to lower the risks of disturbance. Parks can increase property values up to 20% in residential areas on the immediately surrounding properties and up to 10% on properties 2 to 3 blocks away. This would make the overall project more attractive to constituents and make the project more economically viable as there will be more available assets to tax. A playground could even be implemented that would make the overall project even more appealing to constituencies. Some playgrounds come as cheap as several thousand dollars and could easily be implemented on this grassy park area. However, any implemented structure must be flood resistant.

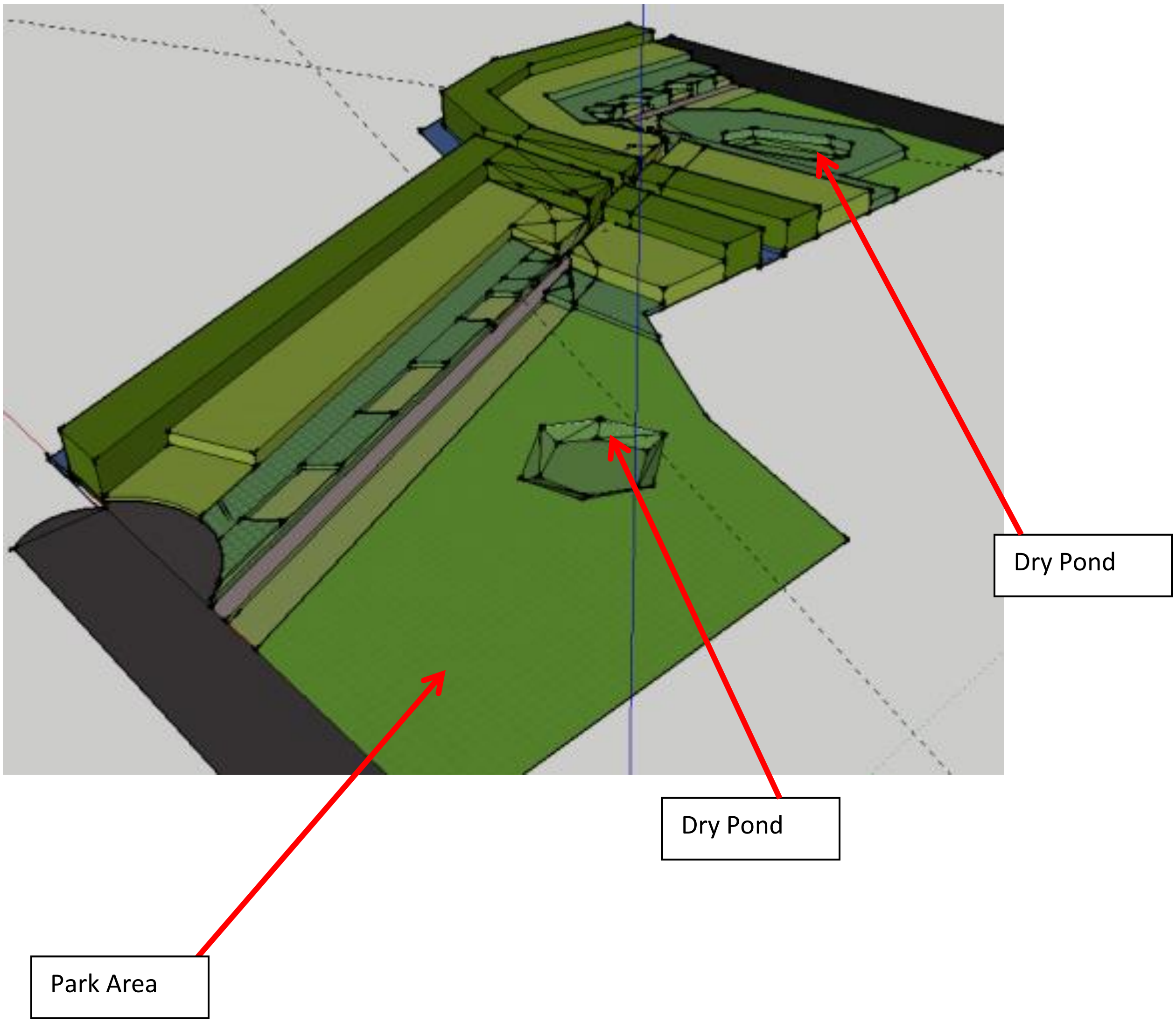
<u>Design</u>


Worthington
Background Satellite Photo Courtesy of Google Earth
Larger Branch of Herring Run
Smaller Branch of Herring Run
Stevenson


Worthington
Larger Branch of Herring Run (Towson Run)
Smaller Branch of Herring Run
Stevenson


Level 3 of Riparian Buffer
Level 2 of Riparian Buffer
Level 1 of Riparian Buffer
Smaller Branch of Herring Run


Level 1
Riparian Buffer
around larger
buffer
Level 2
Riparian Buffer
around larger
buffer
Rain Garden
Pathway
10 foot overlap
between level 3
riparian and rain
garden, there is
only rain garden
around larger
branch


Dry Pond
Dry Pond
Park Area

Costs

Rain Garden- These are mostly filled with flowering perennials, grasses, and shrubs which are all relatively cheap and make the rain garden a cost-effective way to control runoff and allowing the excess water to soak into the ground. However, based on the large scale and construction efforts, a rain garden like this, costs about $6 a square foot and is at the upper end of residential gardens. We would need truckloads of dirt and plants, and hours of labor would be needed to dig and install to make sure it can properly achieve its job. At almost 10,000 square feet, our cost would be near $60,000 after plants and labor. A drainage system and amended soil to increase bioretention could add another $5,000 and bring our cost to $65,000.

Dry Pond-Dry ponds cost around $.30 per cubic foot. We intend to have pond 24,000 cubic feet which brings our cost to around $7,200. Dry ponds have the intended use of soaking up extra rain during storm events so that the other areas aren't flooded out. However, simply digging a whole isn't enough, planning and design is needed, also before any digging you must have proper permitting. Also, earthworks must be done to ensure no utilities are broken in the digging process. Permitting, design, and earthworks can cost an additional $10,000-$15,000. This brings a total cost of the pond to be around $20,000. However, around $2,000 is needed annually for maintenance and upkeep to ensure the pond can effectively soak up and release the excess rainwater.

Permeable Pavers- The pavers are fairly time consuming to install and are much slower than laying traditional concrete. Each one must be hand laid and set which adds heavy labor costs. For the pavers alone, they cost $5 a square foot. At 2538 square feet, our cost is $12,690 for the pavers. However, a large job like this will take days of installment and it must be right for them to do their purpose. After adding another $7,500 for labor, the pavers cost $20,000

Riparian Buffer- A proper buffer will include a variety of trees and plant life. All assortments of trees, roots, annual and perennial, shrubs, grasses, and flowers will be used to effectively filter the pollutants and soak up powerful runoff. A buffer including trees, native plants, grasses, and shrubs can be long and hard to install and isn't cheap. The trees for one acre alone can cost $5,000 including installment. If you include the rest of the plants and grasses, a proper buffer will cost $15,000 bringing the total cost to $20,000. Also, maintenance is need often to ensure the plants remain healthy suitable for the job.

After the installment, and labor for the different solutions, the cost is around $125,000 and annual work is needed at a rate of $5,000 a year to make sure all installments are still working and are effectively helping the health of the stream. This is a conservative cost estimate; however it is well below the targeted maximum of $300,000. Cost overruns and underestimation may lead to high costs, but this $175,000 cushion will certainly ensure that our proposal is achievable.

Other considerations

Issues

- There could be utility infrastructure present under the plots as there used to be houses there. These utility lines would complicate digging and planting jobs possibly leading to the need for a new design and cost overruns compared to the current estimates.
- Other present issues are the slope of the plot. At some locations there are slight slopes that would interfere with the implementation of the dry pond in particular as it generally needs to be on land with a slope less than 15%. If the slope in areas where the dry pond is proposed has a steeper slope leveling may need to occur which would add more costs.
- All of the management practices would need maintenance and thusly there is a supported added cost.
- Some residents may worry about the legitimate possible of larger wildlife such as deer coming into their neighborhoods as a result of the new woodland. Speakers that can scare off deer may need to be implemented and vegetation that is not wanted by deer may be needed. This would add costs to the project.

Bank of River:

The bank of the river is very poor in some locations and not as poor in others. At some locations the bank is vertical or undercut signaling deep erosion. Other points have more steady slopes, while the area towards the bridge has man made walls. These poor banks can interfere with the natural process of the stream as they limit plant growth and interfere with proper development of pools and riffles in the stream. The man made walls do narrow the river causing a bottleneck that could contribute to flooding and could complicate the riparian buffer. If there is adequate funding, it may be worth it to restore the stream bank to have a steadier slope, ultimately reducing flooding.

Park:

- Any park features must be able to weather a flood; otherwise they will wear easily given the conditions of the area. It is unlikely any permanent structure like a playground would be feasible as a result.
- Throughout the entire plot should be placards explaining the role of the different management practices as well as explain environmental factors of the stream such as erosion, flooding, pollution, runoff, etc.
- Possible fencing around dry ponds to prevent interference with natural processes

Works Cited

"A New Tree Grove, Thanks to the Hardy Garden Club." *Blue Water Baltimore*, 8 Mar. 2015, www.bluewaterbaltimore.org/blog/a-new-tree-grove-thanks-to-the-hardy-garden-club/.

"ArcGIS Pro." *Mosaic-Data Management Toolbox | ArcGIS Desktop*, pro.arcgis.com/en/pro-app/tool-reference/spatial-analyst/how-stream-order-works.htm.

ArcGIS Web Application, geodata.md.gov/streamhealth/.

"Authors and Illustrators." *African Studies Review*, Cambridge University Press, 1 Jan. 2009, muse.jhu.edu/article/249675/pdf.

"Baltimore County- My Neighborhood." *ArcGIS Web Application*, bcgis.baltimorecountymd.gov/myneighborhood/.

"Best Management Practices for Stormwater Runoff: Ponds." Laramie County Conservation District.

"Bioretention A Guide for Stormwater Retention & Water Quality Improvement."

"Bioretention Device Cost Estimate Worksheet." *Tanners Lake - Alum Injection for Phosphorus Removal - Minnesota Stormwater Manual*, stormwater.pca.state.mn.us/index.php/Bioretention_device_cost_estimate_worksheet.

Brennan, Amy H. "Cost Analysis of Low Impact Development Best Management Practices." Chagrin River Watershed Partners, Inc.

Bair, Brian. "Stream Restoration Cost Estimates."

Carter, Maria. “3 Ways Plants Help to Control Erosion.” *Popular Mechanics*, Popular Mechanics, 14 Nov. 2017, www.popularmechanics.com/home/lawn-garden/how-to/a8911/3-ways-plants-can-help-you-control-erosion-15445641/.

“Chapter 3 - Detention Basins for Flooding Control.”

“Costs of Stormwater Management Practices In Maryland Counties.” Maryland Department of the Environment, 10 Oct. 2011.

Crompton, John L. “The Impact of Parks on Property Values: A Review of the Empirical. Evidence.” Journal of Leisure Research, 2001

“Design of Riparian Forest Buffers.” *Social Wasps and Bees in the Upper Midwest : Insects : University of Minnesota Extension*,

“Evaluating the Potential Benefits of Permeable Pavement on the Quantity and Quality of Stormwater Runoff.” *How Can Climate Change Affect Natural Disasters?*, www.usgs.gov/science/evaluating-potential-benefits-permeable-pavement-quantity-and-quality-stormwater-runoff?qt-science_center_objects=0.

“File:Vegetated Filter Strip 4.Png.” *Tanners Lake - Alum Injection for Phosphorus Removal - Minnesota Stormwater Manual*, stormwater.pca.state.mn.us/index.php?title=File%3AVegetated_filter_strip_4.png.

“Floodwater Detention and Retention Basins.” *Naturally Resilient Communities*, nrcsolutions.org/floodwater-detention/.

Fox, Amanda, et al. “Planning Your Riparian Buffer: Design and Plant Selection.” University of Nebraska, Feb. 2005. “ Chapter 2 – Dry Extended Detention Basin.” VDOT BMP Design Manual of Practice.

"LID Urban Design Tools - Bioretention." *LID Urban Design Tools - Green Roofs*, www.lid-stormwater.net/bio_costs.htm.

"Maryland Biological Stream Survey Data Search." *Maryland Biological Stream Survey*, eyesonthebay.dnr.maryland.gov/mbss/SA_site2k.cfm?siteyr=BACK-101-R-2002.

"Maryland Native Willow Family Trees, Salicaceae." *West Virginia Native Pine Trees*, www.treesforme.com/md_salicaceae_willow.html.

"Maryland Trees Collection." *Towson University*, www.towson.edu/campus/landmarks/glen/trees.html.

"Native Plants." *Native Plants*, University of Maryland Extension, extension.umd.edu/hgic/native-plants.

"Native Plants for Wildlife Habitat and Conservation Landscaping." U.S. Fish & Wildlife Service .

"Native Trees for Rain Gardens." United States Department of Agriculture.

"Native Trees of Maryland." *West Virginia Native Pine Trees*, www.treesforme.com/maryland.html.

"North American Native Trees in the Willow Family, Salicaceae." *West Virginia Native Pine Trees*, www.treesforme.com/salicaceae_willow_family.html.

N, Rodney. "White Oak Tree on Fast Growing Trees Nursery." *Fast-Growing-Trees.com*, 31 Oct. 2016, www.fast-growing-trees.com/White-Oak-Tree.htm.

Pacella, Rachael. "Baltimore County Shoring up Eroding Herring Run to Prevent Future Problems." *Baltimoresun.com*, 2 Mar. 2017, www.baltimoresun.com/news/maryland/baltimore-county/towson/ph-tt-stream-restoration-0301-20170301-story.html.

Palma, Sarah, et al. “Waterfront Buffer Zones.” University of Vermont, 2 Apr. 2008.

Palone, Roxane S., and Albert H. Todd. “Chesapeake Bay Riparian Handbook: A Guide for Establishing and Maintaining Riparian Forest Buffers.” USDA, May 1997.

“Plants for Riparian Buffers.” Aberdeen Plant Materials Center, Nov. 2011.

“Permeable Pavement Fact Sheet Information for Howard County, Maryland Homeowners.” UMD.

“Porous Pavement Alternatives Cost Analysis.” Century West Engineering for Metro.

“Rain Gardens.” *Naturally Resilient Communities*, nrcsolutions.org/rain-gardens/.

“Rain Gardens.” *The Groundwater Foundation*, www.groundwater.org/action/home/raingardens.html.

“Rain Gardens | The Nature Conservancy.” *Red Foxes in Indiana | The Nature Conservancy*, www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newjersey/explore/rain-gardens-1.xml.

“Rain Gardens for Healthy Streams.” Blue Water Baltimore, 2013.

Randall, Jesse A., and Joe Herring. “Management of Floodplain Forests.” ISU.

“Restoring Floodplain Elements.” *Naturally Resilient Communities*, nrcsolutions.org/restoring-floodplains/.

“Riparian Buffers.” *Freshwater Wetlands Program - NYS Dept. of Environmental Conservation*, www.dec.ny.gov/chemical/106345.html.

“Soak Up the Rain: Rain Gardens.” *EPA*, Environmental Protection Agency, 1 Feb. 2018, www.epa.gov/soakuptherain/soak-rain-rain-gardens.

Scott, Ted. “Bioretention Illustrated: A Visual Guide for Constructing, Inspecting, Maintaining and Verifying the Bioretention Practice.” 20 Oct. 2013.

www.extension.umn.edu/environment/agroforestry/riparian-forest-buffers-series/design-of-riparian-forest-buffers/#three-zone.

"Santa Cruz Riverbank and Ecosystem Restoration, Pima County, Arizona." *Naturally Resilient Communities,* nrcsolutions.org/santa-cruz-riverbank-and-ecosystem-restoration-pima-county-arizona/.

"Site Settings." *Fairfax County Virginia*, www.fairfaxcounty.gov/soil-water-conservation/.

Smith, et al. "STORMWATER MANAGEMENT DETENTION POND DESIGN WITHIN FLOODPLAIN AREAS." *Home - Transport Research International Documentation - TRID,* 30 Nov. 1984, trid.trb.org/view/271864.

Solomon, Libby. "Blue Water Baltimore to Conduct Study for Herring Run Stormwater Project in Towson." *Baltimoresun.com,* 26 Mar. 2018, www.baltimoresun.com/news/maryland/baltimore-county/towson/ph-tt-blue-water-0328-story.html.

"Stormwater 101: Detention and Retention Basins." *Sustainable Stormwater Management*, 10 Jan. 2011, sustainablestormwater.org/2009/05/28/stormwater-101-detention-and-retention-basins/.

Sun, Baltimore. "Six Bridge Trail." *Baltimoresun.com*, 28 Dec. 2017, www.baltimoresun.com/news/maryland/baltimore-county/towson/ph-tt-six-bridge-trail-map-html-20171228-htmlstory.html.

Terhell, Suh-Lin, et al. "Cost and Benefit Analysis of Permeable Pavements in Water Sustainability." Wisconsin Department Of Transportation, 25 May 2015.

"The Rain Garden Is One Of The More Popular Landscape Ideas." *Proscape LLC,* proscapesllc.com/the-rain-garden-is-one-of-the-more-popular-landscape-ideas/.

“The Science Behind the Need for Riparian Buffer Protection.” *Why Preserve Farmland? : ConservationTools*, conservationtools.org/guides/131-the-science-behind-the-need-for-riparian-buffer-protection.

“Topography Viewer.” *Maryland's Mapping and GIS Data Portal*, imap.maryland.gov/Pages/lidar-topography-viewer.aspx.

US Department of Commerce, and NOAA. “National Weather Service Advanced Hydrologic Prediction Service.” *Advanced Hydrologic Prediction Service*, water.weather.gov/ahps2/hydrograph.php?wfo=lwx&gage=idlm2.

“USGS Current Conditions for Maryland_ Streamflow.” *USGS Water Data for the Nation*, waterdata.usgs.gov/md/nwis/current?type=flow&group_key=NONE.

“USGS Current Conditions for USGS 01585200 WEST BRANCH HERRING RUN AT IDLEWYLDE, MD.” *USGS Water Data for the Nation*, waterdata.usgs.gov/md/nwis/uv?site_no=01585200.

USGS WaterWatch -- Streamflow Conditions, waterwatch.usgs.gov/?id=wwchart_ftc&site_no=01585200.

Weiss, Peter T., et al. “ THE COST AND EFFECTIVENESS OF STORMWATER MANAGEMENT PRACTICES.” Minnesota Department of Transportation Research Services Section, June 2005.

“Wet and Dry Stormwater Ponds.” *Panhandling - Montgomery County, MD*, www.montgomerycountymd.gov/water/stormwater/improvements.html.

“ WV Wetland and Riparian Flora.” *Water Quality Monitoring Efforts*, dep.wv.gov/WWE/getinvolved/sos/Pages/WVwetflora.aspx.