

City of Harrisonburg
**2024 Stormwater
Improvement Plan (SWIP)**



CITY OF HARRISONBURG
**PUBLIC
WORKS**

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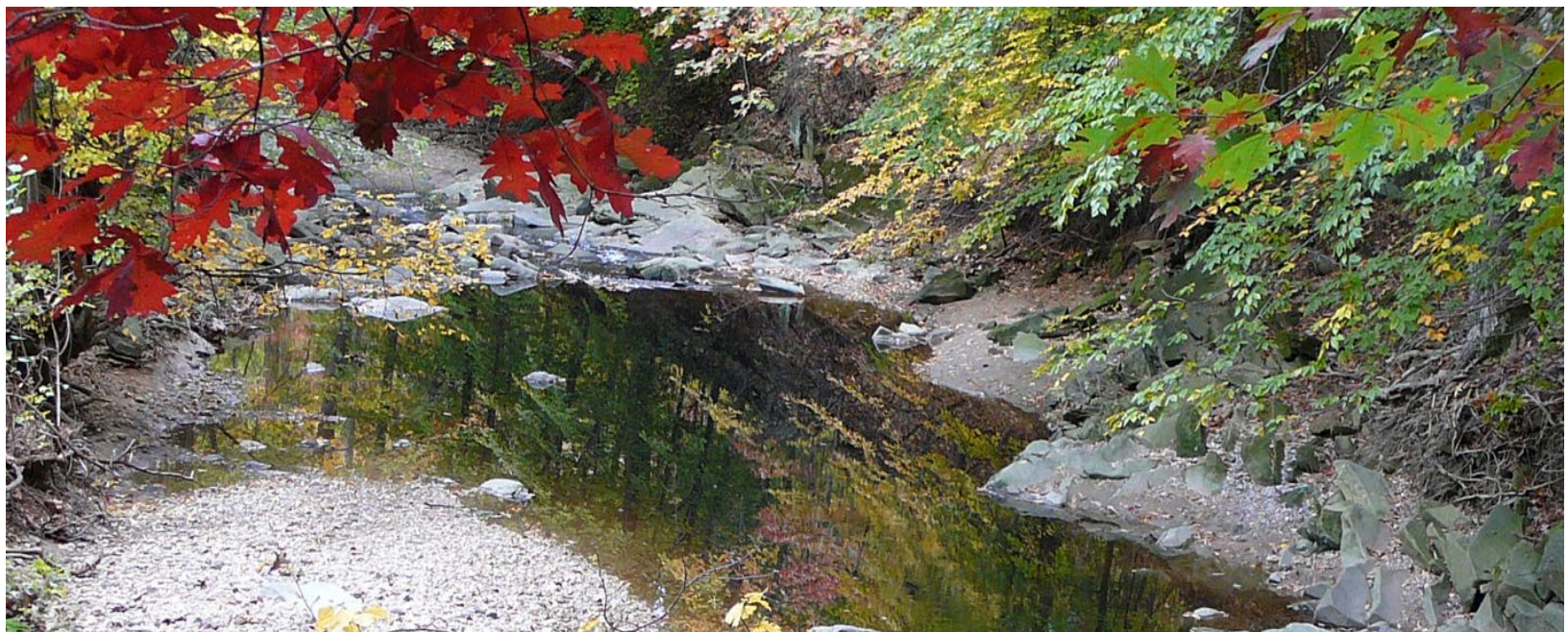
This 2024 Stormwater Improvement Plan for the City of Harrisonburg was prepared by staff of the Department of Public Works and Tetra Tech, Inc. This document updates the 2017 Stormwater Improvement Plan, which was prepared by the Department of Public Works; A. Morton Thomas & Associates, Inc.; Tetra Tech, Inc.; and the Stormwater Advisory Committee. Development of this document would not have been possible without the dedicated efforts of these participants and the involvement of citizens who participated in public meetings and offered their insight and opinions.

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Abbreviations

BMP	[Stormwater] Best Management Practice
CAST	Chesapeake Assessment Scenario Tool
DEQ	[Virginia] Department of Environmental Quality
DPW	[City of Harrisonburg] Department of Public Works
GI	Green Infrastructure
JMU	James Madison University
lb/yr	Pounds Per Year
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
SWIP	Stormwater Improvement Plan
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
VDOT	Virginia Department of Transportation
WLA	Waste Load Allocation

Glossary

Stormwater management can be very technical and confusing to those without a background in it. Some of the more important terms used in this stormwater improvement plan (SWIP) are defined below.

Best management practice (BMP) refers to a stormwater management practice designed to reduce pollution in stormwater runoff. Examples from this SWIP include a bioretention facility and urban stream restoration. BMPs can be new practices, meaning that they treat an area that previously had no stormwater treatment or retrofits (upgrades or enhancements) to existing BMPs that do not provide the maximum possible treatment benefits due to their age or design.

Impervious Surface refers to any hard surface that does not let rainwater pass through to the ground, resulting in water that runs off and picks up pollutants along the way. Examples are streets, rooftops, parking lots, sidewalks, and driveways. Approximately 41% of the City of Harrisonburg is covered by impervious surfaces. By contrast, lawns and yards are considered pervious surfaces; they do not create as much runoff, but they can still contribute pollutants that flow to streams, such as sediment and nutrients in fertilizers.

Municipal separate storm sewer system (MS4) is a municipally operated system of inlets, pipes, ditches, stormwater practices, and other features that collect and carry stormwater runoff to streams. The Clean Water Act regulates MS4s through permits that require communities to develop a local stormwater

program with certain minimum standards. In Virginia, MS4 permits are issued by the Virginia Department of Environmental Quality (DEQ). Harrisonburg and neighboring jurisdictions (e.g., Bridgewater, Staunton, and Waynesboro) are regulated MS4s with permits. Harrisonburg has held an MS4 permit since 2003. The MS4 permit is updated by DEQ in 5-year increments, with the last issued on November 1, 2023.

Regulated/unregulated areas are parts of the City that fall inside or outside the jurisdiction of the City’s MS4 permit. The entire city limits are not included in the MS4 permit. Only those parts that are connected to streams via inlets, pipes, and ditches (urban stormwater system) are part of the regulated area. Examples include streets, yards, rooftops, and parking lots that feed into the stormwater system. Unregulated areas are other parts of the City, such as hillsides or yards whose runoff flows over land to streams.

Pollutants are substances that degrade the water by smothering habitats, depleting oxygen, or introducing chemicals that are unhealthy for humans or aquatic life. This document is concerned primarily with three substances: **total phosphorus (TP)**, **total nitrogen (TN)**, and **total suspended solids (TSS)**. TP and TN are nutrients that can create excessive algal blooms in waterways and deprive the water of oxygen. TSS is a physical measure of sediment, silt, and other suspended particles that can interfere with water clarity, smother aquatic habitats in streams, and erode or fill stream channels so that drainage and flooding issues are exacerbated.

Total maximum daily load (TMDL) is a *pollution diet* that establishes the amount of a pollutant or substance that a water body can absorb without exceeding its water quality standard for that pollutant. It is represented as a mass per unit of time (e.g., pounds per day). TMDLs are developed for waterways that do not fulfill their intended beneficial uses (e.g., fishing, swimming, recreation) because of one or more pollutants. The pollution reduction is critical in a regulatory sense because it becomes a requirement for local and state pollution reduction efforts, including stormwater management programs such as this citywide plan.

The Chesapeake Bay TMDL includes the three pollutants: TP, TN, and TSS. The required load reduction targets are calculated for the Chesapeake Bay watershed for urban (e.g., MS4s, wastewater treatment plants, industries) areas, agriculture, natural sources, and onsite septic systems. A proportionate share of the urban load reduction is allocated to each MS4 in the Chesapeake Bay watershed. Urban load reduction refers to the amount of pollution needed to be reduced by the City of Harrisonburg for the Chesapeake Bay to meet water quality standards. These are often called a **Waste Load Allocation (WLA)** in the permit requirements. Harrisonburg’s MS4 permit requires practices and programs to reduce TP and TN loads as the City’s contribution to the overall pollutant load reduction for urban areas to the Chesapeake Bay. (TSS was removed as a requirement in the 2023 MS4 permit for the Chesapeake Bay TMDL.) Efforts to address the Chesapeake Bay TMDL will also improve local streams and waterways and provide other local benefits tied to this SWIP.

The Blacks Run, Cooks Creek, and Smith Creek TMDLs include TP and TSS. The load reductions required to meet water quality standards are calculated for Blacks Run, Cooks Creek, and Smith Creek. DEQ allocated, through their permitting authority, a proportionate share of the urban load reduction to the City. These are often called WLAs in the permit requirements. Harrisonburg’s MS4 permit requires practices and programs to reduce TP and TSS loads as the City’s contribution to the overall pollutant load reduction for urban areas.



The Blacks Run stream restoration project in the southern part of the City restored just over a mile of stream, reducing streambank erosion and restoring habitat. It helped remove approximately 2,400 pounds per year (lb/yr) of TN, 1,100 lb/yr of TP, and 123 tons/yr of TSS from the Blacks Run watershed.

Introduction

The City of Harrisonburg encompasses 17.4 square miles, with a population of approximately 53,000. Harrisonburg is home to two university campuses, James Madison University and Eastern Mennonite University, as well as numerous businesses and nonprofit organizations. Harrisonburg supports a vibrant downtown area.

The City operates a small MS4, which is “a conveyance or system of conveyances otherwise known as a municipal separate storm sewer system, including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains:

- Owned or operated by a federal, state, city, town, county, district, association, or other public body, created by or pursuant to state law, having jurisdiction or delegated authority for erosion and sediment control and stormwater management, or a designated and approved management agency under Clean Water Act Section 208 that discharges to surface waters;
- Designed or used for collecting or conveying stormwater;
- That is not a combined sewer; and
- That is not part of a publicly owned treatment works.”

The Virginia Department of Environmental Quality (DEQ) issued the City its first MS4 *General VPDES Permit for Discharges of Stormwater from Small Municipal Separate Storm Sewer Systems* in 2003 under the National Pollutant Discharge Elimination System (NPDES) program. The MS4 Permit requires the City to develop an MS4 Program Plan as part of the iterative process to reduce pollutant loadings and to protect water quality.

The City’s MS4 permit program is managed through the Department of Public Works (DPW) and includes operating and maintaining the City’s infrastructure. The overall citywide stormwater program has many functions, including: (1) meeting all regulatory requirements; (2) managing equipment and resources; (3) developing a budget; (4) prioritizing and scheduling capital projects; (5) coordinating design, installation, inspection, and maintenance of practices; (6) engaging citizens and businesses; and (7) communicating with decision-makers and stakeholders.

Figure 1 illustrates both regulated and unregulated areas in the City. James Madison University (JMU) and the Virginia Department of Transportation (VDOT) hold their own MS4 permits, so their land area is not part of the City’s MS4; the land owned by Rockingham County is also not included in the City’s MS4 permit. The City’s priority is to focus on implementing BMP projects in the regulated areas, as that is where pollution reduction efforts will contribute most directly to meeting the permit requirements.

As part of the Special Conditions for the Chesapeake Bay TMDL, the MS4 permit requires that, by 2028, the City of Harrisonburg addresses the excess phosphorus, nitrogen, and sediment that leave the City’s watersheds and eventually reach the Chesapeake Bay. In addition, the City is required to meet wasteload allocations for several local TMDLs. A TMDL is a *pollution diet* that establishes the amount of a pollutant that a water body can absorb without exceeding the water quality standard for that pollutant; a TMDL is represented as a mass per unit of time (e.g., pounds per day). The mass per unit of time is called the load. For instance, a TMDL could stipulate that a maximum load of 1,000 pounds of sediment per day could be discharged into a stream before the stream experiences any negative effects.

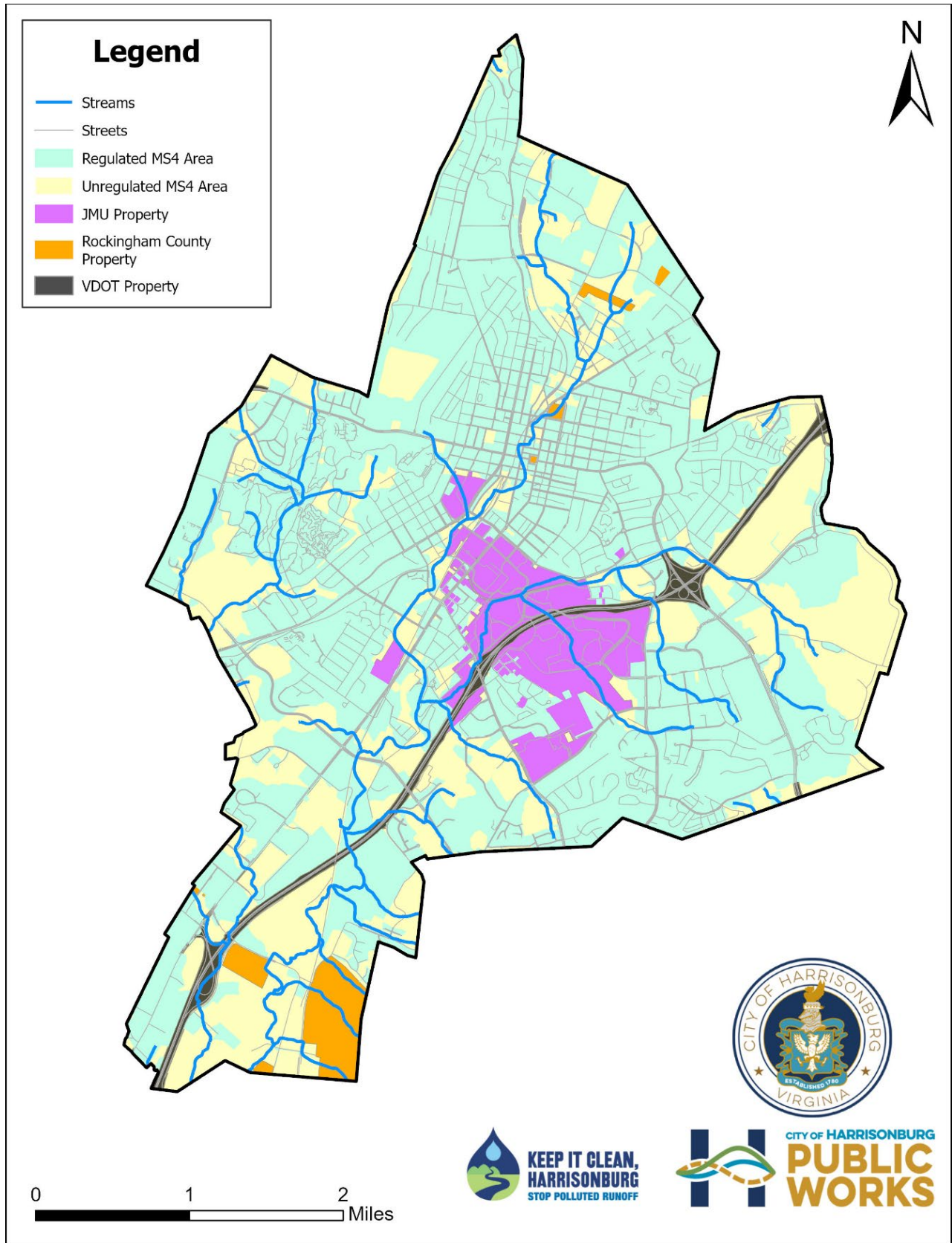


Figure 1. Harrisonburg’s regulated MS4 areas.

The City developed a SWIP in 2017 to address nutrients and sediment reductions required by the Chesapeake Bay TMDL. It was intended to be a long-range visionary plan that incorporates the City’s stormwater needs to achieve regulatory compliance, mitigate areas of drainage concern, and conduct a public input campaign. It was important that the plan be developed in such a way that the City’s stormwater needs were identified and an achievable plan for implementation was provided.

The City initiated this updated SWIP to improve water quality in local waterways and to chart a strategy for the City to comply with state and federal regulations that require the City to manage stormwater pollution entering Blacks Run, Smith Creek, and Cooks Creek, which are part of the Chesapeake Bay watershed. The main objective of the updated SWIP is to identify stormwater best management practices (BMPs) to address the Chesapeake Bay and local TMDLs by reviewing the BMPs included in the 2017 SWIP and identifying new BMPs that could be implemented to help meet local TMDLs. Before the SWIP update, the City had calculated the remaining load reductions needed to meet the Chesapeake Bay and local nutrient and sediment TMDLs (**Table 1**). This information accounts for the BMPs that have been implemented since the TMDLs were developed, as well as the BMPs that are currently being designed, such as the wet pond along Virginia Avenue and Acorn Drive.

Table 1. Remaining load reductions needed to meet TMDLs.

TMDL Watershed	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)
Chesapeake Bay	2,600	n/a	436,000
Smith Creek	n/a	n/a	5,500
Blacks Run	n/a	n/a	1,374,000
Cooks Creek	n/a	3,200	216,000

Note: lb/yr = pounds per year, TN = total nitrogen, TP = total phosphorus, TSS = total suspended solids

This SWIP is organized in the following sections to guide the reader through its development process:

- **Potential Options for Load Reductions** – Presents a summary of nutrient and sediment load reduction options, including new structural BMPs, existing BMP retrofits, street sweeping, tree planting, and nutrient credits.
- **Identifying BMP Opportunities** – Discusses the feasibility review of BMPs identified in the 2017 SWIP and identifies additional BMP opportunities for meeting local TMDL targets.
- **Prioritized List of BMPs and Timelines to Meet TMDL Targets** – Details how BMPs were ranked and prioritized using cost and cost-effectiveness; site and schedule constraints; water quantity; and other factors when determining how to meet the Chesapeake Bay and local TMDL implementation timelines.
- **Public Engagement** – Describes the public engagement campaign conducted to collect community input regarding water quantity concerns and climate change impact.
- **Water Quantity Strategies** – Identifies water quality BMPs that provide the ancillary benefit of water quantity reduction to potentially help address flooding and drainage concerns.
- **BMPs for Residential Properties** – Identifies BMPs that homeowners can implement on residential properties.

- **Attachment A: High Priority Concept Plans** – Contains concept design plans for the highest ranked BMP opportunities to support future implementation needed to meet the Chesapeake Bay and local TMDLs.

Potential Options for Load Reductions

Multiple options with differing degrees of cost-effectiveness and ease of implementation are available for addressing nutrient and sediment reductions. This section describes the most likely options for the City to use when working to meet TMDL load reduction targets.

Load Reduction Approaches

New Structural BMPs

Structural BMPs can be grouped into two categories: runoff reduction practices and stormwater treatment practices. Runoff reduction practices, which have a higher level of pollutant removal, reduce pollutants through infiltration and adsorption by soil (e.g., infiltration practices and permeable pavement). Stormwater treatment practices reduce pollutants through filtration or settling (e.g., sand filters and wet ponds). In the *Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards* (Comstock et al. 2015), the Chesapeake Bay Program Expert Panel classifies BMPs as runoff reduction or stormwater treatment, as shown in **Table 2**.

Table 2. Lists of BMP types classified as runoff reduction and stormwater treatment.

Runoff Reduction Practices	Stormwater Treatment Practices
Bioretention ^a	Constructed wetlands
Dry channel regenerative stormwater conveyance	Filtering practices
Dry swale	Proprietary practices/manufactured treatment devices
Expanded tree pits ^a	Wet ponds
Grass swales (e.g., bioswale, vegetated channel) ^a	Wet swales
Infiltration practices ^a	--
Permeable pavement ^a	--
Rainwater harvesting ^a	--
Riparian buffers ^a	--
Reforestation/tree planting ^a	--
Rooftop disconnection	--
Sheet flow to filter/open space	--

Note:

^a Considered a green infrastructure BMP

Green Infrastructure

There are many ways that organizations define green infrastructure (GI) BMPs and what practices they include. For this SWIP, the City considers GI to be BMPs that rely on natural processes, such as filtration, infiltration, and evapotranspiration, to treat stormwater close to its source, such as driveways, parking

lots, and roads using specialized soil, native plants, and stones. These BMPs also provide added environmental, social, and economic benefits, such as improved aesthetics, increased property value, erosion control, groundwater recharge, reduced urban heat island effects, flood control, and enhanced habitat for wildlife and pollinators. Many of the practices in **Table 2** are considered GI BMPs.

Innovative BMPs

Stormwater BMP technology is evolving, with new or improved technologies continuously being developed. Not all new technologies are approved by the Chesapeake Bay Program and DEQ for use in meeting TMDL targets. There is also a time lag between the technologies being developed and their approval for use. Some of the innovative BMPs in this subsection might be applicable to the City in the future.

Submerged Gravel Wetland

A submerged gravel wetland is a stormwater BMP that uses wetland plants and soil to remove pollutants from the runoff. This BMP has gravel under the water surface to support wetland vegetation. The gravel provides space for the roots of wetland plants, which remove nutrients from the water. Submerged gravel wetlands can treat a medium-sized drainage area, which is advantageous because most GI practices treat small drainage areas, and wet ponds and wetlands only treat large drainage areas. Submerged gravel wetlands are currently used in neighboring states, but DEQ has not yet approved them for use in meeting TMDLs.

Soil Media/Additives

Research has shown that certain media additives, such as biochar and woodchips, can enhance the nitrogen and phosphorus removal in BMPs. Biochar, a type of carbon-rich charcoal, is created from burning organic material under very low oxygen conditions. As stormwater flows through it, biochar can retain nutrients (e.g., nitrogen, phosphorus), heavy metals, and other contaminants. Biochar will also improve water retention in the BMPs and increase the diversity of microorganisms in the soils, making the soils more fertile for vegetation. Woodchips, another carbon source, can help break down nitrogen in the soil. Woodchips are effective when included in a woodchip bioreactor BMP, described below.

Woodchip Bioreactor

Woodchip bioreactors use wood chips contained in saturated soils to remove nitrogen from runoff as it infiltrates through the system. Woodchip bioreactors can be incorporated into other BMPs, such as bioretention systems. This technology has not been approved by DEQ for use in meeting TMDLs. In 2019, the City completed the Purcell Park woodchip bioreactor, which use woodchips from local ash trees damaged by the emerald ash borer. The bioreactor filter water entering Purcell Park Pond from Sieberts Creek. The bioreactor are large pits in the ground filled with woodchips. Water is diverted through the system, and the woodchips serve as a media on which bacteria grow. The bacteria convert nitrate-nitrogen in the water to harmless nitrogen gas. The project was completed in partnership with the nonprofit Ridge to Reefs.¹ The project was entirely funded through a National Fish and Wildlife Foundation grant.

¹ <https://www.ridgetoreefs.org/shenandoah-valley-bioreactors-project-home-page>

Real-time Control Technology

Stormwater real-time control technology uses sensors to monitor and adjust the amount of runoff stored in BMPs, such as wet ponds, using current weather conditions and stream flow information. These adjustments include changes in pump rates, the amount of water allowed to flow out of the pond, and diversions to a different area. The technology allows water to be retained in ponds and then released through a controlled valve to generate water quality improvements. It can also reduce streambank erosion from a smaller, constant flow of water from the pond. Real-time control technology can improve water quality by increasing residence time, which increases the BMP effectiveness through sediment settling or denitrification of runoff. The technology can also increase the amount of runoff volume retained on-site, potentially reducing the frequency and intensity of downstream flooding. DEQ has approved some real-time control technologies.

Retrofits to Existing BMPs

Retrofits are upgrades to existing BMPs. These retrofits increase the amount of water quality and stormwater volume treatment efficiency by improving existing structures or converting them into different BMP types. Most of the existing BMPs are detention ponds (i.e., dry ponds) that were installed to control water volume but provide little or no water quality benefit. The retrofits add water quality benefits without decreasing the water quantity control. Retrofits can often be cost-effective because they are located on land that is already owned by the City or within easements.

Urban Stream Restoration and Outfall Stabilization

Streams are affected by urban stormwater runoff through bank and channel erosion, stream health degradation, and loss of natural habitat. Multiple restoration techniques can be used to mimic the natural state of the stream, provide stability to the channel bed and banks, and improve stream health and habitat in nontidal areas. Various in-stream structures can help restore the main channel by providing stable flow direction and energy dissipation, as well as creating pools where natural habitats can develop. In addition to in-stream structures, the increase in riparian vegetation can help stabilize streambanks, further reducing in-stream erosion in high-velocity areas.

Stormwater conveyance systems end at outfall structures that typically discharge to streams. The outfall structures are often the initial source of stream erosion because they deliver increased runoff from impervious areas. As the stream channel erodes, it often undercuts the outfall structure, resulting in outlet failure. Outfall stabilization typically involves repairing localized areas of erosion below a storm drainpipe and addressing structural and functional problems associated with exposed infrastructure.

Urban Tree Canopy

Urban tree canopy expansion is intended for plantings on developed land and is not intended to result in forest-like conditions. Examples would be trees along a street or adjacent to buildings. The Green Infrastructure Center (2017) wrote *The City of Harrisonburg: Utilizing Urban Tree Canopy for Stormwater Management*, which evaluates the City's urban tree canopy and how to best incorporate the City's urban forests into stormwater management goals. Currently, the SWIP does not take tree planting into consideration as a pollution-reduction strategy. Any credits for this practice will be in addition to the credits in the SWIP and can be accounted for on a per tree basis, given the City's documentation of this practice.

Street Sweeping and Catch Basin Cleaning

The City has programs for street sweeping and catch basin cleaning, both of which qualify as contributing to pollutant load reductions. Nutrient and sediment load reductions from street sweeping are based on the type of street sweeping technology and the frequency of sweeping. Street sweeping has benefits beyond removing debris and sediment from entering storm drains. These benefits include improving air quality by reducing dust and other fine particles from the air we breathe; removing glass and nails from the roadside, which could be hazardous to pedestrians and vehicles; and decreasing bacteria build-up on streets. Removing this debris before it enters the storm drains can also prevent blockages in the storm drains, which could lead to localized flooding during rain and snowmelt events.



Street sweeping is part of the City’s ongoing pollution reduction practices. This practice helps reduce sediment and debris from entering the MS4 and the City’s streams.

The City cleans every City-maintained catch basin annually. This is done by using a vacuum truck to remove accumulated debris in the catch basin. Like street sweeping, this helps prevent debris and sediment from entering the stormwater conveyance system and eventually reaching streams.

Purchasing Nutrient Credits

Meeting all TMDL goals requires a significant financial investment by the City. Elected officials and City departments have an obligation to ensure that investments reflect cost-effective options and that the City and its citizens will get their money’s worth from the selected projects and programs.

To meet the Chesapeake Bay TMDL by 2028, the City will implement off-site compliance, meaning that some pollutant-reduction credits are obtained from outside of the jurisdictional limits of Harrisonburg through various credit purchases or contractual arrangements with private pollutant banks or other entities that hold a pollution discharge permit. The MS4 permit authorizes this type of *trading* arrangement. Two types of off-site compliance strategies need to be considered:

- **Annual Credits:** Annual credits must be purchased every year. This arrangement can be executed through a memorandum of understanding (MOU) or contract with the organization that also has a pollution control permit from the state of Virginia when it has excess credits that it can make available because pollution reductions are beyond currently permitted limits. For the City, the organization most likely to provide credits is the Harrisonburg Rockingham Regional Sewer Authority (HRRSA). There is some risk that annual credits may not be available in future years, so the strategy can be viewed as a “stop-gap” or temporary measure to allow time for local BMPs to be designed and constructed. Given that, annual credits can be very cost-effective and should be included in the overall strategy for compliance.

- **Perpetual Credits:** As compared to annual credits, perpetual credits are a one-time purchase. Virginia has an established *Virginia Nutrient Bank* whereby certain property owners and businesses can establish nutrient banks that generate credits for purchase. The pollution reduction actions that generate these credits are usually on agricultural or larger tracts of land through converting pasture to permanent riparian buffers or restoring degraded streams. These credits are regulated and certified by DEQ. DEQ also requires that credit purchasers be within the same or an adjacent watershed as the one in which the credits are generated. For Harrisonburg, this means the Shenandoah/Potomac watershed. While perpetual credits do not have the same level of risk as annual credits, they are more expensive. At some point, if these credits are more cost-effective than what can be achieved through local BMP implementation, then they become a viable option.

Selected Approaches

The City will use a combination of new structural BMPs, existing BMP retrofits, and stream restoration to meet the local nutrient and sediment TMDL targets. As part of the SWIP development process, the City also reviewed opportunities for outfall stabilization but did not identify good candidates; the City will continue to evaluate outfalls for future opportunities.

The City will continue to perform street sweeping and catch basin cleaning. These practices will be used as part of the strategy for meeting the Chesapeake Bay TMDL targets. The overall strategy also includes new structural BMPs and existing BMP retrofits. In the past, the City conducted the Blacks Run stream restoration project, which is being used to meeting Chesapeake Bay and local TMDL targets. To help meet the aggressive 2028 date for meeting Chesapeake Bay TMDL targets, the City will also purchase nutrient credits and conduct tree planting, as described in the **Chesapeake Bay TMDL BMPs and Timeline** subsection.

Identifying BMP Opportunities

Review of Feasibility of Select 2017 SWIP BMP Opportunities

The City reviewed the feasibility of 33 stormwater BMPs previously identified in the 2017 SWIP to address the Chesapeake Bay TMDL. These 33 BMPs included 17 vegetated filter strips, 8 stream restoration projects, 5 wet ponds, and 3 bioretention systems.

BMP Load Reduction Calculations

The *Guidance Memo No. 20-2003 – Chesapeake Bay TMDL Special Condition Guidance* (VDEQ 2021) allows municipalities to choose one of three methods for calculating the load reductions achieved from BMPs. This SWIP uses the retrofit performance curves

provided by the Chesapeake Bay Program as the default load reduction calculation method, with stream restoration reductions calculated from the average reductions from the City’s recent stream restoration

Goal 1: Review feasibility of 2017 SWIP BMP opportunities.

Objective 1.1: Review the revised list of BMPs from the 2017 SWIP to determine their feasibility of keeping them in the City’s restoration strategies.

Objective 1.2: Update the costs to design, acquire easements, and construct each BMP.

Objective 1.3: Determine the load reduction gap remaining for the three local TMDLs (Smith Creek, Cooks Creek, and Blacks Run) and the Chesapeake Bay TMDL.

projects. The following two special circumstances must be taken into account when calculating load reductions:

- *BMP Treatment Trains*: Treatment trains occur when the treated runoff (discharge) from one BMP flows into a second BMP for additional treatment. The pollutant load going into the downstream BMP needs to be reduced before its load reduction is calculated to account for the benefits of the upstream BMP.
- *Unregulated Areas*: The City must meet baseline loads for BMPs installed outside the MS4 regulated area (**Figure 1**), which is defined by areas where stormwater flows to or through the City’s stormwater conveyance systems. This plan mainly includes BMPs that treat regulated areas because the City will receive more load reduction credit than BMPs that treat unregulated areas.

Cost Development

Knowing the exact cost of each BMP would require design plans for each. Therefore, at the SWIP development stage, the City developed unit costs (i.e., cost per specified area) for each BMP type.

The main source of cost information was obtained from the Chesapeake Assessment Scenario Tool (CAST), which was developed for the Chesapeake Bay Program (CBP 2017). CAST has unit cost information (dollars per impervious acre) for construction and operation and maintenance (O&M) in 2018 dollars for the Commonwealth of Virginia. These were adjusted for inflation to 2024 dollars using annual consumer price index values. The design cost was estimated to be 20% of the total project cost. Because some BMPs are on private land, the cost of land easement acquisition was added to BMPs not on City property or rights-of-way. Using recent land acquisition data, the City estimated that easements are typically around \$3.70/square foot of needed easement. The stream restoration unit costs were estimated using actual stream restoration construction data and adjusted for inflation. The stream restoration O&M costs were the average listed for Virginia in CAST.

The unit costs are the average cost of installing a given BMP. Site conditions (e.g., utilities) can increase the cost of individual BMPs. To account for this, additional costs were estimated for when the following types of site modifications would be needed:

- Trench drain/flow diversion
- Underdrain
- Curb cuts
- Move utilities (e.g., underground electrical wires)
- Move stormwater structure
- Utility crossing (stream restoration only)
- Excessive pavement or vegetation removal

BMP Site Feasibility Assessment

The 33 BMPs were reviewed for conflicts with utilities such as overhead electric lines, underground utilities (e.g., cable, internet), drinking water mains, sanitary sewer lines, and light/utility poles. Recent aerial imagery was reviewed to determine if any major land development or other significant changes have occurred in the BMP areas since the initial review in 2017.

Through this process, eight proposed BMPs were flagged for potential feasibility concerns. The primary concerns with the BMPs were conflicts with utility lines (especially sanitary sewer lines), a lack of nearby stormwater infrastructure, and difficult access for construction and maintenance.

The review of the BMPs from the 2017 SWIP resulted in the potential for seven stream restorations, 15 new BMPs, and two BMP retrofits. **Table 3** presents the remaining loads after the BMP feasibility assessment. The local TMDLs cannot be met by the BMPs in the feasibility analysis. The Smith Creek and Blacks Run (including Sieberts Creek) TMDL are only for total suspended solids (TSS), while the Cooks Creek TMDL is for TSS and total phosphorus (TP). The feasibility analysis did not include any BMPs for Smith Creek; therefore, its local TMDL goals are not met. The Blacks Run TMDL is only half met for TSS if all feasible BMPs are implemented. Significant reductions will still be needed for TP in the Cooks Creek watershed, even with all projects implemented.

Table 3. Remaining reductions needed, compared by cost and site feasibility.

TMDL Watershed	TN (lb/yr)	TP (lb/yr)	TSS (lb/yr)
Remaining to meet TMDL			
Chesapeake Bay	2,600	n/a	436,000
Smith Creek	n/a	n/a	5,500
Blacks Run	n/a	n/a	1,221,983
Cooks Creek	n/a	3,200	216,000
Remaining to meet TMDL (Feasible BMPs from 2017)			
Chesapeake Bay	0	n/a	0
Smith Creek	n/a	n/a	5,500
Blacks Run	n/a	n/a	633,193
Cooks Creek	n/a	2,895	81,185

Notes: lb/yr = pounds per year, TN = total nitrogen, TP = total phosphorus, TSS = total suspended solids

Identify Additional BMP Opportunities

As shown above, additional BMPs are needed to meet local TMDL targets. An assessment was conducted to identify new BMP opportunities. The following types of features were assessed as potential BMP locations:

- Large areas of untreated impervious area in the MS4 area.
- City, institutional (e.g., schools, churches), or vacant properties.
- Areas at or upstream of known drainage issues.
- Existing stormwater detention basins for potential upgrade.
- Stormwater ditches.

Each BMP was reviewed for conflicts with utilities such as overhead electric lines, underground utilities (i.e., cable, internet), water mains, sewer lines, and light/utility poles. The desktop assessment to identify the remaining BMPs needed to meet the Chesapeake Bay and local nutrient and sediment TMDLs identified the opportunities for 4 stream restoration projects, 20 wet ponds/wetlands, 48 bioretention systems, and 32 other BMP types. **Figure 2** shows the locations of potential BMP locations in this SWIP.

Goal 2: Desktop assessment to identify the additional BMPs to meet TMDL targets.

Objective 2.1: Identify sufficient BMP opportunities creditable under the VDEQ *Guidance Memo No. 20-2003 - Chesapeake Bay TMDL Special Condition Guidance* to meet and exceed the load reductions targets from the Chesapeake Bay and local TMDLs.

Objective 2.2: Evaluate large areas of impervious surfaces that are not currently treated by BMPs for potential opportunities, as well as look at reported drainage issues to guide potential implementation planning.

Objective 2.3: Calculate the costs to design, acquire easements, and construct each BMP.



Figure 2. Locations of identified BMP opportunities.

Prioritized List of BMPs and Timelines to Meet TMDL Targets

Prioritization Approach

A standardized set of criteria was applied to prioritize and rank each identified BMP opportunity. Certain BMPs are easier to implement, have more benefits (or less constraints), are lower in cost, or help address drainage concerns. To prioritize the best BMP

Goal 3: Develop prioritization criteria and scoring methodology to drive the timeline of BMP implementation.

opportunities, the plan includes the ranking of all potential BMPs. To do this, the City developed ranking factors and scoring guidelines for each BMP. Each ranking factor was given a scoring range and scoring guidelines regarding which criteria the BMP had to meet to receive a given score. The prioritization criteria were used to score and rank BMPs across the City to implement for maximum benefit to TMDLs and budget. Overall scores from prioritization ranged from 40 to 168, with an average score of 100.

The ranking factors can be separated into four categories as follows.

- Cost and cost-effectiveness
 - ◆ Pounds removed percentiles (TN, TP, TSS)
 - ◆ Percent imperviousness of contributing drainage area
 - ◆ Cost effectiveness (\$/lb) percentile (TN, TP, TSS)
 - ◆ Project cost (design/construction) percentile
 - ◆ Long-term maintenance burden
 - ◆ Virginia Stormwater Local Assistance Fund (SLAF) Grant funding applicability
 - ◆ Virginia Community Flood Preparedness Fund (CFPF) Grant funding applicability
 - ◆ Building Resilient Infrastructure and Communities Grant (BRIC) funding applicability
- Site and schedule constraints
 - ◆ Need for land acquisition
 - ◆ Ease of site access for construction and maintenance
 - ◆ Potential utility constraints
 - ◆ Vegetation removal considerations
 - ◆ Proximity to stormwater network
 - ◆ Typical planning/construction schedule
 - ◆ Construction permitting requirements
- Water quantity
 - ◆ Drainage issues known to the area
 - ◆ Potential to alleviate flooding
- Other factors
 - ◆ Site-specific multi-project potential
 - ◆ Existing BMP retrofit

Chesapeake Bay TMDL BMPs and Timeline

The City’s MS4 permit is reauthorized by DEQ in 5-year permit cycles. The Chesapeake Bay TMDL load reductions are allocated into three permit cycles, or a 15-year span. The City must provide 100% of required load reductions by 2028, divided out through the three permit cycles as follows:

- Cycle 1, 2013–2018: 5% of the total
- Cycle 2, 2018–2023: An additional 35%, or 40% of the total
- Cycle 3, 2023–2028: An additional 60%, or 100% of the total

The City identified more than 100 BMP opportunities to help meet the Chesapeake Bay TMDL. These were scored and ranked to determine the highest ranked BMPs. The highest prioritized BMPs tended to be those that were on City-owned property or in the right-of-way. The City then performed site visits to these BMPs. The purpose of these site visits was to verify site conditions and determine if the site was a good candidate for BMP construction. During the site visit, City staff took photographs and took measurements to aid in future design and construction of the selected BMPs. During the site visits and subsequent discussions, two BMPs were removed from considerations due to site constraints and current development plans. Finally, the City developed conceptual designs for the remaining BMPs (**Attachment A**). These designs provide a more detailed look at the placement of the BMP, site constraints (e.g., power lines), ground elevation, and the surrounding stormwater network.

From these BMPs and other strategies, the City carefully considered the overall costs and timeline to implement the strategies by 2028. **Table 4** includes the final list of BMPs and strategies that the City will use to meet Chesapeake Bay TMDL load reduction targets.

This list includes tree planting and conservation at Saufley Farm. The Saufley Farm project will plant 80–100 acres of trees (300 trees/acre) and preserve 19 acres of existing forest. In addition to the planned tree planting, the City will continue conducting street sweeping in the City and will purchase nutrient credits. The City selected two BMPs identified as part of the SWIP update process to complete the list of BMPs

Goal 4: Develop a prioritized list of BMPs for Chesapeake Bay TMDL.

Objective 4.1: Using the prioritization criteria and methodology developed under Goal 4, the feasible BMPs (from Goal 1) and new BMPs (from Goal 2) for the Chesapeake Bay TMDL will be scored, weighted, ranked, and prioritized.

Objective 4.2: Conduct field visits to verify BMP feasibility for BMPs needed to meet the Chesapeake Bay TMDL by 2028 using a comprehensive consistent field reconnaissance survey template.

Objective 4.3: Create BMP preliminary designs for all BMPs (and buffer BMPs) needed to meet the Chesapeake Bay TMDL by 2028.



City staff visited potential BMP sites to determine the current site conditions and ensure the locations were viable for BMP implementation.

needed to meet the Chesapeake Bay TMDL by 2028. Both BMPs are along West Market Street and are existing dry ponds that will be retrofitted to wet ponds. One is across from Food Maxx, and the other is near Thomas Harrison Middle School.

Table 4. BMP and restoration activities needed to meet the Chesapeake Bay TMDL by 2028.

Practice	TN Load Reduction (lb/yr)	Total BMP Cost (\$) (Design + Const)	BMP Cost / lb TN	Main Watershed	Fiscal Year
Wet pond (across from Food Maxx)	108.5	\$408,946	\$3,769	Blacks	FY27
Wet pond (near Thomas Harrison Middle School)	139.2	\$478,516	\$3,438	Cooks	FY27
Tree planting	1,054.60	\$1,202,645	\$1,140	--	FY27
Credit market	652.57	\$1,937,813	\$2,970	--	FY26
Credit market	152.28	\$418,560	\$2,749	--	FY26
Credit market	191.36	\$552,967	\$2,890	--	FY26
Street sweeping (annual)	52.26	n/a ¹	n/a ¹	--	Annual
Storm drain cleaning (annual)	318.39	n/a ¹	n/a ¹	--	Annual

Notes:

¹ These costs are part of the annual operating budget and have not been quantified separately.

Local Nutrient and Sediment TMDL BMPs and Timeline

The City identified more than 100 BMP opportunities to help meet the local nutrient and sediment TMDLs for Blacks Run, Cooks Creek, and Smith Creek. These were scored and ranked to determine the list of prioritized BMPs to meet each local TMDL. As with the Chesapeake Bay TMDL, the highest prioritized BMPs tended to be those that were on City-owned property or in the right-of-way. The results for each local TMDL are as follows:

- **Blacks Run:** 94 BMPs. Total cost of \$51 million.
- **Cooks Creek:** 57 BMPs. Total cost of \$43 million.
 - ◆ Blacks Run flows into Cooks Creek south of the City; therefore, the 55 BMPs for Cooks Creek (\$40 million) will also help meet the Blacks Run TMDL.
- **Smith Creek:** 6 BMPs. Total cost of \$1 million.

Goal 5: Develop a prioritized list of BMPs for local nutrient and sediment TMDLs.

Objective 5.1: Using the prioritization criteria and methodology developed under Goal 4, the feasible BMPs (from Goal 1) and new BMPs (from Goal 2) for the local TMDLs will be scored, weighted, ranked, and prioritized.

Objective 5.2: Develop reasonable timeline for meeting TMDL targets for the Smith Creek, Cooks Creek, and Blacks Run TMDLs.

The local nutrient and sediment TMDLs do not have a set target date like the Chesapeake Bay TMDL does. However, the City needs to provide justifiable end dates in the SWIP. The City anticipates being able to complete one BMP every three years starting in 2030 once the BMPs required to meet the Chesapeake Bay

TMDL targets have been completed. The City has identified up to 119 BMPs that might be implemented to meet the local nutrient and sediment TMDL targets.

To determine the end date for each watershed, the City developed a potential implementation schedule for the 119 BMPs. Recognizing public sensitivity to the geographic distribution of stormwater projects, the City is opting to construct one BMP in each watershed every nine years. Therefore, with an implementation rate of one BMP every three years, all TMDLs will be achieved by 2367. With a factor of safety, all TMDLs will be met by 2370. The resulting TMDL end dates based on this assumption are summarized in **Table 5**.

Table 5. Local TMDLs, estimated end dates by watershed.

Watershed	Number of Ranked BMPs	Number of BMPs to Be Implemented	TMDL Reductions Required (lbs/yr)	Estimated End Date	End Date with Factor of Safety
Smith Creek	6	4	TSS: 5,500	2057	2060
Cooks Creek ¹	13	13	TP: 3,200	2180	2185
		9	TSS: 216,000	2090	2095
Blacks Run	101	96	TSS: 1,221,983	2367	2370

¹ Blacks Run discharges to Cooks Creek. Therefore, pollutant load reductions from BMPs implemented in Blacks Run contribute to the Cooks Creek cumulative pollutant load reductions and end date. The BMP counts for Cooks Creek in this table do not include those from Blacks Run.

The BMP cost by year and the moving 5-year total cost, which aligns with the Capital Improvement Plan planning window, are shown in **Figure 3** to illustrate how the need for resources changes over time. **Figure 3** is a hypothetical schedule demonstrating one approach to meet the Smith Creek, Cooks Creek, and Blacks Run TMDLs based primarily on the BMP rankings. Other BMP implementation sequences may also be used depending on the City’s available resources.

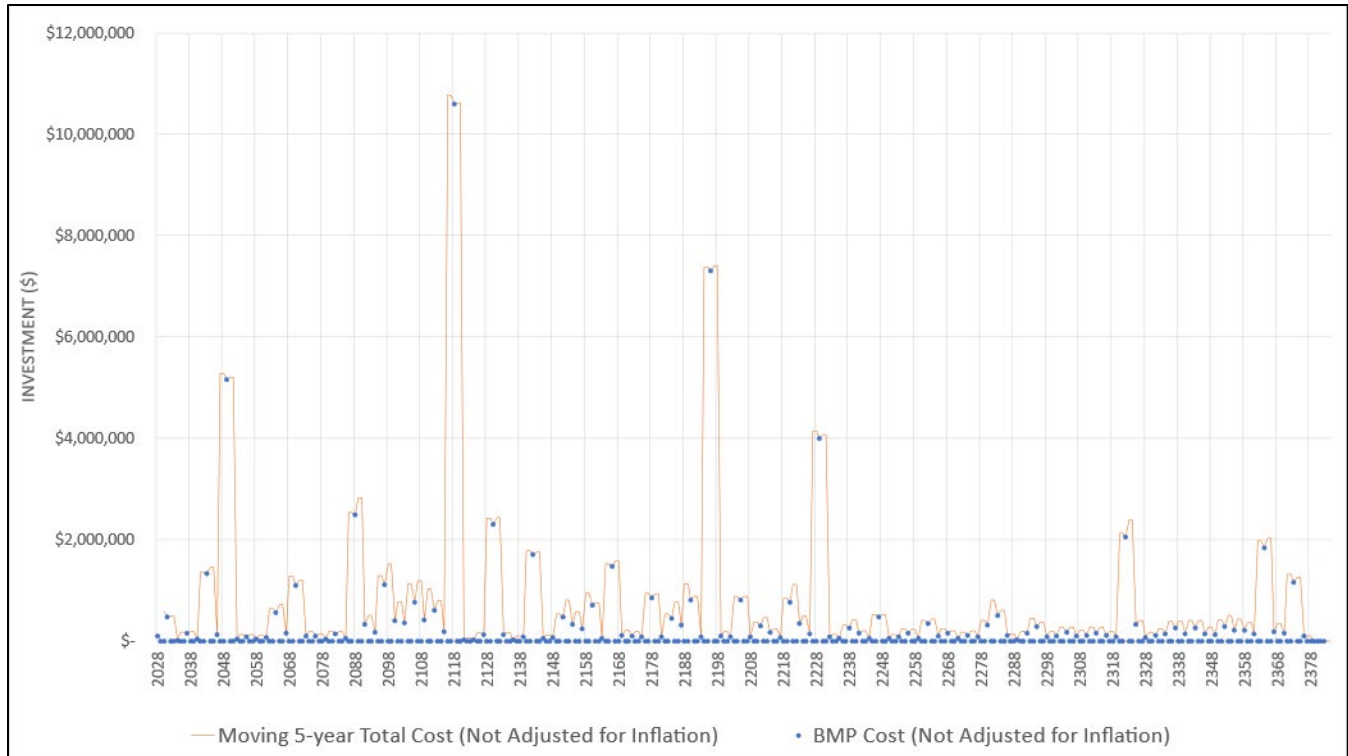


Figure 3. BMP cost and 5-year moving total cost from 2028 until the TMDL end date.

Public Engagement

One of the goals of this SWIP update was to conduct a public engagement campaign that included an online survey to inform the City about how residents would like to see water quantity concerns and climate change impacts incorporated into the stormwater program. Two public meetings were also held.

The SWIP public survey was open from March 8, 2024, through April 17, 2024, and was provided in eight languages: Arabic, English, Kurdish (Sorani), Russian, Spanish, Swahili, Tigrinya, and Ukrainian. The survey gathered feedback about the City’s stormwater quality and quantity plans and learned about the community’s concerns through the 147 responses that were received. The survey questions included the following:

- How often do you experience drainage issues or flooding on your property?
- If flooding occurs on your property, what happens?

Goal 6: Conduct a public engagement campaign.

Objective 6.1: Develop an outreach strategy that addresses City goals and identifies potential partners (e.g., city departments, local homeowner associations, nonprofits) who can help advertise a public survey and public meetings.

Objective 6.2: Conduct an online survey that will inform the City about how residents would like to see water quantity concerns and climate change impacts incorporated into the stormwater program.

Objective 6.3: Host two public meetings—one in spring 2024 and one in fall 2024 to present preliminary SWIP results.

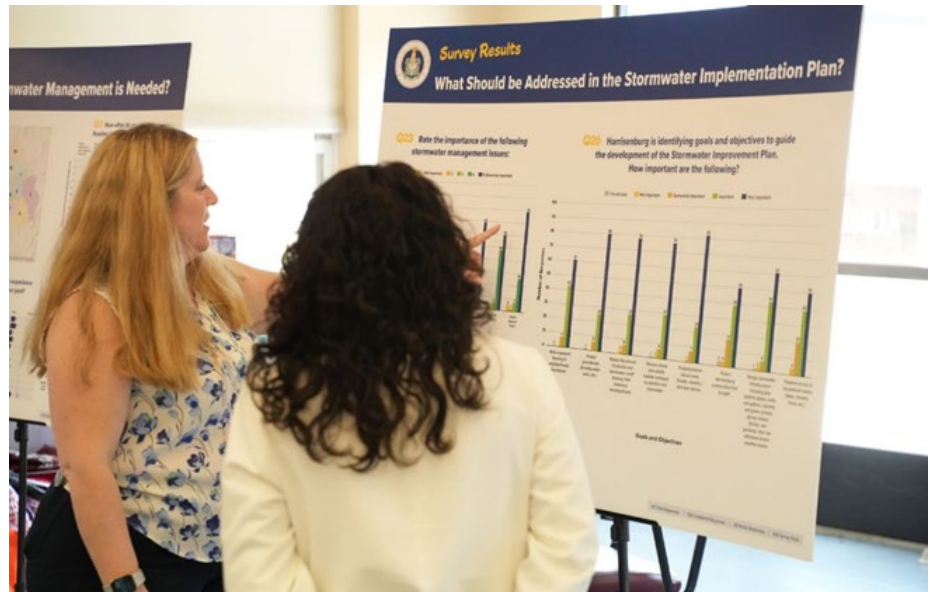
- Rate the importance of the following stormwater management issues (not important to extremely important): flooding and drainage control (water quality); water quality (nutrients, bacteria) of local streams; water quality of Chesapeake Bay; stormwater infrastructure improvements (storm pipes, culverts, inlets); climate change impacts affecting storm intensities/frequencies; erosion control; green spaces/trees.
- Rate topics for the development of the SWIP (e.g., how important are these items?): reduce/prevent flooding in neighborhoods/businesses; protect groundwater (drinking water, wells, etc.); and protect/preserve natural areas (forests, streams) and open spaces.
- Which BMPs would you be willing to implement on your property (conservation landscaping, permeable pavement, roof drain disconnection, nutrient management, rain barrel, tree planting, pavement removal, rain garden)?

The first public meeting was held on May 7, 2024, and hosted 33 attendees. This public meeting was organized like an open house, where attendees visited six stations and interacted with City staff and their on-site consultants. The stations included: (1) program vision, (2) major water-related issues, (3) area of concern locations, (4) survey results, (5) BMP options and city programs, and (6) a kids' corner.

The second public meeting occurred on October 29, 2024, and hosted 23 attendees. The results of the survey and an overview of the SWIP update process were shared with the October public meeting attendees. After the presentation, the City responded to questions from the attendees. Both public meetings had a Spanish translator available. An Arabic translator was available for the October public meeting.

The survey results and follow-up discussion from the May open house and October public meeting are summarized here.

Open house attendees identified green spaces and controlled or no flooding as their vision for a healthy watershed in Harrisonburg. Some noted at the open house that flooding should be ranked higher on the survey. It is possible that those who responded to the survey are not experiencing flooding as much as those who attended the meeting.



The City hosted two open house sessions in May 2024, where residents were able to hear from the City on its stormwater program and the results of the 2024 public survey.

The major water-related issues they would like to see addressed in the SWIP include limiting tree removal; planting native trees and plants; highlighting the need for more pollinators; reducing erosion and flooding; improving stormwater controls; curbing sewer line backup into homes; and adding more retention ponds,

green spaces, and forests that serve wildlife and can be used for recreation as well as a mental escape for people. Seventy percent of survey respondents also indicated that groundwater protection and protection/preservation of natural areas are important topics to include in the SWIP.

When asked which BMPs they would be willing to implement on their own property, nearly 80% or more of all respondents would be willing to implement conservation landscaping, rain barrels, tree planting, and nutrient management (i.e., a lawn care agreement). The open house attendees also identified their areas of concern/drainage complaints (**Figure 4**), which were then evaluated for possible BMPs.

Residents recommended that the City conduct door-to-door outreach to increase participation in the survey. Going door-to-door to educate and reach residents would give the residents an opportunity to respond to the survey. It was suggested that City staff go with a trusted neighbor (an ambassador) to help build trust and share information with residents.

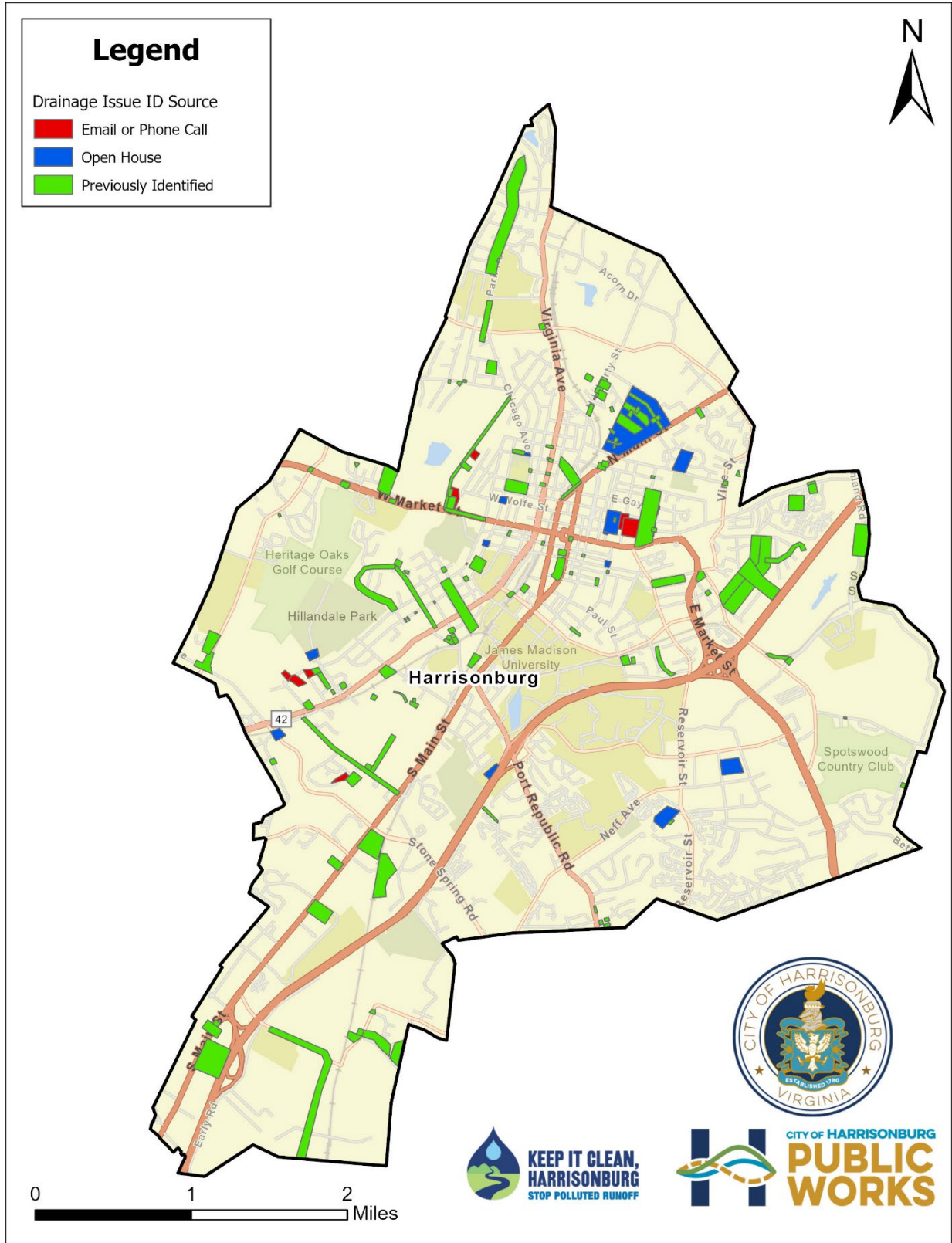


Figure 4. Map of drainage issues identified at the Open House and through emails and phone calls.

Water Quantity Strategies

As seen in the **Public Engagement** section, water quantity was a key issue for many residents. The BMPs in this plan were identified and ranked primarily to meet TMDL water quality targets; however, this SWIP includes careful consideration of water quantity issues related to flooding and drainage concerns throughout the City. This was seen in the inclusion of known drainage issues and consideration of a BMP’s ability to help retain runoff in the **Prioritization**

Approach. All BMPs in this plan that help to reduce or eliminate flooding and drainage issues received additional points during the ranking process.

The City hopes that there will be dual and ancillary benefits to many of the proposed BMPs, thus reducing resources needed for addressing flooding and drainage issues through separate funding in the future. The City established a Stormwater Utility Fee in 2015 to fund its stormwater program; however, the utility fee is not priced to address water quantity issues.

The City currently operates a *Drainage Improvement Program*.² Through this program, residents with concerns about drainage issues that have caused or are threatening to cause damage to private properties can request City-funded improvements. These improvements could include new drainage system projects, improvements to existing drainage systems, improvement of outlets, and implementation of projects to impound, reroute, or divert drainage system waters.

The City assessed its water quantity management challenges by reviewing the City’s *Drainage Improvement Program* and considering the public input received from recent surveys and meetings. From these, the City identified areas of concern and developed potential strategies to address the concerns. The potential strategies include:

- Identifying water quantity issues
- Prioritizing projects
- Developing funding strategies for stormwater Capital Improvement Plan projects
- Addressing drainage issues on private property
- Recognizing the connection between water quality and quantity

The drainage programs of other municipalities in the region were reviewed as part of the SWIP update to identify strategies relevant to the City’s water quantity management challenges. Programs from more than 50 communities that share similar geographical and geological features (e.g., karst topography) were reviewed, including programs in Virginia, Maryland, North Carolina, and Kentucky.

Goal 7: Identify potential strategies for addressing water quantity issues.

Objective 7.1: Create a list of strategies from other municipalities for addressing drainage and flooding concerns.

Objective 7.2: Identify BMP types that also address water quantity issues, either inherently or through design enhancements.

² For additional information on the *Drainage Improvement Program*, please see <https://www.harrisonburgva.gov/drainage-improvement-program>. This website contains links to a manual, application, and description of the process.

Some programs from other regions were included if the drainage program had notable components relevant to the City’s needs. The City is currently reviewing the information that was collected to formulate enhancements to their current programs.

Mechanisms of Water Quantity Management by BMPs

BMPs that improve water quality can also provide some benefits for water quantity management. In addition to the practices presented in **Table 2** (see page 4), impervious surface removal and stream restoration can also provide water quantity management benefits by reducing the amount of stormwater runoff



Drainage issues have been identified as a concern by many City residents and businesses.

generated and restoring the natural ability of streams to manage and convey floodwaters. Because stream restoration is at the outlet of a drainage area, stream restoration should not be treated as a standalone flooding solution for drainage issues in an upstream neighborhood; instead, it should be combined with upland practices that reduce the volume and discharge of stormwater reaching the stream.

Relative Flood Mitigation Benefits of BMPs

Table 7 consolidates information from **Table 2** and information from the *Chesapeake Bay Program Impact Scores Tool*,³ which provides relative flood mitigation benefits for a range of BMP types. The relative flood mitigation benefits can vary based on the location and local site conditions.

Table 6. Flood mitigation benefits for SWIP tool BMP types.

BMP Type	Practice Type (from Table 2)	Flood Mitigation Benefits
Bioretention	Runoff reduction	High
Bioswale	Runoff reduction	High
Dry swale	Runoff reduction	Medium
Filtering practices	Stormwater treatment	Low
Infiltration practice	Runoff reduction	Medium
Permeable pavement	Runoff reduction	Medium
Regenerative stormwater conveyance	Runoff reduction	High
Sand filter	Stormwater treatment	Low
Stream restoration	Not defined	High

³ <https://cast.chesapeakebay.net/EcoHealth/Benefits>, *Impact Scores Spreadsheet Tool*

BMP Type	Practice Type (from Table 2)	Flood Mitigation Benefits
Vegetated filter strip	Runoff reduction	Medium
Wet pond	Stormwater treatment	Medium
Wet swale	Stormwater treatment	Medium
Wetland	Stormwater treatment	Medium

BMPs for Residential Properties

Residential properties account for most of the land area in Harrisonburg. Homeowners can play a more active role in the restoration process. Residents can take a pledge to clean up after their pets and practice environmentally friendly lawn care. Private landowners can aid in restoring the watersheds by installing BMPs (e.g., rain barrels, rain gardens, permeable pavement) on their properties to help minimize their impact on the overall pollution loading to the City’s water bodies. Installing BMPs on private property can also reduce the owner’s stormwater utility fee. Although those practices might seem insignificant, the overall load reductions can be significant if enough private landowners get involved. Organizations such as homeowner associations and neighborhood associations can also help by promoting the City’s programmatic initiatives.

As mentioned above, the City has a stormwater utility fee, which is a fee for service based on the amount of impervious surface area (e.g., driveways, rooftops) on a property. In addition, the City provides credits to reduce their stormwater utility fees for property owners who implement BMPs. Property owners with eligible existing and planned BMPs to reduce stormwater runoff volume and/or pollutant levels from their property can apply for a credit of up to 50%. The credit is valid for five years before the property owner must reapply. Residential property owners may receive credit for the BMP types shown in Table 8 (options from the City’s 2016 *Stormwater Utility Fee Credit Manual for Residential*).⁴



Rain barrels are a common residential BMP. They collect rain runoff from roofs, preventing the runoff from entering storm sewers. The collected water can be used to water plants.

⁴ https://www.harrisonburgva.gov/sites/default/files/PublicWorks/residential_credit_manual_2018.pdf

Table 7. Types of BMPs for residential properties.

Practice	Description ^a
Roof drain disconnection	Downspout disconnection is the process of separating roof downspouts (gutters) from being directed to the storm sewer system and redirecting roof runoff onto pervious surfaces, most commonly a lawn. This reduces the amount of directly connected impervious area to the storm sewer system.
Rain garden	A rain garden is a depressed landscaped area designed to capture and filter stormwater runoff. The plants and soil in a rain garden provide an easy, natural way of reducing the amount of stormwater runoff through infiltration and uptake.
Vegetated filter strip	Vegetated filter strips are runoff flow paths of dense turf, meadow grasses, trees, or other vegetation with a minimum slope to treat runoff from roof downspouts.
Rain barrel/cistern	Rain barrels and cisterns provide temporary storage of rainwater, reducing peak runoff volumes and soil saturation and allowing for stormwater to infiltrate and evaporate.
Urban tree planting	Urban tree planting is the practice of planting deciduous or evergreen trees in grassy areas that will grow and create a leaf canopy that intercepts rainfall and reduces runoff. Native tree species are preferred. Trees can be planted by the owner or a contractor, but species should be selected that will grow best given a variety of conditions, including the soil conditions and sun exposure at the planting site.
Conservation landscaping	Conservation landscaping is the creation of mulched beds planted with perennial plants, shrubs and/or small trees that retain rainfall and absorb runoff from impervious areas. Native plants and organic mulch are highly recommended. This improves water quality, preserves native species, and provides wildlife habitat. Conservation landscaping replaces some of the traditional lawn grass with plants that have adapted to local rainfall and soil conditions and require less water and maintenance.
Homeowner nutrient management & lawn care agreement	Applying pesticides and fertilizers is a common practice for many gardeners. Unfortunately, those lawn care chemicals often wash right into local waterways. The excess nutrients from fertilizers can cause drinking water contamination, algal blooms, and fish kills. The contaminants from pesticides can result in waters that are not fishable or drinkable. Minor changes in your homeowner lawn care practices can mean a healthier lawn and less polluted runoff into local waterways. To receive a Homeowner Nutrient Management and Lawn Care Agreement credit, the homeowner must complete and sign a Homeowner Nutrient Management Agreement.
Impervious surface removal	Removing impervious cover consists of breaking up existing hard surfaces, removing asphalt or concrete from the site, rototilling the underlying soils to relieve compaction, and planting the area with grass or other vegetation. It could also mean installing a permeable material to replace hard surfaces, such as asphalt driveways or concrete walks, or installing a vegetated roof to replace standard roof material. This process requires the proper disposal or recycling of the asphalt or concrete.
Septic to sanitary connection	Septic systems leach nutrients into our waterways. When septic systems are connected to the sanitary sewer system, nutrients no longer leach from the septic drain field.
Residential partnership project with the City of Harrisonburg	This credit option is available to residential property owners who are approached by the City of Harrisonburg about a stormwater project and who have a portion or all of a project footprint or easements on their property. If a stormwater project (or needed easements) spans multiple properties, all associated properties are eligible for credit. This credit is only available when the property owner has donated all necessary easements (permanent and temporary construction easements) to the City.

Note:

^a Descriptions were obtained from the City of Harrisonburg’s [2016 Stormwater Utility Fee Credit Manual for Residential manual](#).

References

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- Comstock, S., S. Crafton, R. Greer, P. Hill, D. Hirschman, S. Karimpour, K. Murin, J. Orr, F. Rose, and S. Wilkins. 2015. *Recommendations of the Expert Panel to Define Removal Rates for New State Stormwater Performance Standards*. Chesapeake Stormwater Network. Timonium, MD. https://chesapeakestormwater.net/wp-content/uploads/2022/07/Final-CBP-Approved-Expert-Panel-Report-on-Stormwater-Performance-Standards-LONG_012015.pdf.
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Attachment A: High Priority Concept Plans

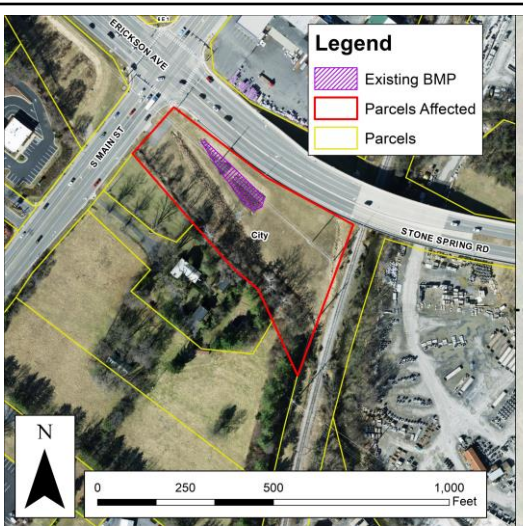
Current Site Location and Watershed Characteristics						
Date of Field Visit	7/17/24	Latitude	38.421628°			
Major Watershed	Blacks Run	Longitude	-78.891263°			
Existing Land Use	Detention Basin	Landowner	City Property			
Street Address	2140 S Main St					
Drainage Area, Acres	27.2	Total Imperviousness	76%			
Load lbs/yr	TN	347	TP	33	TSS	24,106

Design Characteristics*						
Proposed SWMF Type	Level 1 Wet Pond					
BMP Footprint, Acres	0.72	Disturbed Area	1.1			
Anticipated Net Load Reduction lbs/yr	TN	118	TP	18	TSS	16,208
Annual O&M	\$14,000		Total Cost (25 years O&M)	\$795,000		
Design & Construction	\$445,000					
Land Acquisition	\$0					
Total Cost/lb Net Reduction	TN	\$7,000	TP	\$45,000	TSS	\$50

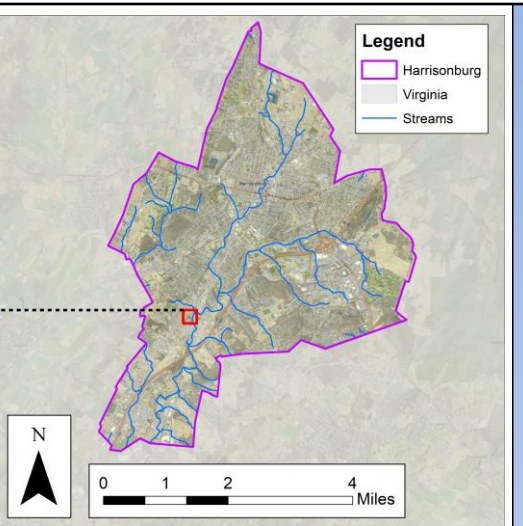
Proposed SWMF Description: Based on drainage area, the level 1 wet pond requires ~77,000 CF of treatment volume. The designed retrofit provides over 80,000 CF with a permanent pool SE of the current basin; to avoid existing water and power lines. The forebay is connected to the pond via a winding path to create a long flow path. Could be possible to divert additional flow from SE pipe if additional treatment is desired. Additional permitting may be required for construction in a flood zone.

Existing Site Description: Existing detention basin in the Blacks Run watershed on City property in a 1% Annual Chance Flood Hazard. The basin is triangular and located below powerlines. Current ponding depth of ~4 ft below the overflow weir for a total of ~25,000 CF detention storage. Stormwater enters the system from the NW through the stormwater pipes under South Main Street and Stone Spring Road and exits SW at the ~4 ft outlet structure. The City currently receives minimal TMDL credit for this BMP.

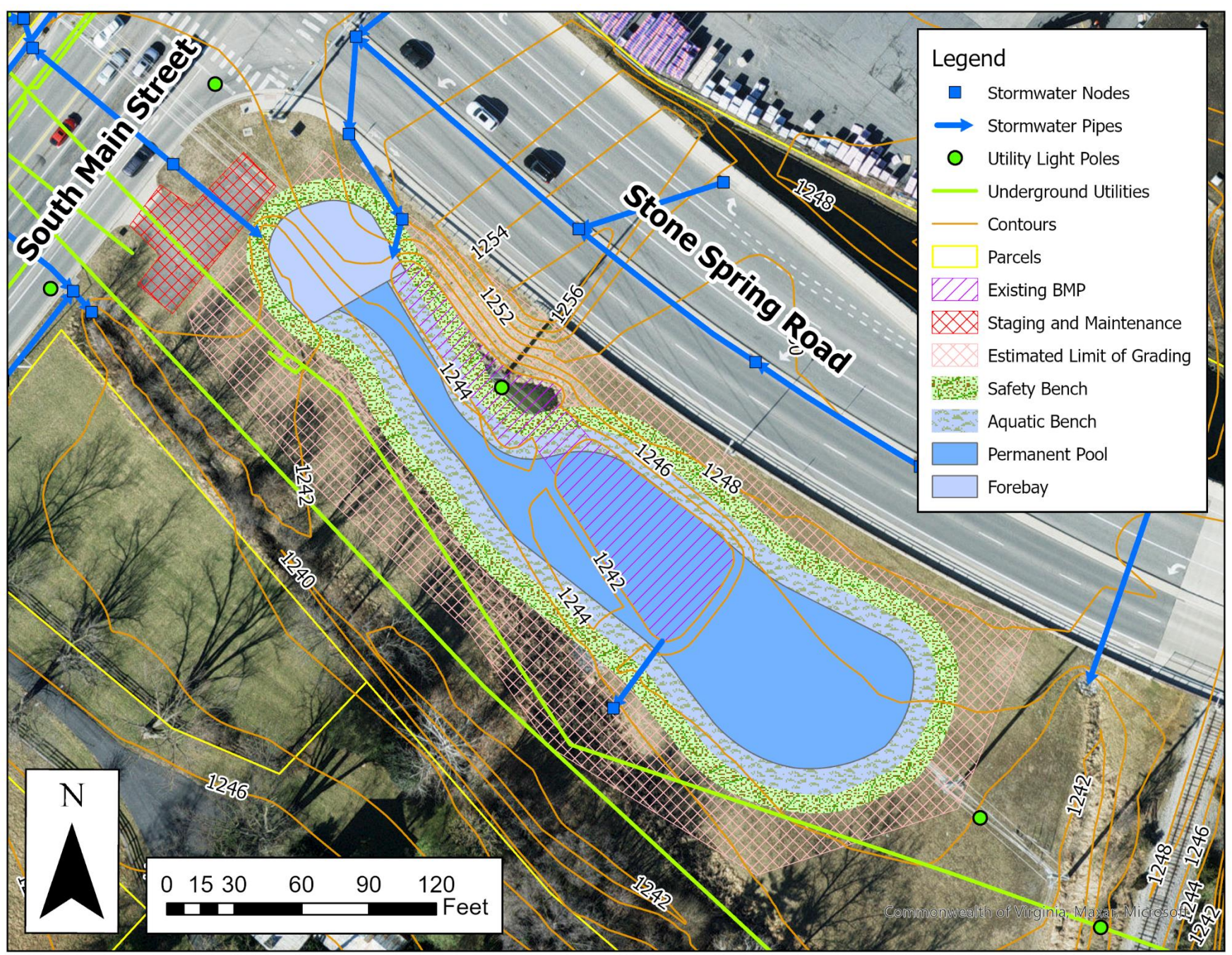
*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics, particularly depending on vertical depth available. Graphical site rendering presented below is for illustrative purposes only.



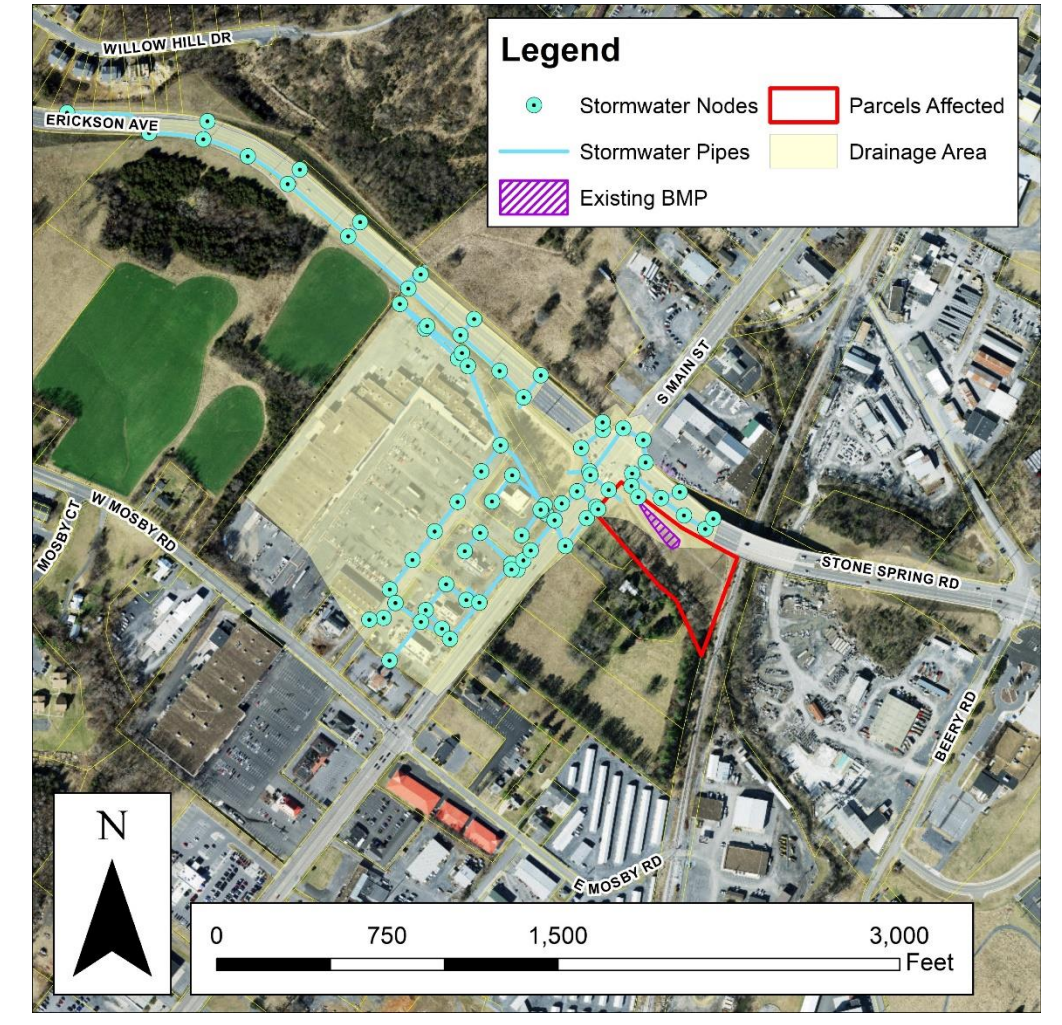
006_B_3 Project Area



Vicinity Map



Existing Site overall photo facing downstream with possible utility conflict (left) and overall site photo facing upstream (right)



006_B_3 STORM WATER MANAGEMENT FACILITY:
 RETROFIT DETENTION POND TO WET POND
 CONCEPTUAL DESIGN: WATER QUALITY IMPROVEMENT STRATEGY RETROFIT

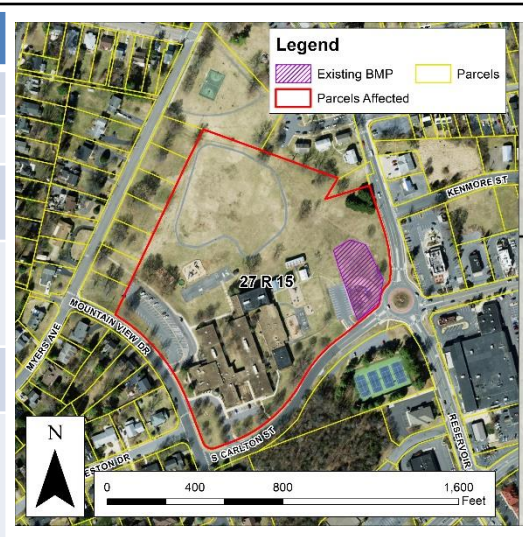
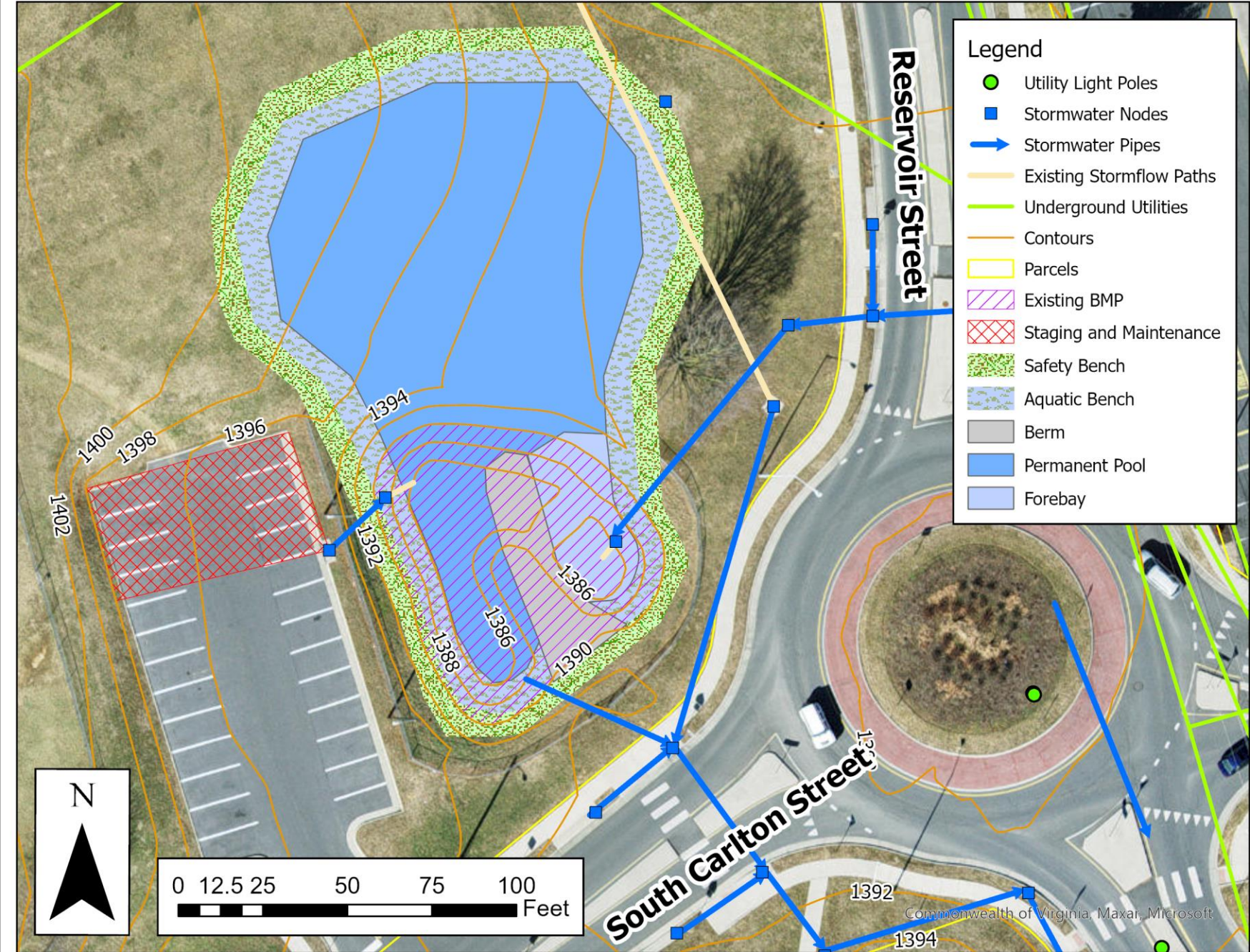


Current Site Location and Watershed Characteristics					
Date of Field Visit	09/05/2024	Latitude	38.442890°		
Major Watershed	Sieberts Creek	Longitude	- 78.858725°		
Existing Land Use	Detention Basin	Landowner	City Property		
Street Address	302 Myers Ave, Harrisonburg, VA 22801				
Drainage Area, Acres	38.4	Total Imperviousness	28%		
Load lbs/yr	TN 320	TP 17	TSS 8,742		

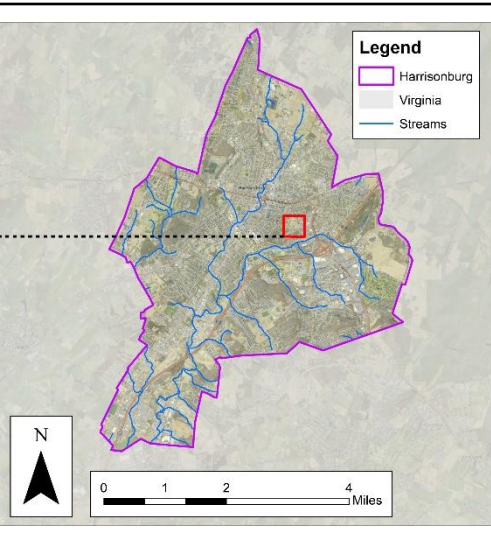
Design Characteristics*					
Proposed SWMF Type	Level 1 Wet Pond				
BMP Footprint, Acres	0.5	Disturbed Area	0.7		
Anticipated Net Load Reduction lbs/yr	TN 96	TP 8	TSS 5,236		
Annual O&M	\$20,000	Total Cost (25 years O&M)	\$980,000		
Design & Construction	\$480,000				
Land Acquisition	\$0				
Total Cost/lb Net Reduction	TN \$11,000	TP \$123,000	TSS \$190		

Proposed SWMF Description: Based on drainage area, the level 1 Wet Pond requires ~62,000 CF treatment volume. The designed retrofit increases the BMP footprint by ~2 and the treatment volume to nearly 65,000 CF. The inlet will flow into a forebay, where a berm will force water into the main pond area to increase flow path length. Both the forebay and permanent pool will be excavated to hold additional water at an average depth of 5 ft.

*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics, particularly depending on vertical depth available. Graphical site rendering presented below is for illustrative purposes only.



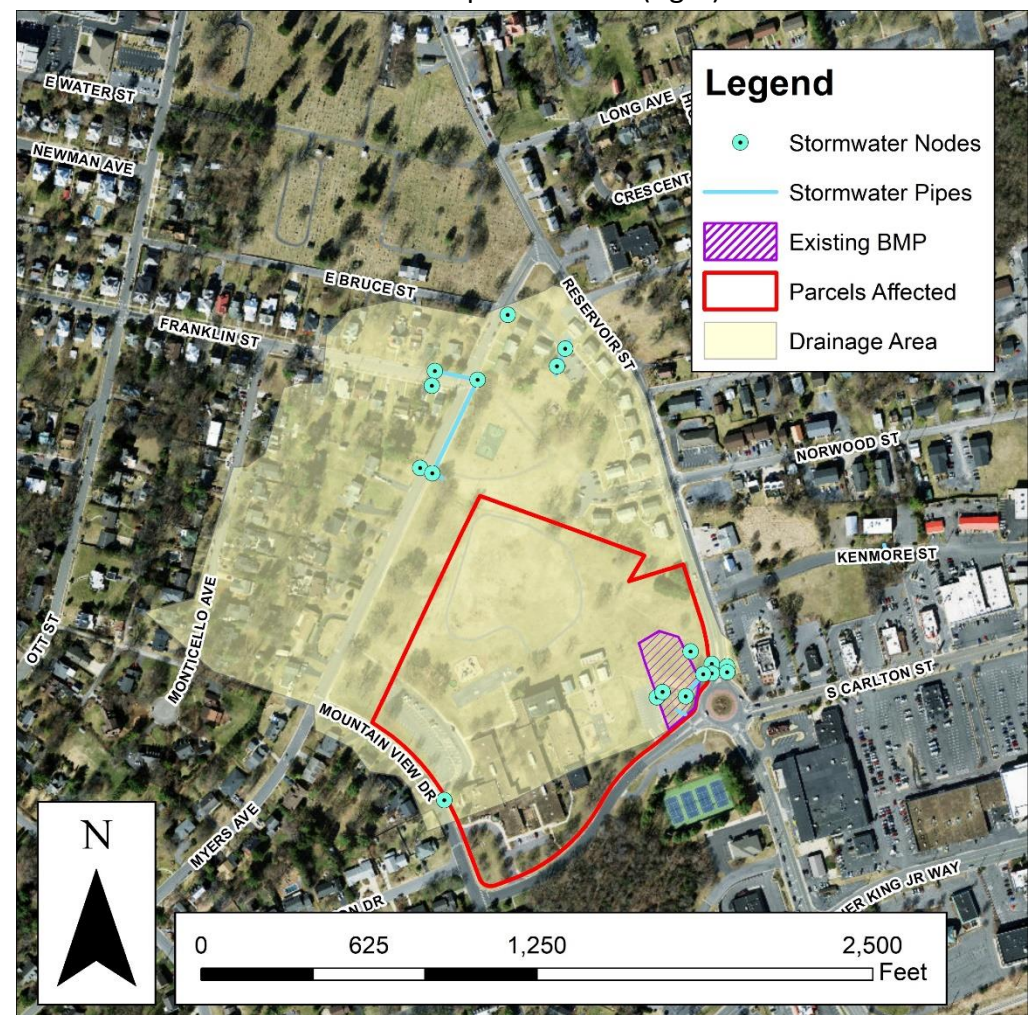
Project Area



Vicinity Map



Existing Site overall photo, outlet pictured (left) and open area north of existing BMP for expansion area (right)



027_R_15_BMP1 STORM WATER MANAGEMENT FACILITY:
 RETROFIT DETENTION POND TO WET POND
 CONCEPTUAL DESIGN: WATER QUALITY IMPROVEMENT STRATEGY RETROFIT



Current Site Location and Watershed Characteristics

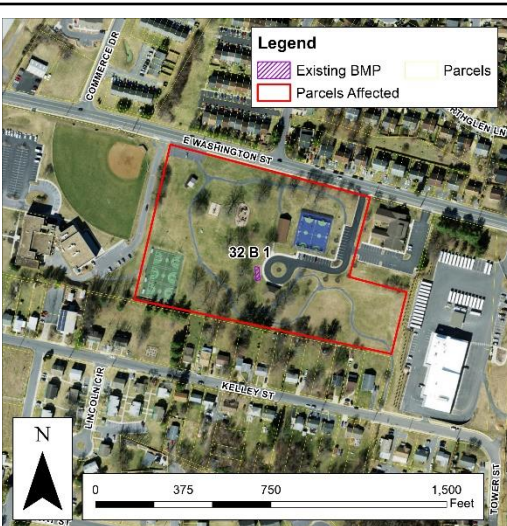
Date of Field Visit	7/17/2024	Latitude	38.454223°
Major Watershed	Blacks Run	Longitude	- 78.855277°
Existing Land Use	None	Landowner	City Property
Street Address	431 E Washington St		
Drainage Area, Acres	0.6	Total Imperviousness	72%
Load lbs/yr	TN 9	TP 1	TSS 528

Existing Site Description: Stormwater drains from the parking circle through a pipe to riprap on the existing hill. No further stormwater management structures. The existing slope is between 9-27% and averages 17%. An existing walking path is located ~130 ft from the parking circle. The site is not located in a flood zone. The City currently receives no TMDL credit for this site.

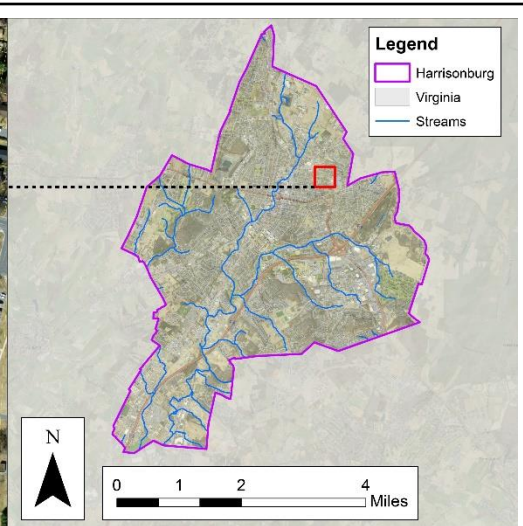
Design Characteristics*

Proposed SWMF Type	Vegetated Filter Strip			
BMP Footprint, Acres	0.28	Disturbed Area	0.8	
Anticipated Net Load Reduction lbs/yr	TN 5	TP 1	TSS	396
Annual O&M	\$300	Total Cost (25 years O&M)	\$21,000	
Design & Construction	\$13,000			
Land Acquisition	\$0			
Total Cost/lb Net Reduction	TN \$5,000	TP \$21,000	TSS	\$53

Proposed SWMF Description: Flow from the impervious area will be conveyed under the existing sidewalk to a 75 ft length vegetated filter strip with a gravel water spreading diaphragm at the top and vegetated, permeable berm at the bottom. Based on the existing conditions, current site grade and walking path location, the grade will have to be filled to a minimum of 6%. Some existing trees may need to be relocated.

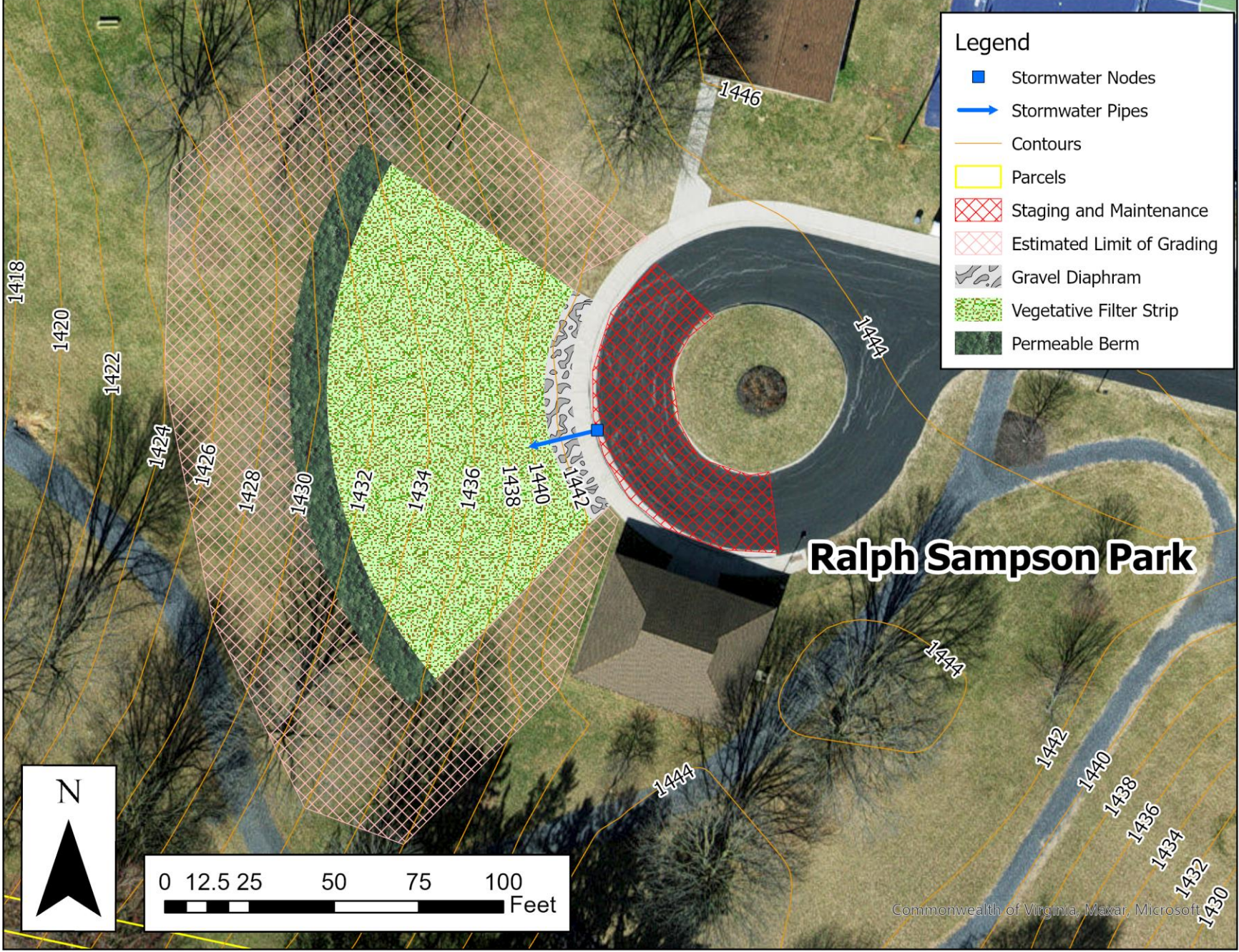


Project Area



Vicinity Map

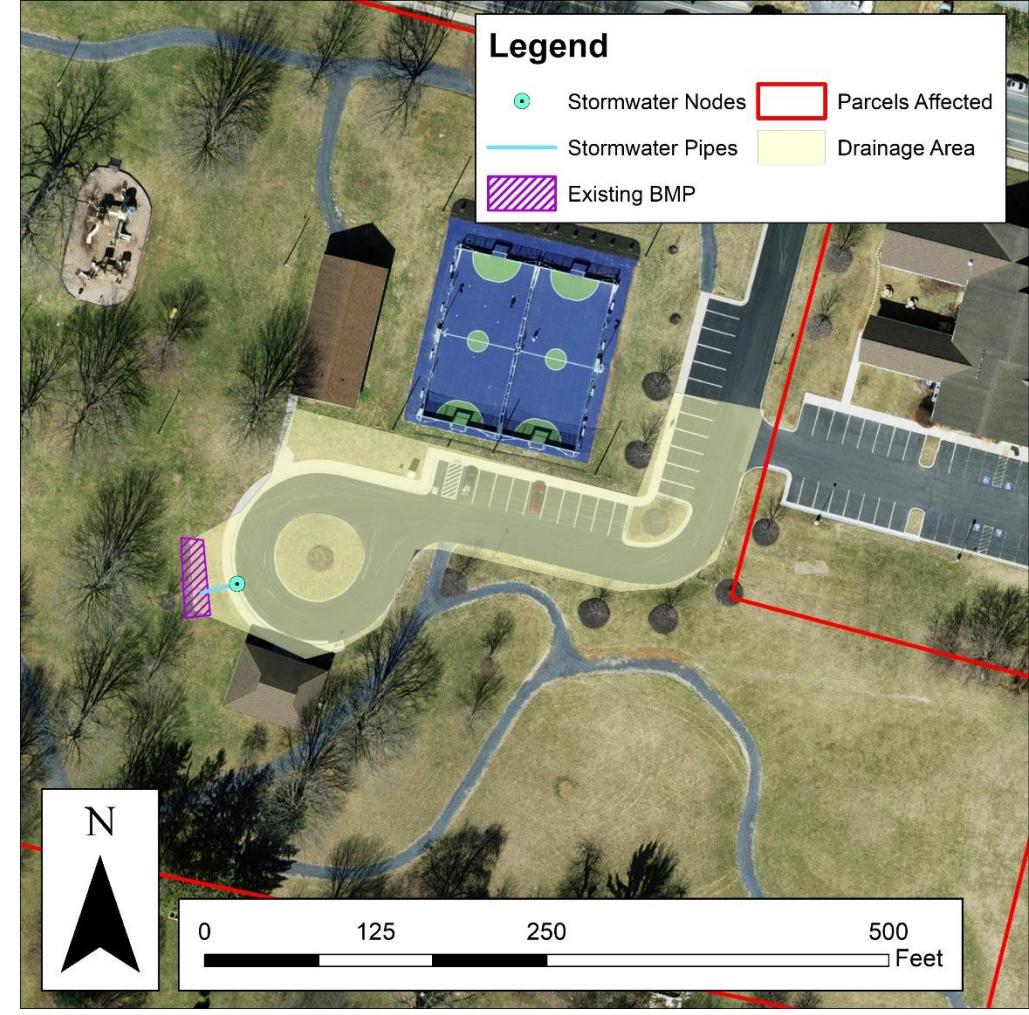
*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics, particularly depending on vertical depth available. Graphical site rendering presented below is for illustrative purposes only.



Ralph Sampson Park



Existing Site overall photo looking toward southern pavilion, outlet pictured bottom middle (left) and photo above outlet looking downhill (right)



032_B_1_BMP1 STORM WATER MANAGEMENT FACILITY:
 NEW BUILD: VEGETATED FILTER STRIP
 CONCEPTUAL DESIGN: WATER QUALITY IMPROVEMENT STRATEGY NEW BUILD



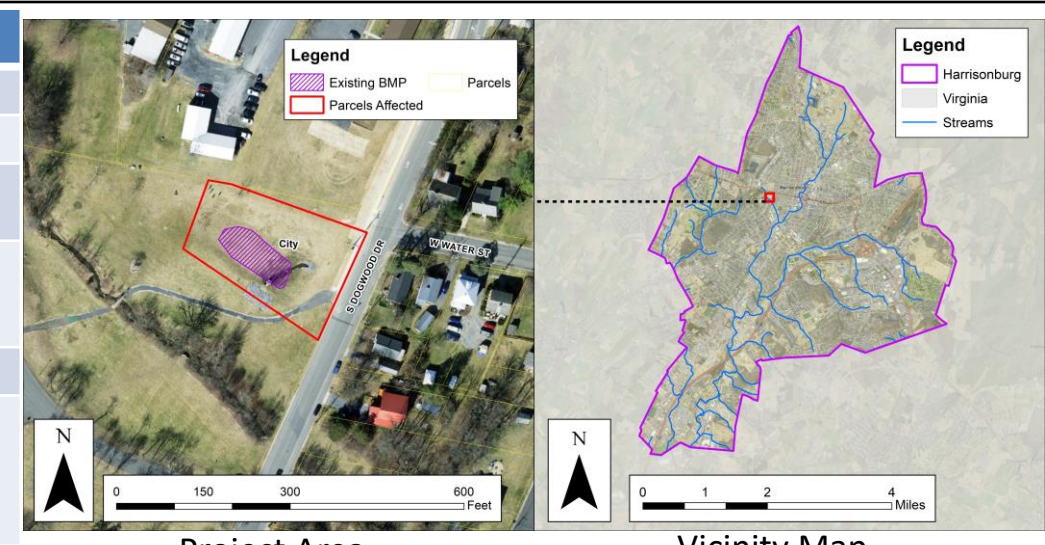
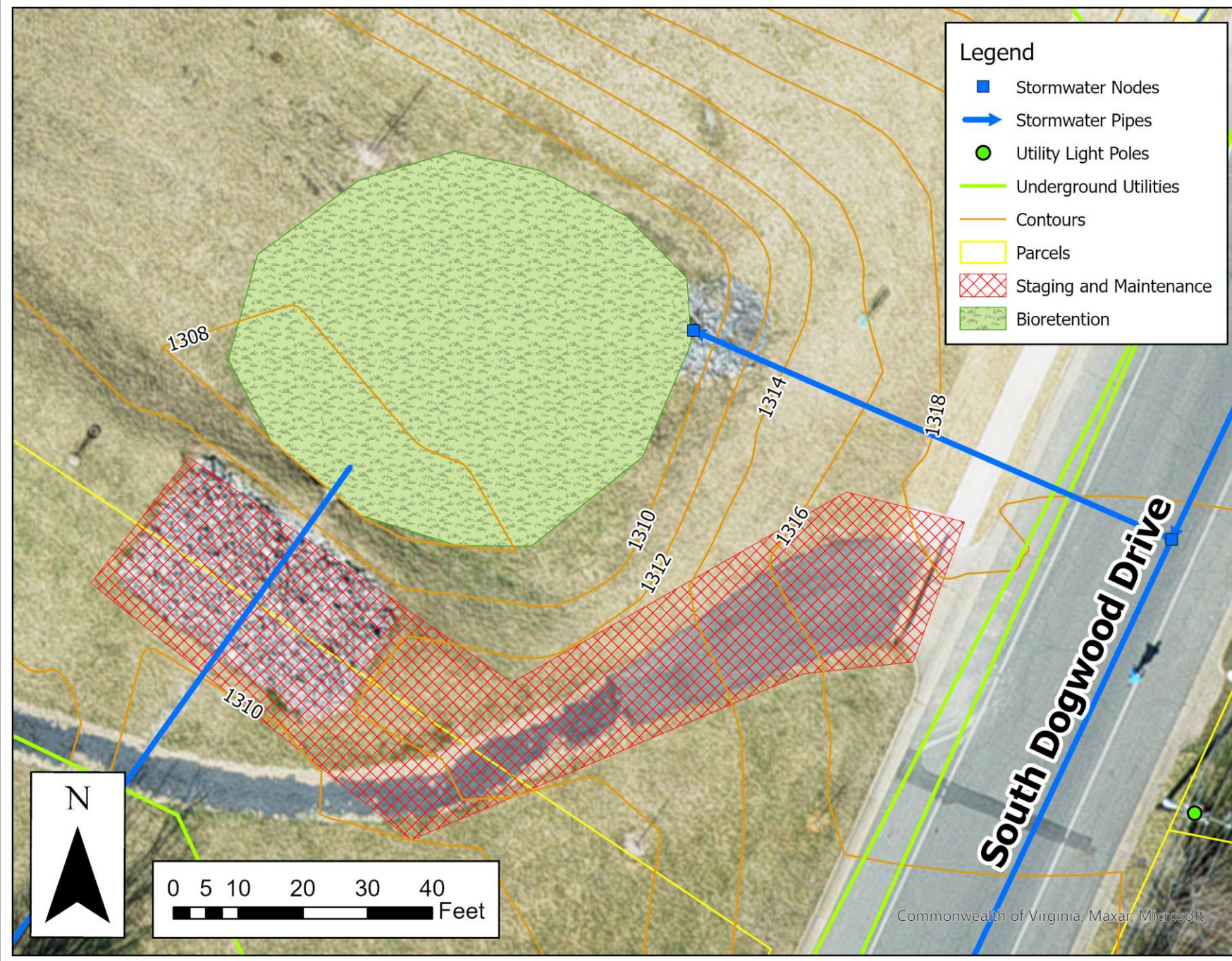


Current Site Location and Watershed Characteristics				
Date of Field Visit		Latitude	38.449797°	
Major Watershed	Cooks Creek	Longitude	- 78.879477°	
Existing Land Use	None	Landowner	City Property	
Street Address	114 South Dogwood Drive			
Drainage Area, Acres	1.9	Total Imperviousness	29%	
Load lbs/yr	TN 22	TP 1	TSS	859

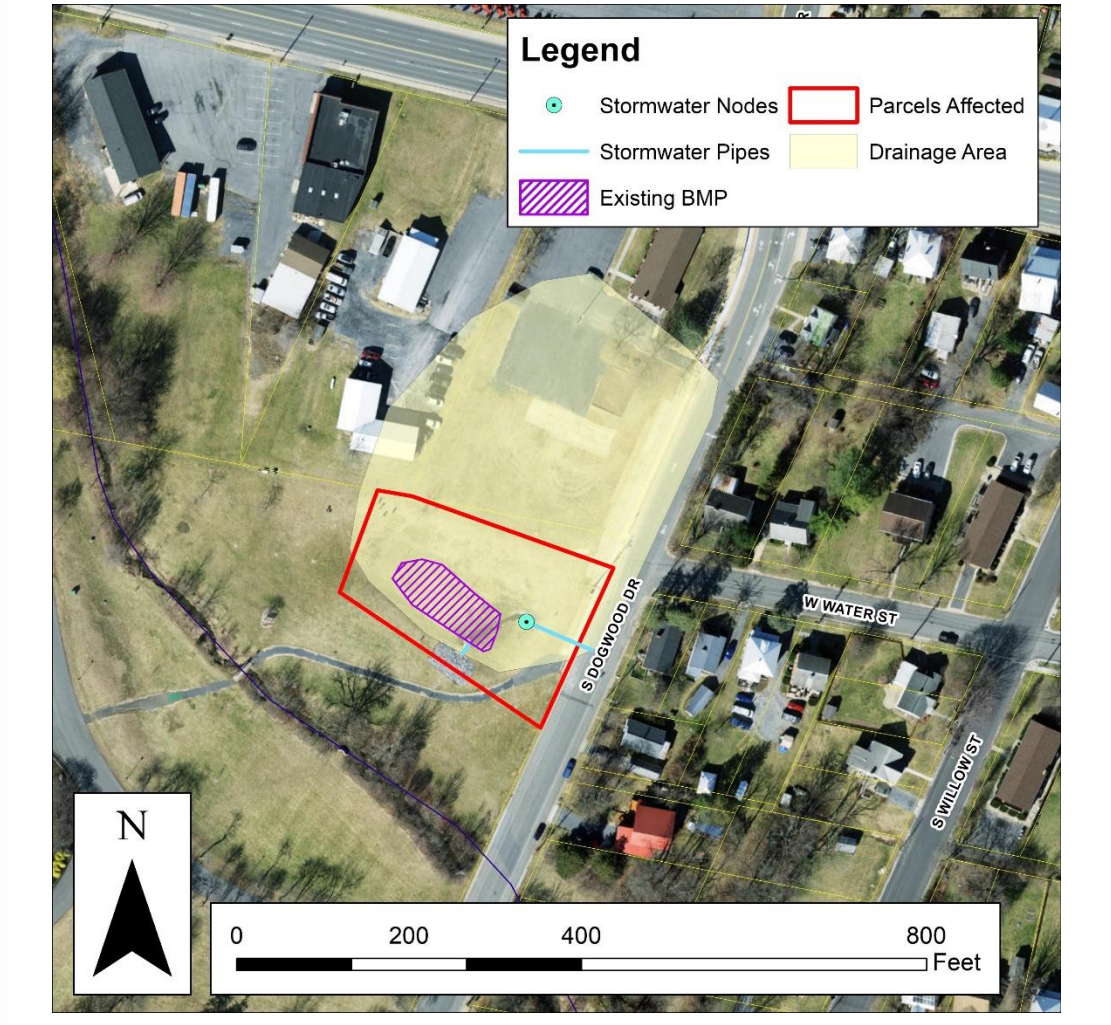
Design Characteristics*				
Proposed SWMF Type	Bioretention			
BMP Footprint, Acres	0.07	Disturbed Area	0.2	
Anticipated Net Load Reduction lbs/yr	TN 12	TP 1	TSS	567
Annual O&M Design & Construction Land Acquisition	\$5,000 \$100,000 \$0	Total Cost (25 years O&M)	\$225,000	
Total Cost/lb Net Reduction	TN \$19,000	TP \$225,000	TSS	\$400

Existing Site Description: Stormwater drains from the street, parking lots, and adjacent buildings to stormwater pipes that flow into an existing dry detention basin. This site is located within a disc golf course but not in a flood zone. Flowing water was found between the existing storm pipe and the outlet. Minor erosion identified next to outlet pipe. The invert elevation of the outlet is minimal and no ponding was seen. The City currently receives no TMDL credit for this site.

Proposed SWMF Description: Based on drainage area, bioretention requires ~3,000 CF of treatment volume. The designed retrofit increases the treatment volume to ~3,200 CF. The retrofit fits into the existing footprint and reduces the footprint by nearly half. Two holes for disc golf may need to be temporarily relocated for construction.



Existing Site overall photo looking SE (left), inlet with flowing water (middle) and existing outlet structure with signs of erosion on pipe (right)



*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics, particularly depending on vertical depth available. Graphical site rendering presented below is for illustrative purposes only.

Current Site Location and Watershed Characteristics			
Date of Field Visit	07/17/2024	Latitude	38.451865°
Major Watershed	Blacks Run	Longitude	-78.884734°
Existing Land Use	Detention Basin	Landowner	City Property
Street Address	895 W Market Street, Harrisonburg, VA		
Drainage Area, Acres	33.3	Total Imperviousness	31%
Load lbs/yr	TN 386	TP 25.4	TSS 15,882

Design Characteristics*					
Proposed SWMF Type			Level 1 Wet Pond		
BMP Footprint, Acres		0.39	Disturbed Area		0.9
Anticipated Net Load Reduction lbs/yr		TN 108	TP 10.5	TSS 9,053	
Annual O&M		\$18,000	Total Cost (25 years O&M)		\$996,000
Design & Construction		\$546,000			
Land Acquisition		\$0			
Cost/lb Net Reduction		TN \$10,000	TP \$100,000	TSS \$110	

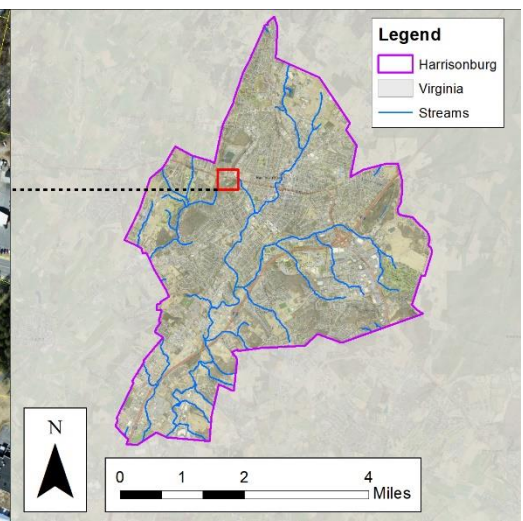
Existing Site Description: The site is an existing volume control detention basin in the Blacks Run watershed on City property. The basin is conical with ~2.5:1 interior side slopes and a ponding depth of ~3 ft below the overflow weir for a total of ~15,800 CF detention storage. Stormwater enters the system from the north through the stormwater pipe under West Market Street and exits east at the ~3 ft outlet structure. The City currently receives minimal TMDL credit for this BMP.

Proposed SWMF Description: Based on drainage area, the level 1 wet pond requires a 56,500 CF treatment volume. The designed retrofit increases the treatment volume to over 59,000 CF. The existing BMP footprint will increase by nearly 2 with a permanent pool at 5 ft deep. If upstream infrastructure limits increased ponding depth additional excavation or an enlarged footprint may be necessary. The increased length of the wet pond provides a 2:1 length to width ratio. The existing stormwater outfall may be relocated to the east end of the pond to provide an optimal flow path.

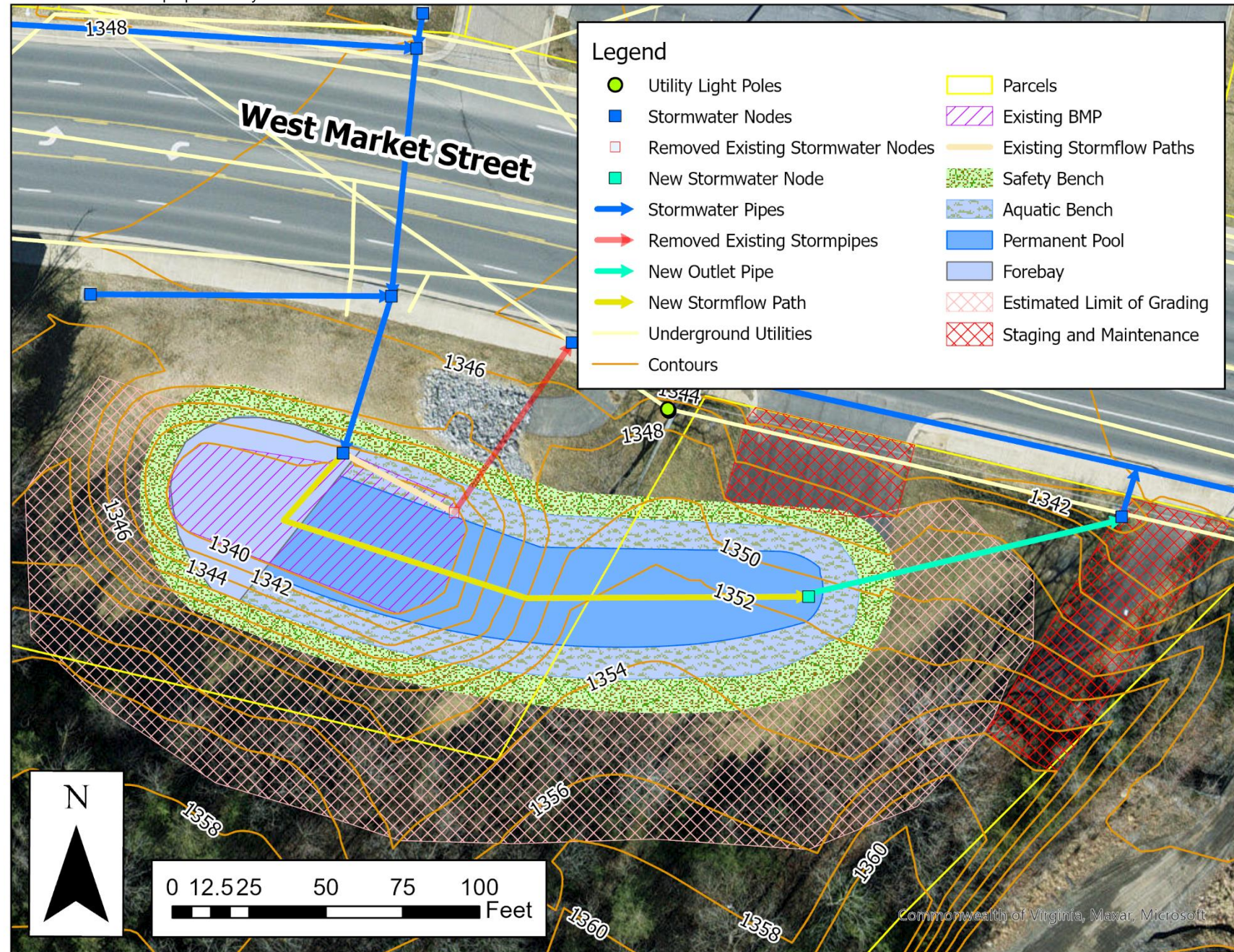
*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics, particularly depending on vertical depth available. Graphical site rendering presented below is for illustrative purposes only.



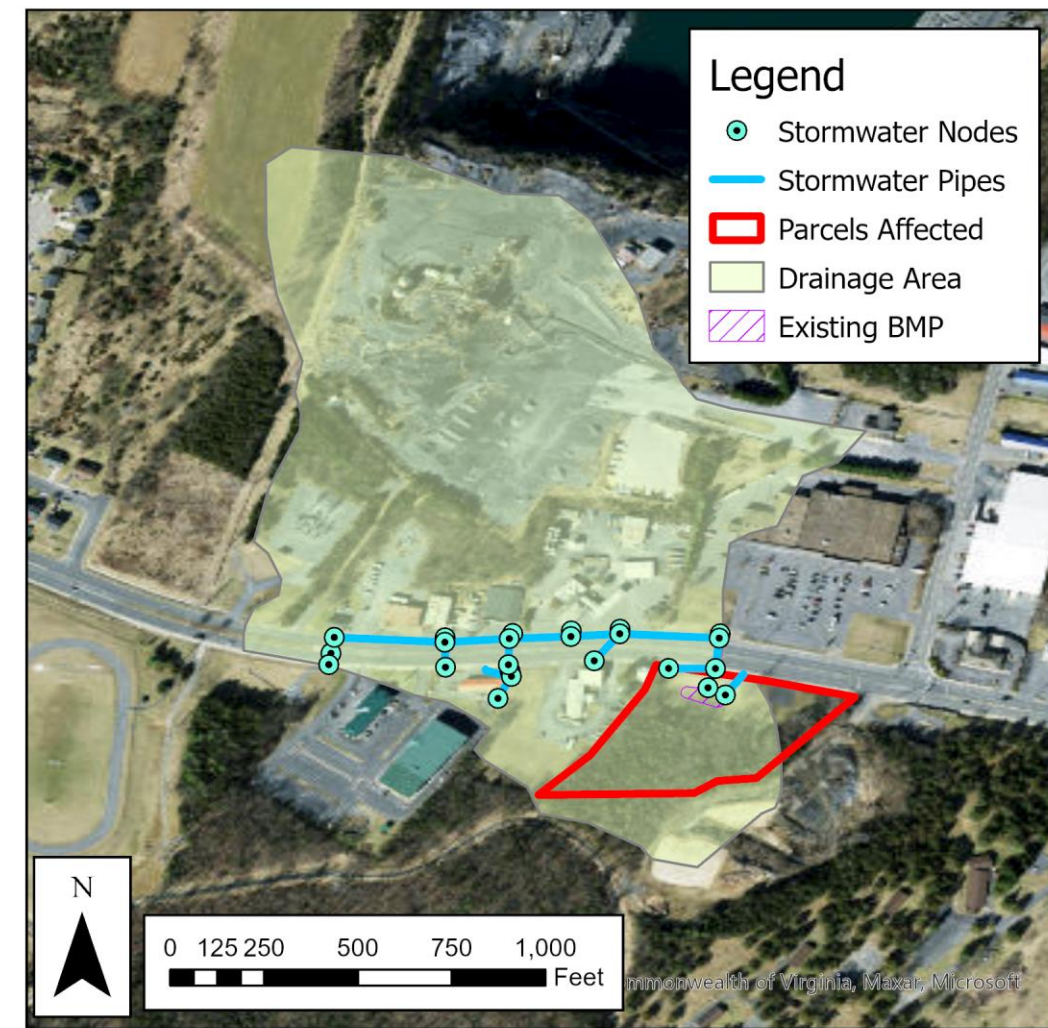
Project Area



Vicinity Map



Existing Site overall photo (left) and photo from within the existing BMP (right)



037_A_11 STORM WATER MANAGEMENT FACILITY:
 RETROFIT DETENTION POND TO WET POND
 CONCEPTUAL DESIGN: WATER QUALITY IMPROVEMENT STRATEGY RETROFIT

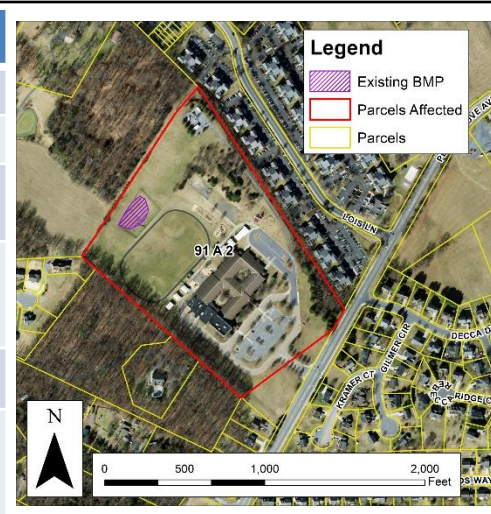


Current Site Location and Watershed Characteristics						
Date of Field Visit	07/17/2024	Latitude	38.416583°			
Major Watershed	Blacks Run	Longitude	- 78.876479°			
Existing Land Use	Detention Basin	Landowner	City Property			
Street Address	1575 Peach Grove Ave, Harrisonburg, VA 22801					
Drainage Area, Acres	10.7	Total Imperviousness	28%			
Load lbs/yr	TN	122	TP	8	TSS	4,763

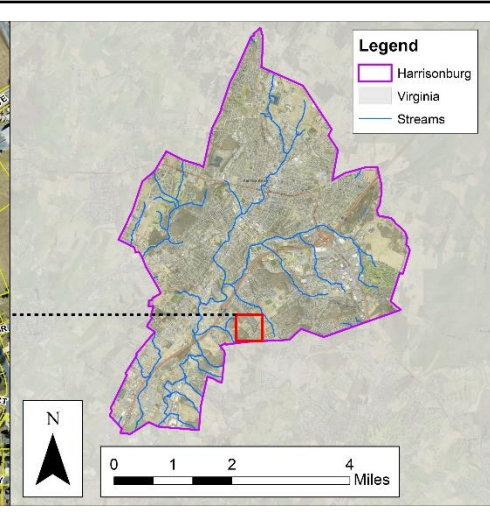
Existing Site Description: A volume control detention basin in the Blacks Run watershed on City property. The basin is wide with a short flow path and steep inlet with low relief to outlet structure ~3 ft elevation for a total of ~10,360 CF detention storage. Stormwater enters the system from the SE through the stormwater pipe under Elementary School track and exits NW at the ~3 ft outlet structure. The site is not in a flood zone. The City currently receives minimal TMDL credit for this BMP.

Design Characteristics*						
Proposed SWMF Type	Level 1 Wetland					
BMP Footprint, Acres	0.3	Disturbed Area	0.5			
Anticipated Net Load Reduction lbs/yr	TN	38	TP	4	TSS	2,948
Annual O&M	\$6,000		Total Cost (25 years O&M)	\$325,000		
Design & Construction	\$175,000					
Land Acquisition	\$0					
Total Cost/lb Net Reduction	TN	\$9,000	TP	\$82,000	TSS	\$110

Proposed SWMF Description: Based on drainage area, the level 1 wetland requires 26,000 CF treatment volume. The designed retrofit increases the BMP footprint by ~2 and the treatment volume to nearly 27,000 CF. The inlet will flow into a forebay, where a berm will force water into two adjoining wetland cells. Opposite the inlet and forebay is a permanent deep pool at the outlet. Both the forebay and permanent pool will be excavated to hold additional water.

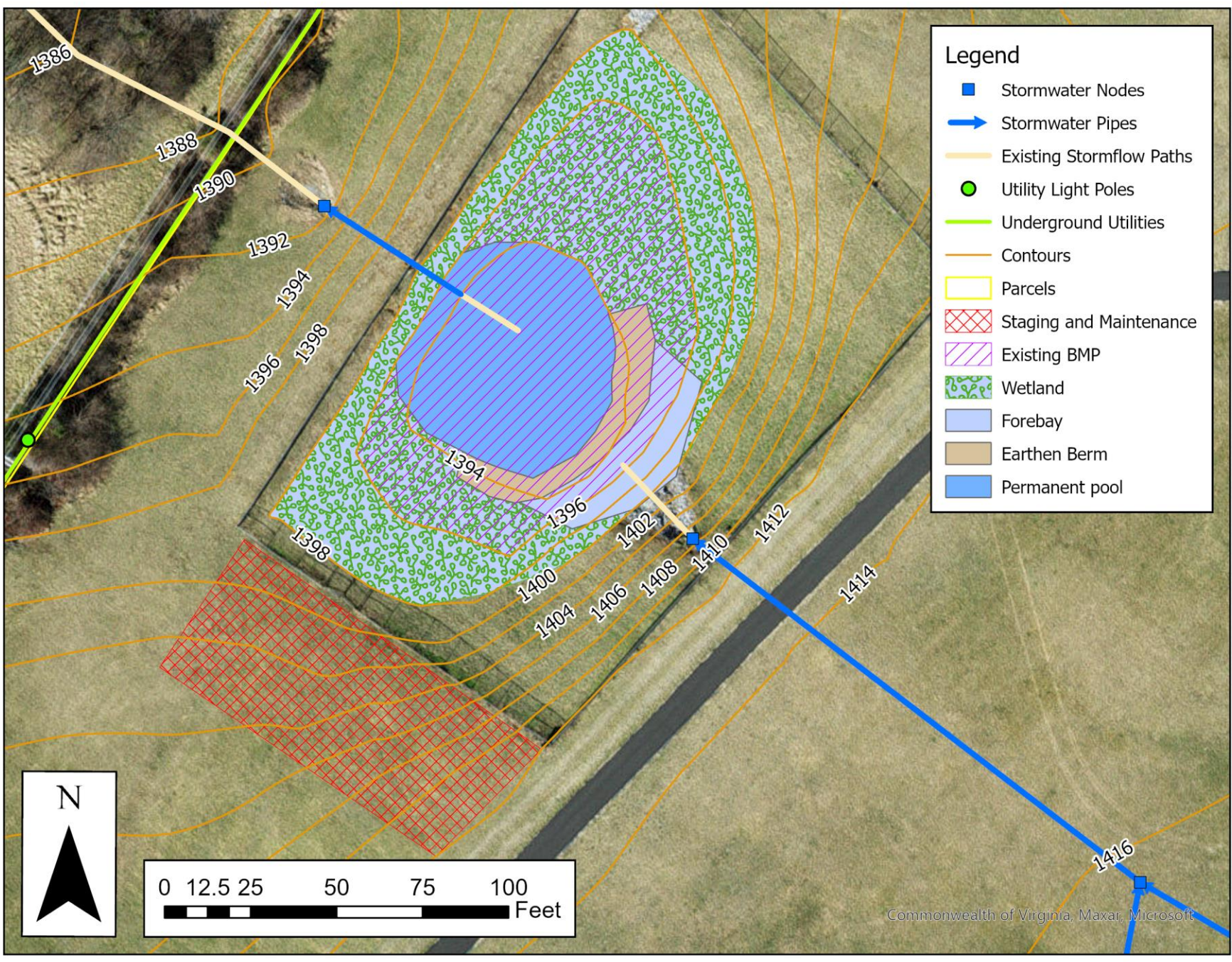


091_A_2_BMP2 Project Area

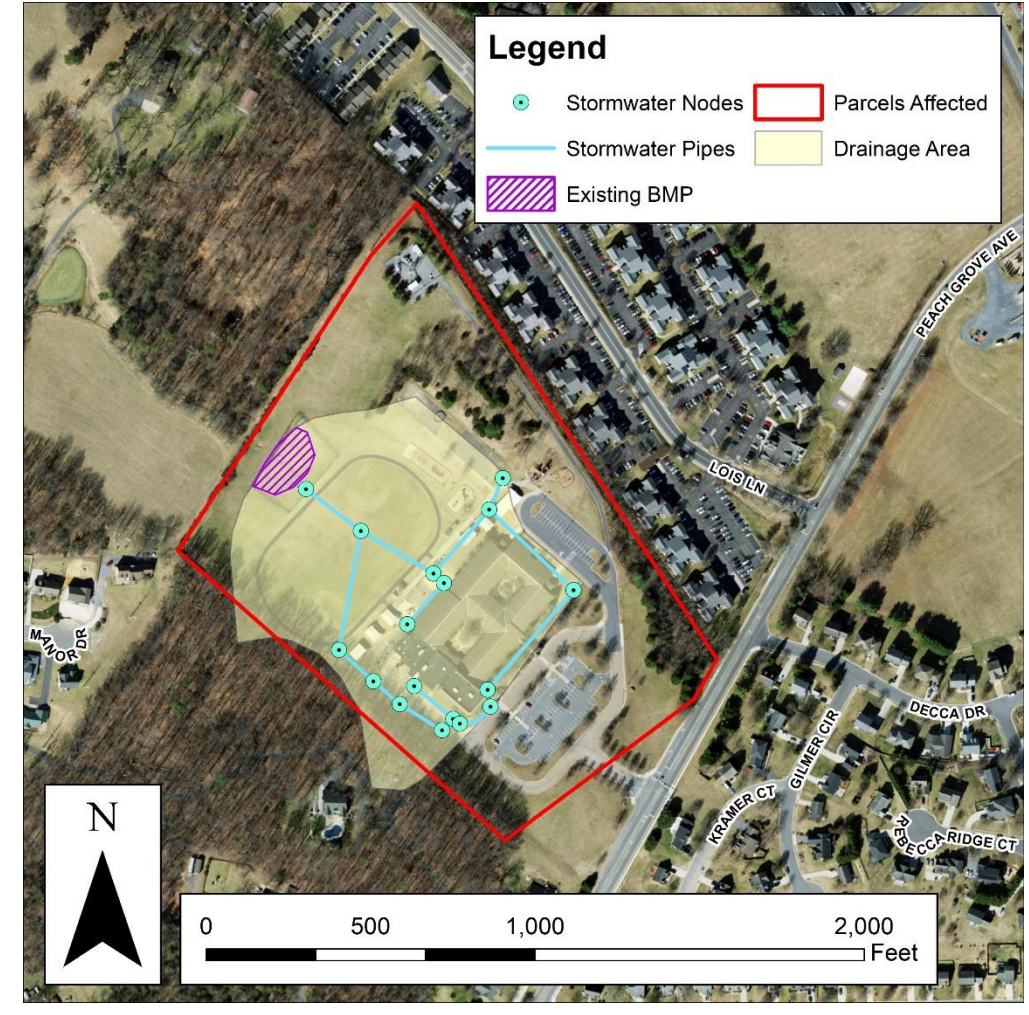


Vicinity Map

*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics, particularly depending on vertical depth available. Graphical site rendering presented below is for illustrative purposes only.



Existing Site overall photo, outlet pictured (left) and photo from within the existing BMP outlet top, existing riprap at inlet bottom (right)



091_A_2_BMP2 STORM WATER MANAGEMENT FACILITY:
 RETROFIT DETENTION POND TO WETLAND
 CONCEPTUAL DESIGN: WATER QUALITY IMPROVEMENT STRATEGY RETROFIT



Current Site Location and Watershed Characteristics						
Date of Field Visit	09/05/2024	Latitude	38.453651°			
Major Watershed	Cooks Creek	Longitude	-78.894507°			
Existing Land Use	Detention Basin	Landowner	City Property			
Street Address	1611 W Market Street, Harrisonburg VA					
Drainage Area, Acres	35.2	Total Imperviousness	47%			
Load lbs/yr	TN	466	TP	34	TSS	22,519

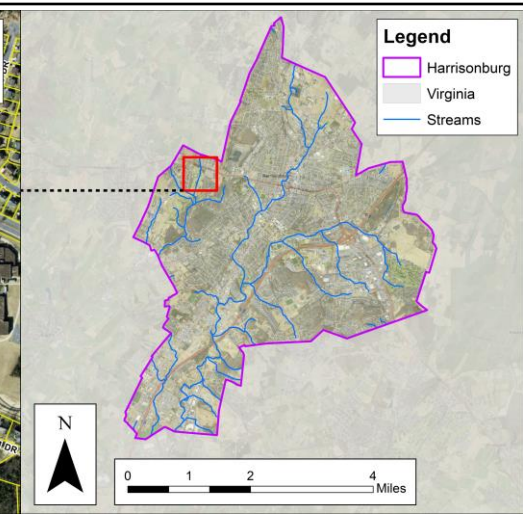
Existing Site Description: An existing volume control detention basin in the Cooks Creek Run watershed on City property. The basin is conical with ~2.5:1 interior side slopes and a ponding depth of ~3 ft below the overflow weir for a total of ~16,000 CF detention storage. Stormwater enters the system from the NE through the stormwater pipe under West Market Street and exits W at the ~3 ft outlet structure. The site is located partially in a 1% annual chance flood hazard zone. The City currently receives minimal TMDL credit for this BMP.

Design Characteristics*						
Proposed SWMF Type	Level 1 Wet Pond					
BMP Footprint, Acres	0.6	Disturbed Area	0.8			
Anticipated Net Load Reduction lbs/yr	TN	139	TP	15	TSS	13,469
Annual O&M	\$19,000		Total Cost (25 years O&M)	\$1,059,000		
Design & Construction	\$584,000					
Land Acquisition	\$35,000					
Total Cost/lb Net Reduction	TN	\$8,000	TP	\$71,000	TSS	\$80

Proposed SWMF Description: A level 1 wet pond requires ~74,000 CF of treatment volume. The designed retrofit proposes over 78,000 CF. The existing southern berm is moved ~65 ft south to increase pond volume. Water entering through the forebay is diverted south before entering the main pond, this allows for increased flow path meeting the 2:1 length to width ratio requirement. Additional permits may be required for construction in a flood zone. Soil coring for shallow substrate should be completed prior to further design.

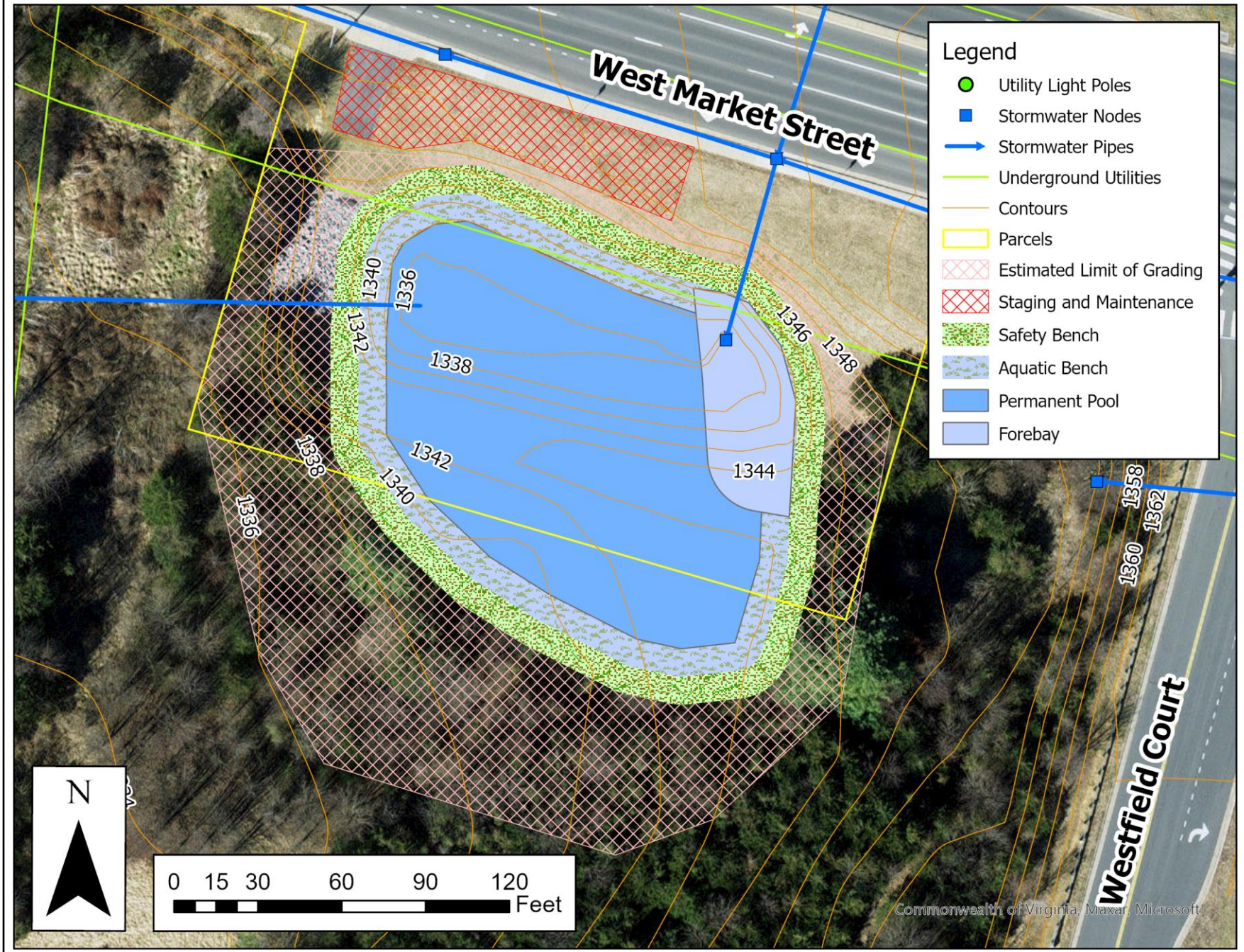


116_A_1_124_B_1_2_BMP1 Project Area

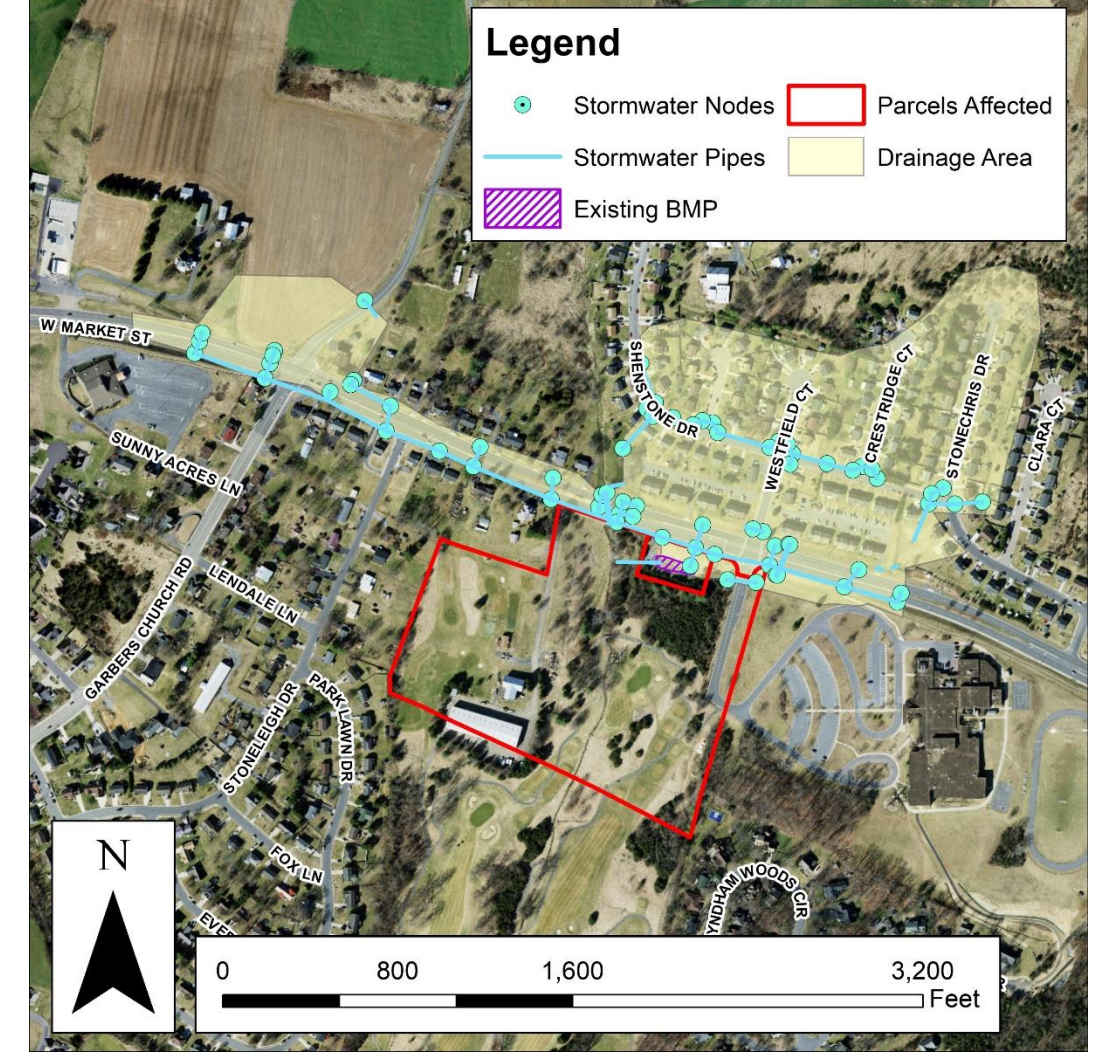


Vicinity Map

*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics, particularly depending on vertical depth available. Graphical site rendering presented below is for illustrative purposes only.



Existing Site overall photo (left) and photo from within the existing BMP (right)



116_A_1_124_B_1_2_BMP1 STORM WATER MANAGEMENT FACILITY:
 RETROFIT DETENTION POND TO WET POND
 CONCEPTUAL DESIGN: WATER QUALITY IMPROVEMENT STRATEGY RETROFIT



Current Site Location and Watershed Characteristics

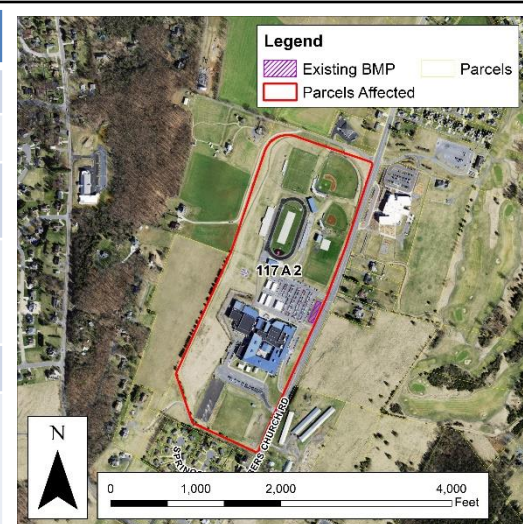
Date of Field Visit	09/05/2024	Latitude	38.454223°
Major Watershed	Cooks Creek	Longitude	-78.855277°
Existing Land Use	None	Landowner	City Property
Street Address	938 Garbers Church Rd		
Drainage Area, Acres	6.2	Total Imperviousness	82%
Load lbs/yr	TN 97	TP 9	TSS 6,136

Existing Site Description: Stormwater drains from the parking lot to stormwater pipes that flow to an existing drainage basin with visible signs of erosion. The existing slope is between 3-10% and averages 7%. The distance between parking lot curb and sidewalk is ~78 ft. Site is not in a flood zone. The City currently receives no TMDL credit for this site.

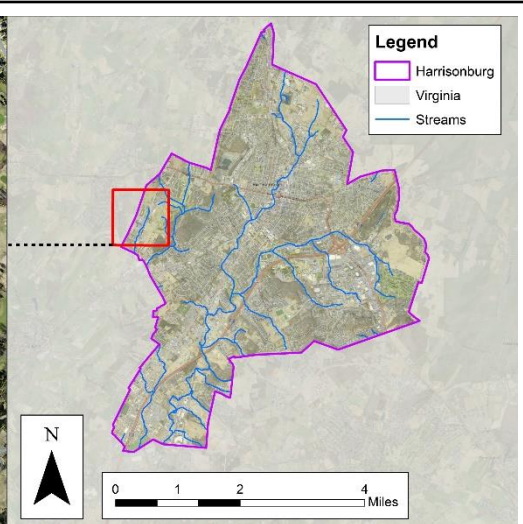
Design Characteristics*

Proposed SWMF Type	Vegetated Filter Strip			
BMP Footprint, Acres	0.4	Disturbed Area	0.6	
Anticipated Net Load Reduction lbs/yr	TN 58	TP 6	TSS 4,596	
Annual O&M	\$1,000	Total Cost (25 years O&M)	\$64,000	
Design & Construction	\$39,000			
Land Acquisition	\$0			
Total Cost/lb Net Reduction	TN \$4,000	TP \$32,000	TSS \$45	

Proposed SWMF Description: A 75 ft vegetated filter strip with gravel water spreading diaphragm will convey parking lot runoff into sheet flow for stormwater treatment. A vegetated, permeable berm is located at the base of the SWMF to allow minimal water pooling. The grade will have to be filled to a maximum of 6% and evened out for lateral flow through the filter strip. Existing sign may need to be relocated.

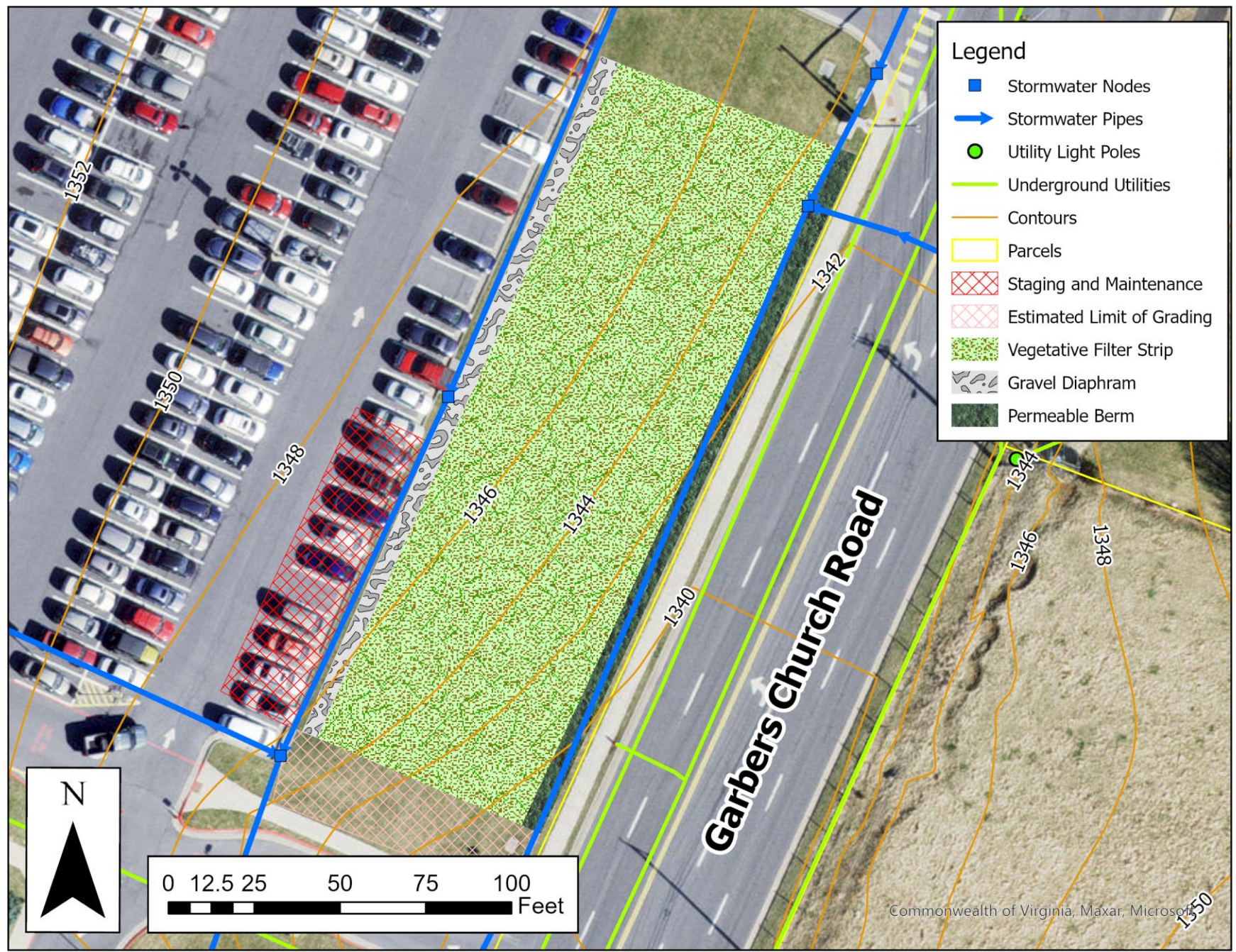


037_A_11 Project Area

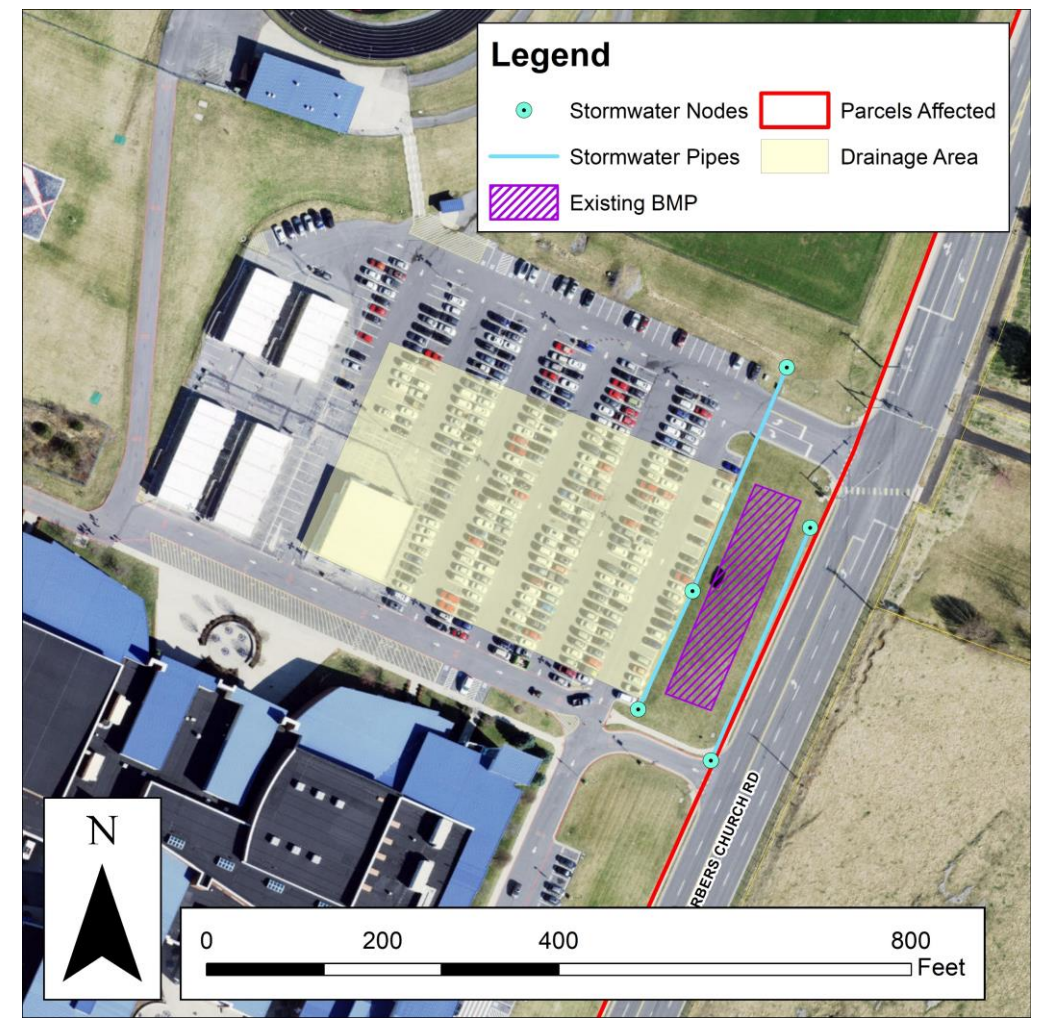


Vicinity Map

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Existing Site overall photo looking north (left) and photo of possible conflict image (right)



Current Site Location and Watershed Characteristics

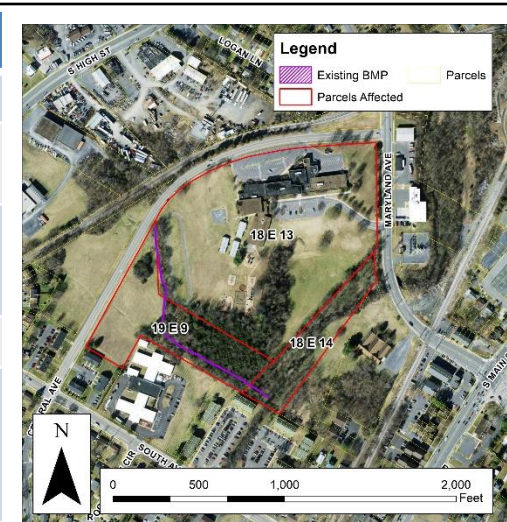
Date of Field Visit	09/05/2024	Latitude	38.451865°
Major Watershed	Blacks Run	Longitude	-78.884734°
Existing Land Use	Stream	Landowner	City Property
Street Address	1369 Central Avenue, Harrisonburg, VA		
Drainage Area, Acres	84	Stream Length, ft	1,058

Existing Site Description: An existing stream in the Blacks Run watershed on City property behind the Keister Elementary School. The City currently receives minimal TMDL credit for this BMP. Existing sewer line crossing at midpoint of stream. The lower third of the stream reach has not been validated by field observations (conflicts with existing topographic information). Stream location conflicts with topographical contours in downstream 1/2 of reach and should be validated prior to design development.

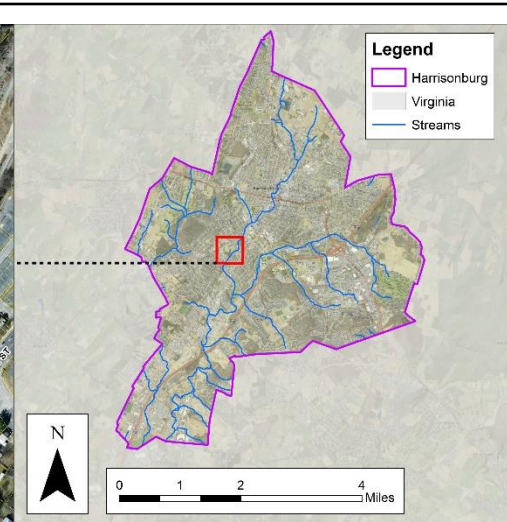
Design Characteristics*

Proposed SWMF Type	Stream Restoration			
	Anticipated Net Load Reduction lbs/yr**	TN 314	TP 137	TSS 44,279
Annual O&M Design & Construction Land Acquisition	\$4,000	Total Cost (25 years O&M)		\$868,000
	\$650,000			
	\$118,000			
Cost/lb Net Reduction	TN \$3,000	TP \$7,000	TSS \$20	

Proposed SWMF Description: Restore existing channel by reconnecting channel flow with the flood overbank area, install instream structures to control stream grade, and implement areas of riparian vegetation. Design should accommodate sewer crossing. Restoration may impact walking path near school (may need to be relocated).



HB_6 Project Area

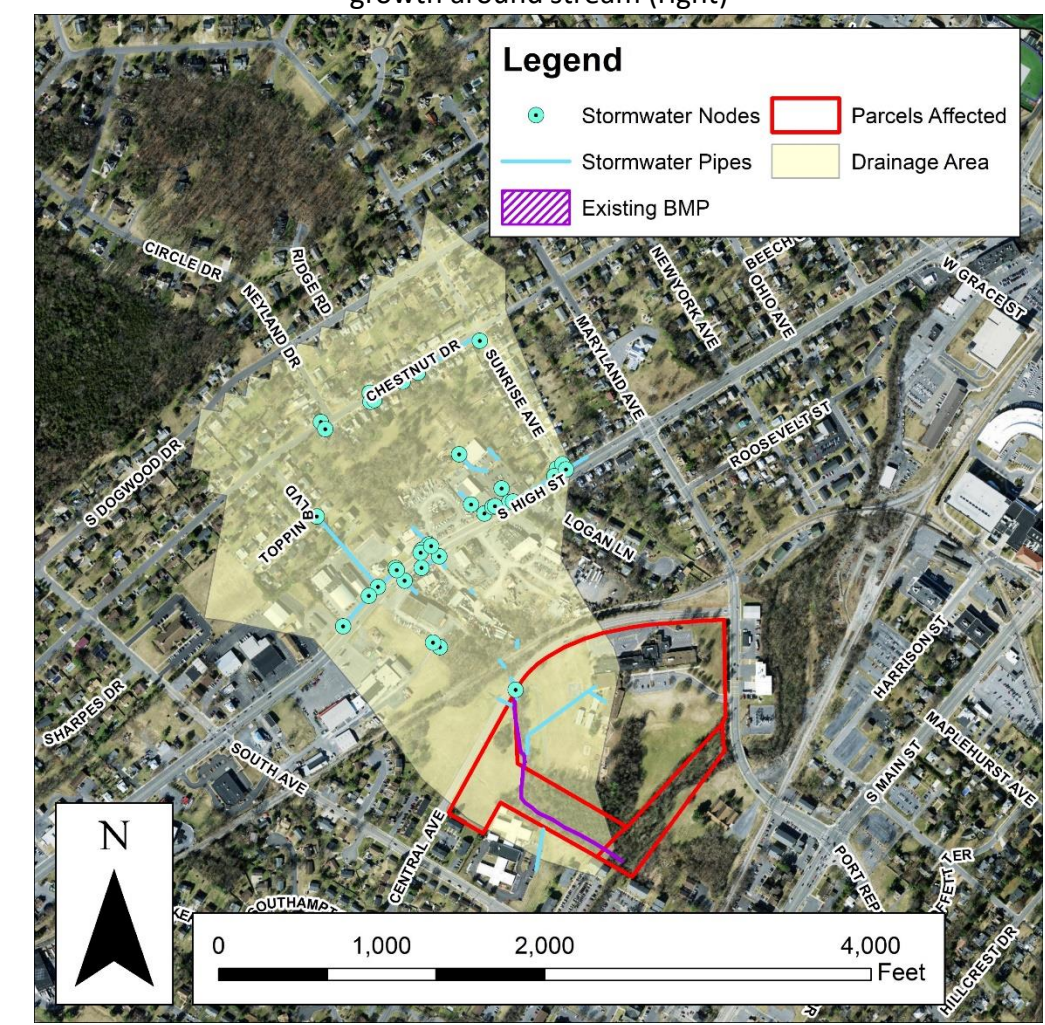


Vicinity Map

*Design characteristics are based on field observations and GIS data resources available at the time of conceptual design analysis. Final design characteristics will depend on a detailed site survey, geotechnical study, and could vary from conceptual design characteristics. Graphical site rendering presented below is for illustrative purposes only.
 **Reductions are based on recent averages from previous stream restoration projects in Harrisonburg, VA. Actual reductions will depend on existing erosion conditions.



Existing Site overall photo from school SW over track (left) and photo of over growth around stream (right)



**HB_6 STORM WATER MANAGEMENT FACILITY:
 CONCEPTUAL DESIGN: WATER QUALITY IMPROVEMENT STRATEGY STREAM
 RESTORATION**

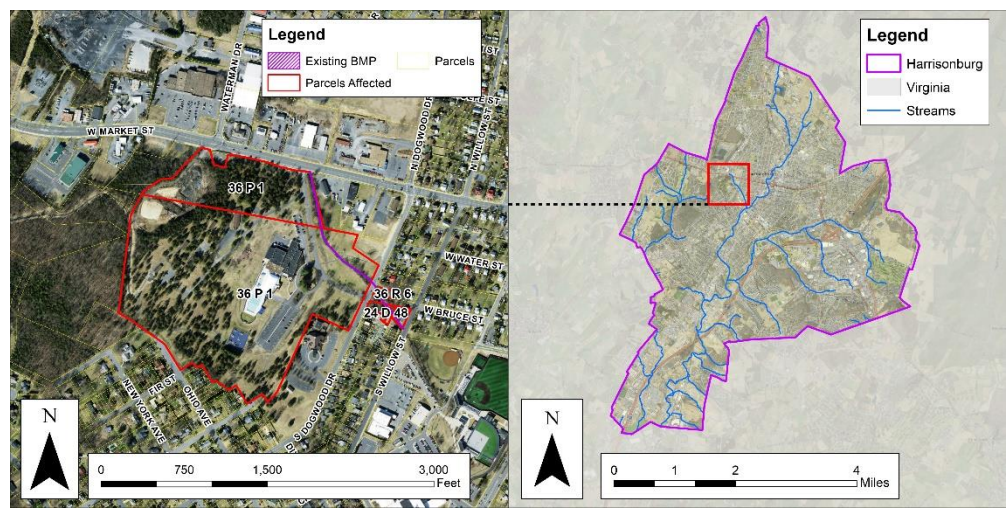


Current Site Location and Watershed Characteristics			
Date of Field Visit	07/18/2024	Latitude	38.445045°
Major Watershed	Cooks Creek	Longitude	-78.897939°
Existing Land Use	Stream	Landowner	City Property and other private properties
Street Address	305 S Dogwood Dr		
Drainage Area, Acres	826	Stream Length, ft	1,346

Design Characteristics*						
Proposed SWMF Type			Stream Restoration			
Anticipated Net Load Reduction lbs/yr	TN	366	TP	171	TSS	53,574
Annual O&M	\$5,000	Total Cost (25 years O&M)		\$1,457,000		
Design & Construction	\$1,032,000					
Land Acquisition	\$299,000					
Cost/lb Net Reduction	TN	\$4,000	TP	\$9,000	TSS	\$27

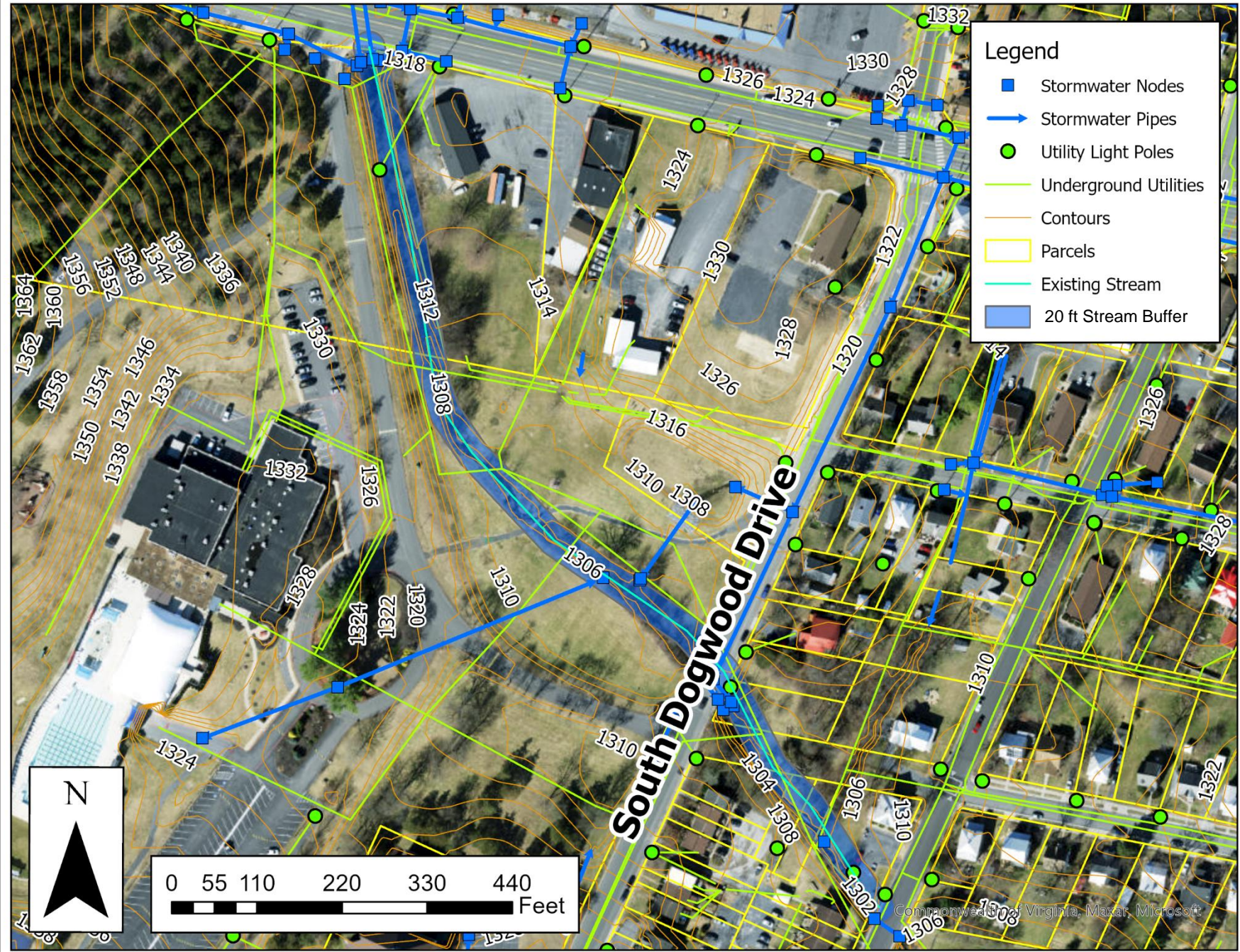
Proposed SWMF Description: Restore existing channel by reconnecting channel flow with the flood overbank area, install instream structures to control stream grade, and implement areas of riparian vegetation. Design should accommodate utility crossings. Easement acquisition is required in 7 private parcels largely downstream of Dogwood Drive. If this is not possible, that section of stream reach will be removed from the design and pollutant reduction numbers will be reevaluated.

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 **Reductions are based on recent averages from previous stream restoration projects in Harrisonburg, VA. Actual reductions will depend on existing erosion conditions.

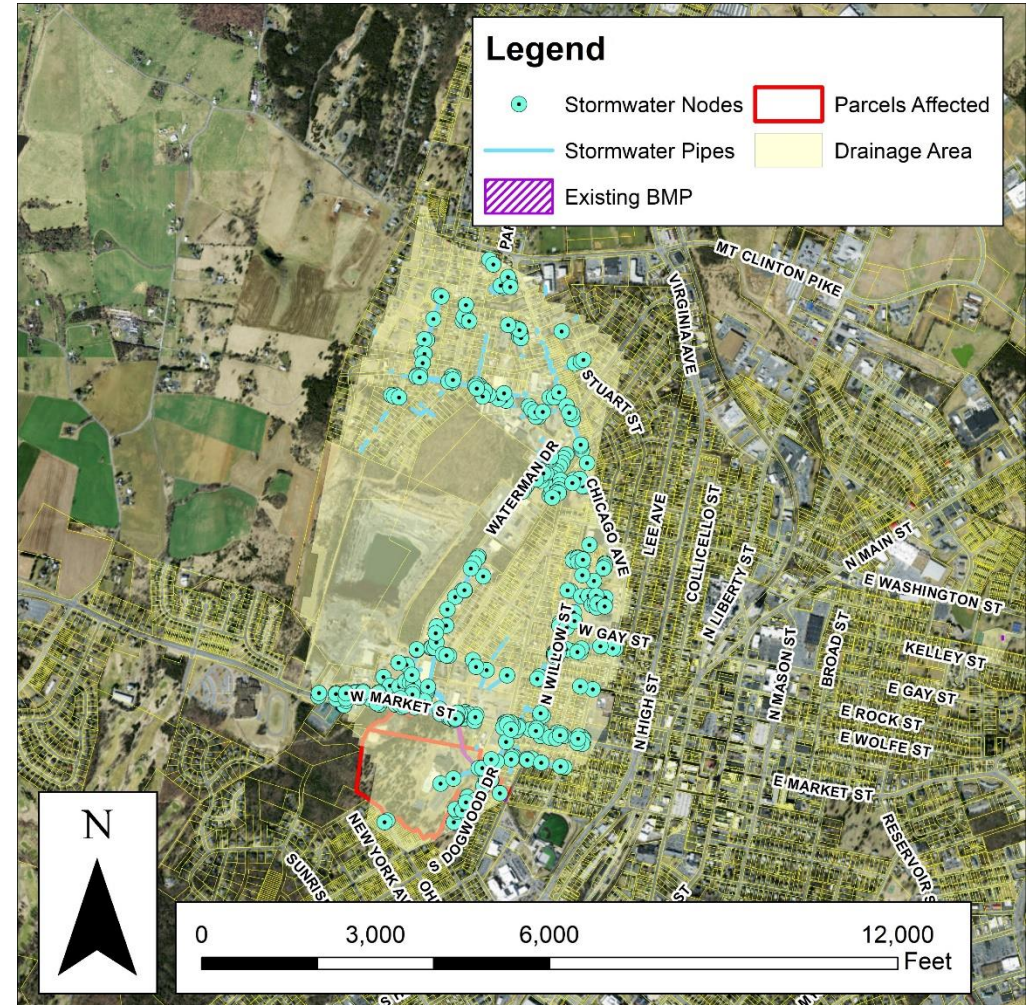


Project Area

Vicinity Map



Existing Site photos demonstrating existing bank erosion and vegetation overgrowth along stream



Current Site Location and Watershed Characteristics

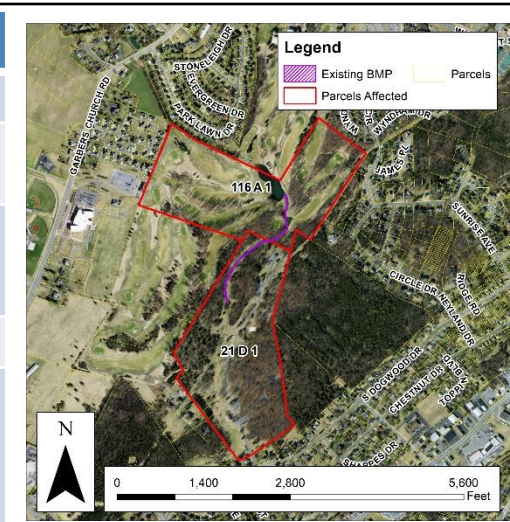
Date of Field Visit	07/18/2024	Latitude	38.445045°
Major Watershed	Cooks Creek	Longitude	-78.897939°
Existing Land Use	Stream	Landowner	City Property
Street Address	711 Hillandale Ave		
Drainage Area, Acres	612	Stream Length, ft	1,783

Existing Site Description: An existing stream in the Cooks Creek watershed on City property that runs along the Heritage Oaks golf course. Most of the stream runs along a sewer line and there is at least one underground utility crossing at the north end. Evidence of bank erosion, vegetative overgrowth, and an unprotected culvert were found onsite. Regulatory floodway.

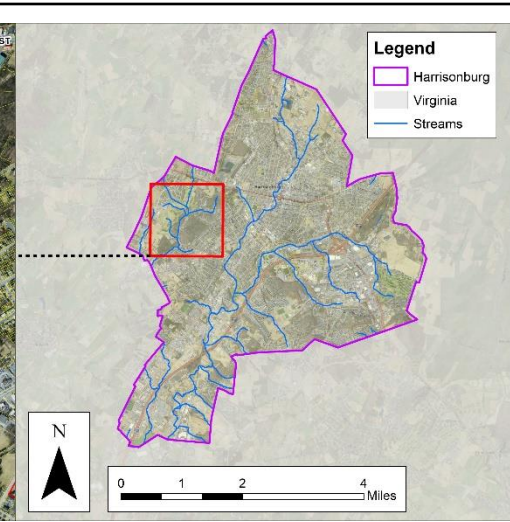
Design Characteristics*

Proposed SWMF Type	Stream Restoration					
Anticipated Net Load Reduction lbs/yr**	TN	450	TP	224	TSS	68,315
Annual O&M	\$6,000	Total Cost (25 years O&M)		\$1,254,000		
Design & Construction	\$1,104,000					
Land Acquisition	\$0					
Cost/lb Net Reduction	TN	\$3,000	TP	\$6,000	TSS	\$18

Proposed SWMF Description: Restore existing channel by reconnecting channel flow with the flood overbank area, install instream structures to control stream grade, and implement areas of riparian vegetation. Design should accommodate any utility crossings or conflicts. Restoration may impact access to golf holes/path (may need to be relocated).

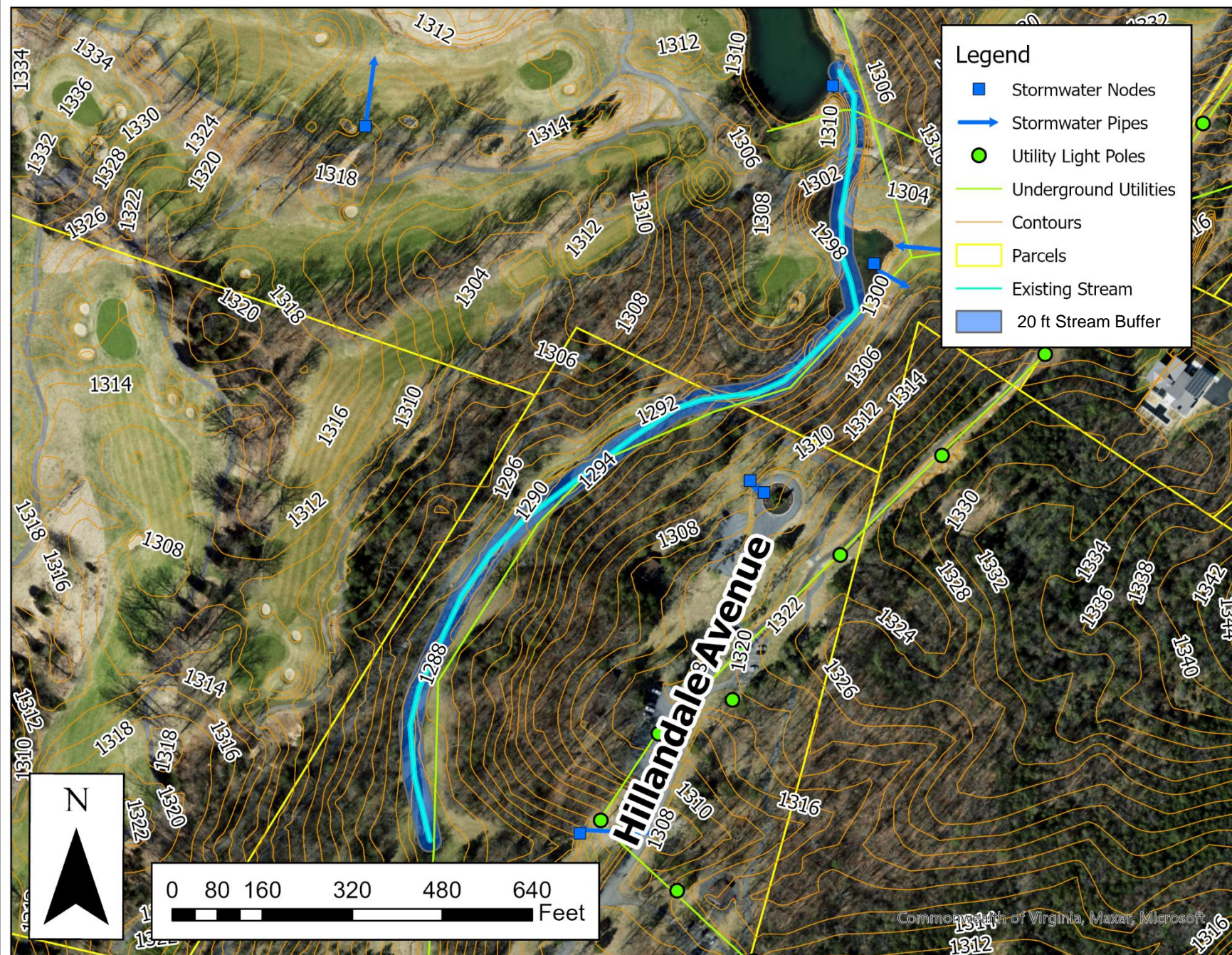


Project Area



Vicinity Map

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 **Reductions are based on recent averages from previous stream restoration projects in Harrisonburg, VA. Actual reductions will depend on existing erosion conditions.



Existing Site photos demonstrating existing bank erosion and vegetation overgrowth as well as an unprotected culvert (right)

