Double Pipe Creek Watershed Assessment
Frederick County, Maryland

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LIST OF ACRONYMS AND ABBREVIATIONS

AKRF	AKRF, Inc., Environmental, Planning, and Engineering Consultants
AOI	Area(s) of Interest
ac	Acres
BMP	Best Management Practice
bn	billion
BST	Bacteria Source Tracking
CBP	Chesapeake Bay Program

cfs	cubic feet per second
DPW	(Frederick County's) Department of Public Works
E.coli	Escheria coli
etc.	et cetera
e.g.	for example
ex.	Existing
FCSS	Frederick County Stream Survey
ft.	Foot or Feet
GIS	Geographic Information System
Inc.	Incorporated
IBI	Indicator of Biological Integrity
LF	Linear Foot or Linear Feet
lbs.	Pounds
MBSS	Maryland Biological Stream Survey
MD	Maryland
MDE	Maryland Department of the Environment
MEP	Maximum Extent Practicable
MERLIN	Maryland's Environmental Resources and Land Information Network
mm	Millimeter(s)
MPN	Most Probable Number
MPR	Maximum Practical Reduction
MS4	Municipal Separate Storm Sewer System
N/A	Not Applicable
NAD	North American Datum
No.	Number
NPDES	National Pollutant Discharge Elimination System
OSER	(Frederick County's) Office of Sustainability and Environmental Resources
PVC	Polyvinyl Chloride
ROW or R/W	Right of Way
RR	Runoff Reduction
SPSC	Step-Pool Stormwater Conveyance
Sq. ft.	Square Foot or Square Feet
SSO	Sanitary Sewer Overflow
SR	State Route

ST	Storm Water Treatment
SW-WLAs	Stormwater Waste Load Allocation
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TP	Total Phosphorous
TN	Total Nitrogen
Yr.	Year

EXECUTIVE SUMMARY

Frederick County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase I Permit, Chesapeake Bay Total Maximum Daily Load (TMDL), and local watershed TMDLs, require the County to identify and prioritize structural and nonstructural water quality improvement projects within its watersheds. Specifically, the County's NPDES MS4 Phase I Permit requires the County to develop detailed watershed assessments for each of its Maryland Department of the Environment- (MDE)-designated hierarchical eight-digit sub-basins located within the entire County. These assessments must identify and rank projects geared towards meeting applicable pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater Waste Load Allocations (WLAs). The goal of this Double Pipe Creek Watershed Assessment is to provide a roadmap to use strategic restoration efforts for meeting NPDES MS4 Phase I and Chesapeake Bay TMDL requirements in the most cost-effective manner and to improve water quality.

In 2018, AKRF, Inc. conducted an assessment of the Frederick County portion of the Double Pipe Creek Watershed to identify and develop specific restoration opportunities to meet the NPDES MS4 permit and TMDL requirements. AKRF applied the County's project prioritization matrix to compare and rank each potential restoration area. The goal of the assessment was to identify the stream and watershed restoration opportunities that will achieve the greatest water quality improvements, including pollutant and sediment load reductions, at the most cost-efficient means.

AKRF completed an initial desktop review of available GIS data and online resources to locate areas for potential stream and watershed improvements. AKRF identified 109 areas of interest (AOIs) for potential in-stream improvements, upland stormwater Best Management Practices (BMPs), or structural stormwater retrofits. Through further desktop assessment, application of the County's prioritization matrix, and discussion with the County's Office of Sustainability and Environment (OSER) personnel, 38 of these AOIs were selected for preliminary field assessments.

AKRF team members performed preliminary assessments in May and June 2018, at the top priority sites, to field truth the findings of the desktop review and gather additional site-specific information to inform potential project design. Based on the information obtained during the field assessments and stakeholder input, AKRF removed several of the AOIs from consideration and combined several adjacent AOIs to form more cohesive potential project opportunities. Potential projects were developed based on multiple factors, including the prioritization of specific study sites with identified impairments of concern, feasibility of implementation, and the potential for ecological and biological uplift of the watershed. AKRF developed 30 potential opportunity sites consisting of the following individual practices, (some of which are lumped together at certain sites):

- 25 stream restoration projects (i.e. streambank stabilization, floodplain reconnection, and/or riparian buffer planting);
- 2 regenerative step-pool stormwater conveyance (SPSC) projects;
- 3 vegetated swales with check dams.

For each of the 30 proposed restoration concept sites, AKRF performed an assessment of pollutant load reductions, impervious surface treatment area, planning-level (order-of-magnitude) cost estimates for cost-benefit analysis, and potential opportunity ranking. Based on the cost-benefit analysis, AKRF and OSER identified three stream restoration projects that should be considered the top priority projects for implementation. The projects total nearly 14,000 linear feet (LF) of stream restoration work and approximately 6.5 acres of riparian buffer tree plantings, and account for more than 100 percent of the County's TMDL requirements for the Double Pipe Creek Watershed. Pollutant reduction estimates (Edge of Stream) for the feasibility concept projects sum to 3,415 lbs/year of Total Nitrogen, 3,096 lbs/year of

Total Phosphorus, and 2,043,258 lbs/year of Sediment. The estimated cost of implementing these restoration projects is $26,956,213. In addition, this watershed assessment assists the County in its future planning and implementations to improve water quality within the Double Pipe Creek Watershed. To meet its local TMDLs, the County will need to implement 11,741 linear feet of stream, 32.80 acres of riparian buffers, and 36 septic repairs and upgrades.

1. INTRODUCTION

1.1 PURPOSE OF WATERSHED STUDY

Frederick County's National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Phase I Permit, Chesapeake Bay Total Maximum Daily Load (TMDL), and local watershed TMDLs, require the County to improve water quality conditions within its watersheds. Specifically, the County's NPDES MS4 Phase I Permit requires the County to develop detailed watershed assessments for the entire County and restore twenty percent (20%) of the impervious area that is not already restored to the maximum extent practicable (MEP).

The goal of this Double Pipe Creek Watershed Assessment is to provide a plan for Frederick County to meet the NPDES MS4 Phase I and Chesapeake Bay TMDL requirements within the Double Pipe Creek watershed, Maryland Department of the Environment (MDE) 8 Digit Watershed #02140304. This watershed assessment identifies and prioritizes potential stormwater best management practices (BMPs) and stream restoration projects required to meet Frederick County's MS4 and TMDL requirements. Concept design plans, planning level (order-of-magnitude) cost estimates, and pollutant load removal estimates from the treated drainage areas were developed for all potential opportunities using the best available guidance and expert panel approved recommendations, to identify the highest priority projects to be implemented by the County to meet the NPDES MS4 Phase I and Chesapeake Bay TMDL requirements.

A conceptual graphic illustrating the watershed assessment process is provided as **Figure 1**.

Figure 1: General Overview of Watershed Assessment Process

1.2 WATERSHED STUDY OBJECTIVES

This Double Pipe Creek Watershed Assessment (covering the portion of the 8-digit State watershed within Frederick County also known as Little Pipe Creek Watershed – see **Figure 2**, below) will further the County's watershed restoration efforts and meet the following requirements (as stated in Part IV.E.1 of the Frederick County NPDES Permit):

- Determine current water quality conditions;
- Include the results of a visual watershed inspection;
- Identify and rank water quality problems;
- Prioritize all structural and nonstructural water quality improvement projects; and
- Specify pollutant load reduction benchmarks and deadlines that demonstrate progress toward meeting all applicable stormwater WLAs.

This Watershed Assessment, therefore, includes the following components to meet all the requirements of the NPDES permit and in how the County will meet individual watershed TMDL goals through:

- Preliminary watershed assessment;
- Desktop site assessment;
- Field site assessment;
- Evaluation and ranking of restoration projects;
- Concept design plans for high priority projects; and
- Pollutant load reduction estimates toward meeting TMDLs.

2. EXISTING WATERSHED CONDITIONS AND POLLUTANT LOADS

The Double Pipe Creek Watershed, MDE 8 Digit Watershed #02140304, is approximately 123,264 acres and is situated in both the State of Maryland and the Commonwealth of Pennsylvania. Within Maryland, it lies within both Frederick and Carroll Counties, and is part of the Monocacy River Basin, which drains to the Potomac River Basin (**Figure 2**). This watershed assessment is limited to the portion of the Double Pipe Creek Watershed within Frederick County comprising approximately 18,000 acres or 28 square miles, hereafter called the "watershed". The Frederick County portion of Double Pipe Creek Watershed includes small unincorporated communities including Clemsonville, Johnsville, and Ladiesburg.

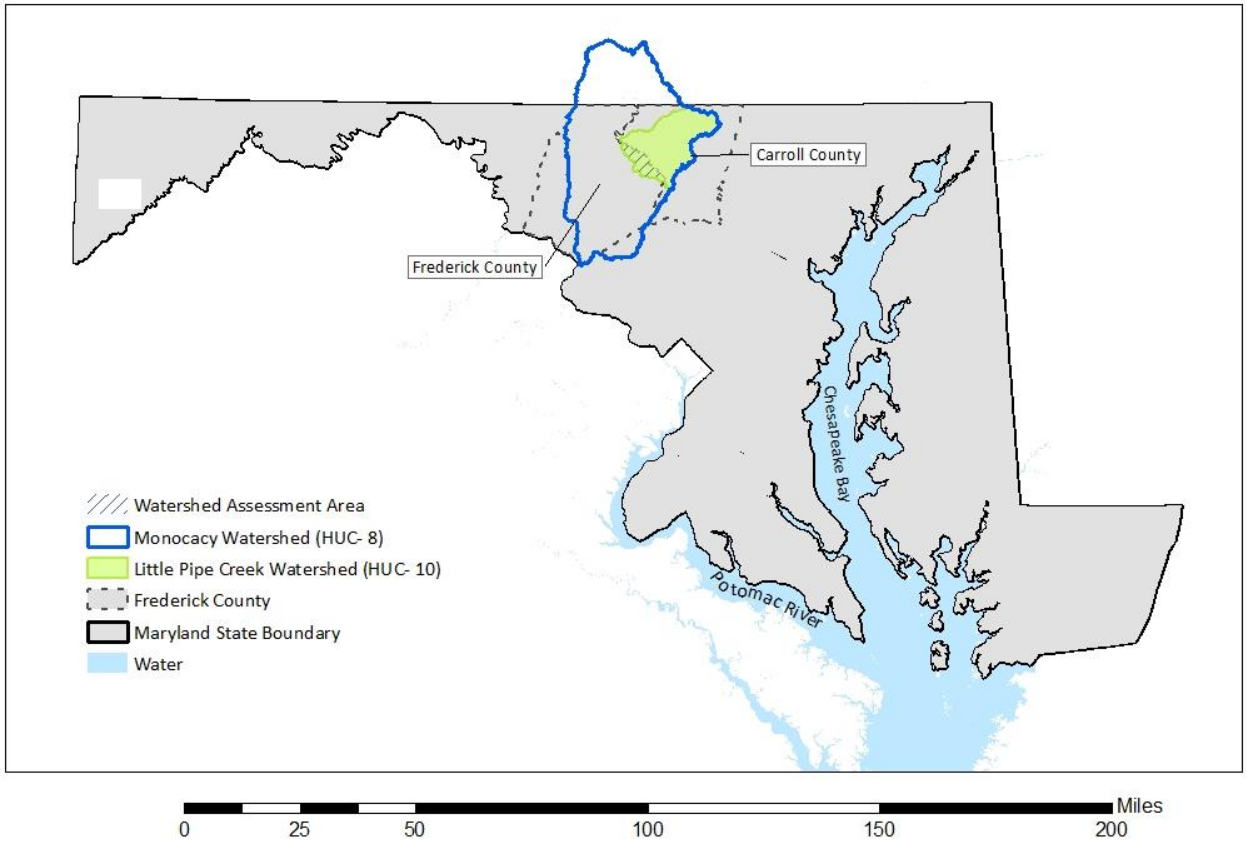


Figure 2. Watershed Assessment Area.

Frederick County's portion of Double Pipe watershed contains approximately 64 miles of streams. Double Pipe Creek is known by three different names depending on its position in Frederick County's portion of the watershed. At the highest elevations in the south, it is known as Sam's Creek. Downstream of Union Bridge (which lies in Carroll County, Maryland), it is known as Little Pipe Creek. Immediately upstream of the confluence with Monocacy Creek, it is known as Double Pipe Creek. Three major tributaries flow into Sam's/Little Pipe/Double Pipe Creek, including Clemson Branch, Haines Branch, and Beaver Dam Creek (**Figure 3**). This watershed assessment only focused on the Frederick County portion of Double Pipe Creek.

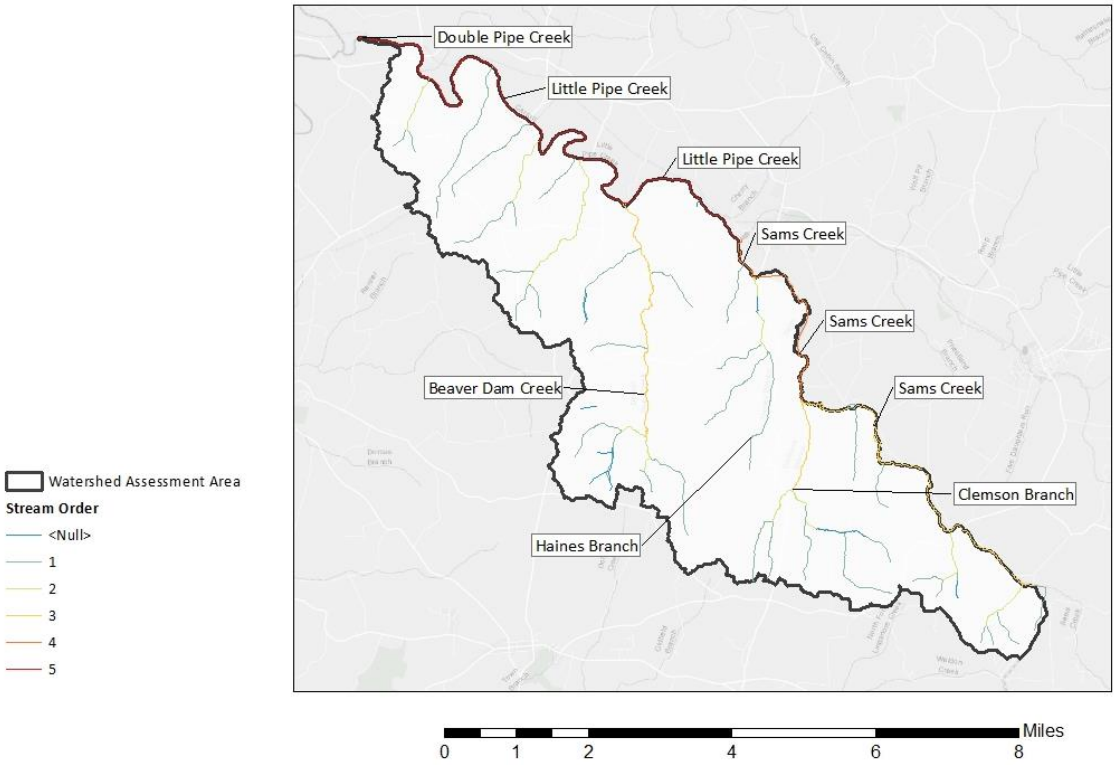


Figure 3. Subwatersheds within Watershed Assessment Area.

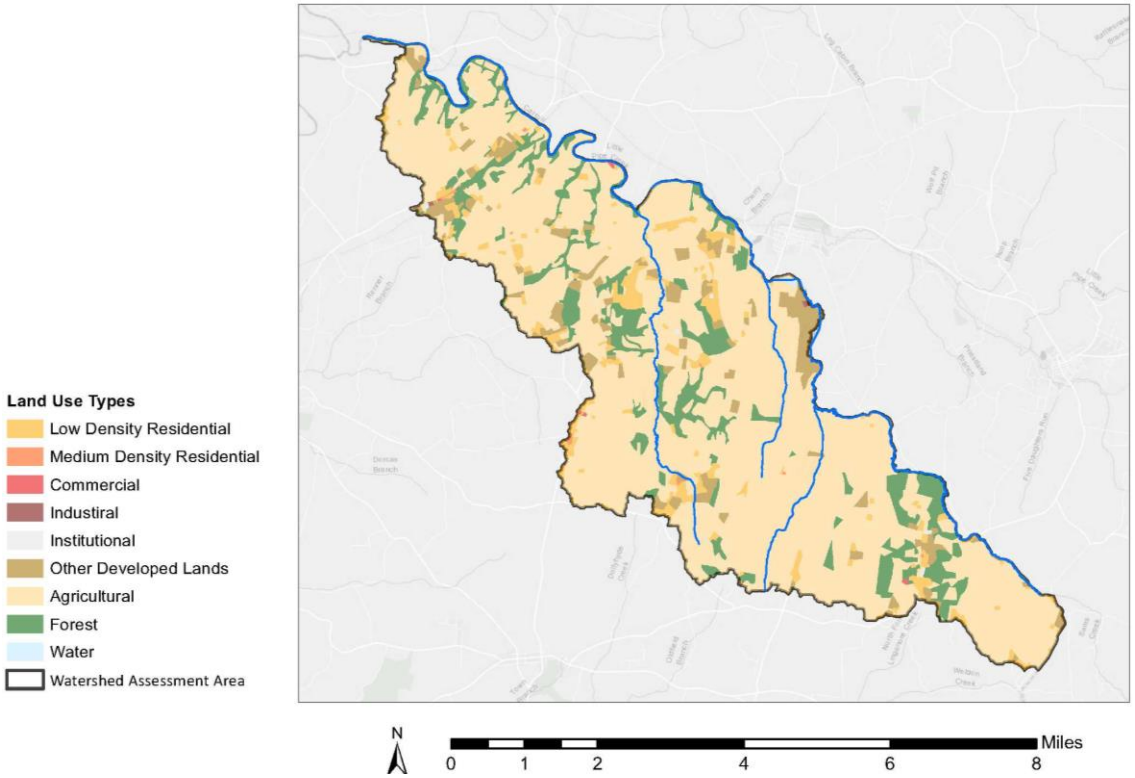


Figure 4. Land Use within Watershed Assessment Area.

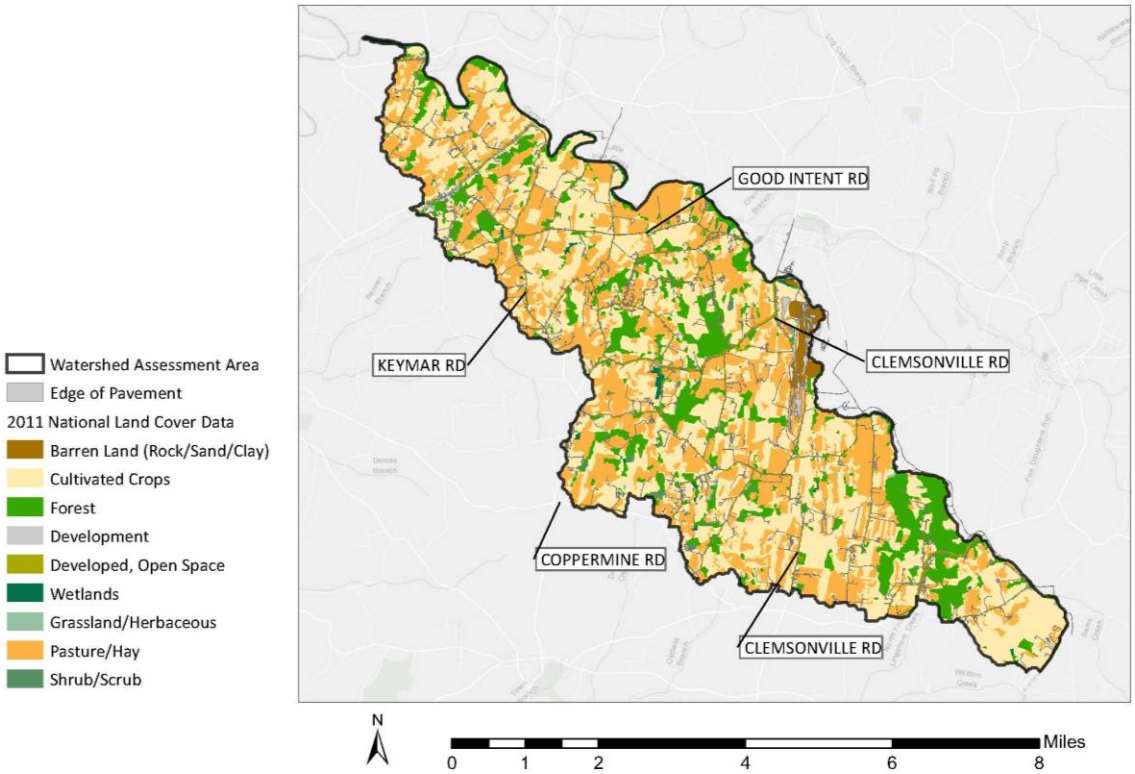


Figure 5. Land Cover within Watershed Assessment Area.

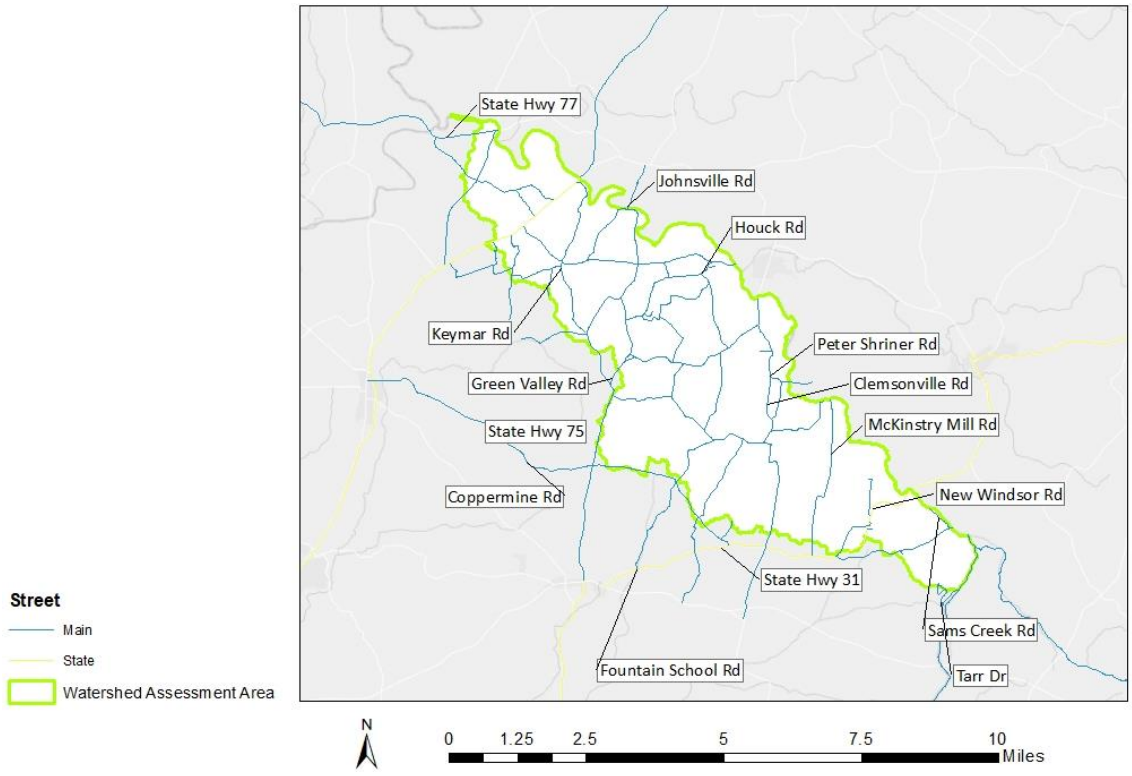


Figure 6. Major Transportation Features within Watershed Assessment Area.

Double Pipe Creek has TMDLs for phosphorus, sediment, and bacteria (**Figure 7**). The Baseline year for the Double Pipe Creek Sediment TMDL was 2000 and the TMDL requires a 46.8% reduction from baseline. The Baseline year for the Double Pipe Creek phosphorus TMDL was 2009 and the TMDL requires a 73.0% reduction from the baseline load. The December 2018 Frederick County Stormwater Restoration Plan describes cumulative treatments in the completed, programmed, identified, and potential tiers that will meet the portion of the TMDLs within the Frederick County Stormwater Wasteload Allocation (Frederick County, December 2018a). Based on the County's projections, the local and Chesapeake Bay TMDLs that the County is subject to will be met by 2040 and 2038, respectively.

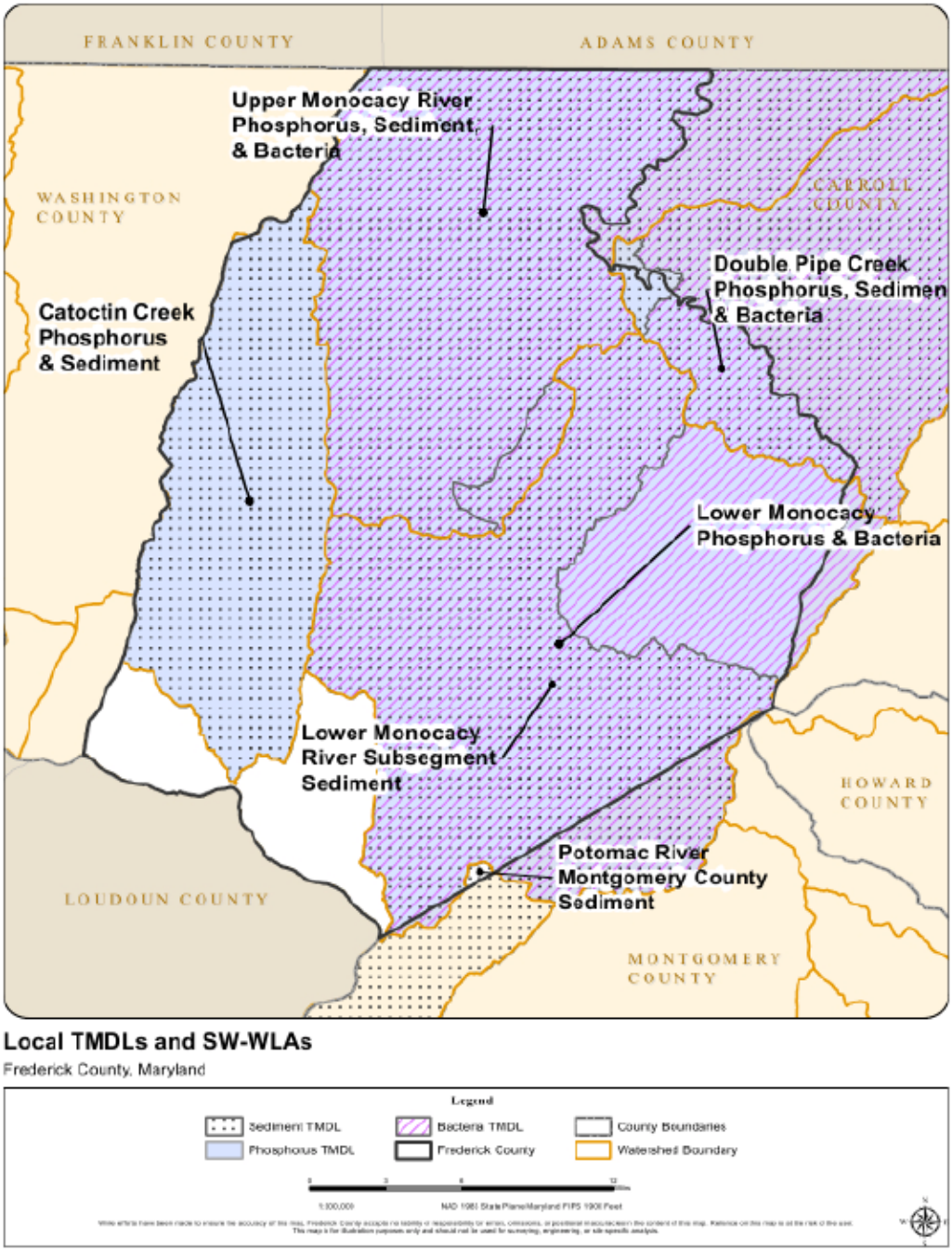


Figure 7. TMDLs and SW-WLAs by Watershed. Double Pipe Creek has TMDLs for Phosphorous (TP), Sediment (TSS), and Bacteria (*E.coli*). Source: Frederick County December 2018a.

3. METHODOLOGY AND PRELIMINARY RESULTS

3.1 UTILIZATION OF WATERSHED GUIDANCE DOCUMENT

Frederick County OSER issued a Watershed Study Guidance document in September 2017 to identify the watershed assessment goals and outline the methodology for all consultants to follow for watershed assessments and the identification of potential BMP opportunities. AKRF utilized this document and the geographic information systems (GIS) resources identified therein as a starting place for the watershed assessment and potential BMP site identification.

Based on the guidance document, stormwater pond management, regenerative step-pool stormwater conveyance, and stream restoration opportunities were intended to primarily target the areas where the Frederick County Stream Survey (FCSS) and Maryland Biological Stream Survey (MBSS) monitoring sites scored low in all four of the key stressors identified by the FCSS: Land Use, Habitat, Water Quality, and Biological Condition. Additionally, the Index of Biotic Integrity (IBI) Score and Stream Bank Erosion data included in the FCSS were used to identify any potential "hotspots" where the stream appears to be reacting to uncontrolled stormwater runoff. Finally, the County provided "Potential Opportunity" locations where the County had previously identified potential BMPs; these were to be assessed (or reassessed) following the County's guidance document and prioritization matrix. During the course of the watershed assessment, if stormwater facilities were identified which did not have a BMP location or where the drainage areas were outside the jurisdiction, they were to be flagged to add to the County's list.

Due to the presence of other studies on County-owned property and limited quantity of private stormwater facilities in this watershed (four BMPs at three facilities), stormwater pond retrofit opportunities were very limited, through the guidance document, to those opportunities that were not located on County-owned property and did not meet MDE's August 2014 guidance for MS4 credit. These criteria were not met within the Double Pipe Creek Watershed, so no stormwater pond retrofit opportunities were pursued. New stormwater pond opportunities were also not pursued within the watershed. The guidance document for the study instructed consultants to identify drainage areas to existing storm drain networks that are not associated with a stormwater facility. However, the rural nature of the watershed limited the prevalence of storm drain networks, and there were no locations where large volumes of uncontrolled runoff could be captured in sufficient quantities to support a stormwater pond, which require ten (10) or more acres of drainage area for stormwater treatment credit, in accordance with the MDE Stormwater Management Design Manual (2000). The guidance document stated: "If possible, consider stormwater ponds first if there is available space, Regenerative Step-Pool Stormwater Conveyance second, and sand filter or bioretention facilities last."

For stream restoration BMPs, the watershed study guidance document recommended utilizing the FCSS sample data to identify impaired stream sites as starting points for potential restoration reaches. Additionally, the County recommended evaluation of the streams located near other potential opportunities found in this watershed study, as well as other stormwater management retrofits that are actively under design or construction.

The County also provided prioritization matrices to use in the ranking of potential BMP sites and stream restoration sites (**Appendix C**). Site constraints such as easement acquisition, tree impacts, Forest Resource Ordinance Easement impacts, and utility impacts were considered in the feasibility of each potential project. Projects that were ranked in the highest tiers were selected to move forward into a 15% conceptual design after OSER's concurrence.

The watershed guidance assumed a target of about 40 concepts in total, with 25 stormwater pond retrofits, 5 new stormwater facilities, 4 stream restoration reaches, and 6 regenerative step-pool stormwater conveyance restoration practices. However, the County and AKRF recognized that there may be certain situations where the concept type may need to be modified based on the available potential opportunities found in the Double Pipe Creek watershed. During the desktop analysis, it was quickly determined that the Double Pipe Creek watershed presents different opportunities for BMPs than those typical to other watersheds; this is discussed in greater detail below.

3.2 PRELIMINARY WATERSHED ASSESSMENT

The preliminary watershed assessment began with a GIS analysis of the watershed and its component resources, as summarized below and shown on the following GIS maps of each resource. The full set of GIS maps are included in **Appendix A**.

1. *Project Area*
   The Little Pipe Creek Watershed, located in Frederick and Carroll Counties, Maryland is part of the Double Pipe Creek Watershed system. Regionally, this area is located within the Monocacy River Basin, which drains to the Potomac River Basin then into the Chesapeake Bay. The watershed assessment area was limited to only the portion of Double Pipe Creek that is located within Frederick County. This region is approximately 28 square miles in size. See **Figure 2**.

2. *Watershed/Subwatershed*
   The watershed contains approximately 64 miles of streams (National Hydrography Dataset - 24k USDA/NRCS, 2016). The main stem (MDE 8 Digit Watershed #02140303) is known by three different names; Sam's Creek in the upper reach, Little Pipe Creek in the middle reach, and Double Pipe Creek in the lowest reach. The Frederick County portion of the main stem watershed is subdivided into four Maryland Department of the Environment (DNR) 12 Digit Watersheds, listed from north to south: #021403040274; #021403040270; #021403040269; and #021403040268. See **Figure 3**.

3. *Land Use*

   Land use within the watershed is 76 percent Agricultural, 12 percent Forested, 5 percent Low Density Residential, and 6 percent classified as Other Developed Lands (Land Use Land Cover Data Set, 2011). See **Figure 4**.

4. *Land Cover*

   Land cover consists primarily of Cropland, Pasture/Hay, and Deciduous Forest (2011 National Land Cover Data Set, 2011). Only 4 percent of the watershed is defined as Developed. See **Figure 5**.

5. *Transportation*

   The majority of the street network within the watershed consists of Local, Neighborhood, and Rural Roads (U.S. Census TIGER Streets, 2016). Remaining streets are classified as Secondary and Connecting Roads or Roads as Other Thoroughfare. There are approximately 370 miles of state highway roadways and 1,150 miles of County roadways within this watershed. See **Figure 6**.

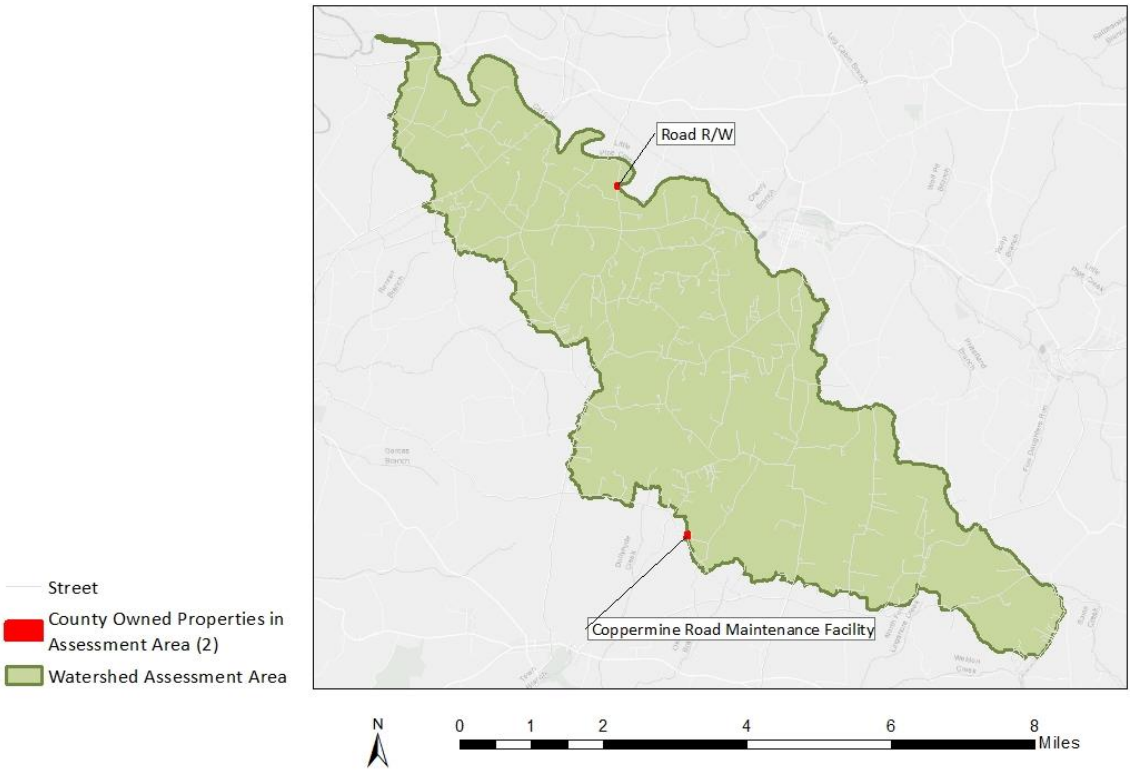


Figure 8. County-Owned Stormwater Management Facilities within Watershed Assessment Area.

6. County Owned Properties

Within the watershed, only two County-owned properties were identified. One site is located in the northernmost section, and the second is located in the southernmost region of the watershed. The addresses of these facilities are shown in **Table 1** below. See .

Table 1. County-Owned Stormwater Managment Facilities.

Facility Name	**Address**	**City, Zip Code**
Coppermine Road Maintenance Facility	13260-13200 Coppermine Rd	Union Bridge, MD 21791
Road R/W	12379-12699 Simpsons Mill Rd	Keymar, MD 21757

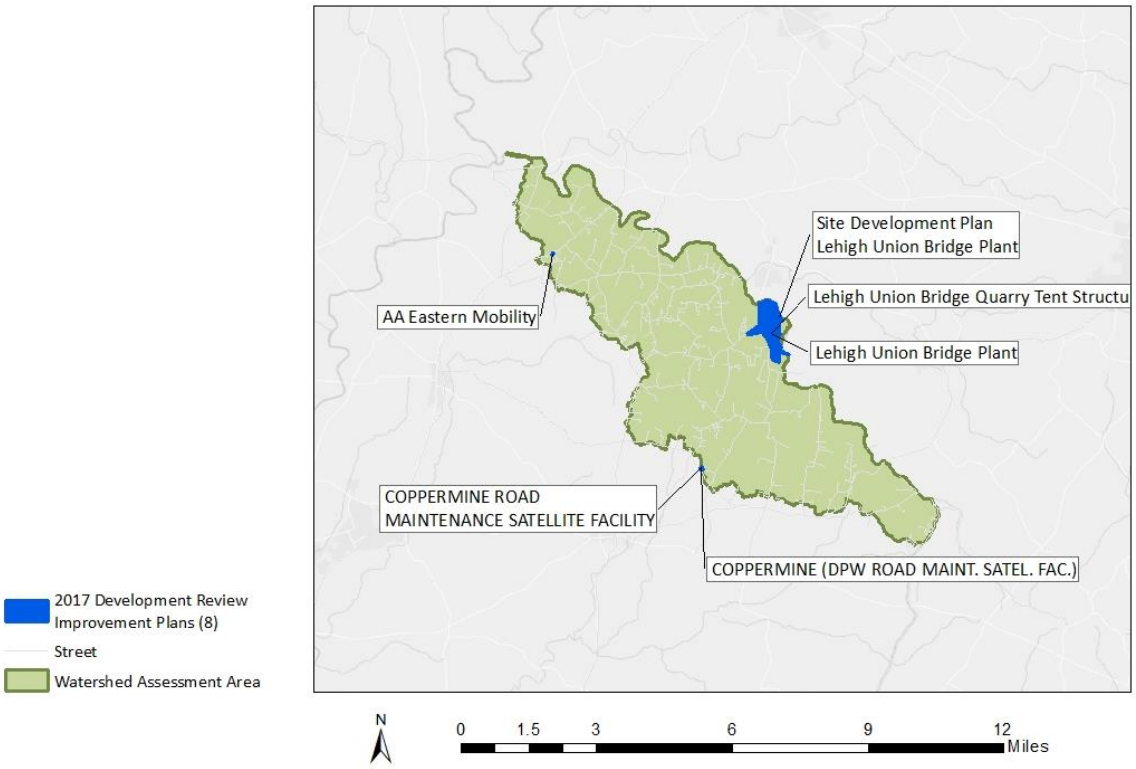


Figure 9. Development Review Improvement Plans (2017) within Watershed Assessment Area.

7. Development Review Improvement Plans

There are eight (8) Development Review Improvement Plans documented within the watershed (Frederick County, 2017). These plans describe proposed new development areas, and may include buildings and/or infrastructure. See .

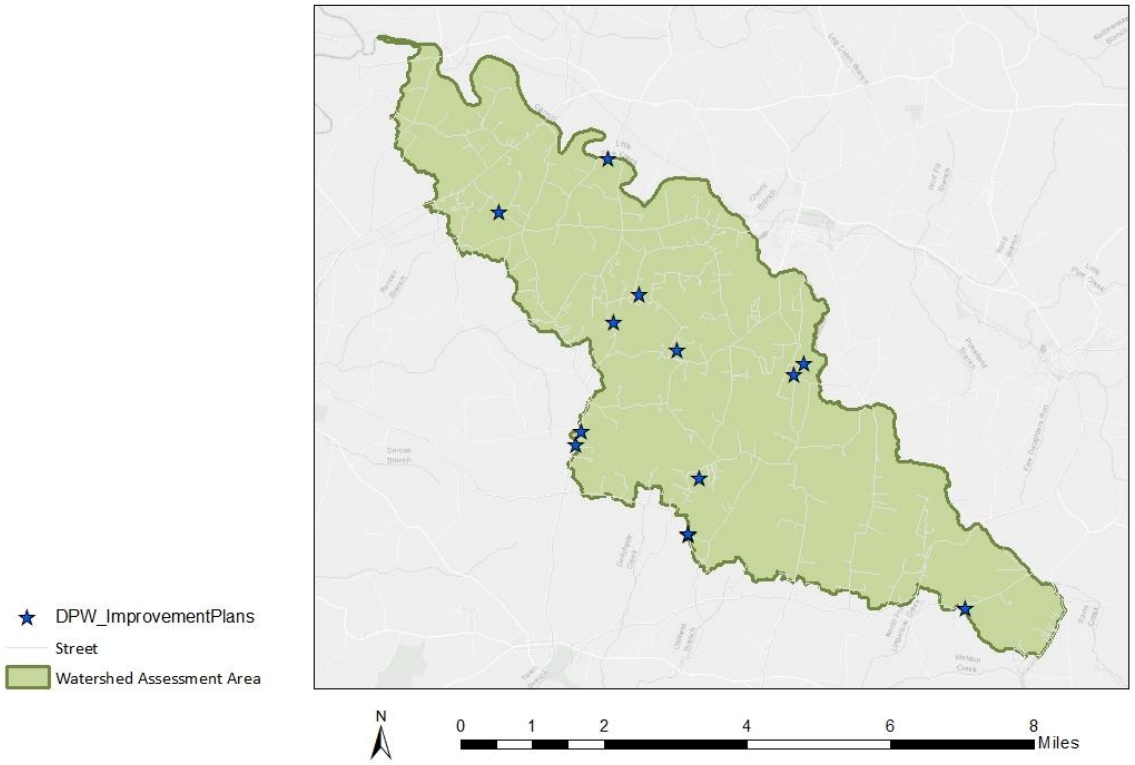


Figure 10. Frederick County DPW Improvement Plan Locations within Watershed Assessment Area.

8. Division of Public Works Improvement Plans

There are 13 Division of Public Works (DPW) Improvement Plans mapped within the watershed (Frederick County, 2017). DPW is the implementing agency responsible for the planning, design, and construction for improvements to the county road and bridge network. This map layer consists of funded DPW Capital Improvement Program (CIP) projects. See .

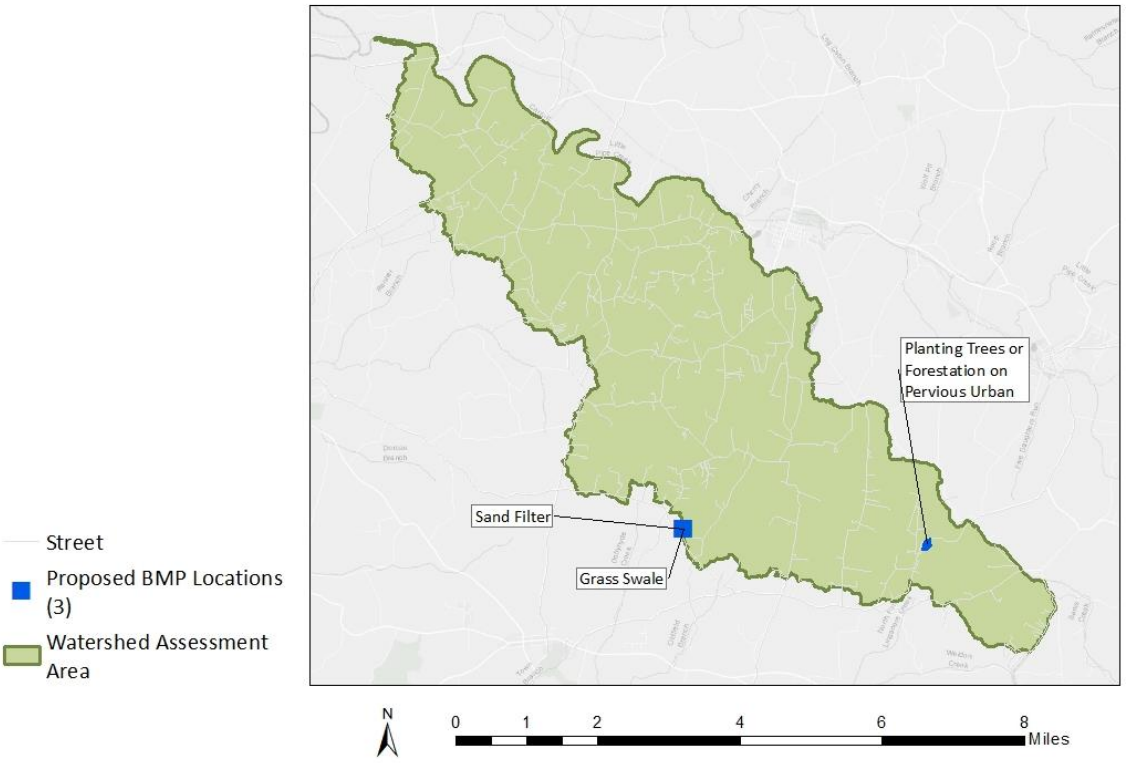


Figure 11. NPDES MS4 Compliance: County-Identified Potential BMP Opportunities within Watershed Assessment Area.

9. NPDES Potential Opportunities

In meeting its NPDES MS4 stormwater permit as well as local and Chesapeake Bay TMDL requirements, Frederick County has identified areas for potential stormwater best management practices (BMPs) and stream restoration opportunities. These opportunities aim to improve stormwater controls and stream conditions within the watershed. The County previously identified three (3) potential BMP types: Sand filter, Grass Swale, and Planting Trees or Forestation on Pervious Urban. See .

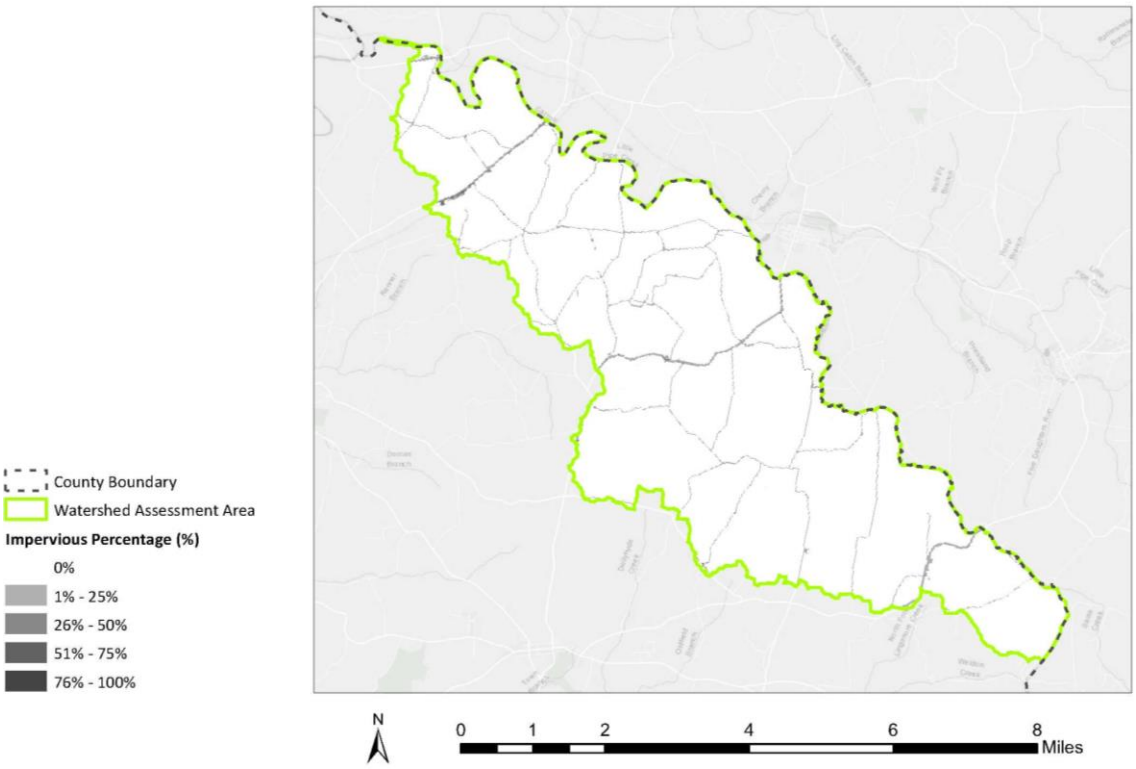


Figure 12. Impervious Areas within Watershed Assessment Area.

10. Impervious and Pervious Cover

Impervious land cover makes up only 5 percent of the total land cover within the watershed (National Land Cover Data Set, 2011). Pervious cover makes up the other 95 percent of the total land cover. See .

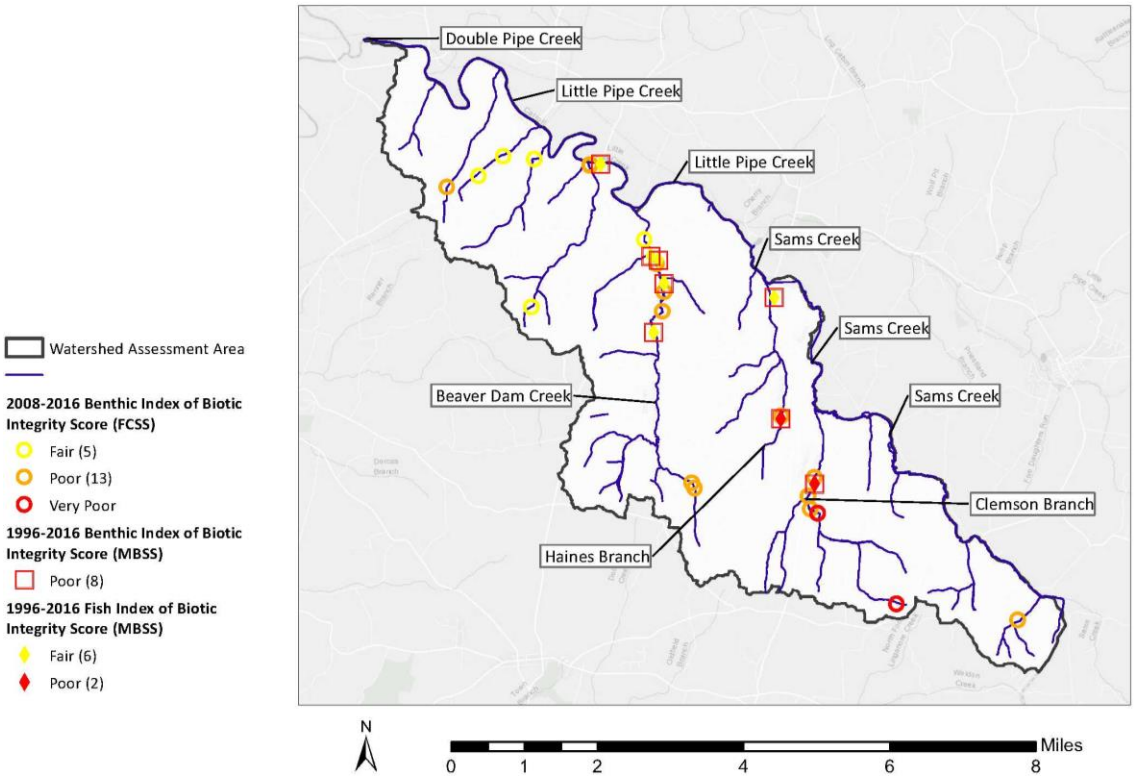


Figure 13. FCSS and MBSS Benthic Sampling within Watershed Assessment Area.

11. Frederick County Stream Survey and Maryland Biological Stream Survey Assessments

The FCSS and MBSS conducted benthic macroinvertebrate sampling at 28 stream sites within the watershed since 1996 (FCSS, 2008-2016; MBSS, 1996-2016). During this time the MBSS also conducted sampling of indicator fish species at 8 stream sites. Based on an assessment of community-level metrics, stream sites were assigned an Index of Biological Integrity (IBI) score, which corresponds to a rating of Good, Fair, Poor, or Very Poor. Of the sites assessed, 5 sites were rated in Fair condition, 21 were rated in Poor condition, and 2 were rated in Very Poor condition. See .

3.3 DESKTOP SITE ASSESSMENT

The desktop site assessment identified opportunities to implement stream restoration and stormwater BMPs in the watershed using the GIS data described in the preliminary watershed assessment. Selected opportunity sites were evaluated in terms of ranking criteria developed by Frederick County. The evaluation and ranking process is outlined below. Opportunity site locations are presented with associated ranking criteria and final scoring in tabular format below, and the full evaluation and ranking process is outlined in **Appendix C**.

Stream Restoration Opportunities

Streams that included FCSS and MBSS sample sites with a rating of Fair, Poor, or Very Poor were identified as preliminary opportunities for stream restoration (). The extents of stream reaches of interest were initially defined by upper and lower grade controls at road crossings (bridges and culverts). After discussion with Frederick County personnel, ten (10) additional reaches were added to the preliminary desktop assessment, based on the County's knowledge of the land owners and field conditions. The 50 opportunity reaches were

scattered throughout the watershed and are of varying stream orders. A preliminary prioritization was conducted as outlined below.

Prioritization Matrix

Frederick County has established a stream restoration prioritization matrix for use in ranking and selecting potential stream restoration opportunities. The matrix consists of 20 criteria grouped into 4 sub-categories: Nutrient and Impervious Acre Credits, Costs, Construction, and Community and Watershed Impacts. Each of the 20 criteria is divided into descriptive categories that are assigned rankings from one to three, with three being the best score. A weight is assigned to each component, to create a weighted ranking; the total maximum possible stream restoration ranking score is 180.

The following criteria were evaluated via this desktop site assessment:

- **Estimated nutrient reduction – total nitrogen (TN), total phosphorous (TP), total suspended sediments (TSS)**
    - Used approved Interim Rates as defined by the Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects which includes rates of nutrient reduction, in pounds per linear foot (LF) of restored stream per year
- **Linear feet of stream restored**
    - Determined from the National Hydrology Dataset stream lines and refined based on aerial imagery
- **Impervious acre credits**
    - Based on the impervious acre equivalent of 0.01 acres per Linear Foot
- **Cost estimates – planning costs, costs per pound of TN removed, costs per pound of TP removed, costs per pound of TSS removed, and costs per impervious area credit**
    - Used County's average construction cost of $350 per LF, and average planning level cost of 32% of the construction cost (or $112 per LF)
- **Conflicts, such as utility conflicts and large impacts to healthy riparian and upland habitats**
    - Used the County-provided stormwater and sewer layers, delineated riparian and upland habitats using the National Land Cover Dataset and aerial imager
- **Constructability or site access issues**
    - Criteria evaluated includes: site topography, wetland impacts, distance from road, and vegetation clearing needs
- **Property ownership and easement requirements**
    - Used a tax parcel GIS layer and County-provided GIS layers showing existing easements within the watershed. Easements include the Agricultural Land Preservation Program's Conservation Reserve Enhancement Program (CREP), Frederick County's Critical Farms program, Frederick County's Installment Purchase Program (IPP), the Maryland Environmental Trust (MET), and the Maryland Agricultural Land Preservation Foundation Easements (MALPF) Easements and districts
    - Determined how many parcels would be involved per project. The larger amount of property owner coordination the harder the project may be to quickly implement.
- **Proximity of the sites to the Forest Resource Ordinance (FRO) areas**
    - Used the Frederick County "Forest Resource" GIS layer
    - None of the proposed stream reaches were within an FRO area
- **Proximity of BMPs to the stream restoration projects**

  - Used the Frederick County NPDES BMP geodatabase and the new geodatabase AKRF populated for the potential stormwater BMPs identified as part of this watershed assessment

- **Land use within the stream's watershed**
  - Rated as sensitive, impacted, or damaged
  - All sub-watersheds were evaluated as being damaged; all have over 70% agricultural land, with very little forested land (typically less than 20%)
- **FCSS and MBSS Indices of Biotic Integrity (IBIs)**
  - Frederick County provided the FCSS data for 2006 to 2016, while the MBSS data was provided by MDNR and covered sample years 1996 to 2016
  - The Benthic invertebrate Index of Biological Integrity (BIBI) and Fish Index of Biological Integrity (FIBI) were utilized where possible
  - Each potential site identified by AKRF had either FCSS or MBSS samples, while those recommended by the County were along stream reaches without sample data.

The remaining ranking criteria (floodplain connectivity, lateral stability of the stream channel, and functional lift potential) were evaluated following the field site assessment, and are discussed further below. For purposes of the desktop assessment, each site received a preliminary score of 0 for the above three ranking criteria.

Stormwater BMP Opportunities

Nine (9) stormwater BMP opportunities were initially identified through a detailed desktop review of development patterns, impervious areas, and drainage networks within the (relatively few) developed regions of the Double Pipe Creek watershed. Two (2) of the potential projects identified were retrofits of existing stormwater ponds on County-owned land, while a third pond identified for retrofit is located on private property. An existing sand filter BMP, which works in conjunction with one of the County-owned stormwater ponds, was also identified for further assessment and potential retrofit.

Stormwater pond retrofit opportunities were limited because only one non-County owned stormwater management pond was identified in the watershed. There are numerous farm ponds within the watershed, but these are not considered urban structural stormwater practice per MDE and also typically are poor candidates for stormwater management retrofit opportunities.

New Stormwater Ponds

New stormwater pond opportunities in the watershed are limited by the agricultural characteristic of the watershed. Stormwater ponds are recommended for drainage areas greater than 25 total acres in size (10 acres for a micro-pool extended detention system), and the watershed topography combined with the locations of impervious area made a new stormwater pond impractical.

Regenerative Step-Pool Stormwater Conveyance

Regenerative step-pool stormwater conveyance opportunities were not identified via desktop assessment because there was little available information about outfalls and eroding gullies, where these practices are typically employed.

A preliminary process of prioritization was conducted as outlined below. Further prioritization was conducted following site visits to the potential opportunity locations.

Prioritization Matrix

The stormwater BMP prioritization matrix developed by Frederick County (**Appendix C**) consists of 21 criteria divided into 4 sub-categories: Nutrient and Impervious Acre Credits, Costs, Construction, and

Community and Watershed Impacts. Each of the 21 criteria is divided into descriptive categories that are assigned rankings from one to three, with three being the best score. A weight is assigned to each component, to create a weighted ranking; the total maximum possible stormwater BMP ranking score is 240.

The following criteria were evaluated via this desktop assessment:

- **Estimated nutrient reduction – total nitrogen (TN), total phosphorous (TP), total suspended sediments (TSS)**
    - Utilized the required minimum nutrient removal rates for Maryland stormwater BMPs: 30% of TN, 40% of TP, and 80% of TSS
- **Impervious acres treated**
    - Estimated in GIS using existing topography and the County's impervious area data layer. Refined as design progressed from preliminary site identification to 15% concept plan.
- **Stormwater BMP construction era**
    - Restoration of older stormwater BMPs was prioritized by the rating matrix
- **Cost estimates – planning costs, costs per pound of TN removed, costs per pound of TP removed, costs per pound of TSS removed, and costs per impervious acre treated**
    - Planning costs were provided by the County for all stormwater BMP types except grass swales, for which costs were determined using AKRF's professional judgement (**Table 2**)
- **Conflicts, such as utility conflicts**
    - Used the County-provided stormwater and sewer layers
- **Constructability or site access issues**
    - Criteria evaluated includes: site topography, wetland impacts, distance from road, and vegetation clearing needs
- **Property ownership and easement requirements**
    - Used a tax parcels GIS layer and a group of GIS layers showing existing easements within the watershed
    - Determined how many property owners will be involved in the project
- **Maintenance burden of proposed BMPs**
    - Utilized Table 4.5 from the 2000 Maryland Stormwater Management Design Manual
- **Proximity of karst to the BMPs**
    - Karst geology regions are characterized by formations underlain by carbonate rock and typified by the presence of limestone caverns and sinkholes. AKRF utilized "Stratigraphy of the Frederick Valley and its Relationship to Karst Development" to identify karst areas.
    - Specific design considerations are required for BMPs proposed within karst areas.
- **Proximity of the BMPs to stream restoration projects**
    - Used the Frederick County NPDES BMP geodatabase and the new geodatabase AKRF created for the potential stream restoration opportunities identified as part of this watershed assessment
- **Public acceptance of the BMP**
    - Utilized Table 4.5 from the 2000 Maryland Stormwater Management Design Manual
- **Potential public safety issues**
    - Sites are determined if they pose any safety concerns which would lower their priority; there is no intermediate rating for this public safety category.
- **Partnership opportunities**
    - Identification of opportunities to pair with other organizations in the stormwater BMP construction, maintenance, operation, etc.

- **Public visibility and outreach opportunities**
    - Stormwater BMPs with higher visibility and greater opportunities for education and outreach were assigned a higher rating

Since construction costs are dependent upon BMP type, the proposed practice type has some effect on the project rankings, and rankings were updated throughout the desktop and site assessment process, as additional information prompted BMP concept changes. As described above, nine (9) stormwater BMP opportunities were initially identified; two (2) retrofits of existing stormwater ponds on County-owned land, a third pond retrofit located on private property, an existing sand filter BMP retrofit, three (3) new vegetated swales, and two (2) new SPSC structures.

AKRF developed unit cost estimates for one proposed stormwater BMP type not listed in the County's matrix: vegetated swale with check dams (**Table 2**). The vegetated swales were estimated to be $50/LF, based on the need for fine grading, vegetation, and stone. Based on the site evaluations, estimated construction costs were adjusted using professional judgement.

Table 2. BMP Estimated Construction Costs.

BMP Type	Estimated Construction Costs*
Regenerative Step-Pool Stormwater Conveyance (per linear foot)	$450
Stream Restoration (per linear foot)	$350
Vegetated Swale with Check Dams (per linear foot)	$50
*Use professional judgement if the site requires additional costs	

The proximity of BMPs to stream restoration projects category has one of the highest weights in the County's matrix; it is one of two categories given a weight of 10, indicating the importance of locating BMPs upstream of stream restoration projects. Four (4) of the nine (9) stormwater BMPs that were initially proposed were located upstream of proposed stream restoration projects, while the other potential projects were too far upland from stream restoration projects to be assigned a rank of three.

The other category with a weight of 10 is the Stormwater Era category, the rating of which is based on the design approval date from the County's Urban BMP database. If no date is available for a BMP, the assigned rating is 1, which is the 1985-2002 era BMP providing treatment of at least 1 inch of rainfall. The high weight for this category results in the prioritization of the oldest (pre-1985) BMPs. In this largely rural watershed, none of the three existing BMPs were constructed before 1985, and all are believed to provide treatment of at least 1 inch of rain or greater, based on the County's Urban BMP database; thus all BMPs received a rating of 1 for this category, and it was not a major factor in determining final rankings.

Since Double Pipe Creek is a largely rural watershed, opportunities for treating impervious area in large-scale regional BMPs are limited. Since all proposed stormwater BMPs would treat less than 5 acres of impervious area, and the nutrient reductions for the BMPs had not been modeled for the preliminary rankings, all twelve (12) proposed BMPs received the same score for the Nutrient and Impervious Area Reduction section of the prioritization matrix (14 out of 60).

Following the preliminary desktop assessment, the highest ranked BMP site has a score of 141 out of 240. This BMP, an existing stormwater management pond (NPDES Facility Number 000088), could potentially be retrofitted with updated technology to improve stormwater treatment. Because the project would be a retrofit, the estimated construction cost would be lower than the cost of many of the proposed new BMPs (which also do not treat as much impervious area). The system also scored well because it is located

upstream of an existing stream restoration project and does not require any additional easements for ownership or construction. However, this location was not investigated past the preliminary desktop assessment, as the existing facilities adequately treat the stormwater draining to them, and are thus a low priority for retrofit actions.

A second round of stormwater BMP desktop assessments and rankings was conducted following OSER's comments on the initial proposed locations. The stormwater pond retrofit opportunities previously identified were removed from consideration, as one was determined to be a County-owned facility, while the other was determined to be a farm pond without an overflow structure, rather than a stormwater pond. Three (3) additional proposed BMP locations were removed from consideration due to limited impervious surfaces in the drainage area and site conditions that would make capture and treatment of the disconnected impervious areas challenging. OSER recommended desktop assessment of four (4) additional potential stormwater BMP locations where they identified existing stormwater easements but no stormwater management practices. The five (5) potential BMP opportunities proposed were two (2) new vegetated swales with check dams, the conversion of a drainage ditch to a vegetated swale with check dams, and a retrofit to an existing grass swale. These were ranked following the criteria described above, and the highest ranked potential site (141/240) was a new vegetated swale at a local business, upstream of potential stream restoration reaches identified as part of the watershed assessment (see above).

Based on the preliminary desktop assessment described above, rankings were assigned to all stream reaches and BMPs identified as opportunity locations. Ranking criteria were updated and final rankings calculated following field assessments during the months of May and June (discussed below). The final ranking results for the 30 highest priority stormwater and stream restoration sites are shown below in **Table 5**, and the full ranking process is detailed in **Appendix C**.

3.4 FIELD SITE ASSESSMENTS

Following the desktop site assessment, field investigations were conducted for the highest priority projects, selected based on the preliminary rankings and OSER's input, as discussed above, to confirm and augment the GIS data and other information described above and in the County prioritization matrices before preparing concept plans for the highest priority projects. AKRF was tasked with preparing approximately 30 restoration concept plans. In May and June 2018, AKRF engineers and scientists walked 34 stream sub-reaches totaling approximately 47,751 LF, and investigated four (4) potential other BMP opportunities that would treat approximately 8.08 acres of impervious area.

Two field forms were developed to capture the proposed stream restoration and other BMP project site conditions, inform prioritization matrix updates and completion, and provide sufficient information for a 15% concept plan at each site, if needed. The field forms were created using Fulcrum, a cloud-based mobile data collection platform by Spatial Networks, Inc. This tool allowed for in-field digital data collection, organization of notes, geolocated photographs of the sites, and the establishment of an online record of the watershed assessment. Each field form contained the results of the desktop site assessment, so that these could be compared to the actual site conditions, as well as additional fields for notes about the drainage area, BMP, and/or stream reach setting, erosion observations, constructability and access issues observed in the field, cultural and historical impacts, environmental impacts, and notes about the potential restoration or BMP opportunities.

Stream Restoration Opportunities

For the potential stream restoration opportunities, each property was assessed as a sub-reach, then sub-reaches were combined during concept development as deemed appropriate for the proposed projects. At each location assessed, the field team spoke with the property owner, if he/she was available or specifically requested a meeting. This typically provided anecdotal information about past land use and stream

conditions, and allowed for a better understanding of the property owner's utilization of the site and their acceptance of a potential restoration practice.

The stream assessment field forms created by AKRF included, in addition to the information described above, fields to record observations of the following stream characteristics that could influence restoration design:

- Dominant (and secondary) stream bed and bank sediments
- Vertical and lateral confinements
- Vertical and lateral adjustments
- Dominant (and secondary) plan form geometry
- Dominant (and secondary) bed form morphology
- Floodplain and terrace presence/absence, condition, and location(s)
- Bank erosion severity and possible local causes contributing to bank erosion
- Bank height – minimum, maximum, and average observed along the reach
- Instream habitat resources or concerns
    - Baseflow depth
    - Fish passage
    - Shading
    - Habitat and flow diversity
    - Woody debris
    - Riffle embeddedness
    - Overhanging banks
- Riparian zone condition and species observed

Prioritization Matrix

The following criteria were revisited and refined through the in-field assessment:

- Stream restoration reach length often changed based on field assessment of the stream reaches, which identified the appropriate bounds of the restoration work.
    - This also changed the impervious acre credit and estimated nutrient reductions that can be achieved by the restoration.
- Any conflicts (such as utility conflicts) and constructability or access issues that could not be determined from the desktop assessment were determined in the field
- Floodplain connectivity was determined from field assessments and followed the County guidance rating categories of "connected," "incised with limited floodplain area," or "incised with large floodplain area".
- Channel lateral stability was determined from field assessments of stream bank condition.

BMP Opportunities

As discussed above, opportunities for BMPs that could treat large impervious area were limited by the rural, sparsely developed nature of this unique watershed, as were opportunities for outfall restoration through SPSC implementation. However, additional BMP opportunities, including several SPSC practices, were

found during the stream reach field assessments, and were evaluated using the desktop site assessment methodology and County ranking matrix as described in Section 3.4, above. All of the identified potential stormwater BMPs (including the SPSCs) had total drainage areas smaller than 10 acres.

Prioritization Matrix

The following criteria were revisited and refined during the in-field assessment:

- Any conflicts (such as utility conflicts) and constructability or access issues that were unable to be determined from the desktop assessment were determined in the field
- If there was any uncertainty about the drainage area to a proposed practice, the infrastructure and grading in the uncertain areas was confirmed in the field, and the impervious area and drainage area calculations were updated, which in turn affected the nutrient removal calculations
- Potential public safety issues were further evaluated following field assessments of the sites and as BMP designs advanced
- Public visibility and outreach opportunities were further evaluated following field assessments of the sites and as BMP designs advanced

3.5 EVALUATION AND RANKING OF RESTORATION PROJECTS

As concept designs advanced following the field site assessments, the potential opportunities were re-evaluated iteratively using the County's matrices and preliminary concept plans.

The following County decision matrices were used to rank the potential restoration opportunities:

Table 3. Frederick County Prioritization Matrix Component Weights

RANKING COMPONENTS	**Weight** (Total 80 Points)	
	Stream Restoration	**Stormwater BMP**
Nutrient and Impervious Acre Credit		
Estimated TN removed (lbs./acre/year)	2	2
Estimated TP removed (lbs./acre/year)	2	2
Estimated TSS removed (lbs./acre/year)	2	2
Impervious Acre Credit (Acres)	10	4
Linear Feet	4	N/A
Stormwater Era	N/A	10
Cost		
Planning Level Costs	3	6
Cost/lb. Nitrogen Removed	1	2
Cost/lb. Phosphorous Removed	1	2
Cost/lb. Sediment	1	2

RANKING COMPONENTS	**Weight** (Total 80 Points)	
	Stream Restoration	**Stormwater BMP**
Removed		
Cost/Impervious Acre Treated	4	8
Construction		
Utility Conflicts	4	2
Easement/ROW Requirements/Property Ownership	2	5
Constructability/Access	2	3
Existing Forest Retention Ordinance (FRO) Present	2	N/A
Maintenance Burden	N/A	4
Proximity to Karst	N/A	2
Permitting Requirements	N/A	4
Benthic IBI Score	4	N/A
Land Use/Impervious Cover Within Watershed	2	N/A
Floodplain Connectivity	4	N/A
Lateral Stability of Stream Channel	5	N/A
Proximity to Stormwater Management BMP	2	N/A
Functional Lift Potential	3	N/A
Proximity to Stream Restoration	N/A	10
Public Acceptance	N/A	2
Public Safety	N/A	4
Partnership Opportunities	N/A	2
Public Visibility/ Outreach Opportunity	N/A	2

For the potential stormwater BMP projects, pollutant removal rates and the costs per pound of pollutant removed were determined using pollutant loading data from the Frederick County Stormwater Restoration Plan (December 2018a) and typical minimum removal rates of the proposed BMPs, as described by the Maryland Stormwater Management Design Manual (2000).

The functional lift potential (as defined by Starr, Harman, and Davis 2015) of the identified stream restoration projects was estimated using (1) data on current conditions collected in the field, (2) the proposed condition following restoration, and (3) the context of nearby stream conditions as described in FCSS and MBSS reports. The Stream Functions Pyramid Framework (Harman et al, 2012) defines levels

of stream function that build on each other, from Level 1-Hydrology, to Level 2-Hydraulics, Level 3-Geomorphology, Level 4-Water Quality, and ultimately Level 5-Biology. The stream sites identified for restoration in the Double Pipe Creek watershed are compromised at most if not all levels of function. With the exception of BMP sites with proposed upstream volume control, the hydrology of sites is predefined. In general, the proposed restoration techniques involve changes to the stream channel plan, profile, and cross-section that will improve hydraulics and geomorphology, thus attaining a functional uplift of Level 3.

Functional uplift beyond Level 3 requires improvements to water quality and/or other components affecting the success of biological communities. Specifically, biological communities are also limited by the absence of habitat features and connectivity with source populations. Each proposed stream restoration concept was evaluated for additional potential functional uplift as follows:

Level 4-Water Quality uplift is expected where suspended sediment, nutrients and other pollutants are reduced by substantial amounts through bank stabilization, floodplain reconnection, and riparian buffer plantings. Riparian plantings will also offer shade that improves the temperature component of water quality.

Level 5-Biology uplift is expected with improvements to water quality, but especially when appropriate instream habitat is increased and where biological source populations can reach the restored stream. Specifically, we determined (1) the amount of habitat added in the form of greater baseflow, channel diversity, pool-riffle features, and large woody debris, and (2) which stream restoration sites were near to streams with BIBIs of 3 or greater (i.e., streams that are in fair to good and non-impaired condition).

Each of the proposed stream restoration concepts was evaluated based on the presence of these uplift factors. For example, many concept plans include plunge pool stabilization, culvert replacement with open bottom structures, floodplain reconnection, riparian buffer plantings, and bank stabilization through soil bioengineering approaches such as live branch layering. Note that connectivity with source populations in fair streams may be limited by barriers not discernable at this time. In addition, the degree of habitat improvement will depend on features that are actually included in more detailed designs.

The following table of additional factors was also applied to each proposed restoration project and addressed in the description of the proposed restoration projects as appropriate.

Table 4. Additional Factors for Assessing Potential Restoration Projects.

Metric	Description
Stormwater Era	BMP constructed pre-1985, 1985-2002
Groundwater Recharge	Amount of recharge based on level of expected infiltration
Channel Protection	Based on proposed level of quantity control and downstream stability
Channel Stabilization	Level of channel stabilization provided will be dependent on channel condition and type of project
Water/Stream Temperature	Does project reduce receiving water temperature?
Instream Habitat Improvement	Does project provide or improve instream habitat?
Riparian Habitat Improvement	Does project provide or improve riparian habitat?
Wetland Habitat Improvement	Does project provide or improve wetland habitat?
Fish Passage	Does project reduce or eliminate barriers to fish passage?
Public Visibility/Education/Outreach	Is the project in close proximity to public places?
Community Aesthetic Improvement	Does the project improve community appearance?
Combined Benefit	Are there multiple projects in close proximity that together provide a larger cumulative benefit?
Adjacent Land Use	Are adjacent properties compatible with the type of potential facility?

The full set of prioritization matrix and ranking tables for these projects and the other areas of interest assessed are provided in **Appendix C**. **Table 5** shows the results of the ranking matrix as applied to the top priority restoration sites, after the final scores were weighted to account for the different BMP and stream scoring systems. The table also introduces the proposed restoration concepts that are discussed in further detail in the next section.

Table 5. Final Rankings and Descriptions of the Identified Potential Restoration Projects.

NPDES ID#	Project CS-#	Location Name	Stream Length (feet) OR		Restoration Type(s)	Design Approach(es)	Score (0-100)
			Impervious Area (ac)	Drainage Area (ac)			
LIPI-2018-STRE-0001	1	Beaver Dam Road	4,298		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements	Bioengineered Bank Stabilization Channel Realignment Rock Grade Control Structure(s) Floodplain Reconnection Riparian Buffer Restoration	89
LIPI-2018-STRE-0002	2	Nicholson Road	4,976		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements	Bioengineered Bank Stabilization Channel Realignment Rock Grade Control Structure(s) Boulder Toe Protection Channel Realignment Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	86
LIPI-2018-STRE-0003	3	Clemsonville Road	4,720		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements	Bioengineered Bank Stabilization Channel Realignment Debris Removal Floodplain Reconnection Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	85
LIPI-2018-STRE-0004	4	Woodsboro Pike	3,170		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements	Bioengineered Bank Stabilization Rock Grade Control Structure(s) Floodplain Reconnection Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	79

NPDES ID#	Project CS-#	Location Name	Stream Length (feet) OR		Restoration Type(s)	Design Approach(es)	Score (0-100)
			Impervious Area (ac)	Drainage Area (ac)			
LIPI-2018-STRE-0005	5	Woodsboro Pike	2,561		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements Could pair with BMP (Potential Project # LIPI-2018-STRE-0014) to stabilize in-stream plunge pool	Bioengineered Bank Stabilization Debris Removal Floodplain Reconnection Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	78
LIPI-2018-STRE-0006	6	Bunker Hill Road	2,075		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration	Bioengineered Bank Stabilization Debris Removal Floodplain Reconnection Riparian Buffer Restoration	76
LIPI-2018-STRE-0007	7	Clemsonville Road	2,074		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration	Bioengineered Bank Stabilization Floodplain Reconnection Riparian Buffer Restoration	73
LIPI-2018-STRE-0008	8	Keymar Road	2,847		Stream Restoration Riparian Buffer Restoration	Bioengineered Bank Stabilization Riparian Buffer Restoration	72
LIPI-2018-STRE-0009	9	Detour Road	2,467		Stream Restoration Riparian Buffer Restoration Stream Crossing Improvements Could pair with BMP (Potential Project # LIPI-2018-DSWA-0003) to treat runoff from buildings and yard	Bioengineered Bank Stabilization Rock Grade Control Structure(s) Debris Removal Livestock Exclusion Fencing Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	71
LIPI-2018-DSWA-0001	10	Woodsboro Pike	2.51	19.49	Improvements to ex. gravel and grass swale upstream of stream channel. BMP to treat runoff from commercial building, parking, and driveway areas.	Vegetated Swale with Check Dams Rock Grade Control Structure(s) Debris Removal Riparian Buffer Restoration	70

NPDES ID#	Project CS-#	Location Name	Stream Length (feet) OR		Restoration Type(s)	Design Approach(es)	Score (0-100)
			Impervious Area (ac)	Drainage Area (ac)			
LIPI-2018-STRE-0010	11	Haughs Church Road	2,245		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements	Bioengineered Bank Stabilization Channel Realignment Rock Grade Control Structure(s) Debris Removal Floodplain Reconnection Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	68
LIPI-2018-STRE-0011	12	Simpsons Mill Road	1,645		Stream Restoration Riparian Buffer Restoration	Bioengineered Bank Stabilization Livestock Exclusion Fencing Riparian Buffer Restoration	68
LIPI-2018-STRE-0012	13	Fountain School Road	1,655		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration	Bioengineered Bank Stabilization Channel Realignment Rock Grade Control Structure(s) Debris Removal Floodplain Reconnection Riparian Buffer Restoration	67
LIPI-2018-RSC-0001	14	Tarr Drive	89		Improvement to ex. carpeted and rip rapped concentrated flow path. SPSC for infiltration and treatment of runoff from residential buildings and driveways.	SPSC with Boulder Cascades Riparian Buffer Restoration	67
LIPI-2018-STRE-0013	15	Woodsboro Pike	2,278		Stream Restoration Riparian Buffer Restoration Stream Crossing Improvements Could pair with BMP (Potential Project # LIPI-2018-RSC-0001) to treat overflow from ex. pond	Bioengineered Bank Stabilization Rock Grade Control Structure(s) Debris Removal Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	66
LIPI-2018-DSWA-0002	16	Bunker Hill	1.71	10.52	Improvements to steep slope concentrated flow path. BMP to treat runoff from residential buildings and driveways.	Vegetated Swale with Check Dams Bioretention Basin	65

NPDES ID#	Project CS-#	Location Name	Stream Length (feet) OR		Restoration Type(s)	Design Approach(es)	Score (0-100)
			Impervious Area (ac)	Drainage Area (ac)			
LIPI-2018-RSC-0001	17	Woodsboro Pike	40		Improvements to ex. gully. SPSC to treat and stabilize overflow from ex. pond. Could pair with downstream stream restoration (Potential Project # LIPI-2018-STRE-0013)	SPSC with Boulder Cascades Riparian Buffer Restoration	65
LIPI-2018-DSWA-0003	18	Detour Road	0.30	6.64	Improvements to ex. "Y"-shaped concrete swale upstream of stream channel. BMP to treat runoff from agricultural buildings and yard. Could pair with downstream stream restoration (Potential Project # LIPI-2018-STRE-0009)	Vegetated Swale with Check Dams	60
LIPI-2018-STRE-0014	19	Woodsboro Pike	76		Improvements to ex. stream plunge pool. SPSC to stabilize channel. Could pair with downstream stream restoration (Potential Project # LIPI-2018-STRE-0005)	SPSC with Boulder Cascades Riparian Buffer Restoration	60
LIPI-2018-STRE-0015	20	Coppermine Road	1,243		Stream Restoration Riparian Buffer Restoration	Bioengineered Bank Stabilization Debris Removal Riparian Buffer Restoration	59
LIPI-2018-STRE-0016	21	Keymar Road	743		Stream Restoration Riparian Buffer Restoration	Bioengineered Bank Stabilization Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	57
LIPI-2018-STRE-0017	22	New Windsor Road	1,062		Stream Restoration Riparian Buffer Restoration	Regenerative Stormwater Conveyance Debris Removal Riparian Buffer Restoration	57

NPDES ID#	Project CS-#	Location Name	Stream Length (feet) OR		Restoration Type(s)	Design Approach(es)	Score (0-100)
			Impervious Area (ac)	Drainage Area (ac)			
LIPI-2018-STRE-0018	23	Keymar Road	903		Stream Restoration Riparian Buffer Restoration	Regenerative Stormwater Conveyance Bioengineered Bank Stabilization Riparian Buffer Restoration	57
LIPI-2018-STRE-0019	24	Toll Road	250		Improvements to ex. gully. SPSC from wetland to stabilize conveyance into stream. Could pair with downstream stream restoration (Potential Project #LIPI-2018-STRE-0022)	SPSC with Boulder Cascades Riparian Buffer Restoration	56
LIPI-2018-STRE-0020	25	Buffalo Road	446		Stream Restoration Riparian Buffer Restoration	Bioengineered Bank Stabilization Rock Grade Control Structure(s) Debris Removal Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	56
LIPI-2018-STRE-0021	26	Woodsboro Pike	1,049		Stream Restoration Riparian Buffer Restoration Stream Crossing Improvements	Bioengineered Bank Stabilization Debris Removal Riparian Buffer Restoration Livestock Crossing Restoration	54
LIPI-2018-STRE-0022							
LIPI-2018-STRE-0022	27	Toll Road	1,000		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements Could pair with BMP (Potential Project # LIPI-2018-STRE-0019) to	Bioengineered Bank Stabilization Floodplain Reconnection Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	54

NPDES ID#	Project CS-#	Location Name	Stream Length (feet) OR		Restoration Type(s)	Design Approach(es)	Score (0-100)
			Impervious Area (ac)	Drainage Area (ac)			
					stabilize and improve wetland to stream conveyance channel		
LIPI-2018-STRE-0023	28	Warner Road	367		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration	Bioengineered Bank Stabilization Floodplain Reconnection Riparian Buffer Restoration Livestock Exclusion Fencing	52
LIPI-2018-STRE-0024	29	Warner Road	734		Stream Restoration Riparian Buffer Restoration	Bioengineered Bank Stabilization Riparian Buffer Restoration	52
LIPI-2018-STRE-0025	30	Handboard Road	643		Stream Restoration Floodplain Reconnection Riparian Buffer Restoration Stream Crossing Improvements	Bioengineered Bank Stabilization Rock Grade Control Structure(s) Debris Removal Floodplain Reconnection Riparian Buffer Restoration Vehicle Crossing and Culvert Restoration	47

4. POTENTIAL OPPORTUNITIES IDENTIFIED

Thirty (30) concept plans were developed, including an assessment of existing conditions, general observations, access, proposed retrofit improvements, photos, water quality treatment/pollutant load reductions, and planning level cost estimates. The conceptual designs considered easement acquisition, tree impacts, Forest Resource Ordinance Easement impacts, utility impacts, and other site constraints.

The 30 concept plans, numbered CS-1 through CS-33 (three were eliminated) and described in **Table 5,** consist of three (3) new stormwater facilities (underground sand filters, vegetated swales, or bioretention basins), 25 stream restoration sites (two of which also include a proposed regenerative stormwater conveyance feature), and two (2) regenerative step-pool stormwater conveyance (SPSC) restoration practices. An overview map showing the locations and final rankings of all 30 concept plans is shown in **Figure 14**. The concept plans for the highest priority sites are shown in Section 5.1, while the full set of concept plans are in **Appendix D1**.

The general stream restoration approach adopted by AKRF for the concept plans was to minimize in-stream disturbance while taking a few key actions to maximize functional stream uplift and nudge the stream system towards the dynamically stable state for the appropriate stream type while stabilizing areas of active bed and bank erosion. Key restoration concepts include stream channel restoration, floodplain reconnection, riparian buffer restoration, and stream crossing improvements. Potential site-specific design approaches would be developed at a 30 percent design level, following additional field work, and are further described in **Appendix D2**. Initial, 15 percent concept level design approaches include:

- Bioengineered/biostructural bank stabilization employing vegetative stabilization techniques (e.g. vegetated encapsulated soil lifts/geogrids) reinforced by rock/boulder bank toe armoring, as necessary (e.g. boulder toe revetment);
- In-channel rock grade control structures (cross-vanes, J-hooks, and W-weirs);
- Floodplain reconnection/floodplain bench grading, including floodplain wetland creation where appropriate;
- Vehicle and/or livestock crossing stabilization and undersized culvert replacements to improve conveyance for large flow events and provide aquatic organism passage;
- Livestock exclusion fencing to reduce erosion and pollution by cattle, sheep, and horses; and
- Riparian buffer improvements such as invasive species removal and supplemental native plantings.

Where possible, the stream restoration projects were paired with stormwater BMP projects to control/treat upstream runoff entering a stream restoration project, and potentially achieve water quality functional uplift in the stream.

The general stormwater BMP design approach was similar in intent to the stream restoration approach—improve riparian and other site vegetation, minimize disturbance, utilize existing site features, and capture and treat the water quality event—in order to reduce erosion and pollution, improve water quality and meet the TMDLs (see Section 5.2, below).

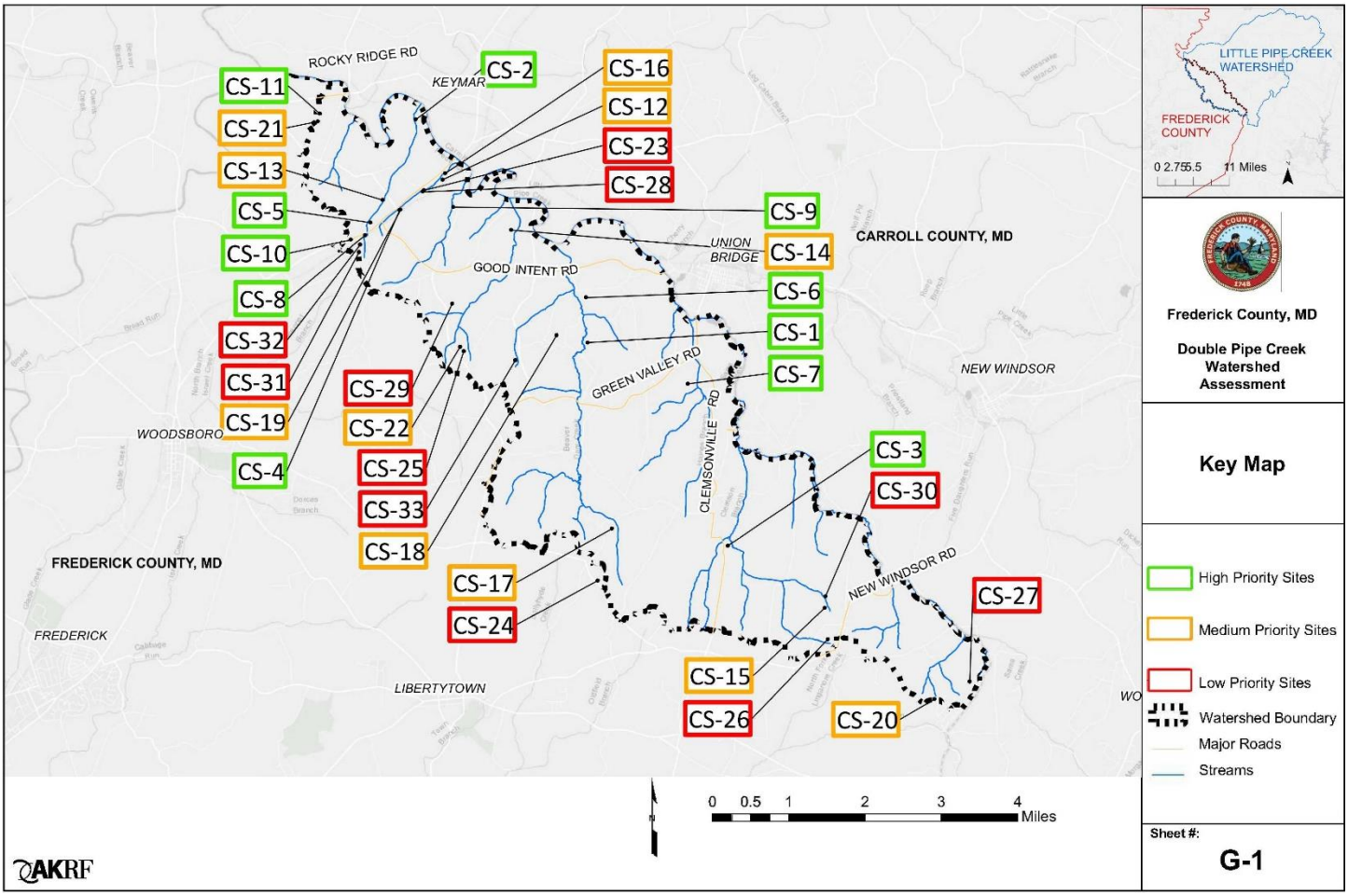


Figure 14. Potential Opportunities Concept Plan Key Map

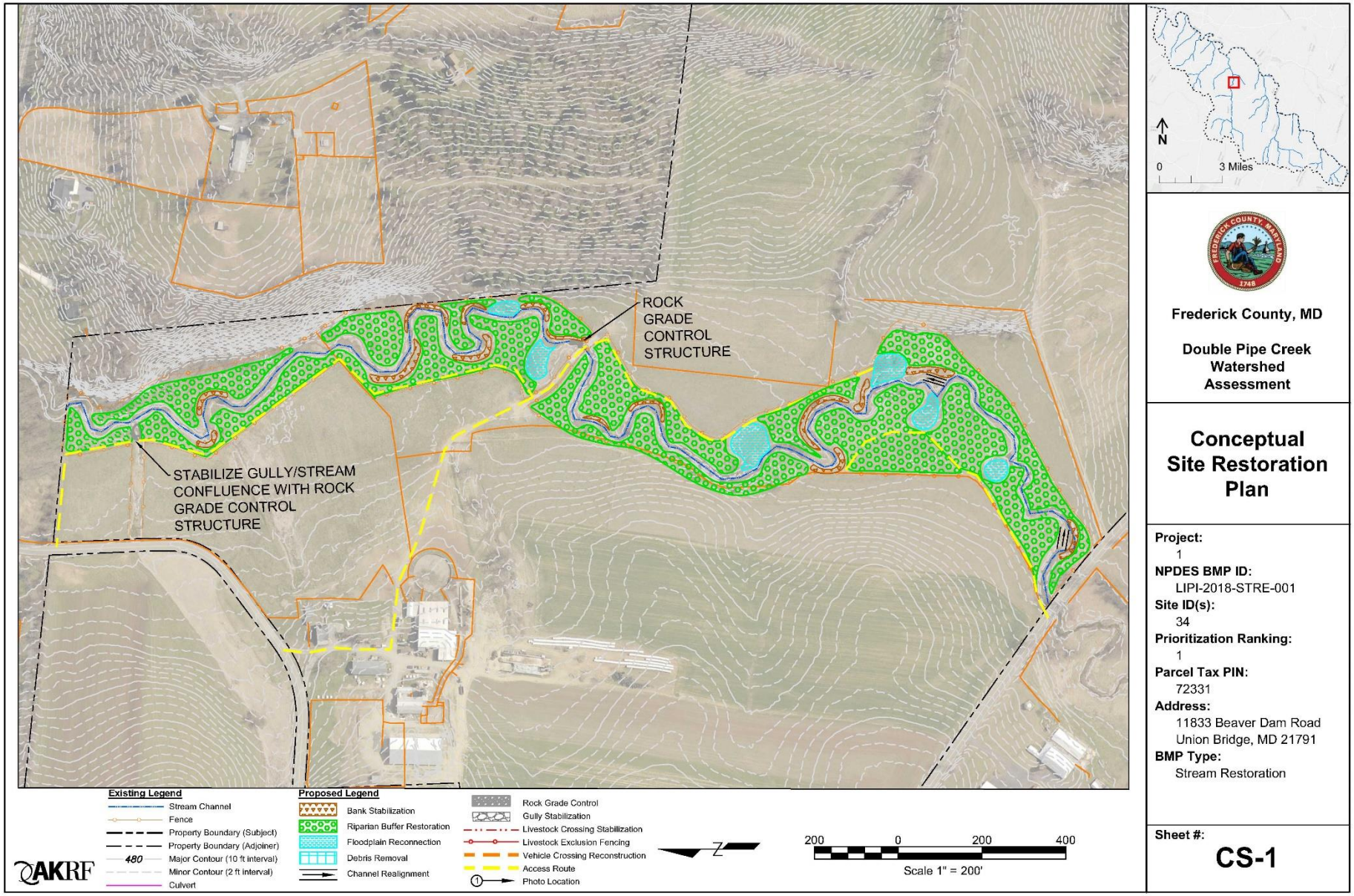
5. PROJECT PRIORITIZATION AND IMPLEMENTATION SCHEDULE

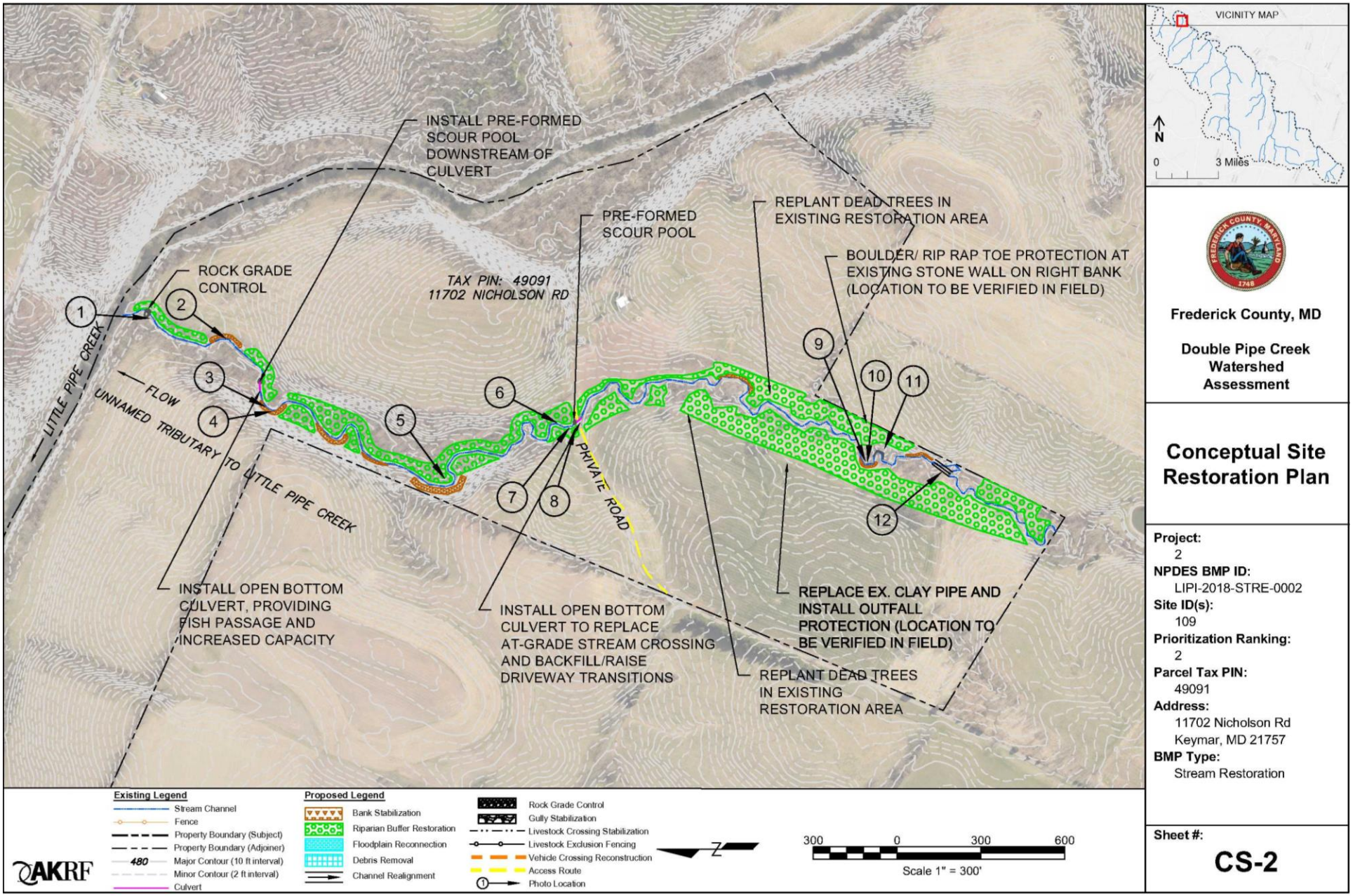
5.1 IDENTIFIED HIGH PRIORITY SITES

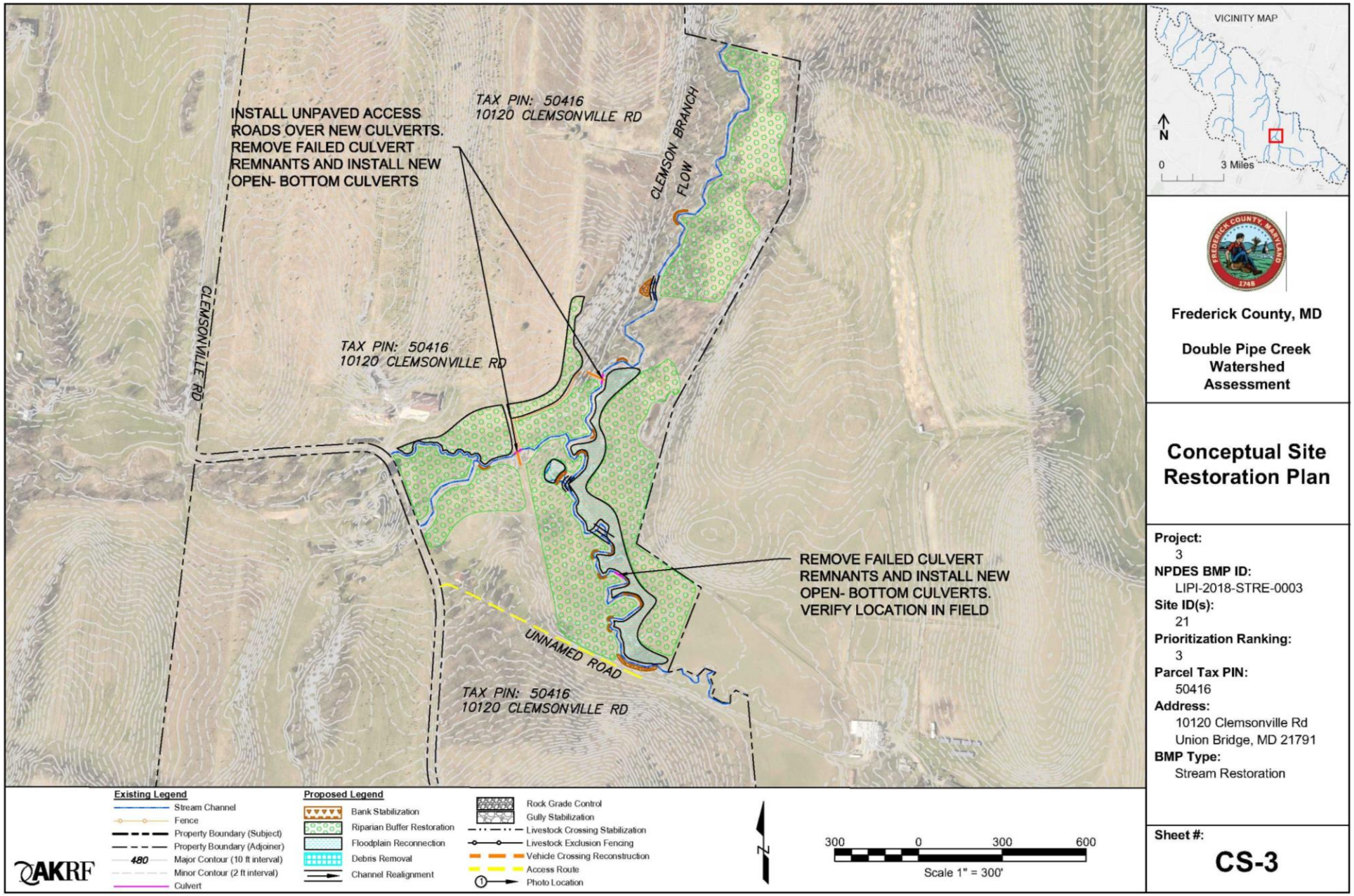
The highest ranked priority sites, summarized in **Table 6**, were three stream restoration sites and will be implemented to meet the Double Pipe Creek TMDLs (see **Section 5.2**). The concept plan overview sheets are shown on the following pages.

Table 6. Highest Priority Sites

NPDES ID#	Concept ID#	Project Address	Project Type	Stream Length (FT)	Impervious Acre Credit (ac)
LIPI-2018-STRE-0001	CS-1	11833 Beaver Dam Rd	Stream Restoration	4298	42.98
LIPI-2018-STRE-0002	CS-2	11702 Nicholson Rd	Stream Restoration	4976	49.76
LIPI-2018-STRE-0003	CS-3	10120 Clemsonville Rd	Stream Restoration	4720	47.20


ROCK GRADE CONTROL STRUCTURE
STABILIZE GULLY/STREAM CONFLUENCE WITH ROCK GRADE CONTROL STRUCTURE
Existing Legend
Stream Channel
Fence
Property Boundary (Subject)
Property Boundary (Adjoiner)
480 Major Contour (10 ft interval)
Minor Contour (2 ft interval)
Culvert
Proposed Legend
Bank Stabilization
Riparian Buffer Restoration
Floodplain Reconnection
Debris Removal
Channel Realignment
Rock Grade Control
Gully Stabilization
Livestock Crossing Stabilization
Livestock Exclusion Fencing
Vehicle Crossing Reconstruction
Access Route
Photo Location
AKRF
N
200 0 200 400
Scale 1" = 200'
N
0 3 Miles
Frederick County, MD
Double Pipe Creek Watershed Assessment
Conceptual Site Restoration Plan
Project:
1
NPDES BMP ID:
LIPI-2018-STRE-001
Site ID(s):
34
Prioritization Ranking:
1
Parcel Tax PIN:
72331
Address:
11833 Beaver Dam Road
Union Bridge, MD 21791
BMP Type:
Stream Restoration
Sheet #:
CS-1


INSTALL PRE-FORMED SCOUR POOL DOWNSTREAM OF CULVERT
PRE-FORMED SCOUR POOL
REPLANT DEAD TREES IN EXISTING RESTORATION AREA
BOULDER/ RIP RAP TOE PROTECTION AT EXISTING STONE WALL ON RIGHT BANK (LOCATION TO BE VERIFIED IN FIELD)
ROCK GRADE CONTROL
TAX PIN: 49091
11702 NICHOLSON RD
LITTLE PIPE CREEK
FLOW
UNNAMED TRIBUTARY TO LITTLE PIPE CREEK
PRIVATE ROAD
INSTALL OPEN BOTTOM CULVERT, PROVIDING FISH PASSAGE AND INCREASED CAPACITY
INSTALL OPEN BOTTOM CULVERT TO REPLACE AT-GRADE STREAM CROSSING AND BACKFILL/RAISE DRIVEWAY TRANSITIONS
REPLACE EX. CLAY PIPE AND INSTALL OUTFALL PROTECTION (LOCATION TO BE VERIFIED IN FIELD)
REPLANT DEAD TREES IN EXISTING RESTORATION AREA
1
2
3
4
5
6
7
8
9
10
11
12
Existing Legend
Stream Channel
Fence
Property Boundary (Subject)
Property Boundary (Adjoiner)
480 Major Contour (10 ft interval)
Minor Contour (2 ft interval)
Culvert
Proposed Legend
Bank Stabilization
Riparian Buffer Restoration
Floodplain Reconnection
Debris Removal
Channel Realignment
Rock Grade Control
Gully Stabilization
Livestock Crossing Stabilization
Livestock Exclusion Fencing
Vehicle Crossing Reconstruction
Access Route
Photo Location
AKRF
N
300 0 300 600
Scale 1" = 300'
VICINITY MAP
N
0 3 Miles
Frederick County, MD
Double Pipe Creek Watershed Assessment
Conceptual Site Restoration Plan
Project:
2
NPDES BMP ID:
LIPI-2018-STRE-0002
Site ID(s):
109
Prioritization Ranking:
2
Parcel Tax PIN:
49091
Address:
11702 Nicholson Rd
Keymar, MD 21757
BMP Type:
Stream Restoration
Sheet #:
CS-2


INSTALL UNPAVED ACCESS ROADS OVER NEW CULVERTS. REMOVE FAILED CULVERT REMNANTS AND INSTALL NEW OPEN- BOTTOM CULVERTS
TAX PIN: 50416
10120 CLEMSONVILLE RD
CLEMSON BRANCH FLOW
CLEMSONVILLE RD
TAX PIN: 50416
10120 CLEMSONVILLE RD
REMOVE FAILED CULVERT REMNANTS AND INSTALL NEW OPEN- BOTTOM CULVERTS. VERIFY LOCATION IN FIELD
UNNAMED ROAD
TAX PIN: 50416
10120 CLEMSONVILLE RD
VICINITY MAP
N
0
3 Miles
Existing Legend
Stream Channel
Fence
Property Boundary (Subject)
Property Boundary (Adjoiner)
480 Major Contour (10 ft interval)
Minor Contour (2 ft interval)
Culvert
Proposed Legend
Bank Stabilization
Riparian Buffer Restoration
Floodplain Reconnection
Debris Removal
Channel Realignment
Rock Grade Control
Gully Stabilization
Livestock Crossing Stabilization
Livestock Exclusion Fencing
Vehicle Crossing Reconstruction
Access Route
Photo Location
AKRF
N
300 0 300 600
Scale 1" = 300'
Frederick County, MD
Double Pipe Creek Watershed Assessment
Conceptual Site Restoration Plan
Project:
3
NPDES BMP ID:
LIPI-2018-STRE-0003
Site ID(s):
21
Prioritization Ranking:
3
Parcel Tax PIN:
50416
Address:
10120 Clemsonville Rd
Union Bridge, MD 21791
BMP Type:
Stream Restoration
Sheet #:
CS-3

5.2 POLLUTANT LOAD REDUCTIONS TOWARD MEETING TMDLS

The Frederick County Stormwater Restoration Plan (December 21, 2018a) satisfies the requirements of Parts IV.E.2.a and b of the NPDES MS4 Permit #11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and Total Maximum Daily Load (TMDL) Restoration Plans. The Restoration Plan addresses twelve (12) TMDLs for local waterways, two (2) for the Chesapeake Bay, and an impervious surface restoration requirement. This Plan demonstrates that Frederick County Government is on track to meet the restoration efforts required under its current permit and has a long term plan to address its portion of stormwater waste load allocations (SW-WLAs) for all TMDLs in Frederick County (Frederick County, 2018a).

Compliance with the Chesapeake Bay TMDL is regulated in the permit through the use of the 20% impervious surface treatment strategy. While not a requirement in the County's MS4 permit, restoration strategies to meet local TMDL reduction targets and impervious restoration treatment were also modeled against the Bay TMDL goals in order to calculate progress in reducing pollutant loads (Frederick County, 2018a). This Double Pipe Creek Watershed Assessment describes how the high-priority projects identified above meet the local TMDL goals for the watershed.

> "All Restoration Plans use a multi-pronged approach that includes stormwater practices. These stormwater practices include volumetric practices such as bioretention and pond retrofits, as well as alternative practices for stormwater including riparian buffer planting and stream restoration. Best Management Practices (BMPs) used are predominantly from MDE's Accounting for Stormwater Waste Load Allocations and Impervious Acres Treated, Guidance for National Pollutant Discharge Elimination System Stormwater Permits (MDE SW 2014). This document determines how impervious acres are accounted for. To assess whether nutrient and sediment local TMDL goals were met, these practices were modeled using a customized script in ArcGIS which calculated pollutant load reductions treatment based on the inventory of existing, programmed, and identified BMPs maintained in the County's NPDES geodatabase. The same tool was used to estimate load reductions applied towards the Chesapeake Bay TMDL. Progress towards *E.coli* TMDL loads and reductions were determined using the Watershed Treatment Model version 2013. Structural stormwater treatment was summarized from the County database, supplemented with literature values and Sanitary Sewer Overflow (SSO) loads and reductions calculated by the Division of Utilities and Solid Waste Management for secondary sources of bacteria." (Frederick County, 2018a).

Double Pipe Creek has TMDLs for phosphorus, sediment, and bacteria (**Figure 7**, **Table 7**). The Baseline year for the Double Pipe Creek Sediment TMDL was 2000 and the TMDL requires a 46.8% reduction from baseline. The Baseline year for the Double Pipe Creek phosphorus TMDL was 2009 and the TMDL requires a 73.0% reduction from baseline. The 2018 Frederick County Stormwater Restoration Plan describes cumulative treatments in the completed, programmed, identified, and potential tiers that will meet the TMDLs by 2040 and 2038, respectively. **Figure 15** shows the County planned versus MDE required pollutant reductions, and **Table 8** outlines the baseline loading factors and calibration results for the Double Pipe Creek Watershed.

Table 7. Double Pipe Creek TMDL Pollutant Load Percent Reductions[1]

Pollutant	MDE Published Reduction	Bacteria Reduction Human / Domestic	County Planned Reduction	% of Goal Achieved	Completion Date
E.coli (EC)	98.8%	56.3%	56.4%	100.1%	2024
Total Phosphorous (TP)	73.0%		101.1%	138.5%	2024
Total Suspended Solids (TSS)	46.8%		279.4%	597.0%	2024
Note 1: Adapted from Table 1: Local TMDL Pollutant Load Percent Reductions by Watershed (Frederick County, 2018a).					

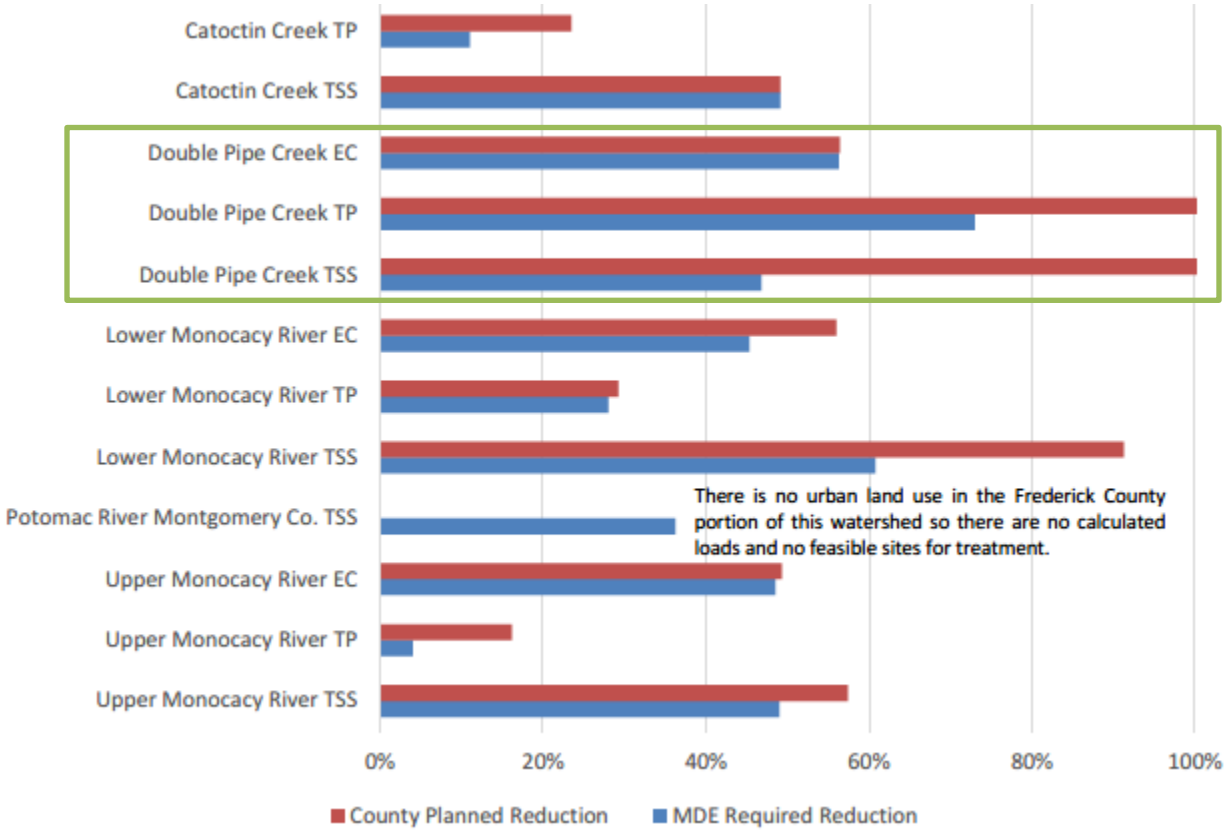


Figure 15. TMDL Pollutant Load Percent Reduction. Adapted from Frederick County, 2018a.

Table 8. Calibrated Nutrient and Sediment Double Pipe Creek TMDL SW-WLAs and Target Load Reductions[1]

Baseline Year	Pollutant	MDE Published Reduction[2]	Baseline Impervious Area (ac)[3]	Baseline Pervious Area (ac) [3]	Calibrated Baseline Load (lb)[4]	Calibrated Reduction (lb)[5]
2009	TP	73.0%	103	887	804	**587**
2000	TSS	46.8%	65	629	192,286	**89,990**
Notes 1) Table adapted from Table 13 in Frederick County, 2018a.						

Target reduction loads used for TMDL compliance shown in bold text.
2) Published Reduction Percent from the MDE TMDL Data Center SW WLAs for County Storm Sewer Systems in Frederick County
3) County MS4 urban impervious and pervious acres for the TMDL baseline year.
4) Baseline loads modeled using County BMPs installed prior to the TMDL baseline year on top of baseline land use background loads.
5) Calibrated reductions calculated by applying the MDE published percent reduction to the calibrated baseline loads.

Requirement for meeting the Sediment TMDL:

The Baseline year for the Double Pipe Creek Sediment TMDL was 2000. The TMDL requires a 46.8% reduction from baseline. The cumulative treatment through the Potential tier is shown in **Table 9** below.

Table 9. Cumulative Restoration Treatment[1]

BMP Type	Treatment (Acres Except as Noted)		
	Impervious	Pervious	Total
Bioretention			
Bioswale			
Filters			
Grass Channel			
Infiltration			
Wet Pond			
Wetland			
Streams (LF)			11,741.0
Tree Planting			
Riparian Buffer		32.8	32.8
Note 1: Adapted from Tables 26 and 28 in Frederick County, 2018a.			

Detail on treatment for each restoration tier for Double Pipe Creek sediment are in **Table 10**. **Table 11** shows the calibrated load reductions for each of the restoration tiers, also shown in **Figure 16**. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the sediment TMDL will be met in 2033.

Table 10. Double Pipe Creek Sediment Scenarios[1]

3 - Complete					
BMP Type	**BMP Code**	**Impervious Area (ac)**	**Pervious Area (ac)**	**Total Area (ac)**	**Sum of TSS (lb)**
Planting Trees or Forestation on Pervious Urban	FPU	0.00	6.48	6.48	1,084.36
5 - Identified					
BMP Type	**BMP Code**	**Impervious Area (ac)**	**Pervious Area (ac)**	**Total Area (ac)**	**Sum of TSS (lb)**
Stream Restoration	STRE	0.00	0.00	11,741.00	528,345.00
Note 1: Extracted from Appendix 13, Frederick County, 2018a.					

Table 11. Reductions by Scenario for Double Pipe Creek Sediment TMDL[1]

Scenario	Scenario Reduction (lb/yr)	Cumulative Reduction (lb/yr)	Load (lb/yr)	% of Required Reduction
Baseline	0	0	192,286	0.0%
Complete	1,084	1,084	191,202	1.2%
Programmed	0	1,084	191,202	1.2%
Identified	528,345	529,429	-337,143	588.3%
Potential	7,816	537,245	-344,959	597.0%
Calibrated Reduction	89,990			
Note 1: Table adapted from Table 27 in Frederick County, 2018a.				

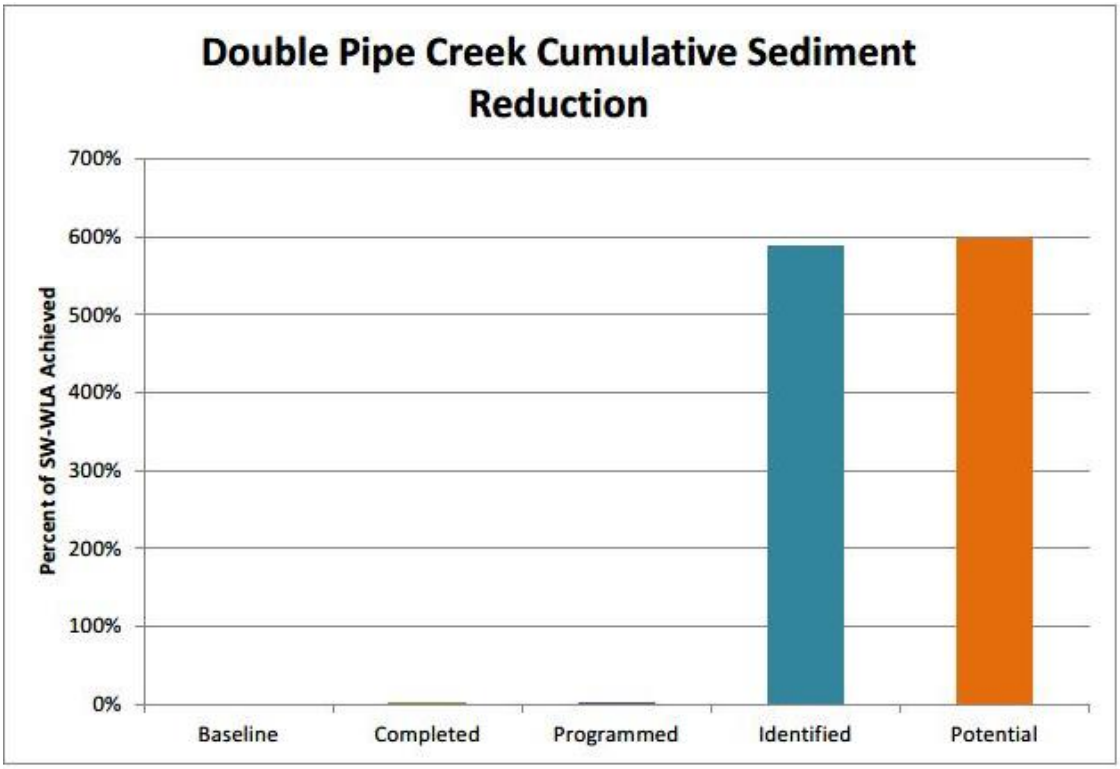


Figure 16. Double Pipe Creek Cumulative Sediment Reductions (Percent). From Frederick County, 2018a.

Requirement for meeting the Phosphorus TMDL:

The Baseline year for the Double Pipe Creek phosphorus TMDL was 2009. The TMDL requires a 73.0% reduction from baseline. The cumulative treatment through the Potential tier is shown in **Table 9**.

Details on treatment for each restoration tier for Double Pipe Creek phosphorus are in **Table 13**. **Table 12** shows the calibrated load reductions for each of the restoration tiers, also shown in **Figure 17**. The SW-WLA reduction percentage will be met with the projects in the Potential restoration tier. It is anticipated that the phosphorus TMDL will be met in 2028.

Table 12. Reductions by Scenario for Double Pipe Creek Phosphorus TMDL[1]

Scenario	Scenario Reduction (lb/yr)	Cumulative Reduction (lb/yr)	Load (lb/yr)	% of Required Reduction
Baseline	0.0	0.0	804.1	0.0%
Complete	0.0	0.0	804.1	0.0%
Programmed	2.9	2.9	801.2	0.5%
Identified	798.4	801.2	2.8	136.5%
Potential	11.6	812.8	-8.8	138.5%
Calibrated Reduction	587.0			
Note 1: Table adapted from Table 13 in Frederick County, 2018a.				

Table 13. Double Pipe Creek Phosphorous Scenarios

3 - Complete					
BMP Type	**BMP Code**	**Impervious Area (ac)**	**Pervious Area (ac)**	**Total Area (ac)**	**Sum of TP (lb)**
Planting Trees or Forestation on Pervious Urban	FPU	0.00	6.48	6.48	2.85
5 - Identified					
BMP Type	**BMP Code**	**Impervious Area (ac)**	**Pervious Area (ac)**	**Total Area (ac)**	**Sum of TP (lb)**
Stream Restoration	STRE	0.00	0.00	11,741.00	798.39
Note 1: Extracted from Appendix 13, Frederick County, 2018a.					

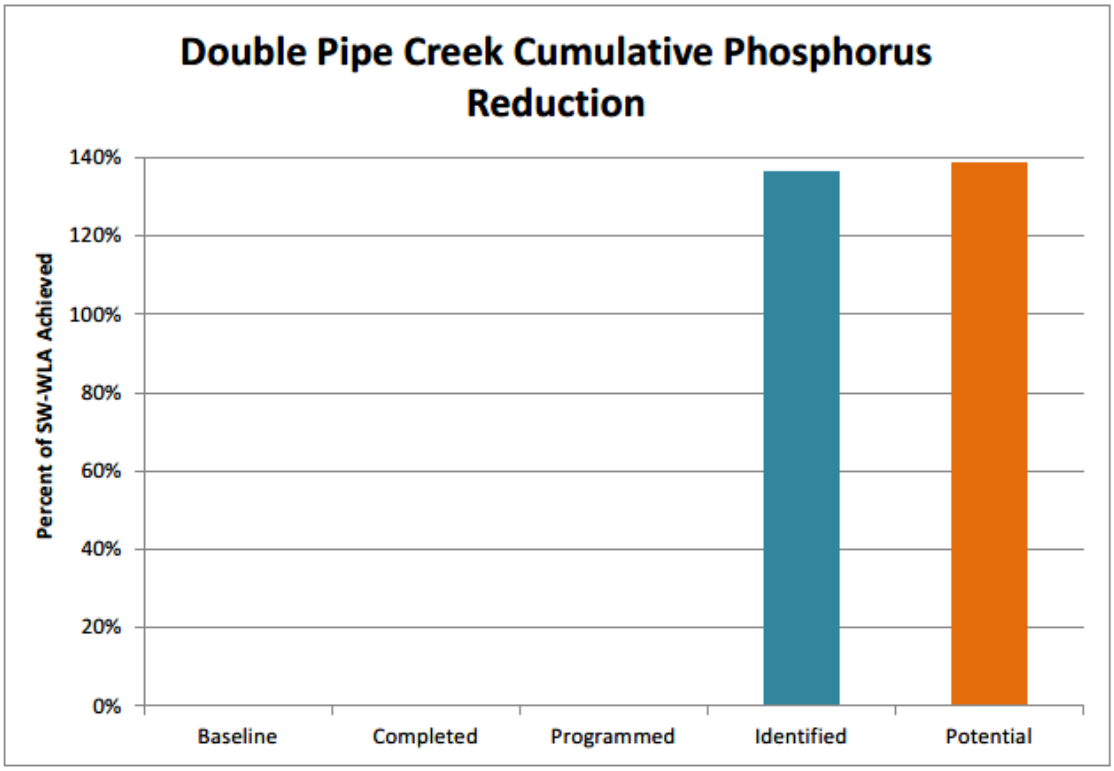


Figure 17. Double Pipe Creek Cumulative Phosphorous Reductions (Percent). From Frederick County, 2018a.

***E.coli* TMDL Goals:**

"Similarly to nutrient and sediment TMDLs, the *E.coli* TMDLs assign a WLA which must be met for compliance. Unlike them, however, these three TMDLs have also been given a Maximum Practicable Reduction (MPR) which acknowledges the fact that it may not be possible to reduce some of the loads. For example, in Double Pipe Creek, the TMDL (MDE DP 2009) states:

> '...water quality standards cannot be attained in any of the seven Double Pipe Creek subwatersheds, using the Maximum Practical Reduction (MPR) scenario. MPRs may not be sufficient in subwatersheds where wildlife is a significant component or where very high reductions of fecal bacteria loads are required to meet water quality standards. In these cases, it is expected that the MPR scenario will be the first stage of TMDL implementation.'

The MPR targets are established for each of the bacteria sources, as shown in **Table 14**" (Frederick County, 2018a).

Table 14. MPR Targets for Each Bacteria Source[1]

Maximum Practicable Reduction (MPR) per Source	Human	Domestic	Livestock	Wildlife
	95%	75%	75%	0%
Rationale	(a) Direct source inputs. (b) Human pathogens more prevalent in humans than animals. (c) Enteric viral diseases spread from human to human	Target goal reflects uncertainty in effectiveness of urban BMPs and is also based on best professional judgment	Target goal based on sediment reductions from BMPs and best professional judgment	No programmatic approaches for wildlife reduction to meet water quality standards. Waters contaminated by wild animal wastes offer a public health risk that is orders of magnitude less than that associated with human waste.
Note 1: Table adapted from un-numbered table on page 46 Frederick County, 2018a.				

E.coli Plan for Double Pipe Creek Watershed

MDE completed monitoring of Double Pipe Creek in 2004. The monitoring data and subsequent analysis showed that the water body was not meeting its designated use criteria due to *E.coli* pollution. According to MDE, the portion of the watershed in Frederick County, sections of Little Pipe Creek and Sam's Creek watersheds, has been designated as Use IV-P (Water Contact Recreation, Protection of Aquatic Life, Recreational Trout Waters and Public Water Supply). MDE developed a TMDL for *E.coli* in Double Pipe Creek in 2009 (MDE DP 2009) which was approved by EPA in 2009. The portion of Double Pipe Creek that is in Frederick County is rural, with its main stormwater inputs from roads and rural residences. There are no sewer lines in this portion of the watershed. Bacteria Source Tracking (BST) monitoring "was conducted at six stations throughout the Double Pipe Creek watershed, where 12 samples (one per month) were collected. To determine the MPR for the SW-WLA, a weighted calculation was performed. Bacteria sources by percent from the BST study included in the TMDL are shown in **Figure 18**. (Frederick County, 2018a).

Each of these sources has a different MPR and contains loads for different sectors, so a weighted average MPR by source and sector in the SW-WLA is used. **Table 15** shows the derivation of the weighted average MPR, provided in MDE DP 2009. (Frederick County, 2018a).

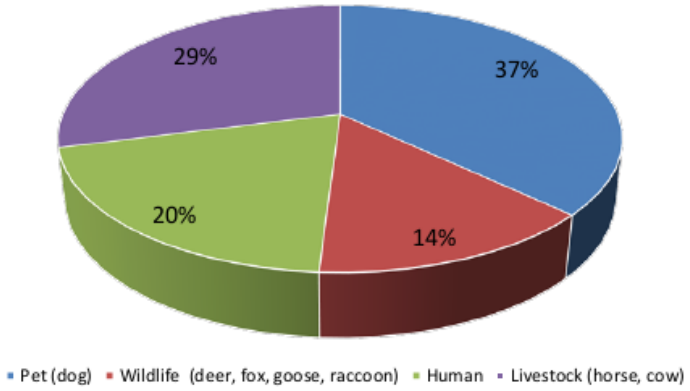


Figure 18. Double Pipe Creek Probable Bacteria Sources. Un-numbered figure on page 50 of Frederick County, 2018a.

Table 15. MPR Percent Derivation for Double Pipe Creek based on Weighted Average by Source[1]

Source	MPR By Source	Baseline Sector Load SW-WLA	Weighted SW-WLA MPR
Human	95%	6,568.6	80.8%
Domestic	75%	3,075.9	
Wildlife	0%	930.1	
Livestock	75%	0.0	
Note 1: Table adapted from Table 34 in Frederick County, 2018a.			

To work towards addressing the loads for the MPR and SW-WLA targets, Frederick County built a restoration scenario for the watershed. This scenario was built using multiple model runs of the Watershed Treatment Model version 2013 per the restoration tiers described in the Introduction. The cumulative treatment from Completed to Potential is shown in **Table 16** and **Table 17**. Detail on the amount of treatment modeled in each scenario is provided in **Table 18** and **Table 19**.

Table 16. Cumulative Restoration Treatment[1]

BMP Type	Total Restoration (Acres Except as Noted)		
	Impervious Area	Pervious Area	Total Drainage Area
Bioretention			
Bioswale			
Filters			
Grass Channel			
Infiltration			
Wet Pond	160.0	320.0	480.0
Wetland			
Streams (LF)			17,000.00
Tree Planting		6.48	6.48
Riparian Buffer		26.32	26.32
Note 1: Table adapted from Table 35 in Frederick County, 2018a.			

Table 17. Cumulative Restoration Treatment for Alternative Bacteria BMPs[1]

Alternative BMPs	Total Restoration	
Pet Waste Education	297	Households
Street Sweeping	0	
Impervious Disconnection	0	
Land Use Change – Vacant to Forest	254	Acres
Illicit Connection Removal	100%	Remediated
SSO Repairs	N/A	
Septic System Education	48	Systems
Septic System Repair	30	Remediated
Septic System Upgrade	6	Systems
Septic System Retirement	0	Systems
Note 1: Table adapted from Table 36 in Frederick County, 2018a.		

Table 18. Structural BMPs in Double Pipe Creek *E.coli* Scenarios

3 - Complete				
BMP Type	**BMP Code**	**Impervious Area (ac)**	**Pervious Area (ac)**	**Total Area (ac)**
Planting Trees or Forestation on Pervious Urban	FPU	0.00	6.48	6.48
4 - Potential				
BMP Type	**BMP Code**	**Impervious Area (ac)**	**Pervious Area (ac)**	**Total Area (ac)**
Planting Trees or Forestation on Pervious Urban	FPU	0.00	26.32	26.32
Note 1: Table adapted from Appendix 17 in Frederick County, 2018a.				

Table 19. Operational BMPs in Double Pipe Creek *E.coli* Scenarios		
1 – Complete		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Urban Downsizing		
Illicit Connection Removal		
SSO Repairs		
Septic System Education		
Septic System Repair	12	Systems
Septic System Upgrade	6	Systems
Septic System Retirement		
2 – Programmed		
BMP Type	**Number**	**Unit**
Pet Waste Education	297	Households
Street Sweeping		
Impervious Disconnection		
Urban Downsizing		
Illicit Connection Removal		
SSO Repairs	N/A	N/A
Septic System Education	48	Systems
Septic System Repair		
Septic System Upgrade		
Septic System Retirement	N/A	N/A
3 – Identified		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Urban Downsizing	11.0	Ac

Table 19. Operational BMPs in Double Pipe Creek *E.coli* Scenarios		
Illicit Connection Removal		
SSO Repairs	N/A	N/A
Septic System Education		
Septic System Repair		
Septic System Upgrade		
Septic System Retirement	N/A	N/A
4 – Potential		
BMP Type	**Number**	**Unit**
Pet Waste Education		
Street Sweeping		
Impervious Disconnection		
Urban Downsizing	243.30	ac
Illicit Connection Removal	100%	Remediation
SSO Repairs	N/A	N/A
Septic System Education		
Septic System Repair	18	Systems
Septic System Upgrade		
Septic System Retirement	N/A	N/A
Note 1: Table adapted from Appendix 17 in Frederick County, 2018a.		

Table 20 shows the calibrated SW-SWA and MPR targets along with the reductions needed to meet them. The results of the improvement scenarios are also shown in **Figure 19**.

Table 20. Reductions by Scenario for Double Pipe Creek Bacteria TMDL (bn MPN/yr.) [1]

Scenario	Cumulative Reduction (lb)	Load (lb)	% of Required Reduction	% of MPR Reduction
Baseline	0	57,383	0.00%	0.00%
Complete	1,939	55,444	6.00%	6.00%
Programmed	2,566	54,817	7.94%	7.94%
Identified	3,240	54,143	10.03%	10.03%
Potential	32,333	25,050	100.05%	122.34%
Calibrated Required BST WLA Reduction	32,316			
Calibrated Required BST MPR Reduction	26,428			
Note 1: Table adapted from Table 37 in Frederick County, 2018a.				

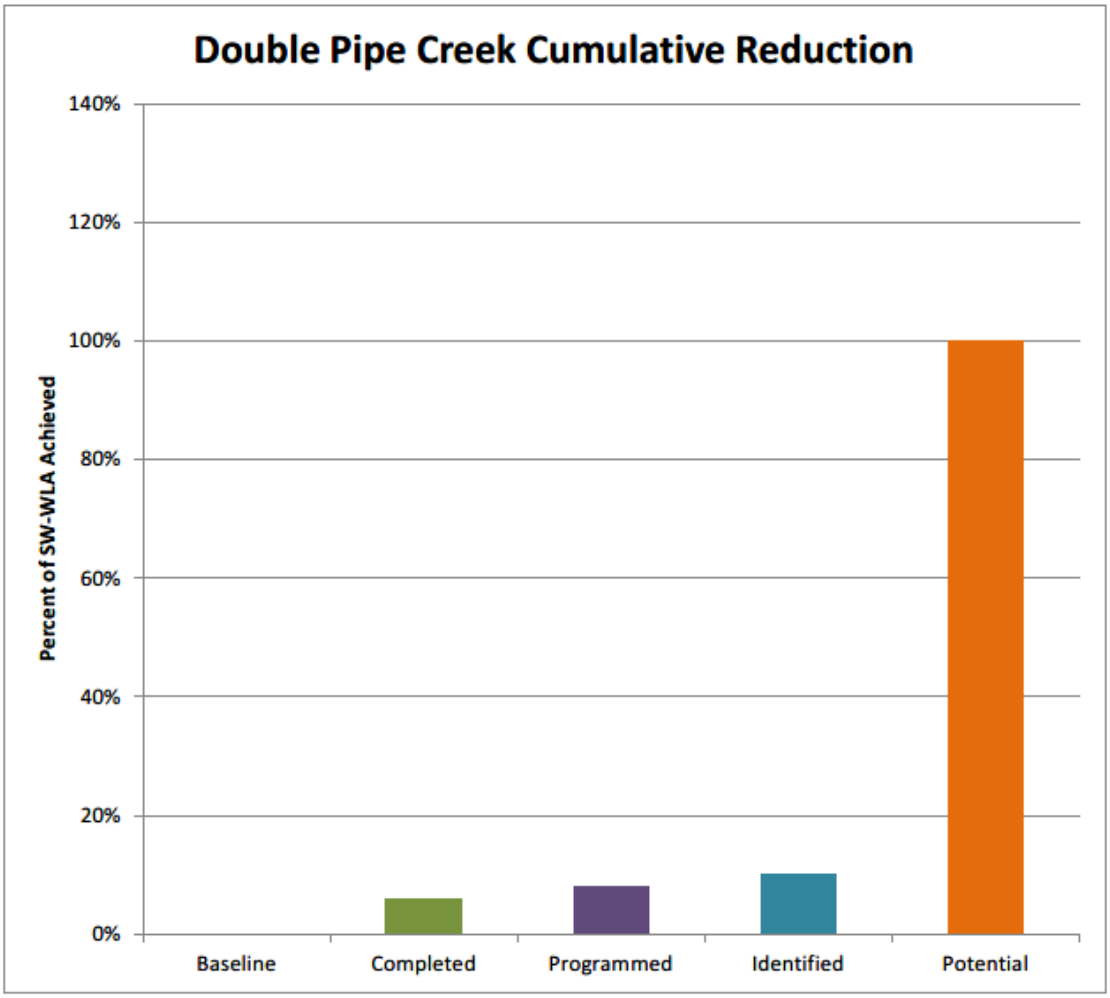


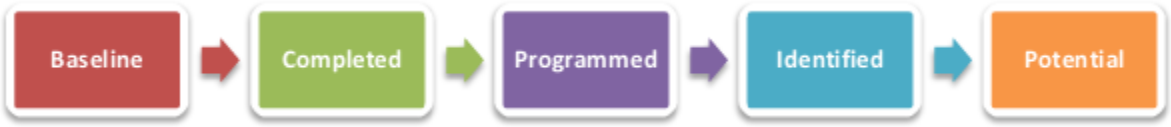
Figure 19. Double Pipe Creek Cumulative Reduction (Percent of SW-WLA). Figure 16 from Frederick County, 2018a.

Both the MPR and the WLA targets for human/domestic sources will be met with the Potential treatment tier. The County will take an Adaptive Management approach to this TMDL, focusing on remediating human sources of bacteria first, implementing structural BMPs according to the schedule, and monitoring the results to determine if additional treatment will be necessary.

5.3 COST ESTIMATES

This section, extracted from the Frederick County Stormwater Restoration Plan (2018a), provides an estimate of the cost of implementing both the Impervious Cover Restoration Plan and TMDL Restoration Plans to meet the stated goals. It is important to note that the costs represent planning level estimates for use in high-level forecast budgeting with many assumptions made. The cost estimates provided here focus on the capital costs associated with implementing the projects described in previous sections. The following presents the methods used to derive the cost estimates per project type with summaries of costs for full implementation at the watershed and County scale.

Projects by Restoration Tier



As stated earlier in this document, Restoration Tiers include Baseline, Completed, Programmed, Identified, and Potential scenarios. Baselines are the TMDL loads without restoration Best Management Practices. Completed projects were finished after March 11, 2007, the expiration date of the previous permit and on or after July 1, 2017, the current reporting period. Programmed projects are programmed into the County's Capital Improvement Program and other programs during the permit term, which is set to expire on December 30, 2019. Identified projects can be found in Watershed Management Plans, Restoration and Retrofit Assessments, Stormwater Master Plans, and other documents completed by Frederick County Government and its partners and consultants to identify watershed restoration opportunities. Potential Projects are hypothetical projects based on the most cost-effective BMP types and acres of available land. These last two tiers are to be completed after January 1, 2020.

Cost estimates for structural BMPs come from the following sources:

- Completed CIP project costs are used where available. When completed costs are not available, Brown and Caldwell's 2014 Technical Memo 1 (B&C 2014) is used. This study was prepared under contract to AquaLaw, Frederick County's outside legal counsel on stormwater matters, as part of a review of the County's MEP Analysis. (B&C 2014). Brown and Caldwell made recommendations on costs based on the King and Hagan study (2011) and adjusted dollars of some practices based on their experience with contracting projects in Maryland. They also adjusted cost estimates to FY 2017 as the midpoint of the permit.
- Programmed and Identified estimates come from the programmed CIP budget for FY 2016 through FY 2020. These represent engineering cost estimates at a 10-30% design phase. Tree planting and easement acquisition program costs come from information on County reforestation projects.
- Potential scenarios use costs derived as described below.

Cost estimates for operational BMPs have been derived from these sources described below.

- Management program costs for *E.coli* are absorbed by the operating budget for the NPDES MS4 permit.
- Costs for denitrification systems are taken from the Bay Restoration Fund and are estimated at $13,800 per system (personal communication by email with Kristin Mielcarek on 1/13/2015).
- Costs for septic upgrades to sewer are estimated from Anne Arundel County (URS ESA 2016) at $50,000.

Costs not included are pre- and post-construction monitoring and operational costs such as additional County staff to manage the work, conduct inspections, enforcement, or maintenance, and similar activities. These costs will be developed in future planning stages and factored into the County's budgeting.

Cost Estimating Procedure for Potential Projects

The County's recent history with restoration projects and preparation of the Capital Improvement Plan (CIP) have been the basis for project costs for potential projects where siting and concept design have not yet been undertaken. For the restoration BMPs proposed, direct costs were estimated for construction, then the following indirect and other costs were estimated based on a pro-rated amount of the construction cost:

- Contingency
- Design
- Inspection
- Project Management

- Site Improvement
- Net Present Value of Operations and Maintenance

For each project, a typical size was used from B&C (2014) and a project cost was derived (see **Table 21**). The number of projects proposed in the Potential tier, multiplied by the project cost, gave the estimated cost for these projects, shown in **Table 21**.

Table 21. Potential Tier Project Costs[1]

BMP Type	Project Size	Unit[2]	Per Unit Costs				Total Cost per Project
			Direct Construction and Contingency	Design and Indirect Costs	Land Acquisition	20-Yr. PV O & M Cost	
Stormwater Pond Retrofit	20	IA	$24,200.00	$12,452	$0	$763	$748,300
Bioretention	10	IA	$82,500.00	$42,450	$10,000	$1,862	$1,278,120
New Stormwater Pond	20	IA	$49,500.00	$25,470	$10,000	$763	$1,524,660
Forest Buffer	2	IA	$32,050.00	$1,603	$10,000	$5,475	$88,255
Stream Restoration	1200	LF	$440.00	$226	$50,000	$15	$867,500

Note 1: Table adapted from Table 48 in Frederick County, 2018a.
Note 2: IA = impervious acres.

Potential projects have been identified by determining the level of treatment required to meet the pollutant load reduction for each of the local TMDLs.

5.4 IMPLEMENTATION TIMEFRAME ESTIMATES

Timeframes for the plan are based on the following by Restoration Tier:

- Baseline: Starts the compliance timeframe for each TMDL.
- Completed: Already completed between March 11, 2007 and June 30, 2018.
- Programmed: A portion of the funded projects scheduled to be completed between July 1, 2018 and December 30, 2019 using timeframes from the Capital Improvement Program. Includes management programs for *E.coli*.
- Identified and Potential: Timeframes begin December 30, 2019, the end date of the current MS4 permit.

As part of its Technical Memorandum No. 1: Report on Frederick County Data Review Findings (2014), Brown and Caldwell provided timeframe estimates per project type per phase based on its experience managing public procurement contracts in the State of Maryland. These project phases are used to determine the length of project phases in the Identified and Potential Restoration Tiers. The level of implementation of identified and potential projects is estimated at $500,000 in Fiscal Year (FY) 2021, $1.2 million in in FY 2022, $3 million in FY 2023, and $4 million in each FY thereafter.

This generic schedule translates to the following project start dates beginning FY 2021 after the end of the current permit cycle. All Identified and Potential projects were projected into this schedule as a starting point. Schedules for the Identified and Potential tiers are governed by a cost cap of $4 million per year to determine the final completion date of all TMDLs.

The Potential tier has been defined by the level of treatment rather than project-by-project. An estimated number of projects has been derived based on average area treated or length of stream restoration for past County projects. Using this factor, along with the amount of treatment proposed, gives a total of 174 projects, split among pond retrofits, bioretention, stream restoration, and riparian buffers. A summary of potential projects is shown in **Table 23**.

Project costs and funding for the Potential tier set the timeline for meeting each of the local TMDLs. The following plan has been developed to optimize completion of TMDLs with lower requirements first, while continuing to implement projects for the more intensive TMDLs. The plan is based on an average funding level of $4.5 million per year. Funding from FY 2019 to FY 2022 is earmarked for Programmed and Identified projects; therefore the start date for Potential projects is the beginning of FY 2023. Results of the analysis through FY 2040 are shown in

Table 24.

Table 22. Double Pipe Creek Identified Projects and Costs to meet local and Chesapeake Bay TMDLs[1]

BMP Type	Number of Projects	Costs
Bioretention	0	$0
Bioswale	0	$0
Filters	0	$0
Grass Channel	0	$0
Infiltration	0	$0
Wet Pond	0	$0
Wetland	0	$0
Streams (per 1,200 LF)	9.8	$8,487,765*
Tree Planting	0	$0
Riparian Buffer	16.4	$1,447,382**
Total	**5**	**$9,935,147**

Note 1: Table adapted from Frederick County, 2018a.
*$867,500 per 1,200 linear feet of Stream Restored
**$88,255 per 2 Impervious Acres Equivalency

Table 23. Double Pipe Creek Potential Projects and Costs[1]

BMP Type	Number of Projects	Costs
Bioretention	0	$0
Bioswale	0	$0
Filters	0	$0
Grass Channel	0	$0
Infiltration	0	$0
Wet Pond	0	$0
Wetland	0	$0
Streams (LF)	0	$0
Tree Planting	0	$0
Riparian Buffer	5	$441,275
Total	**5**	**$441,275**

Note 1: Table adapted from Appendix 4 in Frederick County, 2018a.

Table 24. Potential Tier Funding Timeline for Double Pipe Creek Watershed through FY 2040[1]

	Fiscal Year	in $000
Total Potential Cost		$441
Forecast Completion		**2024**
	FY 2023	$441
Note 1: Table adapted from Table 50 in Frederick County, 2018a.		

Projects that treat sediment also treat phosphorus and to some extent, *E.coli*. As can be seen in **Table 7** and **Figure 15**, in general, in watersheds with TMDLs for these pollutants, if the sediment targets are met, they will be overtreated for other impairments. Because of the nested nature of projects to treat different TMDLs in the same watershed, it was not feasible to determine which of the Potential tier projects would be applicable to which pollutant. As a first approximation of determining end dates for the phosphorus and *E.coli* TMDLs, the duration to meet these TMDLs was pro-rated by the amount of overtreatment, shown in **Table 25**. This analysis will be revisited in subsequent Restoration Plans to develop an estimated completion based on project implementation.

Table 25. Summary of TMDL completion for Sediment, Phosphorus, and *E.coli* TMDLs in Double Pipe Creek Watershed [1]

Pollutant	Years to Complete	Completion Year
Sediment	1	**2024**
Phosporous	1	**2024**
E.coli	1	**2024**
Note 1: Table adapted from Table 51 in Frederick County, 2018a.		

This Frederick County Stormwater Restoration Plan satisfies the requirements of Parts IV.E.2.a and b of the NPDES MS4 Permit #11-DP-3321 MD0068357 dated December 30, 2014 for the Impervious Cover Restoration Plan and TMDL Restoration Plans. The Double Pipe Creek Watershed portion of the Plan will take a cumulative six (6) years from the date of this report to address TMDL requirements, and will cost a cumulative amount of $441,275. The Restoration Plan also meets TMDL pollutant removal targets for all three (3) local TMDL as shown in **Table 7**.

6. PUBLIC EDUCATION AND OUTREACH

Frederick County aims to implement permit-suggested outreach topics, and meet its own goals and objectives from The Strategic Plan to Improve Water Quality through Public Outreach in Frederick County, Maryland, published in November 2003, by conducting outreach and education events and activities with County residents. Outreach activities are used to educate citizens, to direct the course of watershed studies, and to identify landowners/stakeholders for potential restoration activities. This watershed assessment identifies potential restoration opportunities identified through such outreach activities, as well as County research, that could improve water quality and provide community education on the reasoning behind these projects; and how the public can implement additional activities in their own home. The Office of Sustainability and Environmental Resources (OSER) understands the importance of engaging with the public early and often and presents this Watershed Study to the public for feedback so any clarifications necessary to finalize the Watershed Assessment for the Double Pipe Creek Watershed may be addressed.

The draft of the Double Pipe Creek Watershed Assessment will be shared with the general public, soliciting comments and input, and any relevant ideas and program improvements will be incorporated into the final draft. Solicitation of public input will be accomplished through:

- A notice in the local newspapers and on the County's website outlining how the public may obtain information on the development of the watershed assessment;
- Providing copies of the watershed assessment to interested parties upon request; and
- Providing a minimum of thirty (30) day comment period before finalizing the watershed assessment.

In additional to this public document, OSER continually enhances its outreach materials as well as its efforts to provide its citizens with needed educational touchpoints. Some of the County's key public outreach and education initiatives are as follows:

- Outreach related to the Monocacy & Catoctin Watershed Alliance (MCWA) and Green Leader Brigade;
- Outreach related to the Green Homes Challenge (GHC);
- Outreach related to Residential Septic Pump-outs;
- Outreach related to Pet Waste;
- Outreach related to Stormwater Management;
- Outreach related to Watershed Assessments and;
- Other County Outreach Initiatives.

6.1: OUTREACH RELATED TO THE MONOCACY AND CATOCTIN WATERSHED ALLIANCE

The Upper and Lower Monocacy Watershed Restoration Action Strategy (WRAS) Steering Committees developed the Monocacy and Catoctin Watershed Alliance (MCWA or the Alliance) in order to continue outreach begun during the Upper and Lower Monocacy WRAS efforts and to begin implementation of the Upper and Lower Monocacy WRAS plans.

MCWA is a mutual, collaborative, non-advocacy effort among individuals and organizations desiring to work together to improve the health of the Monocacy and Catoctin watersheds. The County continues to coordinate MCWA and meet on a bi-monthly basis enabling attendees to discuss educational outreach opportunities, as well as develop restoration and protection projects to support water quality and habitat initiatives, and review and discuss recently developed watershed assessments and restoration plans. Partners involved in MCWA include but are not limited to:

- Local Organizations
  - Audubon Society of Central Maryland
  - Catoctin and Frederick Soil Conservation Districts
  - Catoctin Forest Alliance
  - Frederick County Forest Conservancy District Board
  - Catoctin Land Trust
  - Frederick County Conservation Club
  - Frederick County Master Gardeners
  - Local Citizens
  - Bar-T Mountainside Challenge & Retreat Center
- Regional Organizations
  - Potomac Conservancy
  - Potomac Watershed Partnership
  - Interstate Commission on the Potomac River Basin (ICPRB)
  - Center for Watershed Protection (CWP)
  - Potomac Valley Fly Fishers, Inc.
  - Chesapeake Conservation Corps

  - Trout Unlimited
- Funding Agencies
  - Chesapeake Bay Trust
  - Alice Ferguson Foundation
  - Maryland Department of the Environment/U.S. EPA Clean Water Act Section 319 (h) Program
  - Maryland Urban and Community Forestry Committee (MUCFC)
  - National Fish and Wildlife Foundation (NFWF)
  - Chesapeake and Atlantic Coastal Bays Trust Fund
- Educational Institutions
  - Hood College
  - Mount Saint Mary's University
  - University of Maryland Extension Office
  - Frederick County Public Schools (FCPS)
- Government Organizations
  - Frederick County Council
  - Frederick County Executive
  - Frederick County Division of Planning and Permitting
  - Office of Sustainability and Environmental Resources
  - Comprehensive Planning
  - Development Review
  - Permits and Inspections
  - Division of Public Works
  - Division of Utilities and Solid Waste Management
  - Health Department, Environmental Health Section
  - Division of Parks and Recreation
  - Sustainability Commission
  - Municipalities in Frederick County
  - Maryland Department of Natural Resources
    - Forest Service
    - Fisheries
    - Watersheds Program
    - Wildlife and Heritage Service
  - Maryland Department of the Environment
  - Cunningham Falls State Park
  - National Park Service
    - Catoctin Mountain Park
    - Monocacy National Battlefield Park
    - Rivers, Trails and Conservation Assistance
  - U.S. Environmental Protection Agency
    - Environmental Information and Analysis
  - U.S. Fish and Wildlife Service

The Alliance website (watershed-alliance.frederickcountymd.gov) is updated with a list of upcoming of events, past articles, links to quarterly meeting presentations, resources, and publications. Information on MCWA is also available in the OSER quarterly e-newsletter, expanding the Alliance's reach to more than 2,200 County households and/or Alliance partners.

7. MONITORING

The County utilizes all of its Watershed Assessments and Feasibility Studies to continually grow the potential opportunities which then feed into the County's overall Restoration Plan, last published December 2018. All identified opportunities have associated water quality benefits including reduction in nutrients and sediments from entering into the County's Waterways. When projects move into being programmed (under contract or funded), designed, and built (Completed) their associated benefits are recalculated based on final project design. These benefits include the success in capturing impervious surface area runoff, as well as nitrogen, phosphorous, sediment, and *E. coli* reductions at the local and Chesapeake Bay TMDL level. The County relies heavily on guidance provided by MDE, The Bay Program, and expert panels to assist in quantifying the reduction benefits for each completed restoration project. In addition to guidance documents, the County utilizes targeted restoration monitoring, as well as a County-wide Stream Survey, to continually learn more about the overall health of the County's streams.

7.1 – LOAD REDUCTION EVALUATION CRITERIA

The County will use both a quantitative and qualitative approach to tracking and measuring progress.

Quantitative measures will track project implementation progress and estimated pollutant and impervious area reductions associated with implementation. Calibrated load reductions will be the targets used for TMDL compliance at the Bay and local levels. These target reductions are calculated based on TMDL percent reductions and baseline loads; and modeled using land use loading rates. Reductions for stormwater treatment have been modeled using a custom geodatabase script that uses the most accurate up-to-date information on BMPs with physical locations. These include all Environmental Site Design (ESD) BMPs, all Structural BMPs, and Alternative BMPs. Reductions for operational BMPs, including street sweeping, catch basin cleaning, storm drain vacuuming, and septic system improvements, have been determined using current data from County agencies working with these programs. Load reductions for each type of BMP are based on the MDE 2014 Accounting Guidance (MDE, 2014).

Qualitative measures will evaluate overall program success. The County will track and report progress annually with the submission of the County's Annual Report for their Phase I NPDES MS4 permit. The County will use the recommendations presented in the Double Pipe Creek Watershed Assessment to establish goals as previously described and evaluate the progress towards meeting those goals in the Annual Report submission.

7.2 – MONITORING PROGRAM

Frederick County has a number of initiatives in place to monitor and assess the results of watershed protection and restoration efforts. As documented in its National Pollutant Discharge Elimination System (NPDES) 2014 Annual Report, the County has designed a monitoring program to include two (2) separate monitoring efforts: (1) targeted restoration monitoring and (2) County-wide, probability-based stream monitoring, with sites randomly selected and stratified by watershed called the Frederick County Stream Survey (FCSS).

7.2.1 – Targeted Restoration Monitoring

The County's targeted stream restoration program assesses the physical, chemical and biological conditions of streams within Frederick County during designated sampling periods. Stream sampling locations vary by year and are based on supporting on-going restoration efforts. In 2018, the County completed targeted restoration monitoring in the Bennett Creek, Fishing Creek, and Potomac Direct (Point of Rocks) NPDES watersheds.

7.2.2 – Frederick County Stream Survey (FCSS)

As described in the County's National Pollutant Discharge Elimination System (NPDES) 2014 Annual Report, the FCSS is a probability-based survey (with random site selection) which uses rapid benthic macroinvertebrate and physical habitat assessments methods to assess County stream conditions. The program was developed using the similar protocols to the Maryland Biological Stream Survey (MBSS) but on a finer scale.

The County's survey includes 200 sites randomly selected across the County's 20 NPDES watersheds. The survey is carried out over a four (4) year period with 50 sites sampled each year. Establishing the timeframe in such a manner minimizes the influence of wet and dry years on the survey results and the combined four-year results provide a snapshot of stream conditions. Round 1 of the FCSS ran from 2008 to 2011. Round 2 began in 2013 and continued through 2016. Round 3 commenced in 2018 and will end in 2022 and is being conducted using methods outlined in the FCSS Sampling and Analysis Plan (Frederick County, May 2018). Sites are visited once during the Spring Index Period (March through April). Data collection includes benthic macroinvertebrate sampling; in-situ water quality; stream discharge; aqueous grab samples; and spring and summer MBSS habitat, index period, and vernal pool data. Grab water samples are analyzed for Turbidity, Total Nitrogen, Total Phosphorus, Ammonia-N, TKN (calculated), Nitrate-Nitrogen, Dissolved Organic Carbon, Total Copper, Total Lead, Total Zinc, Chloride, and Total Hardness.

7.2.3 – State Monitoring Efforts

State monitoring efforts include the Maryland Biological Stream Survey (MBSS). The MBSS is a probability-based or random design stream monitoring program implemented by the Maryland DNR. It provides an unbiased estimate of stream condition with known precision at various spatial scales ranging from large 6-digit river basins and medium-sized 8-digit watersheds to the entire state. The first statewide round was completed in 1997 and the fourth round of MBSS sampling ended in 2018. There are over 5,300 sampling sites statewide. Data from the three previous rounds can be used as baseline conditions. Results from future rounds can be used to evaluate changes within the County.

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APPENDICES