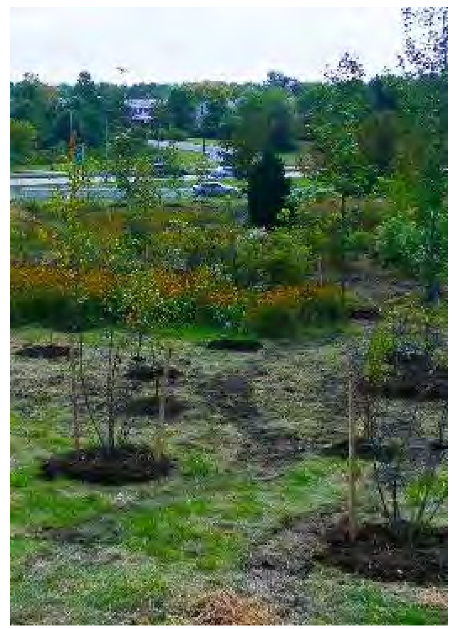
Part IV

SHA Watershed TMDL Implementation Plans



PUBLIC REVIEW DRAFT

IV. SHA WATERSHED TMDL IMPLEMENTATION PLANS

A. ANACOSTIA RIVER WATERSHED

A.1. Watershed Description

The Anacostia River watershed encompasses 145 square miles across both Montgomery and Prince George's Counties, Maryland, and an additional 31 square miles in Washington, DC. The watershed terminates in Washington, D.C., where the Anacostia River flows into the Potomac River, which ultimately conveys water to the Chesapeake Bay. The watershed is divided into 15 subwatersheds: Briers Mill Run, Fort Dupont Tributary, Hickey Run, Indian Creek, Little Paint Branch, Lower Beaverdam Creek, Northeast Branch, Northwest Branch, Paint Branch, Pope Branch, Sligo Creek, Still Creek, Upper Beaverdam Creek, Watts Branch, and the tidal river.

There are 1,815.3 miles of SHA roadway located within the Anacostia River Watershed, associated ROW comprises 4,861.6 acres, of which 2,329.2 acres is impervious. SHA facilities located within the Anacostia watershed consist of three park and ride facilities, three salt storage facilities, one highway office, one weigh station, and one highway garage/shop. See **Figure 4-1** for a map of the watershed.

A.2. SHA TMDLs within Anacostia River Watershed

TMDLs requiring reduction by SHA in the Anacostia River watershed include trash and PCBs as shown in **Table 3-2** (MDE, 2008x). The allocated trash baseline for SHA is to be reduced by 100% (this does not mean that trash within the watershed will be reduced to zero). The allocation is divided into separate requirements for each County.

PCBs are to be reduced in certain subwatersheds of the Anacostia River. The Anacostia River Northeast Branch subwatershed requires a 98.6% reduction and the Anacostia River Northwest Branch subwatershed requires a 98.1% reduction. The Anacostia River Tidal subwatershed is included in the Tidal Potomac PCB TMDL. However, PCB reduction requirements for this portion of the Anacostia watershed have not been determined. Instead of publishing a reduction percentage, the MDE Data Center said "see report." Because of the way the reductions are listed in the tables in the TMDL report, with totals added together either by tributary or by segments or jurisdiction, it is not possible to determine a load reduction for these waterbodies so that SHA's requirement could be calculated.

A.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-2**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional restoration due to minimal right-of-way along residential and wooded areas, which limits the ability to purchase right-of-way for the construction of a new BMP. The remaining grids needing review will be addressed in future tasks. The current results of this ongoing grid search are as follows:

101 Total Grids:

- Nine (9) fully reviewed
- 46 partially reviewed - in progress
- 46 awaiting review (42% of total grids)

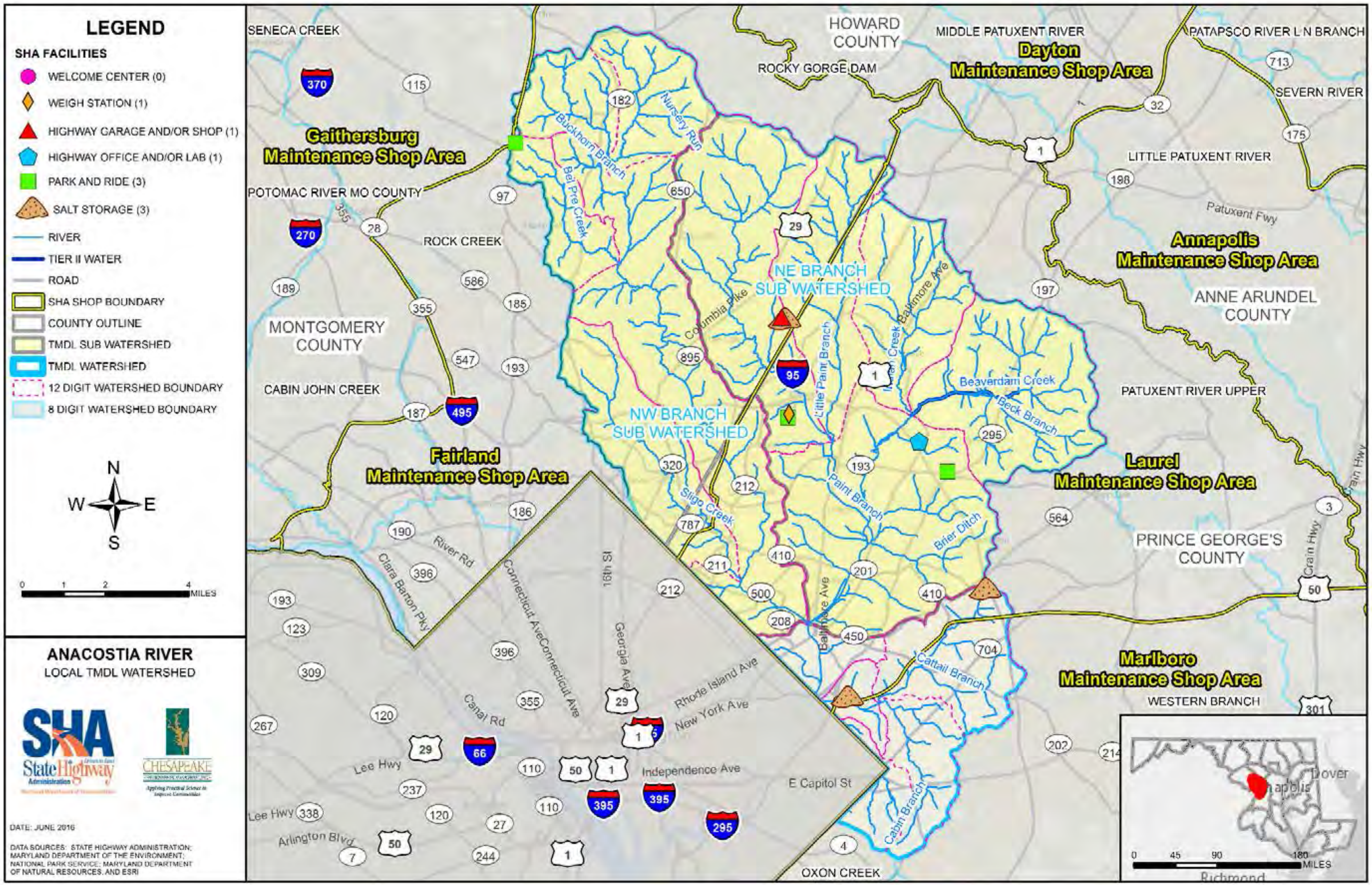


Figure 4-1: Anacostia River Watershed and SHA Facilities

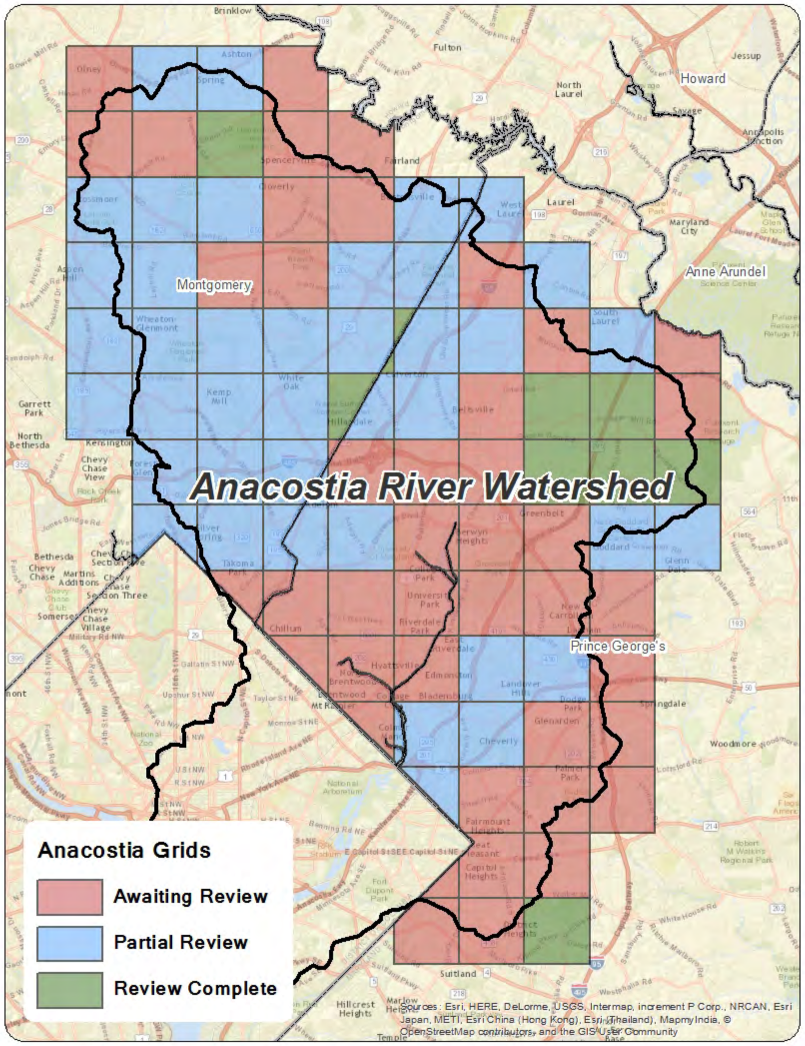


Figure 4-2: Anacostia River Watershed Site Search Grids

The stormwater site search has resulted in a pool of potential sites comprised the following:

- 148 locations identified as possible candidates for new stormwater BMPs.
- 28 facilities undergoing concept design and may be candidates for design contracts in the near future.
- Six (6) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 2,728 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 1.5 acres are undergoing concept design and may be candidates for planting contracts in the future.
- 28 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 235,452 linear feet of stream channel for restoration opportunities. The site search has resulted the following:

- 71,205 linear feet recommended for future restoration potential

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

A.4. Summary of County Assessment Review

Waters within the Anacostia River watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Biochemical oxygen demand (BOD);
- Channelization;
- Chlordane;
- Chlorides;
- Debris/Floatables/Trash;
- *Enterococcus;*
- Heptachlor Epoxide;
- Lack of Riparian Buffer;
- Mercury in Fish Tissue;
- Nitrogen (Total);
- PCB in Fish Tissue;
- Phosphorus (Total);
- Polychlorinated biphenyls (PCBs);
- Sulfates; and
- Total Suspended Solids (TSS)

Both Montgomery and Prince George's Counties have conducted a watershed assessment for areas within the Anacostia River watershed. These include the 2012 *Anacostia River Watershed Implementation Plan (WIP)* produced by Montgomery County Department of Environmental Protection (MC-DEP, 2012x) and the 2014 *Restoration Plan for the Anacostia River Watershed in Prince George's County* by the Prince George's County Department of the Environment (PGC-DoE, 2014x). Prince George's County also prepared the document *Restoration Plan for PCB-Impacted Waterbodies in Prince George's County* in 2015 (PGC-DOE, 2015x).

Many areas of the Anacostia River watershed were developed prior to modern stormwater management and erosion and sediment control regulations. Impervious land cover comprises a large portion of the watershed (24%). Montgomery County identified 6,917 acres (18%) with impervious cover. Likewise, the Restoration Plan for the Anacostia River watershed in Prince George's County identifies 15,435.3 acres (28.5%) of impervious cover. In Montgomery County alone, impervious cover contributes 206,312 lbs. per year of nitrogen, 20,953 lbs. per year of phosphorus, and 7,682 tons per year of sediment to the watershed.

The subwatersheds in Prince George's County were prioritized by ranking the necessary total load reductions for each TMDL parameter. Montgomery County mapped individual stream areas for restoration opportunity prior to 2012, but may have restored several already. Montgomery County noted that according to their testing parameters, Lower Paint Branch, Little Paint Branch, Northwest Branch, and Sligo Creek received consistent "poor" ratings, and should be targeted for restoration efforts.

From 2009-2013 benthic invertebrate surveys were conducted throughout Montgomery and Prince George's Counties. Of the sampled sites, 91% of Montgomery County sites were rated as "fair" or "poor," while approximately 50% of sites in the most recent round of sampling in Prince George's County were rated as "poor" or "very poor." As a result of the studies, both counties identified several similar restoration strategies for meeting pollution reduction and improvement goals within the watershed. These include:

- Stormwater retrofit
- Stream restoration
- Wetland creation/restoration
- Fish blockage removal/modification
- Riparian reforestation/street tree planting
- Green roof
- Dry water pond
- Bioswales
- Permeable pavements/sidewalks
- Rain gardens and rain barrels
- Street sweeping
- Downspout disconnection

Additionally, trash reduction strategies are also discussed by both Counties. Trash loading within the watershed is categorized by land use. The trash reduction strategies were broken into four (4) categories including structural, educational, municipal, and enforcement. In both counties, 68% of this reduction will be addressed by structural BMPS and the rest (32%) from outreach and enforcement activities. All trash reduction efficiencies are a percent reduction from the loading rate of the area's land use. **Table 4-1** outlines the strategies and efficiencies for each.

Table 4-1: County Preferred Trash Reduction Strategies and Efficiencies

BMP Program	Category	Unit Reduction Efficiency
SWM and ESD BMPs	Structural	95% of Drainage Area Loading Rate
Trash Interceptors	Structural	90% of Drainage Area Loading Rate
Land Use Change to Reduce Loading Rate	Municipal	Depends on Land Use
Anti-Littering Campaign	Educational	12% Reduction of Residential Land Use Loading Rate
Recycling Education and Enforcement	Educational, Municipal, and Enforcement	25% Reduction of Land Use Loading rate within Areas with Recycling Service
Plastic Bag Ban	Educational, Municipal, and Enforcement	30% of Total Load
Enforcement of Littering and Illegal Dumping	Enforcement	5% Reduction of Industrial and Commercial Land Use Loading Rate

Many of these strategies are not available to SHA since it is not a municipal entity with its own enforcement capacity. Also, SHA ROW only has a single land use category being transportation, so changes in land use categories would not be possible. Therefore, the most suitable strategies that would apply to SHA include structural and educational strategies.

PCB Reduction

Prince George's County's *Restoration Plan for PCB-Impacted Water Bodies* outlines strategies for PCB reduction. The primary strategy for additional and targeted PCB reduction is the development of a source tracking and elimination program that traces the contamination back to its source and removes it from the system. The source tracking program identifies areas where PCB sources have been documented or are likely to exist. These areas will be assessed to target BMPs (e.g., stormwater ponds) and waterways where PCBs are most likely to have been carried by stormwater. Sediments in these BMPs and waterways will then be sampled and analyzed to determine PCB concentrations. If present above the action level, the PCB-impacted sediments will be removed from the system and the County will take credit for the PCB load reduction. Ideally, the originating source of PCBs can be immediately identified and corrected during the source removal/remediation phase.

The ROW is public space that is owned and maintained either by the County or SHA. Some of these areas may have a high density of substations and transformers that could contain PCBs, particularly in industrial, commercial, and high-density urban areas. BMPs receiving runoff from such ROW areas will be a priority focus area if there are no access restrictions involved.

Superfund sites have high potential for PCB source pollution. Prince George's County Superfund sites and their known PCB presence are listed in **Table 4-2**.

As a whole, structural and nonstructural BMPs have been implemented by the County including permit compliance, TMDL WLAs, flood mitigation, and more. Prince George's County has also engaged in street sweeping, public outreach to promote environmental awareness, green initiatives, and community involvement in protecting natural resources.

Table 4-2: Prince George's County Superfund Sites

Site Name	City	Known PCBs
Andrews Air Force Base	Andrews AFB	X
Beltsville Agriculture Research Center (BARC)	Beltsville	X
Brandywine DRMO	Andrews	X
Chillum Gasoline Release	Chillum	
Chillum PERC	Chillum	
Laurel Chlorine Cylinder	Laurel	
Nazcon Concrete	Beltsville	
Roger's Electric Company	Cheverly	X
Windsor Manor Road	Brandywine	

A.5. SHA Pollutant Reduction Strategies

Proposed practices to meet PCB reduction in the Anacostia River Northwest Branch and Northeast Branch watersheds are shown in **Table 4-3** and **4-4**, respectively. Projected PCB reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline year through 2025. For the Anacostia River Northwest Branch and Northeast Branch TMDL, the baseline is 2005.

2. BMPs built between 2026 through the projected target date of 2045. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Anacostia River Northwest Branch and Northeast Branch watersheds total $4,446,000 and $10,216,000, respectively. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $265,000 from our Operations Budget is estimated for annual inlet cleaning.

Proposed practices to meet Trash reduction in the Anacostia River Montgomery County and Prince Georges County portion of the watershed are shown in **Table 4-5** and **4-6**, respectively. Projected Trash reductions using these activities based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

3. Reduction activities implemented after the TMDL baseline year through 2025. For the Anacostia River Montgomery and Prince Georges County portions of the TMDL, the baseline is 2009.

4. Reduction activities implemented between 2026 through the projected target date of 2045. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

SHA expects to spend $73,440 annually from our Operations Budget for an annual increase in inlet cleaning, yearly maintenance of our new public trash education program, stream cleanup, annual trash pickup from newly constructed stormwater facilities and increased roadside trash pickup.

Figure 4-3 shows a map of SHA's watershed restoration practices and includes those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-3: Anacostia River Northwest Branch Restoration PCB BMP Implementation					
BMP	**Unit**	**2006-2025**	**2026-2045**	**Total**	**Cost**
New Stormwater	drainage area acres	16.5	9.2	25.6	$3,760,000
Retrofit	drainage area acres	43.6		43.6	$686,000
Inlet Cleaning[1]	tons	136.5	136.5	136.5	$130,000
[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.					

Table 4-4: Anacostia River Northeast Branch Restoration PCB BMP Implementation					
BMP	**Unit**	**2006-2025**	**2026-2045**	**Total**	**Cost**
New Stormwater	drainage area acres	38.6	24.9	63.5	$9,052,000
Retrofit	drainage area acres	33.1		33.1	$1,164,000
Inlet Cleaning[1]	tons	140.8	140.8	140.8	$135,000
[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.					

Table 4-5: Anacostia Montgomery County Portion Trash Activities Implementation

BMP	Unit	2010-2025	2026-2045	Total	Cost
Increased Inlet Cleaning	lbs/yr	1,068	1,692	2,670	$9,900
New Public Education Program	lbs/yr	30	45	725	$2,700
New Stream Clean Up	lbs/yr	0	0	0	$0
New Structural SW Controls Pickup	lbs/yr	43	65	108	$400
Increased Roadside Pickup	lbs/yr	1,106	1,659	2,765	$10,240
These trash reducing activities are an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.					

Table 4-6: Anacostia Prince Georges County Portion Trash Activities Implementation

BMP	Unit	2010-2025	2026-2045	Total	Cost
Increased Inlet Cleaning	lbs/yr	2,937	4,406	7,343	$27,200
New Public Education Program	lbs/yr	678	1,017	1,696	$6,300
New Stream Clean Up	lbs/yr	210	315	525	$2,000
New Structural SW Controls Pickup	lbs/yr	75	114	189	$700
Increased Roadside Pickup	lbs/yr	1,513	2,271	3,784	$14,000
These trash reducing activities are an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.					

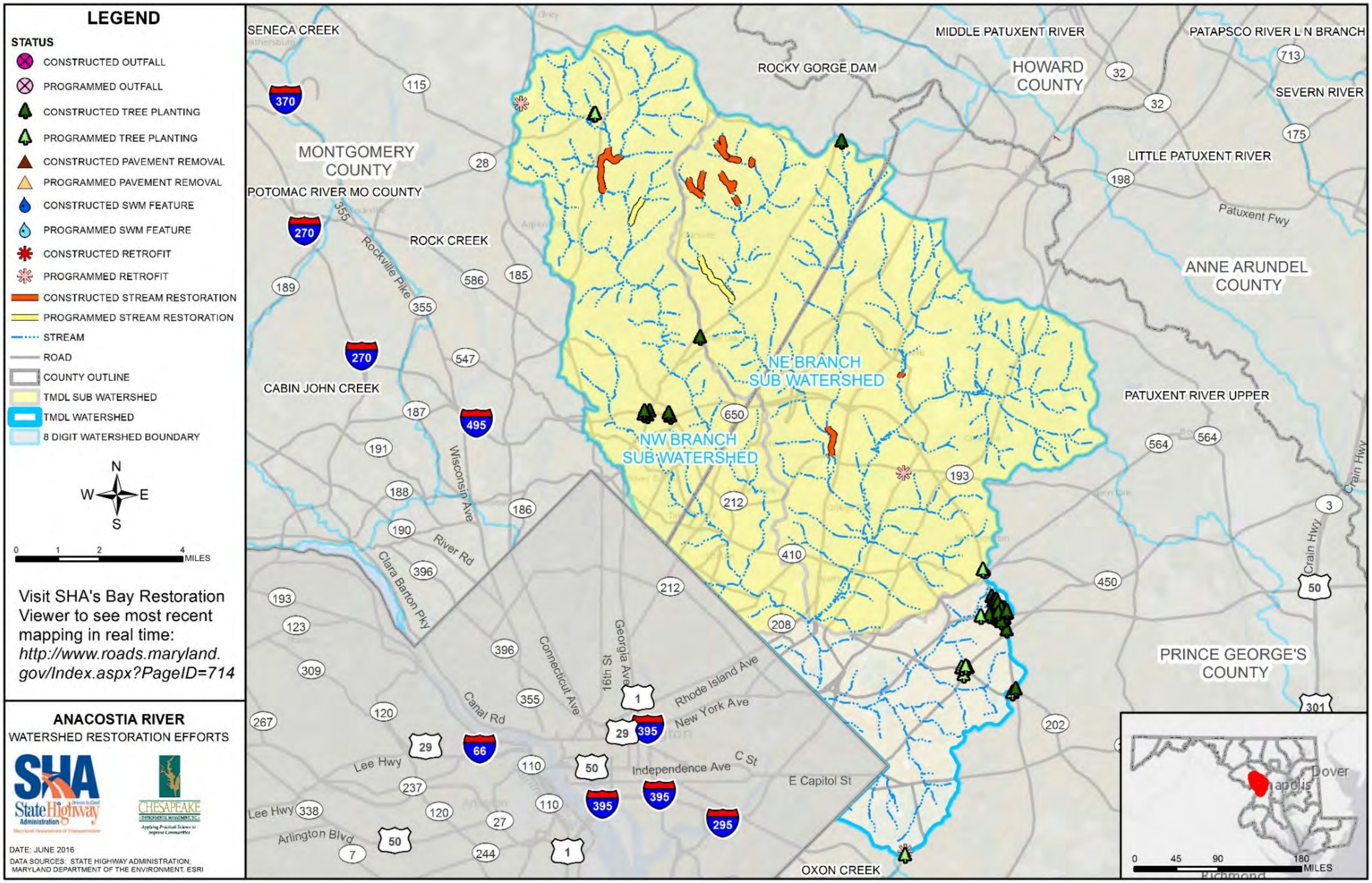


Figure 4-3: SHA Restoration Strategies within the Anacostia River Watershed

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B. ANTIETAM CREEK WATERSHED

B.1. Watershed Description

The Antietam Creek watershed encompasses 290 square miles with 185 square miles in Maryland. Approximately 75% of this watershed occurs in Washington County with the remainder in Franklin and Adams Counties, Pennsylvania. Antietam Creek flows about 54 miles from its headwaters in Pennsylvania's Michaux State Forest to the Potomac River near Antietam, Maryland. Major tributary creeks and streams of the Antietam Creek watershed in Maryland include Little Antietam Creek, Beaver Creek, and Marsh Run.

There are 744.4 miles of SHA roadway located within the Antietam Creek Watershed, associated ROW comprises 2,201.3 acres, of which 853.2 acres is impervious. SHA facilities located within the watershed consist of five park and ride facilities, four salt storage facilities, and two highway garage/shop facilities. See **Figure 4-4** for a map of the watershed.

B.2. SHA TMDLs within Antietam Creek Watershed

TMDLs requiring reduction by SHA include phosphorus (Total) and sediment (also referred as TSS) (MDE, 2013x; MDE, 2008x). Phosphorus is to be reduced by 21.4% and sediment is to be reduced by 58.1% within Antietam Creek, Washington County as shown in **Table 3-2**.

B.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-5**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

The remaining grids needing review will be addressed in future tasks. The current results of this ongoing grid search are as follows:

126 Total Grids:

- 50 fully reviewed
- 71 partially reviewed - in progress
- Five (5) awaiting review (4% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 762 locations identified as possible candidates for new stormwater BMPs.
- Four (4) facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

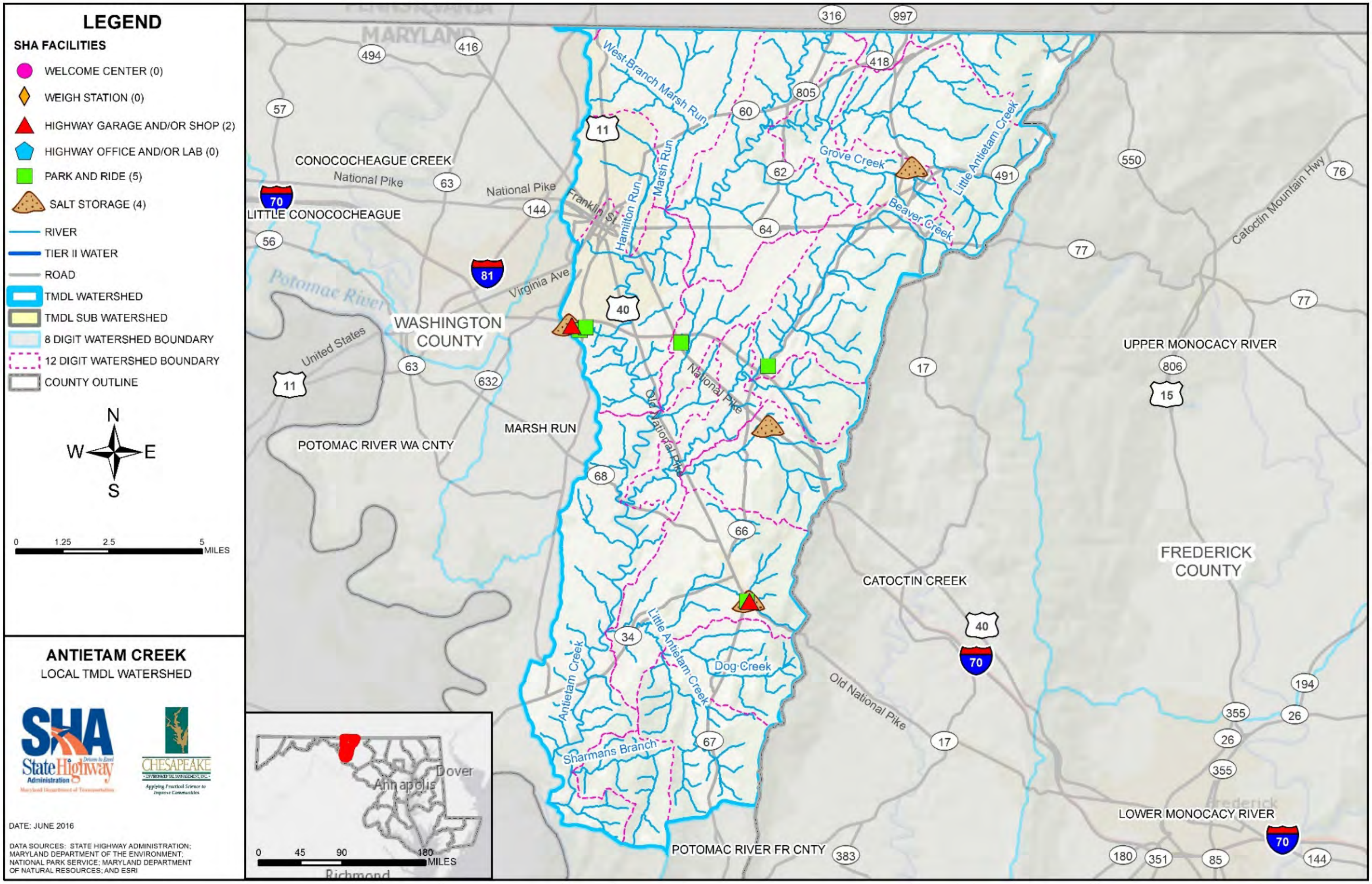

Figure 4-4: Antietam Creek Watershed

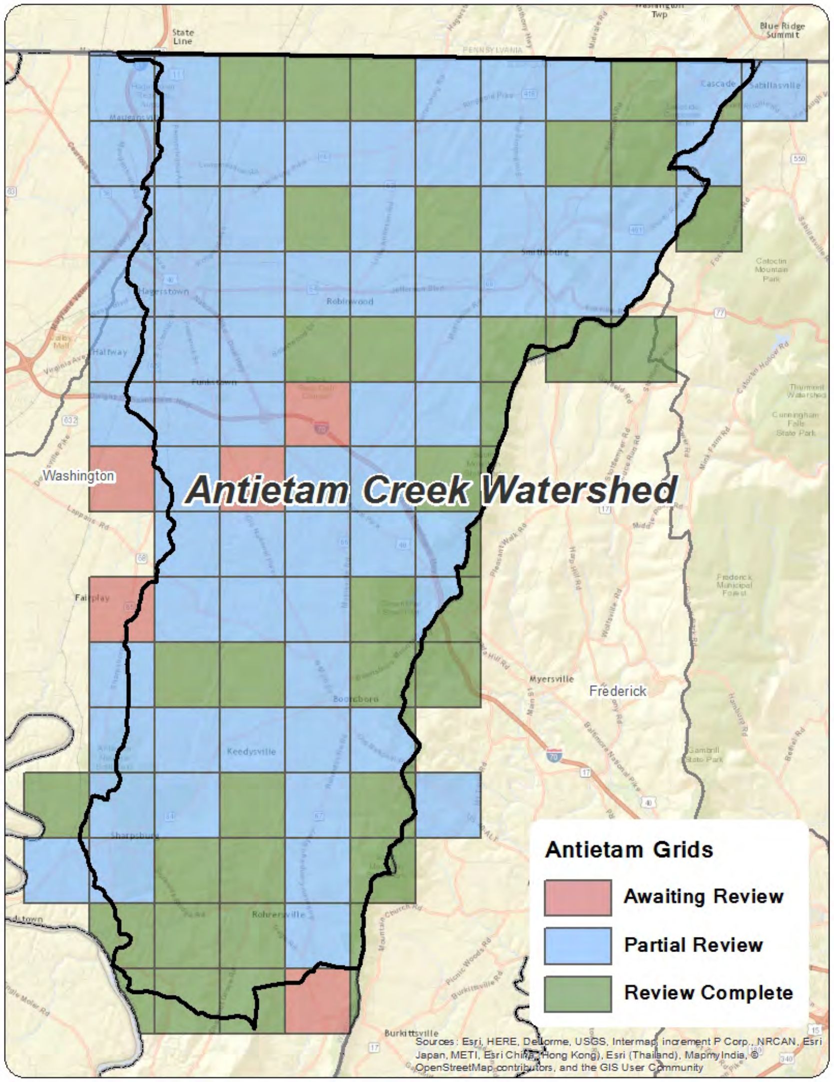

Figure 4-5: Antietam Creek Site Search Grids

The tree planting site search teams have investigated 2,130 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised the following:

- 49 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 11,879 linear feet of stream channel for restoration opportunities. The site search has resulted the following:

- 7,394 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

B.4. Summary of County Assessment Review

Waters within the Antietam Creek watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Biochemical oxygen demand (BOD);
- Channelization;
- *Escherichia coli;*
- Lack of Riparian Buffer;
- Mercury in Fish Tissue;
- Nitrogen (Total);
- Nitrogenous biochemical oxygen demand (NBOD);
- PCB in Fish Tissue;
- Phosphorus (Total);
- Sulfates;
- Temperature; and
- Total Suspended Solids (TSS).

The 2012 *Antietam Creek Watershed Restoration Plan* was developed through a partnership (comprised of several organizations including MDE and led by the Washington County Soil Conservation District [WCSCD]) as a comprehensive summary of the issues impacting the watershed area (WCSCD et al., 2012). Antietam Creek currently has completed TMDLs for phosphorus, total suspended solids, and E.coli. However, TMDLs are still necessary for PCB is fish tissue, sulfates, and temperature (water).

The watershed has been divided into nine subwatersheds. Approximately 59% of the stream miles classified as having fish and/or benthic indices (FIBI, BIBI) of biological impairment in the “poor” to “very poor” category. After review and evaluation, it was determined that three of the nine watersheds be targeted for pollutant reduction implementation, ANT0277, MRS0000, and BEC0001.

Because the watershed has several hundred acres in agricultural use (42%), there are separate BMP’s listed for agricultural practices and urban areas. The suggested BMPs for watershed restoration are shown in **Table 4-7**.

B.5. SHA Pollutant Reduction Strategies

Antietam Creek is listed for both phosphorus and sediment with each TMDL having a baseline year of 2000. Proposed practices to meet the phosphorus and sediment reductions in the Antietam Creek watershed are shown in **Table 4-8**. Projected phosphorus and sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table below:

1. BMPs built after the phosphorus and sediment TMDL baseline through 2025. In this case the baselines are year 2000.

2. BMPs built from 2026 through 2045 the projected target date of the sediment TMDL. 2040 is the projected target date for the phosphorus TMDL. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Table 4-7: Suggested BMPs in the Antietam Watershed

Agricultural BMPs	Urban BMPs
Pet Waste Runoff Campaign*	Bioretention/Rain Gardens*
Septic System Upgrades	Bio-Swale*
Grass Buffers*	Dry Detention Ponds*
Riparian Forest Buffers*	Dry Extended Detention Ponds*
Stream Protection with Fencing*	Forest Conservation (pervious only)*
Stream Protection without Fencing*	Impervious Urban Surface Reduction*
Livestock Stream Crossing	Permeable Pavement
Nutrient Management Planning*	Urban Forest Practices*
Runoff Control Systems*	Urban Filtering Practices*
Cover Crops	Urban Infiltration Practices*
Animals Waste Management	Street Sweeping*
Conservation Tillage	Urban Nutrient Management*
Retire Highly Erodible Lands	Vegetated Open Channel*
Natural Stream Designs/Armored Steam Banks*	Wet Ponds & Wetlands*
** Denotes practices that may be applicable to SHA’s program*	

Estimated Capital Budget costs to design and construct practices within the Antietam Creek watershed total $39,926,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $77,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-6 shows a map of SHA’s restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-8: Antietam Creek Restoration Nutrient and Sediment BMP Implementation					
BMP	**Unit**	**2001-2025**	**2026-2045**	**Total**	**Cost**
New Stormwater	drainage area acres	113.3	148.1	261.4	$30,544,000
Retrofit	drainage area acres	32.9		32.9	$1,074,000
Stream Restoration	linear feet		1,500.0	1,500.0	$1,100,000
Tree Planting	acres planted	145.4	4.0	149.4	$5,026,000
Outfall Stabilization[1]	linear feet		1,000.0	1,000.0	$2,182,000
Inlet Cleaning[2]	tons	32.8	79.9	79.9	$77,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report

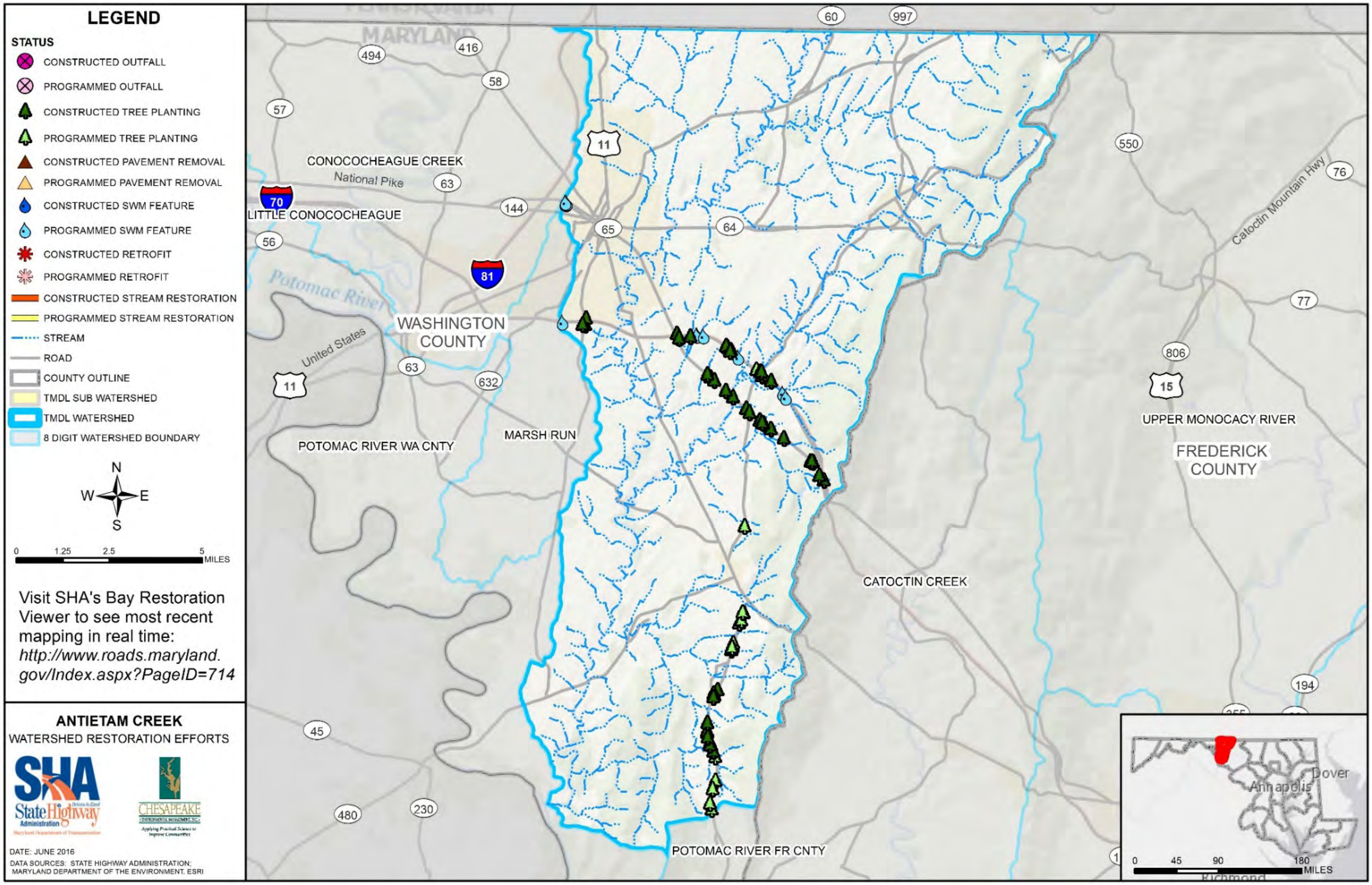

Figure 4-6: SHA Restoration Strategies within the Antietam Creek Watershed

C. BACK RIVER WATERSHED

C.1. Watershed Description

The Back River watershed encompasses 37 square miles in the western shore region of Maryland within City of Baltimore and Baltimore County. Back River drains into the Chesapeake Bay in Baltimore County. Major tributary creeks and streams of the Back River Watershed include Armistead Run, Biddison Run, Bread and Cheese Creek, Brien's Run, Chinquapin Run, Deep Creek, Duck Creek, Herring Run, Moore's Run, Northeast Creek, Redhouse Run, Stemmers Run, and Tiffany Run. The Back River Watershed is comprised of the Upper Back River (UBR) subwatershed and the Tidal Back River (TBR) subwatershed. The UBR subwatershed accounts for 78% of the Back River watershed and the TBR subwatershed accounts for the remaining 22%.

There are approximately 869.3 miles of SHA roadway located within the Back River watershed, associated ROW comprises approximately 1,532.3 acres, of which 718.4 acres is impervious. SHA facilities located within the Back River Watershed consist of three salt storage facilities, and two highway garage/shop facilities. See **Figure 4-7** for a map of the watershed.

C.2. SHA TMDLs within Back River Watershed

The TMDL requiring reduction by SHA is for PCBs (MDE, 2012). PCBs are to be reduced by 53.4% within Back River in Baltimore County as shown in **Table 3-2.**

C.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-8**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal right-of-way along residential and wooded areas, which limits the ability to purchase right-of-way for the construction of a new BMP. The current results of this ongoing grid search are as follows:

40 Total Grids:

- Seven (7) fully reviewed
- 25 partially reviewed - in progress
- Eight (8) awaiting review (20% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 81 locations identified as possible candidates for new stormwater BMPs
- One (1) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

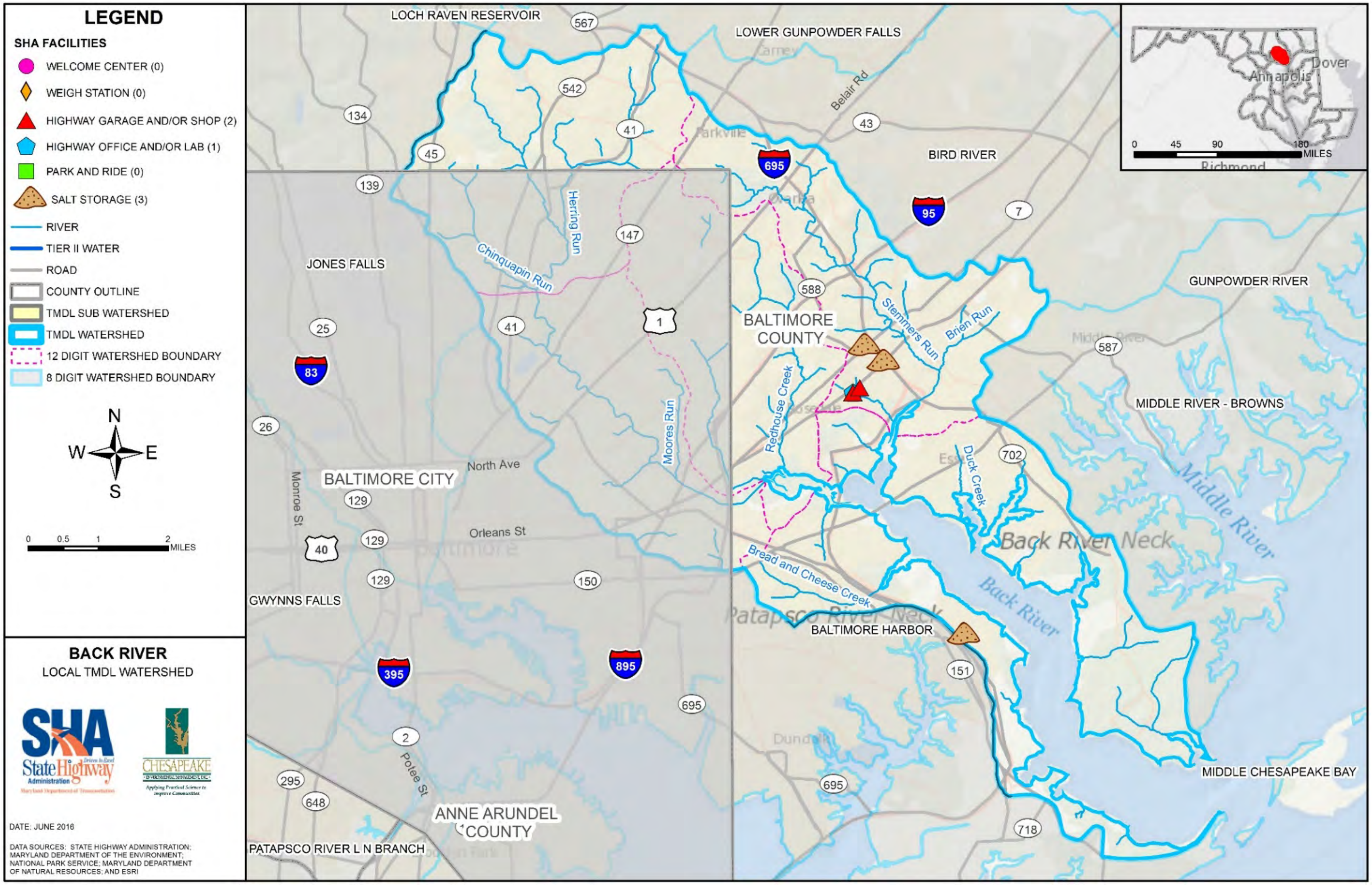

Figure 4-7: Back River Watershed

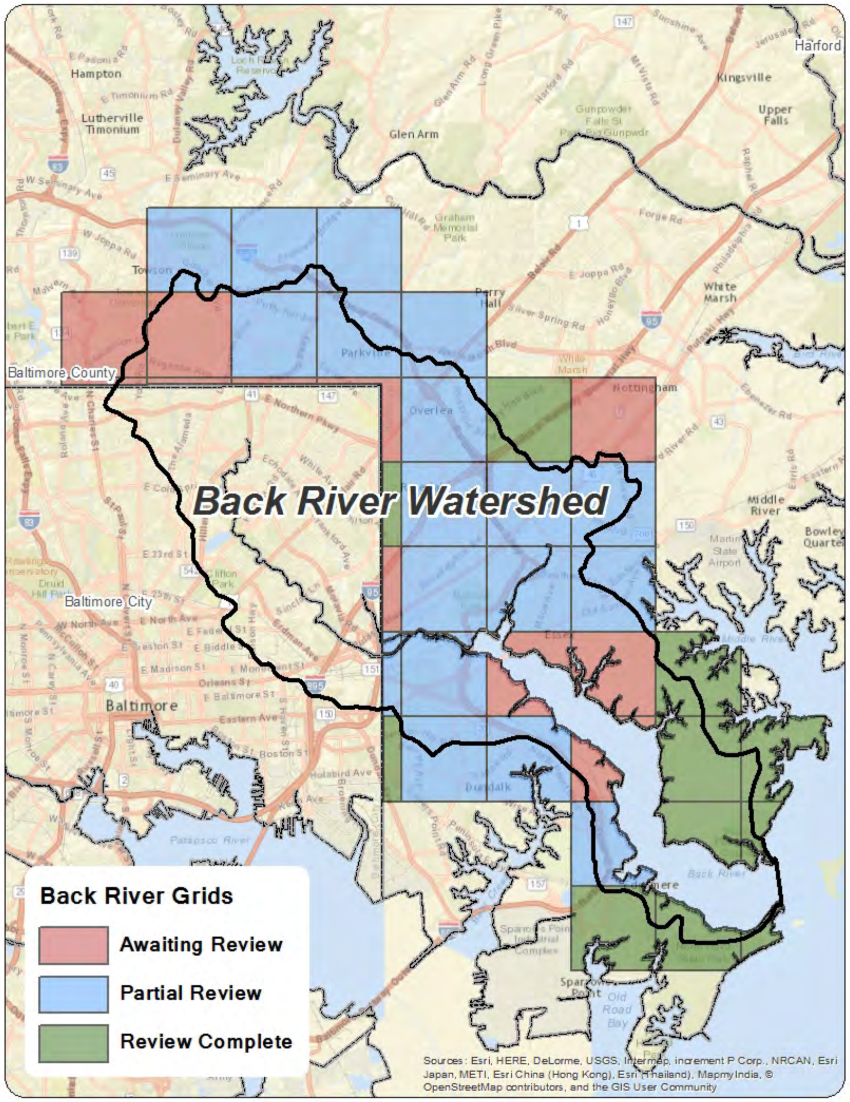

Figure 4-8: Back River Site Search Grids

The tree planting site search teams have investigated 913 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 4 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 8,133 linear feet of stream channel for restoration opportunities. The site search has resulted the following:

- 3,252 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

C.4. County Assessment Review Summary

Waters within the Back River watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Channelization;
- Chlordane;
- Chlorides;
- Fecal Coliform;
- Lack of Riparian Buffer;
- Mercury in Fish Tissue;
- Nitrogen (Total);
- PCB in Fish Tissue;
- Phosphorus (Total);
- Polychlorinated biphenyls (PCBs);
- Sulfates;
- Total Suspended Solids (TSS); and
- Zinc.

The Baltimore County completed Small Watershed Action Plans (SWAPs) for the UBR Watershed in 2008 (BC-DEPRM, 2008) and the TBR Watershed in 2010 (PB, 2010). Impervious land cover comprises 31% of the UBR watershed and 18% of the TBR watershed. Over 46% of soils within the UBR Watershed and over 25% of soils within the TBR watershed are considered of high runoff potential.

Baltimore County estimates that impervious urban land use is responsible for contributing 314,619 lbs. of nitrogen and 40,182 lbs. of phosphorus in the UBR watershed per year (BC-DEPREM, 2008) and 19,444 lbs. of nitrogen and 3,117 lbs. of phosphorus in the TBR watershed per year (PB, 2010). Back River currently has completed TMDLs for nitrogen, phosphorus, TSS, chlordane, and PCBs in the Chesapeake Bay tidal segment and fecal coliform in the river mainstem (Herring Run). Back River also has Category 5 impairment listings (i.e., TMDL required) for sediment, chlorides, and sulfates in 1st through 4th order streams.

The County SWAPs prioritized subwatersheds within the UBR and TBR Watersheds based on ranking criteria in order to identify which subwatersheds have the greatest need and potential for restoration. For the UBR Watershed, Chinquapin Run, Tiffany Run, Herring Run Mainstem, Armistead Run, Biddison Run, Moore's Run, and Redhouse Run were rated "very high" and West Branch Herring Run, East Branch Herring Run, and an unnamed tributary were rated "high" in terms of restoration need and potential (BC-DEPRM, 2008). For the TBR Watershed, Deep Creek, Duck Creek, and Bread and Cheese Creek were rated "very high" and Lynch Point Cove, Back River-G, and Muddy Gut were rated "high" in terms of restoration need and potential. In the UBR Watershed, all sites assessed by Baltimore City (42) and County (25) had Benthic Index of Biotic Integrity scores in the "poor" or "very poor" categories (PB, 2010).

For the purposes of planning, the County SWAPS suggest the following generalized restoration strategies to aid in meeting restoration goals within the Back River Watershed:

- Stormwater management for new development and redevelopment
- Existing stormwater management facility conversions
- Stormwater management retrofits
- Stream restoration
- Street sweeping and storm drain inlet cleaning
- Illicit connection detection and disconnection program and hotspot remediation
- Sanitary sewer consent decrees
- Downspout disconnection
- Citizen awareness (fertilizer application and pet waste)
- Reforestation and tree planting

The County identified numerous potential restoration sites within each subwatershed by conducting neighborhood source assessments, hotspot site investigations, institutional site investigations, and pervious area assessments. The County also identified multiple potential stormwater conversions within each watershed: 91 for the UBR Watershed and 3 for the TBR Watershed. Detailed information on site locations can be found in the SWAPs.

The following potential stream restoration sties were identified within the Back River Watershed in **Table 4-9**. An additional six sites were also identified in the UBR watershed for stormwater management retrofit on County-owned property.

Table 4-9: Potential Stream Restoration Sites in Back River Watershed

Subwatershed	Reach	Number of Sites	Total Linear Feet	Conditions
UBR	Herring Run	24	12,675	-
UBR	Stemmers Run	30	23,488	-
UBR	Brien Run	10	8,603	-
TBR	Bread and Cheese Creek	4	2,600	Erosion, dumping, and inadequate buffers
TBR	Duck Creek	3	80	Severe dumping, inadequate buffers, and invasive vegetation
TBR	Muddy Gut	2	-	Severe dumping and disturbance (ATV Trails)
TBR	Deep Creek	4	1,315	Concrete channels, inadequate buffers, severe channel alterations, severe erosion (scouring), and severe fish barrier

C.5. SHA Pollutant Reduction Strategies

Proposed practices to meet PCB reductions in the Back River watershed are shown in **Table 4-10**. Projected PCB reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table below:

1) BMPs built after the TMDL baseline through 2025. In this case the baseline is 2001.

2) BMPs built between 2026 through 2045, the projected target date. SHA will accomplish the percent reductions presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Back River watershed total $6,529,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $108,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-9 shows a map of SHA's restoration practices in the watershed and include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-10: SHA Practices Proposed for Back River PCB Reduction					
BMP	**Unit**	**2002-2025**	**2026-2045**	**Total**	**Cost**
New Stormwater	drainage area acres	25.3	21.8	47.1	$5,503,000
Retrofit	drainage area acres	21.4		21.4	$1,026,000
Inlet Cleaning[1]	tons	112.9	112.9	112.9	$108,000

1. Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

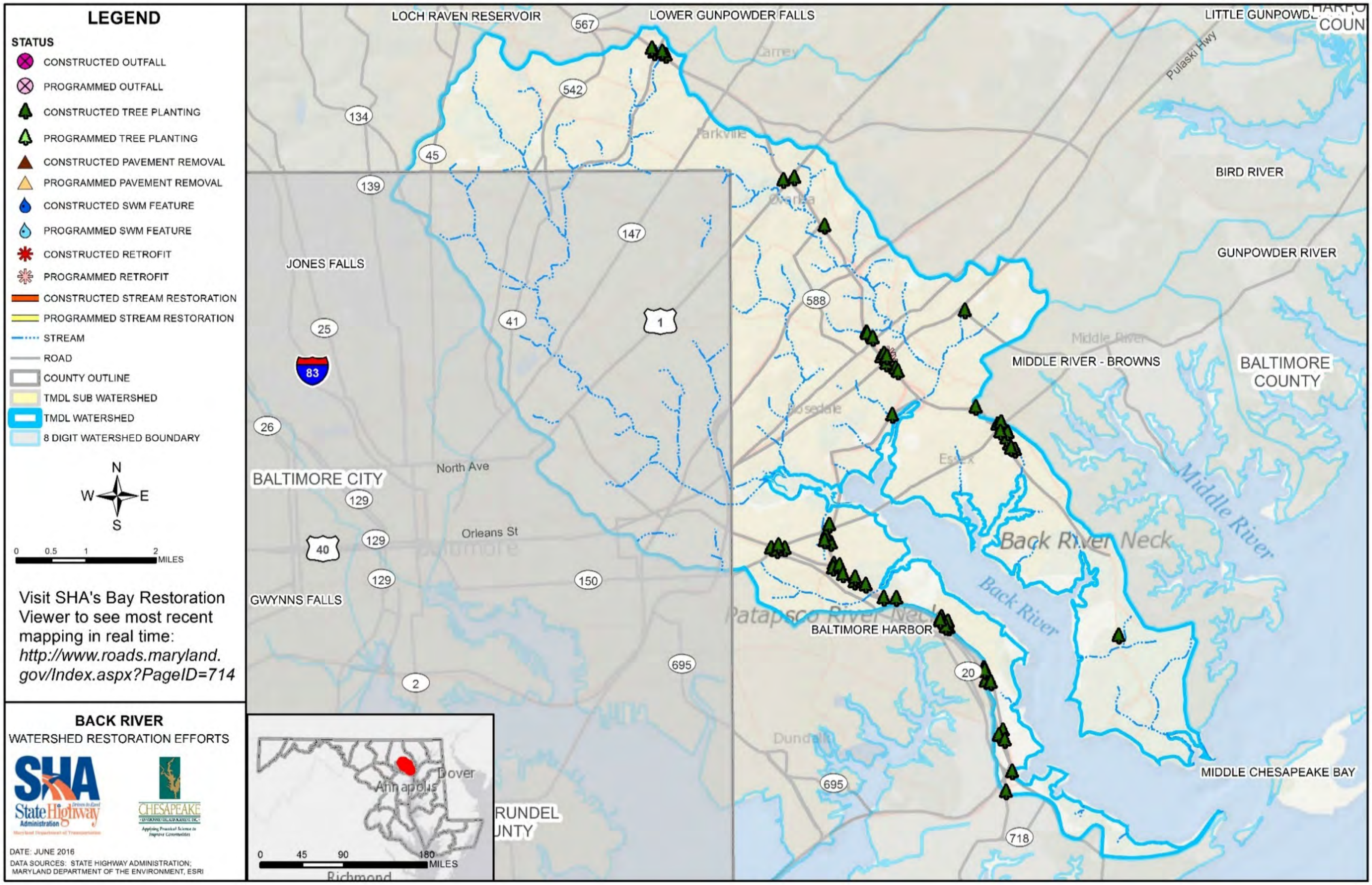

Figure 4-9: SHA Restoration Strategies within the Back River Watershed

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D. BALTIMORE HARBOR

D.1. Watershed Description

The Baltimore Harbor watershed encompasses 90 square miles within Anne Arundel County, Baltimore County, and Baltimore City. The watershed is located in the Western Shore region of Maryland south of the Back River watershed and ultimately drains into the Chesapeake Bay. Tributaries of the Baltimore Harbor watershed include Gwynns Falls, Jones Falls, Bear Creek, and Curtis Bay/Creek. The areas of focus for the TMDLs in this watershed are within the subwatersheds of Baltimore Harbor Embayment, Bear Creek, Curtis Creek, Furnace Creek, and Marley Creek in Baltimore and Anne Arundel Counties.

There are approximately 1,258 miles of SHA roadway located within the 8-digit Baltimore Harbor watershed, associated ROW comprises approximately 2,374 acres, of which 1,031 acres is impervious. SHA facilities located within the watershed consist of two salt storage facilities, and one highway garage/shop. See **Figure 4-10** for a map of the 8-digit Baltimore Harbor watershed with SHA facilities indicated.

D.2. SHA TMDLs within Baltimore Harbor

The TMDLs requiring reduction by SHA are PCBs (MDE, 2012x, x and x) and Bacteria (MDE, 2006x). PCBs are to be reduced by 91.1% in the Baltimore Harbor Embayment, Anne Arundel County, 91.4% in the Baltimore Harbor Embayment, Baltimore County, 93.5% in the Curtis Creek subwatershed, and 91.5% in the Bear Creek subwatershed as shown in **Table 3-2**. Bacteria is to be reduced by 75.8% in the Marley Creek subwatershed and 77.8% in the Furnace Creek subwatershed as shown in **Table 3-3**.

D.3. SHA Visual Inventory of ROW

The MS4 permit requires SHA perform visual assessments to **Part III.C** describes the SHA visual assessment process. Within this watershed SHA is currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking methodology was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5 mile square system as shown in **Figure 4-11**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking methodology.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal right-of-way along residential and wooded areas, which limits the ability to purchase right-of-way for the construction of a new BMP. Additionally, many SHA impervious areas within these grids are already treated by SHA NPDES BMPs. The current results of this ongoing grid search are as follows:

58 Total Grids:

- 21 fully reviewed
- 20 partially reviewed - in progress
- 17 awaiting review (29% of total grids)

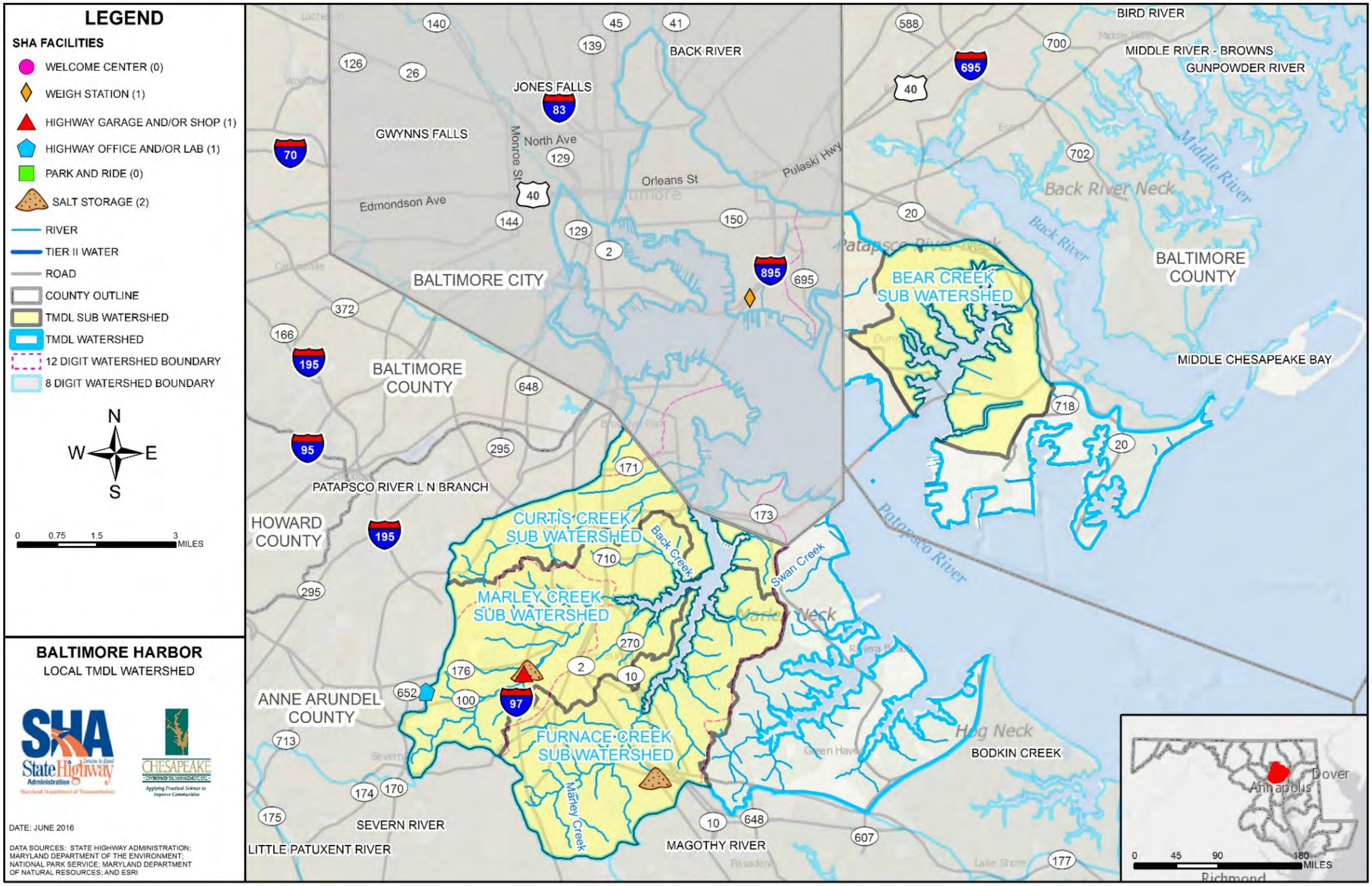

Figure 4-10: Baltimore Harbor Watershed

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 91 locations identified as possible candidates for new stormwater BMPs.
- 39 facilities undergoing concept design and may be candidates for design contracts in the near future.
- Six (6) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations undergoing review

The tree planting site search teams have investigated 1,119 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 4 acres are undergoing concept design and may be candidates for planting contracts in the near future.
- 67 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 7,615 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 5,622 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

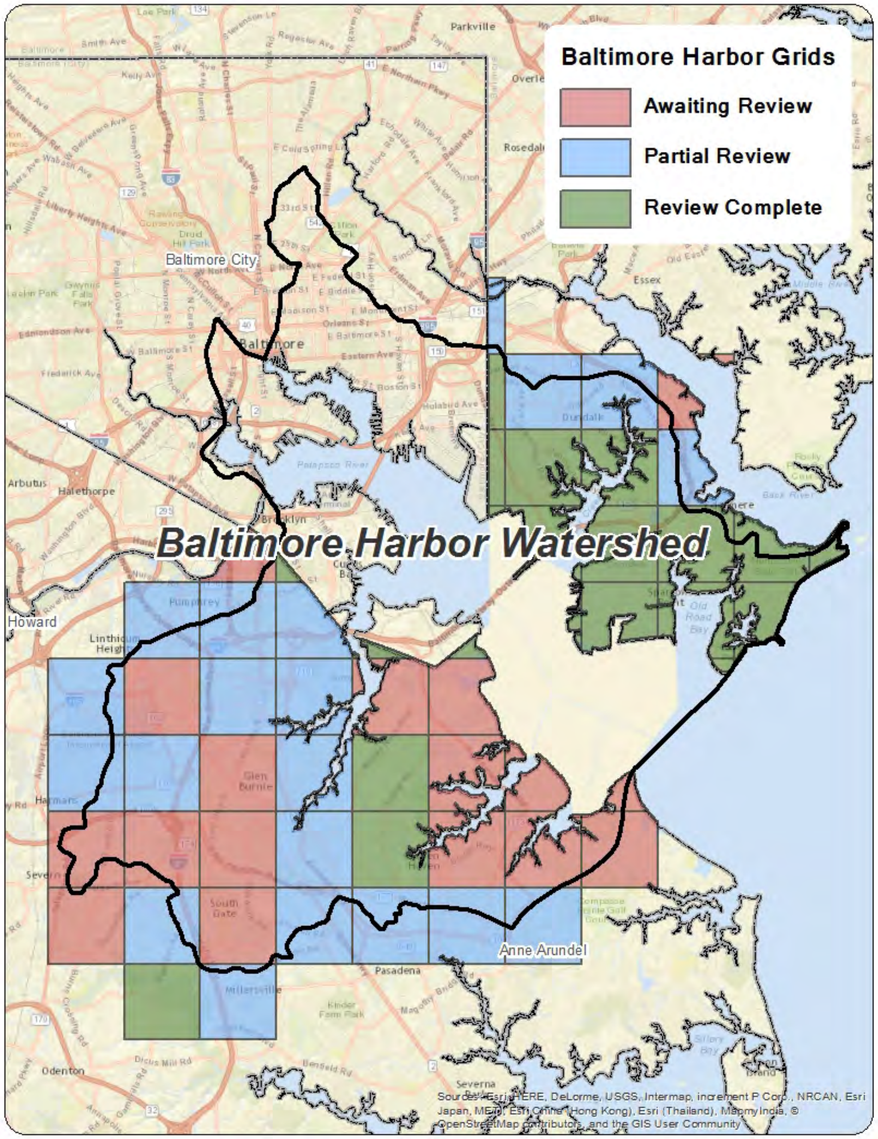

Figure 4-11: Baltimore Harbor Site Search Grids

D.4. Summary of County Assessment Reviews

Waters within the Baltimore Harbor Watershed are subject to the following impairments as noted on MDE's 303(d) List.

- Channelization;
- Chlordane – sediments;
- Chlorides;
- Lack of Riparian Buffer;
- PCB in Fish Tissue;
- Sulfates; and
- Total Suspended Solids (TSS);

Anne Arundel County Department of Public Works prepared the *Patapsco Tidal and Bodkin Creek Watershed Assessment* (AA-DPW, 2012). The assessment determines the condition and prioritizes watershed management activities for areas within the Baltimore Harbor watershed. Bodkin Creek watershed is also included in the County's assessment, but is not part of the Baltimore Harbor 8-digit watershed area.

The majority of soils within the Patapsco Tidal subwatersheds are highly erodible (58%). Residential land cover dominates the Patapsco Tidal watershed (40%), attributing to 30% impervious area over the entire watershed.

Both Patapsco Tidal and Bodkin Creek watersheds fall within the Patapsco River Mesohaline segment-shed which has Chesapeake Bay TMDLs for phosphorus, nitrogen, and TSS and a Baltimore Harbor (Anne Arundel, Baltimore, Carroll, and Howard Counties and Baltimore City) TMDL for nitrogen and phosphorus. The Patapsco River Mesohaline segment-shed also has a Category 5 impairment listing (i.e., TMDL required) for Enterococcus in tidal waters upstream of the Harbor Tunnel. Approximately 16% of the streams evaluated in the Patapsco Tidal watershed were classified as "severely degraded" by the Maryland Physical Habitat Index. Three subwatersheds were identified to have the highest percentages of stream reaches that were either "degraded" or "severely degraded": Cabin Branch 2, Marley Creek 1, and Cabin Branch SWS.

The County identified five subwatersheds within the Patapsco Tidal watershed with more than one-third of their perennial streams rated as "high" or "medium high" for restoration need: Cabin Branch (PT3), Cabin Branch 2 (PT2), Marley Creek 1 (PT8), Marley Creek 3 (PTF), and Sawmill Creek 1 (PT7). Six subwatersheds were identified in Patapsco Tidal for BMP implementation: Marley Creek 3 (PTF), Furnace Creek (PT5), Cabin Branch (PT3), Sawmill Creek 1 (PT7), Back Creek (PTC), and Marley Creek 2 (PTE).

The County suggests the following BMPs for the Patapsco Tidal and Bodkin Creek watersheds:

- Outfall retrofits – all major outfalls characterized by the IMD as impaired
- Stormwater pond retrofits – all ponds constructed prior to 2002 with a drainage area greater than 10 acres
- Stream restoration – targeting degraded and severely degraded reaches
- Street Sweeping – all closed curbed County roads
- Inlet cleaning – vacuum cleaning stormwater curb inlets and catch basins
- Public land reforestation
- ESD retrofit to the MEP – including green roofs, permeable pavement, bioretention, etc.

The County ranked several stream reaches based on priority for restoration as shown in **Table 4-11**, with 1 being the highest priority:

Table 4-11: County Identified Priority Areas for Treatment			
Priority	**Watershed**	**Subwatershed**	**Reach**
1	Patapsco Tidal	Marley Creek 3	PTF016
3	Patapsco Tidal	Rock Creek	PTB048
4	Patapsco Tidal	Cabin Branch 2	PT2026
4	Patapsco Tidal	Cabin Branch	PT3039
10	Patapsco Tidal	Marley Creek 4	PTG086
10	Patapsco Tidal	Cabin Branch	PT3010

D.5. SHA Pollutant Reduction Strategies

Proposed practices to meet PCB reduction in the Baltimore Harbor Embayment, Bear Creek, and Curtis Creek/Bay subwatersheds are shown in **Tables 4-12**, **4-13**, and **4-14**, respectively. Projected PCB reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the tables:

1. BMPs built after the TMDL baselines through 2025. In this case the baseline is 2004.

2. BMPs built between 2026 through 2038, the projected target dates. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Baltimore Harbor Embayment, Bear Creek, and Curtis Creek/Bay watersheds total $708,000, $4,549,000, and $15,992,000, respectively. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $97,000 from our Operations Budget is estimated for annual inlet cleaning.

Proposed practices to meet bacteria reduction in the Marley Creek and Furnace Creek subwatersheds are shown in **Table 4-15**. Projected bacteria reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-3**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2006.

2. BMPs built between 2026 through 2050, the projected target date. SHA will accomplish the percent reduction presented in **Table 3-3**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Marley Creek and Furnace Creek watersheds total $11,614,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category.

Figure 4-12 shows a map of SHA's restoration practices in the watersheds and includes those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-12: Baltimore Harbor Embayment Restoration PCB BMP Implementation

BMP	Unit	2005-2025	2026-2038	Total	Cost
New Stormwater	drainage area acres	3.9	3.1	7.0	$708,000
Inlet Cleaning[1]	tons	7.3	7.3	7.3	$7,000

[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

Table 4-13: Bear Creek Restoration PCB BMP Implementation

BMP	Unit	2005-2025	2026-2038	Total	Cost
New Stormwater	drainage area acres	35.6	7.7	43.3	$4,549,000
Inlet Cleaning[1]	tons	16.7	16.7	16.7	$16,000

[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

Table 4-14: Curtis Creek/Bay Restoration PCB BMP Implementation

BMP	Unit	2005-2025	2026-2038	Total	Cost
New Stormwater	drainage area acres	63.3	10.7	74.0	$9,390,000
Retrofit	drainage area acres	177.6		177.6	$6,602,000
Inlet Cleaning[1]	tons	76.9	76.9	76.9	$74,000

[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

Table 4-15: Marley and Furnace Creeks Restoration Bacteria BMP Implementation					
BMP	**Unit**	**2007 - 2025**	**2026 - 2050**	**Total**	**Cost**
New Stormwater	drainage area acres	36.2	9.2	45.4	$5,918,000
Retrofit	drainage area acres	152.0		152.0	$5,696,000

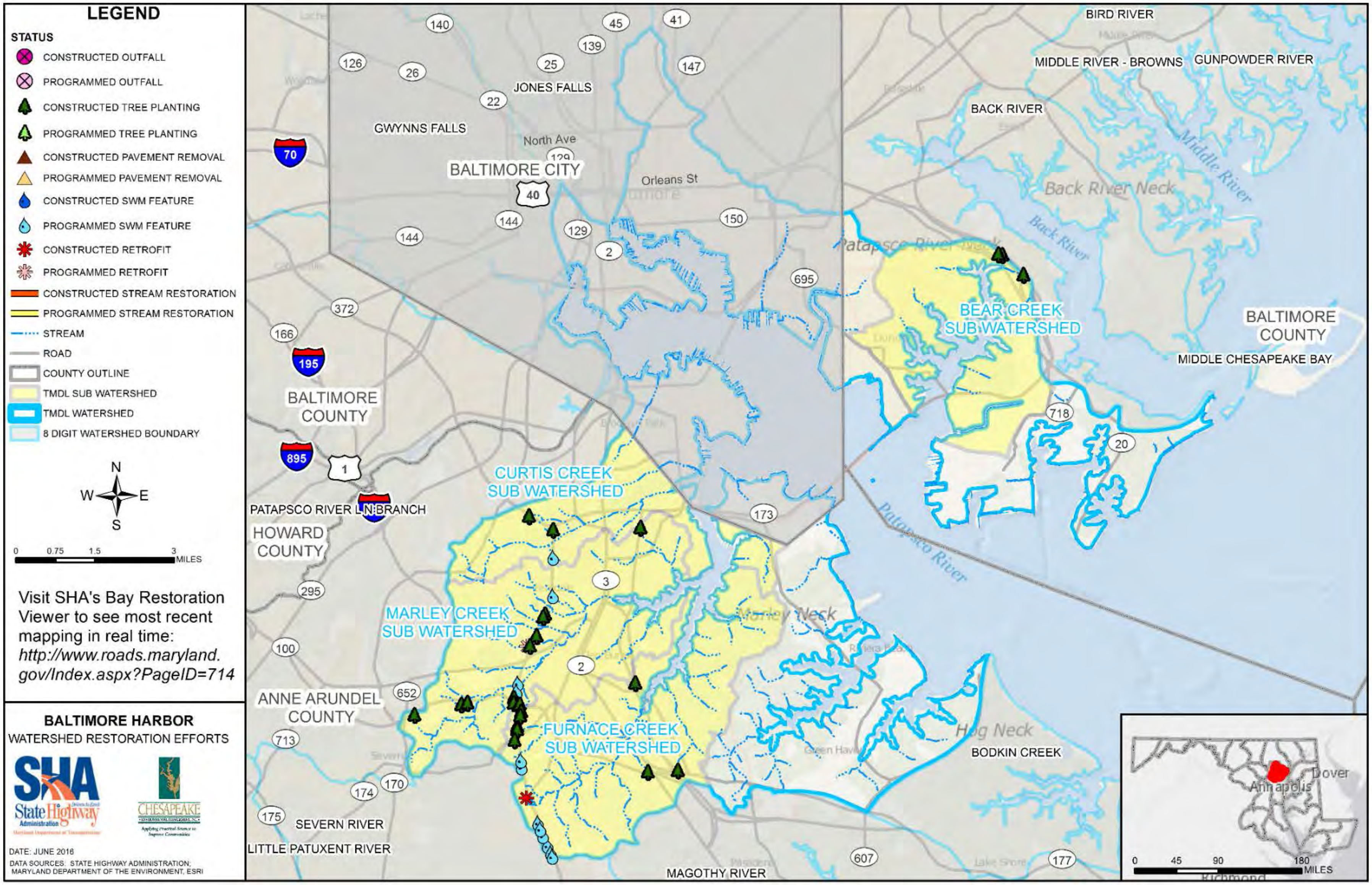

Figure 4-12: SHA Restoration Strategies within the Baltimore Harbor Watershed

E. BYNUM RUN WATERSHED

E.1. Watershed Description

The Bynum Run watershed encompasses 23 square miles solely within Harford County, Maryland. Bynum Run is a stream that originates in the town of Forest Hill, in Harford County, Maryland and flows 14 miles in a southeasterly direction until it empties into the tidally influenced Bush River. The Bush River ultimately flows into the Chesapeake Bay.

There are 220.2 miles of SHA roadway located within the Bynum Run watershed, associated ROW comprises473.8 acres, of which 211.9 acres are impervious. There are three SHA park and ride facilities located in the Bynum Run watershed. See **Figure 4-13** for a map of the watershed.

E.2. SHA TMDLs within Bynum Run watershed

SHA is included in the sediment (TSS) TMDL (MDE, 2005) with a reduction requirement of 22.9% as shown in **Table 3-2**.

E.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-14**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional restoration due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, many SHA impervious areas within these grids are already treated by SHA NPDES BMPs. The current results of this ongoing grid search are as follows:

23 Total Grids:

- Two (2) fully reviewed
- 20 partially reviewed - in progress
- One (1) awaiting review (4% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 101 locations identified as possible candidates for new stormwater BMPs.
- One (1) facility undergoing concept design which may be a candidate for design contracts in the near future.
- Four (4) retrofits of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 282 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 24 acres of tree planting potential for further investigation.
- Some of the reasons for sites being removed from considerations include commercial locations or existing forest.

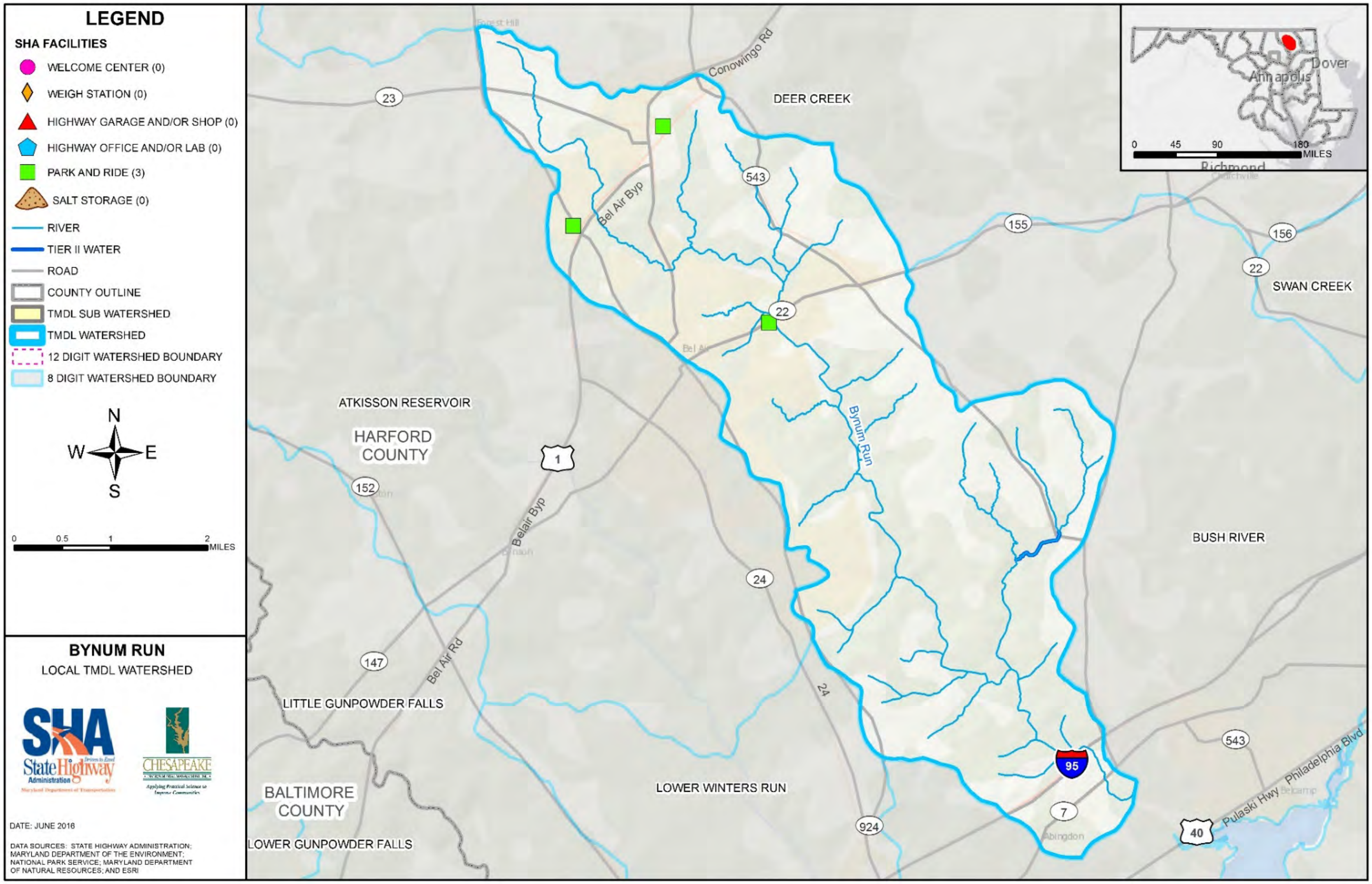

Figure 4-13: Bynum Run Watershed

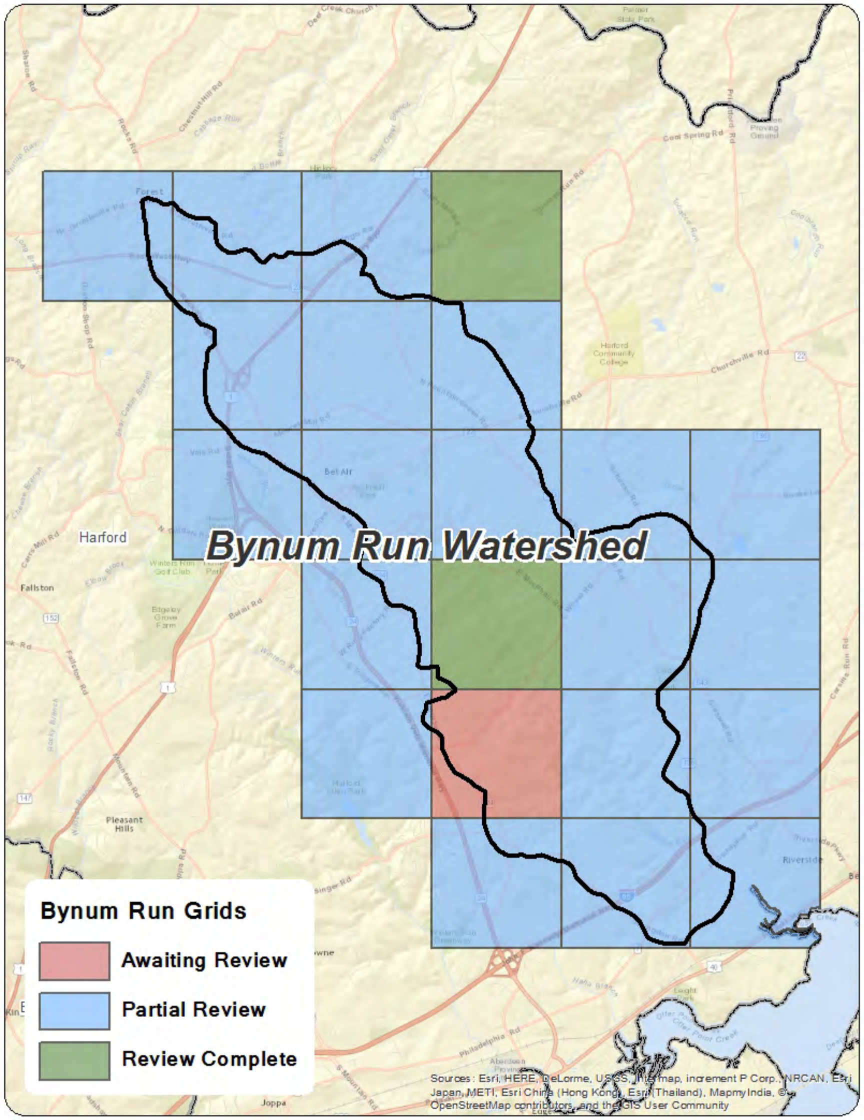

Figure 4-14: Bynum Run Site Search Grids

The stream restoration site search teams have investigated 13,743 linear feet of stream channel for restoration opportunities. The site search has resulted the following:

- 9,587 linear feet recommended for future restoration potential

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

E.4. County Assessment Review Summary

The waters within the Bynum Run watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Channelization;
- Mercury in Fish Tissue;
- Nitrogen (Total);
- PCB in Fish Tissue;
- Phosphorus (Total);
- Temperature, water; and
- Total Suspended Solids (TSS).

In 2014, the Harford County Department of Public Works prepared the *Declaration Run and Riverside Watersheds Small Watershed Action Plan* (URS, 2014d) Declaration Run is within the Bynum Run watershed, and Riverside watershed is outside the Bynum Run watershed. The County has suggested implementing the following means to achieve watershed improvements:

- Stream Restoration

Structural Projects

- Wetland
- Bioretention

- Bioswale
- Step pool conveyance system
- Micropool
- Green roofs
- Green street bump out
- Tree box filters
- Upgrade infiltration basin

Nonstructural Projects

- Public education and outreach
- Preserving existing forested areas, especially stream buffers
- Tree planting
- Downspout disconnection
- Reduction of impervious surfaces
- Curbcuts to direct stormwater runoff to open areas

Although field observations determined there were no stormwater hotspots within the Declaration Run subwatershed, the County suggested the following specific project sites for additional stormwater management. BMP implementation and retrofits shown in **Tables 4-16 4-17,** and **4-18**. These sites have been prioritized based on the following criteria:

- Property ownership
- Access to project site
- Drainage area
- Contributing impervious area
- Cost
- Utility impacts
- Environmental impacts

Table 4-16: Declaration Run Priority Restoration Stream Restoration Projects

Stream Reach ID	Proposed Project	Location	Project Priority
Declaration Run Reach 1	Remediate headcuts with riffle grade control structures or step pools	Upstream Baneberry	High
Tributary DR5	Correct minor headcut with grade control structures; Remediate slope failure at storm drain outfall	Downstream of Baneberry Drive and north of and between Arabis Court and Germander Drive	High
Declaration Run Reach 2	Outfall stabilization	Downstream of Baneberry Drive and west of Arabis Court and Foxglove Court	High
Tributary DR9 Reach 1 and 2	Stream bank stabilization; Remove failed instream stormwater management feature; Remediate headcuts; Remediate storm drain outfall	Downstream of Riverside Parkway and east of Church Creek Elementary School toward Church Creek Road; Downstream of Church Creek Elementary School and upstream of Church Creek Road	High

Table 4-17: Declaration Run Priority Restoration Structural Projects

Project ID	Proposed Project	Location	Project Priority
D-ES-2	Wetland	End of Oreganum Court	High
D-ES-5	Bioretention	North end of Foxglove Court	Low
D-ES-6	Bioretention	Germander Drive	Medium
D-ES-7	Bioswale and Bioretention	Germander Drive and Church Creek Road	High
D-ES-8	Wetland and Step pool conveyance system	Baneberry Drive	High
D-ES-12	Micropool and Wetland	End of Marigold Lane	Medium
D-ES-15	Bioretention	Procedure Way	High
D-NS-3	Green roofs	Liriope Court	Low
D-NS-4	Green street bump out	Church Creek Road	Medium
D-NS-7	Step pool conveyance system	Foxglove Court	Low
D-NS-8	Bioretention	Dalmation Place	High
D-NS-9	Tree box filters	Golden Rod Court	Low
D-NS-12	Bioretention or Tree box filters	Church Creek Elementary School	High
D-NS-13	Green street bump out	Church Creek Road	High
D-SWM0110 (ES-1)	Upgrade infiltration basin	Church Creek Elementary School	High

Table 4-18: Declaration Run Priority Restoration Non-Structural Projects

Project ID	Proposed Project	Location	Project Priority
D-NS-1	Downspout disconnection	Golden Rod Court Neighborhood	NA
D-NS-2	Impervious surface reduction	Wide residential driveways on Marigold Lane	NA
D-NS-5	Curb cuts in parking lots to direct stormwater runoff to open areas	Sedum Square, Horner Lane, Downs Square, Baylis Court	NA
D-NS-6	Curb cuts in parking lots to direct stormwater runoff to open areas	Magness Court, Hampton Hall Court, Talbots Square	NA

E.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reduction in the Bynum Run watershed are shown in **Table 4-19**. Projected sediment reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2005.

2. BMPs built between 2026 through 2032, the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Bynum Run watershed total $9,728,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $48,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-15 shows a map of SHA's restoration practices in the watershed and include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-19: Bynum Run Restoration Sediment BMP Implementation

BMP	Unit	2006-2025	2026-2032	Total	Cost
New Stormwater	drainage area acres	35.9	15.3	51.2	$5,847,000
Retrofit	drainage area acres	24.8		24.8	$1,212,000
Stream Restoration	linear feet	1,350.0		1,350.0	$990,000
Tree Planting	acres planted	24.0		24.0	$806,000
Outfall Stabilization[1]	linear feet		400.0	400.0	$873,000
Inlet Cleaning[2]	tons	10.0	49.5	49.5	$48,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

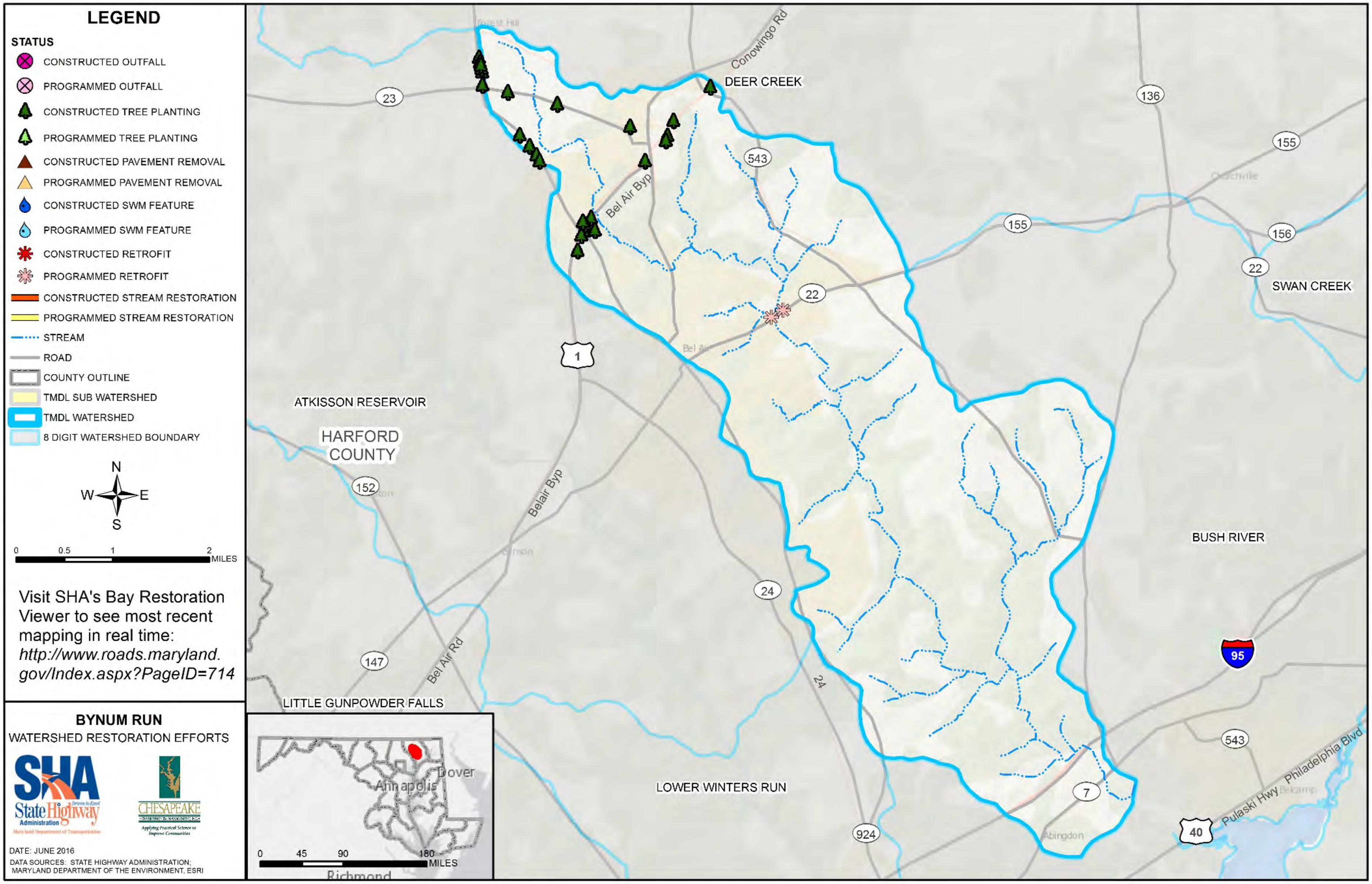

Figure 4-15: SHA Restoration Strategies within the Bynum Run Watershed

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F. CABIN JOHN CREEK WATERSHED

F.1. Watershed Description

The Cabin John watershed encompasses 26 square miles solely within southern Montgomery County, Maryland. Cabin John Creek originates in the City of Rockville and flows south approximately 10 miles to its confluence with the Potomac River near Cabin John and Glen Echo. Major tributary creeks and streams of the Cabin John Watershed include Bogley Branch, Booze Creek, Buck Branch, Congressional Branch, Ken Branch, Old Farm Branch, Snakeden Branch, and Thomas Branch.

There are 353.1 miles of SHA roadway located within the Cabin John watershed, associated ROW comprises 862.6 acres, of which 484.8 acres are impervious. There are no SHA facilities located within the Cabin John watershed. See **Figure 4-16** for a map of the watershed.

F.2. SHA TMDLs within Cabin John Creek

SHA is included in the sediment (TSS) TMDL (MDE, 2011) and has a reduction requirement of 22.9% as shown in **Table 3-2**.

F.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-17**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional restoration due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. The current results of this ongoing grid search are as follows:

22 Total Grids:

- One (1) fully reviewed
- 17 partially reviewed - in progress
- 4 awaiting review (9% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- Eight (8) locations identified as possible candidates for new stormwater BMPs.

- Nine (9) facilities undergoing concept design and may be candidates for design contracts in the near future.

- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 442 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- Zero (0) acres of tree planting potential for further investigation.

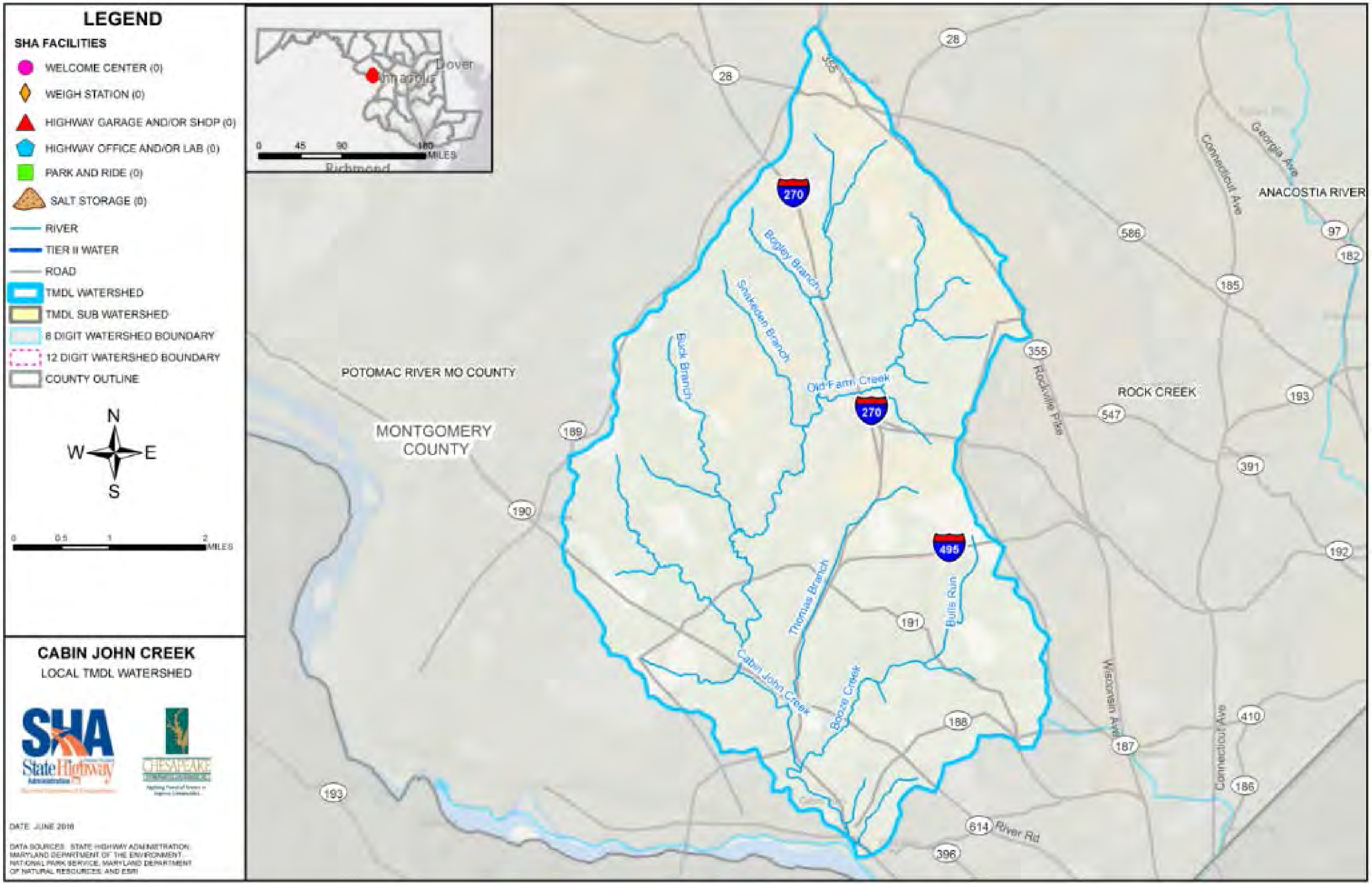

Figure 4-16: Cabin John Creek Watershed

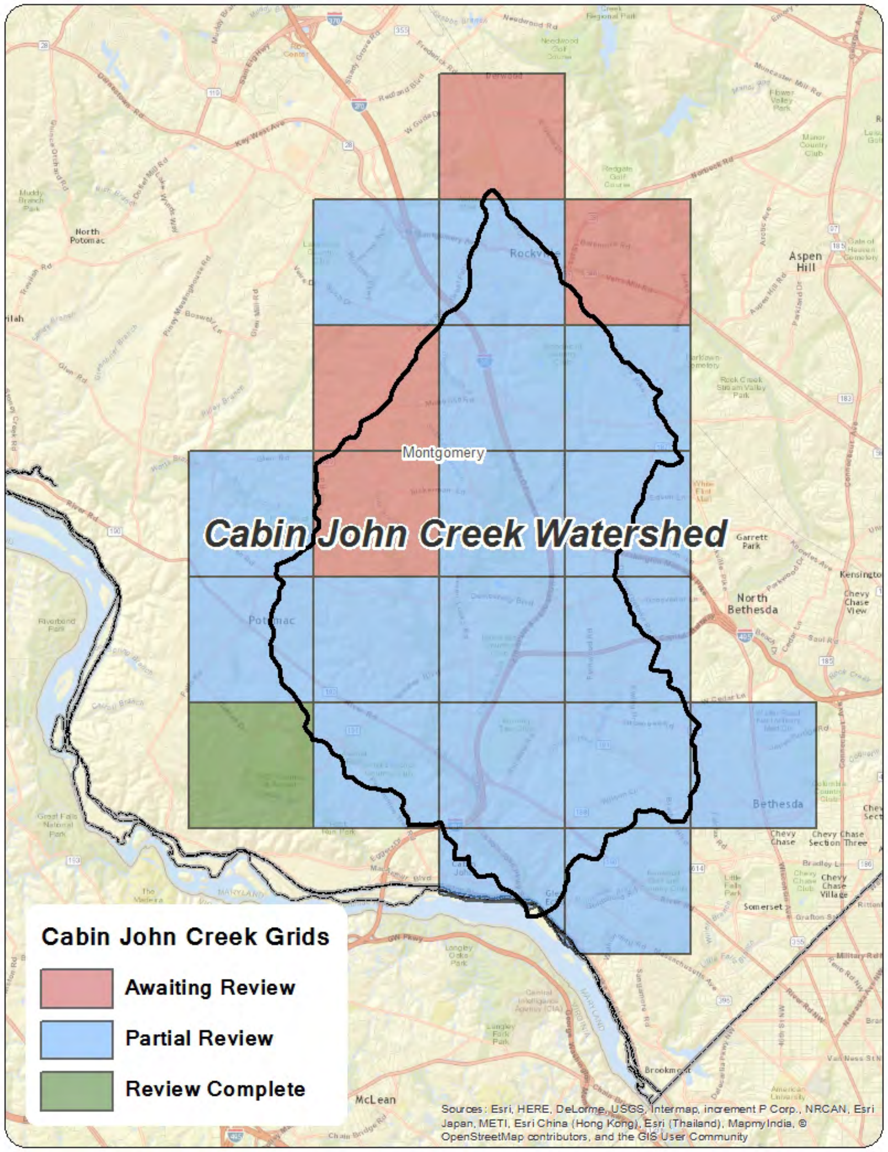

Figure 4-17: Cabin John Creek Site Search Grids

The stream restoration site search teams have investigated 14,732 linear feet of stream channel for restoration opportunities. The site search has resulted the following:

- 10,744 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

F.4. County Assessment Review Summary

Waters within the Cabin John Creek watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Channelization;
- Chlorides;
- Fecal Coliform;
- Phosphorus (Total);
- Sulfates; and
- Total Suspended Solids (TSS).

The *Cabin John Creek Implementation Plan* (Versar, 2012b) prepared by the Montgomery County Department of Environmental Protection, was adopted in January 2012. The implementation plan provides a comprehensive plan for watershed restoration targeting bacteria reduction, sediment nutrient reduction, runoff management, and trash management.

The Cabin John Creek watershed comprises primarily residential land use, covering about 70% of the watershed. Municipal/institutional comprises 13% and roadway comprises approximately 7%. Approximately 5% is identified as forest, open water, or bare ground. The majority of the stream resource conditions in Cabin John Creek were assessed as 'Fair' (82.5%) (Cabin John Creek, Buck Branch, Bogley Branch, Old Farm Creek), the remaining 17.5% were assessed as 'Poor' (Thomas Branch, Bills Run, Boole Creek). Zero stream miles were assessed as 'Good' or 'Excellent.'

MDE developed TMDLs for fecal bacteria and sediment within the Cabin John Creek watershed and nutrient WLAs for the Bay-wide TMDL. BMPs implemented by the county proposed within Cabin John Creek watershed are estimated to result in 41.9% load reductions for total nitrogen, 41.7% for total phosphorus, and 29.5% for total suspended solids.

Montgomery County is focusing on county-owned land for restoration projects, and has not addressed needs on SHA ROW. Projects identified include two new stormwater ponds (Cabin John Shopping Center, Tuckerman I) and four stormwater pond retrofits (Executive Blvd, Fox Hills of Potomac, Pine Knolls, Washington Science Center). Impervious area restoration is also proposed for various sites within the watershed.

F.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reduction in the Cabin John Creek watershed are shown in **Table 4-20**. Projected sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2005.

2. BMPs built between 2026 through 2041, the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Cabin John Creek watershed total $8,075,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $95,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-18 shows a map of SHA's restoration practices in the watershed and include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-20: Cabin John Creek Restoration Sediment BMP Implementation					
BMP	**Unit**	**2001-2025**	**2026-2041**	**Total**	**Cost**
New Stormwater	drainage area acres	41.0	3.5	44.5	$4,973,000
Retrofit	drainage area acres	15.2		15.2	$368,000
Stream Restoration	linear feet	3.5		3.5	$116,000
Tree Planting	drainage area acres	200.0	1,000.0	1,200.0	$2,618,000
Outfall Stabilization[1]	linear feet	102.7	99.0	99.0	$95,000
Inlet Cleaning[2]	tons	41.0	3.5	44.5	$4,973,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

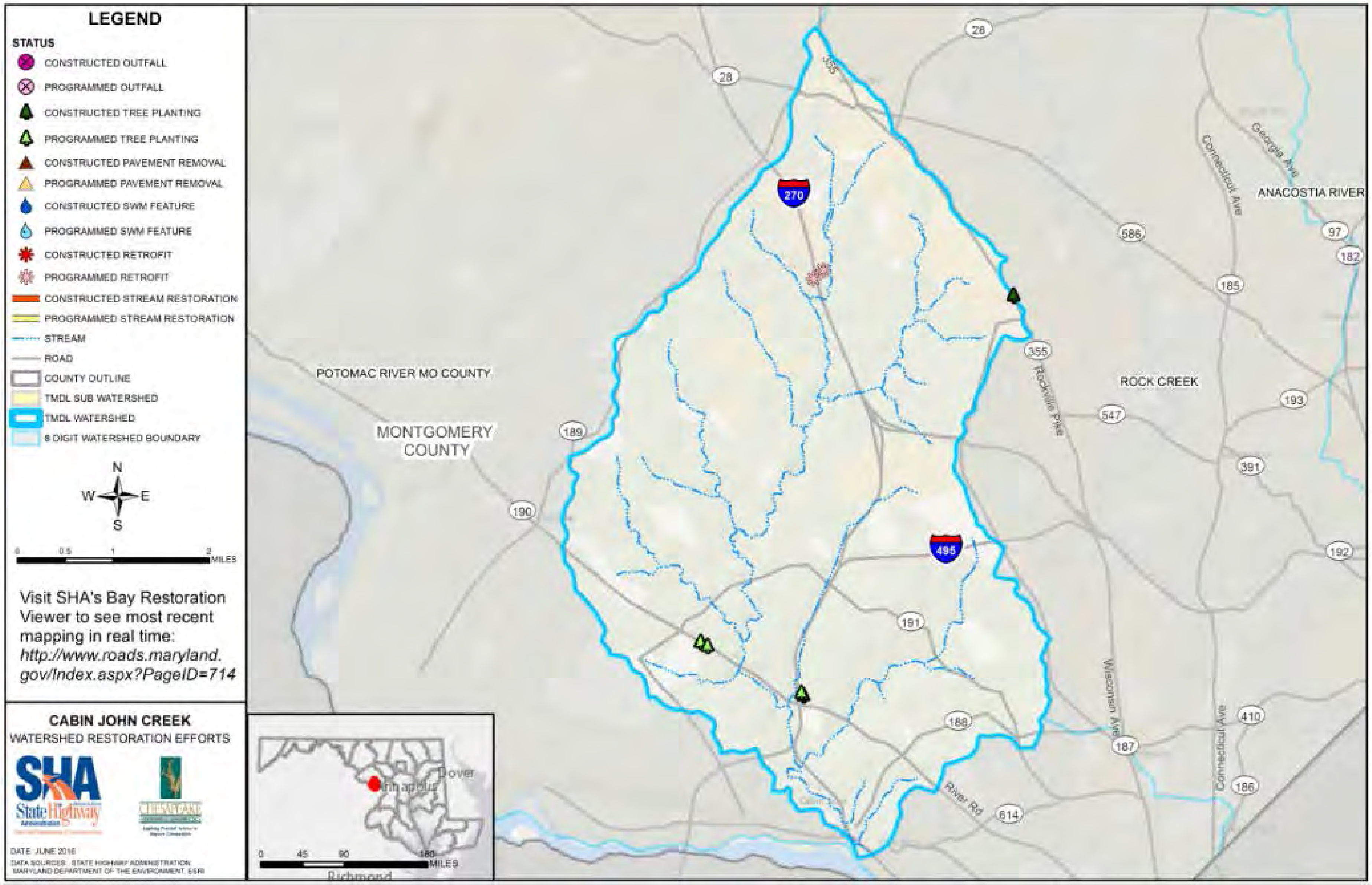

Figure 4-18: SHA Restoration Strategies within the Cabin John Creek Watershed

G. CATOCTIN CREEK WATERSHED

G.1. Watershed Description

The Catoctin Creek watershed is located within the Middle Potomac River sub-basin in Frederick County, Maryland. The Catoctin Creek watershed drains an area of 120 square miles, which includes areas of forested mountain slopes, agricultural valleys, and small areas of urban development. There is a significant amount of agriculture within the watershed, which consists mostly of row crop, but also includes pasture. The largest urban centers within the watershed are the towns of Myersville and Middletown. According to the Chesapeake Bay Program's Phase 5.2 Model, the land use distribution in the watershed is approximately 43% agricultural, 42% forest/herbaceous, and 15% urban.

Tributary creeks and streams of the Catoctin Creek watershed include Bolivar Branch, Broad Run, Burkitts Run, Cone Branch, Deer Springs Branch, Dry Run, Grindstone Run, Harman Branch, Hollow Road Creek, Lewis Mill Branch, Little Catoctin Creek, Middle Creek, and Spruce Run.

There are 359.6 miles of SHA roadway located within the Catoctin Creek watershed, associated ROW comprises approximately 1,300 acres, of which 428.7 acres are impervious. SHA facilities located within the Catoctin Creek watershed consist of two welcome centers, two park and ride facilities, and two salt storage facilities. See **Figure 4-19** for a map of the watershed.

G.2. SHA TMDLs within Catoctin Creek Watershed

SHA is included in both the phosphorus and sediment TMDLs with reduction requirements of 9.0% and 49.1%, respectively, as shown in **Table 3-2**.

G.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-20**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional restoration due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. The current results of this ongoing grid search are as follows:

93 Total Grids:

- 60 fully reviewed
- 29 partially reviewed - in progress
- Four (4) awaiting review (3% of total grids)

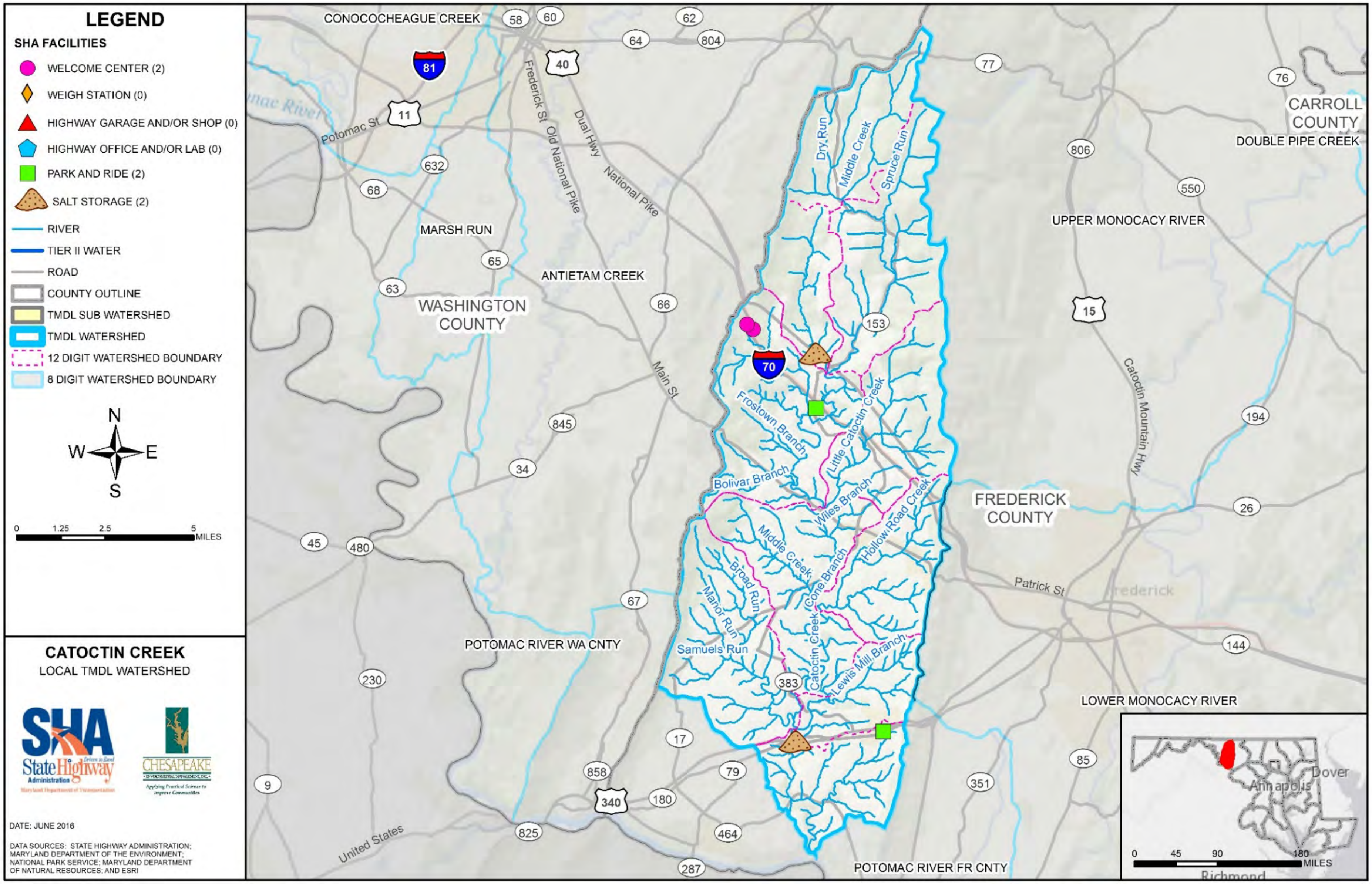

Figure 4-19: Catoctin Creek Watershed

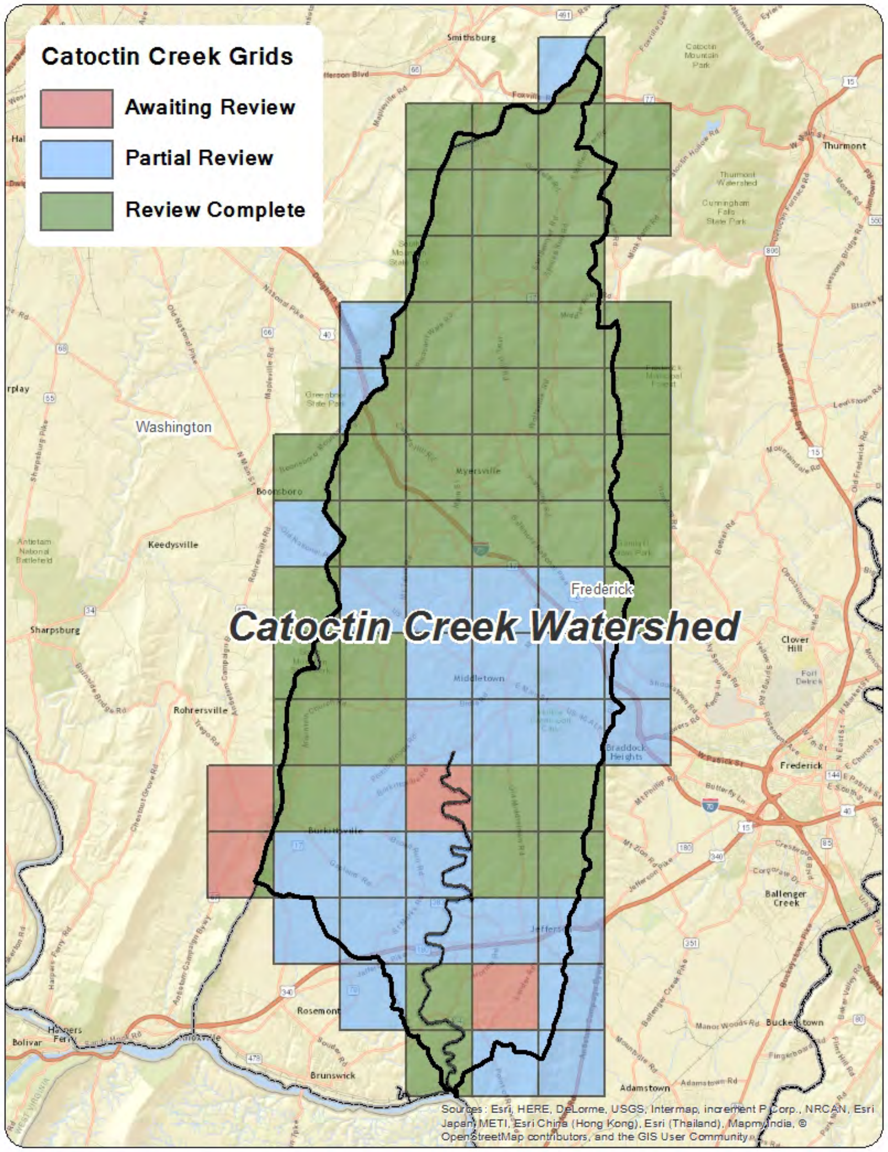

Figure 4-20: Catoctin Creek Site Search Grids

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 752 locations identified as possible candidates for new stormwater BMPs.
- One (1) facility undergoing concept design and may be a candidate for design contracts in the near future.
- Six (6) retrofits of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 962 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 65 acres are undergoing concept design and may be candidates for planting contracts in the near future.
- Two (2) acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 10,464 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 3,528 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility

G.4. County Assessment Review Summary

Waters within the Catoctin Creek watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Fecal Coliform;
- Phosphorus (Total);
- Temperature, water; and
- Total Suspended Solids (TSS).

MDE prepared the *Watershed Report for Biological Impairment of the Catoctin Creek Watershed in Frederick County, Maryland Biological Stressor Identification Analysis Results and Interpretation* (BSID) in 2012 (MDE, 2012x). The following excerpts from the BSID describe land use throughout the watershed and associated potential pollutant sources:

> *Agricultural land use is prevalent in the watershed, and is an important source of pollution when rainfall carries fertilizers, manure, and pesticides into streams. The three major nutrients in fertilizers are nitrogen, phosphorus, and potassium. High concentrations of nutrients in agricultural streams were correlated with inputs from fertilizers and manure used for crops and from livestock wastes.*
>
> *The Biological Stressor Identification (BSID) analysis identified pasture/hay land use as significant in the riparian buffer zone (92%). Pasture/hay land use within the riparian buffer often results in increased incidences of livestock being allowed direct access to streams, and one of the primary sources of nutrients and ammonia to surface waters is livestock waste. The agricultural land uses in the Catoctin Creek watershed are potential sources for the elevated levels of nitrogen, phosphorus, orthophosphate, and ammonia.*
>
> *The lack of a riparian buffer has resulted in a stream ecosystem that eliminates large woody debris and allochthonous input in streams, which results in loss of optimal habitat. Loss of riparian buffers also allows increased terrestrial inputs of nutrients from agricultural sources. Due to the increased proportions of agricultural land use in Catoctin Creek, the watershed has experienced an increase of nutrients that can potentially be extremely toxic to aquatic organisms. The combined AR for riparian habitat stressors and water chemistry stressors is approximately 83%, suggesting that altered riparian habitat and water chemistry stressors adequately account for the biological impairment in Catoctin Creek* (MDE, 2012x).

As stated in the Catoctin Creek sediment TMDL:

> *Potential BMPs for reducing sediment loads and resulting impacts can be grouped into three general categories. The first is directed toward agricultural lands, the second to urban (developed) land, and the third applies to all land uses.*
>
> *In agricultural areas comprehensive soil conservation plans can be developed that meet criteria of the USDA-NRCS Field Office Technical Guide. Soil conservation plans help control erosion by modifying cultural practices or structural practices. Cultural practices may change from year to year and include changes to crop rotations, tillage practices, or use of cover crops. Structural practices are long-term measures that include, but are not limited to, the installation of grass waterways (in areas with concentrated flow), terraces, diversions, sediment basins, or drop structures. In addition, livestock can be controlled via stream fencing and rotational grazing.*
>
> *Sediment from urban areas can be reduced by stormwater retrofits, impervious surface reduction, and stream restoration. Stormwater retrofits include modification of existing stormwater structural practices to address water quality.*

All non-forested land uses can benefit from improved riparian buffer systems. A riparian buffer reduces the effects of upland sediment sources through trapping and filtering. Riparian buffer efficiencies vary depending on type (grass or forested), land use (urban or agriculture), and physiographic region.

G.5. SHA Pollutant Reduction Strategies

Restoration BMP implementation in the Catoctin Creek watershed is shown in **Table 4-19**. Catoctin Creek is listed for both phosphorus and sediment with each TMDL having a different baseline year; 2000 for sediment and 2009 for phosphorus. BMP implementation are shown in three categories: 1) post sediment TMDL baseline through the phosphorus baseline; 2) post phosphorus TMDL baseline through 2025; and 3) 2026 through the TMDL target date. BMP implementation after 2000 was credited towards sediment reductions and implementation after 2009 was credited towards phosphorus reductions. Total phosphorus and sediment removed by the BMP implementation is shown in **Table 3-2**. The total projected cost to implement SHA's structural BMPs within the Catoctin Creek watershed is $27,146,000. $38,000 as an annual cost for inlet cleaning is in addition to this. Structural BMP project costs are estimated based on the average cost per impervious acre treated based on a group of completed projects for each BMP category. Costs for inlet cleaning were derived from SHA data and include equipment, operations, and maintenance costs.

Figure 4-21 shows a map of SHA's watershed restoration strategies throughout the Catoctin Creek watershed. The practices shown only include those that are under design or constructed.

Table 4-21: Catoctin Creek Restoration Nutrient and Sediment BMP Implementation

BMP	Unit	2001 - 2009	2010 - 2025	2026 - 2035	Total	Cost
New Stormwater	drainage area acres		40.2	121.5	161.7	$20,463,000
Stream Restoration	linear feet	719.0	2,009.0		2,728.0	$2,001,000
Tree Planting	acres planted	24.3	110.5		134.7	$4,531,000
Impervious Surface Elimination	acres removed		0.5		0.5	$151,000
Inlet Cleaning[1]	tons		57.3	39.0	39.0	$38,000

[1] Inlet cleaning is an annual practice. Data based on a combination of historical and future projections and will be updated based on FY16 actual data when they are available.

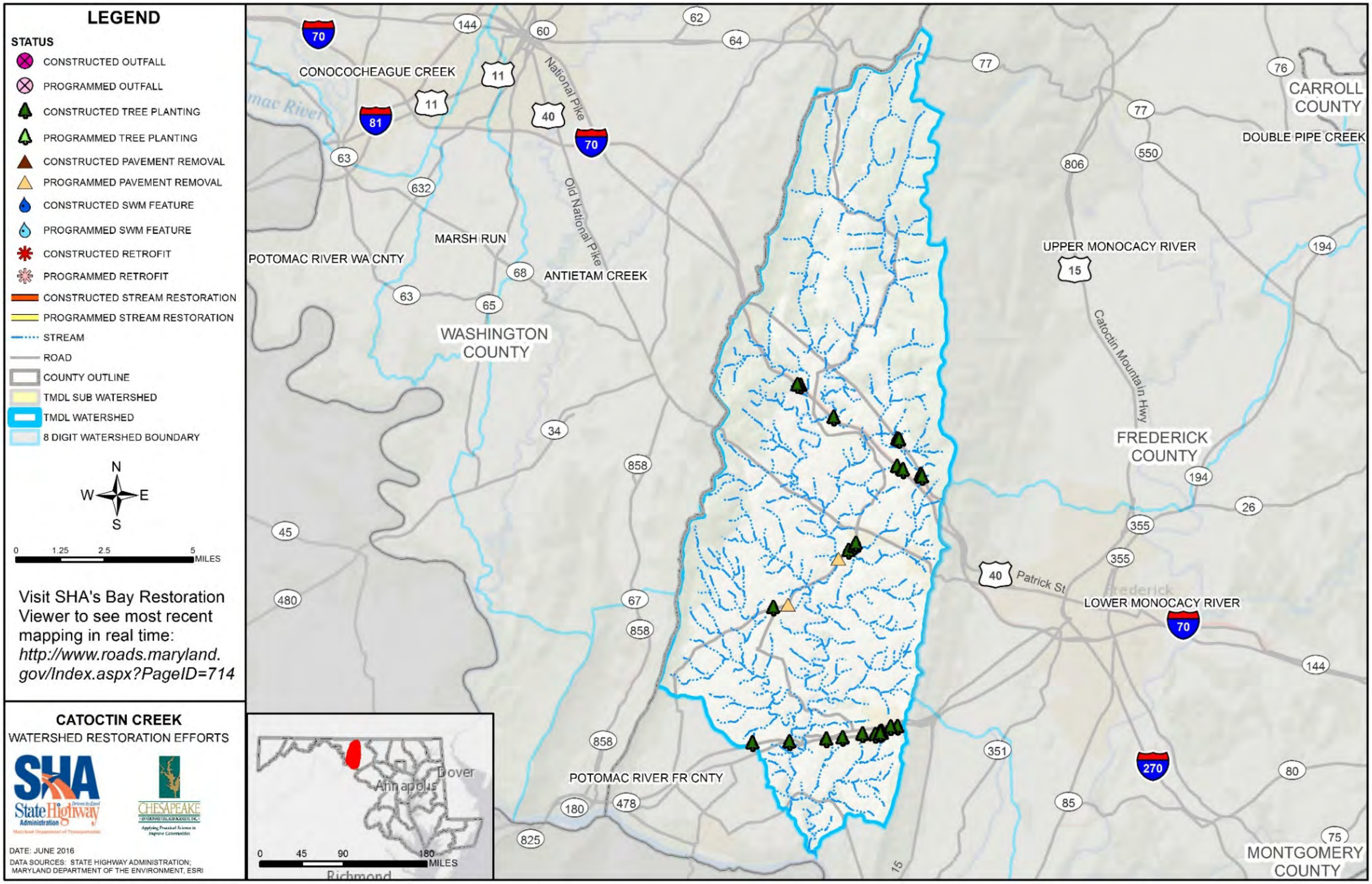

Figure 4-21: SHA Restoration Strategies within the Catoctin Creek Watershed

H. CONOCOCHEAGUE CREEK WATERSHED

H.1. Watershed Description

The Conococheague Creek Watershed encompasses 65 square miles within Washington County, Maryland. The entire watershed is approximately 566 square miles, most of which is located in Pennsylvania. Conococheague Creek flows 80 miles south from its headwaters in Pennsylvania to the Potomac River near Williamsport, Maryland. Tributary creeks and streams of the Conococheague Creek Watershed, within Maryland, include Meadow Brook, Rockdale Run, Rush Run, Semple Run, and Toms Run.

There are approximately 285.6 miles of SHA roadway located within the Conococheague Creek Watershed, associated ROW comprises approximately 1,428.3 acres, of which 489.6 acres is impervious. SHA facilities located within the watershed consist of one park and ride facility, and one salt storage facility. See **Figure 4-22** for a map of the Conococheague Creek Watershed.

H.2. SHA TMDLs within Conococheague Creek

SHA is included in the sediment (TSS) TMDL (MDE, 2008) and has a reduction requirement of 45.3% as shown in **Table 3-2**.

H.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-23**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool. The current results of this ongoing grid search are as follows:

46 Total Grids:

- Ten (10) fully reviewed
- 36 partially reviewed - in progress
- Zero (0) awaiting review (0% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 35 locations identified as possible candidates for new stormwater BMPs.
- 16 facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 1,304 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 152 acres of tree planting potential for further investigation.

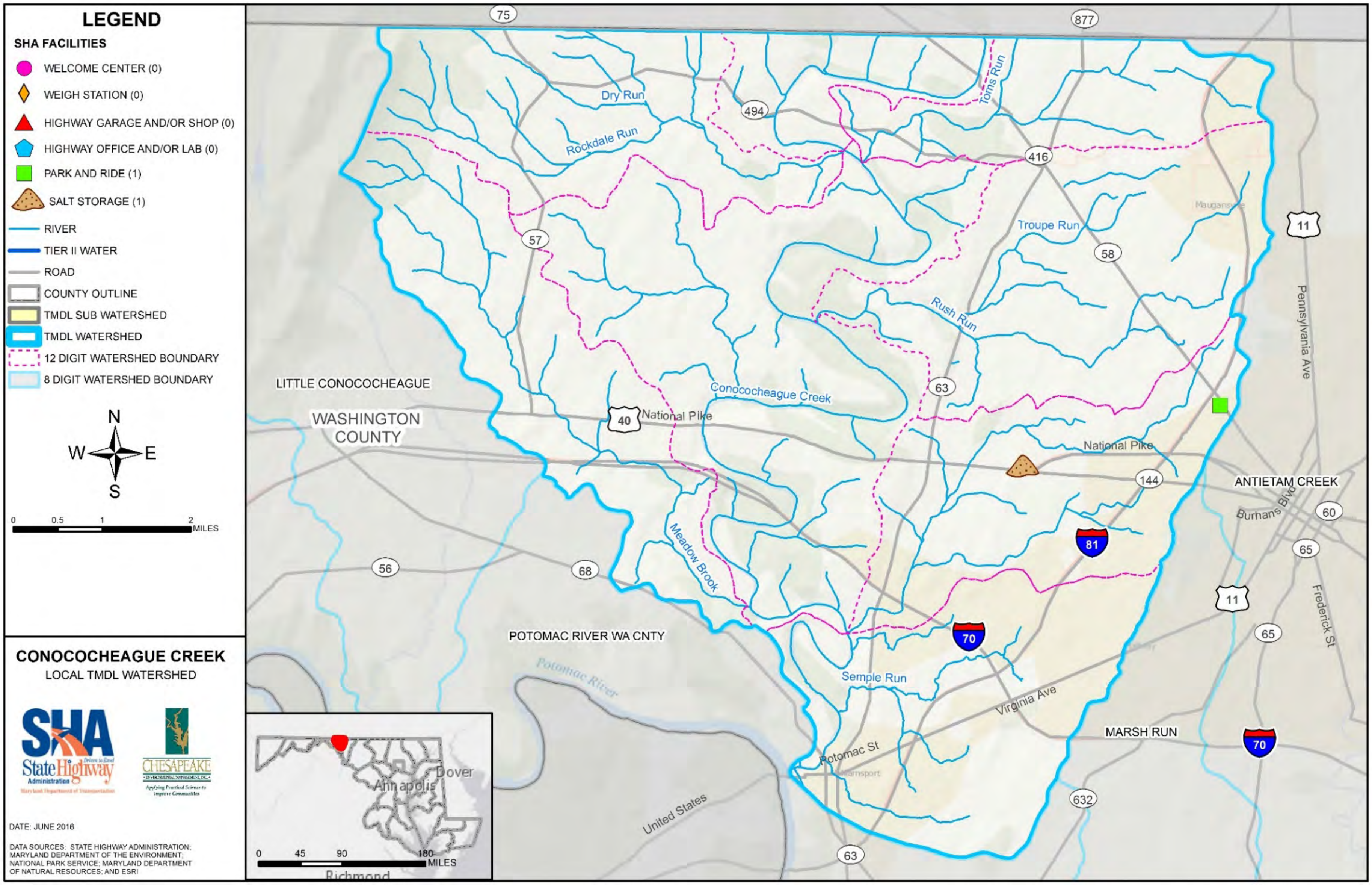

Figure 4-22: Conococheague Creek Watershed

The stream restoration site search teams have investigated 27,514 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 2,982 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

H.4. Summary of County Assessment Review

Waters within the Conococheague Creek Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Biochemical oxygen demand (BOD);
- Chlorides;
- *Escherichia coli;*
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- pH, High;
- Phosphorus (Total);
- Sulfates; and
- Total Suspended Solids (TSS).

According to the 2014 Washington County NPDES MS4 Annual Report, the Conococheague Watershed Restoration Plan was expected to be completed in 2015, but as of May, 2016 this report was not available online.

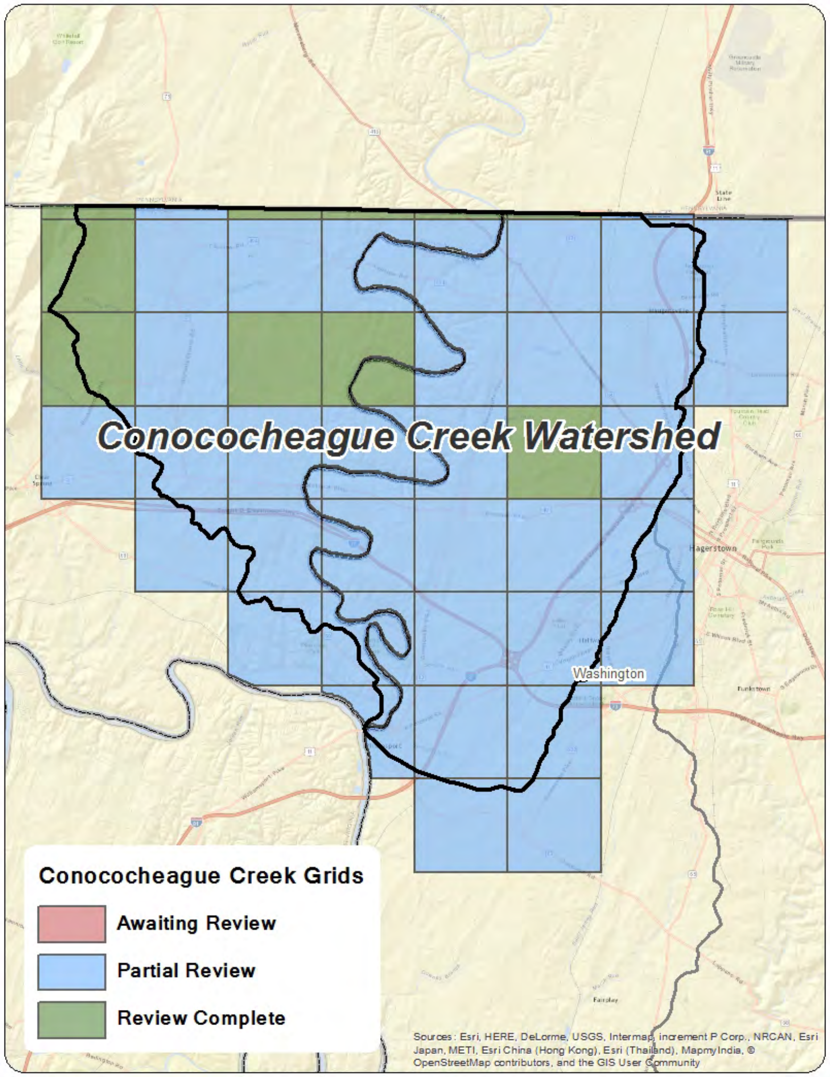

Figure 4-23: Conococheague Site Search Grids

H.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reduction in the Conococheague Creek watershed are shown in **Table 4-22**. Projected sediment reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2000.

2. BMPs built between 2026 through 2045 the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Conococheague Creek watershed total $13,256,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $24,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-24 shows a map of SHA's restoration practices in the watershed and include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-22: Conococheague Creek Restoration Sediment BMP Implementation

BMP	Unit	2001-2025	2026-2045	Total	Cost
New Stormwater	drainage area acres	78.7	8.1	86.8	$9,590,000
Retrofit	drainage area acres	11.2		11.2	$404,000
Tree Planting	acres planted	71.0		71.0	$2,389,000
Outfall Stabilization[1]	linear feet		400.0	400.0	$873,000
Inlet Cleaning[2]	tons	19.9	24.9	24.9	$24,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

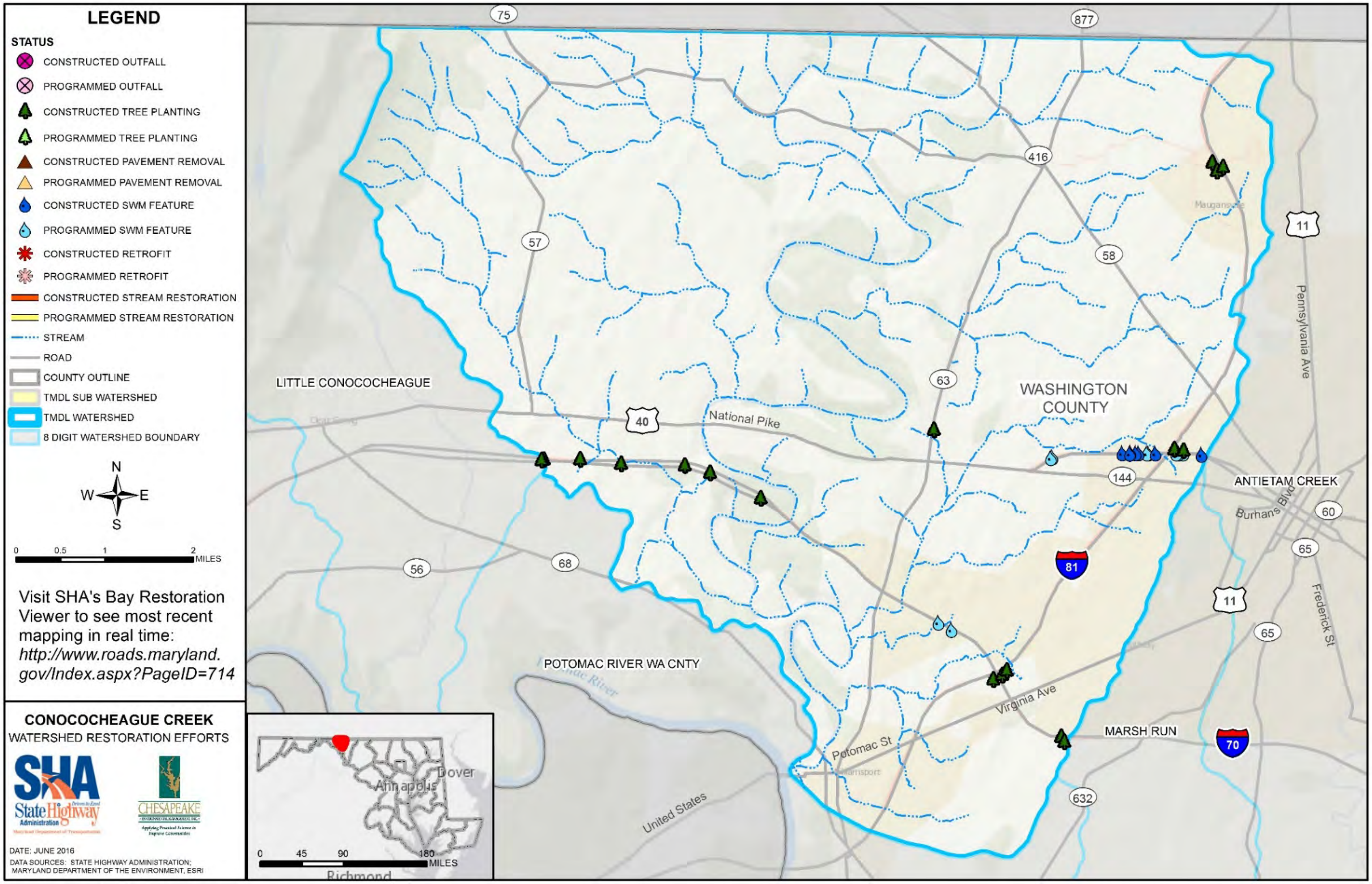

Figure 4-24: SHA Restoration Strategies within the Conococheague Creek Watershed

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I. DOUBLE PIPE CREEK WATERSHED

I.1. Watershed Description

The Double Pipe Creek Watershed encompasses 193 square miles spanning Carroll and Frederick Counties, and is composed of Big Pipe Creek, which makes up 58% of the Watershed, and Little Pipe Creek, which makes up the remaining 42%. The portion of the watershed within Carroll County is approximately 86% of the watershed, with 14% within Frederick County. This watershed drains into the Monocacy River, which is a State-designated Scenic River. The headwaters of Double Pipe Creek Watershed originate in Westminster and Manchester, and flows west toward Rocky Ridge, into the Monocacy River and ultimately into the Middle Potomac River near the town of Dickerson. Tributary creeks and streams of the Double Pipe Creek Watershed include Bear Branch, Big Pipe Creek, Cherry Branch, Deep Run, Dickenson Run, Little Pipe Creek, Meadow Branch, Prisetland Branch, Sams Creek, Silver Run, Turkeyfoot Run, and Wolf Pit Creek.

There are approximately 545.2 miles of SHA roadway located within the Double Pipe Creek Watershed, associated ROW comprises approximately 1,107.1 acres, of which 420.2 acres is impervious. SHA facilities located within the Double Pipe Creek Watershed consist of one park and ride facility, and one salt storage facility. See **Figure 4-25** for a map of the watershed.

I.2. SHA TMDLs within Double Pipe Creek

SHA is included in the phosphorus TMDL (MDE, 2009) and has a reduction requirement of 66% and sediment (TSS) TMDL (MDE, 2000) as shown in **Table 3-2**.

I.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-26**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. The current results of this ongoing grid search are as follows:

132 Total Grids:

- 50 fully reviewed
- 52 partially reviewed - in progress
- 30 awaiting review (20% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 264 locations identified as possible candidates for new stormwater BMPs.

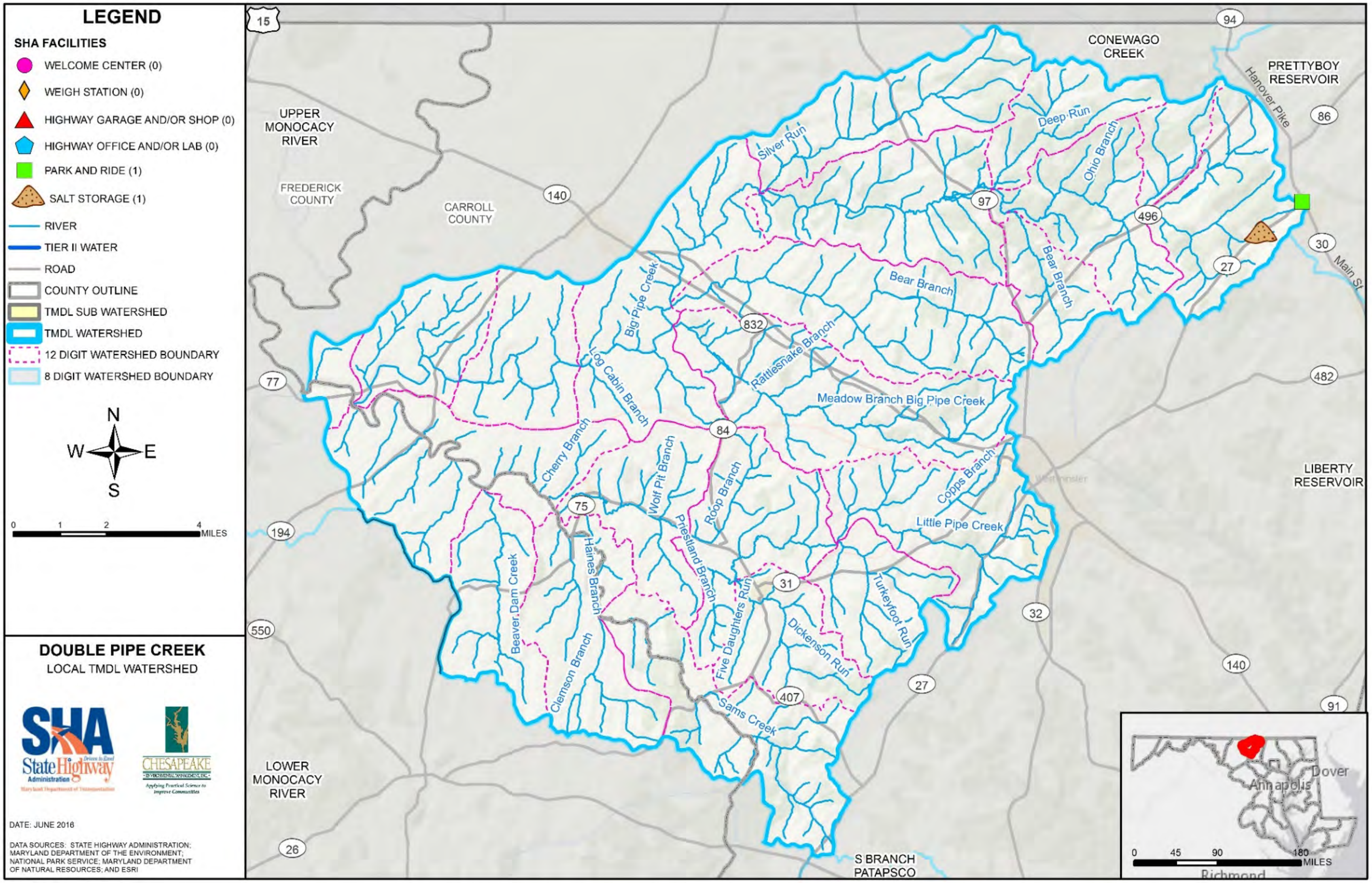

Figure 4-25: Double Pipe Creek Watershed

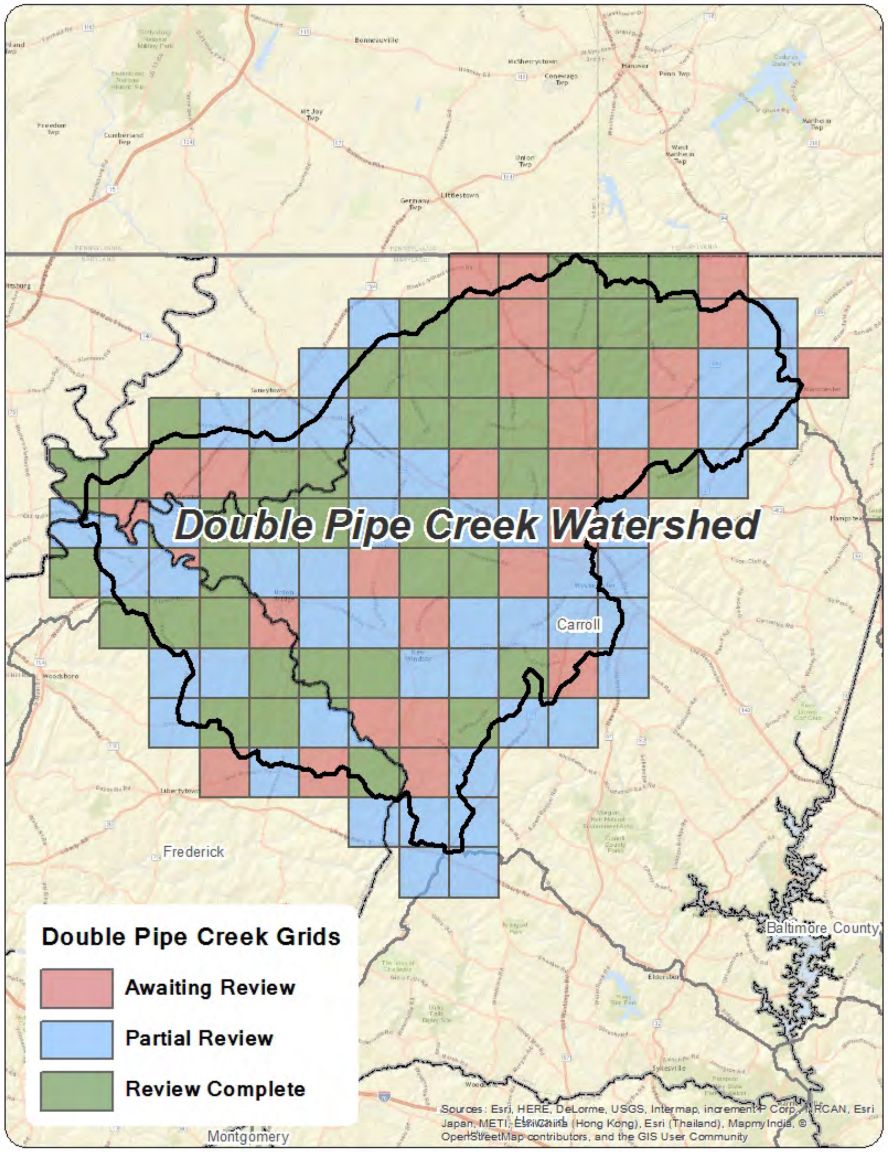

Figure 4-26: Double Pipe Creek Site Search Grids

- 18 facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 647 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 126 acres are undergoing concept design and may be candidates for planting contracts in the near future.
- Eight (8) acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 22,992 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 9,513 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

I.4. Summary of County Assessment Review

Waters within the Double Pipe Creek Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- *Escherichia coli;*
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- Phosphorus (Total); and
- Total Suspended Solids (TSS).

In 2006, MDE completed a report on Prioritizing Sites for Wetland Restoration, Mitigation, and Preservation in Maryland (MDE, 2006). Impervious land cover comprises 2.5% of the Frederick County portion of the Double Pipe Creek Watershed. According to MDE, regulated impervious developed land comprises 2.04% in the Frederick County portion, and 2.14% in the Carroll County portion. The predominant soils in this watershed are considered moderately erodible. Double Pipe Creek currently has completed TMDLs for sediment (Total Suspended Solids), fecal bacteria, and phosphorus. Double Pipe Creek also has a Category 5 impairment listing for PCBs in fish tissue.

Little data is available for this watershed, though Carroll County has scheduled a watershed assessment to begin in 2016. The Frederick County Office of Sustainability and Environmental Resources conducted Stream Corridor Assessments (SCAs) between 2008 and 2014 that include the portion of the Little Pipe Creek subwatershed of Double Pipe Creek located in that county.

Information on water quality, erosion, physical habitat, and benthic index of biotic integrity scores for several sites within Little Pipe Creek can be found in the SCA reports, however detailed location information is not provided.

I.5. Pollutant Reduction Strategies

Double Pipe Creek is listed for both sediment and phosphorus with each TMDL having a different baseline year; 2000 for sediment and 2009 for phosphorus. Proposed practices to meet the sediment and phosphorus reduction in the Double Pipe Creek watershed are shown in **Table 4-23**. Projected sediment and phosphorus reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Three timeframes are included in the table below:

1. BMPs built after the sediment TMDL baseline through 2009. In this case the baseline is 2000.

2. BMPs built after the phosphorus TMDL baseline through 2025. In this case the baseline is 2009.

3. BMPs built from 2026 through 2045 the projected target date of the phosphorus TMDL. 2025 is the projected target date for the sediment TMDL. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Double Pipe Creek watershed total $28,816,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $26,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-27 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-23: Double Pipe Creek Restoration Nutrient and Sediment BMP Implementation

BMP	Unit	2001 - 2009	2010 - 2025	2026 - 2045	Total	Cost
New Stormwater	drainage area acres		84.9	64.3	149.2	$17,321,000
Stream Restoration	linear feet		2,000.0		2,000.0	$1,466,000
Tree Planting	acres planted		164.5	2.8	167.3	$5,628,000
Outfall Stabilization[1]	linear feet			2,000.0	2,000.0	$4,363,000
Impervious Source Elimination	acres removed		0.2		0.2	$38,000
Inlet Cleaning[2]	tons		50.9	26.7	26.7	$26,000

[1] *Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits*

[2] *Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.*

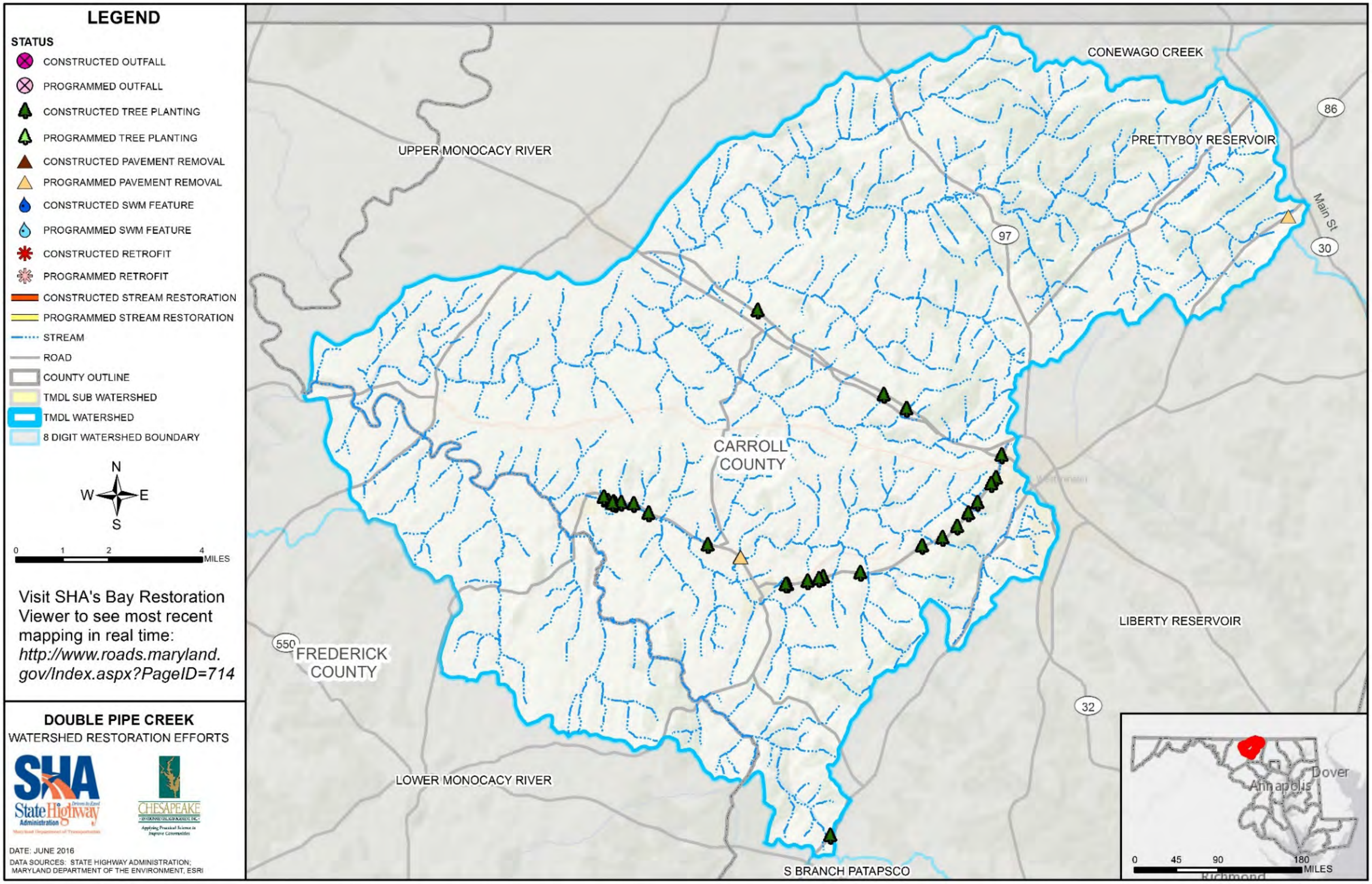

Figure 4-27: SHA Restoration Strategies within the Double Pipe Creek Watershed

J. GWYNNS FALLS WATERSHED

J.1. Watershed Description

The Gwynns Falls Watershed encompasses 43 square miles within Baltimore County and City of Baltimore. The Gwynns Falls Stream flows from Baltimore County for 25 miles in a southeasterly direction to City of Baltimore where it empties into the Patapsco River, which runs into the Chesapeake Bay. Tributary creeks and streams of the Gwynns Falls Watershed include Dead Run, Horsehead Ranch, Maidens Choice Run, Powder Mill Branch, Red Run, and Scotts Level Run.

There are approximately 1,055.7 miles of SHA roadway located within the Gwynns Falls Watershed, associated ROW comprises approximately 1,515.7 acres, of which 892.5 acres is impervious. SHA facilities located within the Gwynns Falls Watershed consist of one tower, one park and ride facility, one highway garage/shop facility and two salt storage facilities. See **Figure 4-28** for a map of the Gwynns Falls Watershed.

J.2. SHA TMDLs within Gwynns Falls Watershed

SHA is included in the sediment (TSS) TMDL (MDE, 2005) and has a reduction requirement of 36.4% within Baltimore County as shown in **Table 3-2**

The Gwynns Falls is also included in the Middle Branch and Northwest Branch Patapsco TMDL for Trash (MDE, 2014). The allocated trash baseline for SHA is to be reduced by 100% (this does not mean that trash within the watershed will be reduced to zero).

J.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-29**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

The grids awaiting review have little potential for additional impervious treatment due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. The current results of this ongoing grid search are as follows:

40 Total Grids:

- Seven (7) fully reviewed
- 20 partially reviewed - in progress
- 13 awaiting review (20% of total grids)

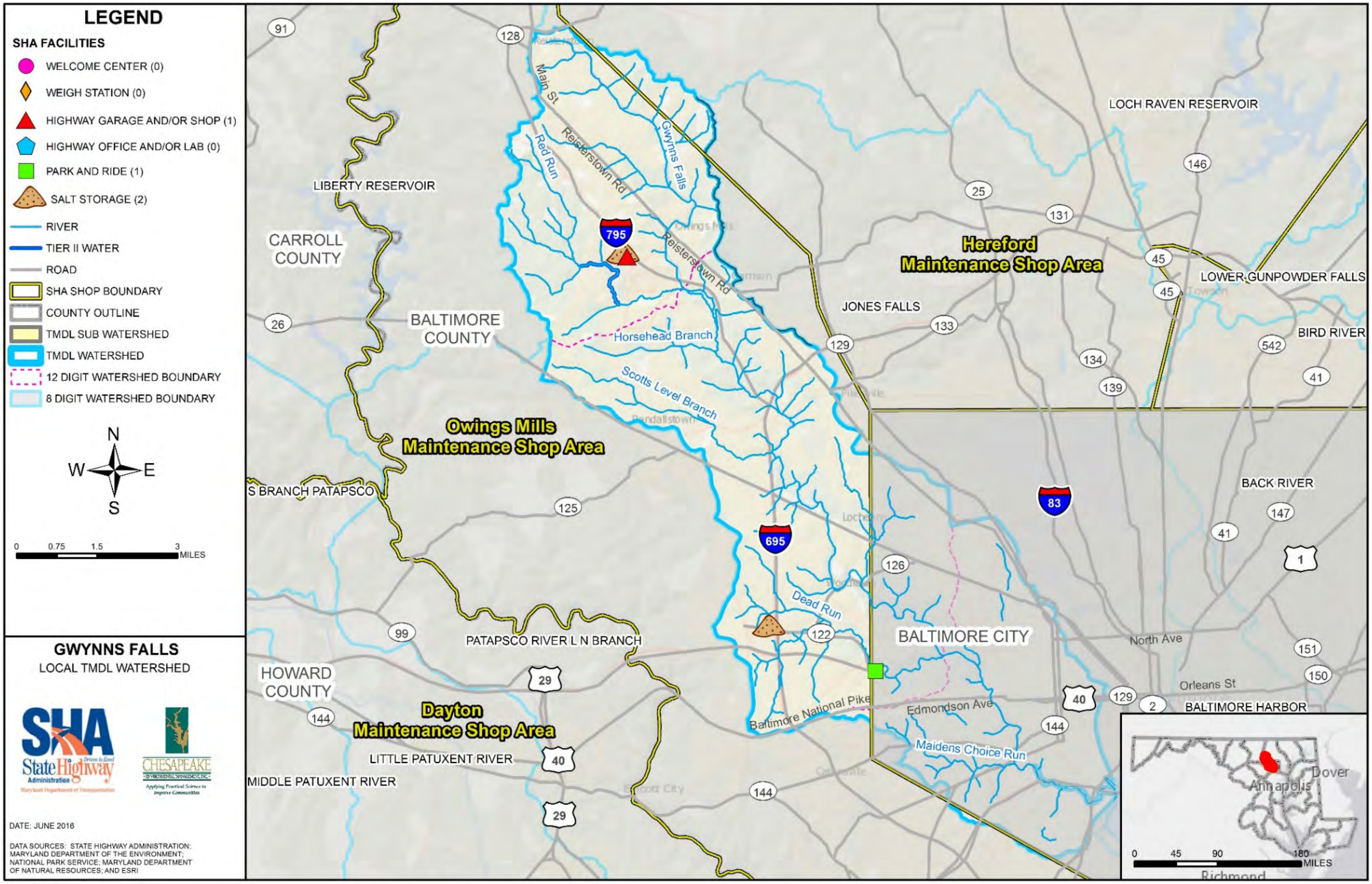

Figure 4-28: Gwynns Falls Watershed

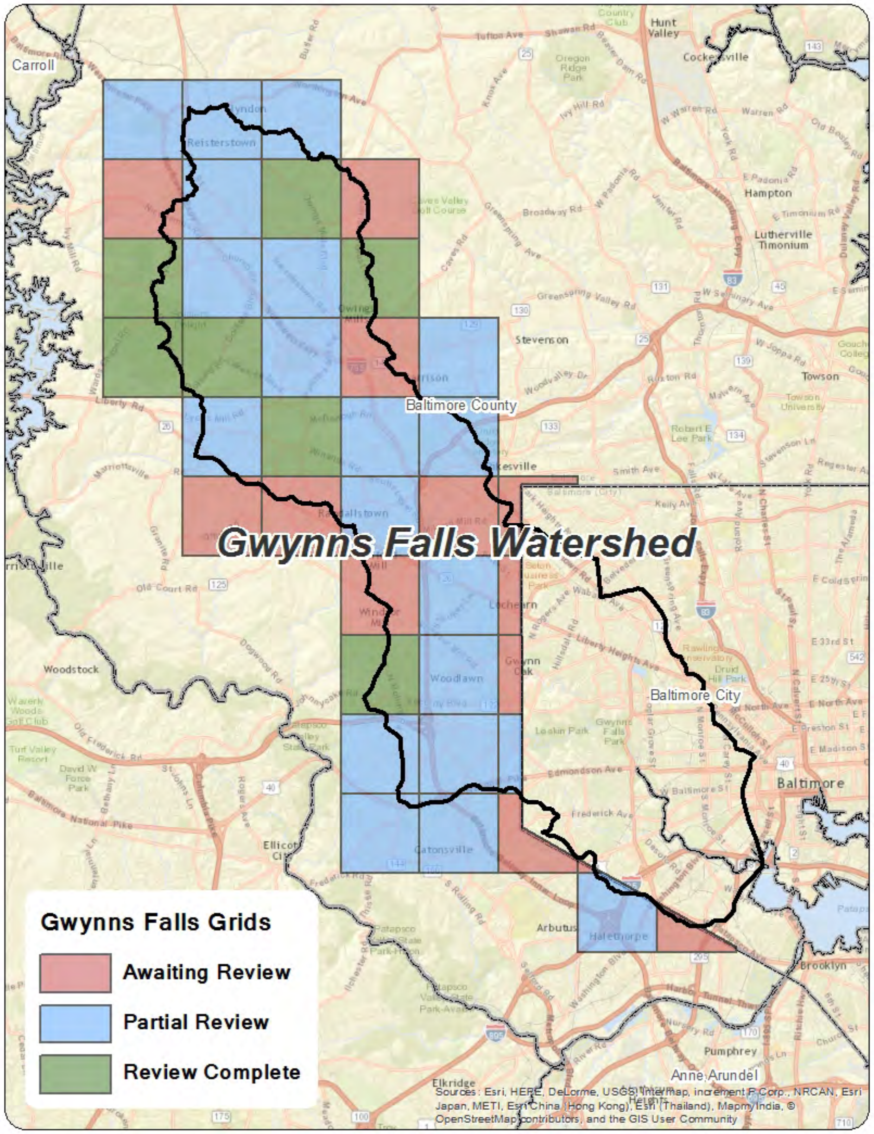

Figure 4-29: Gwynns Falls Site Search Grids

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 95 locations identified as possible candidates for new stormwater BMPs.
- One (1) facility undergoing concept design and may be candidates for design contracts in the near future.
- Five (5) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 913 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- Three (3) acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 7,398 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 1,320 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

J.4. Summary of County Assessment Review

Waters within the Gwynns Falls Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Channelization;
- Chlorides;
- Fecal Coliform;
- PCB in Fish Tissue;
- Phosphorus (Total);
- Temperature;
- Total Suspended Solids (TSS); and
- Trash

The Baltimore County Department of Environmental Protection and Sustainability completed Small Watershed Action Plans (SWAPs) for the Upper Gwynns Falls (UGF) Watershed (AMT, 2011) and the Middle Gwynns Falls (MGF) Watershed (PB, 2013) in an effort to guide the restoration efforts. Impervious land cover makes up 20% of the UGF Watershed and 29% of the MGF Watershed. Approximately 11% of soils within the UGF Watershed and over 30% of the soils within the MGF Watershed are considered of high runoff potential. The County estimates that impervious urban land use is responsible for contributing 39,029 lbs. of nitrogen and 6,256 lbs. of phosphorus in the UGF Watershed per year and 74,468 lbs. of nitrogen, 6,502 lbs. of phosphorus, and 8,833,323 lbs. of sediment in the MGF Watershed per year.

There are 28 NPDES-permitted facilities within the UGF Watershed, including a SHA maintenance yard. There are five process water sources with explicit TSS limits within the watershed. The total TSS load from all process water sources within the watershed is estimated at 213.2 tons per year (AMT, 2011).

The County prioritized subwatersheds within the Gwynns Falls Watershed based on ranking criteria to identify which subwatersheds have the greatest need and potential for restoration. For the UGF Watershed, UGF D was rated "very high" and UGF B and Roche's Run were rated "high" in terms of restoration need and potential (AMT, 2011). For the MGF Watershed, Dead Run was rated "very high" and Gwynns Falls was rated "high" in terms of restoration need and potential (PB, 2013).

For the purposes of planning, the County has selected the following generalized restoration strategies to aid in meeting restoration goals within the Gwynns Falls Watershed:

- Using present stormwater management facilities
- Converting stormwater facilities
- Stormwater retrofits
- Impervious cover removal
- Stormwater education and outreach
- Stream restoration
- Community Reforestation Program (CRP)
- Street sweeping
- Illicit connection detection/disconnection
- Sanitary sewer decree
- MS4 retrofits
- Credits for Fertilizer Act of 2011
- Increased State owned property restoration
- Redevelopment of urban areas
- Reforestation
- Downspout disconnection
- Urban nutrient management

The County identified numerous potential restoration sites within each subwatershed by conducting neighborhood source assessments, hotspot site investigations, institutional site investigations, and pervious area assessments. The County also identified multiple potential stormwater conversions within each watershed: 28 for the UGF watershed (AMT, 2011) and 15 for the MGF watershed (PB, 2013). Detailed information on site locations can be found in the SWAPs.

The County also identified 28 high priority sites for stormwater conversions and 42 proposed project sites for stream restoration and stabilization. Additionally, the County proposed 15 "large projects" (>$300,000) in the UGF Watershed. Details on project type and site location for potential restoration projects in the UGF Watershed are not included in the SWAP.

The following sites were identified as high priorities for stream restorations in the MGF Watershed as shown in **Table 4-24** below.

Table 4-24: County-Identified Potential Stream Restoration Sites in Gwynns Falls Watershed

Reach	Number of Sites	Total Linear Feet	Conditions
Gwynns Falls	14	6,000	Severe bank erosion, severe buffer erosion, concrete channels, inadequate buffers, unstable aprons, unstable banks, unstable outfalls
Powder Mill Run	3	5,000	Erosion, unstable banks, inadequate buffers
Maiden Choice Run	2	2,100	Concrete channels, absent floodplains, unstable banks
Scotts Level	3	8,100	Concrete channels, absent floodplains, unstable banks

J.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reduction in the Gwynns Falls watershed is shown in **Table 4-25**. Projected sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2005.

2. BMPs built between 2026 through 2045 the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Gwynns Falls watershed total $13,315,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $119,000 from our Operations Budget is estimated for annual inlet cleaning.

Proposed practices to meet Trash & Debris reduction in the Middle Branch & NW Patapsco River-Gwynns Falls watershed are shown in **Table 4-26**. Projected Trash reduction using these activities based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. Reduction activities implemented after the TMDL baseline year through 2025. For the Middle Branch & NW Patapsco River-Gwynns Falls TMDL, the baseline is 2011.

2. Reduction activities implemented in 2026 which is the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

SHA expects to spend $9,175 annually from our Operations Budget for yearly maintenance of our new public trash education program, and increased roadside trash pickup. In the future other trash reducing activities may be implemented to help in meeting our reduction goal.

Figure 4-30 shows a map of SHA's restoration practices in the watershed and include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-25: Gwynns Falls Restoration Sediment BMP Implementation

BMP	Unit	2006-2025	2026-2045	Total	Cost
New Stormwater	drainage area acres	15.1	17.2	32.3	$3,880,000
Retrofit	drainage area acres	205.0		205.0	$6,957,000
Tree Planting	Acres of planting	58.6	15.1	73.8	$2,478,000
Inlet Cleaning[1]	tons	203.5	124.2	124.2	$119,000

[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

Table 4-26: Patapsco-Gwynns Falls Trash & Debris Activities Implementation

BMP	Unit	20012-2025	2026	Total	Cost
Increased Inlet cleaning	lbs/yr	0	0	0	$0
New Public Education Program	lbs/yr	260.0	30.0	290.0	$1,075
New Stream Clean Up	lbs/yr	0	0	0	$0
New Structural SW Control Pickup	lbs/yr	0	0	0	$0
Increased Roadside Pickup	lbs/yr	2000.0	181.0	2181.0	$8,100

These trash reducing activities are an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

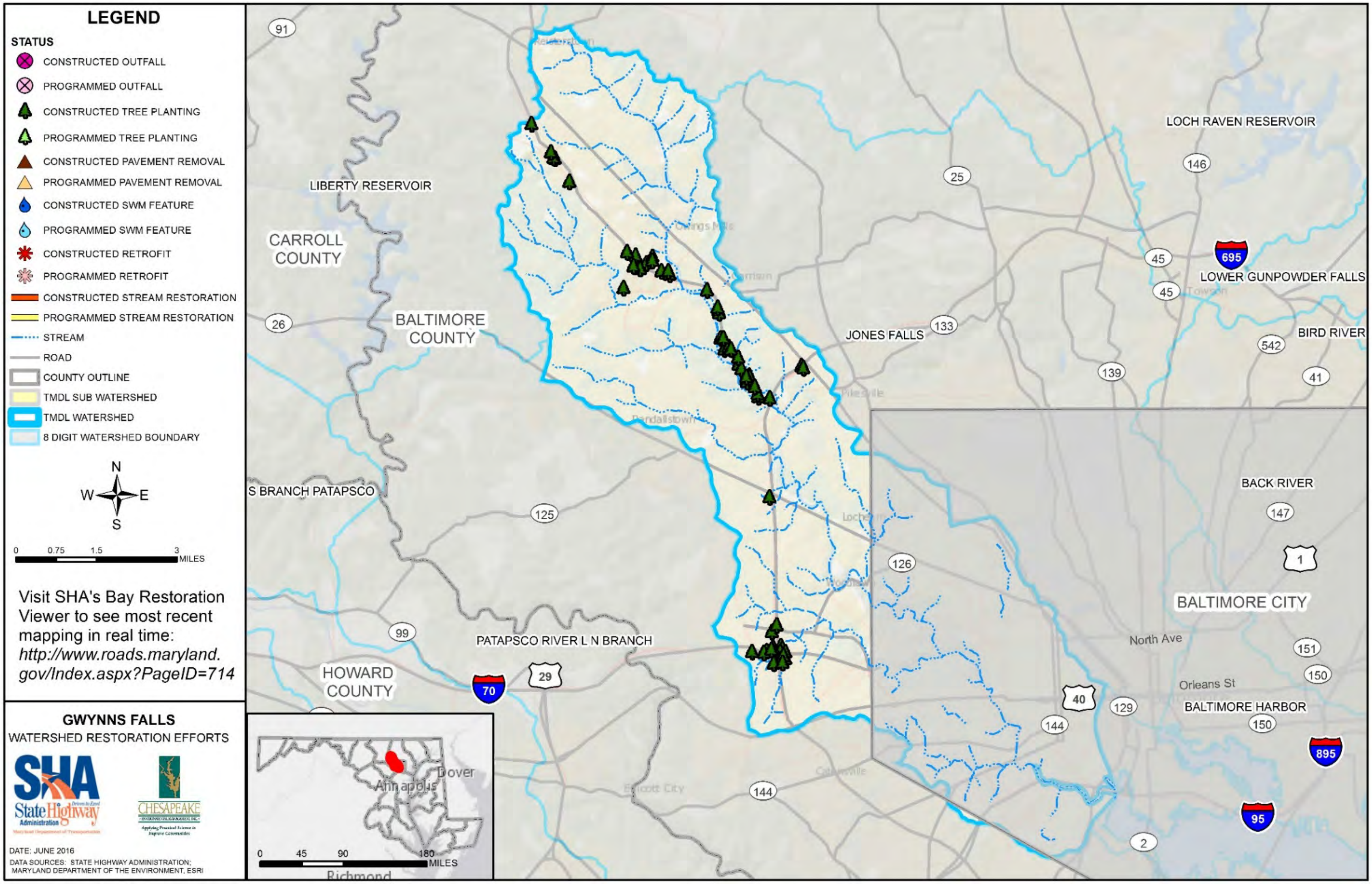

Figure 4-30: SHA Restoration Strategies within the Gwynns Falls Watershed

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K. JONES FALLS WATERSHED

K.1. Watershed Description

The Jones Falls Watershed encompasses 77 square miles within Baltimore County and City of Baltimore. The headwaters of the Jones Falls Stream are located near Garrison in Greenspring Valley, from which it flows east until it reaches Lake Roland, where it is impounded. From Lake Roland the river merges with eastern tributaries and then continues south through City of Baltimore to City of Baltimore's Inner Harbor. The Jones Falls Watershed is comprised of the Upper Jones Falls (UJF) Watershed, Northeastern Jones Falls (NJF) Watershed, and Lower Jones Falls (LJF) Watershed. The UJF Watershed makes up approximately 36% of the watershed, the NJF Watershed makes up 19% of the watershed, and the LJF Watershed makes up the lower 45% of the watershed. Tributary creeks and streams of the Jones Falls Watershed include Moores Branch, Roland Run, Towson Run, Western Run, and Stoney Run.

There are approximately 790.9 miles of SHA roadway located within the Jones Falls Watershed, associated ROW comprises approximately 857.9 acres, of which 583.2 acres is impervious. SHA facilities located within the Jones Falls Watershed consist of one highway office/lab facility and one salt storage facility. See **Figure 4-31** for a map of Jones Falls Watershed.

K.2. SHA TMDLs within Jones Falls Watershed

SHA is included in the sediment (TSS) TMDL (MDE, 2005) and has a reduction requirement of 21.7% within Baltimore County as shown in **Table 3-2**

The Jones Falls is also included in the Middle Branch and Northwest Branch Patapsco TMDL for Trash (MDE, 2014). The allocated trash baseline for SHA is to be reduced by 100% (this does not mean that trash within the watershed will be reduced to zero).

The Lake Roland subwatershed within the Jones Falls Watershed also has a TMDL for PCBs (MDE, 2013) with a reduction requirement of 29.3% as shown in **Table 3-2**.

K.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-32**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, many SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

32 Total Grids:

- Three (3) fully reviewed
- 11 partially reviewed – in progress 14 partially reviewed - in progress
- 18 awaiting review (53% of total grids)

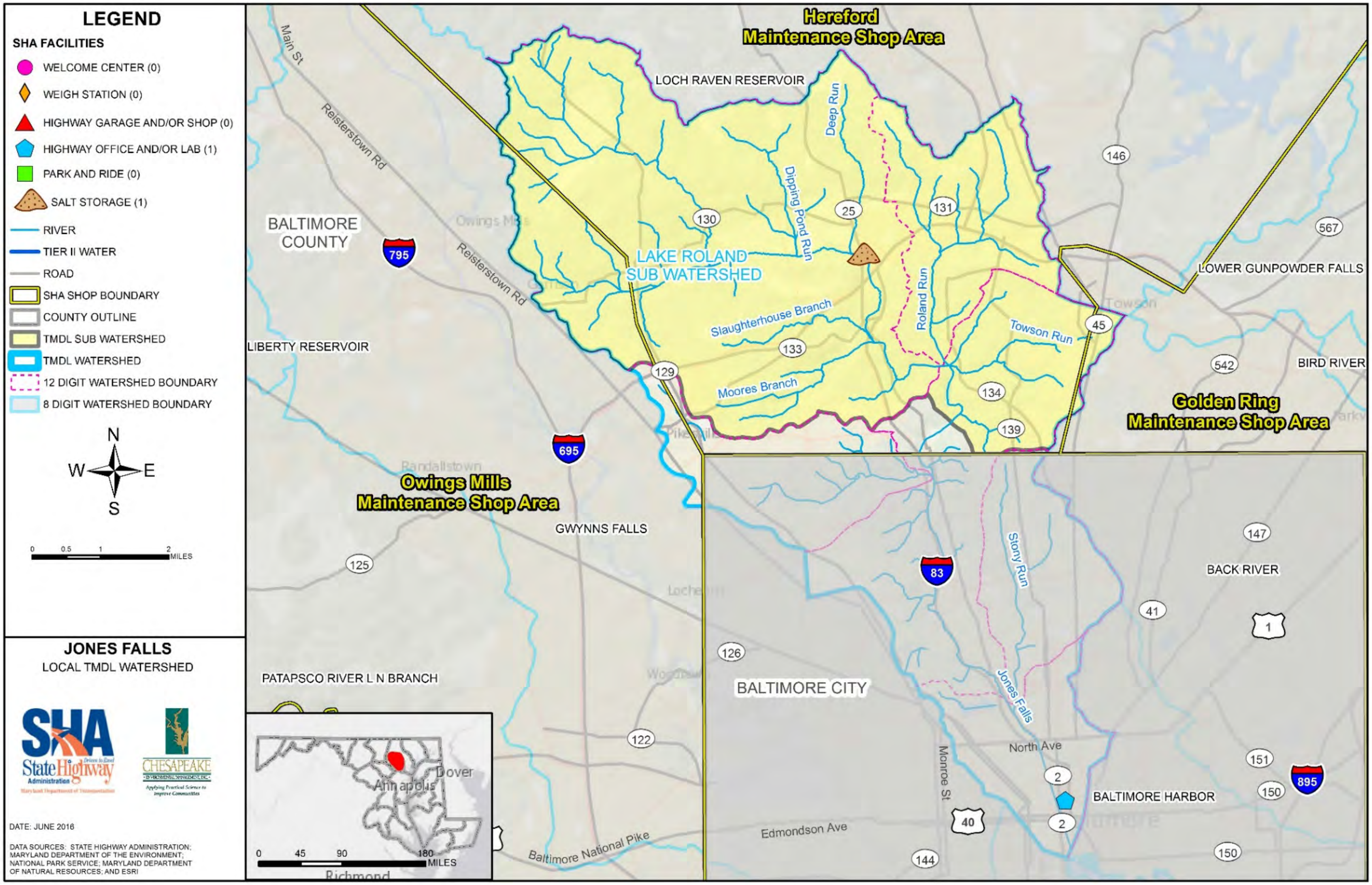

Figure 4-31: Jones Falls Watershed

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 143 locations identified as possible candidates for new stormwater BMPs.
- 12 facilities undergoing concept design and may be candidates for design contracts in the near future.
- One (1) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 404 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- Seven (7) acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 11,514 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 783 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

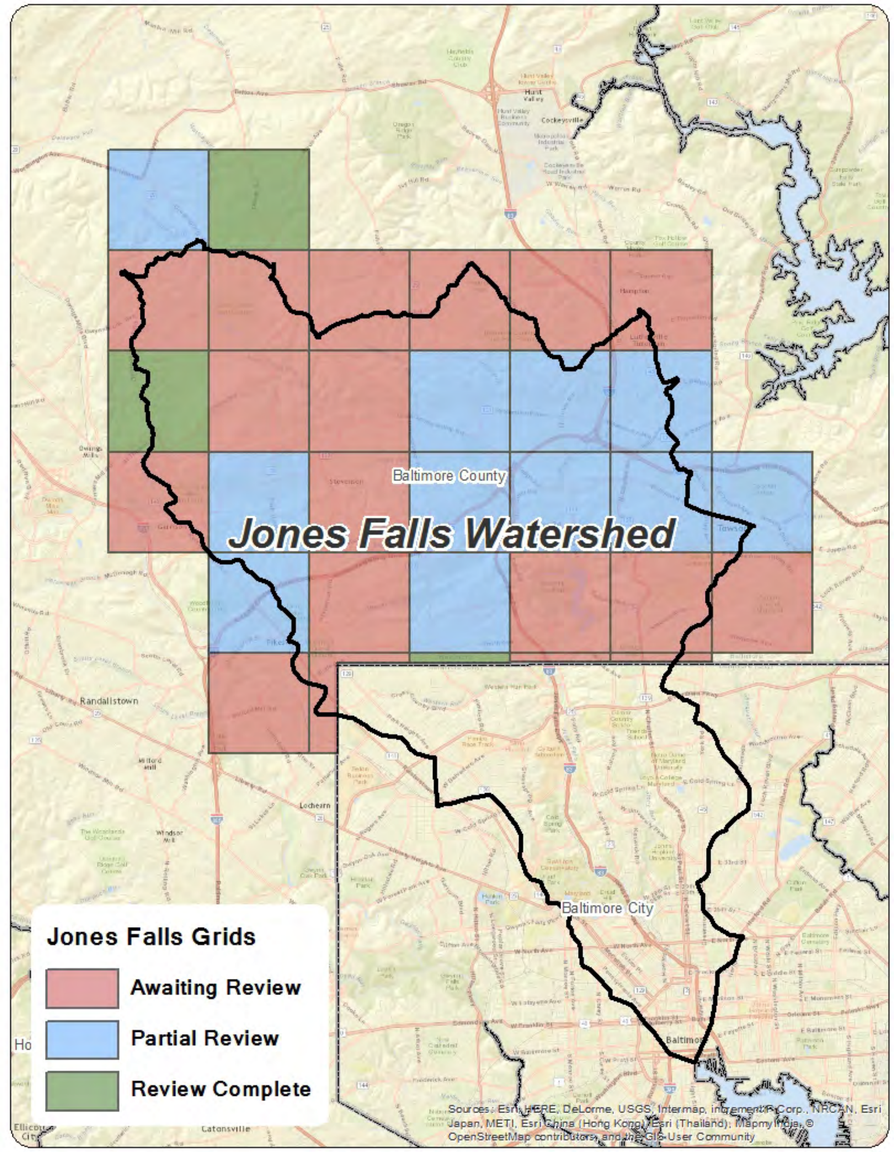

Figure 4-32: Jones Falls Site Search Grids

K.4. Summary of County Assessment Review

Waters within the Jones Falls Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Channelization;
- Chlordane;
- Chlorides;
- Copper;
- Fecal Coliform;
- Lead;
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- Phosphorus (Total);
- Sulfates;
- Temperature, water;
- Total Suspended Solids (TSS);
- Trash and
- Zinc;

The Baltimore County Department of Environmental Protection and Sustainability completed Small Watershed Action Plans (SWAPs) for the UJF Watershed (CWP, 2015), the NJF Watershed (BC-DEPS, 2012), and the LJF Watershed (CWP, 2008b). Impervious land cover comprises 9% of the UJF Watershed, 25% of the NJF Watershed, and 32% of the LJF Watershed. Approximately 7% of the soils within the UJF Watershed, 9% of the soils within the NJF Watershed, and 60% of the soils within the LJF Watershed are considered of high runoff potential. Urban impervious and cropland are the land uses responsible for the greatest nitrogen, phosphorus, and sediment loads within the UJF and NJF Watersheds.

Jones Falls currently has completed TMDLs for TSS and fecal coliform in the river and PCBs in an impoundment (Lake Roland). Jones Falls also has Category 5 impairment listings for chlorides and sulfates in the river and temperature in the Slaughterhouse Branch and two unknown tributaries. The Jones Falls Watershed also falls within the Patapsco River Mesohaline segment-shed of the Chesapeake Bay, which has TMDLs for nitrogen, phosphorus, and TSS and Category 5 impairment listings for zinc and lead in the Northwest Branch and trash and Enterococcus in the Middle Branch/Northwest Harbor.

The County prioritized subwatersheds within the UJF and NJF Watersheds based on ranking criteria in order to identify which subwatersheds have the greatest need and potential for restoration. For the UJF Watershed, Jones Falls was the only subwatershed rated "high" in terms of restoration potential. For the NJF Watershed, Roland Run was rated "very high" and Towson Run was rated "high" in terms of restoration need and potential. For the LJF Watershed, the stream corridor assessment identified Moore's Branch as the most impacted subwatershed based on stream erosion and inadequate buffer. In the NJF Watershed, 20 of the 22 sites assessed by the County had Benthic Index of Biotic Integrity scores in the "poor" or "very poor" categories. In the LJF Watershed, 31 of the 32 sites assessed by the City and 13 of the 15 sites assessed by the County had Benthic Index of Biotic Integrity scores in the "poor" or "very poor" categories.

For the purposes of planning, the County has selected the following generalized restoration strategies to aid in meeting restoration goals within the Jones Falls Watershed:

- Stormwater management for new development and redevelopment
- Existing stormwater management facility conversions
- Stormwater management retrofits
- Stream corridor restoration
- Street sweeping and storm drain inlet cleaning
- Illicit connection detection and disconnection program and hotspot remediation
- Sanitary sewer consent decrees
- Downspout disconnection

- Citizen awareness (fertilizer application and pet waste)
- Pervious Area Restoration (reforestation and tree planting)
- Agricultural BMPs (stream protection via fencing and conservation tillage)

The County identified numerous potential restoration sites within each subwatershed by conducting neighborhood source assessments, hotspot site investigations, institutional site investigations, and pervious area assessments. The County also identified multiple potential stormwater retrofits and conversions within each watershed: 13 in the UJF Watershed, 16 in the NJF Watershed, and 43 in the LJF Watershed. Detailed information on site locations can be found in the SWAPs. The County identified five potential stormwater dry pond conversions in the NJF Watershed as "high" priorities for improving water quality. The County also identified 18 potential stream restoration project sites in the NJF Watershed, however, location information for these sites is not included in the SWAP.

The following potential stream restoration sites within the Jones Falls Watershed are identified in the SWAPs as shown in **Table 4-27.**

Table 4-27: County-Identified Potential Stream Restoration Sites in Jones Falls Watershed

Watershed	Reach	Number of Sites	Total Linear Feet	Conditions
UJF	Deep Run	1	-	Fish Barrier
UJF	Dipping Pond Run	10	2,214	Severe erosion, fish barrier, unstable outfalls, inadequate buffers
NJF	Towson Run	1	-	Inadequate buffers, requires naturalization
LJF	Jones Falls	1	-	Inadequate buffers, requires naturalization
LJF	Western Run	1	-	Runofff of I-695
LJF	Lower Jones Falls	1	-	Runoff from upstream urbanization

K.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reduction in the Jones Falls watershed are shown in **Table 4-28**. Projected sediment reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2005.

2. BMPs built between 2026 through 2043 the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Jones Falls watershed total $10,527,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $81,000 from our Operations Budget is estimated for annual inlet cleaning.

Proposed practices to meet PCB reduction in the Lake Roland watershed are shown in **Table 4-29**. Projected PCB reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. One timeframe is included in the table:

1. BMPs built after the TMDL baseline through 2025 the projected target date. In this case the baseline is 2010. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Lake Roland watershed total $5,328,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $85,000 from our Operations Budget is estimated for annual inlet cleaning.

Proposed practices to meet Trash reduction in the Middle Branch & NW Patapsco River-Jones Falls watershed are shown in **Table 4-30**. Projected Trash reduction using these activities based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. Reduction activities implemented after the TMDL baseline year through 2025. For the Middle Branch & NW Patapsco River-Jones Falls TMDL, the baseline is 2011.

2. Reduction activities implemented in 2026 which is the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

SHA expects to spend $5,595 annually from our Operations Budget for yearly maintenance of our new public trash education program, stream cleanup, annual trash pickup from newly constructed stormwater facilities and increased roadside trash pickup. In the future other trash reducing activities may be implemented to help in meeting our reduction goal.

Figure 4-33 shows a map of SHA's restoration practices throughout the Jones Falls Watershed. The practices shown include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-28: Jones Falls Restoration Sediment BMP Implementation					
BMP	**Unit**	**2006 - 2025**	**2026 - 2043**	**Total**	**Cost**
New Stormwater	drainage area acres	39.7	38.7	78.4	$9,235,000
Tree Planting	drainage area acres	38.5		38.5	$1,292,000
Inlet Cleaning[1]	tons	98.4	84.5	84.5	$81,000

[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

Table 4-29: Lake Roland Restoration PCB BMP Implementation				
BMP	**Unit**	**2006 - 2025**	**Total**	**Cost**
New Stormwater	drainage area acres	44.0	44.0	$5,328,000
Inlet Cleaning[1]	tons	88.8	88.8	$85,000

[1] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

Table 4-30: Patapsco-Jones Falls Trash & Debris Activities Implementation					
BMP	**Unit**	**2012-2025**	**2026**	**Total**	**Cost**
Increased Inlet Cleaning	lbs/yr	0	0	0	$0
New Public Education Program	lbs/yr	1,618	18	179	$670
New Stream Clean Up	lbs/yr	315	335	350	$1,300
New Structural SW Controls Pickup	lbs/yr	45	9	54	$225
Increased Roadside Pickup	lbs/yr	1,513	2,271	914	$3400
These trash reducing activities are an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.					

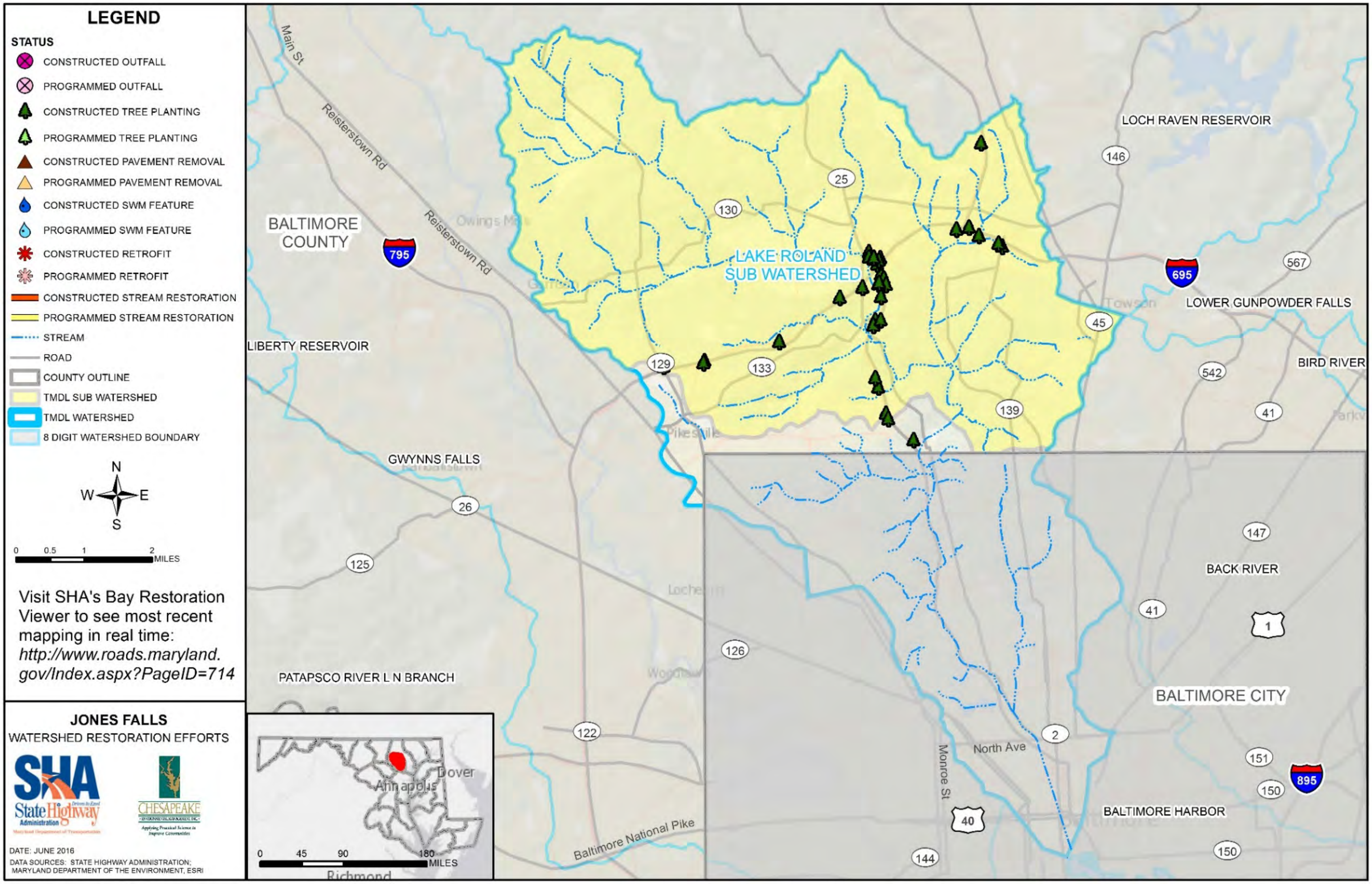

Figure 4-33: SHA Restoration Strategies within the Jones Falls Watershed

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L. LIBERTY RESERVOIR WATERSHED

L.1. Watershed Description

The Liberty Reservoir Watershed encompasses 164 square miles within eastern Carroll County and western Baltimore County. The North Branch Patapsco River is the main tributary flowing into the watershed which empties in the Lower Patapsco River Watershed. Liberty Reservoir itself is located to the south of the watershed. Tributary creeks and streams of the Liberty Reservoir Watershed include Aspen Run, Beaver Run, Beaver Run, Cooks Branch, Deep Run, East Branch North Branch Patapsco, Little Morgan Run, Middle Run, Middle Run, Morgan Creek, Morgan Run, North Branch Patapsco, Norris Run, and Roaring Run.

There are approximately 621.2 miles of SHA roadway located within the Liberty Reservoir Watershed, associated ROW comprises approximately 1,979.0 acres, of which 633.1 acres is impervious. SHA facilities located within the watershed consist of one highway garage/shop facility, two park and rides, and two salt storage facilities. See **Figure 4-34** for a map of the Liberty Reservoir Watershed.

L.2. SHA TMDLs within Liberty Reservoir Watershed

TMDLs requiring reduction by SHA pertain to phosphorus and sediment (MDE, 2009). Both of which are to be reduced by 45.0% as shown in **Table 3-2**.

L.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-35**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal right-of-way along residential and wooded areas, which limits the ability to purchase right-of-way for the construction of a new BMP. Additionally, many SHA impervious areas within these grids are already treated by SHA NPDES BMPs. The current results of this ongoing grid search are as follows:

111 Total Grids:

- 38 fully reviewed
- 42 partially reviewed – in progress
- 31 awaiting review (27% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 774 locations identified as possible candidates for new stormwater BMPs.
- 12 facilities undergoing concept design and may be candidates for design contracts in the near future.
- One (1) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

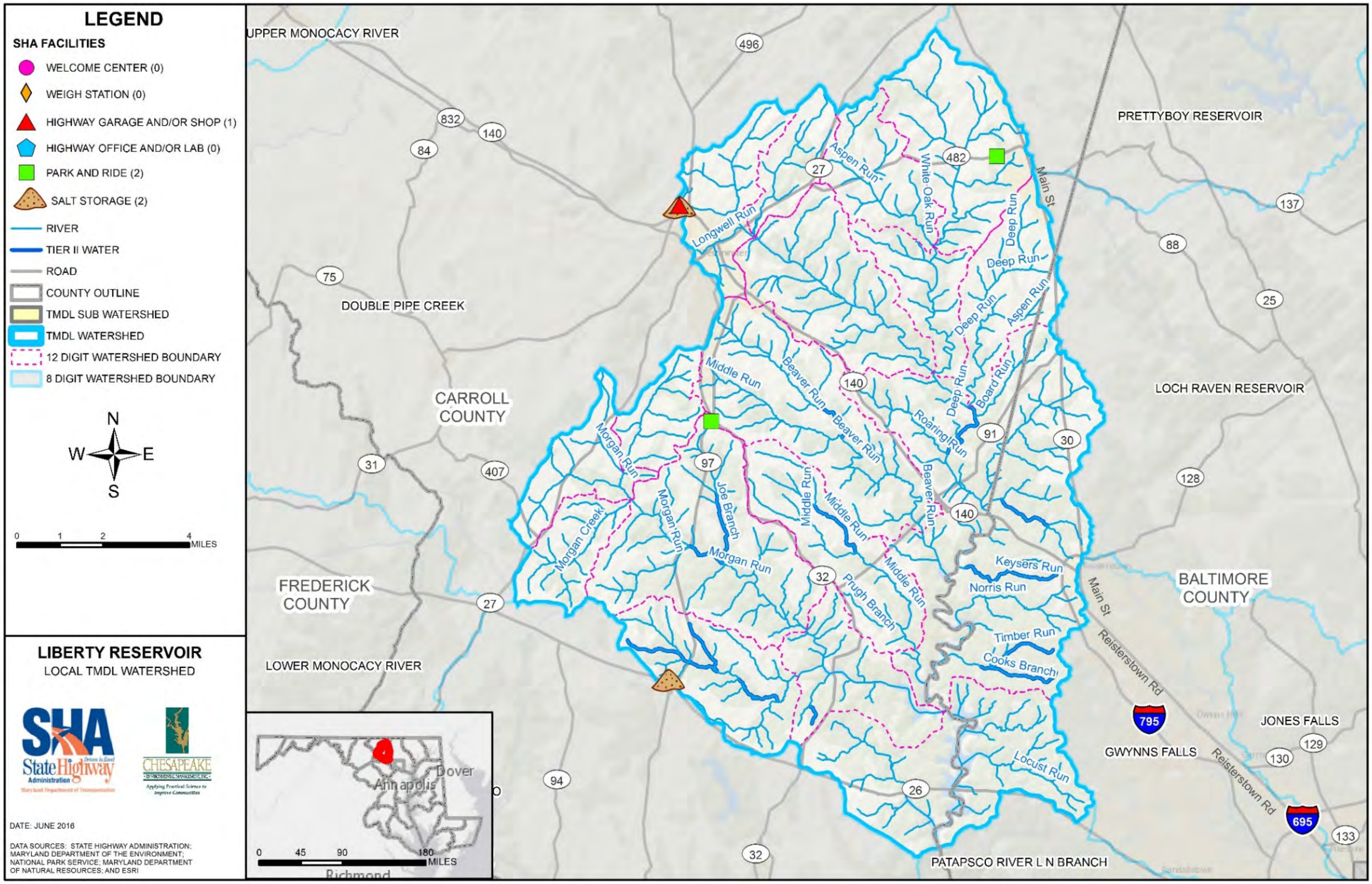

Figure 4-34: Liberty Reservoir Watershed

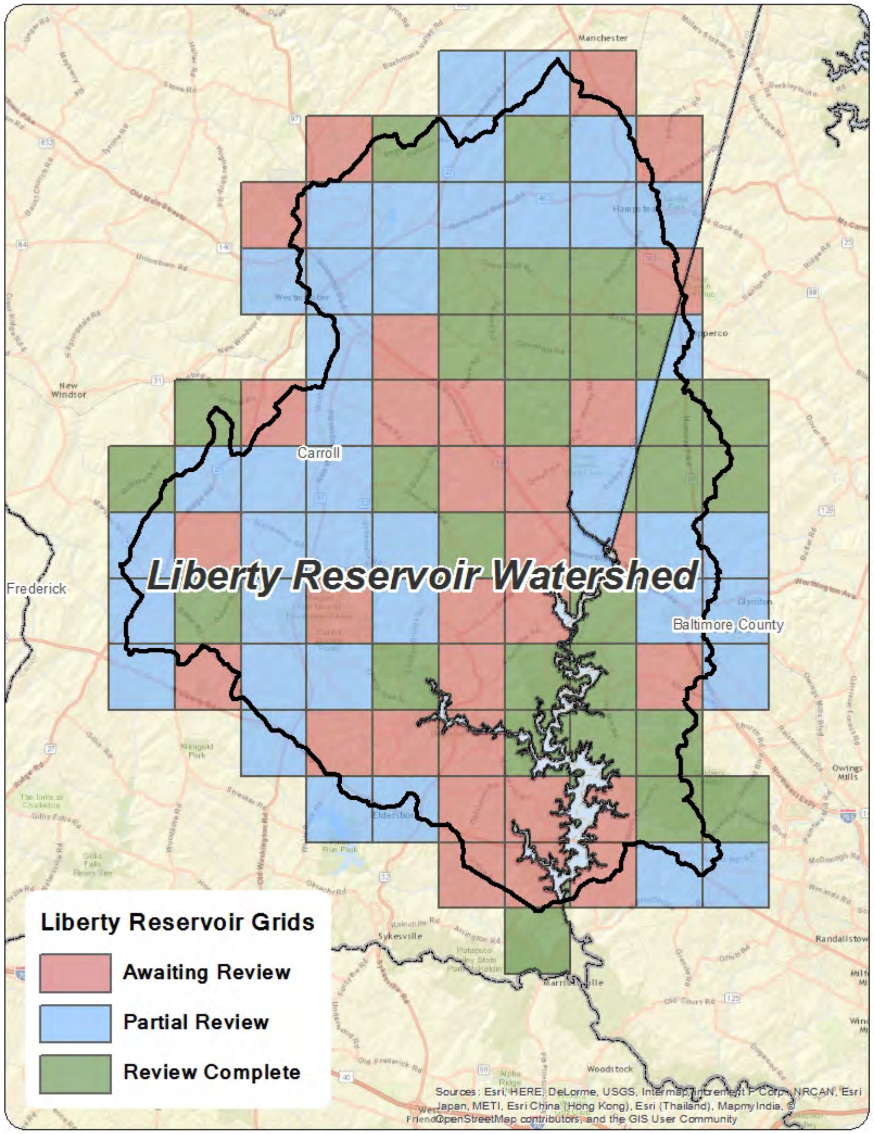

Figure 4-35: Liberty Reservoir Site Search Grids

The tree planting site search teams have investigated 1,425 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 34 acres are undergoing concept design and may be candidates for planting contracts in the near future.
- 10 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 42,292 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 4,985 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

L.4. Summary of County Assessment Review

Waters within the Liberty Reservoir Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Chlorides;
- Chromium (total);
- *Escherichia coli;*
- Lead;
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- Phosphorus (Total);
- Sedimentation/siltation; and
- Temperature, water.

The watershed is ranked by DNR in Maryland's Clean Water Action Plan as a "Priority Category 1," a watershed not meeting clean water and other natural resource goals and therefore needing restoration, and "Selected Category 3", a pristine or sensitive watershed most in need of protection. The Liberty Reservoir Watershed also received the highest priority for restoration and protection by the Clean Water Action Plan. Six stream segments within this watershed are classified as Tier II waters, high quality waters with catchments under regulatory anti-degradation protection that exceeds minimum water quality standards. Two Tier II segments are located in both Glenn Falls Run and Timber Run, and one in both Keyser Run and Cooks Branch. Impervious land cover comprises 6.3% of the watershed on average. Approximately 43% of streams in the Liberty Reservoir lack tree buffers. The Liberty Reservoir Watershed currently has completed TMDLs for sediment (Total Suspended Solids), phosphorus, and methyl-mercury in fish in the reservoir itself, and fecal coliform in the tributaries. The reservoir was delisted as impaired for mercury in fish in 2013.

Stream Corridor Assessments were conducted in both counties. The Baltimore County Department of Environmental Protection and Sustainability completed a Small Watershed Action Plan (SWAP)[1] for the Liberty Reservoir Watershed in 2012, and The Carroll County Bureau of Resources Management released The Liberty Reservoir Stream Corridor Assessment[2] report in 2012, as well. Carroll County assessments were conducted in 17 subwatersheds, and found 286 inadequate buffer sites, 447 erosion sites, and 151 fish passage barriers, for a total of 93,992 feet of erosion, and 304,986 feet of inadequate buffers (linear footage includes both banks). Site locations were not specified, only included as points on maps in the Liberty Reservoir Watershed Stream Corridor Assessment. Baltimore County assessments were conducted in three subwatersheds (Cliffs Branch, Keyser Run, and Norris Run), and found 91 inadequate buffer sites, 314 erosion sites, and 78 fish passage barriers, for a total of 26,561 ft of erosion and 39,680 ft of inadequate buffer.

Table 4-31 lists potential stream restoration sites that were identified by the Baltimore County SWAP, limited to those rated as Moderate, Severe, or Very Severe:

Table 4-31: Potential Stream Restoration Sites in Liberty Reservoir, Baltimore County

Subwatershed	Reach ID	Length (ft.)	Impact(s)	Severity
Cliffs Branch	039A1 21-ES	26	Stage I Incision	Moderate
Cliffs Branch	039A1 40-ES	78	Stage I Incision	Moderate
Cliffs Branch	039A1 48-ES	612	Stage I Incision	Moderate
Cliffs Branch	039A1 02-ES	69	Stage II Widening	Severe
Cliffs Branch	039A1 32-ES	18	Stage II Widening	Moderate
Cliffs Branch	031A2 02-ES	44	Stage I Incision	Severe
Cliffs Branch	031A2 03-ES	29	Stage I Incision	Severe
Cliffs Branch	031A2 12-ES	166	Stage I Incision	Moderate
Cliffs Branch	031A2 13-ES	107	Stage I Incision	Moderate
Cliffs Branch	031C3 07-ES	24	Stage I Incision	Moderate
Cliffs Branch	031C2 08-ES	246	Stage I Incision	Very Severe
Cliffs Branch	031C2 09-ES	238	Stage I Incision	Very Severe
Cliffs Branch	031C2 10-ES	257	Stage I Incision	Severe
Cliffs Branch	031C2 11-ES	257	Stage I Incision	Severe
Cliffs Branch	031C2 13-ES	106	Stage I Incision	Moderate
Cliffs Branch	031C2 14-ES	59	Stage I Incision	Moderate
Cliffs Branch	031C2 14-	24	Stage I Incision	Moderate

[1] http://resources.baltimorecountymd.gov/Documents/Environment/Watersheds/2016/libertyreservoir/libertyswapvol1complete.pdf
[2] http://www.mde.state.md.us/assets/document/wetlandswaterways/CR.pdf

Table 4-31: Potential Stream Restoration Sites in Liberty Reservoir, Baltimore County

Subwatershed	Reach ID	Length (ft.)	Impact(s)	Severity
	ES			
Cliffs Branch	031C2 13-ES	71	Stage I Incision	Moderate
Cliffs Branch	031C2 14-ES	53	Stage I Incision	Moderate
Cliffs Branch	031C2 14-ES	36	Stage I Incision	Moderate
Cliffs Branch	03182 58-ES	106	Stage I Incision	Moderate
Cliffs Branch	03182 57-ES	106	Stage I Incision	Moderate
Cliffs Branch	03182 54-ES	148	Stage I Incision	Moderate
Cliffs Branch	03182 55-ES	153	Stage I Incision	Moderate
Cliffs Branch	03183 03-ES	192	Stage II Widening	Moderate
Keyser Run	047C2 12-ES	86	Stage II Widening	Moderate
Keyser Run	048a2 52-ES	58	Stage II Widening	Moderate
Keyser Run	048a2 53-ES	83	Stage II Widening	Moderate
Keyser Run	048a2 61-ES	110	Stage II Widening	Moderate
Keyser Run	048a2 03-ES	39	Stage I Incision	Moderate
Keyser Run	048a2 04-ES	28	Stage I Incision	Moderate
Keyser Run	04881 07-ES	112	Stage I Incision	Severe
Keyser Run	04881 08-ES	120	Stage I Incision	Severe
Keyser Run	04881 10-ES	121	Stage I Incision	Moderate
Keyser Run	04881 09-ES	201	Stage I Incision	Moderate
Cliffs Branch	03981 09-FB	--	Fish passage block	Moderate
Cliffs Branch	03182 01-FB	--	Fish passage block – road crossing	Moderate
Cliffs Branch	03981 39-FB	--	Fish passage block – debris dam	Moderate

Table 4-31: Potential Stream Restoration Sites in Liberty Reservoir, Baltimore County

Subwatershed	Reach ID	Length (ft.)	Impact(s)	Severity
Cliffs Branch	03182 19-FB	--	Fish passage block – road crossing	Severe
Cliffs Branch	031A3 32-FB	--	Fish passage block	Moderate
Cliffs Branch	031C3 11-FB	--	Fish passage block – road crossing	Moderate
Cliffs Branch	03182 48-FB	--	Fish passage block – channelized	Moderate
Keyser Run	047C1 06-FB	--	Fish passage block – road crossing	Moderate
Keyser Run	047C2 10-FB	--	Fish passage block – road crossing	Very Severe
Keyser Run	048A2 27-FB	--	Fish passage block – road crossing	Severe
Keyser Run	048A2 57-FB	--	Fish passage block – dam	Severe
Keyser Run	048A2 62-FB	--	Fish passage block – natural falls	Moderate
Keyser Run	048A2 34-FB	--	Fish passage block – road crossing	Moderate
Keyser Run	048A2 36-FB	--	Fish passage block – debris dam	Moderate
Keyser Run	048B1 27-FB	--	Fish passage block – natural falls	Moderate
Keyser Run	078B1 30-FB	--	Fish passage block – natural falls	Moderate
Norris Run	047C2 02-FB	--	Fish passage block – road crossing	Moderate
Norris Run	048B3 17-FB	--	Fish passage block – debris dam	Severe
Norris Run	048A3 05-FB	--	Fish passage block - channelized	Moderate
Norris Run	048B3 33-FB	--	Fish passage block – debris dam	Moderate
Norris Run	048B3 34-FB	--	Fish passage block – debris dam	Moderate

L.5. SHA Pollutant Reduction Strategies

Liberty Reservoir is listed for both phosphorus and sediment with each TMDL having a baseline year of 2009. Proposed practices to meet the phosphorus and sediment reductions in the Liberty Reservoir watershed are shown in **Table-4-32**. Projected phosphorus and sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table below:

1. BMPs built after the phosphorus and sediment TMDL baseline through 2025. In this case the baseline is 2009.

2. BMPs built from 2026 through 2040 the projected target date of the sediment TMDL. 2036 is the projected target date for the phosphorus TMDL. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Liberty Reservoir watershed total $32,942,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $76,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-36 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-32: Liberty Reservoir Restoration Nutrient and Sediment BMP Implementation					
BMP	**Unit**	**2010 - 2025**	**2026 - 2040**	**Total**	**Cost**
New Stormwater	drainage area acres	70.1	116.3	186.4	$22,184,000
Stream Restoration	linear feet	3,000.0	1,500.0	4,500.0	$3,299,000
Tree Planting	drainage area acres	36.5	28.4	64.9	$2,186,000
Outfall Stabilization[1]	linear feet		2,400.0	2,400.0	$5,235,000
Impervious Surface Elimination	acres of removed	0.2		0.2	$38,000
Inlet Cleaning[2]	tons	115.2	79.4	79.4	$76,000
[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits					
[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.					

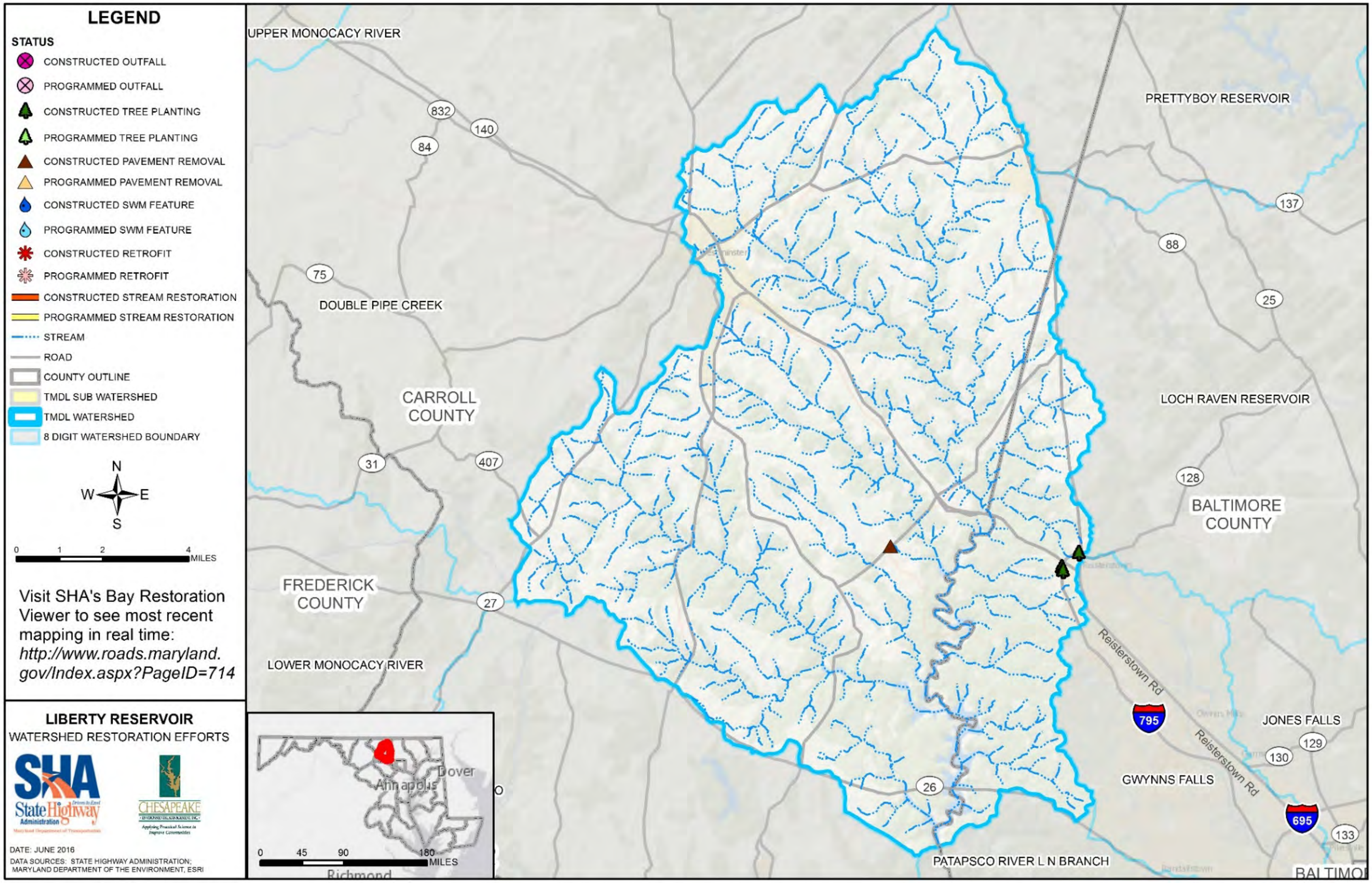

Figure 4-36: SHA Restoration Strategies within the Liberty Reservoir Watershed

M. LITTLE PATUXENT RIVER WATERSHED

M.1. Watershed Description

The Little Patuxent River Watershed encompasses 103 square miles across Anne Arundel and Howard Counties. The Little Patuxent River begins near the Howard County Landfill north of Route 70. Little Patuxent River joins the Patuxent River between the towns of Bowie and Crofton, southeast of the Patuxent Research Refuge. Major tributaries of the Little Patuxent River include Hammond Branch and Midway Branch.

There are approximately 857.9 miles of SHA roadway located within the Little Patuxent River Watershed, associated ROW comprises approximately 3,427.4 acres, of which 1,262.9 acres is impervious. SHA facilities located within the watershed consist of one salt storage facility, and five park and rides. See **Figure 4-37** for a map of the Little Patuxent River Watershed.

M.2. SHA TMDLs within Little Patuxent River Watershed

The TMDL requiring reduction by SHA inlcudes sediment (MDE, 2005). Sediment is to be reduced by 36.1% as shown in **Table 3-2**.

M.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-38**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, many SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

87 Total Grids:

- 21 fully reviewed
- 35 partially reviewed – in progress
- 31 awaiting review (36% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 209 locations identified as possible candidates for new stormwater BMPs.
- 20 facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

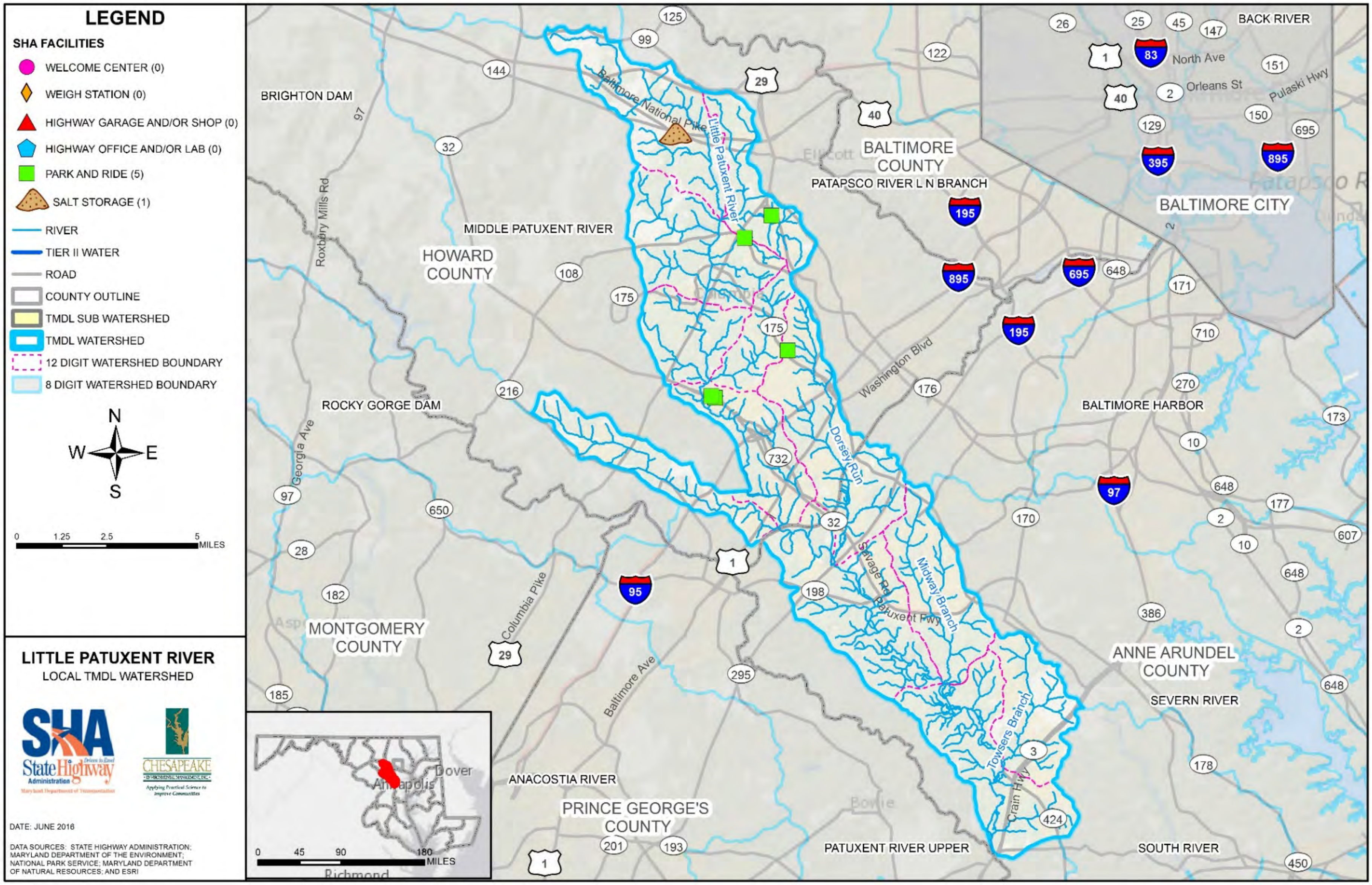

Figure 4-37: Little Patuxent River Watershed

The tree planting site search teams have investigated 2,179 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 29 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 65,489 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 29,293 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

M.4. Summary of County Assessment Review

Waters within the Little Patuxent Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Cadmium;
- Chlorides;
- *Escherichia coli;*
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- Phosphorus (Total); and
- Total Suspended Solids (TSS)

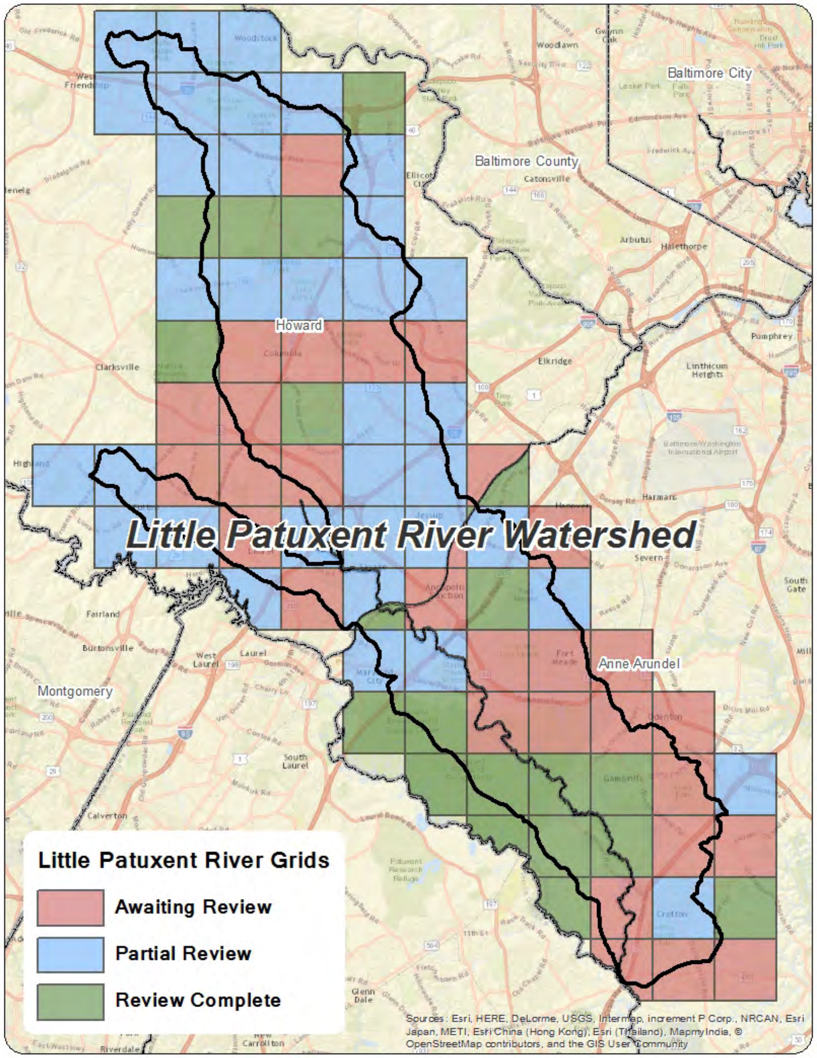

Figure 4-38: Little Patuxent Site Search Grids

In 2015, Howard County Department of Public Works prepared the *Little Patuxent River Watershed Assessment* (Versar, 2015). In 2016, report was completed by the Anne Arundel County Department of Public Works completed the *Little Patuxent Watershed Assessment Comprehensive Summary Report* (Versar, 2016) in an effort to assess the conditions in the Little Patuxent watershed and to rate and prioritize restoration and protection activities.

Howard County Assessment

Howard County conducts biological monitoring at randomly selected stations in its Countywide monitoring program, which began in 2001. The Little Patuxent Watershed consists of the Lower Little Patuxent, Middle Little Patuxent, Upper Little Patuxent subwatersheds, as well as Dorsey Run and Hammond Branch. With the exception of Hammond Branch and Dorsey Run, which were last sampled in 2009, the watershed was sampled most recently in 2013 (Versar, 2015).

Of the 281 sites in Little Patuxent Watershed identified by Howard County, only 10 (4%) were in good condition, 31 (11%) were rated fair, 79 (28%) were rated poor, and 160 (57%) rated very poor. Some good sites were found in the Upper Little Patuxent sub-watershed and upper reaches of Hammond Branch. However, most sites in Lower Little Patuxent sub-watershed and Dorsey Run were in poor to very poor condition. Stream habitat condition was also evaluated by Howard County using EPA's Rapid Bioassessment Protocol (RBP) for habitat assessment. Of the 124 sites assessed, only one site (less than 1%) was rated as comparable to reference condition (the highest scoring category). 17 (14%) sites were rated as supporting, 48 (39%) as partially supporting, and 58 (47%) as not supporting (the lowest scoring category), indicating that many streams in the Little Patuxent Watershed show evidence of habitat degradation (Versar, 2015).

In 2014-2015, Howard County's Stormwater Management Division sponsored an assessment of the Little Patuxent Watershed within Howard County in order to (1) assess current conditions and (2) recommend watershed restoration opportunities. Employing GIS and field investigations, the project team recommended a suite of opportunities including upgrades to existing stormwater Best Management Practices (BMPs), new BMPs, tree plantings, stream restoration, and stabilization of stormwater outfalls. In all, this assessment yielded 760 potential projects and produced concept plans for 109 of the top-ranked opportunities identified (Versar, 2015).

While stream conditions vary across the county, degradation is more prevalent in the heavily developed urban areas. This reflects the history of urban and suburban development prior to effective stormwater management regulations. Watershed condition is generally better in the more rural parts of the county, but stream degradation still occurs in these areas as a result of large lot development and agricultural impacts. By reducing the adverse effects of stormwater runoff throughout the county, the process of watershed assessment, restoration planning, and implementation of prioritized BMPs should improve the water quality condition in Little Patuxent Watershed over time (Versar, 2015).

For the purpose of planning, the County has developed the following project concepts within the Little Putuxent watershed:

- 15 BMP Conversions
- 10 New BMPs
- 19 Tree Plantings
- 20 Outfall Stabilizations
- 45 Stream Restorations

Howard County listed several stream reaches recommended for restoration due to active erosion, threatened infrastructure and limited habitat. Overall, 14 stream reaches in the Northern Middle Patuxent watershed and 13 stream reaches in the Dorsey Run watershed have high stream restoration potential. Of these high priority reaches, those with the most potential are listed below:

- DOR-SR-F906 is a heavily incised and actively eroding channel which is currently threatening private property as the stream continues to erode and meander.
- DOR-SR-F909, DOR-SR-F910, and DOR-SR-F911 are experiencing moderate to severe erosion, an abundance of depositional areas, and pools filled with fine sediment (primarily silt) indicating large sediment loads upstream.
- DOR-SR-F912 has moderate to severe erosion throughout include degradation and lateral migration. Restoration could include outfall stabilization and BMPs in several locations and the length may be extended further downstream.
- NMP-SR-F133, NMP-SR-F136, and NMP-SR-F145 have severe bank erosion, numerous tree falls, lack of riparian vegetation, and moderate bar deposition.
- NMP-SR-F135 has moderate to severe erosion including headcuts and is highly sinuous.
- NMP-SR-F152 is experiencing severe active erosion along the left bank. Homeowners mow to top of bank, but expressed interest in the County planting a stream buffer.
- NMP-SR-F168 and NMP-SR-F-169 are the main stem of the Northern Middle Patuxent and a large tributary to the main stem, both experiencing severe erosion throughout. This is likely a more expensive restoration opportunity than lower order streams.

Anne Arundel County Assessment

The Little Patuxent watersheds were assessed in the spring of 2012 to determine the conditions of the watershed and prioritize watershed management activities. The minority of land within the LP subwatersheds is highly erodible (10%), with the majority being low in erodibility (37%). 35% of streams assessed had more than 25% impervious cover, with 33% of streams with 0-10% impervious cover. Approximately 2% of the County's Onsite Sewage Disposal Systems are located within the watershed. As a result, five subwatersheds, Towsers Branch 3 (LPC), Little Patuxent 6 (LPF), Jessup (LPK), Towsers Branch 2 (LP6), and Little Patuxent 5 (LP7) are rated "Very Poor" or "Poor" for total nitrogen contributions. Two subwatersheds were not assessed due to access restrictions (Versar, 2016).

Based on Benthic Index of Biotic Integrity scores, Podickery Creek (MGZ), Cornfield Creek (MR0), Gray's Creek (MRE), and Black Hole Creek (MRG) were rated as "very poor" and identified as target watersheds for restoration. Following a subwatershed restoration assessment, the County identified 13 subwatersheds as having "high" or "medium high" priority for restoration: Magothy Branch 2 (MG1), Indian Village Branch (MGW), Cypress Creek (MGC), Nannys Branch (MGY), Magothy River Tidal (MGF), Cockey Creek (MR6), Dividing Creek (MGH), Hunters Harbor (MRD), Mill Creek (MGI), Old Man's Creek (MRF), Deep Creek (MGT), Cattail Creek (MRI/MRO), and Little Magothy River (MGV). Of the 29 subwatersheds with assessed perennial streams, six had greater than one-third of their perennial streams rated as "medium high" or "high" for restoration: Cypress Creek (MGC), Magothy Narrows (MRM), Little Magothy River (MGV), Dividing Creek (MGH), Magothy Branch 1 (MR3), and Forked Creek (MGL) (Versar, 2016).

For the purposes of planning, Anne Arundel County has selected the following six generalized restoration project types to focus on:

- Shallow marsh and regenerative wetland seepage system
- Regenerative step pool outfall sand filtration device
- Dry pond retrofit
- Concrete ditch retrofit to water quality swale
- Enhanced stormwater retrofit (bioretention facility)

- Onsite sewage discharge system retrofits

The County ranked several stream reaches based on priority for restoration, with 1 being the highest priority as shown below in **Table 4-33** (Versar, 2016). :

Table 4-33: Anne Arundel County Priority Stream Restoration Projects in Little Patuxent Watershed

Priority	Subwatershed	Reach
1	Cypress Creek	MGC001
2	Cypress Creek	MGC002
2	Little Magothy River	MGV009
2	Magothy Narrows	MRM001
2	Cypress Creek	MGC002
2	Bailys Branch	MR1006
8	Little Magothy River	MGV010
10	Magothy Branch 1	MR3019
10	Dividing Creek	MGH005
14	Kinder Branch	MR9008

M.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reduction in the Little Patuxent River watershed is shown in **Table 4-34**. Projected sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2005.

2. BMPs built between 2026 through 2042 the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Little Patuxent River watershed total $35,352,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $122,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-39 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-34: Little Patuxent River Restoration Sediment BMP Implementation

BMP	Unit	2006 - 2025	2026 - 2042	Total	Cost
New Stormwater	drainage area acres	67.9	53.2	121.1	$14,535,000
Retrofit	drainage area acres	38.5		38.5	$1,230,000
Stream Restoration	linear feet	12,517.0	600.0	13,117.0	$9,617,000
Tree Planting	acres of tree planting	136.3		136.3	$4,584,000
Outfall Stabilization[1]	linear feet	2,400.0		2,400.0	$5,235,000
Impervious Surface Elimination	acres removed	0.5		0.5	$151,000
Inlet Cleaning[2]	tons	79.0	127.3	127.3	$122,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

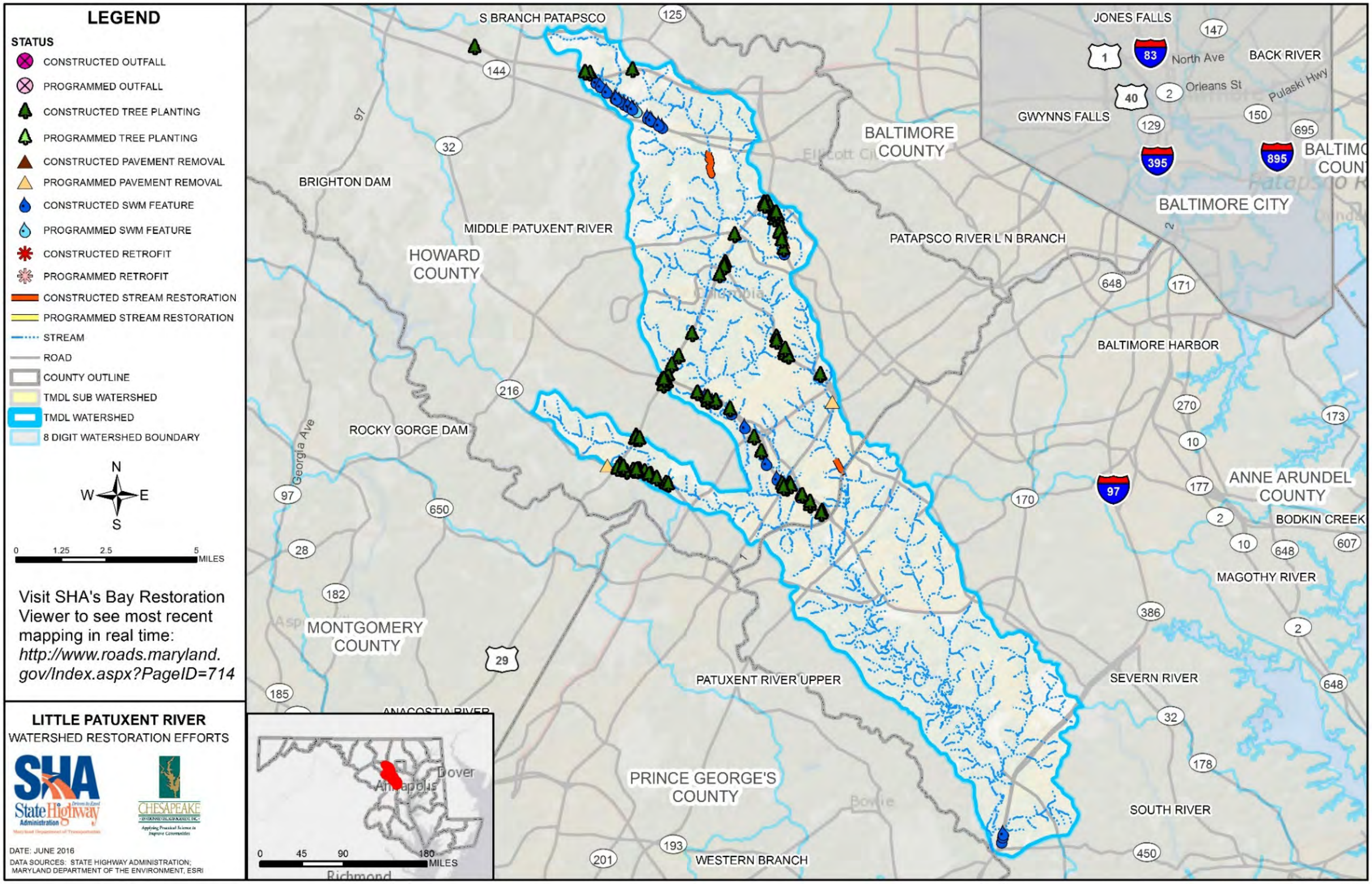

Figure 4-39: SHA Restoration Strategies within the Little Patuxent River Watershed

N. LOCH RAVEN RESERVOIR WATERSHED

N.1. Watershed Description

The Loch Raven Reservoir Watershed encompasses 220 square miles within Maryland and Pennsylvania. Within Maryland, the watershed is primarily located within Baltimore County, with small areas in Carroll and Harford Counties. Tributary creeks and streams of the Loch Raven Reservoir Watershed include Beaverdam Run, Beetree Run, Blackrock Run, First Mine Branch, Gunpowder Falls, Little Falls, McGill Run, Piney Run, Second Mine Branch, Third Mine Branch, and Western Run.

There are approximately 792.1 miles of SHA roadway located within the Loch Raven Reservoir Watershed, associated ROW comprises approximately 1,581.0 acres, of which 825.7 acres is impervious. SHA facilities located within the watershed consist of one highway garage/shop facility, one highway office/lab facility, one salt storage facility, one weigh station, and four park and rides. See **Figure 4-40** for a map of the Loch Raven Reservoir Watershed.

N.2. SHA TMDLs within Loch Raven Reservoir Watershed

The TMDL requiring reduction by SHA pertains to bacteria (MDE, 2004). Bacteria is to be reduced by 88.0% in Baltimore County and 95% in Carroll County as shown in **Table 3-3**.

N.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-41.** Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal right-of-way along heavily residential and wooded areas, which limits the ability to purchase right-of-way for the construction of a new BMP. Additionally, some SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

134 Total Grids:

- 47 fully reviewed
- 60 partially reviewed – in progress
- 27 awaiting review (19% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 186 locations identified as possible candidates for new stormwater BMPs.
- 12 facilities undergoing concept design and may be candidates for design contracts in the near future.
- Two (2) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

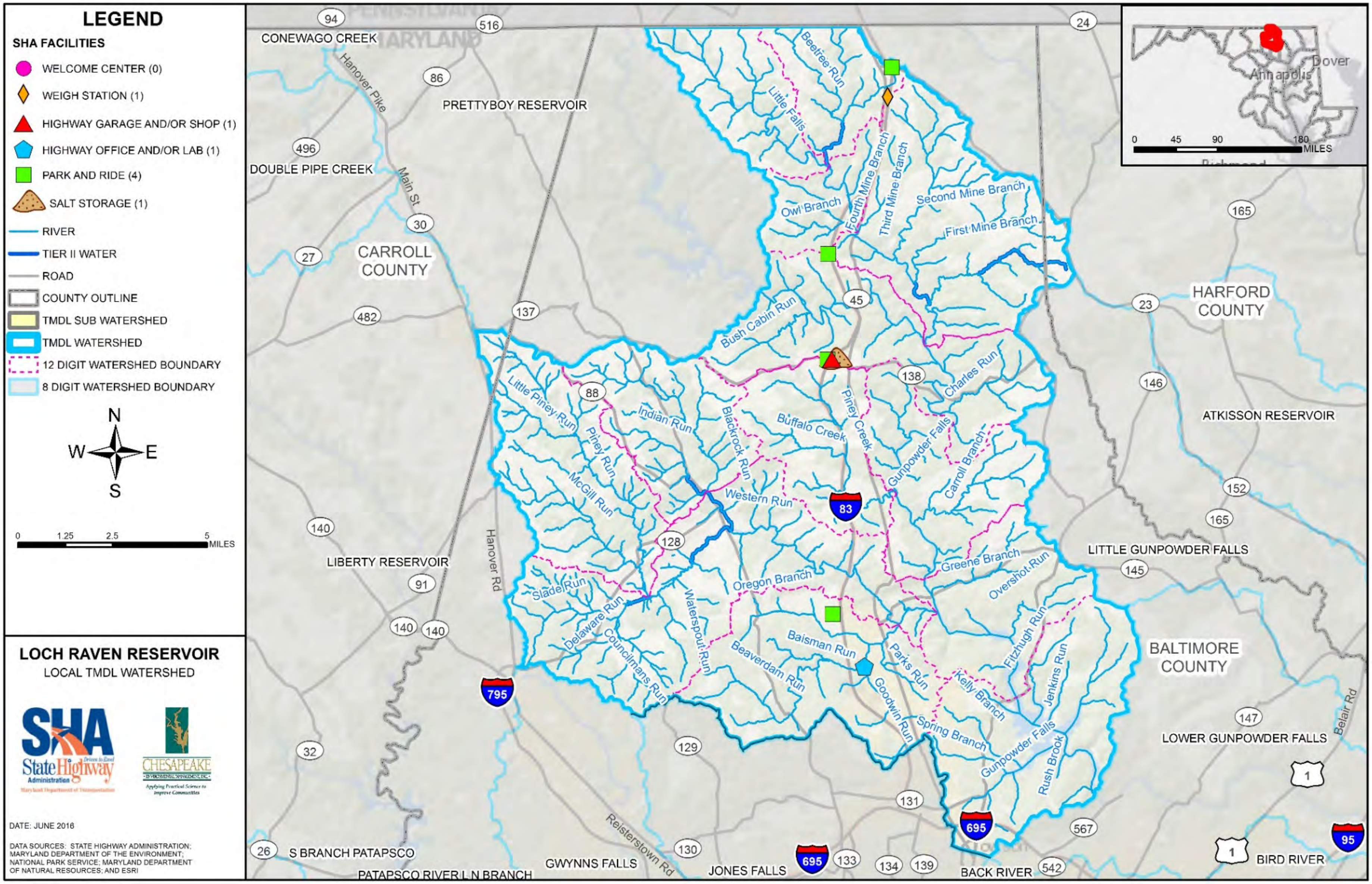

Figure 4-40: Loch Raven Reservoir Watershed

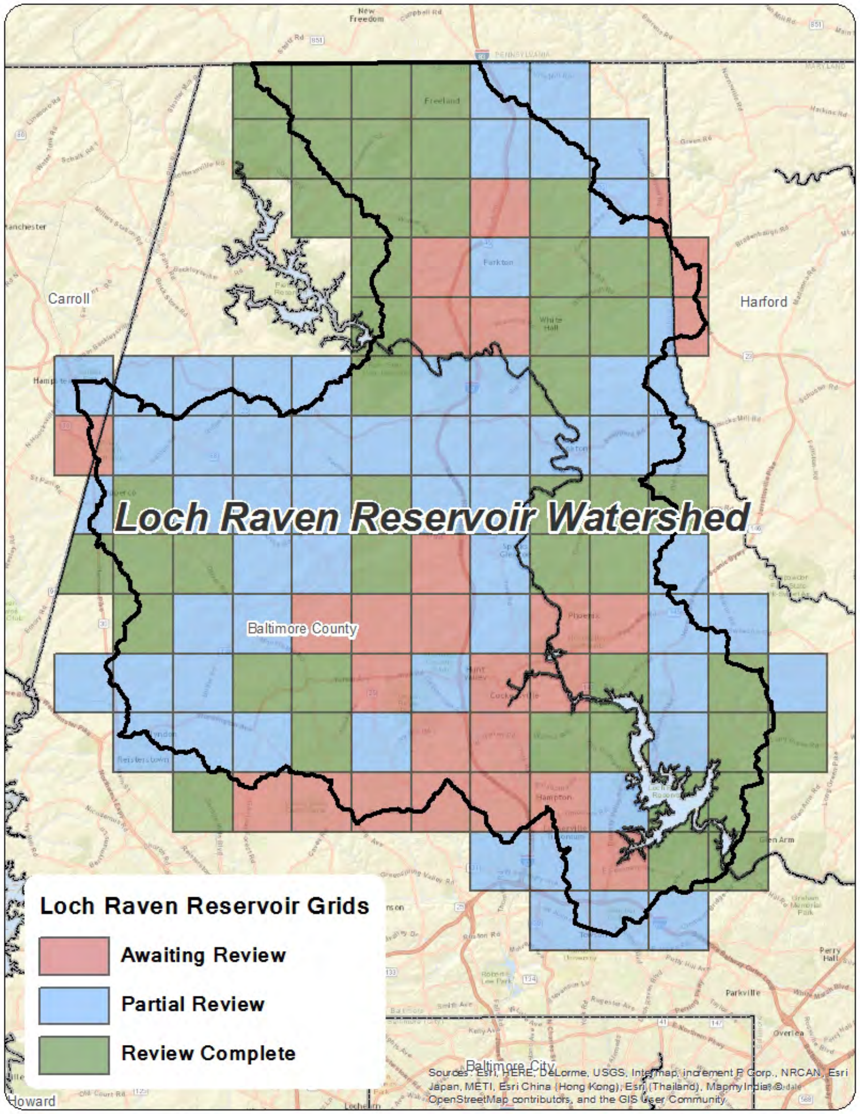

Figure 4-41: Loch Raven Reservoir Site Search Grids

The tree planting site search teams have investigated 901 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 12 acres are undergoing concept design and may be candidates for planting contracts in the near future.
- Four (4) acres of tree planting potential for further investigation.
- Some of the reasons for sites being removed from considerations include commercial locations or existing forest.

The stream restoration site search teams have investigated 38,288 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 1,753 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility

N.4. Summary of County Assessment Review

Waters within the Loch Raven Reservoir Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Arsenic;
- Cadmium;
- Chlorides;
- Chromium (total);
- Copper;
- Escherichia coli;
- Lack of Riparian Buffer;
- Lead;
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- Nickel;

- Phosphorus (Total);
- Sedimentation/siltation;
- Selenium;
- Sulfates; and
- Temperature, water.

The Baltimore County Department of Environmental Protection and Sustainability completed Small Watershed Action Plans (SWAPs) for the Loch Raven North in 2015 (PB, 2015), Beaverdam Run, Baisman Run, and Oregon Branch subwatersheds in 2011 (CWP. 2011), Loch Raven East subwatershed in 2014 (CWP, 2014), and the Spring Branch subwatershed in 2008 (BC-EPS. 2008b).

The Beaverdam Run, Baisman Run, and Oregon Branch subwatersheds (BBO) makes up approximately 6% of the drainage area to the Loch Raven Reservoir watershed. The Loch Raven East subwatershed (LRE) makes up approximately 8% of the Loch Raven Reservoir watershed drainage area. The Spring Branch subwatershed (SB) makes up less than 1% of the Loch Raven Reservoir watershed drainage area (CWP, 2011).

Impervious land cover comprises 6.5% of the BBO subwatersheds, 4.8% of the LRE subwatershed, and 18.6% of the SB subwatershed. 16.6% of the soils within the BBO subwatershed, 14.8% within the LRE subwatershed, and 25.9% of the soils within the SB subwatershed are considered highly erodible. Impervious urban, livestock, and cropland are the land uses responsible for the greatest phosphorus loads within the BBO and SB subwatersheds, while cropland and stream channel scour are responsible for the greatest sediment loads. Impervious urban, livestock, and cropland are the land uses responsible for the greatest nitrogen, phosphorus, and sediment loads within the LRE subwatershed (CWP, 2011).

The BBO SWAP identified many moderate environmental problems, and several severe problems in Beaverdam Run, Baisman Run, and Oregon Branch based on channel alterations, erosion, and fish blockages (CWP. 2011). The LRE SWAP identified eight stream areas in Dulaney Valley Branch, totaling 5,381 ft of erosion, and 34 fish barriers, 10 of which are categorized as very severe and severe. Biological assessments showed a generally unimpaired community in the BBO subwatersheds. While the majority of Benthic Index of Biotic Integrity scores in the LRE subwatersheds were Good, the majority of Fish Index of Biotic Integrity scores were Poor (CWP, 2014).

For the purposes of planning, the County has selected the following generalized restoration strategies to aid in meeting restoration goals within the Loch Raven Reservoir Watershed:

- Stormwater management for new development and redevelopment;
- Existing stormwater management facility conversions
- Stormwater management retrofits;
- Stream corridor restoration;
- Illicit connection detection and disconnection program and hotspot remediation;
- Downspout disconnection;
- Citizen awareness (bayscaping, fertilizer application, and pet waste); and
- Pervious Area Restoration (reforestation and tree planting).

The County identified numerous potential restoration sites within each subwatershed, with the exception of Spring Branch where assessments were not completed. The county also identified 13 stormwater retrofit or conversion projects, seven of which fell in the BBO subwatersheds, and the remaining six within the LRE subwatersheds. Detailed information on site locations can be found in the SWAPs. Loch Raven Reservoir Watershed restoration recommendations are shown in **Table 4-31**:

Table 4-35: Potential Stream Restoration Sites in Loch Raven Reservoir Watershed			
Reach	**Number of Sites**	**Total Linear Feet**	**Conditions**
Dulaney Valley Branch	8	5,381	Erosion and unstable channels
Fitzhugh Run	1	2,140	
Green Branch	1	26,400	
Overshot Run	1	15,840	
Beaverdam Run	6	3,637	Erosion with headcutting, downcutting, and widening
Baisman Run	1	2,606	Erosion with downcutting

N.5. Pollutant Reduction Strategies

Loch Raven Reservoir is listed for a bacteria TMDL having a baseline year of 2004. Proposed practices to meet the bacteria reduction in the Loch Raven Reservoir watershed are shown in **Table 4-36**. Projected bacteria reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-3**. Two times frames are included in the table below:

1. BMPs built after the bacteria TMDL baseline through 2025. In this case the baseline is 2004.
2. BMPs built from 2026 through 2048 the projected target date of the bacteria TMDL. SHA will accomplish the percent reduction presented in **Table 3-3**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Loch Raven Reservoir watershed total $7,801,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category.

Figure 4-42 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction.

Table 4-36: Loch Raven Reservoir Restoration Bacteria BMP Implementation					
BMP	**Unit**	**2005 - 2025**	**2026 - 2048**	**Total**	**Cost**
New Stormwater	drainage area acres	37.6	38.3	75.9	$7,527,000
Retrofit	drainage area acres	8.9		8.9	$274,000

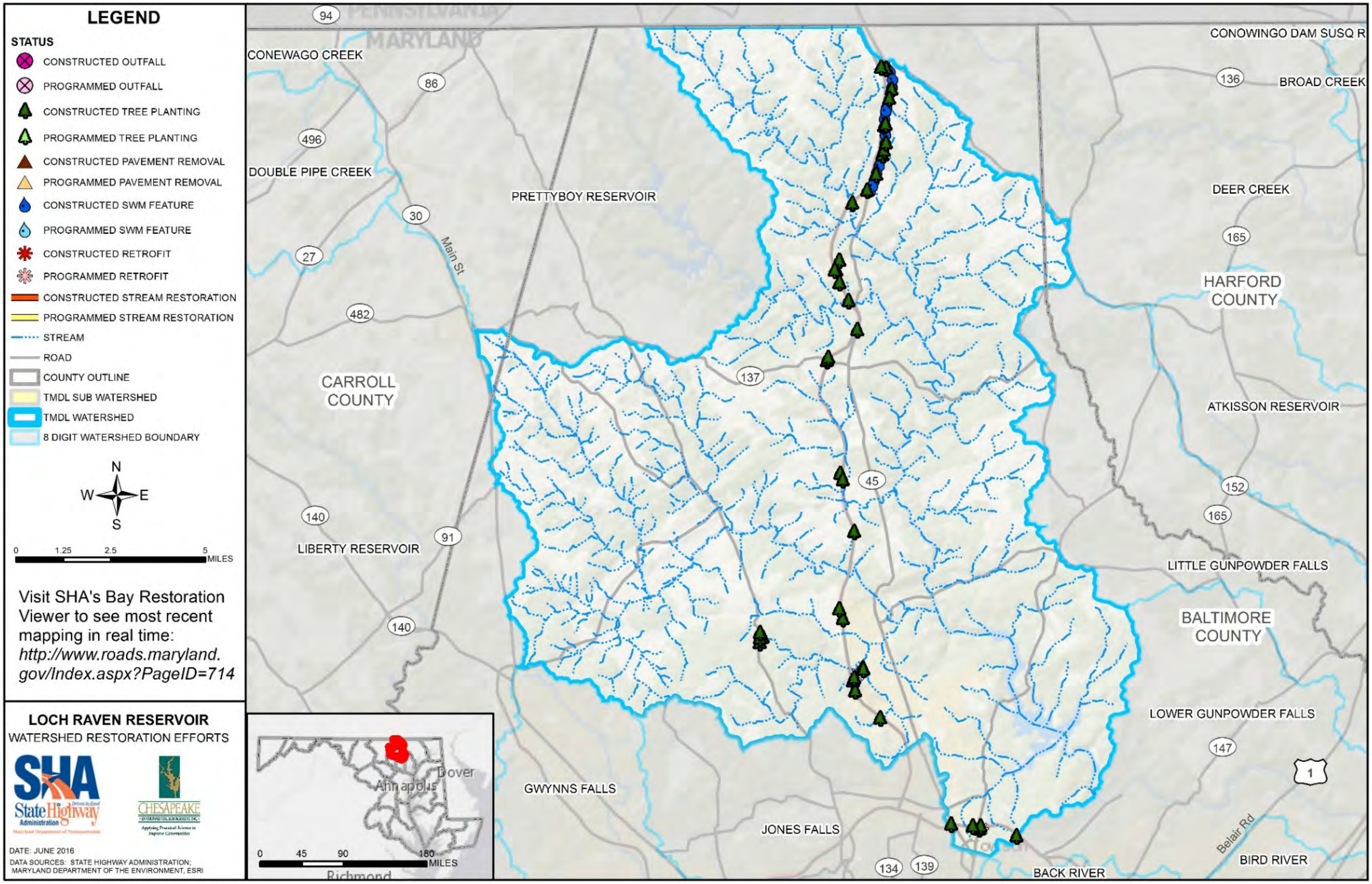

Figure 4-42: SHA Restoration Strategies within the Loch Raven Reservoir Watershed

O. LOWER MONOCACY RIVER WATERSHED

O.1. Watershed Description

The Lower Monocacy Watershed encompasses 495 square miles within primarily Frederick County and small areas of Montgomery and Carroll Counties. The Monocacy River is a stream that originates in Pennsylvania and flows through Maryland and ultimately into the Potomac River. The Lower Monocacy River flows south through Frederick, and ultimately into the Middle Potomac River near Dickerson. Tributary creeks and streams of the Lower Monocacy Watershed include Israel Creek, Carroll Creek, Linganore Creek, Bush Creek, Bennett Creek, and Ballenger Creek.

There are approximately 1,224.8 miles of SHA roadway located within the Lower Monocacy Watershed, associated ROW comprises approximately 3,562.6 acres, of which 1,886.4 acres is impervious. SHA facilities located within the watershed consist of one highway office/lab facility, two salt storage facilities, three weigh stations, and seven park and rides. See **Figure 4-43** for a map of the Lower Monocacy Watershed.

O.2. SHA TMDLs within Lower Monocacy River Watershed

TMDLs requiring reduction by SHA pertains to Phosphorus (MDE, 2009) and sediment (MDE, 2000). Phosphorus is to be reduced by 25.0% in Carrol, Frederick and Montgomery Counties and sediment is to be reduced by 60.8% in Frederick and Montgomery Counties as shown in **Table 3-2**.

O.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-44**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal ROW along residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, many SHA impervious areas within these grids are already treated by SHA NPDES BMPs. The current results of this ongoing grid search are as follows:

192 Total Grids:

- 95 fully reviewed
- 62 partially reviewed – in progress
- 35 awaiting review (12% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 953 locations identified as possible candidates for new stormwater BMPs.
- 43 facilities undergoing concept design and may be candidates for design contracts in the near future.
- Four (4) retrofit of existing facilities under current contracts.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

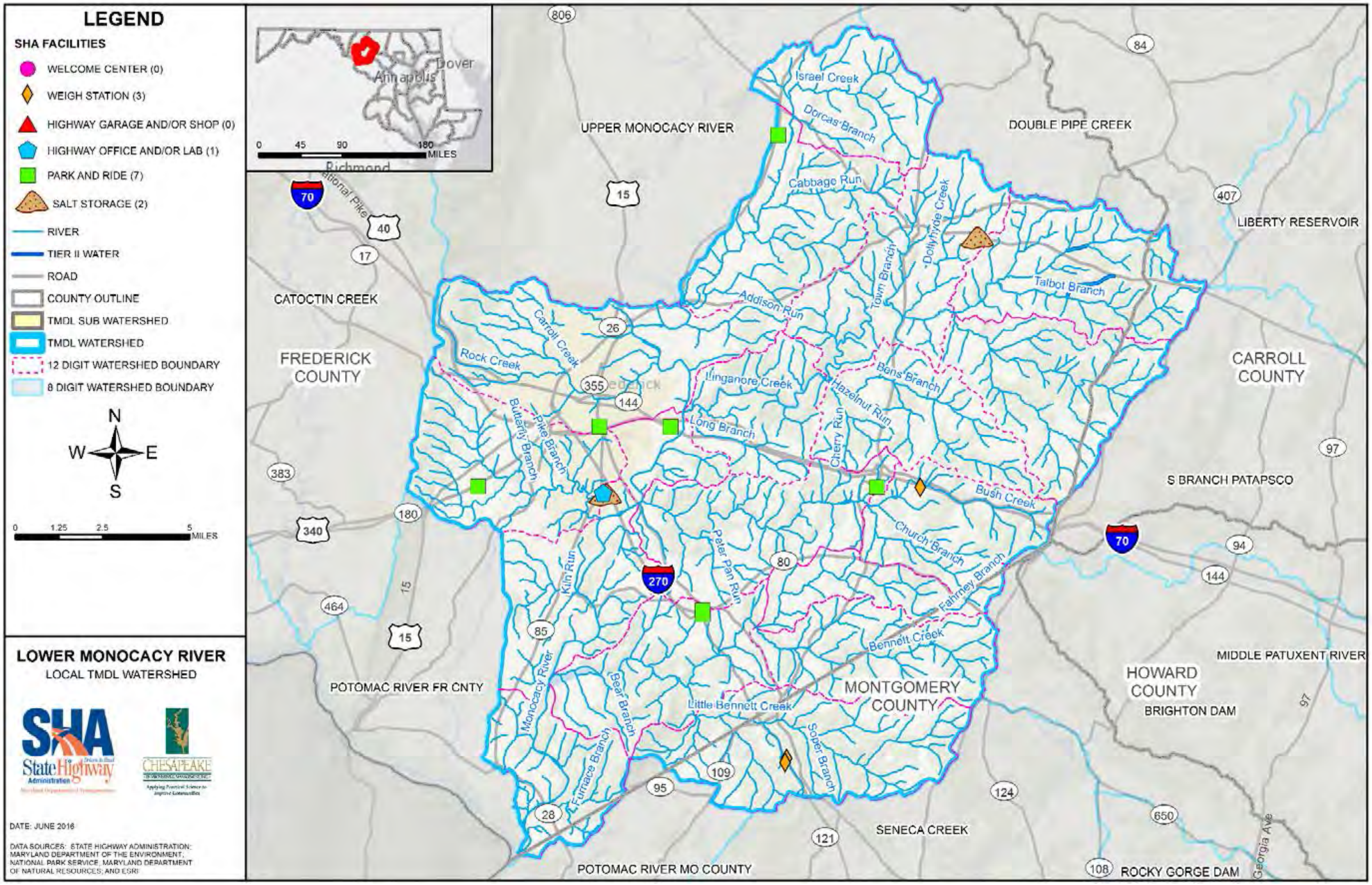

Figure 4-43: Lower Monocacy River Watershed

The tree planting site search teams have investigated 2,455 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- Eight (8) acres are undergoing concept design and may be candidates for planting contracts in the near future.
- Four (4) acres of tree planting potential for further investigation.
- Some of the reasons for sites being removed from considerations include commercial locations or existing forest.

The stream restoration site search teams have investigated 111,081 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 53,979 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

O.4. Summary of County Assessment Review

Waters within the Lower Monocacy Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- *Escherichia coli;*
- Lack of Riparian Buffer;
- PCB in Fish Tissue;
- Phosphorus (Total);
- Sedimentation/siltation;
- Temperature, water; and
- Total Suspended Solids (TSS).

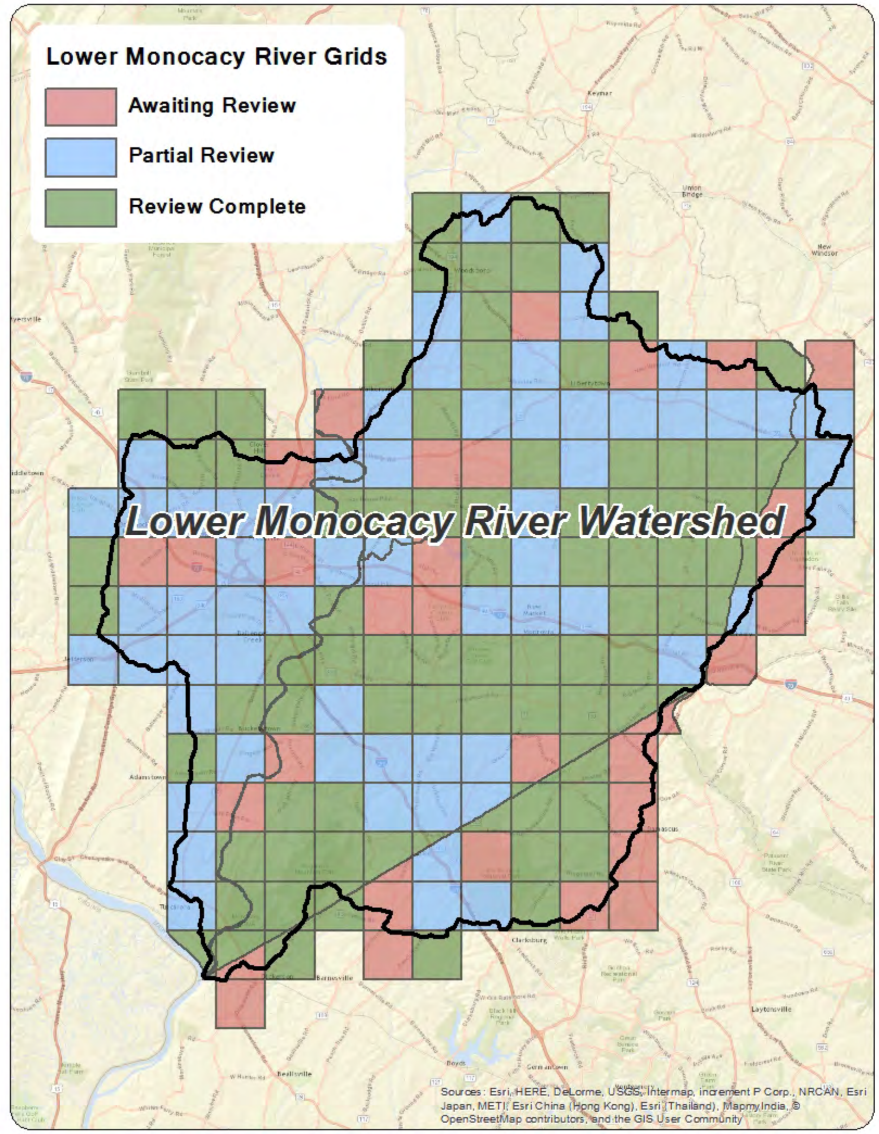

Figure 4-44: Lower Monocacy Site Search Grids

The *Lower Monocacy River Watershed Restoration Action Strategy* (WRAS), prepared by the Frederick County Division of Public Works, was adopted in May 2004 (FC-DPW, 2004). The primary focus of the strategy is the portion of the drainage within Frederick County, 87% of the total area. The Lower Monocacy River watershed is ranked as a 'Priority Category 1 and Select Category 3 Watershed' in the State's Clean Water Action Plan.

The Lower Monocacy River watershed land use consists of crops (29.4%), forest (29.4%), residential (17.5%), pasture (8.8%), commercial (5.2%), and water (0.4%). A *Stream Corridor Assessment Survey* (FC-DPW, 2004), to support the WRAS, found 247 potential environmental problem sites following a survey of 75 out of 600 miles. Issues identified included inadequate buffers, erosion, fish barriers, pipe outfalls, channel alterations, trash dumping, and exposed pipes.

The *Frederick County Stream Survey* (Versar, 2014) found the average score of streams within Frederick County was 'Poor' for benthic index of biotic integrity (IBI). The stream survey also indicated 7% scored 'Very Poor', 41% scored 'Poor', 37% scored 'Fair' and 15% scored 'Good'.

An *Assessment of Stormwater Management Retrofit and Stream Restoration Opportunities in Bennett Creek Watershed* was published in 2009 (Tetra-Tech, 2009). The assessment identified eleven potential restoration projects. Six of the potential sites are located in Fahrney sub watershed and the others are located in the Bennett Middle, Bennett Upper, Little Bennett, Pleasant, and Urbana sub watersheds.

Restorations approaches proposed across the watershed comprise primarily of county-owned properties and residential properties outside of SHA ROW. The Bennett Creek Assessment identified three potential stream restoration projects (Tetra-Tech, 2009):

- The channel downstream of the Englandtowne SWM Pond site, is experiencing bank erosion, the upstream channel is also eroding and is contributing to silt deposition within the stormwater pond. Thus reducing the effectiveness of the stormwater pond. Stream restoration is proposed upstream and downstream.
- The stream corridor at Kemptown Park is experiencing severe erosion with widening and lateral migration also occurring. It is proposed this stream is restored.
- The stream corridor is located in close proximity to the Persimmon residential area and is experiencing severe erosion, habitat degradation, a fish barrier and man-made channel alteration. It is recommended the stream corridor is restored.

O.5. SHA Pollutant Reduction Strategies

Lower Monocacy is listed for both phosphorus and sediment with each TMDL having a different baseline year; 2000 for sediment and 2009 for phosphorus. Proposed practices to meet the phosphorus and sediment reduction in the Lower Monocacy River watershed are shown in **Table 4-37**. Projected phosphorus and sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Three timeframes are included in the table below:

1. BMPs built after the sediment TMDL baseline through 2009. In this case the baseline is 2000.
2. BMPs built after the phosphorus TMDL baseline through 2025. In this case the baseline is 2009.
3. BMPs built from 2026 through 2040 the projected target date of the phosphorus TMDL. 2036 is the projected target date for the sediment TMDL. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Lower Monocacy River watershed total $64,439,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $145,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-45 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-37: Lower Monocacy River Restoration Nutrient and Sediment BMP Implementation

BMP	Unit	2001 - 2009	2010 - 2025	2026 - 2040	Total
New Stormwater	drainage area acres		113.3	184.4	297.7
Retrofit	drainage area acres		108.4		108.4
Stream Restoration	linear feet		7,507.0	1,500.0	9,007.0
Tree Planting	acres of tree planting	8.4	135.5		143.9
Outfall Stabilization[1]	linear feet			6,200.0	6,200.0
Impervious Surface Elimination	drainage area acres		3.4		3.4
Inlet Cleaning[2]	tons		158.6	151.9	151.9

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

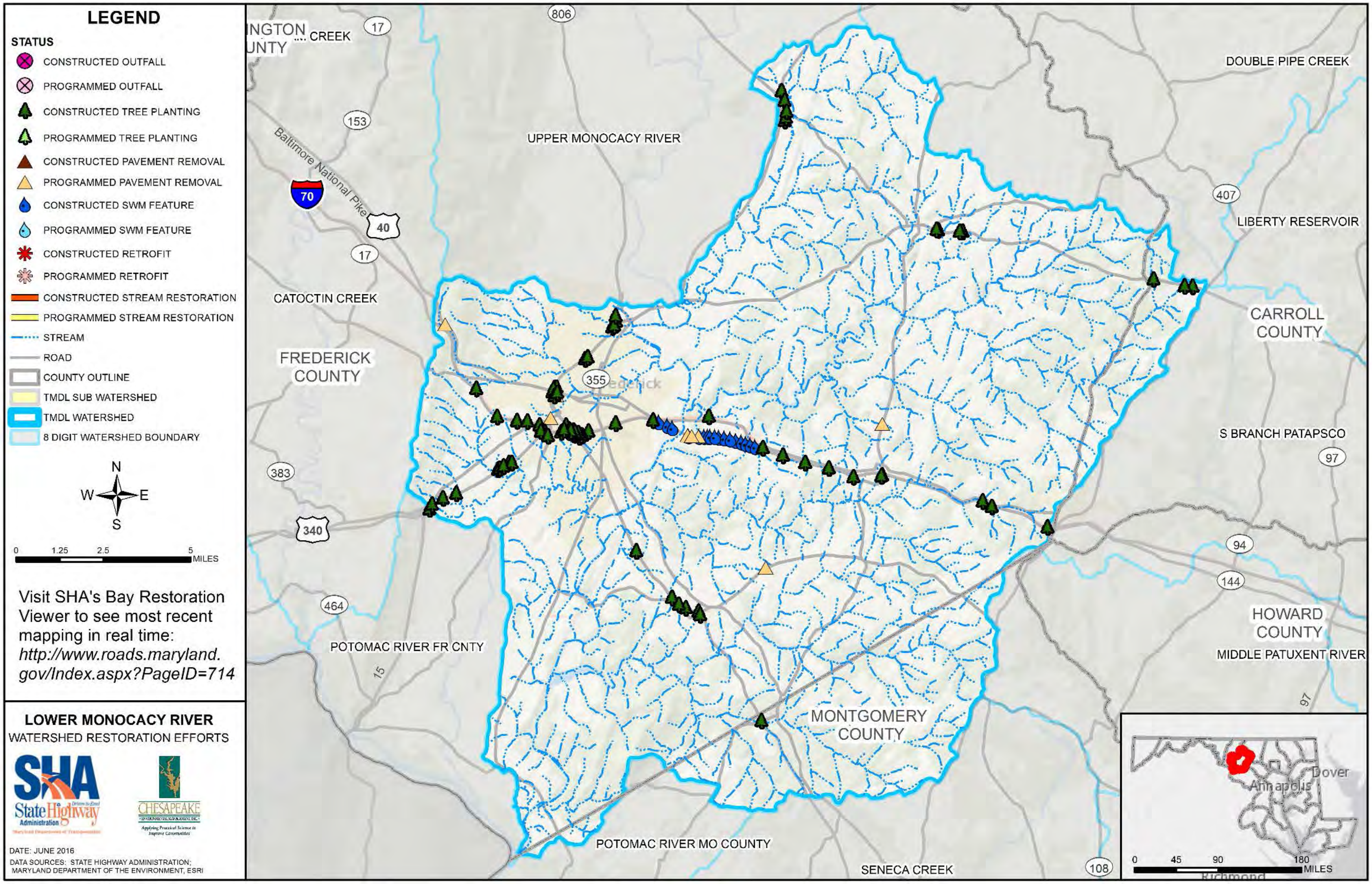

Figure 4.45: SHA Restoration Strategies within the Lower Monocacy River Watershed

P. PATAPSCO RIVER LOWER NORTH BRANCH WATERSHED

P.1. Watershed Description

The Patapsco River Lower North Branch Watershed encompasses 115 square miles across Anne Arundel County, Baltimore County, City of Baltimore, Carroll County, and Howard County. The Patapsco River originates in Carroll County and flows to the Baltimore Harbor and ultimately to the Chesapeake Bay.

There are approximately 1,019.8 miles of SHA roadway located within the Patapsco River Lower North Branch Watershed, associated ROW comprises approximately 3,799.2 acres, of which 1,693.7 acres is impervious. SHA facilities located within the watershed consist of one highway office/lab facility, one highway garage/shop, two salt storage facilities, and seven park and rides. See **Figure 4-46** for a map of the Patapsco River Lower North Branch Watershed.

P.2. SHA TMDLs within Patapsco River LNB Watershed

TMDLs requiring reduction by SHA inlcude bacteria (MDE, 2003) and sediment (MDE, 2005). Sediment is to be reduced by 18.0% in Anne Arundel, Baltimore and Howard Counties as shown in **Table 3-2**. Bacteria is to be reduced by 20.7% in Anne Arundel County, 13.0% in Baltimore County, and 13.4% in Howard County as shown in **Table 3-3.**

P.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-47**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

The grids awaiting review have little potential for additional impervious treatment due to minimal ROW along heavily residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, some SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

104 Total Grids:

- 34 fully reviewed
- 40 partially reviewed – in progress
- 30 awaiting review (21% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 258 locations identified as possible candidates for new stormwater BMPs.
- 14 facilities undergoing concept design and may be candidates for design contracts in the near future.

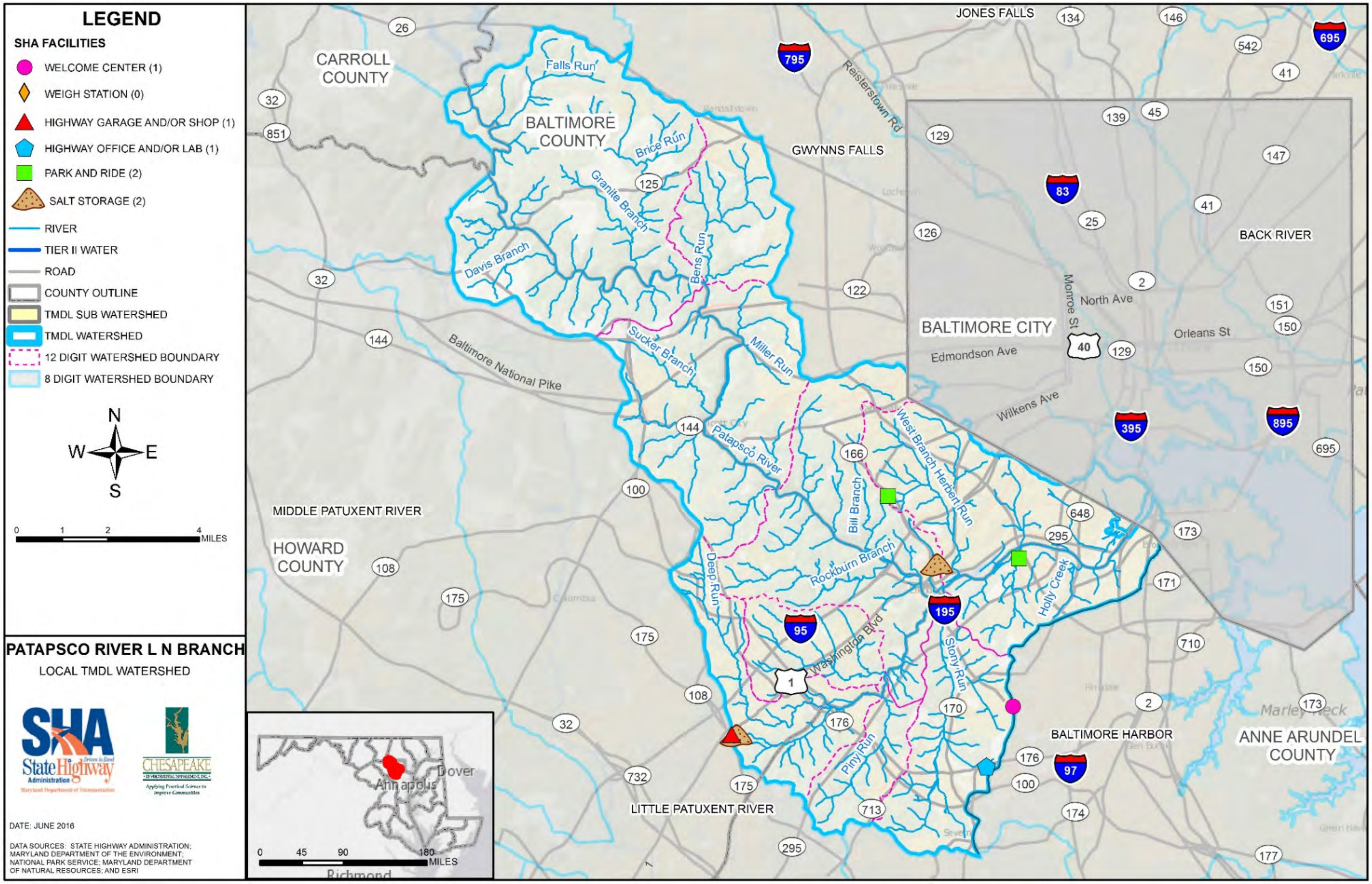

Figure 4-46: Patapsco River Lower North Branch Watershed

- Five (5) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 2,449 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 104 acres are undergoing concept design and may be candidates for planting contracts in the near future.
- 123 acres of tree planting potential for further investigation.
- Some of the reasons for sites being removed from considerations include commercial locations or existing forest.

The stream restoration site search teams have investigated 31,032 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 16,712 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

P.4. Summary of County Assessment Review

Waters within the Patapsco River Lower North Branch Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Arsenic;
- Cadmium;
- Channelization;

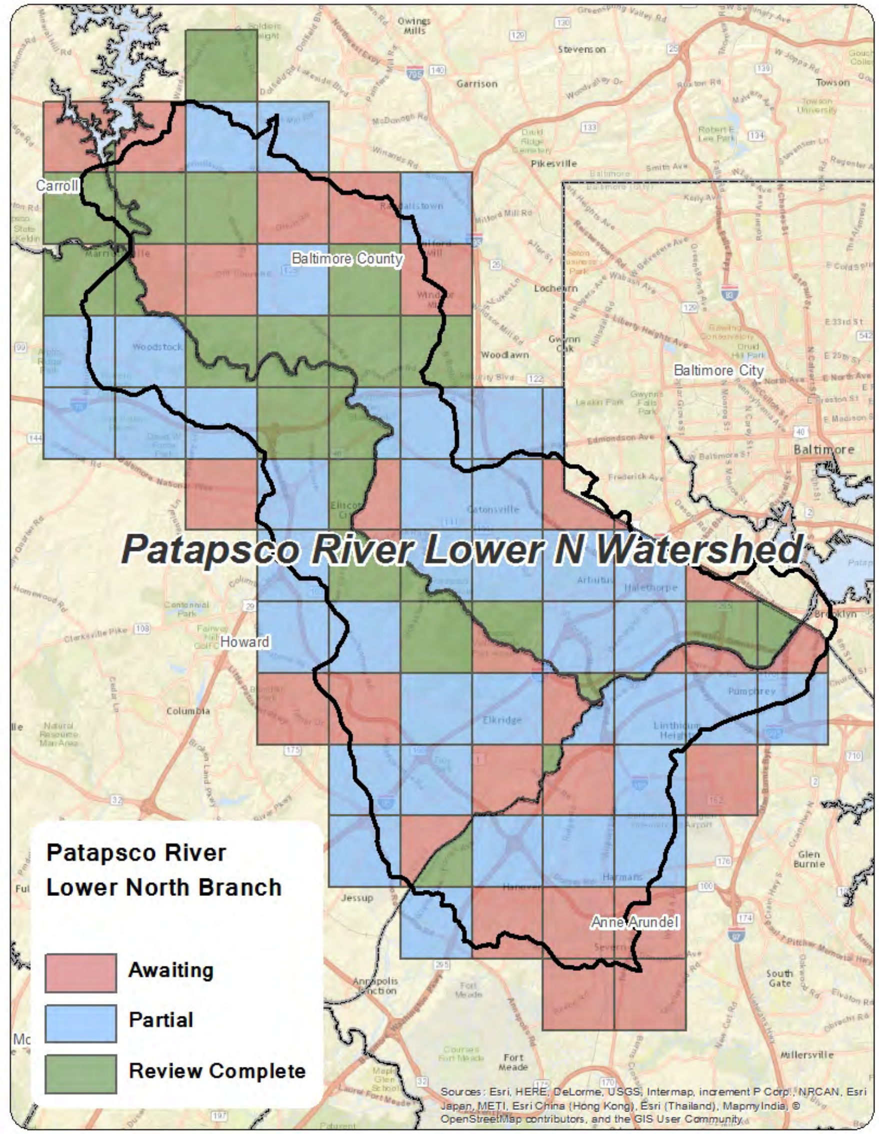

Figure 4-47: Patapsco Site Search Grids

- Chlorides;
- Chromium (total);
- Copper;
- *Escherichia coli;*
- Lead - water column;
- Lead;
- Mercury;
- Nickel;
- PCB in Fish Tissue;
- Phosphorus (Total);
- Selenium;
- Sulfates;
- Total Suspended Solids (TSS); and
- Zinc.

This summary reviews findings from the *2011 Patapsco Non-Tidal Watershed Assessment* (KCI/CH2M Hill, 2011) (Anne Arundel County Watershed Assessment & Planning Program), the *2012 Lower Patapsco River Small Watershed Action Plan* (Versar, 2012) (Baltimore County Department of Environmental Protection and Sustainability), and the *2012 Tiber-Hudson & Plumtree Branch Stream Corridor Assessment* (S&S Planning and Design, 2012) (Howard County Department of Public Works). These reports discuss specific issues that contribute to overall watershed impairments and identify high priority restoration projects. The Patapsco River Lower North Branch 8-digit watershed currently has completed TMDLs for *E. coli* and Sediment. The Patapsco River Lower North Branch also has Category 5 impairment listings for sulfates and chlorides.

The Lower Patapsco River Watershed, which is the lower portion of the Patapsco LNB Watershed that is located within Baltimore County, has 41.8% high/very highly erodible soils. Restoration assessments identified seven subwatersheds as “high” or “very high” priority for restoration. Patapsco River-A5, Herbert Run (E. Br.), and Herbert Run (W.Br.) received the highest scores and the prioritization category of “Very High.” Cooper Branch, Miller Branch, Dogwood Branch, and Cedar Branch received a priority categorization of “High.” Surveys identified Soapstone Branch as a potential reference stream for future restoration projects. 25 existing detention ponds were identified for conversion potential (Versar, 2012)

The Patapsco Non-Tidal Watershed, which is the lower portion of the Patapsco LNB Watershed that is located within Anne Arundel County, has 39.7% of the soils classified as highly erodible and 44.5% classified as potentially highly erodible. There were six subwatersheds that were given Final Habitat Scores in the “severely degraded” category: Unnamed Tributary (PN4), Patapsco Mainstem (PN5), Stoney Run 3 (PN8), Stoney Run 4 (PN9), Deep Run (PNA), and Deep Run (PNC). The Patapsco Mainstem (PN1) was identified as the subwatershed with the highest priority for restoration based on the County’s subwatershed restoration assessment. Deep Run (PNA) and the Patapsco Mainstem (PN5) were ranked as the highest priority for preservation within the watershed (KCI/CH2M Hill, 2011).

The *Tiber-Hudson & Plumtree Branch Stream Corridor Assessment* identified areas of concern in the Ellicott City watershed that were highly susceptible to erosion/flooding and recommended BMPs to improve conditions and downstream watershed health. Only the Tiber-Hudson was considered, as Plumtree Branch falls in the Little Patuxent drainage. In the Tiber-Hudson there were four severe and ten moderate erosion sites, 19 debris blockages, and seven with bank erosion from channelization (S&S Planning and Design, 2012).

Recommended BMP’s for the watershed include:

- Stormwater management
- Stormwater management conversions
- Stormwater retrofits
- Impervious cover removal
- Stream corridor restoration proposed
- Street sweeping and trash reduction
- Illicit discharge elimination
- Sanitary sewer consent decree

- Pond retrofits
- Septic system upgrades
- ESD retrofits
- Inlet cleaning

A compiled list of Lower Patapsco River priority project recommendations from the three watershed assessments are shown in **Table 4-38**:

Table 4-38: Priority Restoration Projects in the Patapsco Lower North Branch Watershed

Subwatershed	Reach	Length (ft)	Description
Dogwood Branch		6252	Two subareas with high impervious cover
Cedar Branch		13475	
Mill Branch			Trash removal/debris blockages
Patapsco River-A1		1000	
Cooper Branch	Subarea 163-03	5052	Exposed sewer line, gabions failing
Thistle Run	Subarea 149-21		
Sawmill Branch	Downstream of Frederick Rd	2800	
Sawmill Branch	Tributary south of Park Grove Ave	2100	
Santee Branch			Downcutting, sediment deposits
Bull Branch		8225	Severe channel erosion in upper 4000 ft
Patapsco River-A4	Subarea 149-36	5103	
Herbert Run	West Branch subarea 173-08; subarea 173-06	4940; 2825	Gabion failing, erosion, sewer line overflows, eroded sewer lines
Herbert Run	East Branch	850	Exposed sewer lines, significant erosion
Patapsco River-A5	Subareas 149-41, 149-48, 149-49, and 149-51		
Deep Run	PNC022	888	Potential for emergency road crossing impairment
Deep Run	PNC040	673	Poor habitat, buffer impairments

Table 4-38: Priority Restoration Projects in the Patapsco Lower North Branch Watershed

Subwatershed	Reach	Length (ft)	Description
Deep Run	PNC006	1526	Incised, buffer impacts
Stoney Run 3	PNC8012	6231	Exposed sewer main, previously breached
Stoney Run 4	PN9059	2045	Incised
Deep Run	PNC003	1010	Headcuts
Deep Run	PNC025		
Deep Run	PNA001		
Deep Run	PNC065		
Stoney Run 3	PN8014	867	Headcuts, infrastructure impacts
Patapsco Mainstem	PN1012	3100	Restore piped segment to functioning habitat
Stoney Run 4	PN9037	1094	Incised

P.5.SHA Pollutant Reduction Strategies

Patapsco River Lower North Branch is listed for both bacteria and sediment with each TMDL having a different baseline year; 2003 for bacteria and 2005 for sediment. Proposed practices to meet the bacteria and sediment reductions in the Patapsco River Lower North Branch watershed are shown in **Table 4-39**. Projected bacteria and sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-3** and **Table 3-2**, respectively. Three times frames are included in the table below:

1. BMPs built after the bacteria TMDL baseline through 2005. In this case the baseline is 2003. Stream restoration, tree planting, outfall stabilization, inlet cleaning, and impervious surface reduction were not including in the bacteria load reduction modeling.
2. BMPs built after the sediment TMDL baseline through 2025. In this case the baseline is 2005.
3. BMPs built from 2026 through 2046 the projected target date of the bacteria TMDL. 2041 is the projected target date for the sediment TMDL. SHA will accomplish the percent reduction presented in **Table 3-3** and **Table3-2**, respectively. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Patapsco Lower North Branch watershed total $36,908,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $209,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-48 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map. .

Table 4-39: Patapsco River Lower North Branch Restoration BMP Implementation

BMP	Unit	2004-2005	2006 - 2025	2026 - 2046	Total	Cost
New Stormwater	drainage area acres		59.2	64.3	123.5	$14,480,000
Retrofit	drainage area acres		171.6		171.6	$6,268,000
Stream Restoration	linear feet		525.0		525.0	$389,000
Tree Planting	acres planted		201.6	20.5	222.1	$7,468,000
Outfall Stabilization[1]	linear feet			3,800.0	3,800.0	$8,288,000
Impervious Surface Elimination	acres removed		0.1		0.1	$15,000
Inlet Cleaning[2]	tons		241.4	218.5	218.5	$209,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

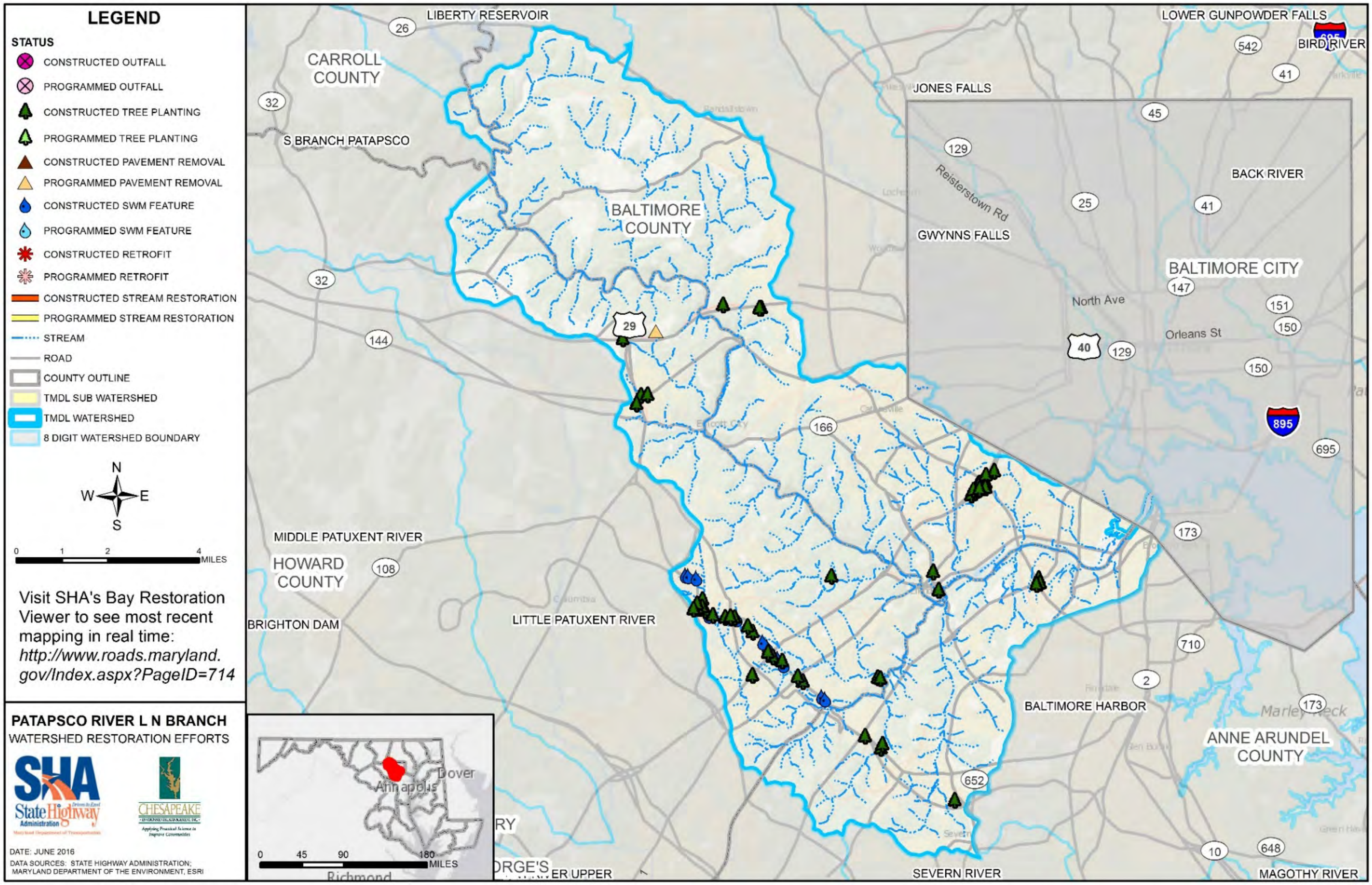

Figure 4-48: SHA Restoration Strategies within the Patapsco River Lower North Branch Watershed

Q. PATUXENT RIVER UPPER WATERSHED

Q.1. Watershed Description

The Patuxent River Upper Watershed encompasses 88 square miles across primarily west Anne Arundel and northeast Prince George's Counties, in addition to small areas in Montgomery and Howard Counties. The watershed begins in Howard County to the north and flows south ultimately draining to the Chesapeake Bay.

There are approximately 556.5 miles of SHA roadway located within the Patuxent River Upper Watershed, associated ROW comprises approximately 1,801.9 acres, of which 784.5 acres is impervious. SHA facilities located within the watershed consist of one highway garage/shop, one salt storage facility, and one park and ride. See **Figure 4-49** for a map of the Patuxent River Upper Watershed.

Q.2. SHA TMDLs within Patuxent River Upper Watershed

TMDLs requiring reduction by SHA pertains to bacteria (MDE, 2009) and sediment (MDE, 2005). Sediment is to be reduced by 11.4% in Anne Arundel, Prince George's and Howard Counties as shown in **Table 3-2**. Bacteria is to be reduced by 22.3% in Anne Arundel County, and 53.4% in Prince George's County as shown in **Table 3-3**.

Q.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5 mile square system as shown in **Figure 4-50.** Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal right-of-way along heavily residential and wooded areas, which limits the ability to purchase right-of-way for the construction of a new BMP. Additionally, some SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

89 Total Grids:

- 32 fully reviewed
- 19 partially reviewed – in progress
- 38 awaiting review (28% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 153 locations identified as possible candidates for new stormwater BMPs.
- One (1) facility undergoing concept design and may be candidates for design contracts in the near future.

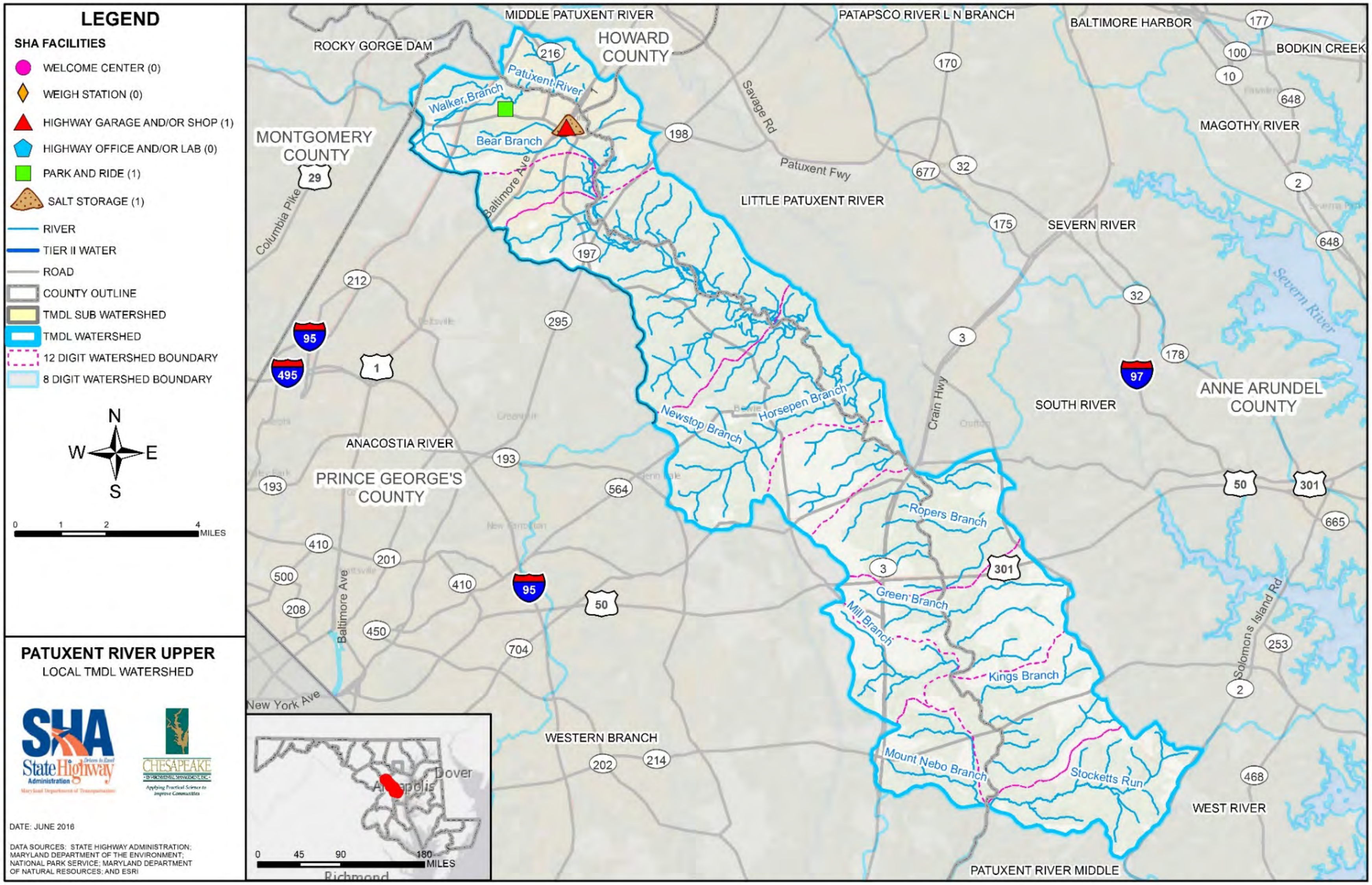

Figure 4-49: Patuxent River Upper Watershed

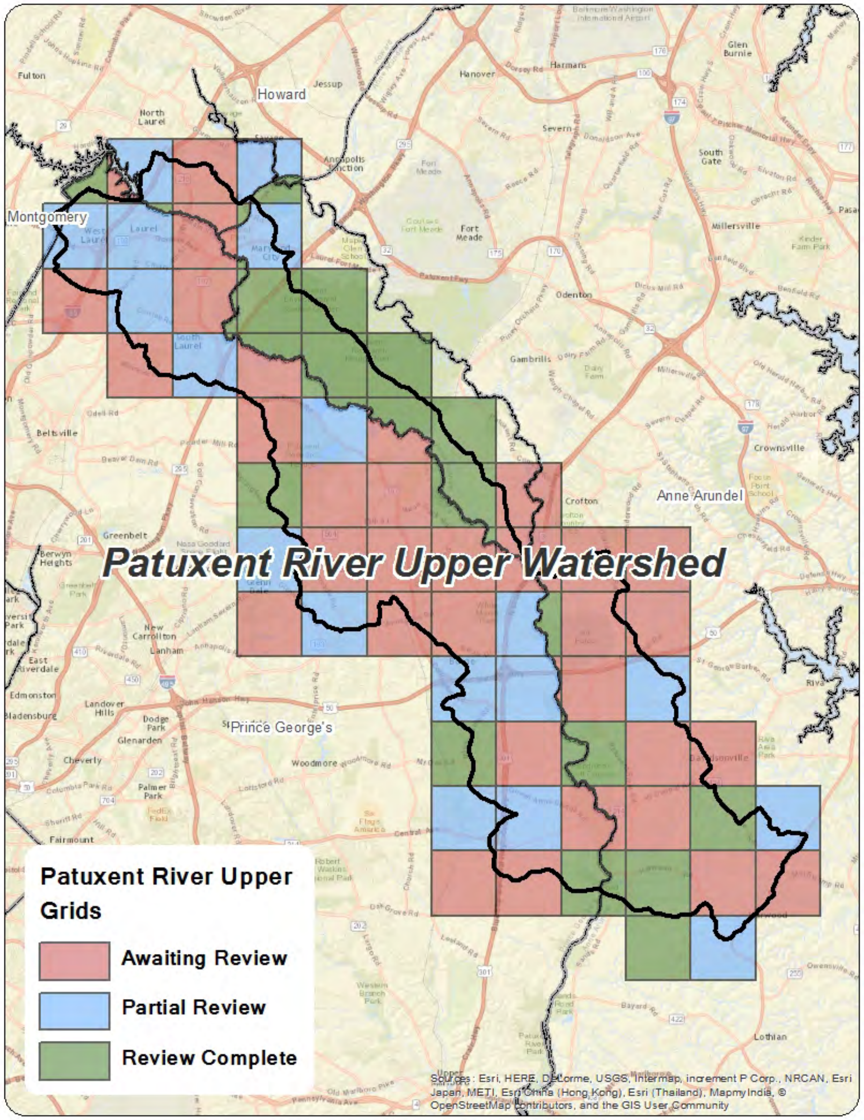

Figure 4-50: Patuxent Site Search Grids

- Two (2) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 1,027 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 7 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 63,074 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 29,066 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

Q.4. Summary of County Assessment Review

Waters within the Upper Patuxent Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Chlorides;
- *Escherichia coli;*
- Mercury in Fish Tissue;
- Nitrogen (Total);
- PCB in Fish Tissue;
- Phosphorous (Total), only for the Rocky Gorge Reservoir portion (MDE 2008);
- Sulfates; and
- Total Suspended Solids (TSS).

Prince George's County Department of the Environment prepared a *Watershed Existing Condition Report for the Upper Patuxent* (Tetra-Tech, 2014) and a *Restoration Plan for the Upper Patuxent River and Rocky Gorge Reservoir Watersheds in Prince George's County* (Tetra-Tech, 2015). The phosphorus in Rocky Gorge Reservoir, which is approximately 55 square miles in size, can be associated with non-point sources and urban runoff. In the Upper Patuxent River watershed, the problem with fecal coliform bacteria is attributed to wildlife and domestic animals, land surfaces, humans via septic and sewer systems, regulated storm water, and sanitary sewer overflow (SSO), which may also affect the watershed.

Total suspended solid issues in the Upper Patuxent watershed can be attributed to agricultural and urban land uses and stream bank erosion from increased storm water sources. Western Branch has a problem with BOD, which can be an indicator of organic pollution. There is also a problem with lower dissolved oxygen (DO) in Western Branch and its 15 subwatersheds associated with discharge streams near waste water treatment plants and storm water runoff, agriculture feed lots, septic systems and natural debris. Within the Upper Patuxent River, Laurel and Bowie have the largest volumes of runoff, which are generated due to higher percent of impervious cover[1]. In the lower portions of the Upper Patuxent River and Western Branch the land use is primarily forest and agriculture, which shows areas of higher nutrient loads (Tetra-Tech, 2014).

An evaluation of each subwatershed in the Upper Patuxent River watershed was performed to aid in the selection of BMPs in the areas with the highest required pollutant loading reductions. The County prioritized the subwatersheds by ranking the necessary total load reduction for each TMDL parameter and then averaging the individual ranks to obtain an overall rank for the subwatershed. The highest ranked watersheds tended to be in areas with the largest amount of impervious cover. Subwatersheds PX-28, PX30, and PX-34 are among the highly ranked watersheds. These subwatersheds encompass the cities of Laurel and South Laurel in the upper portion of the Upper Patuxent River watersheds. Subwatersheds PX-12, PX-13, PX-14, and PX-17 are also highly ranked, with PX-13 emerging as the highest ranked subwatershed as a whole. These subwatersheds encompass the city of Glenn Dale just in the fringes of the city of Bowie. These areas are dominated by commercial and residential areas with some minor institutional areas that could be used for BMP implementation in the future (Tetra-Tech, 2015).

Storm water ponds are the most implemented BMP, which usually treat residential and non-urban areas, they treat larger areas, but with less efficiency removing pollution. Infiltration practices are the second most implemented storm water control, they treat smaller areas but remove pollution with greater efficiency. The oil and grit separators are known for treating more area, but have lower removal efficiencies than infiltration practices. The Upper Patuxent River currently has no bio-retention, infiltration, oil/grit separators, and ponds in use. Western Branch has bio-retention, grass swales, infiltration, oil/grit separators and ponds (Tetra-Tech, 2014).

There were three sites mentioned in the watershed assessment report regarding benthic invertebrate and B-IBI sampling within the Upper Patuxent River and Western Branch watersheds; these sites are (Tetra-Tech, 2014):

- Horsepen Branch – in 2013, four sites were sampled, three yielding a poor score and one receiving a fair rating. The estimated number of biologically degraded stream miles increased from 33 percent to 75 percent.
- Southwest Branch – a total of 7 streams were sampled – 6 first order and one second order. One was rated very poor, three poor and the remaining as fair. The number of biologically degraded stream miles decreased from 100 percent to 57 percent.
- Collington Branch - a total of 12 streams were sampled. One was rated very poor, three sites poor, seven as fair and one as

good. The stream miles classified as biologically impaired went from 58 percent to 33 percent.

As a whole, structural and nonstructural BMPs have been implemented by the county including permit compliance, TMDL WLAs, flood mitigation and more. Prince George's County has also engaged in street sweeping, public outreach to promote environmental awareness, green initiatives and community involvement in protecting natural resources. Past public outreaches conducted include educational brochures on storm water pollution awareness, outreach in schools, *Can the grease* program to decrease SSO's and recycling programs (Tetra-Tech, 2014).

Q.5. SHA Pollutant Reduction Strategies

Patuxent River Upper is listed for both sediment and bacteria with each TMDL having a different baseline year; 2005 for sediment and 2009 for bacteria. Proposed practices to meet the sediment and bacteria reductions in the Patuxent River Upper watershed are shown in **Table 4-40**. Projected sediment and bacteria reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2** and **Table 3-3**, respectively. Three times frames are included in the table below:

1. BMPs built after the sediment TMDL baseline through 2009. In this case the baseline is 2005.
2. BMPs built after the bacteria TMDL baseline through 2025. In this case the baseline is 2009. Stream restoration, tree planting, outfall stabilization, inlet cleaning, and impervious surface reduction were not included in bacteria load reduction modeling.
3. BMPs built from 2026 through 2048 the projected target date of the bacteria TMDL. 2040 is the projected target date for the sediment TMDL. SHA will accomplish the percent reduction presented in **Table 3-3** and **Table3-2**, respectively. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Patuxent River Upper watershed total $10,519,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $91,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-51 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-40: Patuxent River Upper Restoration Sediment and Bacteria BMP Implementation

BMP	Unit	2006 - 2009	2010 - 2025	2026 - 2048	Total	Cost
New Stormwater	drainage area acres		4.0	37.1	41.1	$5,137,000
Retrofit	drainage area acres		6.4		6.4	$212,000
Stream Restoration	linear feet			900.0	900.0	$660,000
Tree Planting	acres of planting	1.1	16.2		17.3	$584,000
Outfall Stabilization[1]	linear feet			1,800.0	1,800.0	$3,926,000
Inlet Cleaning[2]	tons		65.6	94.9	94.9	$91,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

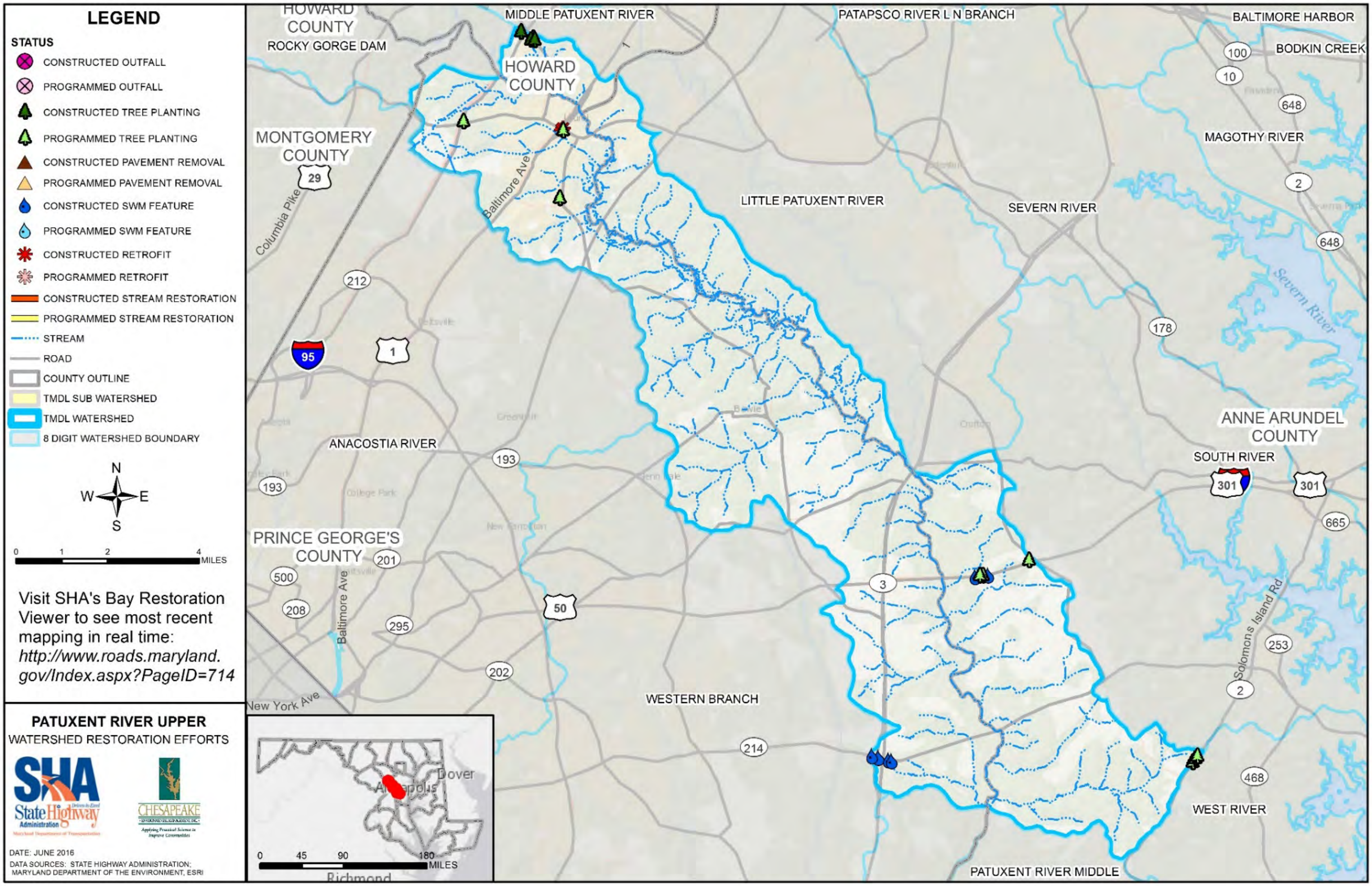

Figure 4-51: SHA Restoration Strategies within the Upper Patuxent River Watershed

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R. POTOMAC RIVER (MONTGOMERY COUNTY) WATERSHED

R.1. Watershed Description

The Potomac River Montgomery County Watershed encompasses 137 square miles within Montgomery and Frederick Counties, Maryland and Washington, D.C. The Montgomery County section of the Potomac River flows 39 miles from the Frederick County border down to Washington, D.C. Tributary creeks and streams of the Potomac River Montgomery County Watershed include Broad Run, Cabin Branch, Greenbrier Branch, Horsepen Branch, Little Falls Branch, Little Monocacy River, Muddy Branch, Piney Branch, Rocks Run, Sandy Branch, and Watts Branch.

There are approximately 760.6 miles of SHA roadway located within the Potomac River Montgomery County Watershed, associated ROW comprises approximately 1,282.4 acres, of which 1,203.1 acres is impervious. There are no SHA facilities located within the Potomac River Montgomery County Watershed. See **Figure 4-52** for a map of the Potomac River Watershed in Montgomery County.

R.2. SHA TMDLs within Potomac River (Montgomery County) Watershed

The TMDL requiring reduction by SHA is sediment (MDE, 2005), which is to be reduced by 36.2% within Montgomery County as shown in **Table 3-2**.

R.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-53**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

The grids awaiting review have little potential for additional impervious treatment due to minimal ROW along heavily residential and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, some SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

98 Total Grids:

- 46 fully reviewed
- 31 partially reviewed – in progress
- 21 awaiting review (21% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 78 locations identified as possible candidates for new stormwater BMPs.
- Six (6) facilities undergoing concept design and may be candidates for design contracts in the near future.
- Three (3) retrofit of existing stormwater facilities undergoing concept design and may be candidates for design contracts in the near future.

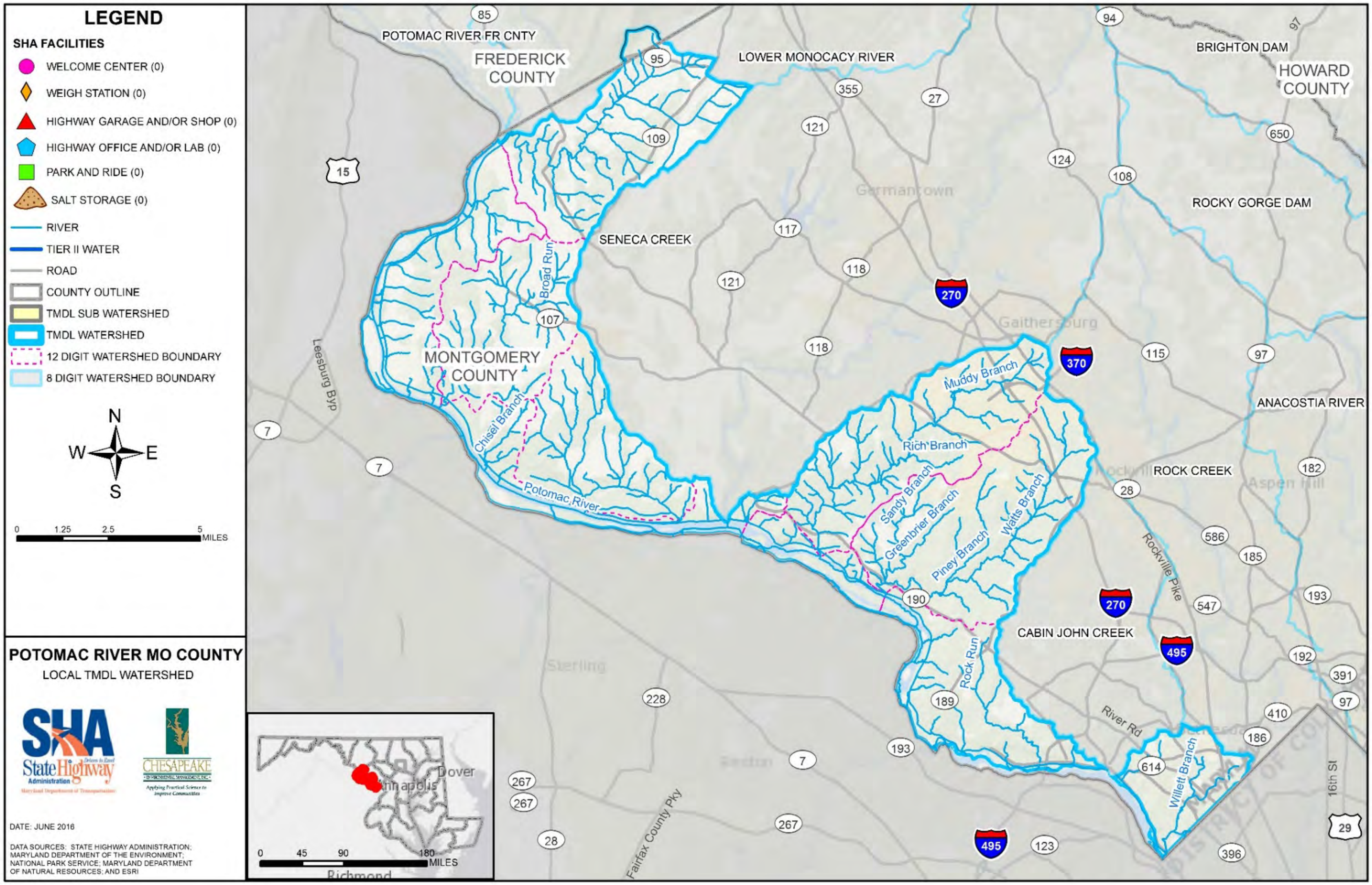

Figure 4-52: Potomac River Watershed in Montgomery County

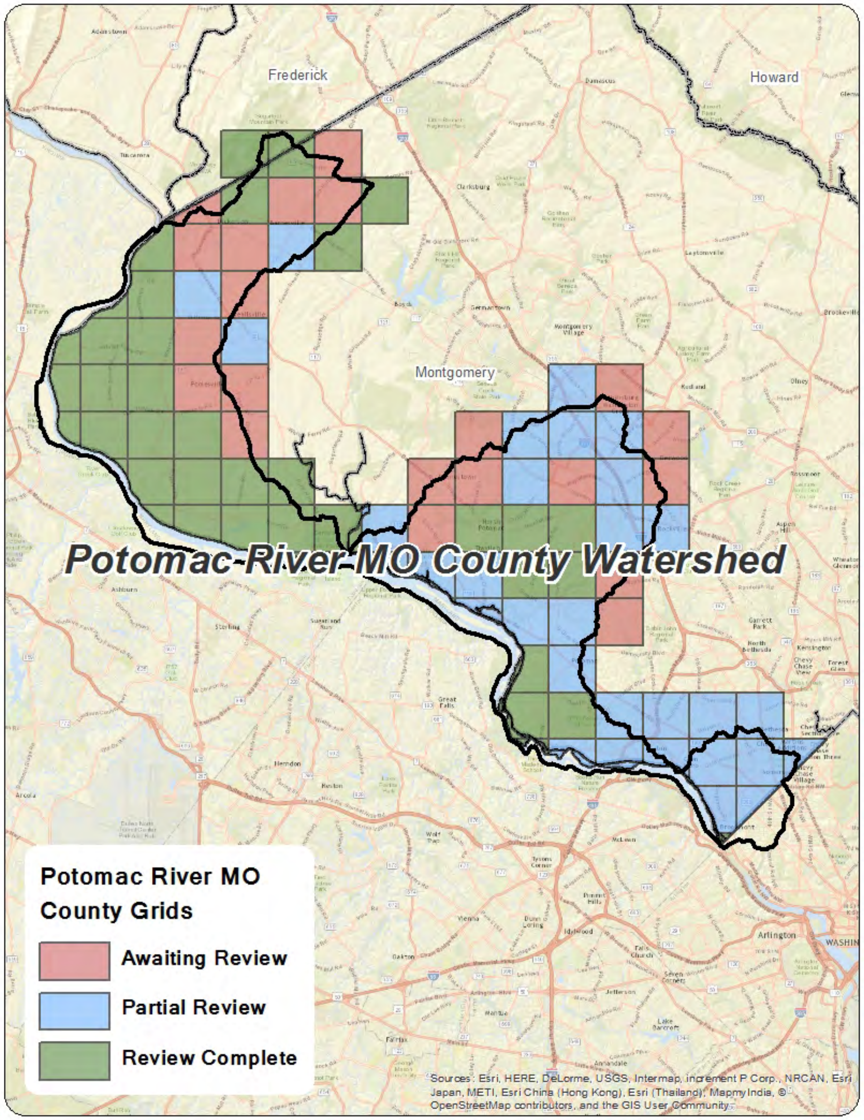

Figure 4-53: Potomac Montgomery Site Search Grids

- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting sites search has explored 722 acres of SHA-owned pervious area. The site search has resulted in a pool of potential sites comprised of the following:

- Four (4) acres are undergoing concept design and may be candidates for planting contracts in the near future.
- Seven (7) acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 50,452 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 22,325 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

R.4. Summary of County Assessment Review

Waters within the Potomac River Montgomery County Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Chlorides;
- Fecal Coliform;
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- pH, High;
- Phosphorus (Total);
- Sulfates; and
- Total Suspended Solids (TSS).

In 2011 and 2012, Montgomery County Department of Environmental Protection (MC-DEP) published the *Muddy Branch and Watts Branch Subwatersheds Implementation Plan* (HWG, 2012a) the *Upper Potomac Direct Watershed Pre-Assessment* Report (Versar, 2011b), and the *Lower Potomac Direct Watershed Pre-Assessment Report* (Versar, 2011c). MC-DEP also published the *Watts Branch Watershed Restoration Study* (AMT, 2003). The City of Gaithersburg published the *Muddy Branch Watershed Study* (URS, 2014).

The Potomac River Montgomery County watershed comprises primarily urban land use, covering approximately 42% of the watershed (7% of which is impervious). Forested land comprises approximately 38% and agricultural comprises approximately 20%. Within the Muddy Branch and the Watts Branch subwatersheds the majority of the stream resource conditions were assessed as 'Fair' (75%) and were 25% assessed as 'Good' (HWG, 2014a). Within the Lower Potomac the majority of stream resource conditions were assessed as 'Fair' or 'Poor', with only one site in the Rock Run subwatershed rated 'Good (Versar, 2011c). Within the Upper Potomac the majority of stream resource conditions were assessed as 'Good' or 'Fair' with only one site in the Broad Run watershed rated as 'Poor (Versar, 2011b).

The *Upper* and *Lower Potomac Direct Pre-Assessment Reports* identified priorities for stormwater BMP retrofits. These include areas treated by pre-1986 permitted stormwater management facilities as high priority. Medium and lower priority sites did not include any SHA ROW, and focused on county-owned and privately-owned sites (Versar, 2011b and c).

The *Muddy Branch Watershed Study* identified four proposed stream restoration projects (URS, 2014):

- M2 Stream Reach: Future Park City, experiencing widespread bank erosion, debris jams, sediment deposition and poor aquatic habitat. Proposed measures include grade control, rock toe protection, root wads, and a deflector.
- T3.1 Stream Reach: Quince Orchard Park, experiencing active lateral headcuts, poor aquatic habitat, and lateral channel migration. Proposed measures include grade control and rock toe protection.
- T4.1 Stream Reach: Brighton Village, experiencing widespread bank erosion, unstable banks, falling trees. Proposed measures include grade control and rock toe protection.
- T5.2a Stream Reach: I-370 Outfall, experiencing unstable banks and streambed, and poor aquatic habitat.

R.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reductions in the Potomac River MO County watershed is shown in **Table 4-41**. Projected sediment reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2006.
2. BMPs built between 2026 through 2040 the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Seneca Creek watershed total $15,810,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $175,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-54 shows a map of SHA's restoration practices in the watershed and include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-41: Potomac River Montgomery County Restoration Sediment BMP Implementation

BMP	Unit	2006 - 2025	2026 - 2040	Total	Cost
New Stormwater	drainage area acres	29.4	15.7	45.1	$5,273,000
Retrofit	drainage area acres	98.8		98.8	$3,084,000
Stream Restoration	linear feet		1,600.0	1,600.0	$1,173,000
Tree Planting	acres of planting	1.1 58.2	11.9	70.1	$2,354,000
Outfall Stabilization[1]	linear feet		1,800.0	1,800.0	$3,926,000
Inlet Cleaning[2]	tons	142.3	183.0	183.0	$175,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

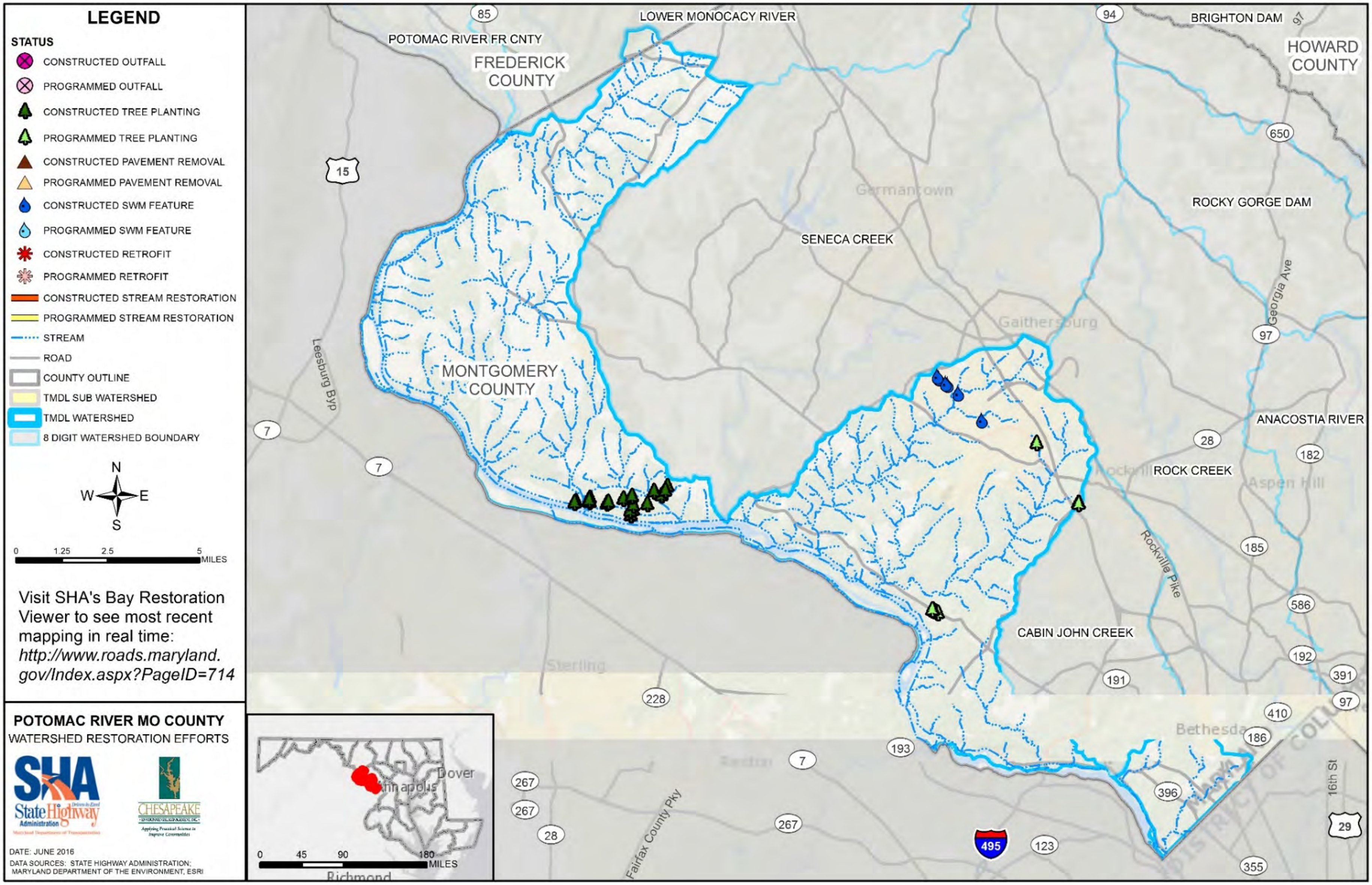

Figure 4-54: SHA Restoration Strategies within the Potomac River Watershed in Montgomery County

S. ROCK CREEK WATERSHED

S.1. Watershed Description

The Rock Creek Watershed encompasses 61 square miles across Montgomery County, Maryland and Washington, D.C. Rock Creek headwaters are located in the Laytonsville area from which the river flows south to Washington, D.C where it empties into the Potomac River. Tributary creeks and streams of the Rock Creek Watershed include Alexandra Aqueduct, Crabbs Creek, Mill Creek, and North Branch Rock Creek.

There are approximately 801.0 miles of SHA roadway located within the Rock Creek Watershed, the associated ROW encompasses approximately 1,358.1 acres, of which 832.8 acres is impervious. SHA facilities located within the Rock Creek Watershed consist of one salt storage facility, and one highway garage/shop facility. See **Figure 4-55** for a map of the Rock Creek Watershed.

S.2. SHA TMDLs within Rock Creek Watershed

TMDLs requiring reduction by SHA include phosphorus (MDE, 2009) and sediment (MDE, 2005). Phosphorus is to be reduced by 32% and sediment is to be reduced by 37.9% as shown in **Table 3-2**.

S.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5 mile square system as shown in **Figure 4-56**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

The grids awaiting review have little potential for additional impervious treatment due to minimal right-of-way along heavily residential and wooded areas, which limits the ability to purchase right-of-way for the construction of a new BMP. Additionally, some SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

47 Total Grids:

- Two (2) fully reviewed
- 25 partially reviewed – in progress
- 20 awaiting review (36% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 61 locations identified as possible candidates for new stormwater BMPs.
- Three (3) facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

The tree planting site search teams have investigated 570 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- Four (4) acres of tree planting potential for further investigation. ’

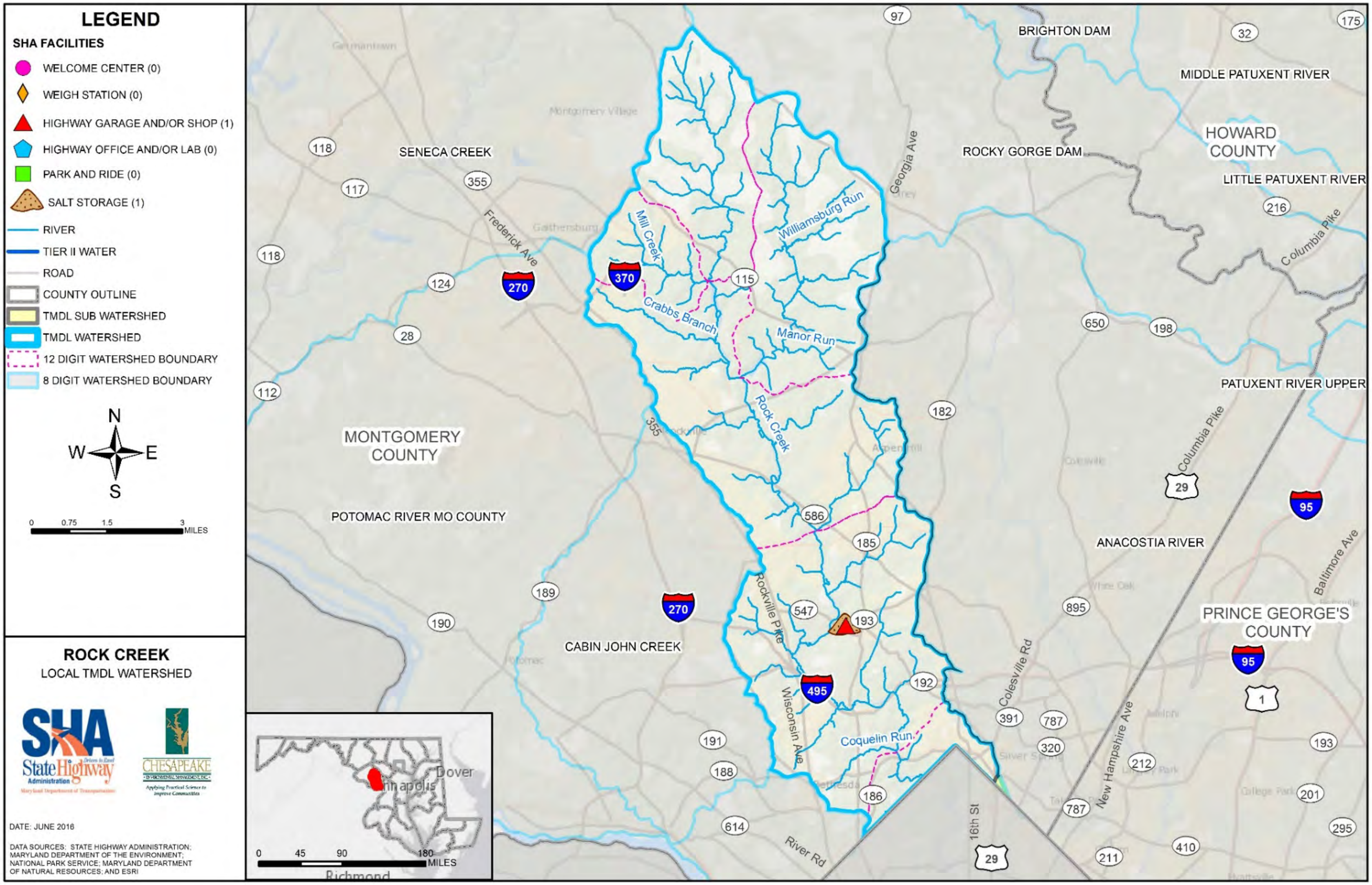

Figure 4-55: Rock Creek Watershed

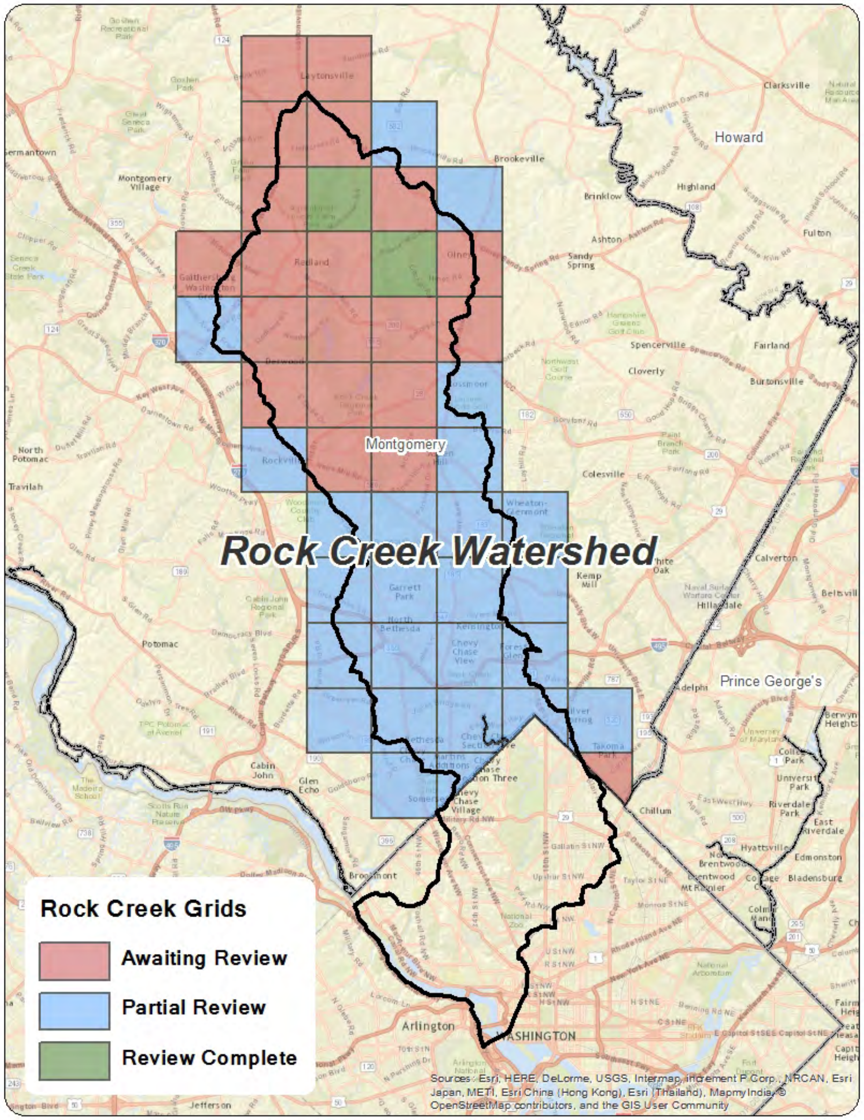

Figure 4-56: Rock Creek Site Search Grids

The stream restoration site search teams have investigated 48,162 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 34,688 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

S.4. Summary of County Assessment Review

Waters within the Rock Creek Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- *Enterococcus*;
- Mercury in Fish Tissue;
- Phosphorus (Total);
- Temperature, water; and
- Total Suspended Solids (TSS).

The Rock Creek Implementation Plan (Biohabitats, 2012), prepared by the Montgomery County Department of Environmental Protection, was adopted in January 2012. The plan provides a comprehensive plan for watershed restoration targeting bacteria reduction (with a TMDL), sediment and nutrient reduction (with a TMDL), runoff management and impervious cover treatment, and trash management.

The Rock Creek watershed comprises primarily residential land use, covering approximately 65% of the watershed. Municipal/institutional comprises approximately 10% and roadway comprises approximately 8%. Approximately 6% is identified as forest, open water, or bare ground. The majority of the stream resource conditions in Rock Creek were assessed as 'Fair' (53%), 18% were assessed as 'Good' and 22% as 'Poor.' The remaining 2% were assessed as 'Excellent (Biohabitats, 2012).

Montgomery County's BMPs proposed within Rock Creek watershed are estimated to result in 52% load reductions for total nitrogen, 53% for total phosphorus, and 49% for total suspended solids. An approximate 55% reduction of trash over baseline conditions is also anticipated (Biohabitats, 2012). Preferred BMPs include ESD property retrofits, new structural stormwater management facilities, retrofitting underperforming stormwater management facilities, and stream restoration projects (Biohabitats, 2012). Projects sites for ESD, pond retrofits, and new stormwater ponds have been identified and are focused on county-owned properties and priority neighborhood areas, which do not include SHA ROW.

S.5. SHA Pollutant Reduction Strategies

Rock Creek is listed for both phosphorus and sediment with each TMDL having a different baseline year; 2009 of phosphorus and 2005 for sediment. Proposed practices to meet the phosphorus and sediment reduction in the Rock Creek watershed are shown in **Table 4-42**. Projected phosphorus and sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Three timeframes are included in the table below:

1. BMPs built after the phosphorus TMDL baseline through 2025. In this case the baseline is 2009.
2. BMPs built after the sediment TMDL baseline through 2009. In this case the baseline is 2005.
3. BMPs built from 2026 through 2035. 2025 is the projected target date for the phosphorus and sediment TMDL. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Rock Creek watershed total $20,334,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $239,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-57 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-42: Rock Creek Restoration Sediment and Nutrient BMP Implementation

BMP	Unit	2006 - 2009	2010 - 2025	2026 - 2035	Total	Cost
New Stormwater	drainage area acres		25.3	21.8	47.1	$5,546,000
Retrofit	drainage area acres		63.5		63.5	$1,818,000
Stream Restoration	linear feet		13,764.0		13,764.0	$10,086,000
Tree Planting	acres of planting		7.8		7.8	$266,000
Outfall Stabilization[1]	linear feet		1,200.0		1,200.0	$2,618,000
Inlet Cleaning[2]	tons		181.2	250.3	250.3	$239,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

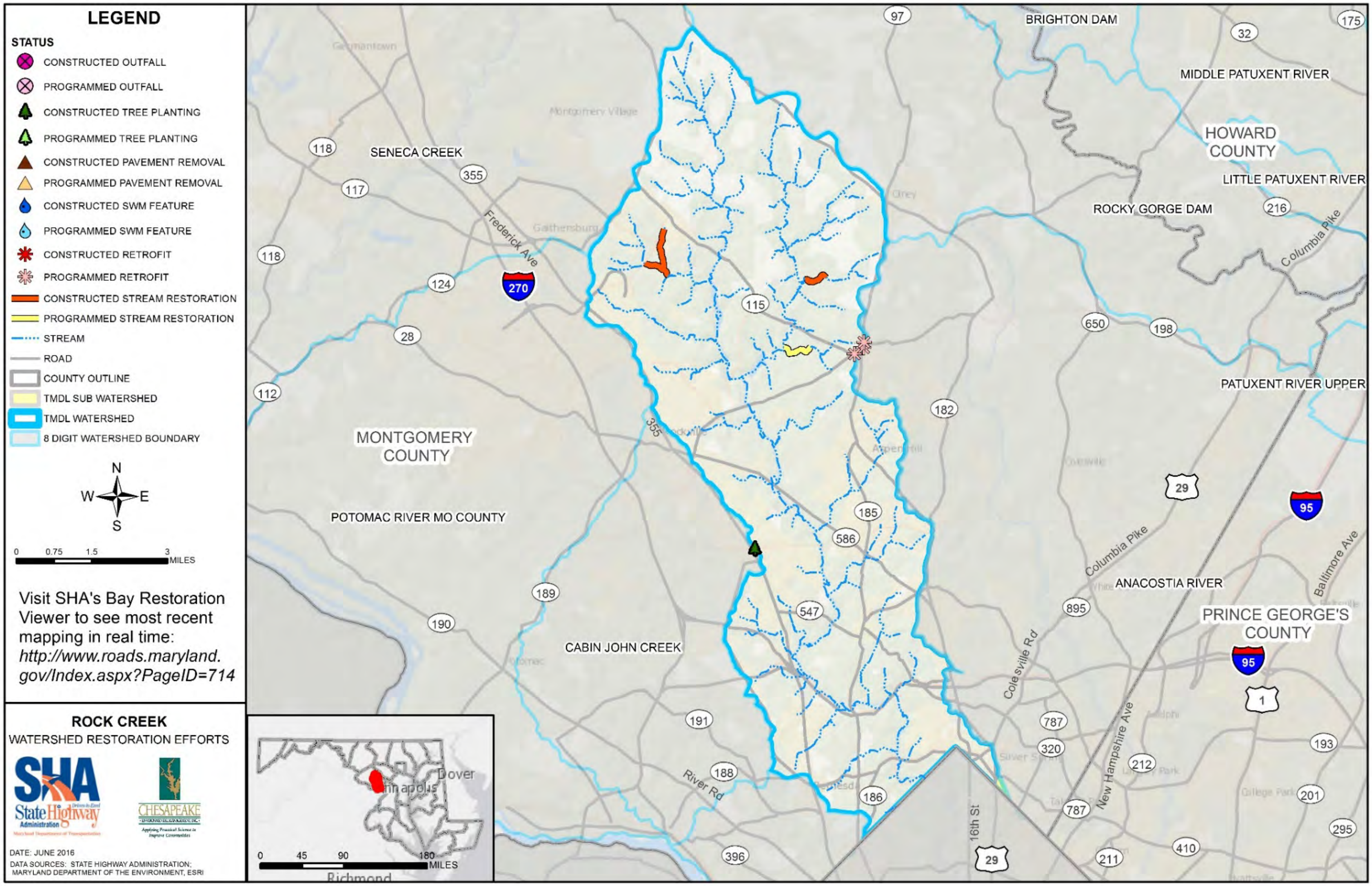

Figure 3-49: SHA Restoration Strategies within the Rock Creek Watershed

T. SENECA CREEK WATERSHED

T.1. Watershed Description

The Seneca Creek Watershed encompasses 129 square miles located solely within Montgomery County. Seneca Creek begins in the northwestern portion of the County, near Damascus. It flows about 27 miles south, passing through the City of Gaithersburg, before joining the Potomac River. Tributary creeks and streams of the Seneca Creek Watershed include Bucklodge Branch, Cabin Branch, Goshen Branch, Gunners Branch, Long Draught Branch, Magruder Branch, North Creek, Tenmile Creek, Whetstone Run, and Wildcat Branch.

There are approximately 676.2 miles of SHA roadway located within the Seneca Creek Watershed, associated ROW comprises approximately 1,504.9 acres, of which 1,182.9 acres is impervious. SHA facilities located within the watershed consist of two salt storage facilities, two park and rides, and one highway garage/shop facility. See **Figure 4-58** for a map of the Seneca Creek Watershed.

T.2. SHA TMDLs within Seneca Creek Watershed

SHA is included in the sediment (TSS) TMDL (MDE, 2011) and has a reduction requirement of 44.9% as shown in **Table 3-2**.

T.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-59**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

Many of the grids awaiting review have little potential for additional impervious treatment due to minimal ROW along residential, agricultural, and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, some SHA impervious areas within these grids are already treated by SHA NPDES BMPs or are part of another SHA highway project that may ultimately provide stormwater BMPs. The current results of this ongoing grid search are as follows:

82 Total Grids:

- 17 fully reviewed
- 25 partially reviewed – in progress
- 40 awaiting review (45% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 193 locations identified as possible candidates for new stormwater BMPs.
- One (1) facility undergoing concept design and may be candidates for design contracts in the near future.
- One (1) retrofit of existing facility under current contracts.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

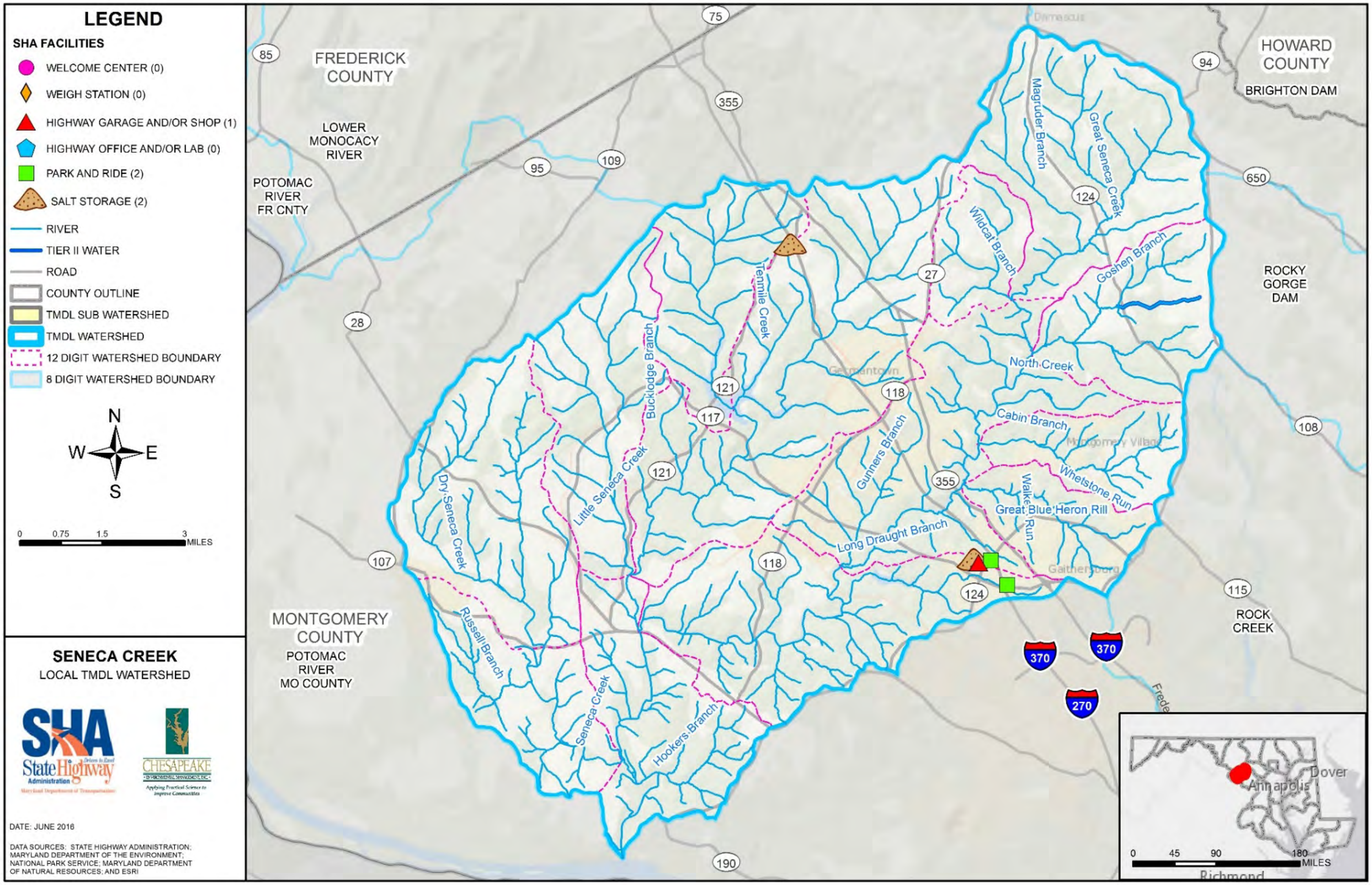

Figure 3-50: Seneca Creek Watershed

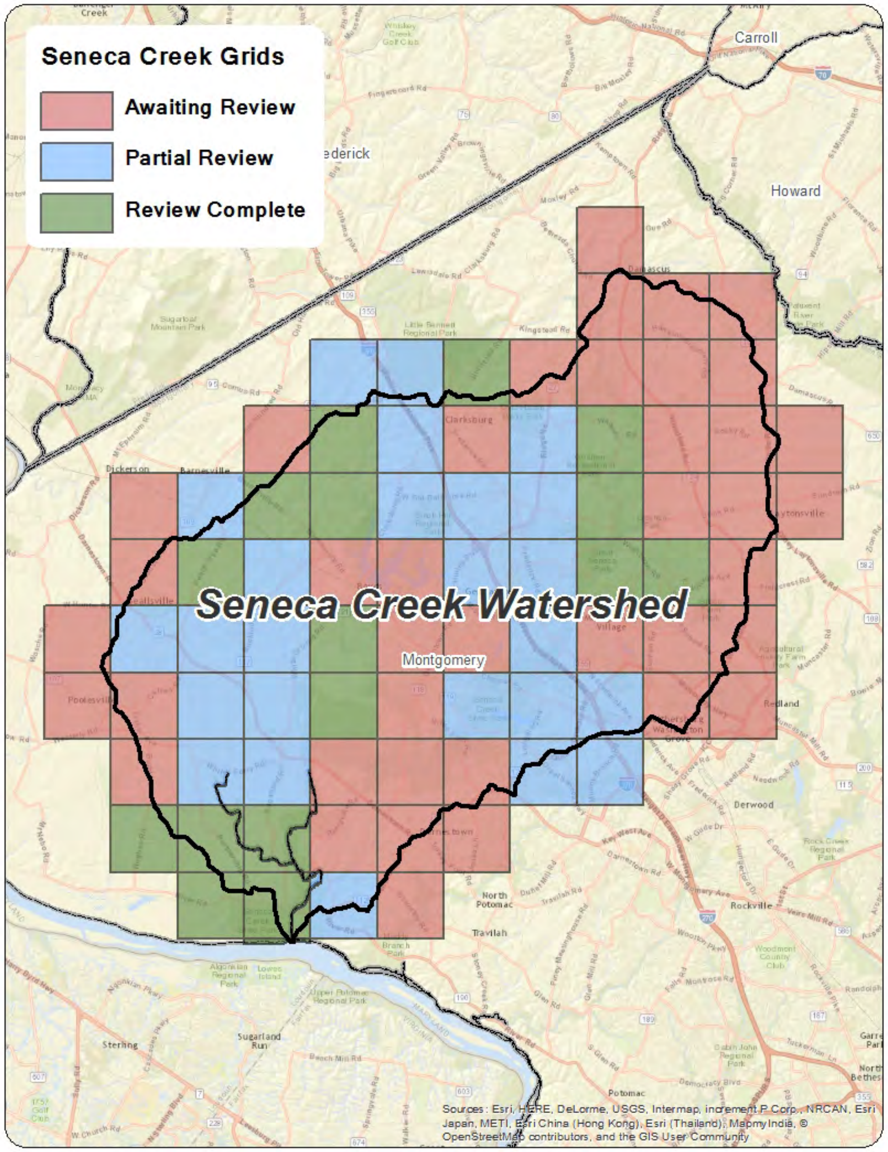

Figure 4-59: Seneca Creek Site Search Grids

The tree planting site search teams have investigated 728 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- Eight (8) acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated 31,587 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 15,835 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

T.4. Summary of County Assessment Review

Waters within the Seneca Creek Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- Ammonia (Total);
- Chlorides;
- Mercury in Fish Tissue;
- Phosphorus (Total);
- Sedimentation/siltation;
- Temperature, water; and
- Total Suspended Solids (TSS).

In 2011, Montgomery County Department of Environmental Protection (MC-DEP) published the *Dry Seneca Creek and Little Seneca Creek Watershed Pre-assessment Report* (Versar, 2011) and the *Great Seneca Watershed Implementation Plan* (HWG, 2012). MC-DEP also published the *Great Seneca Creek Watershed Study* in 1999 (MC-

DEP, 1999). The *Middle Great Seneca Watershed Study* was completed in 2013 (MC-DEP, 2013) and the *Lower Great Seneca Creek Watershed Study* in 2014 (URS, 2014).

The Seneca watershed is mostly comprised of urban, forest, agriculture, and pasture land uses. Urban land covers approximately 38.5% of the watershed (7.5% of which is impervious), forested land is approximately 37.3%, agricultural is approximately 20.7%, and pasture is 3.5%. (Versar, 2011)

Within the Upper Great Seneca, the majority of the streams were rated as 'Good' (48%) or 'Fair' (41%), with 11% not assessed. The highest quality streams were found in the Upper and Lower Great Seneca watersheds, with poorer streams, primarily rated as 'Fair', found in the Middle Great Seneca Watershed, due to higher levels of development surrounding Gaithersburg. Stream conditions within the Dry Seneca Creek and Little Seneca Creek subwatersheds were rated as 'Excellent' to 'Poor', with most streams rated 'Good.' (HWG, 2012)

The *Dry Seneca Creek and Little Seneca Creek Pre-Assessment Report* (Versar, 2011) identified priorities for stormwater BMP retrofits as the areas treated by pre-1986 permitted stormwater management facilities. Using ESD, stormwater management retrofiit, and new stormwater management ponds are the preferred BMP types for these areas. Medium and lower priority sites did not include any SHA ROW, and focused on county-owned and privately-owned sites.

The *Middle Great Seneca Creek Watershed Study* identified five proposed stream restoration projects (MC-DEP, 2013):

- Stream Reach GST-1 on Whetstone Run, experiencing meandering, downcutting, over-widening, lack of vegetation and poor aquatic habitat. Proposed measures include grade control, bank protection, and channel realignment.
- Stream Reach GST-2a on Watkins Mill Run, experiencing erosion, limited riparian zone, and lack of vegetation. Proposed measures include grade control, and bank protection.
- Stream Reach GST-2b on Watkins Mill Run, experiencing channelization, steep banks, invasive species, and incision. Proposed measures include flow diversion and bed and bank stabilization.
- Stream Reach 2012-1a on the unnamed tributary, experiencing channelization, poor aquatic habitat, and bank erosion. Proposed measures include flow diversion and bed and bank stabilization.
- Stream Reach 2012-1b on the unnamed tributary, experiencing incision, trash, lack of vegetation, downcutting, and bank erosion. Proposed measures include step pool storm conveyance, grade control, and bank regrading.

The *Lower Great Seneca Creek Watershed Study* (URS, 2014) identified two proposed stream restoration projects:

- Rabbit East #4 Stream Reach, experiencing steep banks, bank erosion, and incised channels. Proposed measures include grade control, bank protection, and channel realignment.
- Solitaire North Stream Reach, experiencing steep banks, bank erosion, and incised channels. Proposed measures comprise bed and bank stabilization.

T.5. SHA Pollutant Reduction Strategies

Proposed practices to meet sediment reduction in the Seneca Creek watershed are shown in **Table 4-43**. Projected sediment reduction using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Two timeframes are included in the table:

1. BMPs built after the TMDL baseline through 2025. In this case the baseline is 2006.

2. BMPs built between 2026 through 2042 the projected target date. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Seneca Creek watershed total $23,517,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $169,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-60 shows a map of SHA's restoration practices in the watershed and include those that are under design or constructed. Inlet cleaning is not reflected on this map.

Table 4-43: Seneca Creek Restoration Sediment BMP Implementation

BMP	Unit	2006 - 2025	2026 - 2042	Total	Cost
New Stormwater	drainage area acres	32.7	46.7	79.4	$9,617,000
Retrofit	drainage area acres	102.8		102.8	$3,506,000
Stream Restoration	linear feet	3,991.0	1,500.0	5,491.0	$4,024,000
Tree Planting	acres of planting	33.5	78.1	111.6	$3,752,000
Outfall Stabilization[1]	linear feet	1,200.0		1,200.0	$2,618,000
Inlet Cleaning[2]	tons	150.4	176.8	176.8	$169,000

[1] Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits

[2] Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.

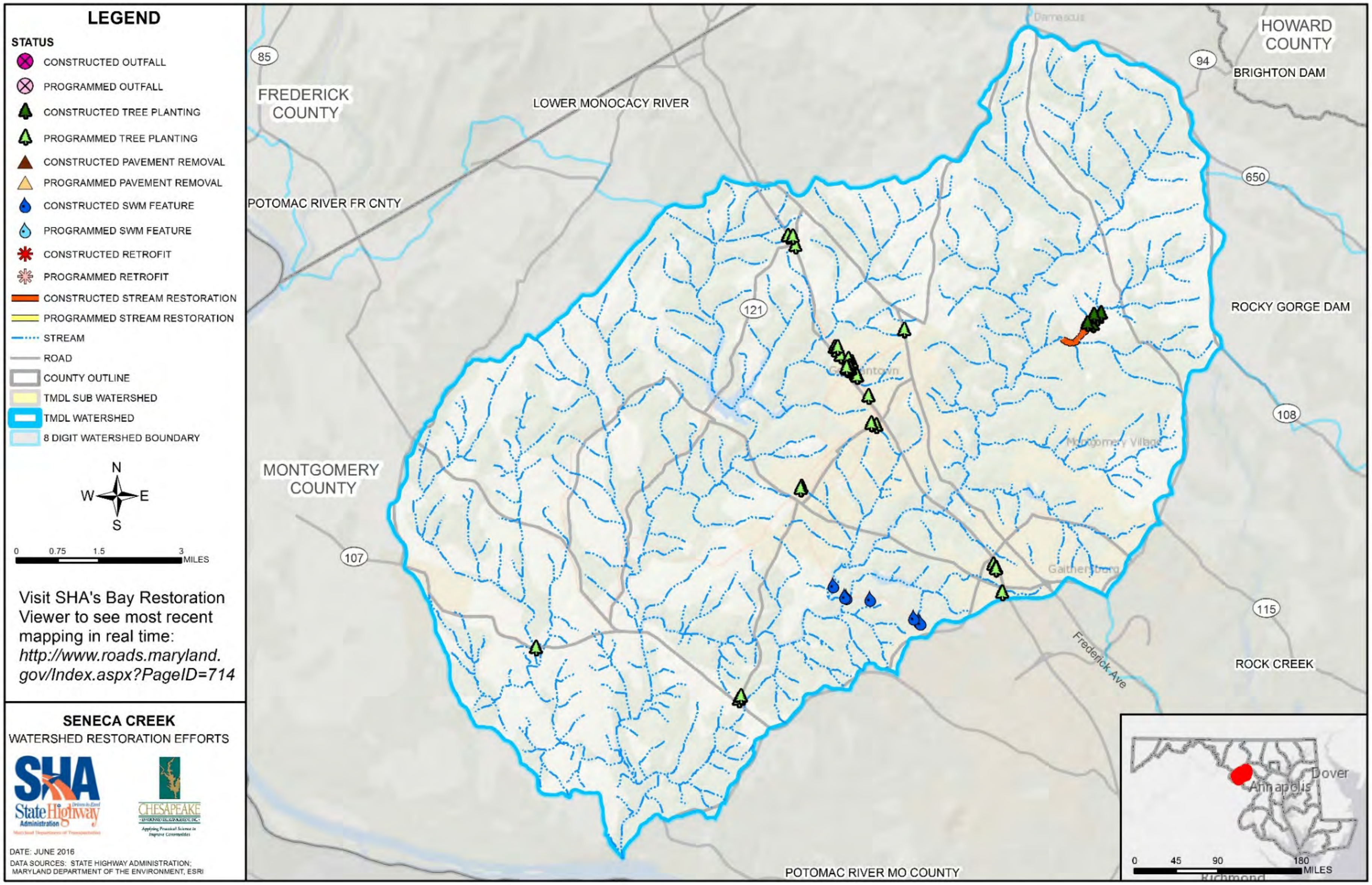

Figure 4-60: SHA Restoration Strategies within the Seneca Creek Watershed

U. UPPER MONOCACY RIVER WATERSHED

U.1. Watershed Description

The Monocacy River is a stream that originates in Pennsylvania and flows through Maryland, which ultimately flows into the Potomac River. The watershed encompasses approximately 274 square miles within the state of Pennsylvania and approximately 724 square miles in both Frederick and Carroll Counties, Maryland. In Frederick County it is divided into six subwatersheds: Fishing Creek, Glade Creek, Hunting Creek, Owens Creek, Toms Creek, and Tuscarora Creek.

There are approximately 665.1 miles of SHA roadway located within the Upper Monocacy River Watershed, associated ROW comprises approximately 1,219.9 acres, of which 630.5 acres is impervious. SHA facilities located within the watershed consist of one highway garage/shop facility, one welcome center, and two salt storage facilities. See **Figure 4-61** for a map of the Upper Monocacy River Watershed.

U.2. SHA TMDLs within Upper Monocacy River Watershed

TMDLs requiring reduction by SHA include Phosphorus (MDE, 2009) and sediment (MDE, 2000). Phosphorus is to be reduced by 3.0% and sediment is to be reduced by 49% as shown in **Table 3-2**.

U.3. SHA Visual Inventory of ROW

The stormwater implementation teams are currently evaluating grids in the watershed and will continue to do so until all are completed and accepted. The grid-tracking tool was developed to assist teams to efficiently search each watershed on a 1.5 x 1.5-mile square system as shown in **Figure 4-62**. Future planning efforts will continue to be centered on areas with local TMDL needs that have been identified using the site search grid-tracking tool.

The grids awaiting review have little potential for additional impervious treatment due to minimal ROW along residential, agricultural, and wooded areas, which limits the ability to purchase ROW for the construction of a new BMP. Additionally, some SHA impervious areas within these grids are already treated by SHA NPDES BMPs. The current results of this ongoing grid search are as follows:

157 Total Grids:

- 105 fully reviewed
- 46 partially reviewed – in progress
- Six (6) awaiting review (4% of total grids)

The new stormwater site search has resulted in a pool of potential sites comprised of the following:

- 787 locations identified as possible candidates for new stormwater BMPs.
- Seven (7) facilities undergoing concept design and may be candidates for design contracts in the near future.
- Potential existing grass swale locations and grass swale rehabilitation locations undergoing review.

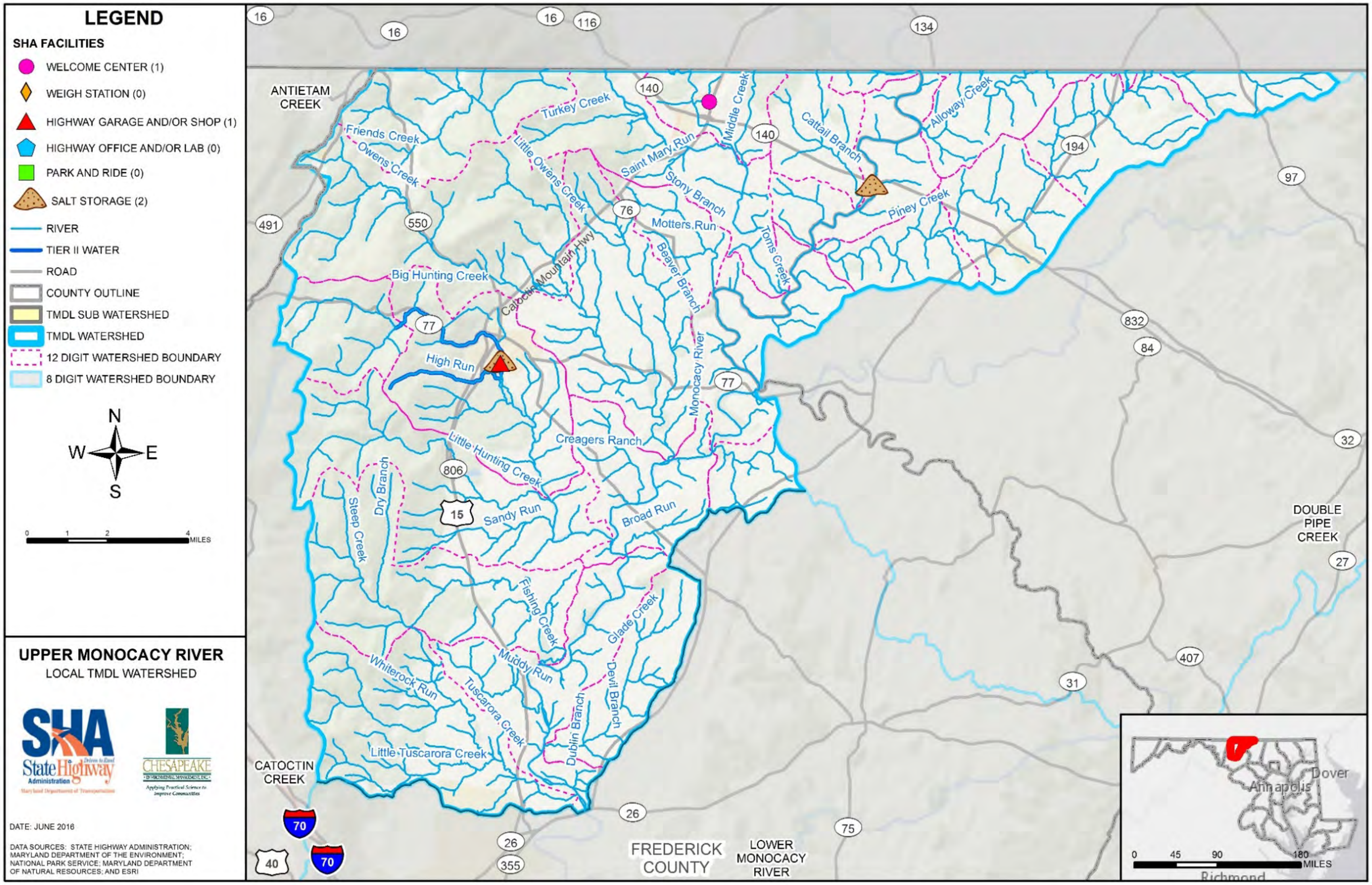

Figure 4-61: Upper Monocacy River Watershed

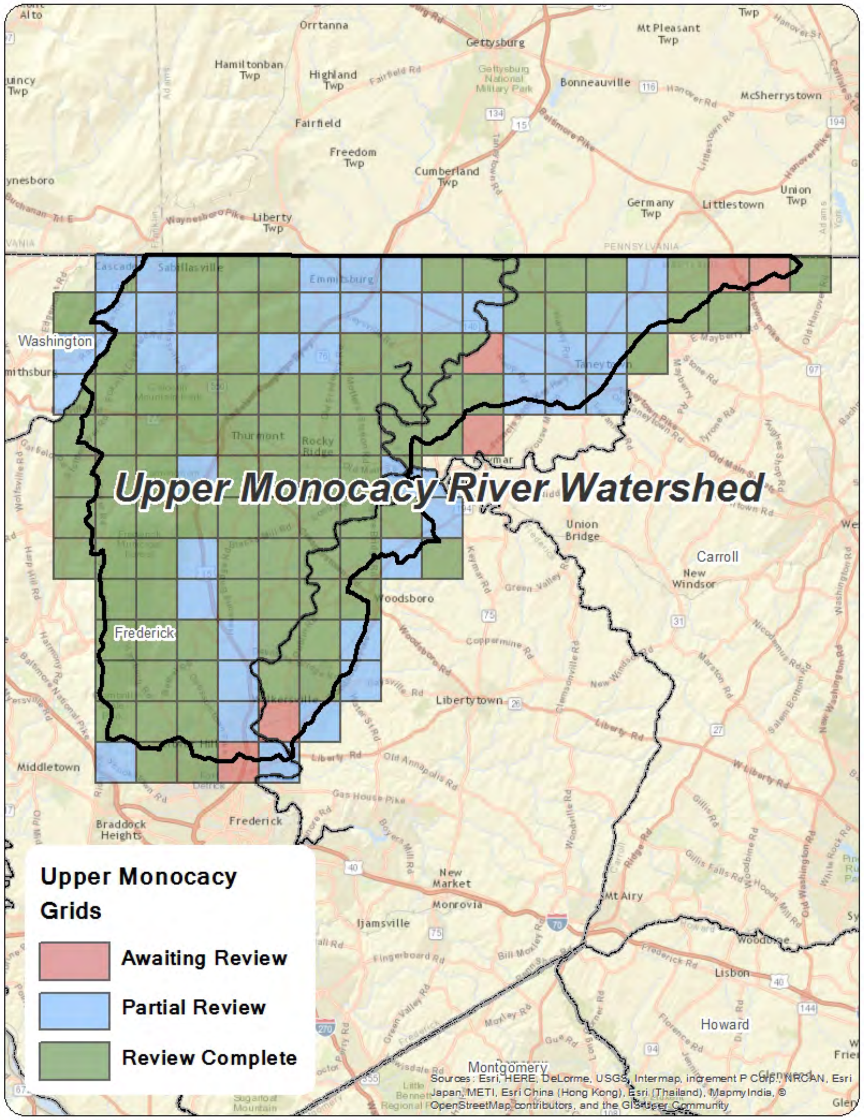

Figure 4-62: Upper Monocacy Site Search Grids

The tree planting site search teams have investigated 639 acres of SHA-owned pervious area. The ongoing site search has resulted in a pool of potential sites comprised of the following:

- 24 acres are undergoing concept design and may be candidates for planting contracts in the near future.
- 11 acres of tree planting potential for further investigation.

The stream restoration site search teams have investigated over 23,313 linear feet of stream channel for restoration opportunities. The site search has resulted in the following:

- 20,846 linear feet recommended for future restoration potential.

Teams will continue to pursue the most viable and cost-effective BMPs that are currently within the existing pool of sites based on site feasibility.

U.4. Summary of County Assessment Review

Waters within the Upper Monocacy River Watershed are subject to the following impairments as noted on MDE's 303(d) List:

- *Escherichia coli;*
- Mercury in Fish Tissue;
- PCB in Fish Tissue;
- Phosphorus (Total);
- Temperature, water; and
- Total Suspended Solids (TSS).

The Upper Monocacy River watershed is ranked in Maryland's Clean Water Action Plan (CWAPTW, 1998) as a "Priority Category 1," a watershed not meeting clean water and other natural resource goals and therefore needing restoration, and "Selected Category 3", a pristine or sensitive watershed most in need of protection. The Frederick County Division of Public Works completed a Watershed

Restoration Action Strategy (WRAS) for the Upper Monocacy Watershed within Frederick County in 2005 (FR-DPW, 2005). According to the WRAS, impervious land cover comprises 3.7% of the Upper Monocacy Watershed within Frederick County, and 25% of the soils within the Upper Monocacy Watershed in Frederick County are considered of highly erodible. The Upper Monocacy River Watershed currently has completed TMDLs for total suspended solids, phosphorus, and fecal coliform.

For the purposes of planning, Frederick County has selected the following generalized restoration strategies to aid in meeting restoration goals within the Upper Monocacy Watershed:

- Restore riparian corridors
- Improve impaired streams
- Identify and preserve pristine areas
- Protect and expand existing green infrastructure and riparian corridors
- Protect water quality and habitat through appropriate zoning

The Maryland Department of Natural Resources (DNR) conducted a stream corridor assessment in Frederick County and identified 226 sites with varying degrees of severity in terms of channel alteration, erosion (120,153 linear feet), exposed pipes, fish passage barriers, inadequate buffers, and pipe outfalls. Sites were prioritized based on the greatest need and potential for restoration. The sites with the most severe problems are listed below in **Table 4-44.**

Detailed information on site locations and less severe sites can be found in the 2004 Upper Monocacy Stream Corridor Assessment Survey (DNR, 2004). According to this survey, the following potential stream restoration sites were identified within the Upper Monocacy Watershed with a severity rating of 2 or 1.

Table 4-44: Upper Monocacy Stream Corridor Assessment Survey Restoration Site Recommendations

Subwatershed	Reach ID	Length (ft.)	Impact(s)
Glade Creek	2719205	107	Downcutting
Glade Creek	2819202	69	Downcutting
Glade Creek	2821402	10247	Downcutting
Hunting Creek	1914103	409	Widening
Owens Creek/Beaver Branch	1621201	1980	Downcutting
Toms Creek	2208201	570	Downcutting
Tuscarora Creek	0510302	12464	Widening
Fishing Creek	1510104	--	Total fish blockage (dam)
Fishing Creek	1510106	--	Total fish blockage (dam)
Fishing Creek	1512312	--	Total fish blockage (channelized)
Hunting Creek	1813301	--	Total fish blockage (channelized)
Hunting Creek	1813302	--	Total fish blockage
Owens Creek/Beaver Branch	2419103	--	Total fish blockage (road crossing)
Toms Creek	1924301	--	Total fish blockage (channelized)
Toms Creek	2307303	--	Total fish blockage (road crossing)

The Frederick County Office of Sustainability and Environmental Resources conducted Stream Corridor Assessments (SCA's) between 2008 and 2014 that include the Fishing Creek, Glade Creek, Hunting Creek, Owens Creek, Toms Creek, and Tuscarora Creek subwatershed of the Upper Monocacy River Watershed. Information on water quality, erosion, physical habitat, and benthic index of biotic integrity scores for several sites within the Upper Monocacy River

Watershed can be found in the SCA reports, however detailed location information is not provided.

U.5. SHA Pollutant Reduction Strategies

Upper Monocacy is listed for both phosphorus and sediment with each TMDL having a different baseline year; 2009 for phosphorus and 2000 for sediment. Proposed practices to meet the phosphorus and sediment reduction in the Upper Monocacy River watershed are shown in **Table 4-45**. Projected phosphorus and sediment reductions using these practices based on modeling described in **Part III** of this Plan are shown in **Table 3-2**. Three timeframes are included in the table below:

1. BMPs built after the phosphorus TMDL baseline through 2025. In this case the baseline is 2009.

2. BMPs built after the sediment TMDL baseline through 2009. In this case the baseline is 2000.

3. BMPs built from 2026 through 2034 the projected target date of the sediment TMDL. 2025 is the projected target date for the phosphorus TMDL. SHA will accomplish the percent reduction presented in **Table 3-2**. The percent may not equal 100%.

Estimated Capital Budget costs to design and construct practices within the Upper Monocacy watershed total $35,839,000. These projected costs are based on an average cost per impervious acre treated that was derived from cost history for a group of completed projects for each BMP category. In addition to Capital Budget costs, $26,000 from our Operations Budget is estimated for annual inlet cleaning.

Figure 4-63 shows a map of SHA's restoration practices in the watershed and include those that are under design or construction. Inlet cleaning is not reflected on this map.

Table 4-45: Upper Monocacy River Restoration Nutrient and Sediment BMP Implementation

BMP	Unit	2001 – 2009	2010 – 2025	2026 – 2034	Total	Cost
New Stormwater	drainage area acres		111.4	105.4	216.8	$24,998,000
Retrofit	drainage area acres		26.3		26.3	$680,000
Stream Restoration	linear feet		1,650.0	1,500.0	3,150.0	$2,309,000
Tree Planting	acres of planting	0.1	69.9		70.0	$2,354,000
Outfall Stabilization[1]	linear feet			2,400.0	2,400.0	$5,235,000
Impervious Surface Elimination	acres removed		0.9		0.9	$263,000
Inlet Cleaning[2]	tons		18.7	27.3	27.3	$26,000

[1] *Outfall stabilization treatment calculated based on 200 linear foot assumption per number of outfall stabilization retrofits*

[2] *Inlet cleaning is an annual practice. Projected load reductions included here are based on a combination of historical and future projections for the purposes of this implementation plan. Actual reductions will be reported each FY in the SHA MS4 annual report.*

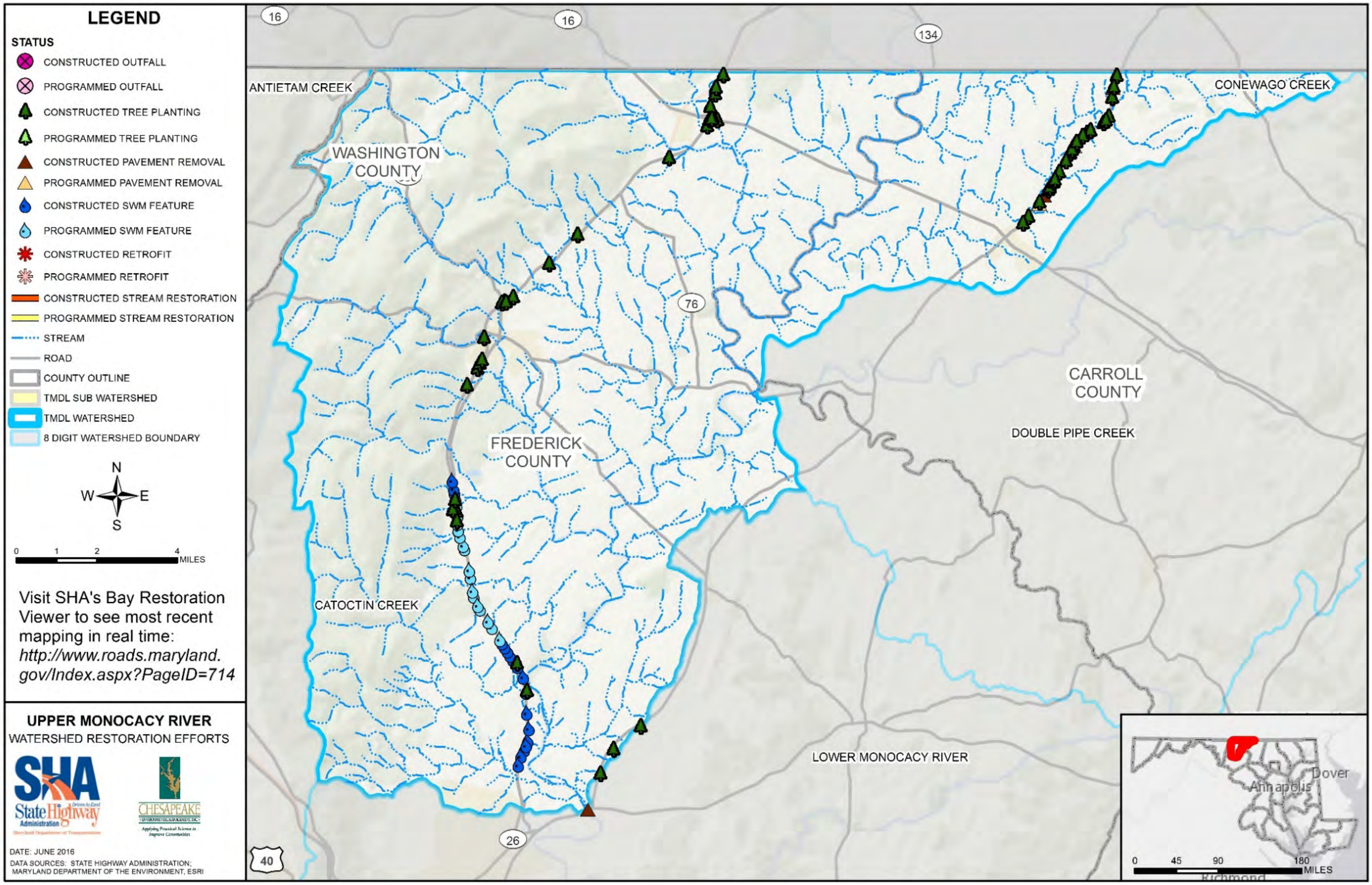

Figure 4-63: SHA Restoration Strategies within the Upper Monocacy River Watershed

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