Appendix C: Water Quality Assessment

Introduction

A water quality assessment was performed to address the SWIP Objectives 1.2, 1.3, and 1,5 (see main SWIP document).

The following strategies were employed for the task:

- Identify BMPs and restoration activities currently implemented or planned by the City
- Calculate and summarize pollution reduction estimates for the current and planned BMPs and restoration activities, and
- Identify the load reduction gap between the planned reductions and the required load reduction targets.

Required Pollutant Load Reductions

For this study, the baseline loading (2009) and required pollutant load reductions were calculated using the information in the City of Harrisonburg TMDL Action Plan (City of Harrisonburg 2015) and the DEQ guidance document (DEQ 2015).

DEQ requires MS4 permittees (e.g., the City of Harrisonburg) to reduce TN, TP, and TSS levels to the target reductions incrementally across three permit cycles. In the first permit cycle by 2018, the City is required to reduce loads by 5 percent, then by an additional 35 percent (40 percent cumulative) by 2023, and then by the remaining 60 percent (100 percent cumulative) by 2028. These resulting load reduction requirements are also summarized in the main SWIP document.

Potential Options for Load Reductions

To meet its load reductions, the City looked at a variety of activities that reduce the amounts of nutrients and sediment in stormwater runoff. The following list of potential restoration activities and BMPs was determined as likely to be implemented with this plan, and are described in the remainder of this appendix. See the main SWIP document for descriptions and photos of these practices.

1. Retrofits to Existing BMPs
2. Urban Stream Restoration
3. Urban Tree Canopy
4. Street Sweeping and Catch Basin Cleaning
5. Septic System to Sanitary Sewer Conversion
6. Homeowner BMPs
7. Nutrient Trading and Programmatic Strategies (discussed in Appendix E of the SWIP)

Retrofits to Existing BMPs

Fifteen (15) existing city-owned BMPs and five (5) existing private BMPs were identified as opportunities for BMP retrofits, listed in Table C-1 and shown in Figure C-1. These retrofits will increase water quality and stormwater volume treatment efficiency through improvements to existing structures or conversions into different BMP types. Most of the existing BMPs are detention ponds (i.e., dry ponds) that were installed to control water volume and that provide little or no water quality benefit. The load reduction credit received by enhancing or retrofitting an existing BMP was determined using the methodology described in DEQ's Chesapeake Bay TMDL guidance (DEQ 2015).

Bay Program efficiencies were obtained from Chesapeake Assessment Scenario Tool (CAST) and were used to estimate potential load reductions from BMP retrofits (CBP 2017). This method requires a determination of the drainage area, pervious/impervious areas, and general land use (e.g., urban, forest, agriculture) to determine a load reduction and does not require a preliminary design of each retrofit.

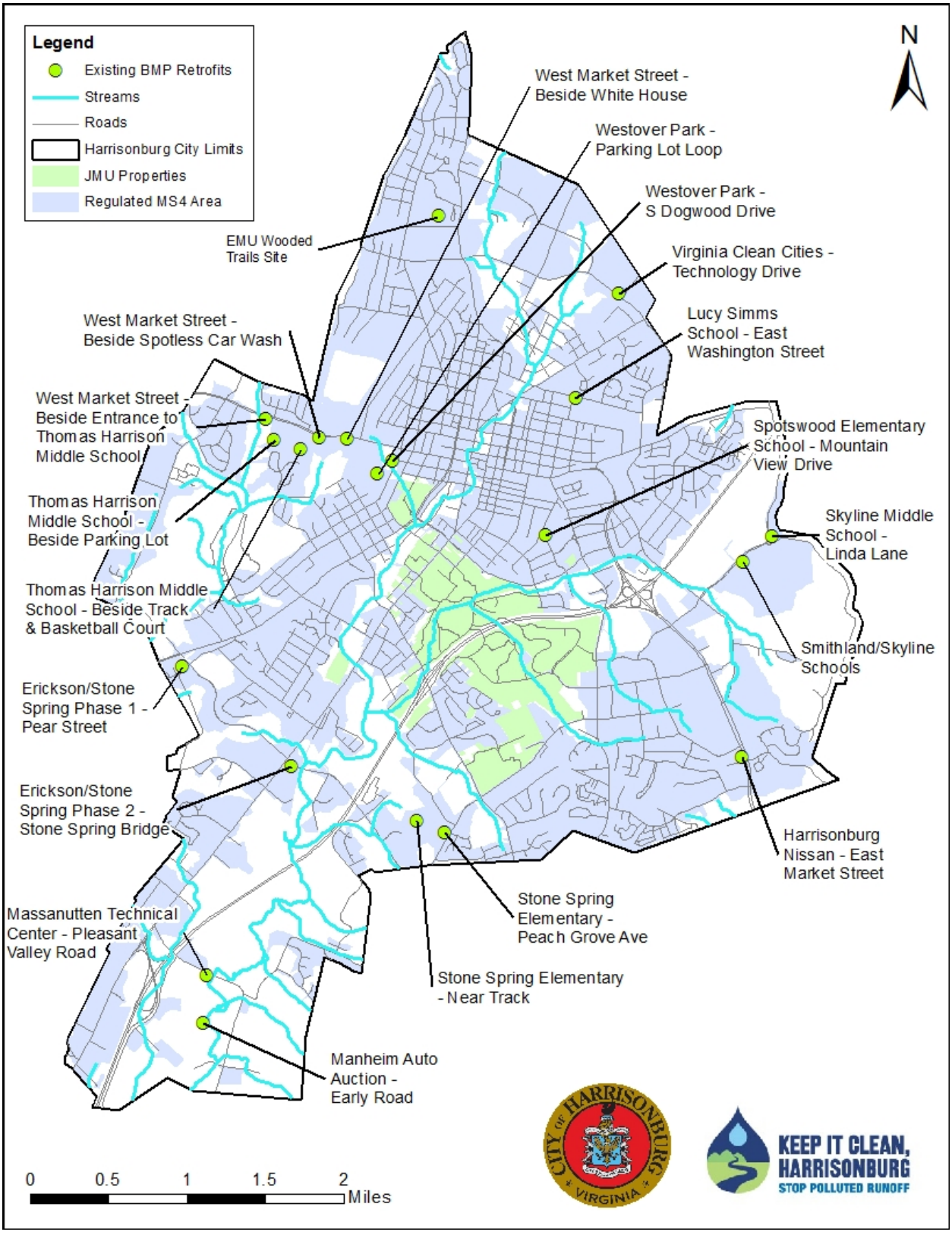
Table C-1. Existing BMP Retrofit Opportunities

Site Name	Existing BMP Type	Enhanced BMP Type	Comment
Westover Park - S Dogwood Drive	Detention Basin	Enhanced Extended Detention	Divert additional drainage area to retrofit based on space availability. Add forebay for pre-treatment.
Westover Park - Parking Lot Loop	Bioretention	Bioretention	Resize and retrofit by redirecting flow and expanding BMP footprint.
Lucy Simms School - East Washington Street	Detention Basin	Bioretention	Convert to bioretention system.
Spotswood Elementary School - Mountain View Drive	Bioretention/ Rain Garden	Bioretention Retrofit	Undersized, Recommended retrofit. Increase size for drainage area and impervious area to facility.
Skyline Middle School - Linda Lane	Extended Detention Basin	Extended Detention	Add permanent pool, micro-pools, and sediment forebay.
Smithland/Skyline Schools	Extended Detention Basin	Enhanced Extended Detention	Add permanent pool, micro-pools, high marsh, and low marsh.
Stone Spring Elementary - Near Track	Detention Basin	Bioretention	Install bioretention providing treatment to smaller isolated area in vicinity of school without treating field. Retain current flow control.
Stone Spring Elementary - Peach Grove Ave	Detention Basin	Bioretention	Large bioretention facility with available space. Continuing to provide existing flow control.
Erickson/Stone Spring Phase 1 - Pear Street	Extended Detention Basin	Extended Detention	Install micro-pools and permanent pool. Improve grading for better access.
Erickson/Stone Spring Phase 2 - Stone Spring Bridge	Extended Detention Basin	Wet Pond	Maintain extended detention basin, but add wet pond.
Thomas Harrison Middle School - Beside Track & Basketball Court	Detention Basin	Bioretention	Convert neglected detention basin to bioretention facility with pre-treatment.
Thomas Harrison Middle School - Beside Parking Lot	Detention Basin	Bioretention	Convert neglected detention basin to bioretention facility with pre-treatment.
West Market Street - Beside Entrance to Thomas Harrison Middle School	Detention Basin	Wet Pond	Convert to wet pond sized to treat drainage area. Will require raising of inflow to prevent backup.
West Market Street - Beside Spotless Car Wash	Detention Basin	Extended Detention	Add permanent pool, micro-pools, sediment forebay. Remove existing trickle ditch and extend flow path.
West Market Street - Beside White House	Detention Basin	Extended Detention	Add permanent pool, micro-pools, and sediment forebay.
EMU Wooded Trails Site**	Detention Basin	Enhanced Extended Detention	Create areas of aquatic vegetation and conservation landscaping. Perform erosion repairs and channel stabilization.

Site Name	Existing BMP Type	Enhanced BMP Type	Comment
Massanutten Technical Center - Pleasant Valley Road**	Detention Basin	Vegetated Filter	Convert to vegetated filter and modify drainage area to incorporate flow from road through drainage diversions.
Manheim Auto Auction - Early Road**	Detention Basin	Wet Pond	Convert to wet pond and increase the drainage area. Install flow diversions, as needed.
Virginia Clean Cities - Technology Drive**	Dry Swale	Bioretention	Convert existing dry swale to higher performing bioretention.
Harrisonburg Nissan - East Market Street**	Dry Swale	Vegetated Filter	Convert existing dry swale to higher performing vegetated filter.

Note: Privately-owned BMPs are marked with **.

Figure C-1. Existing BMP Retrofit Opportunities



Urban Stream Restoration

Twelve (12) potential urban stream restoration projects totaling 7.89 miles were identified based on field observations and are listed in Table C-2 and shown in Figure C-2. As a conservative estimate, this plan assumes that only 70 percent of the total stream restoration project length (5.52 miles) will be implemented through this SWIP.

One thing to note about stream restoration projects is that the City cannot receive the full pollutant reduction credit if the drainage area of the stream being restored extends beyond the City limits or even beyond the *regulated area* of the MS4 that is within the City's boundaries. The main SWIP document explains the difference between MS4 *regulated* and *unregulated* land. DEQ has put out guidance on how stream restoration projects in this category should be credited. In short, any pollutant reduction on unregulated land is "discounted" because the state is already responsible for a certain load reduction for land that is not subject to a permit, such as the MS4. The level of reduction is known as the "baseline." The loads in Table C-2 account for a preliminary assessment of the baseline discounts for identified stream restoration projects.

Table C-2. Urban Stream Restoration Opportunities

Reach ID	Reach Name	Reach Length (mi)	TN (lbs)[a]	TP (lbs)[a]	TSS (lbs)[a]
HB-1	East Mosby Rd to City Limits	3.08	857	788	512,559
HB-3	Mall Creek - Country Club Road	2.01	597	662	424,987
HB-4	Mountain View Drive[b]	0.33	100	101	63,260
HB-5	South Avenue to South Main Street	0.46	150	136	89,688
HB-6	Keister Elementary School	0.20	79	72	47,410
HB-7	Mongers to Ohio Avenue	0.29	93	85	55,920
HB-8	Westover Park to South Willow Street	0.26	90	89	58,682
HB-9	Ice House to Chesapeake Avenue	0.15	49	44	29,226
HB-10	Charles Street to Ashby Avenue	0.24	80	79	50,466
HB-11	North End Greenway Trail[c]	0.43	595	86	40,475
HB-12	Heritage Oaks Golf Course	0.34	92	98	61,585
HB-13	EMU Gym	0.10	39	35	23,428
	Total =	7.89	2,821	2,275	1,457,686
	70% Total =	5.52	1,975	1,593	1,020,380

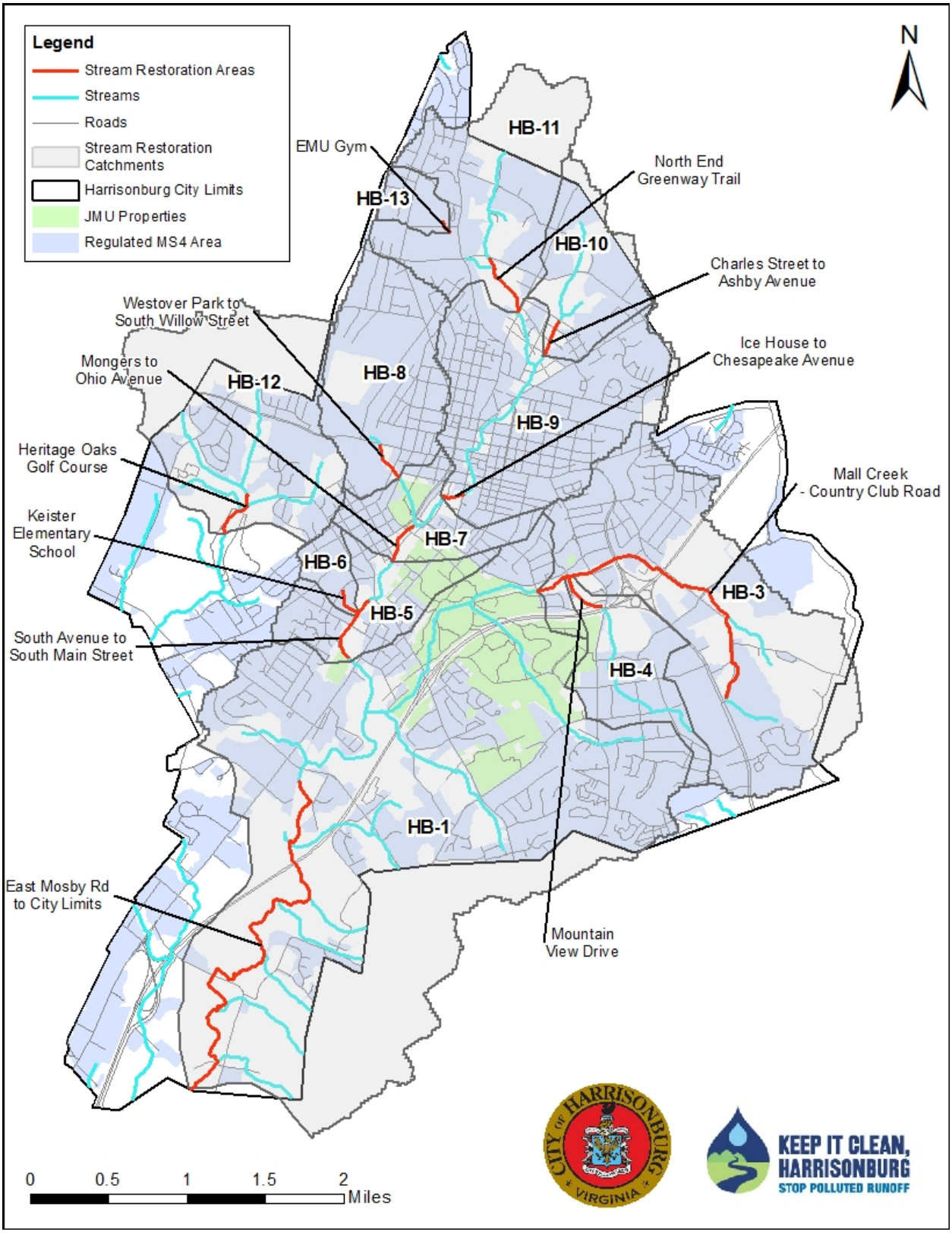
Notes:

[a] Loading rates were obtained from DEQ 2015. TN - 0.075 lbs/linear ft; TP - 0.068 lbs/linear ft; 44.88 lbs/linear ft.

[b] A stream assessment study was recently completed for this project due to concerns related to erosion and exposed utilities. It can be used as reference material for future project planning and implementation.

[c] Load reductions for the North End Greenway stream restoration project were calculated using the actual stream restoration design documents for this project. This project is being privately developed and the City will only receive a portion of the pollutant removal credits.

Figure C-2. Urban Stream Restoration Opportunities



Urban Tree Canopy

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

Credit for this program is on a tree-by-tree basis as described in the Chesapeake Bay Program's 2016 Expert Panel recommendations (CBP 2016a). Each tree represents 144 ft (1/300th of an acre) and there is no density requirement, so single trees are eligible for credit. Table C-3 presents the tree canopy reductions from the original land use loading rate for turf grass or impervious area.

Table C-3. Tree Canopy BMP Load Reductions

Canopy Type	TN % Reduction	TP % Reduction	TSS % Reduction
Canopy over turf grass	23.8	23.8	5.8
Canopy over impervious	8.5	11.0	7.0

Note: Reductions are the load reductions from the original land use (e.g., impervious cover).
Source: CBP 2016a.

Table C-4 shows the potential load reductions from a hypothetical program to expand urban tree canopy by 300 trees over turf or 300 trees over impervious cover.

Table C-4. Tree Planting BMP Load Reductions

Parameter	# Trees (300 trees per acre)	Load Reduction (lbs)
TN	600	3.83
TP	600	0.28
TSS	600	92.19

The City's website (https://www.harrisonburgva.gov/tree-canopy-grant) has additional information about the City of Harrisonburg's potential tree planting program throughout the City.

Street Sweeping and Catch Basin Cleaning

The City has maintained existing programs for street sweeping and catch basin cleaning, both of which qualify towards pollutant load reductions.

Street Sweeping

Load reductions from street sweeping are based on the type of street sweeping technology and the frequency of sweeping, where one curb mile is equivalent to treatment of one acre (CBP 2016b). The load reductions are calculated using the loading rates, curb miles swept (converted to acres), and reduction efficiencies that vary based on technology and frequency of sweeping. These rates are

expected to remain consistent in the future. Figure C-3 shows the current street sweeping routes in the City. The load reductions for street sweeping in 2016 are shown in Table C-5.

Table C-5. Summary of Load Reductions from Street Sweeping

Lane Miles/ Acres	Harrisonburg Street Cleaning Practice (SCP) #	Description	Approx. Passes/ Year	Removal Rate (%)			Mass Removed (lbs)		
				TN	TP	TSS	TN	TP	TSS
15.62	SCP-1	AST-2PW	100	4	10	21	9.68	3.01	4,264.26
132.24	SCP-3	AST-1P2W	25	2	5	11	40.99	12.76	18,910.32
172.80	SCP-4	AST-1P4W	10	1	3	6	26.78	10.01	13,478.40
3.39	SCP-4 (parking lot)	AST-1P4W	10	1	3	6	0.53	0.20	264.42
4.53	SCP-5 (parking lot)	AST-1P8W	6	0.7	2	4	0.49	0.17	235.56
						Total	**78.47**	**26.15**	**37,152.96**

Notes:
AST = vacuum assisted/vacuum or regenerative air cleaner
2PW = 2 passes per week; 1P2W = 1 pass per every 2 weeks; 1P4W = 1 pass per every 4 weeks; 1P8W = 1 pass per every 8 weeks; Average loads were determined using TN-15.5 lb/acre/yr; TP-1.93 lb/acre/yr; TSS-1,300 lb/acre/yr (CBP 2016b).

Catch Basin Cleaning

The City cleans every City-maintained catch basin annually. This is done by using a vacuum truck to remove accumulated debris in the catch basin.

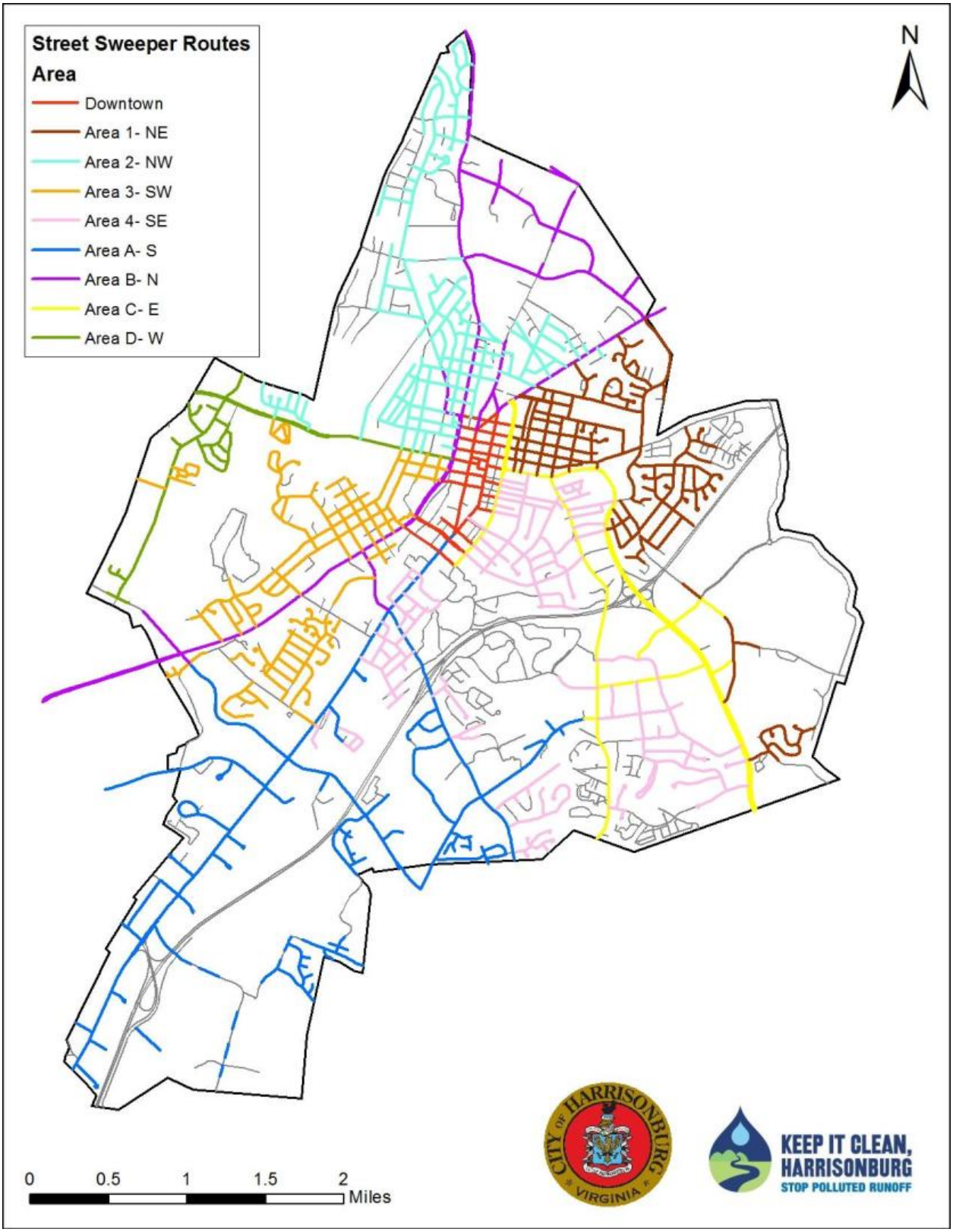
The method for calculating the load reductions from catch basin cleaning is the mass load converted to a dry weight, times an enrichment factor (CBP 2016b). The conversion from mass load to dry weight is 0.7. The enrichment factors are different based on the material collected—sediments or organic matter—as shown in Table C-6, along with the amount of material removed in fiscal year 2016. As a conservative assumption, all material was assumed to be sediment, as opposed to organic material, which provides additional nutrient load reductions. There is no TSS load reduction credit for catch basin cleaning.

Table C-6. Enrichment Factors for Catch Basin Cleaning

	Material Removed (lbs)	Dry Load (lbs)	Removal Rate (%)	Mass Removed (lbs)
TN	117,960	82,572	0.27%	222.9
TP			0.06%	49.5

Note: Removal rate source: CBP 2016b

Figure C-3. Street Sweeping Routes



Septic System to Sanitary Sewer Conversion

The City can claim TN credits for the practice of converting onsite septic systems to sanitary sewer connections. This is because older septic systems are not very efficient at processing the nutrients from household wastewater. Nutrients can leach into the ground and be conveyed through shallow groundwater flow to streams and waterbodies.

Virginia guidance is that TN reductions are calculated as 9 lb/year/person with 60 percent attenuation from the drain-field to the edge of stream, resulting in a 3.6 lb/year/person credit for each conversion to sanitary sewer. The number of people per sewer connection is estimated using the U.S. Census data for the average number of people per household. In Harrisonburg, the average is 2.69 people per household (U.S. Census Bureau 2017). Per city records, 19 households were converted from septic to sanitary sewer between 2006 and 2016, yielding a TN reduction of 184 lbs/year. The City projects that another 11 connections will be made or found during the next few permit cycles, yielding an additional 106.5 lbs/year TN reduction, when all 30 systems are connected. There are approximately 100 properties within the City that have onsite septic systems.

Homeowner BMPs

As explained in the main SWIP document, a stormwater utility fee credit is available to both residential and non-residential customers that implement on-site BMPs. There are credit manuals for both categories on the City's stormwater webpage that outline the types of practices authorized and how to calculate the fee credit. There are 10 practices for residential properties. However, three have been used most frequently by homeowners since the program's inception. These are: rain barrels, roof drain disconnections, and nutrient management plans.

The City can take pollutant reduction credit for the load reductions from homeowner implementation of these practices. Table C-7 summarizes the TN and TP reduction efficiencies for these homeowner BMPs from land use loads without BMPs. There is no TSS credit for these practices. The homeowner BMP credits are valid for five years with regular maintenance. For the credit to continue beyond five years, the City requires a reapplication to verify the practice is still in place and functioning correctly. Load reduction calculations assume that verification is complete and all practices continue to receive credit.

Table C-7. Reduction Efficiencies for Homeowner BMPs

Homeowner BMP Type	TN % Reduction	TP % Reduction
Rain Barrels	28	33
Roof Drain Disconnection	45	52
Nutrient Management Plan	6	3

Source: Goulet and Schueler, 2014.

The load reduction calculations for rain barrels and roof drain disconnections use the acres of impervious area treated times the land use loading rate and the removal rate. For nutrient management plans, the load reduction is calculated as the impervious area times the land use loading rate and the removal rate. A compliance factor (assumed 75 percent) was also applied to nutrient management plans. The compliance factor for rain barrels and roof drain disconnections is 100 percent, so the full load reduction credit is used for these two practices.

The load reductions from the current 2015 and 2016 records for participation amount to 71.37 and 39.93 pounds of TN, and 4.96 and 3.32 pounds of TP, respectively. To calculate the potential additional load reductions from future participation in the homeowner BMP program, we assumed that the rate of participation in subsequent years will follow a consistent percentage decline as willing homeowners are less likely to be found in subsequent years. The change in new load reductions between 2015 and 2016 was applied to the years 2017–2023. The change in TN is a 44 percent reduction in annual additional load reductions, and the change in TP is 33 percent. Table C-8 summarizes the annual load reduction projections through 2023 and provides the projected cumulative load reduction through that timeframe.

Table C-8. Annual Additional Load Reductions from Homeowner BMPs

	2015	2016	2017	2018	2019	2020	2021	2022	2023	Cumulative Load Reduction
TN (lbs)	71.37	39.93	22.34	12.50	7.00	3.91	2.19	1.22	0.69	161.14
TP (lbs)	4.96	3.32	2.22	1.49	1.00	0.67	0.45	0.30	0.20	14.60

Summary of Load Reductions

Table C-9 summarizes the projected nutrient and sediment load reductions from each structural and non-structural activity as described in this chapter and provides the total projected reductions from all planned activities.

Table C-9. Summary of Load Reductions by Implementation Activity

		TN	TP	TSS
Total Reduction Needed (lbs)		6,711.0	885.5	759,697
Implementation Activity (lbs reduced)	Annual Street Sweeping / Catch Basin Cleanout	301.4	75.7	37,153
	Stream Restoration	1,974.3	1,592.6	1,020,380
	Homeowner BMPs	161.1	14.6	0[a]
	Septic Connections	290.5	0[a]	0[a]
	Existing BMP Retrofits[b]	817.3	122.9	97,883
Total Reductions (lbs)		3,544.7	1,805.8	1,155,416
Load Reduction Gap (lbs)		3,166.3	0.0	0

[a] This practice does not receive load reduction credit for this parameter.

[b]. See Appendix H for details.

With the currently planned and implemented activities, the TP and TSS load reductions can be met with a large amount of load reduction kept in reserve; however, there is a significant gap in the TN reductions of an estimated 3,166 pounds. Additional BMPs are needed to address the gap. These additional BMPs are discussed in Appendix D.