

ROANOKE RIVER SEDIMENT TMDL ACTION PLAN

(2018 - 2023 MS4 General Permit)

**A Plan for Achieving Sediment Load Reductions
to Meet Salem's TMDL Wasteload Allocation**



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This document addresses Part II B of the General Virginia Pollution Discharge Elimination System (VPDES) Permit for Discharges of Stormwater from Small Municipal Separate Storm Sewer Systems (MS4). This document serves as a City-specific Total Maximum Daily Load (TMDL) Action Plan to identify the best management practices and other interim milestone activities to be implemented to address the sediment waste load allocation (WLA) assigned to the City's regulated MS4 area in the "Benthic TMDL Development for the Roanoke River, Virginia" approved by the Environmental Protection Agency on May 10, 2006.

City of Salem



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EXECUTIVE SUMMARY

The City of Salem is authorized to discharge stormwater from its municipal separate storm sewer system (MS4) under the Virginia Pollutant Discharge Elimination System (VPDES) General Permit for Discharge of Stormwater from Small MS4s (MS4 General Permit). To maintain permit compliance, the City implements a MS4 Program Plan that includes best management practices (BMPs) to address the six minimum control measures (MCMs) and special conditions for the *“Benthic Total Maximum Daily Load (TMDL) Development for the Roanoke River, Virginia.”* The Benthic TMDL for the Roanoke River, approved by the Environmental Protection Agency (EPA) on May 10, 2006, was required to be developed under the authority of the Clean Water Act (CWA) in response to the river’s listing as impaired by the Virginia Department of Environmental Quality (DEQ) for not meeting water quality standards.

The Environmental Protection Agency (EPA) describes a TMDL as a “pollution diet” that identifies the maximum amount of a pollutant the waterway can receive and still meet water quality standards. In the case of the Roanoke River TMDL, sediment was identified as a pollutant of concern and MS4s within the watershed of the impaired segment of the river were assigned a wasteload allocation (WLA). A WLA determines the required reduction in sediment loadings from the MS4s to meet water quality standards and is represented as a 69.5% reduction in sediment loads from urban, agricultural, and transitional land-based sources and instream erosion. The MS4 General Permit serves as the regulatory mechanism for addressing the load reductions described in the TMDL, predominantly through the requirement of a TMDL Action Plan.

Consistent with an approach taken by numerous MS4s throughout the country to achieve significant sediment load reductions, this Action Plan identifies street sweeping as the primary practice to achieve the water quality standard described in the TMDL. Salem has been sweeping to achieve the targeted sediment reductions for its street sweeping program.

Implementation of this Action Plan is consistent with the provisions of an iterative MS4 Program, which constitutes compliance with the MS4 General Permit requirements for reducing pollutants to the maximum extent practicable (MEP).

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Acronyms

BMP	Best Management Practice
CBP	Chesapeake Bay Program
CN	Curve Number
CWA	Clean Water Act
DCR	Virginia Department of Conservation and Recreation
DEQ	Virginia Department of Environmental Quality
EPA	United States Environmental Protection Agency
ESC	Erosion and Sediment Control
GIS	Geographic Information System
GP	General Permit
GPS	Global Positioning System
GWLF	Generalized Watershed Loading Function
HSG	Hydrological Soil Group
IDDE	Illicit Discharge Detection and Elimination
IP	Implementation Plan
LA	Load Allocation
MCM	Minimum Control Measure
MEP	Maximum Extent Practicable
MOS	Margin of Safety
MS4	Municipal Separate Storm Sewer System
MS4 GP	General Permit for Discharge of Stormwater from Small MS4s
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PEOP	Public Education and Outreach Plan
POC	Pollutant of Concern
SWCB	State Water Control Board
SWM	Stormwater Management
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Sediment
VAC	Virginia Administrative Code
VDOT	Virginia Department of Transportation
VPDES	Virginia Pollutant Discharge Elimination System
VSMP	Virginia Stormwater Management Program
WLA	Wasteload Allocation
WTM	Watershed Treatment Model

1.0 INTRODUCTION AND PURPOSE

Mandated by Congress under the Clean Water Act (CWA), the National Pollutant Discharge Elimination System (NPDES) storm water program includes the Municipal Separate Storm Sewer System (MS4), Construction, and Industrial General Permits. In Virginia the NPDES Program is administered by the Department of Environmental Quality (DEQ) through the Virginia Stormwater Management Program (VSMP) and the Virginia Pollutant Discharge Elimination System (VPDES) Program. The City of Salem, Virginia, is authorized to discharge stormwater from its MS4 under the VPDES General Permit for Discharge of Stormwater from Small MS4s (MS4 GP). As part of the permit authorization, Salem developed and implements an MS4 Program Plan that includes best management practices (BMPs) to address the six minimum control measures (MCMs) and special conditions for applicable total maximum daily loads (TMDLs) outlined in the MS4 GP. Implementation of these BMPs is consistent with the provisions of an iterative MS4 Program, which constitutes compliance with the standard of reducing pollutants to the "maximum extent practicable," or MEP.

"The Roanoke River flows through southcentral Virginia before crossing the North Carolina state line and discharging into the Albemarle Sound in North Carolina."

- Benthic TMDL Development
for the Roanoke River, Virginia

1.1 Roanoke River TMDL

A TMDL is defined as the total amount of a given pollutant that a waterbody can assimilate and still meet water quality standards. Typically, TMDLs are represented numerically in three main components: Wasteload Allocations (WLAs), a Load Allocation (LA), and a Margin of Safety (MOS). A WLA is the allocated amount of pollutant from areas discharging through a pipe or other conveyance considered a point source. Point sources include sewage treatment plants, industrial facilities and storm sewer systems. In contrast, an LA is the amount of pollutant from existing non-point sources and natural background sources such as farmland runoff and atmospheric deposition. For the Roanoke River TMDL, an explicit MOS of 10% of the calculated TMDL pollutant load is used to reflect uncertainty in representative modeling computations. In this context, MS4 permittee's are assigned a WLA representing the annual loading of the pollutant of concern (POC) that can be discharged from its regulated MS4 area.

The Virginia DEQ listed segments of the Roanoke River on their biennial 303(d) list in 1996 to due to benthic impairments. Subsequent to the initial listing, a TMDL for Roanoke River, entitled Benthic TMDL for Roanoke River, Virginia was developed. This document is referred to herein as the Roanoke River TMDL. As part of the approved TMDL, Salem's permitted MS4 (VAR040010) was assigned a WLA for sediment discharge to the Roanoke River.

The Roanoke River TMDL assigns a WLA for permitted MS4s within the watershed, which represents an annual sediment load resulting from a percent reduction of the existing and projected future load from the MS4 to meet water quality standards for the watershed. The WLA represents a percent reduction from Salem’s MS4 load. Specifically, the WLA requires a 69.5% reduction of sediment, the pollutant of concern, across specified land use types in the City’s MS4 regulated area.

1.2 TMDL Special Conditions

The special conditions of the MS4 GP are triggered where a permittee has been assigned a WLA under the TMDL. Since the Roanoke River TMDL assigned a WLA to Salem’s MS4, per Part II.B of the MS4 GP, the City is required to “develop a local TMDL action plan designed to reduce loadings for pollutants of concern” (Part II.B.1) and to “complete implementation of the TMDL action plans as soon as practicable. TMDL action plans may be implemented in multiple phases over more than one permit cycle using the adaptive iterative approach provided adequate progress is achieved in the implementation of BMPs designed to reduce pollutant discharges in a manner that is consistent with the assumptions and requirements of the applicable TMDL” (Part II.B.2). Per Part II.B.3 of the MS4 GP, “each local TMDL action plan developed by the permittee shall include the following:

- a. The TMDL project name;
- b. The EPA approval date of the TMDL;
- c. The wasteload allocated to the permittee (individually or in aggregate), and the corresponding percent reduction, if applicable;
- d. Identification of the significant sources of the pollutants of concern discharging to the permittee's MS4 and that are not covered under a separate VPDES permit. For the purposes of this requirement, a significant source of pollutants means a discharge where the expected pollutant loading is greater than the average pollutant loading for the land use identified in the TMDL;
- e. The BMPs designed to reduce the pollutants of concern in accordance with Parts II B 4, B 5, and B 6;
- f. Any calculations required in accordance with Part II B 4, B 5, or B 6;
- g. For action plans developed in accordance with Part II B 4 and B 5, an outreach strategy to enhance the public's education (including employees) on methods to eliminate and reduce discharges of the pollutants; and
- h. A schedule of anticipated actions planned for implementation during this permit term.”

Additionally, per Part II.B.5 of the MS4 GP, the following items specific to local sediment, phosphorus, and/or nitrogen TMDLs apply:

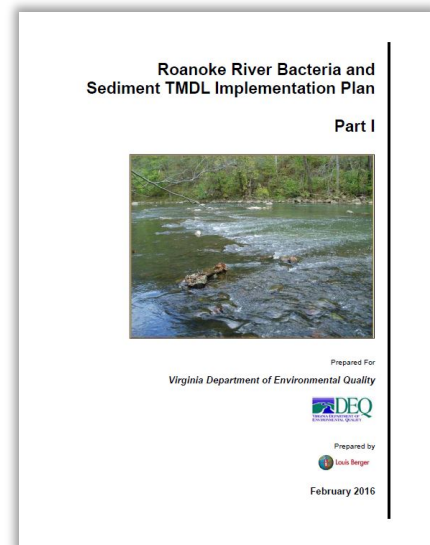
- a. The permittee shall reduce the loads associated with sediment, phosphorus, or nitrogen through implementation of one or more of the following:

- One or more of the BMPs from the Virginia Stormwater BMP Clearinghouse listed in 9VAC25-870-65 or other approved BMPs found on the Virginia Stormwater BMP Clearinghouse website;
 - One or more BMPs approved by the Chesapeake Bay Program; or
 - Land disturbance thresholds lower than Virginia's regulatory requirements for erosion and sediment control and post development stormwater management.
- b. The permittee may meet the local TMDL requirements for sediment, phosphorus, or nitrogen through BMPs implemented to meet the requirements of the Chesapeake Bay TMDL in Part II A as long as the BMPs are implemented in the watershed for which local water quality is impaired.
- c. The permittee shall calculate the anticipated load reduction achieved from each BMP and include the calculations in the action plan required in Part II B 3 f.
- d. No later than 36 months after the effective date of this permit, the permittee shall submit to the department the anticipated end dates by which the permittee will meet each WLA for sediment, phosphorus, or nitrogen.”

Salem submits reporting on the implementation of the MS4 program annually to the Virginia DEQ. The TMDL Action Plan shall be submitted by May 1, 2020 and in subsequent years when any significant modifications occur. Implementation will be reported annually as described in Section 5.3.

1.3 Roanoke River Bacteria and Sediment TMDL Implementation Plan

Following approval of a TMDL, various stakeholders may create an Implementation Plan (IP). Although such plans are alluded to in the Federal CWA legislation, they are not a specific requirement. However, such IPs are a state requirement through Virginia’s 1997 Water Quality Monitoring, Information, and Restoration Act. The Roanoke River Bacteria and Sediment TMDL Implementation Plan, referred to herein as the IP, was developed “to reduce bacteria and sediment to the levels stated in the TMDLs and to restore the waterbodies to conditions that support the primary contact recreation use and attain the aquatic life use standard.”



In regards the City of Salem, the IP includes sediment reductions to be achieved through street sweeping and continued implementation of the City’s stormwater management program. According to the IP, the City estimated significant sediment reductions in 2013 (533 tons) and

plans to expand the City’s street sweeping program to address the TMDL. The IP projects that the expansion to Salem’s street sweeping program would amount to an annual net increase of approximately 270 tons of sediment (see Table 1).

Table 1: Estimated Load Reductions by Street Sweeping Programs in the TMDL Watershed

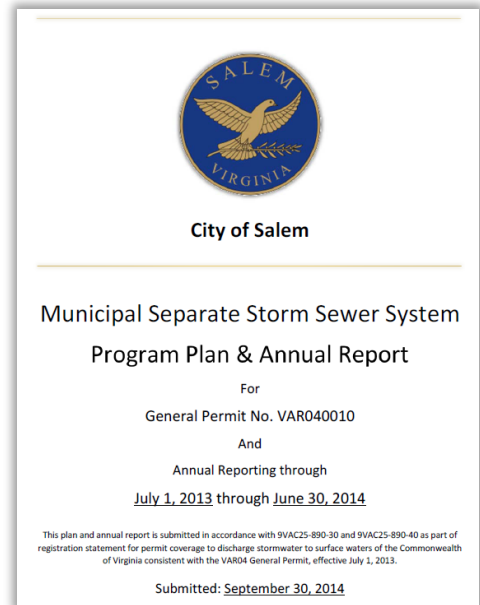
Municipality	Existing Program		Proposed Program		Total Annual Sediment Reduction
	Miles Swept Annually	Annual Sediment Reduction (tons)	Additional Miles Swept Annually	Annual Additional Sediment Reduction (tons)	
City of Roanoke	10,763	9,226	2,526	2,165	11,391
City of Salem	2,115*	533	1,058*	267	800
County of Roanoke	-	-	5,092	2,824	2,824

* Estimated with ArcGIS

** Table 5-12 of the IP

2.0 MS4 PROGRAM ASSESSMENT

The City maintains compliance with the MS4 GP through implementation of BMPs defined in the *City of Salem MS4 Program Plan*. A majority of the program BMPs can be considered nonstructural that, in contrast to structural BMPs. Structural BMPs such as retention ponds capture pollutants after they have washed off the ground surface and been conveyed to the pond through stormwater runoff. Nonstructural BMPs can be considered as “source controls” where the pollutant is either prevented from accumulating or collected from the ground surface prior to exposure to precipitation that would convey the pollutant downstream. Source controls are typically performed at some defined frequency to minimize pollutant build-up and downstream wash-off during a rainfall event. Examples of nonstructural BMPs include community education programs, staff training, good housekeeping and pollution prevention procedures, catch basin cleanout, and street sweeping. There is limited data available for quantifying the pollutant removal efficiencies of nonstructural BMPs. However, the limited research indicates significant reductions are achieved with a higher degree of cost effectiveness than with structural practices. Removal estimates for total suspended solids (TSS) are estimated to range from 30 – 70%.



Consistent with the special conditions described in Section 1.2, the following sub-sections characterize Salem’s existing MS4 program in context of the Roanoke River TMDL pollutant of concern, sediment.

2.1 MS4 General Permit Minimum Control Measures

The City maintains compliance with the MS4 GP through implementation of their MS4 Program that addresses the Minimum Control Measures (MCMs) outlined in the permit. Inherently, most are applicable to addressing reduction or elimination of sediment. Applicability is summarized as:

- ✓ MCM 1: Salem has incorporated information regarding TMDL POCs into the relevant message of the high-priority water quality issue #1 in the City’s Public Education and Outreach Plan (PEOP). As such, public education and outreach incorporates sediment concerns related to water quality in outreach to the general public.
- ✓ MCM 2: Public participation events are developed in conjunction with the PEOP and incorporate sediment as a water quality issue.

- ✓ MCM 3: Salem conducts dry-weather outfall screenings for non-stormwater discharges, including sediment, and implements written procedures for detecting and eliminating identified discharges. Salem has also conducted a city-wide assessment to identify potential sources of sediment. Where applicable per the permit, stormwater pollution prevention plans (SWPPPs) are developed to address potential pollutant discharges, including discharges of sediment. Salem also disseminates information to the public for the reporting of illicit discharges. A prohibition of illicit discharges in the City is established through the municipal code.
- ✓ MCM 4: Regulated land disturbance projects in the City are required to be consistent with the City's erosion and sediment control (ESC) and stormwater management (SWM) Ordinances, which require approved plans that minimize sediment discharge from construction activity and post-construction. Inspections are required to be performed during construction activity and on any post-construction facilities built to address stormwater management.
- ✓ MCM5: Salem's ESC and SWM programs require regulated land disturbance projects to address post-construction water quality. The MCM also requires a long-term inspection and maintenance program for stormwater management facilities to ensure functionality. Although facilities are designed to target phosphorus reductions; facilities that remove phosphorus inherently also remove sediment from passing downstream.
- ✓ MCM 6: Salem developed good housekeeping procedures that are incorporated into staff training. The potential for discharge of sediment was also included in the City's assessment to identify high priority facilities that will be targeted for site-specific SWPPPs.

For further detail on the PEOP, Salem's MS4 Program Plan and Annual Report are available at <https://www.salemva.gov/Departments/Community-Development/Stormwater-Information/Program-Information>.

2.2 Enhanced Public Outreach

The City partners with the Clean Valley Council which implements public education and outreach and Public Involvement and Participation activities to promote methods to eliminate or reduce the discharge of bacteria in the Roanoke River watershed. Examples of enhancement activities could include the following:

- Stream School Seminars
- Stormwater Educational Programs
- Storm Drain Stenciling
- Fall Waterways Cleanup
- Go Fest
- Clean Valley Day Clean Up
- Grandin Earth Day
- Party for the Planet with Mill Mountain Zoo
- Riverfest

2.3 Additional Applicable Practices

Salem's efforts to reduce sediment loads to the Roanoke River go beyond the requirements of the MCMs in the MS4 GP. The additional efforts incorporated into the current MS4 program that are applicable to the reduction of sediment discharges from the MS4 include:

- A more stringent land disturbance area threshold for the requirement of ESC and SWM plans;
- Restrictions for development within floodplains; and
- Partnership in the Clean Valley Council

2.4 Facilities Assessments

Salem has performed a city-wide evaluation for the identification of areas that are significant and/or potential sources of sediment to stormwater runoff. The evaluation was consistent with the MS4 GP Special Condition Part II.B.3. Salem has also identified high priority areas as part of their MS4 Program consistent with Part I.E.6 (c) of the current MS4 GP. The facilities are considered to have a high potential to discharge pollutants and site-specific Stormwater Pollution Prevention Plans (SWPPPs) has been developed to minimize pollutant discharges. The following City-owned and operated facilities were identified as a potential significant sediment source due to include stockpiles and denuded areas:

- The City of Salem's Street and General Maintenance Facility
- Mowles Spring Park

Stormwater Pollution Prevention Plans (SWPPPs) have been developed to minimize pollutant discharges consistent with the schedule requirements of the MS4 GP and the City of Salem MS4 Program Plan.

3.0 ROANOKE RIVER TMDL WLA

The Roanoke River TMDL wasteload allocation for MS4s is land used based and applies to all MS4s in the TMDL watershed, including Roanoke County, the City of Roanoke, the Town of Vinton, Botetourt County, the City of Salem, VDOT Roanoke and Montgomery County Urban Areas, Virginia Western Community College, the Virginia Medical Center, the Town of Blacksburg, and the Town of Christiansburg’s MS4s. The TMDL directs that the WLA is achieved with a “Percent Reduction Method” that compares water quality data to applicable water quality criteria. It identifies a percent reduction of the current sediment load required to meet water quality standards for the watershed.

3.1 TMDL Model Approach

The Roanoke River TMDL describes a modeling approach that used a biomonitoring station at river mile 224.54 of the Roanoke River to develop a “reference watershed” approach to meet the water quality standard. Sediment load reduction throughout the impaired watershed, scaled up from the reference watershed location, is “expected to restore support of the aquatic life use for the Roanoke River.” An area-weighted sediment load for land-based sources was determined for the MS4s and WLAs for MS4s were based on an equal percent reduction (including a 10% margin of safety) across the applicable land use types. The WLA specific to the City is 428.8 tons/year, equivalent to a 69.5% reduction in the existing loads computed at the time of the TMDL development.

3.2 TMDL Implementation Plan WLA Modifications

The IP updated the percent reduction from 69.5% as described above to 75.1% for updated land uses depicted in Table 2. This is a 5.6% increase from the reduction rate of 69.5% across land uses in the 2006 TMDL. Having been developed in 2006 using 1992 land use data, updates to the land use distributions in the modeling scenarios were necessary for a clearer understanding of existing sediment loads. Most notably, there was a drastic increase in urban areas of the TMDL watershed with a corresponding decrease in forested and agricultural areas in the 2006 NLCD (National Land Cover Dataset) data. Updates were also considered due to an overestimation in the original TMDL regarding instream erosion loads in the impaired and reference watersheds.

The IP states, “IPs may be utilized by localities for pollutant reduction strategies; however, they are not considered a requirement for permit compliance.” Therefore, this Action Plan is reliant upon the reduction requirements from the approved TMDL.

As an iterative MS4 program, the City of Salem will update this Action Plan as necessary to meet the reduction requirements as more refined information becomes available.

Table 2: TMDL Load Allocation for Salem

Consolidated Source Category Land Use	TMDL Wasteload Allocation (% reduction)	Draft IP Wasteload Allocation (% reduction)
Agriculture (pasture/hay/row crop)	69.5%	75.1%
Residential (high/low intensity)*	69.5%	75.1%
Commercial/Industrial/Mining*	69.5%	75.1%
Transitional*	69.5%	75.1%
Urban/Recreational Grasses*	69.5%	75.1%
Instream Erosion	69.5%	75.1%

* Applicable for potential discharge to the City's MS4.

As indicated in Table 2, sediment from agriculture and instream erosion would not be applicable to the City's MS4 since sediment from stream bank erosion would not be likely to enter the storm sewer and agricultural land use within the city is less than 3% of the total land area. Table 3 provides an updated land use summary for the City using the 2011 NLCD data.

Table 3: Land Use Summary for the City of Salem based on NLCD 2011

Land Use	Area* (Acres)	% of Total Area	Sediment Source Characteristics	Significant Sediment Source to the MS4?
Developed, High Intensity	822	9	Reduced vegetation and developed exposes soils	yes
Developed, Low Intensity	3,183	35		
Developed, Med. Intensity	2,009	22		
Developed, Open Space	1,729	19		
Evergreen Forest	63	1	Loads from forest are natural condition	no
Mixed Forest	27	0		
Deciduous Forest	947	10		
Hay/Pasture	227	3	Small contributing area	no
Herbaceous Grassland	11	0		
Cultivated Crops	8	0		
Open Water	2	0	Not a sediment source	no

* Total area is 9,030 acres.

3.3 Quantification of Required Reductions

To determine the sediment load reduction required to achieve the WLA of 428.8 tons/year, the required percentage reduction of 69.5% is simply used as:

$$\text{Existing TMDL Load from Salem's MS4} = \frac{428.8 \frac{\text{tons}}{\text{year}}}{(1 - 0.695)} = 1,405 \frac{\text{tons}}{\text{year}}$$

The existing load was computed since it was not explicitly provided in the TMDL. The resulting required reduction in sediment is computed as:

$$\text{Required Sediment Reduction from Salem's MS4} = 1,405 \frac{\text{tons}}{\text{year}} - 428.8 \frac{\text{tons}}{\text{year}} = 976.2 \frac{\text{tons}}{\text{year}}$$

The required load reduction computation is based on the explicit WLA in the TMDL. It is understood that the TMDL incorporated potential sources such as instream erosion that would not contribute to Salem's regulated MS4 area; therefore, the computed existing load may be inaccurate. The resulting calculated loadings likely exceeds the actual sediment contribution from the City's MS4. The City reserves the right to modify the characterization of sediment loadings from its MS4 in the future and modify this Action Plan. Any modifications will be based on refined data inputs and the measures of effectiveness obtained by the means and methods to achieve the WLA, as described in Section 4.

4.0 METHODS TO ACHIEVE THE WLA

The City has served as an active participant in efforts to address the impairments described in the Roanoke River TMDL through maintained compliance with the MS4 General Permit and with implementation of the BMPs described in the IP. In addition to the practices described in Section 2.1 that are beyond those required by the MCMs, the City will implement a street sweeping program to maximize and verify sediment reduction.

4.1 Street Sweeping

Source controls remove sediment from the land surface prior to its conveyance downstream. A source control such as street sweeping can be more cost-effective at a watershed scale than structural controls, such as a detention pond, since larger surface (drainage) areas can be addressed. As discussed in previous sections of this Action Plan and the IP, the City currently performs street sweeping.

As of 2021, the City owns and operates two street sweepers (P134 – 2005 IH 4300 with Tymco Model 600 Regenerative Air Sweeper and a P1037 – 2007 Freightliner FC80 with Tymco DST-6 Regenerative Air Dustless Sweeper). The sweepers operate Tuesday through Friday from 4am to 7am on arterial roads and 7am to 2:30pm on collector roads. Every week 80-90 Lane Miles are swept and the entire City (350 Lane Miles) are typically swept in a month’s time.

4.2 Quantification of Street Sweeping Sediment Reduction

The IP reports that Salem removed 533 tons of sediment in 2013 as a result of street sweeping and predicts 800 tons/year of removal as lane miles of sweeping are increased by 33%. Based on the data provided in the IP, street sweeping has provided significant progress towards achieving the TMDL and further progress is anticipated (see Table 4).

Table 4: Progress from Street Sweeping towards Achieving the WLA According to the IP

Required Reduction (tons/year)	Removed in 2013 (tons/year)	% of Required Reductions (2013)	Predicted removal with increased lane mileage (tons/year)	% of Required Reductions (Future)
976.2	533	55	800	82

Although promising, the 2013 estimate of 533 tons of sediment removed from the IP is lacking quantifiable supporting data. Further, basing future reductions of 800 tons/year on standard “reduction per lane miles swept” does not provide an accurate representation of the actual sediment removed by the City’s efforts.

Consistent with an iterative Program, the City seeks to verify previous estimates of sediment reduction and establish reliable methods for predicting reduction based on future enhancements of the Street Sweeping Program as described in the means and methods listed in Section 5.

4.3 Implementation of MS4 Program

Consistent with the intent of the TMDL and IP, the City also intends to achieve reductions with implementation of the City's MS4 Program Plan. Quantification of sediment reduction resulting from implementation of a stormwater program is difficult; however, peer-reviewed literature indicates significant reductions can be achieved. Ports (2009) campaigns for the importance of source controls as a cost-effective approach to improve water quality, specifically discussing reductions achieved from urban forestry controls (i.e. urban leaf removal), pet waste management and lawn management. Nonstructural practices may also include day to day activities of public works staff or educational efforts to change the behavior of the public. Riggs (2010) recognizes the need to reduce pollutant loads from existing developed lands, citing load reductions resulting from a social marketing approach to educate and excite land owners into participating in efforts, specifically water conservation. Research conducted within Florida MS4s by Raje (2013) analyzed particulate matter from street sweeping, catch basin cleanout, and structural BMPs finding pollutant removal is significantly more economical (by several orders of magnitude) than the use and maintenance of structural BMPs (\$/pound removed). Research applying quantification of reductions is summarized as:

- Murphy and Lokey (1999) developed a spreadsheet model using a Monte Carlo style simulation module to accommodate the uncertainty in published removal efficiencies and other solicited efficiency data for the 36 nonstructural BMPs included the City of Phoenix's MS4 program. The spreadsheet sums the cumulative effect of the BMPs. Removal efficiency is further estimated based on both a physical and implementation factor. Results found the cumulative load reductions of the MS4 Program BMPs to fall between 30 – 51% of a baseline estimate.
- Taylor (2002) reports that city-wide urban stormwater quality management programs are thought to range from roughly 25 – 40% in their cumulative pollutant removal efficiency. Monitoring for the City of Tulsa Oklahoma before and after implementing a stormwater quality management program resulted in reductions of 13% for sediment, 17% for phosphorus, and 18% for nitrogen.
- Taylor and Wong (2002) reference preliminary results from a monitoring based study by Smith and Simmons (2002a, 2002b, and 2000) to estimate the following removal efficiencies for good housekeeping on an industrial site: 8% for TSS (sediment), 40% for N, and 49% for P. With the inclusion of a pollution prevention plan, removal efficiencies are increased to 60% for TSS, 43% for TN, and 56% for TP.

The literature indicates that the implementation of the City’s MS4 Program Plan results in significant reduction in pollutant discharges, including sediment. An initial conservative estimate of the reductions achieved by the MS4 program is based on the cited research and provided in Table 5.

Table 5: Summary of Cited Data & Estimated Reductions from Program Implementation

Reference	Median (%)	Additional Reduction (tons/year)
Murphy and Lokey (1999)	40*	562
Taylor (2002)	13**	183
Taylor and Wong (2002)	60***	605

* General reduction, specific pollutant not specified

** Specific sediment reduction based on monitoring for implementation of an overall program

*** Specific sediment reduction from site with SWPPP

Table 5 gives insight into the potential sediment reduction from implementation of nonstructural BMPs. As a conservative estimate, this Plan considers Taylor (2002) to predict reductions for sediment from implementation of the City’s MS4 program as:

$$1,405 \frac{\text{tons}}{\text{year}} \times 0.13 = 182.65 \frac{\text{tons}}{\text{year}}$$

The required Sediment Reduction is reduced by 13% for the implementation of the City’s MS4 Program as calculated below:

$$\text{Required Sediment Reduction from Salem's MS4} = 976.2 \frac{\text{tons}}{\text{year}} - 182.65 \frac{\text{tons}}{\text{year}} = 793.55 \frac{\text{tons}}{\text{year}}$$

Sediment reduction calculations for street sweeping have been updated from previous Action Plan submittals to now match the guidelines in the Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices final report approved by the CBP dated May 19, 2016 (referred to here as the Expert Panel Report). The Expert Panel Report recommended phasing out the previous methods of calculating sediment reduction from street sweeping in favor of the lane-mile based approach reflected in Table 6.

In lieu of the mass loading approach to quantify reductions, the City will be using the lane mile approach from 2016 Expert Panel Report. The information in Table 6 indicates the mileage required to be swept annually per street sweeping practice in order to meet the sediment reduction required (793.55 tons/year or 1,587,100 lbs./year) for future sediment loads towards achieving the WLA.

Table 6: Estimate of Sediment Removal by Sweeping Using the Lane Mile Approach

	Salem TSS TMDL WLA Reduction Scenarios				Approximate Minimum Lane Miles or Acres/Yr.	Approximate Minimum Lane Miles or Acres to Sweep per Pass
	Street Cleaning Practices Available for Credit			Removal Rate		
	Practice	Description*	Passes/Yr.	TSS		
Advanced Sweeping Technology	SCP-1	2 passes per week	100	0.21	5,814	58
	SCP-2	1 pass per week	50	0.16	7,631	153
	SCP-3	1 pass per 2 weeks	25	0.11	11,099	444
	SCP-4	1 pass every 4 weeks	10	0.06	20,348	2,035
	SCP-5	1 pass every 8 weeks	6	0.04	30,522	5,087
	SCP-6	1 pass every 12 weeks	4	0.02	61,043	15,261
	SCP-7	Seasonal scenario 1 or 2	15	0.07	17,441	1,163
	SCP-8	Seasonal scenario 3 or 4	20	0.1	12,209	610
Mechanical Broom Technology	SCP-9	2 passes per week	100	0.01	122,085	1,221
	SCP-10	1 pass per week	50	0.005	244,170	4,883
	SCP-11	1 pass every 4 weeks	10	0.001	1,220,847	122,085

*Seasonal scenarios are defined as follows:

S1: Spring - One pass every week from March to April. Monthly otherwise.

S2: Spring - One pass every other week from March to April. Monthly otherwise.

S3: Spring and fall - One pass every week (March to April, October to November) Monthly otherwise.

S4: Spring and fall - One pass every other week during the season. Monthly otherwise.

Notes:

(1) The standard street cleaning unit is the number of curb miles swept. One impervious acre is equivalent to one curb-lane mile swept assuming swept on one side only.

(2) Acres of parking lot swept are converted to lane miles using one acre = one curb lane mile.

(3) Loading Rates associated with urban impervious cover in the Chesapeake Bay Watershed.

Average TN Load 15.5 lbs/ac/yr

Average TP Load 1.93 lbs/ac/yr

Average TSS Load 1,300 lbs/ac/yr

5.0 ACTION PLAN

Based on the literature review and predicted reductions from street sweeping, the City concludes the WLA can be achieved with street sweeping and implementation of the MS4 Program, consistent with the IP. Verification of this conclusion will be evaluated with the implementation of the Action Plan described in the following subsections. For planning purposes, an estimated “end date” for achieving the WLA will be June 30, 2040.

5.1 Street Sweeping Program

Street sweeping is anticipated to achieve the bulk of the reductions necessary to achieve the WLA, specifically with the planned implementation of the City’s Street Sweeping Program.

Street sweeping efforts will take the following action steps:

1. Coordination with DEQ to be able to take additional credit for the implementation of Salem’s MS4 Program. Evaluate a credit for the reduced land disturbance threshold written in Salem’s ordinance. Determine the lane miles swept potential of City streets. Select a practice to implement from Table 6 of this report.
2. Develop necessary documentation per expert panel report.
3. Develop sweeping training materials and implement training.
4. Assess numerical progress towards meeting the WLA over the permit cycle. Re-evaluate Street Sweeping Program.

The action steps identified above are intended to serve as a defined method that inherently aids as an adaptive iterative approach to achieve the WLA.

5.2 Continued MS4 Program Plan Implementation

The City will continue to implement its MS4 Program Plan and update the literature provided in Section 4.3. If necessary, after quantification of street sweeping reductions, the City will attempt to quantify reductions achieved by programmatic reductions based on research and other methods as additional information becomes available.

5.3 Progress Reporting

Progress will be reported through explicit accounting of sediment reductions using the “Lane Mile Approach” to quantify sediment reductions. The City’s Annual Report will serve as the annual documentation for tracking progress.

5.4 Street Sweeping Schedule

Since the approval of the Roanoke River Sediment TMDL, the City has made significant progress in the reduction of sediment loads from its MS4. These reductions are demonstrated qualitatively in the MS4 Program assessment described in Section 2 and with the estimated reductions from street sweeping described in the IP. Additional reductions will be quantified from street sweeping efforts as described in Section 5.1. Table 7 summarizes the schedule for the implementation of the Action Plan’s Street Sweeping Program steps described in Section 5.1.

Table 7: Schedule for Salem’s TMDL Action Plan Street Sweeping Program

Step	General Description	Measurable Goal	Completion Date
1	Research additional credits to decrease the required reduction and select a street sweeping scenario to implement	<p>Coordination with DEQ to be able to take additional credit for the implementation of Salem’s MS4 Program.</p> <p>Evaluate a credit for the reduced land disturbance threshold written in Salem’s ordinance.</p> <p>Determine lane miles swept potential of City streets. Select a street sweeping scenario to implement from Table 6 of this report.</p>	June 30, 2021
2	Tracking documentation	Develop necessary documentation per expert panel report.	June 30, 2022
3	Staff training	Develop sweeping training materials and implement training.	June 30, 2023
4	Program evaluation	<p>Assess numerical progress towards meeting the WLA over the permit cycle.</p> <p>Re-evaluate Street Sweeping Program.</p>	June 30, 2024

6.0 REFERENCES

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