VERMONT AGENCY OF TRANSPORTATION TS4 STORMWATER MANAGEMENT PROGRAM (SWMP)

National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007

November 2022

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LIST OF ATTACHMENTS

1.0 PURPOSE, PERMIT OVERVIEW, AND AUTHORITY

The Vermont Agency of Natural Resources (VT ANR) Department of Environmental Conservation issued the National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 (GP 3-9007) for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4; the Permit), effective November 29, 2022. GP 3-9007 for stormwater discharges from the Vermont Agency of Transportation (VTrans; the Agency) owned or controlled impervious surfaces. Per Part 1 of the Permit, the purpose of the Permit is to provide efficiencies in overall program management by combining post-construction operational stormwater requirements for VTrans that are associated with its designated regulated small municipal separate storm sewer systems (MS4s); industrial activities, commonly regulated under the Multi-Sector General Permit 3-9003 (MSGP 3-9003); and previously permitted, new, redeveloped, and/or expanded impervious surfaces, commonly regulated under State Operational Stormwater Permits.

The Permit is issued pursuant to the Vermont Water Pollution Control statute, 10 V.S.A. Chapter 47, specifically §§ 1258 and 1264; the Vermont Water Pollution Control Permit Regulations (Environmental Protection Rules, Chapter 13), including the rule governing general permits in Section 13.12; the Vermont Stormwater Management Rule (Environmental Protection Rules, Chapter 18); the Vermont Stormwater Management Rule for Stormwater-Impaired Waters (Environmental Protection Rules, Chapter 22); the federal Clean Water Act (CWA), as amended, 33 U.S.C. § 1251 *et seq.*; and related regulations of the United States Environmental Protection Agency (U.S. EPA) at 40 C.F.R. 122.

2.0 COVERAGE UNDER THIS PERMIT

As outlined in Part 2 of the Permit, the Permit applies to:

- VTrans-owned or controlled state highways, sidewalks, multi-use pedestrian paths, welcome centers, airports, gravel pits, mineral mining, maintenance facilities, park & rides, truck weigh stations, and VTrans-owned facilities leased to third parties, including welcome centers and airport facilities (hangars and terminals), and excludes rail lines, rail yards, public transit facilities, and rail trails.
- State highways and VTrans-owned or controlled non-road impervious surfaces in the urbanized areas and stormwater-impaired watersheds of Burlington, Colchester, Essex, Essex Junction, Milton, Shelburne, South Burlington, Williston, Winooski, the University of Vermont, the Burlington International Airport, Jericho, Underhill, St. Albans, the Town of St. Albans, the Town of Rutland, and the City of Rutland.
- VTrans-owned or controlled airport facilities and non-metallic mineral mining facilities.

3.0 APPLICATION REQUIREMENTS

VTrans has prepared the enclosed Stormwater Management Program (SWMP) to address Part 5 of the Permit. The SWMP is a comprehensive plan for all stormwater discharges that are covered under the Permit to address information required within specific parts of the Permit. It is intended that this SWMP will advance and evolve through the term of the Permit. VTrans will coordinate the implementation of this SWMP with the related activities of the Municipal and Non-Traditional MS4s in Vermont, as necessary where overlap with these MS4s may occur.

Per Part 3 of the Permit, VTrans is submitting the following materials to VT ANR in conjunction with this SWMP to serve as an application for authorization to discharge stormwater from the TS4:

3.1 NOTICE OF INTENT

In conjunction with submittal of this SWMP to VT ANR, VTrans has provided a completed and signed Notice of Intent (NOI) in accordance with submittal requirements of Subpart 3.1 and deadlines of Subpart 3.2 of the Permit.

3.2 ATTACHMENTS

Necessary attachments are included with this SWMP as follows:

- Attachment A: List of Waters (Table 1 and Table 2)
- Attachment B: Chittenden County MS4 Stormwater Program Agreement (July 1, 2017)
- Attachment C: VTrans Bridge Washing Best Management Practices and VT ANR Vehicle Washing Policy
- Attachment D: VTrans Flow Restoration Plan
- Attachment E: VTrans Phosphorus Control Plan
- Attachment F: Incorporation of Previously Permitted Stormwater Systems
- Attachment G: Stormwater Program Evaluation Top 13 Actions
- Attachment H: Gap Procedure

3.3 APPLICATION FEE

In addition to the SWMP, NOI, and attachments, VTrans is also providing payment of the applicable fee (per 3 V.S.A. § 2822(j)(2)) via electronic transfer of funds.

4.0 DISCHARGE REQUIREMENTS

REQUIREMENT – *Per Part 4 of the Permit, impaired waters are those waters that VT ANR has identified pursuant to Section 303(d) of the Clean Water Act as not meeting the Vermont Water Quality Standards (VWQS). Impaired waters encompass both those with approved Total Maximum Daily Loads (TMDLs) or Water Quality Restoration Plans (WQRPs), and those for which TMDL development has been identified as necessary, but for which a TMDL has not yet been approved by the U.S. EPA.*

Per the Permit, except for Part 9, a VTrans project is considered to discharge to an impaired water if the first water of the State to which runoff discharges is identified as an impaired water. For discharges that enter a separate storm sewer system prior to discharge, the first water of the State to which runoff is discharged is the waterbody that receives the stormwater discharge from the storm sewer system.

VTRANS RESPONSE – To address this requirement, VTrans has developed and provided a complete list of first waters to which designated MS4 areas discharge, refer to Table 1 in Attachment A.

4.1 DISCHARGES TO IMPAIRED WATERS WITH AN APPROVED TOTAL MAXIMUM DAILY LOAD WITH WASTELOAD ALLOCATION

REQUIREMENT – *Per Subpart 4.2 of the Permit, for any discharge from the TS4 to impaired waters with an approved TMDL, VTrans shall control discharges consistent with the assumptions and requirements of any wasteload allocation (WLA) applicable to VTrans in the TMDL. VTrans shall describe in the SWMP all measures that are being used to address this requirement.*

If the applicable TMDL specifies a WLA or other requirements either individually or categorically for the TS4 discharge, VTrans shall describe in its annual reports all control measures which have been or are planned to be implemented to control discharges consistent with the assumptions and requirements of the TMDL WLA. VTrans shall include in the annual reports and the SWMP the rationale supporting VTrans' assessment that such controls are adequate to meet the applicable TMDL requirements.

VTRANS RESPONSE – To address this requirement, discharges from the TS4 to impaired waters with an approved TMDL, including descriptions of the measures being used to address requirements where applicable, are listed in Tables 1 and 2 in Attachment A.

VTrans will report annually on control measures that have been or are planned to be implemented to control discharges consistent with the assumptions and requirements of the TMDL WLA.

4.2 DISCHARGES TO IMPAIRED WATERS WITH AN APPROVED TOTAL MAXIMUM DAILY LOAD WITHOUT WASTELOAD ALLOCATION

REQUIREMENT – *Per Subpart 4.2 of the Permit, if the applicable TMDL does not specify a WLA or other requirements either individually or categorically for the TS4 discharge and VTrans has complied with the terms and conditions of this permit, and has undertaken VT ANR-approved measures and documented them in the SWMP to address the pollutant(s) of concern addressed by the TMDL, then compliance with these conditions will be presumed adequate to meet the requirements of this permit.*

VTRANS RESPONSE – To address this requirement, Tables 1 and 2 in Attachment A provide a list of discharges from the TS4 to impaired waters with approved TMDLs, where the TMDL does not specify a WLA or other requirements for the TS4 discharge. These tables also provide a summary of VT ANR-approved measures that VTrans is implementing and documenting in the SWMP to address the pollutant(s) of concern addressed by the TMDL.

4.3 DISCHARGES TO IMPAIRED WATERS WITHOUT AN APPROVED TOTAL MAXIMUM DAILY LOAD

REQUIREMENT – *Per Subpart 4.2 of the Permit, if the TS4 discharges to an impaired water that is without an approved TMDL, but that is listed as impaired on the "State of Vermont 303(d) List of Impaired Waters, Part A – Impaired Surface Waters in Need of TMDL," VTrans shall address in its SWMP and annual reports how any identified and mapped VTrans' discharges that cause or contribute to the impairment will be controlled to ensure compliance with the VWQS.*

VTRANS RESPONSE – To address this requirement, Tables 1 and 2 in Attachment A provide a list of identified and mapped discharges from the TS4 to impaired waters that are listed on the "State of Vermont 303(d) List of Impaired Waters, Part A – Impaired Surface Waters in Need of TMDL." Where VTrans' discharges may cause or contribute to the impairment, measures VTrans is implementing to ensure compliance with the VWQS are summarized in these tables and embedded in this SWMP.

5.0 STORMWATER MANAGEMENT PROGRAM (SWMP)

REQUIREMENT – *Per Subpart 5.1 of the Permit, VTrans shall develop a written SWMP to include information required, as necessary, under Part 3 of the Permit; the information required under Part 4 of the Permit to address discharges to impaired waters; the required elements under the six minimum control measures in Part 6 of the Permit; the industrial control measures in Part 7 of the Permit, including the Stormwater Pollution Prevention Plan (SWPPP); the operation stormwater requirements under Part 8 of the Permit; and the Flow Restoration Plan (FRP) and Phosphorus Control Plan (PCP) developed in accordance with Part 9 of the Permit.*

VTRANS RESPONSE – See each corresponding part within this SWMP for required information. To meet requirements of Subpart 5.2 of the Permit, VTrans will perform an annual review of the SWMP in conjunction with preparation of the annual report required under Subpart 10.2.

6.0 MINIMUM CONTROL MEASURES

REQUIREMENT – *Per Part 6 of the Permit, VTrans shall develop, implement, and enforce a SWMP, which shall include the six minimum control measures, designed to reduce the discharge of pollutants from the TS4 to the maximum extent practicable (MEP), to protect water quality, and to satisfy the appropriate water quality requirements of the Clean Water Act. For purposes of the six minimum control measures, implementation of Best Management Practices (BMPs) consistent with the provisions of the SWMP shall constitute compliance with the standard of reducing pollutants to the MEP. The SWMP must include the following information for each of the six minimum control measures:*

1. *The person or persons responsible for implementing or coordinating the SWMP and the BMPs for the SWMP.*

   VTRANS RESPONSE – Fulfilling the requirements of the SWMP is a cross agency effort, requiring the support of multiple internal stakeholders to implement the minimum control measures. The District Maintenance and Fleet Division Pollution Prevention and Compliance Program's Water Quality Unit plays the lead role in coordination and is the ultimate responsible party for implementation of the TS4 SWMP.

2. *The BMPs that VTrans or another entity will implement for each of the six minimum control measures. EPA has provided a list of sample BMPs on its website:* https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu

   VTRANS RESPONSE – Please see responses under each minimum control measure below.

3. *The measurable goals for each of the BMPs including, as appropriate, the months and years in which the required actions will be undertaken, including interim milestones and the frequency of the action. When possible, the measurable goals should include outcome measures related to the BMPs impact on water quality, stream channel stability, ground water recharge, and flood protection. EPA has provided guidance on developing measurable goals at the link above.*

   VTRANS RESPONSE – Please see responses under each minimum control measure below.

4. *A rationale for how and why VTrans selected each of the BMPs and measurable goals for the SWMP. The rationale should describe: (1) the stormwater problems to be addressed by the BMPs, (2) the major alternative BMPs to the ones selected and why they were not adopted, (3) the behavioral and institutional changes necessary to implement the BMPs, and (4) expected water quality outcomes.*

VTRANS RESPONSE AND RATIONALE – VTrans has been complying with these minimum control measures under the MS4 permit from 2003 to 2017 and then the TS4 permit since 2017 and collaborating with the Agency of Natural Resources on the effectiveness of the selected BMPs. We have found based on experience and trial and error that the selected BMPs are best suited to address permit specified stormwater problems and achieve expected water quality outcomes for the transportation sector. VTrans is committed to stewardship of the natural and cultural resources of the State of Vermont.

The six minimum control measures include:

1. Public Education and Outreach on Stormwater Impacts (MCM 6.A)
2. Public Involvement and Participation (MCM 6.B)
3. Illicit Discharge Detection and Elimination (MCM 6.C)
4. Construction Site Stormwater Runoff Control (MCM 6.D)
5. Post-Construction Stormwater Management for New Development and Redevelopment (MCM 6.E)
6. Pollution Prevention and Good Housekeeping for VTrans' Operations (MCM 6.F)

MCM 6.A: PUBLIC EDUCATION AND OUTREACH ON STORMWATER IMPACTS

REQUIREMENT – *Per Subpart 6.3.A of the Permit, VTrans shall develop and implement a public education campaign reasonably designed to educate frequent facility users about the impacts of stormwater* discharges *on water bodies. The program shall include the steps that facility users can take to reduce pollutants in stormwater runoff including an explanation of the problem of stormwater volume and solutions for reducing the amount of runoff volume reaching waters of the State.*

VTRANS RESPONSE – For the purpose of this SWMP, the definition of "public" includes "the employees, clients and visitors to the TS4 property, and any contractors working at the facility where the TS4 is located."

To meet this *requirement* VTrans has been and will continue to implement the following practices.

1. Maintain a web site with locally relevant stormwater management information, including the problem of stormwater and solutions for reducing the amount of runoff reaching waters of the State, and promote the web site's existence and use. The website is available at the following link: https://vtrans.vermont.gov/highway/project-delivery-environmental/stormwater

   Measurable Goal: VTrans will update the web site annually.

   Reporting: There are no reporting requirements.

2. Establish educational kiosks or demonstration projects at public facilities. VTrans has established and maintained educational kiosks and demonstration projects at public facilities at the St. Albans Park and Ride, Randolph Park and Ride, and the Williston I-89 northbound welcome center that highlight steps taken to reduce pollutants in stormwater runoff.

   Measurable Goal: VTrans will establish one additional education kiosk or demonstration project in the permit term.

   Reporting: VTrans will report annually on progress.

3. Participate in the Chittenden County Regional Stormwater Education Program (RSEP) described in the July 1, 2018, memorandum of understanding between designated small MS4s, VTrans, and Chittenden County Regional Planning Commission or subsequent amendment, or in a regional public education and outreach strategy approved by VT ANR; see Attachment B.

   Measurable Goal: VTrans will continue to participate in the Chittenden County MS4 Stormwater Program Agreement, effective July 1, 2018 (see Attachment B).

   Reporting: VTrans will report annually on accomplishments achieved under this activity.

VTRANS RATIONALE – Educating frequent facility users about the impacts of stormwater discharges on water bodies fosters greater support for and greater compliance with the TS4 (and MS4) program. VTrans will continue to maintain a website, educational kiosks, and demonstration sites at public facilities; and will participate in the Chittenden County MS4 Stormwater Program Agreement (or subsequent amendment/agreement). These educational opportunities have proven effective in increasing people's awareness of their connection to and impact on activities occurring in their watershed to improve water quality, stream channel stability, groundwater recharge, and flood protection.

One example of an alternative BMP that was used in the 2003 SWMP to comply with this MCM was storm drain marking. However, there is little pedestrian activity on much of VTrans's roads, and the activity of storm drain marking along busy highways was hazardous to Agency personnel completing the activity. The BMP was found to not be effective and was discontinued in 2012.

MCM 6.B: PUBLIC INVOLVEMENT AND PARTICIPATION

REQUIREMENT – *Per Subpart 6.3.B of the Permit, VTrans shall develop and implement a public involvement and participation program, and the program shall, at a minimum, comply with applicable state and local public notice requirements.*

VTRANS RESPONSE – For the purpose of this SWMP, the definition of "public" includes "the employees, clients and visitors to the TS4 property, and any contractors working at the facility where the TS4 is located."

To meet this requirement VTrans has been and will continue to:

1. Participate in the Chittenden County MS4 Stormwater Program Agreement described in the July 1, 2018 memorandum of understanding between designated

small MS4s, VTrans, and the Chittenden County Regional Planning Commission (website: http://smartwaterways.org/) or subsequent amendment, or in a regional public involvement and participation program approved by the Secretary; see Attachment B.

Measurable Goal: VTrans will continue to participate in the Chittenden County MS4 Stormwater Program Agreement, effective July 1, 2018 (see Attachment B).

Reporting: VTrans will report annually on accomplishments achieved under this activity.

VTRANS RATIONALE – Public participation increases people's awareness of their connection to and impact on activities occurring in their watershed. Although not directly quantifiable, these activities and increased awareness can positively impact water quality, stream channel stability, groundwater recharge, and flood protection. Due to the success of the program, VTrans will continue to participate in the "Stream Team" as described in the July 2018 memorandum of understanding (or subsequent amendment), as opposed to implementing a different regional public involvement and participation strategy such as one outlined in the Permit.

One example of an alternative BMP that was used in the 2003 SWMP to comply with this MCM was storm drain stenciling, where VTrans had a goal of developing and implementing a storm drain stenciling within its MS4 area. However, the activity of storm drain marking along busy highways was quite hazardous to both the traveling public and the volunteers completing the activity. The BMP was re-assessed in 2004 and VTrans chose to pursue partnerships with other MS4s. Ultimately it was more effective for VTrans to participate in the Stream Team and the storm drain stenciling BMP was discontinued.

MCM 6.C: ILLICIT DISCHARGE DETECTION AND ELIMINATION

REQUIREMENT – *Per Subpart 6.3.C, VTrans shall develop, implement, and enforce a program to detect and eliminate illicit discharges into the stormwater systems of the TS4.*

VTRANS RESPONSE – To meet this requirement, VTrans will:

1. Develop and maintain a storm sewer geographic information systems (GIS) map of the separate storm sewer systems within the VTrans' designated regulated small MS4s and showing the location of all outfalls and the names and location of all waters of the State that receive discharges from those outfalls, and, to the extent practicable, map the remainder of the stormwater systems of the TS4. VTrans will utilize publicly available natural resources and stormwater infrastructure layers and as built plans along with the field collected data to create and maintain this map. This will be made available to the public through the VTrans website.

   Measurable Goal: The MS4 was mapped under the 2003 MS4 permit and then updated to add in additional MS4 areas for the 2012 MS4 permit. VTrans will use ArcGIS Collector to maintain the current MS4 mapping and expand it to capture the statewide system as resources are available, including verifying outfall locations with field surveys. In 2022, VTrans updated its mapping protocol to include a more intensive data collection of the system. This update allows VTrans to collect more detailed data to be used for the development and implantation of the Lake Champlain Phosphorus Control Plan. Currently there are 25,598 swales in the VTrans database, to date 6,848 swales have been inspected. VTrans will inspect the remaining swales within the permit term.

Reporting: VTrans will report annually on progress and accomplishments.

2. Adopt a policy prohibiting non-stormwater discharges, except for those listed in Subpart 2.2.B of the Permit, into the stormwater systems of the TS4 and implement appropriate enforcement procedures and actions.

   Measurable Goal: In 2021VTrans adopted a policy to Prohibit Illicit (non-stormwater) discharges into VTrans TS4 https://vtrans.vermont.gov/sites/aot/files/SupportServices/Non-stormwater%20Prohibition%20into%20TS4.pdfVTrans will continue to comply with this policy.

   Reporting: There are no reporting requirements.

3. Develop and implement a plan pursuant to Subpart 6.3.C.1.c to detect and address non-stormwater discharges, with emphasis on outfalls in the stormwater-impaired watersheds, and random illegal dumping to the stormwater systems of the TS4, such as the dumping of RV wastes, used oil, and paint.

   Measurable Goals: VTrans completed testing of outfalls for illicit discharges in the MS4 areas. VTrans developed a plan to conduct a similar testing approach outside the MS4 areas within the TS4. In the permit term, VTrans will begin implementing the plan within a pilot area to determine its effectiveness with the goal of finalizing the plan in the 2nd year of the permit. VTrans will then begin full implementation of the plan starting in year 3 of the permit. VTrans developed a reporting and enforcement standard operating procedure (SOP) in collaboration with ANR Enforcement Division, other state agencies and local officials to address non- stormwater discharges coming from outside of our Rights-of-Way (ROW) where we are lacking legal authority.

   In addition, the Agency has a HazMat Unit that addresses spill response, prevention and source control such as used oil, fuel storage and dumping of hazardous materials. See MCM 6.F for more information.

   Reporting: VTrans will report annually on progress and accomplishments including the number of illicit discharges encountered each year. VTrans will report annually on the status of the plan to conduct a similar testing approach outside of the MS4 area. VTrans will report annually on the number of outfalls tested starting in year 3.

4. Inform public employees and the general public of hazards associated with illegal discharges and improper disposal of waste.

   Measurable Goals: Within the first 3 years of the permit term, VTrans will develop an informational webpage to Inform public employees and the general public that discusses these hazards.

   In addition, the Agency conducts various trainings for public employees and the public. See MCM 6.A, 6.D, 6.E, and 6.F.

   Reporting: VTrans will report annually on progress and accomplishments.

5. VTrans will address the following categories of non-stormwater discharges, if VTrans identifies them as significant contributors of pollutants to the TS4 stormwater systems:

   - Water line flushing
   - Landscape irrigation
   - Diverted stream flows
   - Rising ground waters
   - Uncontaminated ground water infiltration
   - Uncontaminated pumped ground water
   - Discharges from potable water sources
   - Foundation drains
   - Air conditioning condensation
   - Irrigation water
   - Springs
   - Water from crawl space pumps
   - Footing drains
   - Lawn watering
   - Individual residential car washing
   - Flows from riparian habitats and wetlands
   - Dechlorinated swimming pool discharges
   - Street wash water
   - Discharges from firefighting activities

   Discharges from bridge washing and vehicle washing are not authorized under this permit; to address these discharges, the Agency will follow the VTrans Bridge Washing BMPs and VT ANR's Vehicle Washing Policy (see Attachment C). Any other discharge to the Agency's TS4 that is not authorized under this permit will be treated as an unpermitted discharge and dealt with per the requirements of this permit.

   VTrans will continue to implement an existing program that issues permits for residential and commercial access to the State ROW. VTrans also issues permits for non-VTrans projects within the ROW. The program includes review of proposals for open and/or closed connection to the VTrans TS4 from residential and commercial property owners. To the extent allowable under State or local law, VTrans uses this Title 19 Section 1111 Permitting authority to effectively prohibit non-stormwater discharges into the VTrans TS4 storm sewer system and implement appropriate enforcement procedures and actions to satisfy the terms of the Permit. This is implemented through the imposition of Special Conditions (put in place in 2007) under its Title 19, Section 1111 Permitting Authority on all identified proposed and existing connections to the VTrans TS4 stormwater system.

   Measurable Goals: VTrans will continue to monitor for these categories of discharges, investigate the significance of each and take appropriate enforcement action for those that warrant action. Collaboration with VT ANR Enforcement Division, other State Regulatory Agencies and Local Official may be required to take the lead role on enforcement.

Reporting: VTrans will report annually on any non-stormwater discharges discovered and actions taken.

VTRANS RATIONALE – The BMPs selected above are intended to keep non stormwater discharges out of the storm sewer system. In order to do that, it is important to know where the assets are located which requires a robust mapping program as proposed in subpart 6.3.C.1.a. Establishing a policy was integral to ensure appropriate enforcement procedures and actions are being taken and sets expectations for internal and external stakeholders. The above practices are intended to inform employees and the public of hazards associated with illegal discharges and improper disposal of waste. This plan will be coordinated with the public education and outreach, public involvement and participation, and pollution prevention and good housekeeping minimum control measures.

Many of the BMPs proposed above have proven successful over the past years in the limited area that they were applied and will now be expanded to a greater area. Due to the need to expand this program to a larger area, following the policy and SOPs become even more important to achieve the water quality benefits that accrue from eliminating illicit discharges.

For this MCM, no BMPs have been ineffective and so alternative BMPs were not considered as replacements for existing ones. However, the program and BMPs are being expanded in geographic extent as a result of implementation of the TS4.

MCM 6.D: CONSTRUCTION SITE STORMWATER RUNOFF CONTROL

REQUIREMENT – *Per Subpart 6.3.D of the Permit, VTrans shall develop, implement, and enforce a program to reduce pollutants in any stormwater runoff from construction activities that result in a land disturbance of greater than or equal to one acre. Reduction of stormwater discharges from construction activity disturbing less than one acre shall be included if that construction activity is part of a larger common plan of development or sale that would disturb one acre or more.*

VTRANS RESPONSE – To meet this requirement, VTrans has and will continue to:

1. Implement procedures to assure that construction activities undertaken by VTrans are properly permitted and in compliance with the terms of their stormwater construction permits.

   Measurable Goals: VTrans will comply with the Construction General Permit (GP 3-9020) and/or Individual Stormwater Discharge Permit (INDC) coverage.

   Reporting: VTrans will report annually a list of projects in the TS4 with Construction General Permit (GP 3-9020) and/or Individual Stormwater Discharge Permit (INDC) coverage.

2. Review existing policies to determine their effectiveness in managing construction-related erosion prevention and sediment control (EPSC), and controlling waste such as discarded building materials, concrete truck washout, chemicals, litter, and sanitary waste at construction sites that may cause adverse impacts to water quality.

Measurable Goals: VTrans will review existing policies on their effectiveness in meeting this standard. VTrans will inventory its existing policies related to erosion control and waste management and will conduct an effectiveness evaluation on the policies and update as needed.

Reporting: VTrans will report annually on existing policies inventoried, policies reviewed and any changes that are made.

3. Review its policies for their consistency with the requirements of the VT ANR general permits for stormwater runoff from large and small construction sites and construction EPSC guidelines for low-impact development.

   Measurable Goals: VTrans will review existing policies on their effectiveness in meeting this standard. VTrans will inventory its existing policies related to their consistency with VT ANR construction stormwater requirements and conduct an effectiveness evaluation on the policies and update as needed.

   Reporting: VTrans will report annually on existing policies inventoried, policies reviewed and any changes that are made.

4. Implement a plan that addresses stormwater runoff from VTrans' construction activities not subject to state or federal EPSC requirements.

   The VTrans EPSC Protocol, established in February 2007 and revised in September 2020 sets guidelines for Consultants, VTrans Designers, VTrans Construction Management Staff and District field staff for creating and implementing consistent EPSC Plans that meet the requirements of CGP 3-9020 and for those projects disturbing less than one acre with any potential to impact resources. The VTrans EPSC Protocol can be found at the following link: https://vtrans.vermont.gov/working/enviro/erosion-prevent

   Measurable Goal: VTrans will continue to follow the EPSC Protocol Statewide under the TS4.

   Reporting: VTrans will report annually on the number of projects following the EPSC Protocol.

5. VTrans will continue to conduct environmental compliance site visits to projects during construction which includes review of EPSC measures. The primary purpose of these visits is to ensure that VTrans protects natural resources and complies with state and federal regulations through implementation of project EPSC Plan and compliance with environmental permit conditions.

   Measurable Goals: The VTrans Construction Engineers will visit VTrans-contracted construction projects to provide input, training, support, and resources relative to EPSC.

Reporting: VTrans will report annually on the number of construction sites visited within the TS4.

6. VTrans offers a broad range of formal and informal training on EPSC and stormwater management design to Agency staff. These training classes have been led by both VTrans and non-VTrans subject experts from around the country and have been attended by other regulators and consultants. VTrans provides an extensive amount of annual EPSC training to maintenance and construction employees through internal training meetings. VTrans staff are also encouraged to seek training opportunities outside the Agency. Annual training for Maintenance District personnel training includes a session on stormwater management, EPSC, and compliance with regulations governing these activities.

   Measurable Goal: VTrans will conduct and attend trainings on an annual basis.

   Reporting: VTrans will report annually on number of trainings, class titles, target audience, and attendance.

VTRANS RATIONALE – The above BMPs were selected to control runoff and sediment transport from construction sites. VTrans has successfully implemented the BMPs around construction phase stormwater management on projects of any size for the past 15 years. This has become ingrained in the culture of the Agency to such an extent that other major alternative BMPs do not warrant consideration at this time. Expected water quality outcomes are those established in the regulatory programs for construction stormwater discharge.

An alternative BMP that was previously tracked and reported under this MCM was the number of VTrans personnel who were CPESC-credentialed. VTrans does pay for and encourage attendance at trainings including the preparatory workshops for CPESC certification but has found that staff taking the exam and becoming credentialed is less important than routine application of the information presented at the trainings in their daily work. As a result, VTrans ceased tracking this BMP in 2013.

MCM 6.E: POST-CONSTRUCTION STORMWATER MANAGEMENT FOR NEW DEVELOPMENT AND REDEVELOPMENT

REQUIREMENT – *Per the NOI, If the TS4 is incorporating a Stormwater system that was previously authorized under a State Stormwater permit, the Stormwater management practices associated with the permit listed below shall be listed in VTrans Stormwater Management Program (SWMP) under Minimum Control Measure 5, Post-Construction Stormwater Management.*

VTRANS RESPONSE – To meet these requirements, VTrans created a list of the stormwater treatment practices covered by the TS4 permit (refer to Attachment F).

Measurable Goal: VTrans will annually review and update the list of stormwater treatment practices covered by the TS4 to ensure compliance with the VT ANR post-construction stormwater permit program for these practices.

Reporting: Refer to part 8 for this information.

REQUIREMENT – *Per Subpart 6.3.E of the Permit, VTrans shall develop, implement, and enforce a program to address post-construction stormwater runoff from new development and redevelopment projects that involve land disturbance of greater than or equal to one acre and that are not subject to regulation under the VT ANR post-construction stormwater management permit program. The program must ensure that controls are required that will prevent or minimize water quality impacts.*

VTrans shall develop, implement, and enforce a program to reduce pollutants in any post-construction stormwater runoff from only those activities that result in land disturbance of greater than or equal to one acre and that are not subject to regulation under the VT ANR post-construction stormwater permit program.

VTRANS RESPONSE – To meet these requirements, VTrans will:

1. Review existing policies to determine their effectiveness in managing stormwater runoff that discharges from new development and redevelopment projects to prevent adverse impacts to water quality; determine their consistency with the requirements of VT ANR's rules and general permits regulating post-construction stormwater runoff; assess whether changes can be made to such policies, regulations, and ordinances in order to support low-impact design options; and assess whether changes can be made to current street design and parking lot guidelines and other requirements that affect the creation of impervious surfaces to support low-impact design.

   The VTrans Project Post-Construction (Operational) Stormwater Protocol: VTrans projects that fall within VT ANR's jurisdictional thresholds for post-construction stormwater management are permitted by the VT ANR Stormwater Program. VTrans designers follow the VTrans Project Post-Construction (Operational) Stormwater Protocol to facilitate coordination with VT ANR. VTrans designers will follow the current *Vermont Stormwater Management Manual Rule and Guidance*. The VTrans Project Post-Construction (Operational) Stormwater Protocol can be found at the following link:
   https://vtrans.vermont.gov/sites/aot/files/highway/documents/environmental/2022%20Stormwater%20Protocol.pdf

   Measurable Goal: VTrans updated this protocol April 2022, in the permit term VTrans will review the protocol to ensure effectiveness under this measure.

   Reporting: VTrans will report annually on progress and accomplishments.

   Stormwater Program Evaluation: From the fall of 2015 through March 2017, VTrans completed a process evaluation and benchmarking of the current state of stormwater management efforts during project development. The Stormwater Program Evaluation's purpose was to highlight opportunities for improving consistency in how stormwater management is addressed across different Programs or Units while remaining consistent with VT ANR's existing and proposed stormwater management rules and policies and identify potential efficiencies that might be gained in making changes to existing stormwater management activities within

VTrans. The evaluation resulted in 13 high-priority recommendations for improving consistency in addressing stormwater management considerations across the Agency (See Attachment G).

Measurable Goal: VTrans will use the results of this evaluation to further develop and implement VTrans' Stormwater Management Program and ensure future compliance with all stormwater regulations over the term of this permit. At minimum VTrans will address one of the high-priority recommendations within this permit term.

Reporting: VTrans will report annually on progress and accomplishments.

2. Develop and implement procedures to identify new development and redevelopment projects that disturb greater than or equal to one acre and that are not subject to regulation under VT ANR's post-construction stormwater management permit program.

   VTrans Gap SOP: VTrans has developed and implemented an internal Gap SOP (see Attachment H) to address the permit jurisdictional threshold gap between the VT ANR GP 3-9050 jurisdictional thresholds and the EPA one acre of land disturbance permit threshold that exist. This internal procedure protects water quality by incorporating post-construction stormwater management measures on VTrans projects to comply with the Vermont Stormwater Management Manual to the extent that is practical.

   Measurable Goals: VTrans began implanting this procedure statewide July 2021 and will continue to use the procedure during this permit term.

   Reporting: VTrans will report annually a list of projects that followed the internal Gap SOP.

3. Adopt a plan for stormwater runoff from new development and redevelopment projects that disturb greater than or equal to one acre and that are not subject to regulation under VT ANR's post-construction stormwater permit program to:

   - Prevent or minimize water quality impacts from post-construction stormwater runoff from such developments,
   - Utilize an appropriate combination of structural, non-structural, and low-impact BMPs, and
   - Ensure adequate long-term operation and maintenance of BMPs.

   VTrans Gap SOP: VTrans has developed and implemented an internal Gap SOP to address the permit jurisdictional threshold gap between the VT ANR GP 3-9050 jurisdictional thresholds and the EPA one acre of land disturbance permit threshold that exist. This internal procedure protects water quality by incorporating post-construction stormwater management measures on VTrans projects to comply with the Vermont Stormwater Management Manual to the extent that is practical.

Measurable Goals: VTrans began implanting this procedure statewide July 2021 and will continue to use the procedure during this permit term.

Reporting: VTrans will report annually a list of projects that followed the internal Gap SOP.

4. Develop and implement procedures for inspecting development and redevelopment projects for compliance with the conditions of VTrans' policies for stormwater runoff that discharges from new development and redevelopment projects that disturb greater than or equal to one acre.

   Asset Management Tool: VTrans has developed and implemented an asset management tool that ensures adequate inspections and long-term operation and maintenance of BMPs.

   Measurable Goal: VTrans will continuously maintain the asset management tool to keep it up to date. At a minimum it will be reviewed and updated annually.

   Reporting: None. New operational stormwater management practices are added to the asset management tool after construction of the practices are completed.

5. VT ANR post-construction stormwater permit program: Develop and implement procedures to ensure that development and redevelopment activities are undertaken by VTrans, including road projects, are properly permitted, constructed, and maintained for stormwater runoff that discharges from new development and redevelopment projects that disturb greater than or equal to one acre.

   Measurable Goal: VTrans will ensure compliance with the VT ANR post-construction stormwater permit program.

   Reporting: Refer to part 8 for this information.

6. Training: VTrans will continue to conduct and attend Stormwater Management and EPSC Training.

   VTrans offers a broad range of formal training on EPSC and stormwater management design to Agency staff. These training classes are instructed by VTrans and non-VTrans subject experts from around the country. When space allows, the training classes are open to employees of VT ANR, FHWA, USDA NRCS, and consulting companies. VTrans also provides an extensive amount of annual EPSC training to maintenance and construction employees through internal training meetings. VTrans staff is encouraged to seek training opportunities outside the Agency. Annual training for Maintenance District personnel training includes a session on stormwater management, EPSC, and compliance with regulations.

   Measurable Goals: VTrans will conduct and attend trainings on an annual basis.

Reporting: VTrans will report annually on number of trainings, class titles, target audience, and attendance.

VTRANS RATIONALE – The above BMPs were selected to control and treat post-construction runoff. VTrans has successfully implemented a post construction runoff management program that complies with the state operational stormwater program and applies those standards to the maximum extent practicable on sub-jurisdictional projects. For jurisdictional projects, this has become ingrained in the culture of the Agency to such an extent that other major alternative BMPs do not warrant consideration at this time. For sub-jurisdictional projects, additional guidance was needed and the BMPs proposed will further ingrain operational stormwater considerations into these projects. Another objective of these BMPs is to have stormwater considered earlier in the project development process and become inherent in the VTrans culture.

For this MCM, no BMPs have been ineffective and so alternative BMPs were not considered as replacements for existing ones.

MCM 6.F: POLLUTION PREVENTION/ GOOD HOUSEKEEPING FOR VTRANS' OPERATIONS

REQUIREMENT – *Per Subpart 6.3.F of the Permit, VTrans shall develop and implement an operation and maintenance program that includes a training component and has the ultimate goal of preventing or reducing pollutant runoff from all VTrans' operations related to the TS4.*

VTRANS RESPONSE –

1. By implementing this TS4 SWMP, VTrans has developed and is implementing a program that includes:

    - A list of the VTrans operations covered by the program,
    - A training component, maintenance activities, maintenance schedules, and long- term inspection procedures for controls to reduce floatable and other pollutants;
    - Controls for reducing or eliminating the discharge of pollutants from the TS4; and
    - Procedures for compliance with applicable state and federal laws for the proper disposal of waste, including dredged spoil, accumulated sediments, floatables, and other debris.

    Measurable Goals: Maintain and comply with the SWMP.

    Reporting: Report as outlined under the various Parts of the SWMP.

2. Prohibit the use of any phosphorus-containing fertilizer, unless warranted by a current soil test, where lawn or garden fertilizers are used in the facility operation. If a phosphorus fertilizer is used, a soil test shall be performed annually, and a copy of the test will be submitted with the annual report.

Measurable Goals: As an erosion control practice, VTrans may use fertilizer containing phosphorus in establishing turf. However, VTrans will not use phosphorus fertilizer associated with turf management unless a current soil test warrants the use of it.

Reporting: VTrans will report annually on testing if phosphorus- containing fertilizer is used for turf management.

3. Provide a copy of its operation and maintenance program to prevent or reduce pollutant runoff from VTrans' operations as part of its SWMP.

Stormwater Pollution Prevention Plan (SWPPP) and a Spill Prevention Control & Countermeasure Plan (SPCCP). VTrans has developed SWPPPs for all facilities located within the MS4 area and SPCCPs for facilities that contain bulk fuel and/or bulk brine statewide. VTrans has been conducting trainings on these plans and facility inspections on an annual basis. For the remaining state garages located outside of the MS4 but within the TS4, VTrans will develop a SWPPP and will conduct annual trainings inspections.

Facilities Audit Tool – VTrans utilizes a GIS-based audit tool for use in creating SWPPPs and informing SPCCP updates.

Measurable Goals: VTrans will continue to conduct annual trainings and inspections at facilities currently covered under SWPPPs in the MS4 and SPCCPs statewide. VTrans will maintain and update these documents on an annual basis. For facilities that are not currently covered under a SWPPP, VTrans will develop plans for 4 facilities a year using the new Facilities Audit Tool until all facilities have plans, until all facilities have completed plans. SWPPPs, annual training, annual inspection reports and SPCC plans can be found at the following link. https://outside.vermont.gov/agency/VTRANS/external/docs/stormwater/Forms/AllItems.aspx

Reporting: VTrans will provide VT ANR with an annual status report of trainings, monitoring activities, corrective actions, and new SWPPPs developed.

Good Housekeeping Measures:

- Follow the VTrans Bridge Washing BMPs for all bridge washing activities (see Attachment C).
- Follow the VT ANR Vehicle Washing Policy for the washing of fleet vehicles (see Attachment C).
- Implement a tiered winter maintenance plan with a goal to be more efficient with winter maintenance usage of snow and ice controls. The snow and ice control plan can be found at the following link. https://vtrans.vermont.gov/operations/winter-maintenance
- Conduct street sweeping on 2,000 lane miles of VTrans roads.
- Conduct on average storm drain inspections on 20% of VTrans roads, with the goal of inspecting 100% over a 5-year period.
- Properly dispose of materials collected per VT ANR Guidelines during routine street sweeping and storm drain cleaning.
- Implement roadside bank stabilization projects that have a water quality benefit.

Measurable Goals: VTrans will implement the good housekeeping measures described above annually and will consider the development of additional measures.

Reporting: Report annually on salt and sand usage for winter road maintenance (for previous winter season), street sweeping, storm drain inspections, slope stabilization, erosion repair projects completed, and any additional measures established.

4. VTrans HazMat Unit develops SPCCPs and Facility Response Plans as required by 40 CFR Part 112 and Part 110 and conducts trainings and inspections in accordance with these plans at VTrans facilities statewide. Additionally, the HazMat Unit monitors and conducts hazmat spill response and reporting on illegal dumping on VTrans sites, including incidences that may involve non-VTrans operators (e.g., independent truck drivers traveling on a state highway). The VTrans HazMat Unit also coordinates with VTrans project development staff, and state and federal regulators when hazardous materials are encountered on VTrans sites.

   Measurable Goals: VTrans will provide VT ANR with an annual status report of monitoring activities conducted and corrective actions taken.

   Reporting: VTrans will report annually on inspections and trainings conducted at facilities and hazmat spills and illegal dumping on VTrans sites to include number of trainings, trainees, and topics.

VTRANS RATIONALE – The above BMPs were selected to prevent or reduce pollutant runoff from all VTrans' operations related to the TS4 by maintaining and complying with the SWMP, limiting use of phosphorus fertilizer unless a soil test determines that its use is warranted, maintaining and complying with SWPPPs and SPCCPs, maintaining and complying with good housekeeping measures, and annual reporting in an integrated approach to meet the requirements of pollution prevention and good housekeeping for VTrans' operations. Limiting sources of pollution will prevent water quality impacts. This is a program that has been implemented since 2003 and has been adjusted over time to best meet the needs of VTrans' operations and become more effective.

For this MCM, no BMPs have been ineffective and so alternative BMPs were not considered as replacements for existing ones. In previous SWMPs, many BMPs included in MCM 6.F were better reflected in other MCMs. For instance, good housekeeping activities related to hazardous materials handling, spill prevention, and response remain tracked in this MCM. However, EPSC guidance materials updates, construction site inspections, and stormwater management and stormwater erosion and sediment control trainings are still conducted but are now reported in MCM 6.D.

7.0 INDUSTRIAL ACTIVITY CONTROL MEASURES

REQUIREMENT – Per Part 7 of the Permit, airport transportation facilities and facilities that conduct non-metallic mineral mining and dressing as the primary activity on site and that have the SIC Codes listed in the Permit shall develop and implement Stormwater Pollution Prevention Plans (SWPPPs) and follow all requirements of Part 7 of the Permit.

VTrans shall select, design, install, and implement control measures, including BMPs, to minimize pollutant discharges that address the selection and design considerations, meet the non-numeric effluent limits, meet limits contained in applicable effluent limitations, and meet the water quality-based effluent limitations per the relevant subparts of Part 7 of the Permit.

VTRANS RESPONSE – In response to this requirement, VTrans has developed the following Table, which lists the airport transportation facilities and non-metallic mineral mining and dressing facilities that are included in the VTrans TS4 and that were previously issued an MSGP 3-9003 by VT ANR. The link to SWPPPs and related documents can be found at the following link. https://outside.vermont.gov/agency/VTRANS/external/docs/stormwater/Forms/AllItems.aspx

> **Measurable Goal**: maintain SWPP Plans for these facilities and maintain compliance under MSGP requirements.
>
> **Reporting:** VTrans will report annually on trainings, inspections, monitoring, and any corrective actions taken.

Previously issued MSGP #-9003	Facility Name	Address	City	Primary SIC
VTrans Airport Transportation Facilities				
4579-9003.R	William H. Morse State Airport	1563 Walloomsac Road	Bennington	4512-4581
4582-9003.R	E.F. Knapp State Airport	1979 Airport Road	Berlin	4512-4581
3769-9003.R	Rutland Southern Vermont Regional State Airport	1002 Airport Road	North Clarendon	4512-4581
3836-9003.R	Newport State Airport	2628 Airport Road	Coventry	4512-4581
3065-9003.R	Franklin County State Airport	629 Airport Road	Highgate	4512-4581
3896-9003.R	Caledonia County State Airport	2107 Pudding Hill Road	Lyndonville	4512-4581
4581-9003.R	Middlebury State Airport	467 Airport Road	Middlebury	4512-4581
4272-9003.R	Morrisville-Stowe State Airport	2305 Laporte Road	Morrisville	4512-4581
4580-9003.R	Hartness State Airport	15 Airport Road	Springfield	4512-4581
4574-9003	J.H. Boylan Airport – No Exposure	3597 VT 105	Island Pond	4512-4581
Mineral Mining and Dressing Facilities				
4576-9003.R	East Dorset Sand and Gravel Pit	18 Village Street	East Dorset	1442
4577-9003.R	Hinesburg Sand and Gravel Pit	14573 Route 116	Hinesburg	1442
6054-9003.R	Calais Sand and Gravel Pit	6011 Route 14	Calais	1442

The SWPPPs for these sites can be found at: https://outside.vermont.gov/agency/VTRANS/external/docs/stormwater/Forms/AllItems.aspx

8.0 STORMWATER DISCHARGES FROM IMPERVIOUS SURFACES

REQUIREMENT – Per Part 8 of the Permit, permit coverage is provided for: (1) previously permitted stormwater runoff discharges and proposed new stormwater runoff discharges from impervious surfaces that trigger jurisdiction as outlined in Subpart 8.1.A of the Permit, (2) stormwater discharges to waters of the State that are not impaired by stormwater and to waters of the State that are listed as principally impaired due to stormwater runoff with a stormwater WQRP or TMDL on the EPA-approved State of Vermont List of Priority Surface Waters (Part D, Impaired Surface Waters with Completed and Approved TMDLs) and that have an approved FRP or other approved implementation plan.

VTRANS RESPONSE – VTrans will maintain compliance with the standards established in this Part.

> **Reporting:** VTrans will report annually a list of projects in the TS4 with VT ANR Operational Permit coverage, including status, inspections, and corrective actions needed or taken.

9.0 TOTAL MAXIMUM DAILY LOAD IMPLEMENTATION

9.1 FLOW RESTORATION PLANS

REQUIREMENT – Per Subpart 9.1 of the Permit, VTrans submitted its FRP on October 1, 2016, pursuant to the requirements of "General Permit 3-9014 for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems" (2012). The Secretary approved VTrans' FRP and it is part of VTrans' SWMP. The FRP applies to VTrans' designated regulated small MS4.

VTRANS RESPONSE – VTrans has infrastructure within the watersheds of the following stormwater-impaired waters: Allen, Bartlett, Centennial, Indian, Moon, Munroe, Potash, Rugg, Stevens, and Sunderland brooks. Per the FRP (see Attachment D), VTrans has been and will continue to implement measures within these watersheds necessary to achieve the flow restoration targets in the stormwater TMDLs for the waters within the VTrans designated regulated small MS4 and submit semi-annual reporting on development and implementation of the FRP per the required deadlines.

Included in the VTrans FRP is a design and construction schedule that provides a long-term plan for implementation. Implementation of the 54 projects included in the VTrans FRP was spaced out over a 16-year timeframe in 7 separate phases, providing adequate time for design, acquisition of necessary permits, regulatory approvals, acquisition of necessary land, and construction.

> **Reporting:** VTrans will report annually on implementation of the FRP.

9.2 LAKE CHAMPLAIN PHOSPHORUS CONTROL PLANS

REQUIREMENT – *Per Subpart 9.2 of the Permit, VTrans shall develop and implement a comprehensive PCP for the TS4 within the Lake Champlain Basin. The PCP shall be developed in phases and submitted to VT ANR per the schedule in Subpart 9.2.C.*

VTRANS RESPONSE – VTrans has infrastructure in all 13 lake segments within the Lake Champlain Basin. VTrans submitted its PCP on April 1, 2020

REQUIREMENTS –

1. *Plan to achieve, on average, a 25% load reduction of the total combined reduction targets in all Lake segments in each 4-year phase, so that, the total reductions equal 100% after all phases are completed. For each phase, VTrans shall:*

   - Identify the suite of necessary stormwater BMPs that will be used to meet the required phosphorus load reduction.
   - Prepare a design and construction schedule for the stormwater BMPs that have been identified by VTrans as necessary to achieve the phosphorus reduction targets.
   - Prepare a financing plan that estimates the costs for implementing the PCP Phase and describes a strategy for financing the PCP Phase. The financing plan shall include the steps VTrans will take to implement the financing plan.
   - Identify any parties, other than VTrans, that will be responsible for implementing any portion of the VTrans PCP, and which portion they will be responsible for implementing.

2. *Continuing April 1, 2023, VTrans shall submit reports on an annual basis on its development and implementation of the PCP. The reports shall be submitted on forms provided by VT ANR to enable VT ANR to track phosphorus reductions across the Basin.*

   VTRANS RESPONSE – The generalized PCP for the entire TS4 in the Lake Champlain Basin will be developed into a series of four-year implementation plans for each Lake segment that achieve, on average, a 25 percent load reduction of the total combined reduction targets in all Lake segments. The first four-year implementation plan was submitted VT ANR on October 1, 2020. The implementation plan for each four-year phase will include:

   - Identification of the suite of necessary BMPs that will be used to meet the required phosphorus load reduction
   - A design and construction schedule for BMPs identified as necessary to achieve the phosphorus reduction targets
   - A financing plan that estimates costs for implementing the PCP Phase and describes a strategy for financing implementation, including the steps VTrans will take to implement the financing plan
   - Identification of parties other than VTrans responsible for implementing any portion of the VTrans PCP, and identification of portions the other parties are responsible for implementing.

     Reporting: VTrans will report on development and implementation of the four-year implementation plans, submit the second four-year implementation plan (Phase II) by April 1, 2024, and submit annual reports on Phosphorus Control Plan implementation by April 1, 2023, and every year thereafter.

9.3 LAKE MEMPHREMAGOG PHOSPHORUS CONTROL PLAN

REQUIREMENT – *Per Subpart 9.3 of the Permit, VTrans shall develop and implement a PCP for the TS4 within the Lake Memphremagog Watershed. The PCP shall be developed in phases and submitted to VT ANR per the schedule in Subpart 9.3.C.*

VTRANS RESPONSE – VTrans has infrastructure within the Lake Memphremagog Watershed. VTrans will develop and implement its PCP in phases, beginning with the establishment of baseline phosphorus loading and calculation of the phosphorus load reductions needed to achieve its percent reduction from the TS4 for the watershed, which will be submitted by April 1, 2024.

REQUIREMENTS –

1. <u>*Establish baseline phosphorus loading assessments for the TS4.*</u> Using this baseline, VTrans shall calculate the phosphorus load reduction needed to achieve a 18.2% percent reduction from the TS4.

VTRANS RESPONSE – VTrans will work with VT ANR to calculate the phosphorus load reduction needed to achieve a 18.2% percent reduction from the TS4.

Reporting: VTrans will report on established baseline phosphorus loading for the TS4, and calculation of phosphorus load reduction needed to achieve its percent reduction from the TS4 for each lake segment, by April 1, 2024.

2. <u>*Investigate phosphorus loading factors that will inform the prioritization of retrofit projects.*</u> Investigation shall include at least a GIS inventory of hydrologic connectivity and areas of active erosion for the TS4.

VTRANS RESPONSE – VTrans will develop a GIS inventory of hydrologic connectivity and areas of potential localized active erosion for the TS4. VTrans will investigate the application of these key phosphorus loading factors to inform the prioritization of both field conformation and the prioritization of retrofit projects.

Reporting: VTrans will complete the GIS inventory of phosphorus loading factors and complete development of coefficients of loading rates by April 1, 2024.

3. <u>*Develop a plan for the entire TS4 within the Lake Memphremagog watershed*</u> that at a minimum estimates the area (acreage or road miles) to be treated and the extent and type of BMPs to meet the entire phosphorus load reduction.

VTRANS RESPONSE – VTrans will develop a PCP for the entire TS4 within the Lake Memphremagog watershed that estimates the area to be treated (acreage or road miles) within each Lake segment, and necessary measures to be implemented to achieve the entire phosphorus load reduction no later than September 28, 2037. The generalized PCP will be submitted to VT ANR by April 1, 2025.

Reporting: VTrans will report on development of the PCP and submit the PCP by April 1, 2025.

4. _Plan to achieve, on average, a 33% load reduction in each 4-year phase_, so that after all phases are completed the total reductions equal 100%. For the plan, VTrans shall:
    - Identify the suite of necessary stormwater BMPs that will be used to meet the required phosphorus load reduction.
    - Prepare a design and construction schedule for the stormwater BMPs that have been identified by VTrans as necessary to achieve the phosphorus reduction targets.
    - Prepare a financing plan that estimates the costs for implementing the PCP Phase and describes a strategy for financing the PCP Phase. The financing plan shall include the steps VTrans will take to implement the financing plan.
    - Identify any parties, other than VTrans, that will be responsible for implementing any portion of the VTrans PCP, and which portion they will be responsible for implementing.

5. _Starting April 1, 2023, VTrans shall submit reports on an annual basis_ on its development and implementation of the PCP. The reports shall be submitted on forms provided by VT ANR to enable VT ANR to track phosphorus reductions across the Basin.

VTRANS RESPONSE – The PCP for the Lake Memphremagog Watershed will be developed to achieve, on average, a 33 percent load reduction of the TMDL target over a 4 year period. The plan will be submitted to ANR by April 1, 2025.

The plan for will include:

- Identification of the suite of necessary BMPs that will be used to meet the required phosphorus load reduction
- A design and construction schedule for BMPs identified as necessary to achieve the phosphorus reduction targets
- A financing plan that estimates costs for implementing the PCP Phase and describes a strategy for financing implementation, including the steps VTrans will take to implement the financing plan
- Identification of parties other than VTrans responsible for implementing any portion of the VTrans PCP, and identification of portions the other parties are responsible for implementing.

Reporting: VTrans will report on development and implementation of the PCP, submit the PCP by April 1, 2025, and submit annual reports on Phosphorus Control Plan implementation by April 1, 2026, and every year thereafter.

10.0 RECORD KEEPING AND REPORTING

REQUIREMENT – *Per subpart 10.1 of the Permit, VTrans shall retain records of all monitoring information, copies of all reports required by the Permit, copies of Discharge Monitoring Reports (DRMs), a copy of its authorization and amended authorizations under this Permit, and records of all data used to complete the applications NOI for this Permit, for a period of at least three years* *from the date of the sample, measurement, report or application, or for the term of this permit, whichever is longer. VTrans shall retain copies of all written records relating to the stormwater collection, treatment, and control systems, and BMPs, including calculations used to size STPs, authorized under this permit. VTrans shall submit its records to VT ANR when specifically asked to do so. VTrans shall retain a copy of this SWMP and a copy of the permit language at a location accessible to VT ANR. VTrans shall make its records, including the NOI and SWMP, available to the public, if requested to do so in writing.*

VTRANS RESPONSE – VTrans will comply with this requirement.

REQUIREMENT – *Per subpart 10.2 of the Permit, VTrans shall submit its annual reports to the Vermont Department of Environmental Conservation, Watershed Management Division, Stormwater Management Program by April 1st each year. FRP and PCP reports may be included with the annual report when reporting deadlines coincide. In addition to any FRP and PCP reporting requirements, the annual report shall include all annual reporting requirements under Parts 4, 5, 6, and 7 of the Permit, as well as:*

A. *The status of VTrans' compliance with permit conditions, an assessment of the appropriateness of the identified BMPs, progress towards achieving implementation of BMPs necessary to meet TMDL requirements and progress towards achieving the statutory goal for the six minimum measures of reducing the discharge of pollutants to the MEP, and the measurable goals for each of the minimum control measures and TMDL implementation measures;*

B. *Any inspection report on the condition of VTrans' stormwater management systems that notes all problem areas and all measures taken to correct any problems and to prevent future problems;*

C. *Results of information collected and analyzed, if any, during the reporting period, including monitoring data used to assess the success of the program at meeting TMDL requirements and the success of the six minimum control measures;*

D. *A summary of the stormwater activities VTrans plans to undertake during the next reporting cycle (including an implementation schedule);*

E. *Proposed changes to this SWMP, including changes to any BMPs or any identified measurable goals that apply to the program elements; and*

F. *Notice that VTrans is relying on another government entity to satisfy some of its permit obligations (if applicable).*

VTRANS RESPONSE – VTrans will satisfy this requirement in its annual reporting.

I. Appendices

ATTACHMENT A LIST OF WATERS (TABLE 1 AND TABLE 2)

Table 1
First Waters to which Designated MS4 Areas Discharge, Impairment Status, and Pollutants, Measures, and Controls for Impaired Waters
November 7, 2022

Waterbody Name	Pollutant	MS4 Towns	Impairment Status (Yes/No)	Impaired Waterbody Partially Outside MS4 Area	TMDL (Yes/No)	Vtrans/TS4 Allocation (Yes/No)	Measure No. (see Lookup Table)
MUDDY BROOK	CHLORIDE	South Burlington, Williston	Yes		No	No	2
SUNNYSIDE BROOK	CHLORIDE	Colchester	Yes		No	No	2
CENTENNIAL BROOK	CHLORIDE	Burlington, South Burlington	Yes		No	No	2
ENGLESBY BROOK	CHLORIDE	Burlington	Yes		No	No	2
POTASH BROOK	CHLORIDE	Burlington, South Burlington	Yes		No	No	2
EAST CREEK	E. COLI	Rutland City	Yes		No	No	3
OTTER CREEK	E. COLI	Rutland City	Yes		No	No	3
WINOOSKI RIVER	E. COLI	Burlington, Colchester, Winooski	Yes		No	No	3
ALLEN BROOK	E. COLI	Williston	Yes		Yes	No	4
ENGLESBY BROOK	E. COLI	Burlington	Yes		Yes	No	5
INNER MALLETTS BAY	E. COLI	Colchester	Yes		Yes	No	5
LAPLATTE RIVER	E. COLI	Shelburne	Yes		Yes	No	5
POTASH BROOK	E. COLI	South Burlington	Yes		Yes	No	5
LOWER LAMOILLE RIVER	LOW D.O.	Milton	Yes		No	No	6
ARROWHEAD MOUNTAIN LAKE (Milton)	MERCURY	Milton	Yes	Yes	Yes	No	7
BURLINGTON BAY - LAKE CHAMPLAIN (Burlington)	MERCURY	Burlington, South Burlington	Yes	Yes	Yes	No	7
LAMOILLE RIVER	MERCURY	Milton	Yes		Yes	No	7
LAPLATTE RIVER	MERCURY	Shelburne	Yes		Yes	No	7
MAIN SECTION - LAKE CHAMPLAIN (South Hero)	MERCURY	Burlington, South Burlington	Yes	Yes	Yes	No	7
MALLETTS BAY - LAKE CHAMPLAIN (Colchester)	MERCURY	Colchester	Yes	Yes	Yes	No	7
NORTHEAST ARM - LAKE CHAMPLAIN (Swanton)	MERCURY	St. Albans Town	Yes	Yes	Yes	No	7
SHELBURNE BAY - LAKE CHAMPLAIN (Shelburne)	MERCURY	Shelburne	Yes	Yes	Yes	No	7
ST. ALBANS BAY - LAKE CHAMPLAIN (St. Albans)	MERCURY	St. Albans Town	Yes	Yes	Yes	No	7
WINOOSKI RIVER	MERCURY	Burlington, Winooski	Yes		Yes	No	7
LAMOILLE RIVER TRIB #4	METALS	Milton	Yes		No	No	8
STEVENS BROOK	METALS (Cd, Ba, CN, Zn)	St. Albans City	Yes		No	No	9
WINOOSKI RIVER UNNAMED TRIB	METALS (Fe, As)	Winooski	Yes		No	No	10
MCCABES BROOK	NUTRIENTS	Shelburne	Yes		No	No	12
JEWETT BROOK	NUTRIENTS, SEDIMENT, E. COLI	St. Albans Town	Yes		No	No	14
RUGG BROOK	NUTRIENTS, SEDIMENT, E. COLI	St. Albans Town	Yes		No	No	14
STEVENS BROOK	NUTRIENTS, SEDIMENT, E. COLI	St. Albans Town	Yes		No	No	14
BURLINGTON BAY - LAKE CHAMPLAIN (Burlington)	PCBs	Burlington	Yes		No	No	15
MAIN SECTION - LAKE CHAMPLAIN (South Hero)	PCBs	Shelburne	Yes	Yes	No	No	15
MALLETTS BAY - LAKE CHAMPLAIN (Colchester)	PCBs	Colchester	Yes	Yes	No	No	15
NORTHEAST ARM - LAKE CHAMPLAIN (Swanton)	PCBs	St. Albans Town	Yes		No	No	15
SHELBURNE BAY - LAKE CHAMPLAIN (Shelburne)	PCBs	Shelburne	Yes		No	No	15

Table 1

First Waters to which Designated MS4 Areas Discharge, Impairment Status, and Pollutants, Measures, and Controls for Impaired Waters

November 7, 2022

Waterbody Name	Pollutant	MS4 Towns	Impairment Status (Yes/No)	Impaired Waterbody Partially Outside MS4 Area	TMDL (Yes/No)	Vtrans/TS4 Allocation (Yes/No)	Measure No. (see Lookup Table)
ST. ALBANS BAY - LAKE CHAMPLAIN (St. Albans)	PCBs	St. Albans Town	Yes	Yes	No	No	15
SHELBURNE POND (Shelburne)	PHOSPHORUS	Shelburne	Yes		No	No	16
BURLINGTON BAY - LAKE CHAMPLAIN (Burlington)	PHOSPHORUS	Burlington, South Burlington	Yes	Yes	Yes	Yes	17
MAIN SECTION - LAKE CHAMPLAIN (South Hero)	PHOSPHORUS	Burlington, South Burlington	Yes	Yes	Yes	Yes	17
MALLETTS BAY - LAKE CHAMPLAIN (Colchester)	PHOSPHORUS	Colchester	Yes	Yes	Yes	Yes	17
NORTHEAST ARM - LAKE CHAMPLAIN (Swanton)	PHOSPHORUS	St. Albans Town	Yes	Yes	Yes	Yes	17
SHELBURNE BAY - LAKE CHAMPLAIN (Shelburne)	PHOSPHORUS	Shelburne	Yes	Yes	Yes	Yes	17
ST. ALBANS BAY - LAKE CHAMPLAIN (St. Albans)	PHOSPHORUS	St. Albans Town	Yes	Yes	Yes	Yes	17
BURLINGTON BAY - LAKE CHAMPLAIN - PINE STREET BARGE CANAL (Burlington)	PRIORITY & NONPRIORITY ORGANICS, METALS, OIL, GREASE, PCBs	Burlington	Yes		No	No	19
ALLEN BROOK	STORMWATER	Williston	Yes		Yes	Yes	23
BARTLETT BROOK	STORMWATER	South Burlington	Yes		Yes	Yes	23
CENTENNIAL BROOK	STORMWATER	Burlington, South Burlington	Yes		Yes	Yes	23
ENGLESBY BROOK	STORMWATER	Burlington	Yes		Yes	Yes	23
INDIAN BROOK	STORMWATER	Essex	Yes		Yes	Yes	23
MOON BROOK	STORMWATER	Rutland City, Rutland Town	Yes		Yes	Yes	23
MOREHOUSE BROOK	STORMWATER	Winooski	Yes		Yes	Yes	23
MUNROE BROOK	STORMWATER	Shelburne	Yes		Yes	Yes	23
POTASH BROOK	STORMWATER	Burlington	Yes		Yes	Yes	23
RUGG BROOK	STORMWATER	St. Albans City	Yes		Yes	Yes	23
STEVENS BROOK	STORMWATER	St. Albans City	Yes		Yes	Yes	23
SUNDERLAND BROOK	STORMWATER	Colchester	Yes		Yes	Yes	23
MUSSEY BROOK	STORMWATER, TEMPERATURE	Rutland City, Rutland Town	Yes		Yes	No	24
MUDDY BROOK	TOXICS	Williston	Yes		No	No	25
Alder Brook		Essex	No				
Allen Brook		Colchester	No				
Browns River		Essex, Jericho	No				
Clarendon River		Rutland Town	No				
Cold River		Rutland Town	No				
East Creek		Rutland Town	No				
Hungerford Brook		St. Albans Town	No				
Indian Brook		Colchester	No				
Lamoille River		Milton	No				
Malletts Creek		Colchester	No				
Muddy Brook		South Burlington	No				
Otter Creek		Rutland City, Rutland Town	No				
Pond Brook		Colchester	No				

Table 1
First Waters to which Designated MS4 Areas Discharge, Impairment Status, and Pollutants, Measures, and Controls for Impaired Waters
November 7, 2022

Waterbody Name	Pollutant	MS4 Towns	Impairment Status (Yes/No)	Impaired Waterbody Partially Outside MS4 Area	TMDL (Yes/No)	Vtrans/TS4 Allocation (Yes/No)	Measure No. (see Lookup Table)
Rugg Brook		St. Albans Town	No				
Sucker Brook		Williston	No				
Sunderland Brook		Colchester	No				
Unnamed Tributary to Alder Brook		Essex	No				
Unnamed Tributary to Allen Brook		Milton	No				
Unnamed Tributary to Allen Brook		Williston	No				
Unnamed Tributary to Arrowhead Mountain Lake		Milton	No				
Unnamed Tributary to Browns River		Essex	No				
Unnamed Tributary to East Creek		Rutland Town	No				
Unnamed Tributary to Hungerford Brook		St. Albans Town	No				
Unnamed Tributary to Indian Brook		Essex	No				
Unnamed Tributary to Lamoille River		Milton	No				
Unnamed Tributary to Malletts Bay		Colchester	No				
Unnamed Tributary to Muddy Brook		South Burlington	No				
Unnamed Tributary to Otter Creek		Rutland City	No				
Unnamed Tributary to Otter Creek		Rutland Town	No				
Unnamed Tributary to Pond Brook		Colchester	No				
Unnamed Tributary to Potash Brook		South Burlington	No				
Unnamed Tributary to Rugg Brook		St. Albans Town	No				
Unnamed Tributary to Shelburne Pond		Shelburne	No				
Unnamed Tributary to St. Albans Bay		St. Albans Town	No				
Unnamed Tributary to Stevens Brook		St. Albans Town	No				
Unnamed Tributary to Streeter Brook		Milton	No				
Unnamed Tributary to Sunderland Brook		Colchester	No				
Unnamed Tributary to Tenney Brook		Rutland Town	No				
Unnamed Tributary to Winooski River		Burlington	No				
Unnamed Tributary to Winooski River		Essex	No				
Unnamed Tributary to Winooski River		South Burlington	No				
Unnamed Tributary to Winooski River		Williston	No				
Unnamed Tributary to Winooski River		Winooski	No				
Winooski River		Essex, South Burlington, Colchester	No				

Table 2
Impaired Waters with Mapped and Identified VTrans Discharges Outside Designated MS4 Areas
November 7, 2022

Waterbody Name	Pollutant	Impaired Waterbody Partially Within MS4 Area	Vermont Priority Waters List Part	TMDL (Yes/No)	Vtrans/TS4 Allocation (Yes/No)	Measure No. (see Lookup Table)
UPPER DEERFIELD RIVER	ACID		A	No		1
LOWER SLEEPERS RIVER	E. COLI		A	No		3
PASSUMPSIC RIVER	E. COLI		A	No		3
WINOOSKI RIVER (Above Montpelier WWTF)	E. COLI		A	No		3
FIRST BRANCH WHITE RIVER	E. COLI		A	No		4
METTAWEE RIVER	E. COLI		A	No		4
SECOND BRANCH WHITE RIVER	E. COLI		A	No		4
DOG RIVER	E. COLI		A	No		4
STEVENS BRANCH	E. COLI		A	No		4
WINOOSKI RIVER (Marshfield)	E. COLI		A	No		4
WINOOSKI RIVER (Cabot)	E. COLI		A	No		4
FLOWER BROOK	E. COLI		D	Yes	No	5
MAD RIVER	E. COLI		D	Yes	No	5
NO. BRANCH DEERFIELD RIVER	E. COLI		D	Yes	No	5
SAMSONVILLE BROOK	E. COLI		D	Yes	No	5
WEST RIVER	E. COLI		D	Yes	No	5
ARROWHEAD MOUNTAIN LAKE (Milton)	MERCURY	Yes	D	Yes	No	7
BURLINGTON BAY - LAKE CHAMPLAIN (Burlington)	MERCURY	Yes	D	Yes	No	7
HARRIMAN RESERVOIR (Whitingham)	MERCURY		D	Yes	No	7
ISLE LAMOTTE - LAKE CHAMPLAIN (Alburg)	MERCURY		D	Yes	No	7
LAKE SALEM (Derby)	MERCURY		D	Yes	No	7
MAIN SECTION - LAKE CHAMPLAIN (South Hero)	MERCURY	Yes	D	Yes	No	7
MALLETTS BAY - LAKE CHAMPLAIN (Colchester)	MERCURY	Yes	D	Yes	No	7
MISSISQUOI BAY - LAKE CHAMPLAIN (Alburg)	MERCURY		D	Yes	No	7
NORTHEAST ARM - LAKE CHAMPLAIN (Swanton)	MERCURY	Yes	D	Yes	No	7
OTTER CREEK SECTION - LAKE CHAMPLAIN (Ferrisburg)	MERCURY		D	Yes	No	7
PORT HENRY SECTION - LAKE CHAMPLAIN (Ferrisburg)	MERCURY		D	Yes	No	7
SHELBURNE BAY - LAKE CHAMPLAIN (Shelburne)	MERCURY	Yes	D	Yes	No	7
SOUTHERN SECTION - LAKE CHAMPLAIN (Bridport)	MERCURY		D	Yes	No	7

Table 2
Impaired Waters with Mapped and Identified VTrans Discharges Outside Designated MS4 Areas
November 7, 2022

Waterbody Name	Pollutant	Impaired Waterbody Partially Within MS4 Area	Vermont Priority Waters List Part	TMDL (Yes/No)	Vtrans/TS4 Allocation (Yes/No)	Measure No. (see Lookup Table)
ST. ALBANS BAY - LAKE CHAMPLAIN (St. Albans)	MERCURY	Yes	D	Yes	No	7
UPPER DEERFIELD RIVER	MERCURY		D	Yes	No	7
TRIB #10 TO BREWSTER RIVER (1 MILE)	METALS (IRON)		A	No		11
GIDDINGS BROOK	NUTRIENTS, STORMWATER		A	No		12
ROARING BROOK	NUTRIENTS		A	No		12
TROUT BROOK	NUTRIENTS		A	No		12
SAMSONVILLE BROOK	NUTRIENTS, SEDIMENT		A	No		13
HOOSIC RIVER	PCBs		A	No		15
ISLE LAMOTTE - LAKE CHAMPLAIN (Alburg)	PCBs		A	No		15
MAIN SECTION - LAKE CHAMPLAIN (South Hero)	PCBs	Yes	A	No		15
MALLETTS BAY - LAKE CHAMPLAIN (Colchester)	PCBs	Yes	A	No		15
NORTHEAST ARM - LAKE CHAMPLAIN (Swanton)	PCBs		A	No		15
OTTER CREEK SECTION - LAKE CHAMPLAIN (Ferrisburg)	PCBs		A	No		15
PORT HENRY SECTION - LAKE CHAMPLAIN (Ferrisburg)	PCBs		A	No		15
SOUTHERN SECTION - LAKE CHAMPLAIN (Bridport)	PCBs		A	No		15
ST. ALBANS BAY - LAKE CHAMPLAIN (St. Albans)	PCBs	Yes	A	No		15
LAKE CARMI (Franklin)	PHOSPHORUS		D	Yes	No	16
BURLINGTON BAY - LAKE CHAMPLAIN (Burlington)	PHOSPHORUS	Yes	D	Yes	Yes	17
ISLE LAMOTTE - LAKE CHAMPLAIN (Alburg)	PHOSPHORUS		D	Yes	Yes	17
MAIN SECTION - LAKE CHAMPLAIN (South Hero)	PHOSPHORUS	Yes	D	Yes	Yes	17
MALLETTS BAY - LAKE CHAMPLAIN (Colchester)	PHOSPHORUS	Yes	D	Yes	Yes	17
MISSISQUOI BAY - LAKE CHAMPLAIN (Alburg)	PHOSPHORUS		D	Yes	Yes	17
NORTHEAST ARM - LAKE CHAMPLAIN (Swanton)	PHOSPHORUS	Yes	D	Yes	Yes	17
OTTER CREEK SECTION - LAKE CHAMPLAIN (Ferrisburg)	PHOSPHORUS		D	Yes	Yes	17
PORT HENRY SECTION - LAKE CHAMPLAIN (Ferrisburg)	PHOSPHORUS		D	Yes	Yes	17
SHELBURNE BAY - LAKE CHAMPLAIN (Shelburne)	PHOSPHORUS	Yes	D	Yes	Yes	17
SOUTHERN SECTION (A) - LAKE CHAMPLAIN (Bridport)	PHOSPHORUS		D	Yes	Yes	17

Table 2

Impaired Waters with Mapped and Identified VTrans Discharges Outside Designated MS4 Areas

November 7, 2022

Waterbody Name	Pollutant	Impaired Waterbody Partially Within MS4 Area	Vermont Priority Waters List Part	TMDL (Yes/No)	Vtrans/TS4 Allocation (Yes/No)	Measure No. (see Lookup Table)
SOUTHERN SECTION (B) - LAKE CHAMPLAIN (Bridport)	PHOSPHORUS		D	Yes	Yes	17
ST. ALBANS BAY - LAKE CHAMPLAIN (St. Albans)	PHOSPHORUS	Yes	D	Yes	Yes	17
LAKE MEMPHRAMAGOG (Newport)	PHOSPHORUS		D	Yes	Yes	18
MUD POND (Craftsbury)	PHOSPHORUS		A	No		14
WALKER POND (Coventry)	PHOSPHORUS		A	No		14
CROSBY BROOK	SEDIMENT		A	No		21
DEER BROOK	SEDIMENT		A	No		20
LADD BROOK	SEDIMENT		A	No		21
SOUTH MOUNTAIN BRANCH (TRIB # 7) (2.2 MI.)	SEDIMENT		A	No		21
SOUTH MOUNTAIN BRANCH (TRIB # 3)	SEDIMENT		B	No		22
BARNEY BROOK	SEDIMENT, IRON		A	No		21
SPRUCE BROOK	STORMWATER		A	No		21
NO. BRANCH DEERFIELD RIVER	TEMPERATURE		A	No		24
WEST BRANCH LITTLE RIVER	UNDEFINED		B			26

Measures Lookup and Descriptions for Tables 1 and 2
November 7, 2022

Measure No.	Measure Description
1	No TMDL, no specific actions required
2	MCM #1 and #6 (SWMP Parts 6.A and 6.F); VAOT Snow and Ice Control Plan (SIC Plan); annual reporting on chloride usage within impaired watersheds. VTrans owns and controls approximately 9% of total impervious cover in Muddy Brook watershed, 14% of total impervious cover in Sunnyside Brook watershed, 7% of total impervious cover in Centennial Brook watershed, 0% of total impervious cover in Englesby Brook watershed, and 8% of total impervious cover in Potash Brook watershed.
3	No specific actions required; combined sewer overflow
4	No specific actions required; VTrans will implement MCM #1 and #3 (SWMP Parts 6.A and 6.C)
5	No VTrans allocation, VTrans will implement MCM #1 and #3 (SWMP Parts 6.A and 6.C)
6	Part B - plan in place to mitigate - no specific actions required
7	No VTrans allocation, no specific actions required
8	No specific actions required - contamination from historic hazardous site
9	No specific actions required - contamination from historic hazardous site
10	Part B - plan in place to mitigate - no specific actions required
11	No specific actions required; BMPs in place to mitigate. Impairment cause is ski area development.
12	No specific actions required; VTrans will implement MCM #1, #3, and #6 (SWMP Parts 6.A, 6.C, and 6.F)
13	No specific actions required; VTrans will implement MCM #1, #3, and #6 (SWMP Parts 6.A, 6.C, and 6.F)
14	VTrans will implement MCM #1, #3, and #6 (SWMP Parts 6.A, 6.C, and 6.F). Inspect hydrologically connected road segments, stabilize visible erosion, report progress annually. Primary impairment source is agricultural runoff.
15	No specific actions required; MCM #6 for spill prevention and if PCBs encountered
16	No VTrans allocation, VTrans will implement MCM #1 and #6 (SWMP Parts 6.A and 6.F). Inspect hydrologically connected road segments if any, stabilize visible erosion, report progress annually. Primary impairment source is agricultural runoff.
17	PCP development and implementation (SWMP Part 9.2)
18	PCP development and implementation beginning in 2022; VTrans will implement MCM #1 and #6 (SWMP Parts 6.A and 6.F)
19	Part B - plan in place to mitigate - no specific actions required
20	Consider priority inclusion in PCP development and implementation (SWMP Part 9.2). VTrans owns or controls approximately 29% of total impervious cover in the Deer Brook watershed. Participate in planning/design activities, report progress annually.
21	No specific actions required; VTrans will implement MCM #1, #3, and #6 (SWMP Parts 6.A, 6.C, and 6.F).
22	Part B - plan in place to mitigate - no specific actions required. VTrans will implement MCM #1, #3, and #6 (SWMP Parts 6.A, 6.C, and 6.F). Inspect hydrologically connected road segments, stabilize visible erosion, report progress annually. Primary impairment cause is ski area development.
23	FRP implementation (TS4 Permit Part 9.1)
24	Plan in place to mitigate, no specific actions required. VTrans will implement MCM #1, #3, and #6 (SWMP Parts 6.A, 6.C, and 6.F)
25	No specific actions required; MCM #6 for spill prevention and if toxics encountered
26	Part B - plan in place to mitigate - no specific actions required. VTrans will implement MCM #1, #3, and #6 (SWMP Parts 6.A, 6.C, and 6.F)

ATTACHMENT B CHITTENDEN COUNTY MS4 STORMWATER PROGRAM AGREEMENT (JULY 1, 2018)

CHITTENDEN COUNTY MS4
STORMWATER PROGRAM AGREEMENT
EFFECTIVE July 1, 2017
Amended effective July 1, 2018

Preamble

This Stormwater Program Agreement ("Agreement") is entered into by and between a group of Municipal Separate Storm Sewer System ("MS4") permittees ("MS4 Permittees") and the Chittenden County Regional Planning Commission ("CCRPC") to operate an MS4 Stormwater Program ("Program") that conforms with and satisfies the relevant requirements of both Minimum Control Measure One (Public Outreach and Education) and Minimum Control Measure Two (Public Involvement and Participation) of the Phase II NPDES Permit issued by the Vermont Department of Environmental Conservation ("DEC") on December 2012 through General Permit 3-9014 ("MS4 Permit"), as these requirements may be continued, renewed, amended, or otherwise modified during the term of this Agreement.

1. **Prior Agreements** – Effective July 1, 2017, this Agreement

   a. supersedes an MOU signed by the CCRPC and twelve MS4 permittees, effective March 10, 2013 through March 9, 2018, governing the operation of a Regional Stormwater Education Program to satisfy the relevant requirements of Minimum Control Measure One (Public Outreach and Education), and

   b. supersedes an MOU signed by the CCRPC and eleven MS4 permittees, effective July 1, 2011 through June 30, 2016, and an amendment to this MOU extending its effective date through June 30, 2017, governing the operation of a Regional Stormwater Public Involvement and Participation Program to satisfy the relevant requirements of Minimum Control Measure Two (Public Involvement and Participation).

2. **Service Agreement** – This Agreement constitutes a service agreement pursuant to 24 V.S.A. § 4345b (Intermunicipal Service Agreements).

3. **Definitions**—For purposes of this Agreement, the term "MS4 Permittees" includes the Vermont Agency of Transportation, which on December 28, 2016 became eligible for coverage under General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4).

4. **Parties** – The following are the parties to this Agreement:

   a. **MS4 Permittees** – the undersigned MS4 Permittees, and

   b. **CCRPC** – the undersigned regional planning commission.

5. **MS4 Steering Committee**

   a. **Composition** – The Members of the Steering Committee shall consist of one representative from each of the signatory MS4 Permittees to this Agreement. Another MS4 permittee may request to join this Agreement if approved by a two-thirds vote of the Members. The Members shall be appointed either by the governing bodies of their municipalities at publicly warned meetings or, if a Member representing an MS4 Permittee is non-municipal agency, via a process consistent with that agency's policies. At its first meeting, the Steering Committee shall elect a Chair by a majority vote. The Chair shall serve until such time as the Chair resigns or the Steering Committee elects a new Chair.

b. **Duties** – The Steering Committee shall direct the CCRPC on the development and performance of Program Services in particular and on all other matters bearing on the administration of this Agreement. All actions of the Steering Committee shall be by majority vote unless otherwise specified in this Agreement.

c. **Organization of Meetings** – The Steering Committee shall meet on a quarterly basis at a minimum. The CCRPC shall provide Steering Committee Members with reasonable notice of meetings. Notice shall include a meeting agenda and draft meeting minutes. In addition, the CCRPC shall post notice of Steering Committee meetings on its website and on the Program website.

6. **CCRPC**

a. **Duties** – The CCRPC shall:

1) Administer this Agreement and agreements with contractors (including executing contracts approved by the Steering Committee, receiving and disbursing funds, and monitoring the provision of services) for the benefit of the MS4 Permittees.

2) Provide other services contributing to the operation of the Program (including, but not limited to, social media management, public relations, grant writing, creating and managing a Program website, organizing meetings as set forth in Section 4.c, above, etc.) as directed by the Steering Committee; and at a level consistent with each year's Program Budget as described in Section 8.b, below.

3) Provide a quarterly budget report to the Steering Committee detailing expenses the CCRPC incurred and the payments it has received.

4) Pay contractors and vendors for charges consistent with the relevant contract, using funds from the Program Budget, as defined in Section 8, below.

5) Upon approval of the Steering Committee or its designee, reimburse itself for personnel and other expenses for charges consistent with its duties, using funds from the Program Budget.

6) Consult with the Steering Committee prior to authorizing any contractor activities or charges outside the scope of work of a contract.

7) Notify the Steering Committee when 75% of the annual budget (as defined in Section 8, below) for an individual category of expenses (e.g., contractors, CCRPC fees, advertising, etc.) is reached. When these levels are reached, subsequent expenditures by the CCRPC in that category shall be reviewed and approved by the Steering Committee Chair in advance.

8) At the request of the Steering Committee, assign any or all contracts that the CCRPC has entered into pursuant to this Agreement to the MS4 Permittees who are signatories to this Agreement at the time or to another contractor of the Steering Committee's choosing.

9) Comply with all applicable federal, state, and local laws, including Burlington's Livable Wage Ordinance as applicable.

b. **Compensation** – Through the Program Budget, the MS4 Permittees shall compensate the CCRPC for the actual costs of performing its duties defined in Section 5.a, above; provided, however, that the CCRPC shall not be entitled to compensation that would exceed ten percent (10%) of the Program Budget as specified in Section 8.b, below, without the prior approval of a majority of the Steering Committee.

c. **Invoices** – The CCRPC shall invoice the Program to cover personnel charges, mileage reimbursement, and other direct expenses necessary to perform its duties. Personnel charges for CCRPC staff shall be calculated at a rate of salary plus fringe plus CCRPC's applicable indirect rate as required by 24 V.S.A. § 4345b. As set forth in Section 5.b, above, upon approval of the Steering Committee or its designee, the CCRPC may reimburse itself for charges consistent with its duties, using funds from the Program Budget.

7. **<u>Selection of Contractors</u>**

a. The CCRPC, in consultation with the Steering Committee, shall competitively bid for contract(s) for Program services that collectively satisfy the requirements for Minimum Control Measure One (Public Outreach and Education) and Minimum Control Measure Two (Public Involvement and Participation) of the Phase II NPDES Permit then in effect. The parties to the contracts shall be the contractors and the CCRPC. All contracts shall require the contractor to indemnify and hold harmless the MS4 Permittees from any claims related to the contract and to procure and maintain liability insurance for all services performed under the contract.

b. All contracts shall be awarded based on qualifications, price, and the ability of the entity to provide services that meet the relevant MS4 Permit requirements. The selection of contractors shall comply with the procurement policy of the CCRPC and with applicable state and federal procurement laws and procedures.

c. Contracts shall generally be 1 to 5 years in length and shall include, but not be limited to, a Maximum Limiting Amount and the right of the CCRPC to 1) cancel a contract if services are not being adequately provided, 2) specify that payments to contractors shall be made only for services rendered, 3) specify the annual scope of work and budget as approved by the Steering Committee, 4) allow a contract extension if desired, and 5) assign the contract to the MS4 Permittees that are signatories to this Agreement at the time of the assignment or to a contractor of the Steering Committee's choosing.

d. Contracting for services under this Agreement shall comply with the Fair Employment Act and Americans with Disabilities Act: the CCRPC shall comply with the requirement of Title 21 V.S.A Chapter 5, Subchapter 6, relating to fair employment practices, to the full extent applicable. The CCRPC shall also ensure, to the full extent required by the Americans with Disabilities Act of

1990, that qualified individuals with disabilities receive equitable access to the services, programs, and activities provided by the Steering Committee under this Agreement. This provision shall also be included in all contracts and subcontracts executed under this Agreement.

e. The CCRPC and the Steering Committee recognize the important contribution and vital impact which small businesses have on the State's economy. In this regard, the CCRPC shall ensure a free and open bidding process that affords all businesses equal access and opportunity to compete, except under circumstances where competitive bidding may not be practicable and is not required by applicable procurement policies. The CCRPC and the Steering Committee also recognize the existence of businesses owned by minorities and women, and the CCRPC shall make a good faith effort to encourage these firms to compete for contracts involving state or federal funds and comply with applicable law relating to civil rights and disadvantaged business enterprises.

8. **<u>Program Services</u>** – The Steering Committee, assisted by the CCRPC and its contractors, shall implement a unified Program that satisfies the relevant requirements of Minimum Control Measure One (Public Education and Outreach) and Minimum Control Measure Two (Public Involvement and Participation) of the MS4 Permit.

   The Program Content for each Program Year shall be as defined in writing by a majority of the Steering Committee. The Program Year shall be the State of Vermont's fiscal year. The Program Content shall implement the following deliverables:

   a. **Public Education and Outreach** – Elements shall include, at a minimum:

      1) operating the Program's website, www.smartwaterways.org, or its equivalent; and

      2) advertising in various media.

   b. **Public Involvement and Participation** – Elements shall include, at a minimum:

      1) operating the Program's website, www.ccstreamteam.org, or its equivalent;

      2) hosting and/or organizing workshops, projects, and other events to engage the public; and

      3) recruiting volunteers to support projects, promote events, and/or engage the public.

   c. **End of MS4 permit year annual reporting –** Elements shall include preparation of a narrative report 25 business days prior to the MS4 Permittees' reporting deadline to DEC.

9. **<u>Program Dues, Budget, Costs, and Payments</u>**

   a. **Dues**

      1) For State Fiscal Year, FY18, July 2017-June 2018, the annual dues for each of the undersigned MS4 Permittees shall be $5,500.

2) For the following fiscal years, the annual dues shall be set by a two-thirds majority by October 15th of the preceding calendar year. In the absence of agreement, the dues shall remain at $5,500.

3) The CCRPC shall invoice each MS4 Permittee on or about July 1st of each year with payment to the CCRPC due 30 days later.

4) All Members shall pay equal dues.

b. **Program Budget**

1) The annual Program Budget shall consist of the sum of the annual payments for each Program Year made by MS4 Permittees, plus any funds from other sources made available to the Program by majority vote of the Steering Committee.

2) Prior to the start of each Program Year, the Steering Committee shall adopt a Program Budget governing expenditures for the subsequent Program Year. Budget categories shall include, but not be limited to: CCRPC Duties, Contractual Services, and Expenses.

3) Once the Program Year starts, a majority of the Steering Committee may amend the Program Budget as needed, for example to reflect any surplus or deficits from the prior Program Year, receipt of new sources of funds, or a desired change in the Program Budget, subject to Section 8.a, above.

4) In the event that costs are less than anticipated or that grants or other funding sources become available, a majority of the voting Members of the Steering Committee may decide to reduce each Member's payment by an equal amount or to credit all or part of the following Program Year assessment to each MS4 Permittee.

c. **Maximum Annual Costs and Payments** – Except as otherwise provided by this section, each MS4 Permittee shall within 30 days of receipt of an invoice make a single annual dues payment, as provided by Section 8.a, above.

d. **Other Funds** – Any funds made available to the Program shall be dedicated to reducing the annual costs of each MS4 Permittee participating in the Program, except as a majority of the voting Members of the Steering Committee may decide.

e. **Excess Funds** – Any funds remaining at the end of a Program Year shall be carried over to the next Program Year, unless a majority of the voting Members of the Steering Committee decides otherwise.

f. **Non-appropriation** – The obligations of each MS4 Permittee to make payments under this Agreement shall constitute a current expense of the MS4 Permittee and shall not in any way be construed to be a debt of the MS4 Permittee in contravention of any applicable constitutional or statutory limitation or requirement, or the MS4 Permittee's charter or articles of incorporation; nor shall anything contained in this Agreement constitute a pledge of the credit or tax revenues, funds, or monies of the MS4 Permittee. The decision whether or not to budget and appropriate funds during each fiscal year of the MS4 Permittee is within the discretion of the governing body of the MS4 Permittee. The obligations of a MS4 Permittee under the Agreement are subject to annual appropriations by the governing body of the MS4 Permittee, except as provided by Section 12 of this Agreement. An MS4 Permittee cannot choose to not appropriate funds and then withdraw in a manner that shifts prior contractual obligations on to the others. Non-appropriation will be considered withdrawal and must be prospective in fairness to all signatories as per Section 13.

10. **Contract Approval** – All CCRPC contracts shall be conditioned upon approval by a majority of the voting Members of the Steering Committee and shall be consistent with Section 6, above.

11. **Termination of CCRPC** – The CCRPC on its own or the Steering Committee by a majority vote of its full Membership may elect to terminate the CCRPC's future participation in this Agreement by providing 90 days' written notice to the other. In the event of termination under this section, the CCRPC shall continue to administer and comply with each existing contract, and the MS4 Permittees shall continue to reimburse the CCRPC from the Program Budget for the actual costs of administering and complying with each contract, as provided by this Agreement, unless and until the CCRPC assigns the contract pursuant to Sections 5.a.8 and 6.c of this Agreement.

12. **Termination of Agreement**

    a. This Agreement shall become null and void with no further obligation of the parties if:

        1) Two-thirds of the Members of the Steering Committee vote to end participation, or

        2) DEC determines that the Program outlined in this Agreement does not meet the relevant requirements for Minimum Control Measure One (Public Education and Outreach) or Minimum Control Measure Two (Public Involvement and Participation), and the parties to this Agreement are unable to craft a Program to satisfy DEC.

    b. In the event of termination, any funds remaining in the Program Budget (after payment of obligations to vendors or to satisfy debts) shall be reimbursed to the MS4 Permittees with each MS4 Permittee receiving a share proportional to the number of MS4 Permittees at the time of termination. For example, if there are twelve MS4 Permittees at the time of termination, each MS4 Permittee shall receive a 1/12th share.

13. **Withdrawal of Member** – An MS4 Permittee may withdrawal from participation in this Agreement only at the end of a state fiscal year. If an MS4 Permittee wishes to withdrawal from participation, it shall provide at least 90 days' notice to the other MS4 Permittees and the CCRPC. After withdrawal, a MS4 Permittee shall remain responsible for its share of the costs of contracts that the Steering Committee approved prior to the effective date of the withdrawal.

14. **Effective Date and Duration of Agreement** – The effective date of this Agreement shall be July 1, 2017, and this Agreement shall terminate June 30, 2022.

15. **Amendment** – This Agreement may be amended only upon unanimous action of all the Members.

16. **Counterparts** – This Agreement may be executed in multiple counterparts, each of which is deemed an original and all of which constitute one and the same document. Each such counterpart may be a facsimile or PDF copy, and such facsimile or PDF copy shall be deemed an original.

17. **Public Records** – Any and all records submitted to the CCRPC or MS4 Permittees - including Bids, Proposals, Qualifications, Contracts, etc.-- whether electronic, paper, or otherwise recorded, are subject to the Vermont Public Records Act.

Signature of CCRPC

[signature] 5/24/18

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

Name Title The Burlington International Airport Date

Name Title The City of Burlington Date

Name Title The Town of Colchester Date

Name Title The Town of Essex Date

Name Title The Village of Essex Junction Date

Name Title The Town of Milton Date

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Signature of CCRPC

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

[signature]		Director of Aviation	3-28-18
Name	Title	The Burlington International Airport	Date
Name	Title	The City of Burlington	Date
Name	Title	The Town of Colchester	Date
Name	Title	The Town of Essex	Date
Name	Title	The Village of Essex Junction	Date
Name	Title	The Town of Milton	Date

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Signature of CCRPC

______________________________ __________

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

Name	Title	The Burlington International Airport	Date
S. Chapin Spencer	Director	[signature]	4/9/18
Name	Title	The City of Burlington	Date
Name	Title	The Town of Colchester	Date
Name	Title	The Town of Essex	Date
Name	Title	The Village of Essex Junction	Date
Name	Title	The Town of Milton	Date

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Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

______________________________ ________

Name Title The Burlington International Airport Date

______________________________ ________

Name Title The City of Burlington Date

Dawn H. Francis Town Manager Town of Colchester 3/27/18

Name Title The Town of Colchester Date

______________________________ ________

Name Title The Town of Essex Date

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Name Title The Village of Essex Junction Date

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Name Title The Town of Milton Date

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Signature of CCRPC

____ ________

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

____ ________

Name Title The Burlington International Airport Date

____ ________

Name Title The City of Burlington Date

____ ________

Name Title The Town of Colchester Date

[signature], Public Works Director 4-11-18

Name Title The Town of Essex Date

____ ________

Name Title The Village of Essex Junction Date

____ ________

Name Title The Town of Milton Date

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Signature of CCRPC

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

Name Title The Burlington International Airport Date

Name Title The City of Burlington Date

Name Title The Town of Colchester Date

Name Title The Town of Essex Date

Water Quality Supt 4/13/2018
Name Title The Village of Essex Junction Date

Name Title The Town of Milton Date

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Signature of CCRPC

Christopher D. Roy, Board Chair, Chittenden County Regional Planning Commission Date

Signatures of Members

Name Title The Burlington International Airport Date

Name Title The City of Burlington Date

Name Title The Town of Colchester Date

Name Title The Town of Essex Date

Name Title The Village of Essex Junction Date

Town Manager 5/8/18

Name Title The Town of Milton Date

Joe Colangelo	Town Manager	The Town of Shelburne	6-March-2018 Date
Name	Title	The City of South Burlington	Date
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Name	Title	The Town of Williston	Date
Name	Title	The City of Winooski	Date

Name Title The Town of Shelburne Date

Helen Riehle Chair 4/2/18

Name Title The City of South Burlington Date

Name Title Vermont Agency of Transportation Date

Name Title The University of Vermont Date

Name Title The Town of Williston Date

Name Title The City of Winooski Date

Name	Title	The Town of Shelburne	Date
Name	Title	The City of South Burlington	Date
Joe Flynn		e-Signed by Joe Flynn on 2018-04-02 12:47:56 GMT	April 02, 2018
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Name	Title	The Town of Williston	Date
Name	Title	The City of Winooski	Date

Name Title The Town of Shelburne Date

Name Title The City of South Burlington Date

Name Title Vermont Agency of Transportation Date

Linda Seavey 3/28/2018

Linda Seavey, Director, Campus Planning Services The University of Vermont Date

Name Title The Town of Williston Date

Name Title The City of Winooski Date

Name	Title	The Town of Shelburne	Date

Name	Title	The City of South Burlington	Date

Name	Title	Vermont Agency of Transportation	Date

Name	Title	The University of Vermont	Date

Richard McGuire Town Manager [signature] 3/21/18

Name	Title	The Town of Williston	Date

Name	Title	The City of Winooski	Date

Name	Title	The Town of Shelburne	Date
Name	Title	The City of South Burlington	Date
Name	Title	Vermont Agency of Transportation	Date
Name	Title	The University of Vermont	Date
Name	Title	The Town of Williston	Date
Jessie Baker City Manager			3/23/18
Jessie Baker - City Manager		The City of Winooski	Date

ATTACHMENT C VTRANS BRIDGE WASHING BEST MANAGEMENT PRACTICES AND VT ANR VEHICLE WASHING POLICY

State of Vermont
Operations Division
Web: http://www.aot.state.vt.us/maint/Operations.htm

Agency of Transportation
One National Life Drive – Dewey Bldg
Montpelier, VT 05633-5001

Best Management Practice: **"BRIDGE WASHING"**

Effective Date: **5/1/2013**

VTrans Authorized Signature: *Scott A. Rogers*
Director, Operations Division

VTRANS STATE HIGHWAY SYSTEM
BRIDGE WASHING
BEST MANAGEMENT PRACTICES (BMPS)

PURPOSE STATEMENTS

Washing bridges is a preventative maintenance task performed on a recurring basis in order to protect bridge decks, components and superstructure against corrosive effects of chlorides, de-icing chemicals and the accumulation of sand on bridge surfaces throughout the winter.

The VTrans State Highway System Bridge Washing BMP guides maintenance activities in order to:

- Define appropriate level of service and performance expectations;
- Maintain safe bridges for the traveling public and bridge maintenance employees;
- Prevent infrastructure deterioration, extend useful life and provide for a better functioning structure;
- Comply with VTrans Policy and Federal or State rules and regulations;
- Reduce Cost (water consumption, energy, equipment and personnel costs);
- Protect water quality and aquatic wildlife habitats;
- Create mechanisms and standards for addressing environmentally sensitive areas;
- Preserve the scenic qualities of the highway corridor.

GUIDING PRINCIPLES

These BMPs have several guiding principles:

- VTrans Bridge Washing Policy;
- State and Federal Regulatory Requirements;
- Create consistent requirements throughout the state that protects water quality;
- Preserve the scenic qualities of the corridor to the extent practicable, while maintaining environmental stewardship and conserving resources.

LEVEL OF SERVICE & PERFORMANCE EXPECTATIONS

Sweep 100% and wash 50% of all bridges annually in the Spring. It is expected that all bridges will be washed at least every other year and that bridge washing operations are compliant with all applicable Safety and Environmental Regulations. Annual Trainings shall be provided to VTrans Maintenance Personnel directly involved in bridge washing activities.

General Standards

These standards are applicable only to bridges on the VTrans State Highway System, are subject to the conditions and exceptions noted below and are intended to be implemented to the extent reasonable and practicable when not otherwise required by rule, regulation or law. Bridge washing operations shall not violate any written VTrans Policy or State/Federal Rule, Regulation or Permit.

The VTrans District Transportation Administrator (DTA) or its designee must ensure compliance with all VOSHA standards and the Manual for Uniform Traffic Control Devices (MUTCD) by use of contract language and safety plan review meetings with contractors or VTrans personnel. Items to be addressed in addition to VOSHA and MUTCD standards should include, but are not limited to, equipment loading, storage, and access plans; safety plans for working over water; traffic control and mobile operations sign planning, and protection of personnel, infrastructure, and the traveling public.

Target Audience

These BMPs are primarily intended for VTrans Operations Division. In addition, these BMP's may also be applicable to municipally managed structures and Municipal bridge maintenance crews.

Municipalities may wish to refer to these standards and implement the practices mentioned herein. VTrans will not be responsible for monitoring Municipal performance nor compliance under these standards and practices, but may serve as a technical resource for Municipalities regarding the implementation of these practices.

Policy & Regulatory Requirements

VTrans Policy and State/Federal Regulations will dictate how, where and when these BMSs are applied and to what performance level. The BMPs noted herein are directed at addressing these requirements.

- VTrans Bridge Washing Policy (Attachment A) – applicable statewide
  Requirements have statewide implications and include but are not limited to:
  - Removal and proper disposal of sand, debris and other material from bridge deck prior to use of water to clean bridge surface.
  - Water used to flush salts and de-icing chemicals from the bridge must come from a water source which has no potential to harm the receiving water body.
  - Minimize impact to the receiving waters when washing bridge seats, pier caps, diaphragms and any other superstructure (steel) components of the bridge.

- "Transport of Aquatic Plants and Other Nuisance Species" V.S.A Title 10 Chapter 50 Section 1454 **http://www.leg.state.vt.us/statutes/fullsection.cfm?Title=10&Chapter=050&Section=01454** (Attachment B) – applicable statewide.
  On July 1, 2010 the then 22-year old law was amended prohibiting:
  - Transport of any invasive aquatic species in Vermont. Specifically, the law prohibits transport on the outside of boats, personal watercraft, trailer or other equipment. That means the outside of an intake hose on any pump or water truck and any pump equipment used by VTrans to get water from natural water bodies. This is a law that has statewide jurisdiction and may require:
    - Avoid taking water from document water bodies that are known to have aquatic invasive species **http://www.anr.state.vt.us/dec/waterq/lakes/docs/ans/lp_transportlaw2010.pdf**
    - Drawing water from nearby municipal water supplies or stand pipes installed by various fire districts or other clean/non-contaminated water source.
    - Clean off any equipment used for "working over water" safety programs before moving to next bridge.

- Vermont Water Quality Standards in effect or as may be amended and are applied statewide. **http://www.nrb.state.vt.us/wrp/rules.htm**

- Federal Clean Water Act – National Pollutant Elimination System – Municipal Separate Storm Sewer System (MS4) General Permit – applicable in designated MS4 areas.
  - Districts with bridges in MS4 areas are **NOT** allowed to discharge bridge deck washing water into waster bodies subject to MS4 Permit requirements. The list of waters is noted on ANR's web site (link below) and is subject to change. This is a regulation that has limited geographical jurisdiction in the state that can and does change periodically. See the Agency of Natural Resources MS4 Map: **http://www.vtwaterquality.org/stormwater/docs/ms4/sw_MS4_map.pdf**

- Federal Migratory Bird (MBTA)/Bald & Golden Eagle Protection Act and Endangered Species Act – applicable statewide. Both Federal programs are intended to protect species of concern.

  The MBTA provides that it is unlawful to pursue, hunt, take, harass, capture, kill, possess, sell, purchase, barter, import, export, or transport any migratory bird, or any part, nest, or egg or any such bird, unless authorized under a permit issued by the Secretary of the Interior. Some regulatory exceptions apply. Take is defined in regulations as: "pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect." The Bald/Golden Eagle Act is extremely comprehensive, prohibiting the take, possession, sale, purchase, barter, or offer to sell, purchase, or barter, export or import of the bald or Golden eagles at any time or in any manner. **http://www.fws.gov/migratorybirds/mbpermits/ActSummaries.html**

  The migratory bird species protected by the Act are listed in 50 CFR 10.13. View the list of MBTA protected birds and Migratory Bird Program Rule at **http://www.fws.gov/migratorybirds/index.html.**

  The Endangered Species Act (ESA) and the Vermont Rare, Threatened, and Endangered Species Rules (VRTER) are designed to regulate a wide range of activities affecting animals designated as endangered or threatened, and the habitats upon which they depend. With some exceptions, the ESA and VRTER prohibits taking and other activities affecting these protected species and their habitats unless authorized by a permit. Permitted activities are designed to be consistent with the conservation of the species. Take - From Section 3(18) of the Federal Endangered Species Act means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. **http://www.fws.gov/endangered/species/index.html** and **http://www.vtfishandwildlife.com/cwp_elem_spec_rte.cfm**

  Contact VTrans Program Development Environmental Program Staff Biologist or the Vermont Department of Fish & Wildlife (links below) if you find a nest with or without eggs or young and if you feel you have a rare, threatened or endangered species present (ie. Bats or other listed species using the bridge has habitat). Be advised, you may be instructed to avoid disturbing the nest and to wash areas around the nest, leaving the nest undisturbed. **http://vtransengineering.vermont.gov/sections/environmental/natural_resources** and **http://www.vtfishandwildlife.com/cwp_contact_us.cfm**

- Highway Safety – applicable statewide
  The DTA or its designee must ensure compliance with all VOSHA standards and the Manual for Uniform Traffic Control Devices (MUTCD) by use of contract language and safety plan review meetings with contractors or VTrans personnel. Items to be addressed in addition to VOSHA and MUTCD standards should include, but are not limited to, equipment loading, storage, and access plans; safety plans for working over water; traffic control and mobile operations sign planning, and protection of personnel, infrastructure, and the traveling public.

BRIDGE WASHING PROCEDURES & BEST MANAGEMENT PRACTICES

1. **Prepare for and set up a work plan** for each bridge site addressing, among other things:
   a. Traffic control, fall protection, working over water plan, and other MUTDC/VOSHA requirements.
   b. Location of bridges to be washed and acknowledgement of higher standards if located in a designated MS4.
   c. Consider proximity of bridge to various clean bridge washing water sources (even sources on route),
   d. Consider presence of invasive/nuisance aquatic plants/organisms in local surface water sources;
   e. Consider presence of bird nests or other protected species and complete coordination with the VTrans Program Development Environmental Section's Staff Biologist or Vermont Department of Fish & Wildlife prior to disturbing any nests, birds or other protected species. Bridge washing between April 1 and August 1 is more likely to encounter birds and nesting. Bridge Maintenance Crews that experience recurring bird use, nesting or use by rare, threatened or endangered species may want to consider installing deterrents on that specific bridge.

2. **Identify appropriate water source** for bridges scheduled for washing:
   a. Check for local sources of fresh/clean water and if considering using a local water body as source, check Agency of Natural Resources (ANR) web site for presence of aquatic invasive/nuisance species. If the surface water body intended for use to fill the tanker truck is or is suspected of carrying aquatic invasive/nuisance species then that water body SHALL NOT be used and an alternate clean water source will need to be found, most likely municipal.
   b. When considering water sources, first consideration is to use a clean untreated or de-chlorinated water source from a municipal supply, second from fire stand pipe in the same watershed as the bridge scheduled for washing, and final last option is from a water body under bridge being washed or in the same watershed if the bridge is not over waters and those water bodies are not known or suspected of carrying aquatic invasive/nuisance species.
   c. If the only available option is to us a surface water body to fill a water tanker truck first inspect all hoses, pipes, pumps that will come in contact with the water for any plant material or mud prior to putting this equipment into the water….remove any materials if found and properly dispose of the plant material. Proper disposal means bagged and disposed of in trash receptacle. After pumping is completed, inspect again and remove plant materials and mud if any are found before moving on to the next bridge. Empty tanker truck of all water taken up from surface water body before moving onto the next bridge.
      i. **Inspect** and clean off any aquatic plants, animals, and mud from all equipment before leaving bridge location where water was drawn from.
      ii. **Drain** pumps, hoses and all other water containing devices.
      iii. Dispose of unused water on location if source of water is from non-municipal supply.
      iv. Never dump live fish, vegetation or other organisms from one water body into another.

   The intent of these actions is to clean off any visible large-bodied organisms attached to equipment. Draining can also remove small organisms such as zebra mussel veligers, however, additional steps are needed to remove small-bodied organisms from other parts of the equipment. Those can be easily rinsed off or die out of water in a short period of time. To this end, added precautions that improve treatment effectiveness are to:
      i. **Spray/rinse** equipment with high pressure hot water to clean off mud and kill aquatic invasive species,
      ii. **Flush pump** motor according to owner's manual, and/or
      iii. **Dry** everything for at least five days before reuse or **wipe** with a towel before reuse.
   d. If a surface water body is used as bridge washing water source the pipes/hoses used to withdraw water shall be screened to prevent fish entrainment and to help prevent uptake of vegetation.

3. **Prior to washing bridge surface**, the following activities will be completed:
   a. Sweep sand, debris and deicing chemical contaminated sediment from the bridge.
   b. Sweepings will be removed by hand using shovels, wheelbarrows or bobcat buckets and placed off the roadway shoulder. Larger amounts of sweepings will be spread out along roadway shoulder after trash and larger debris has been removed for proper disposal. Sweepings can also be trucked back to Maintenance Yard and added to sand pile for future re-use (again after trash and larger debris has been removed and properly disposed of). Sweepings will not be swept into open deck drains or over the edge of the bridge.
   c. Prior to washing bridge surfaces, all scuppers and other drains will be blocked with unbroken sand bags to prevent accidental discharge of wash water to surface waters under bridge or onto roadway below bridge.
   d. Brush and vegetation may need to be removed from around wings abutments and piers. Any vegetation management in river buffers should follow the VTrans Riparian Tree and Brush Cutting BMP. **http://vtransoperations.vermont.gov/bmp**
   e. Invasive terrestrial (plant) species encountered and in need of removal should be managed per the VTrans Invasive Species BMP. **http://vtransoperations.vermont.gov/bmp**

4. **Prior to washing bridge superstructure**, the following activities will be completed:
   a. If nests are found while on-site working or if you feel you may have a rare, threatened or endangered species present (ie. Indiana Bat or other listed species using the bridge has habitat), contact Vermont Department of Fish & Wildlife **http://www.vtfishandwildlife.com/wildlife_nongame.cfm** or VTrans Environmental Biologist **http://vtransengineering.vermont.gov/sections/environmental/natural_resources**.
   b. If bird nests are present they must not be disturbed. Bridge washing operations may proceed so long as nests and birds can be avoided and left undisturbed.
   c. If rare, threatened or endangered species are suspected or are present, Bridge Maintenance Crews must contact VTrans Environmental Biologist or Vermont Department of Fish & Wildlife to confirm species and secure guidance on how to proceed before bridge washing operations commence on that specific bridge.

5. **Washing the bridge surface and superstructure** will follow these procedures:
   a. Water hose nozzles will be aimed to minimize overspray into surface waters or roads below bridge.
   b. Limit psi when washing steel bridge components so as to avoid the accidental dislodging of paint which might end up in the water body beneath the bridge. Pressure washing equipment shall be operated at pressures that do not damage the paint or other coatings on the bridge or undercut the grout or harm the masonry plates beneath the bearings.
   c. Water will be aimed along the curb line to wash any accumulated sand/salt towards the bridge down slope.
   d. Washing will include bridge joints, finger joint troughs, bridge shoe and seats and any bridge components that are within the splash zone.
   e. To the extent practicable, washing of bridges will be scheduled on structures over waterways during the springtime to coincide with high-flow periods or during other high-flow periods following storm events.
   f. Any bridge deficiencies should be repaired or noted and added to the work schedule.
   g. **Bridge deck washing in designated MS4** – All bridge drainage systems shall be blocked during surface washing and to the extent practicable, residual wash water will be diverted to upland areas (i.e. over embankments into vegetated areas or into catch basins) so that sediments may settle out prior to reaching the waterway. Water washed over a vegetated area must not cause scour or contribute to sedimentation of the waterway. This is an absolute requirement in MS4 designated watersheds.
   h. **Bridge deck washing in designated MS4** - REPORT within 5 business days, to VTrans Operations Environmental Program Stormwater Technician any accidental discharges to water bodies and corrective measures taken to cease the discharge and prevent additional discharges.
   i. Clean off any equipment used for "working over water" safety programs before moving to next bridge.

USEFUL LINKS

VTrans Bridge Washing Policy
https://inside.vermont.gov/agency/vtrans/VTransIntranetHome/Ops/Policy%20and%20Procedures%20Manual/BridgeWashing3011.pdf

VSA Title 10 – Aquatic Plants & Aquatic Invasive Species Transport Law
http://www.vtwaterquality.org/lakes/htm/ans/lp_ans-index.htm
http://www.anr.state.vt.us/dec/waterq/lakes/docs/ans/lp_transportlaw2010.pdf

ANR Aquatic Invasive Species Site (Map)
http://www.vtwaterquality.org/lakes/docs/ans/lp_aismapmajorspecies2011.pdf#zoom=100
http://www.vtwaterquality.org/lakes/docs/ans/lp_infestedwaterbodieslist.pdf

Migratory Bird Treaty Act & Bald/Golden Eagle Protection Act
http://www.fws.gov/migratorybirds/index.html
View the list of MBTA protected birds
http://www.fws.gov/migratorybirds/mbpermits/ActSummaries.html

Federal Endangered Species Act
http://www.fws.gov/endangered/species/index.html

Vermont Rare, Threatened, and Endangered Species
http://www.vtfishandwildlife.com/cwp_elem_spec_rte.cfm

State of Vermont DEC - EPA NPDES – State MS4
http://www.vtwaterquality.org/stormwater/htm/sw_ms4.htm

Map of designated MS4's
http://www.vtwaterquality.org/stormwater/docs/ms4/sw_MS4_map.pdf

VT Water Quality Standards
http://www.nrb.state.vt.us/wrp/rules.htm

VTrans Training PowerPoint (most recent posted on VTrans Web Site)
http://vtransoperations.vermont.gov/bmp

OSHA
Contact VTrans Safety Officer
http://vtransoperations.vermont.gov/technical_services/occupational_safety

VTrans Safety Site (working over water, etc)
Contact VTrans Safety Officer
http://vtransoperations.vermont.gov/technical_services/occupational_safety

VTrans Riparian Tree & Brush Cutting BMP
http://vtransoperations.vermont.gov/bmp

VTrans Invasive Species BMP
http://vtransoperations.vermont.gov/bmp

Operations Division Vermont Agency of Transportation	Original Policy Adopted Date: N/a	Original Identification No. 05-MOP--3011
Policy and Procedures Manual	**Responsible Section: Maintenance Districts**	**Policy Name: Bridge Washing**
Subject: Training	**Approval Date: 11/29/2005**	**Page(s) 1 of 1**

Statutory Reference / Other Authority: Federal and state rules and regulations, and the Manual on Uniform Traffic Control Devices (MUTCD)

Approved by: Samuel B. Lewis, Director of Operations

BRIDGE WASHING

Purpose:

Bridge preventive maintenance is critical in extending the life of bridges. Decks, seats, pier caps and troughs need to be periodically cleaned of debris and salt residue. Over the winter, sand and debris accumulate along the deck /curbing interface, as well as on abutments or pier caps, allowing a perfect medium for residual salt to penetrate to the reinforcing steel and cause deterioration of both the steel and structural concrete. It is important that the process of removing of the sand and debris is accomplished early in the spring and in a manner that does not harm the environment or violate state or federal regulations.

Policy:

Sand, debris, and other material must be removed from the bridge deck prior to the use of pressure water which will remove the salt latents from the deck/curbing interface. Appropriate removal of material can be accomplished with hand tools and power or hand brooms. All removed material must be deposited in an area which will not affect the river, brook or other body of water crossed by the bridge. Generally, an appropriate place for depositing the material can be found along the approaches of the bridge. **No foreign material can be deposited over the side of the bridge rail, even if it is not directly over water!**

Water used to flush the salt latents from the deck must come from a source which has no potential to harm the receiving water body. Scuppers will need to be sand bagged or plugged if they have a direct route to the body of water crossed by the bridge.

Care needs to taken when washing bridge seats, pier caps, and diaphragms to minimize any impact on the receiving water.

Traffic control shall follow the guidance provided in the MUTCD.

It is expected that bridges will be washed at least every other year.

Law Prohibits the Transport of Aquatic Plants and Aquatic Invasive Species in Vermont

Invasive species such as Eurasian watermilfoil and zebra mussels are typically spread by "hitchhiking" on boat trailers, propellers and fishing gear that isn't cleaned, or in bilge water, bait buckets, or livewells that aren't drained before moving to a different water body. It often takes only a tiny fragment of an invasive plant, sometimes less than an inch, to start a whole new infestation.

On July 1, 2010, Vermont's 22-year old law prohibiting the transport of important aquatic invasive species changed. Previously, the law prohibited the transport of the invasive plants Eurasian watermilfoil and water chestnut. Come July 1, Vermont's invasive species transport law **prohibits the transport of *all* aquatic plants or aquatic plant parts** on the outside of a vehicle boat, personal watercraft, trailer or other equipment.

The law defines an aquatic plant as " …a plant that naturally grows in water, saturated soils or seasonally saturated soils, including algae and submerged, floating leafed, floating, or emergent plants."

The law change means both the public and those who enforce the law will not have to know how to distinguish one type of aquatic plant from another.

Vermont's invasive species transport law also will continue to prohibit the transport of two animal species, zebra mussels and quagga mussels.

The full law is available here.

A person who violates this law may be subject to a penalty of up to $1,000 per violation (Vermont Statutes Annotated Title 23, Chapter 29 § 3317. Penalties).

More information

- Click here for the full text of Vermont's aquatic invasive species transport law.
- For more information on aquatic invasive species, visit the VT Water Quality Division Web site at http://www.vtwaterquality.org

Washwater Discharges From Vehicle Washing

Water used in washing cars, trucks, and other equipment may contain a wide range of contaminants including oil, other hydrocarbons, metals, detergents, road salt, and grit. These pollutants can be toxic and harmful to living organisms, including fish and the people who eat the fish. It is important to keep these contaminants out of our surface and drinking water. **The Department of Environmental Conservation's (DEC) policy** (dated 12/09/02) **covers only the washwater generated from washing the exterior of vehicles** (cars, trucks, buses, and light or heavy equipment). It supersedes the parts of the "DEC's Floor Drain Procedure" (signed October 8, 1993) that refer to Vehicle washing.

There are four options for handling your vehicle washwater:

1) Install a closed system with no discharge

Operate a "closed loop system" by recycling your washwater. Because no wastewater is discharged to the ground's subsurface or surface, this would not require a UIC permit. However, if it includes a holding tank, the tank will need to be permitted by the DEC Regional Office in your area.

2) Install a holding tank

Install a holding tank to collect the washwater from the floor drain and have the contents disposed of properly. Holding tanks can be installed and pumped out as needed by a qualified hauler. The holding tank contents must be disposed of at an approved disposal facility (i.e. a municipal wastewater treatment facility.) Holding tanks require a permit from the DEC Regional Wastewater Office in your area (see contact info on back). The town may also need to approve the disposal at its wastewater treatment facility.

3) Discharge to municipal sanitary sewer

Connections to the local wastewater treatment facility must be permitted by the Regional Offices and may require adequate pretreatment (e.g. an oil/water separator.) The town may also have an approval process for connections to its wastewater treatment facility.

4) Limit washings to 30 or fewer vehicles per week

If the following conditions are met, the washwater from 30 or fewer vehicle washings per week may be discharged to the **ground surface**.

A) Whether these vehicle washings occur indoors or outside, the following conditions must be met:

i. The washwater going to the ground surface must sheet flow over a vegetated area and infiltrate or evaporate on-site, therefore the site should not be graded in a way that encourages the collection of the washwater.

ii. The washwater must not cause soil erosion and must not reach waters of the state, either directly or through stormwater drains or ditches.

iii. Only non-phosphorus soaps may be used.

iv. The use of acids, bases, metal brightners and degreasing agents as well as pressure washing engines, undercarriage washing and engine cleaning are all prohibited.

Continued▶

B) If the vehicle washing takes place indoors (discharging to ground surface), the following **additional** conditions must be met:

  i. All washing must occur in a wash bay that has a floor drain and is physically separated from where vehicles are serviced.
  ii. An oil-water separator must be installed on the floor drain piping.
  iii. The floor drain must be registered with the UIC program (call the UIC Program, 802-241-3822).
  iv. Hazardous materials can't be stored in the wash area unless adequate containment is provided.

C) If the vehicle washing takes place outside; the following **additional** conditions must be met:

  i. Whenever possible, the washing should occur on an impermeable surface (i.e. concrete, asphalt, plastic, or other) and then sheet flow over a vegetated area.

Regardless of which option you chose, remember:

If there is ever a hazardous spill to a floor drain or to the ground and there is a potential for groundwater contamination or the contents of a holding tank is in question, contact the Hazardous Spills Hotline 1-800-641-5005 for assistance.

For more information, contact:

Wastewater Management Division
Underground Injection Control (UIC) Program
103 South Main Street - Sewing Building
Waterbury, VT 05671-0405
Telephone: 802-241-3822
Fax: 802-241-2596

DEC Regional Wastewater Offices

Barre:	5 Perry Street, Suite 80	802-479-0190	fax: 479-4272
Essex:	111 West Street	802-879-5656	fax: 879-3871
Springfield:	100 Mineral Sreet, Suite 303	802-885-8855	fax: 885-8890
Rutland:	450 Asa Bloomer State Building	802-786-5900	fax: 786-5915
St. Johnsbury:	184 Portland Street	802-751-0130	fax: 748-6687

ATTACHMENT D VTRANS FLOW RESTORATION PLAN

(Appendices for FRP have been included as a separate attachment)

VTrans Flow Restoration Plan

MS4 GENERAL PERMIT REQUIREMENT (IV.C.1)

June 1, 2017

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A. Disclaimer

The intent of this plan is to present the data collected, evaluations, analysis, designs, and cost estimates for the Vermont Agency of Transportation (VTrans). This document provides information for stormwater retrofit projects proposed to meet VTrans flow restoration obligations in watersheds subject to a Flow Restoration Plan (FRP) under the National Pollutant Discharge Elimination System (NPDES) General Permit 3-9014 (VTDEC 2012). This plan should be considered to be the regulatory document for VTrans to meet FRP obligations under General Permit 3-9014. If VTrans is included in FRPs submitted by other MS4s, the information contained in this plan should supersede that information. In addition, retrofit projects identified in this plan have not been fully assessed for feasibility or completely design. The work completed has been done at a planning level, and will be subject to change based on site conditions, permitting, budgetary constraints and other unforeseen issues.

B. Executive Summary

This Flow Restoration Plan (FRP) for the 10 stormwater impaired watersheds where the Vermont Agency of Transportation (VTrans) owns impervious cover was developed in accordance with requirements in the Municipal Separate Storm Sewer System (MS4) General Permit #3-9014 (2012). Components of this FRP include the identification of retrofits to existing BMPs, identification of new BMP controls, an implementation schedule, a financial plan, and a regulatory analysis. Once approved by the Vermont Department of Environmental Conservation (VT DEC), this FRP will become part of the Stormwater Management Plans (SWMP) for VTrans for these watersheds. The purpose of the FRP is to provide a planning tool for VTrans to implement stormwater BMPs over a 20-year timeframe from the date of permit issuance (December 2012) in the effort to restore these impaired watersheds to their attainment conditions.

Vermont developed Total Maximum Daily Load (TMDL) documents for these stormwater impaired watersheds using flow as a surrogate for pollutant loading. The basis for the TMDL development was the comparison of modeled Flow Duration Curves (FDCs) between impaired and attainment watersheds. The Program for Predicting Polluting Particles Passage through Pits, Puddles, and Ponds, Urban Catchment Model (P8) was used to model gauged and ungauged watersheds in Vermont and develop Flow Duration Curves (FDC) from which a normalized high flow and low flow per drainage area (cfs/mi^2) were extracted. An FDC is a curve displaying the percentage of time during a period that flow exceeds a certain value, with the “low” flow represented by the 95th percentile (Q 95%) of the curve and the “high” flow represented by the 5th percentile (Q 0.3%). The high and low flow values from the FDCs were then compared between impaired watersheds and similar attainment watersheds to determine a percent change (reduction of high flow and increase of low flow). In addition to the modeled flows, future non-jurisdictional growth predictions were made for each watershed and used to predict the flow reductions needed 20 years in the future. The percent change was reported in the Environmental Protection Agency (EPA) approved TMDL for each impaired watershed. In certain watersheds, the future growth prediction was modified as it was deemed excessive based on further review. The flow targets were modified in three watersheds to account for these changes.

The TMDLs for the 10 watersheds discussed in this report were approved between 2006 and 2009. They require high flow reductions ranging by watershed from 1.3% in Indian Brook to 63.0% in Centennial Brook. The TMDLs also suggest an increase in stream flow during base flow conditions. These range by watershed from 1.1% in Indian Brook to 24.3% in Stevens Brook.

As a part of the FRP development, an assessment was completed to determine to what extent current stormwater controls have reduced high flows from the Pre-2002 condition to the current (Post-2002) condition. The Vermont Best Management Practice Decision Support System (BMPDSS) model, a GIS-based hydrologic model used to assess the impact of various stormwater Best Management Practice (BMP) scenarios, was used for the assessment. The model was created by VT DEC and its partners as part of the initial TMDL development. By watershed, the BMPDSS estimated that between 3.8% (Stevens Brook) and 213.8% (Sunderland Brook) of the total high-flow reduction target was met with existing BMPs designed to meet the Vermont 2002 Stormwater Design Standards when compared to the Pre-2002 condition. The reduction for the VTrans portion of the impervious area ranged from 0% in Centennial Brook and Moon Brook to 377.4% in Sunderland Brook, averaging 49.7% per watershed. In all watersheds except Sunderland Brook, additional BMPs are required to meet 100% of the actionable flow target.

For Sunderland Brook, even though modeled flow targets for the Post-2002 condition model exceeded TMDL flow targets, additional BMPs were also identified for potential future implementation. The MS4 entities are not required to implement any new stormwater controls under the MS4 permit requirement IV.C.1. However, the FRP document provides the MS4s with a list of possible projects that could be constructed in the event that future biomonitoring of the stream reveals non-compliance with Vermont water quality standards.

After the existing model scenarios were reviewed, new BMPs were identified, inspected, and assessed in the BMPDSS. The final proposed BMP list includes 54 projects—31 median filters, 12 detention basins, 5 gravel wetlands, 4 underground detention systems, and 2 infiltration systems. There are also several additional projects in most watersheds that manage minimal amounts of VTrans owned impervious areas, but these projects are not considered to be the responsibility of VTrans to implement and are thus not detailed in this document.

By watershed, the BMPDSS estimated that between 25.9% (Moon Brook) and 482.4% (Sunderland Brook) of the total high-flow target was met with the proposed BMP scenario (Credit model). The high flow reduction target met for the VTrans portion of each watershed ranged from 43.7% in Potash Brook to 847.3% in Sunderland Brook, averaging 201.9% per watershed (Appendix D). VTrans flow reduction targets were met at over 100% in six of the 10 watersheds. Although the VTrans portion of the high flow target was not met fully in the remaining four watersheds, the proposed BMP implementation plan presented represents the most feasible and effective watershed-wide approach to meeting flow reduction targets. The planning level cost for implementation of the 54 BMPs presented in this FRP is $6,871,000.

A ranking was developed to prioritize the proposed projects based on the percentage of VTrans impervious area managed, runoff channel protection volume storage, VTrans high flow target managed, and cost. The ranking is a tool for VTrans to use to prioritize projects for implementation (Appendix F). The prioritization was also used to aid in the development of a Design and Construction Schedule (D&C), for long term implementation of the plan.

C. Background

The purpose of the FRP is to outline a plan for the retrofit of existing unmanaged VTrans impervious cover with stormwater BMPs to meet the VTrans allocated portion of the TMDL flow targets. The modeled high-flow (Q 0.3%) included flows occurring less than 0.3% of the time, determined to be relatively equivalent to the 1-year design storm flow. As such, BMPs are designed to Channel Protection volume (CP_v) storage standard to address the high-flow reduction target. These BMPs can include detention basins, bioretention filters, infiltration basins, and other management strategies. The TMDLs set forth that watershed hydrology must be controlled in each of the stormwater impaired watersheds to reduce high flow discharges and increase base flow in order to restore degraded water quality and achieve compliance with the Vermont Water Quality Standards.

The 10 stormwater impaired watersheds analyzed in this FRP are primarily located in Chittenden County. Stevens Brook and Rugg Brook are located in Franklin County, and Moon Brook is located in Rutland County. Watersheds range in size from 751 acres to 6230 acres, with impervious area covering from 6% to 31% of these watersheds and averaging 16% coverage by watershed (Table C1). Each of these watersheds requires a collaborate effort to meet flow reduction targets as each has impervious area owned by a minimum of two and a maximum of five MS4 entities. VTrans impervious cover makes up between 0.5% (Moon Brook) and 16% (Rugg Brook) of the total impervious cover within each watershed.

Table C 1 Watershed characteristics for each of the 10 watersheds assessed in this FRP

Watershed Name	Total Watershed Area (acres)	Total Impervious Cover (acres)	Total Impervious Cover (%)	VTrans Impervious Cover (acres)	VTrans Impervious Cover (% of Total Impervious Cover)	MS4 Impervious Owners
Allen Brook	6230	401	6%	49	12%	Williston, VTrans
Bartlett Brook	751	138	18%	5	4%	Town of Shelburne, South Burlington, VTrans
Centennial Brook	879	270	31%	13	5%	UVM, BTV, South Burlington, VTrans, Burlington
Indian Brook	4587	410	9%	31	8%	Town of Essex, Village of Essex Junction, VTrans
Moon Brook [1]	5032	503	16%	2	0.5%	Rutland City, Rutland Town, VTrans
Munroe Brook	3468	270	8%	13	5%	Shelburne, VTrans, South Burlington
Potash Brook	4510	924	20%	76	8%	UVM, BTV, South Burlington, VTrans, Burlington
Rugg Brook	1759	205	12%	32	16%	St. Albans City, St. Albans Town, VTrans

Stevens Brook	1735	309	18%	21	7%	St. Albans City, St. Albans Town, VTrans
Sunderland Brook	1426	314	22%	10	3%	Town of Essex, Village of Essex Junction, Town of Colchester, VTrans

[1] Summaries included in this table include area within the Town of Mendon despite the fact that this town is not an MS4 community. Later tables exclude this area.

D. Allen Brook

1. Allen Brook TMDL Flow Targets

In the effort to restore Allen Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and suggested increases in stream low or base flows (Q 95%). These flow targets (Table D1) serve as the basis for this section (Section D) of the Flow Restoration Plan (FRP).

Table D 1 Allen Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-3.3%	**7.4%**

In Table D1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. The VT DEC, in cooperation with the Town of Williston, estimated a future growth of 35 acres in the watershed based on local development and projected growth for Allen Brook. The approved TMDL flow targets for Allen Brook are shown in Table D1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

Approximately 87.7% of the impervious cover in the Allen Brook Watershed is within the town of Williston and the remaining 12.3% is owned by VTrans (Table D2). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where the town of Williston is responsible for a 2.89% high flow reduction and VTrans is responsible for a 0.41% high flow reduction.

Table D 2 Allen Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Williston	6013.2	351.3	87.7%	-2.89%	6.49%
VTrans	217.2	49.3	12.3%	-0.41%	0.91%
Watershed Total	**6230.4**	400.6		**-3.30%**	**7.40%**

2. *Allen Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. Both the Post-2002 and Credit models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Model

The VT DEC developed a Pre-2002 condition model for Allen Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The VT DEC also developed a Post-2002 or existing condition model for the watershed. This model scenario included all known existing BMPs designed to the VT Stormwater Standards and providing credit toward the flow target. The Allen Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place managing the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 3.3% in the watershed, current BMPs reduced high flows by 0.29%, which equates to 8.8% of the total required flow reduction (Table D3). Of that reduction, 2% of the VTrans allocation was addressed, reducing high flows by 0.01% of the 0.41% required reduction. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow reduction target.

Table D 3 Allen Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Williston	-2.89%	-0.28%	-2.61%	9.7%
VTrans	-0.41%	-0.01%	-0.40%	2.0%
Watershed Total	**-3.30%**	**-0.29%**	**-3.01%**	**8.8%**

3. Allen Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final modeled BMP list used for the BMPDSS Credit run included 13 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 111.2% of the high-flow target, providing a factor of safety. The Credit model showed a high flow reduction of 0.34% for the

VTrans allocation for the Allen Brook Watershed, which equates to 84% of the total VTrans required high flow reduction (Table D4). Progress was not made towards the increase in stream low flow. Although this plan does not address 100% of the VTrans high flow allocation, the proposed scenario was determined to be the most feasible watershed-wide plan.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table D4.

Table D 4 Allen Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Williston	-2.89%	-3.33%	0.43%	115.0%
VTrans	-0.41%	-0.34%	-0.06%	84.0%
Watershed Total	**-3.30%**	**-3.67%**	**0.37%**	**111.2%**

3.2. VTrans Proposed BMPs

There are 13 proposed VTrans BMPs summarized in Table D5 and further described in Appendix B (see Appendix A for a map of all 13 BMPs). Of the 13 proposed BMPs, 12 were designed as median filters between the northbound and southbound lanes of I-89. Each of these BMPs manage impervious area entirely owned by VTrans and treats that impervious area on VTrans owned property. CPv will be retained in the swale system and Water Quality Volumes (WQv) will be captured and filtered through the subsurface sand media prior to discharge to the underdrain. WCA-1, WCA-4, and the Town Office BMPs provide overbank flood protection and will either be partially retained and infiltrated or partially bypassed through a raised outlet structure. Extreme storm events will pass safely through the system. It is not possible to accommodate the recharge volume in the median without compromising the interstate select gravel subbase.

The remaining VTrans BMP consists of a retrofit of the existing detention pond at the Williston Rest Area. The rest area was developed by the Vermont Department of Buildings and General Services through a land lease from VTrans. As such, implementation of this BMP will need to be a collaborate effort. As proposed, the pond design is in full compliance with the CPv requirement. Additionally, the design ensures that the 1-year 24-hour storm is released over 24 hours as the pond appears to drain to a wetland area, and thus a warm water habitat. The calculated CPv based on the modeling analysis is 29,172 cf. The 10-year storm peak discharge will be reduced by 30% and the pond will provide adequate free board and safely pass the extreme storm events (100-year storm). The pond retrofit does not address groundwater recharge, though recharge is currently provided on site via grass swales and vegetated disconnections.

The remaining 6.5 acres of managed VTrans impervious cover is managed by 9 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of the high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 84% of the VTrans high flow target was met by these proposed BMPs. The single largest contributor to this target attainment was the Williston Rest Area pond retrofit, which met 23.8% of the VTrans high flow target. The median filters contribute additional progress towards the high flow target. All 13 BMPS are summarized in Table D5. This table includes the impervious cover managed, drainage area, and CPv storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for the Town Office and the WCA-1, -2, -3, and -4 projects can be found in Appendix H-1.

Table D 5 VTrans final proposed BMPs for the Allen Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Rest Area Pond Retrofit	VTrans / Town	VTrans	Detention Basin	NP	26.8	4.4	16.5%	4.4	100%	0.670	23.8%	$158,000
Town Office	VTrans	VTrans	Median Filter	NP	2.2	0.4	16.6%	0.4	100%	0.061	2.0%	$32,000
WCA_1	VTrans	VTrans	Median Filter	NP	4.2	0.7	16.1%	0.7	100%	0.175	3.7%	$92,000
WCA_2	VTrans	VTrans	Median Filter	NP	2.5	0.4	17.3%	0.4	100%	0.043	2.3%	$25,000
WCA_3	VTrans	VTrans	Median Filter	NP	2.3	0.6	23.9%	0.6	100%	0.030	3.0%	$25,000
WCA_4	VTrans	VTrans	Median Filter	NP	3.3	0.7	21.8%	0.7	100%	0.101	3.8%	$53,000
VTrans Median A	VTrans	VTrans	Median Filter	NP	1.3	0.3	23.6%	0.3	100%	0.116	1.6%	$60,000
VTrans Median B	VTrans	VTrans	Median Filter	NP	0.7	0.2	28.7%	0.2	100%	0.078	1.1%	$41,000
VTrans Median E	VTrans	VTrans	Median Filter	NP	1.2	0.3	25.6%	0.3	100%	0.084	1.6%	$44,000
VTrans Median F	VTrans	VTrans	Median Filter	NP	1.1	0.2	18.9%	0.2	100%	0.085	1.1%	$44,000
VTrans Median G	VTrans	VTrans	Median Filter	NP	1.5	0.3	20.6%	0.3	100%	0.117	1.7%	$61,000

VTrans Median H	VTrans	VTrans	Median Filter	NP	1.3	0.2	18.9%	0.2	100%	0.113	1.3%	$59,000
VTrans Median I	VTrans	VTrans	Median Filter	NP	1.7	0.4	22.2%	0.4	100%	0.134	2.0%	$70,000
Other non-VTrans dominated BMPs	*Town/ VTrans*	*Non-VTrans*	*Assorted*	--				*6.5*		--	*35.0%*	
Watershed Total:								**15.6**			**84.0%**	**$764,000**

E. Bartlett Brook

1. Bartlett Brook TMDL Flow Targets

In the effort to restore Bartlett Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table E1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table E 1 Bartlett Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-33.2%	13.2%

In Table E1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the Pre-2002 condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the Pre-2002 condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, this type of growth is important to account for within the 20 year stormwater management plan.

The original TMDL assumed a non-jurisdictional impervious growth of 50 acres, whereas a study completed by the Chittenden County Regional Planning Commission (CCPRC) estimated that a more realistic future growth estimate was 5.7 acres based on the actual non-jurisdictional growth rate from 2003 to 2010. The future growth rate was calculated as follows:

$$\text{Growth Rate} = \left(\left(\frac{Non-Jurisdictional\ Impervious, 2010}{Non-Jurisdictional\ Impervious, 2003}\right)^{\left(\frac{1}{years}\right)} - 1\right) * 100$$

The revised future growth reduced the high-flow target (Q 0.3%) reduction from 33.0% to 11.6%, which was calculated as shown in the following equation.

$$\text{Modified Flow Target} = (Target\ \%\ with\ no\ FG) + (Target\ \%\ from\ FG) * (\frac{Revised\ FG\ acres}{Original\ FG\ acres})$$

The modified TMDL flow targets with a revised future growth for Bartlett Brook are shown in Table E2.

Table E 2 Bartlett Brook TMDL flow restoration targets with a modified future growth target of 5.7 acres

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-11.6%	**9.3%**

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads. Additionally, the University of Vermont (UVM) owns land within the Bartlett Brook Watershed, used for the operation of the UVM Horticulture Farm. However, agricultural impervious area is not subject to FRPs. As such, UVM was determined to not be an eligible MS4 for Bartlett Brook.

Approximately 1.9% of the impervious cover in the Bartlett Brook Watershed is within the Town of Shelburne, 3.8% is owned by VTrans, and the remaining 94.2% within the City of South Burlington (Table E3). The TMDL flow targets were allocated to each MS4 based on their relative impervious ownership in the watershed where the Town of Shelburne is responsible for a 0.22% high flow reduction, VTrans is responsible for a 0.44% high flow reduction, and the City of South Burlington is responsible for the remaining 10.93% high flow reduction.

Table E 3 Bartlett Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
University of Vermont	----	----	----	NA	NA
Town of Shelburne	60.6	2.7	1.9%	-0.22%	0.18%
VTrans	9.5	5.2	3.8%	-0.44%	0.35%
South Burlington	680.5	129.7	94.2%	-10.93%	8.76%
Watershed Total	**750.7**	**137.6**		**-11.60%**	**9.30%**

2. Bartlett Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. Both the Post-2002 and Credit models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Bartlett Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Bartlett Brook Post-2002 (existing condition) model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 11.6% in the watershed, current BMPs reduced high flows by 2.54%, which equates to 21.9% of the total required flow reduction (Table E4). Of that reduction, 54.7% of the VTrans allocation was addressed, reducing high flows by 0.24% of the 0.44% required reduction. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table E 4 Bartlett Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Town of Shelburne	-0.22%	0.00%	-0.22%	0.0%
VTrans	-0.44%	-0.24%	-0.20%	54.7%
South Burlington	-10.93%	-2.30%	-8.63%	21.0%
Watershed Total	**-11.60%**	**-2.54%**	**-9.06%**	**21.9%**

3. Bartlett Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

The final watershed-wide BMP scenario includes the implementation of 18 stormwater BMPs including five retrofits to existing BMPs with expired permits, four new detention systems, three new infiltration systems, and six green stormwater infrastructure (GSI) systems. Credit toward the flow target is also provided by nine existing (Post-2002) stormwater structures. The VTrans proposed BMPs are summarized in Table E6, including the impervious cover treated, drainage area, and CPv volume storage estimated by the HydroCAD design model. A map of the proposed BMP locations is included in Appendix A.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 2 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 194.5% of the modified high-flow target, providing a robust factor of safety. The Credit model showed a high flow reduction of 1.18% for the VTrans allocation of the Bartlett Brook Watershed, which equates to 267.2% of the total VTrans required high flow reduction and a 167.2% factor of safety (Table E5). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. Of the suggested 9.3% increase in low flow, 47% of the target was achieved (4.35% low flow increase).

The ultimate determination for implementation of projects within the watershed providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table E5.

Table E5 Bartlett Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Town of Shelburne	-0.22%	0.00%	-0.22%	0.0%
VTrans	-0.44%	-1.18%	0.74%	267.2%
South Burlington	-10.93%	-21.38%	10.44%	195.5%
Watershed Total	**-11.60%**	**-22.56%**	**10.96%**	**194.5%**

As discussed in section E1.1. Future Growth Target, the modified future growth estimate of 5.7 acres was utilized for this analysis. However, in the event that the original future growth estimate of 50 acres was proven to be accurate, the original TMDL high flow reduction target of 33.2% would be required. This equates to a high flow reduction of -1.27% for VTrans as opposed to the -0.44% required with the modified future growth assessment.

In order to predict the amount of additional impervious cover that would need to be managed by VTrans, the results from iterative Bartlett Brook BMPDSS model runs were used to perform a linear regression. The impervious cover managed by VTrans for the proposed BMPs by model scenario were regressed with the unmodified high flow target met (%) by that model run. With this original TMDL high flow reduction target, VTrans will meet 93.4% of the target with the currently proposed BMPs. To meet the full target, management of a total of 5.52 acres of impervious cover is required, which necessitates management of an additional 0.51 acres of impervious cover (R^2=0.83; Figure E1).

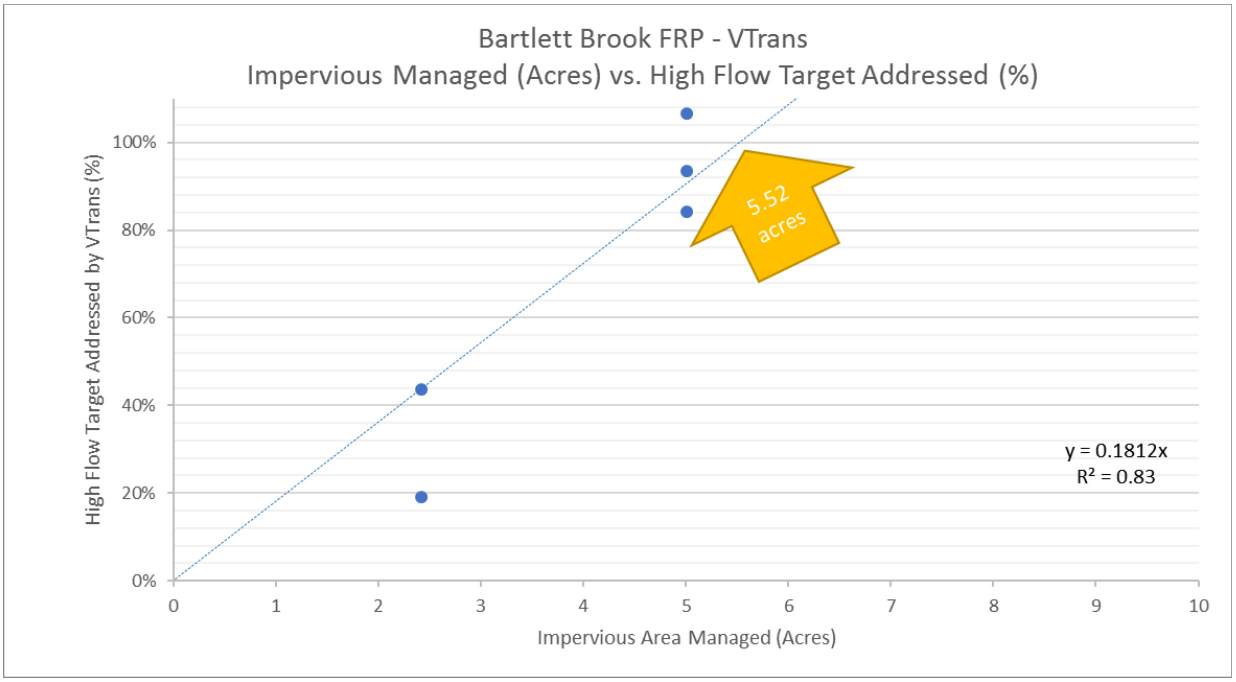

Figure E 1 Regression for predicting required impervious cover managed by VTrans to meet original TMDL high flow reduction targets for Bartlett Brook.

Currently, a project or projects will not be developed to manage this additional 0.51 acres of impervious surface as current controls do meet nearly 200% of the required high flow reduction with the modified future growth assessment. If this assumption of the modified future growth estimate is proven to be false moving forward, VTrans will identify and construct additional control(s). If this is the case, the control(s) will be identified near the end of the design and construction schedule (Phase 5). Projects would be designed and constructed in the final two phases of the design and construction schedule.

3.2. VTrans Proposed BMPs

There are two proposed VTrans BMPs in the Bartlett Brook Watershed, which are summarized in Table E6. Both of these BMPs were designed as underground detention structures within the VTrans right-of-way (ROW). The Bartlett Bay Treatment System (BBTS) Expansion manages 9.2 acres of impervious cover, 20.4% (1.9 acres) of which is owned by VTrans. The underground detention proposed for 1690 Shelburne Rd. manages 0.4 acres of impervious area, 100% of which is owned by VTrans. The remaining 2.7 acres of treated VTrans impervious cover is managed by an existing Post-2002 BMP that currently detains the CPv.

The existing BBTS was designed in 2002 to provide water quality treatment for runoff from a portion of Route 7 and several buildings along Green Mountain Dr. A 15" pipe was installed with the original system to plan for future connections from Route 7. The BBTS expansion would route an additional 15.86 acres to the BBTS system via a new stormline connection on Route 7 from a portion of Route 7 and Harborview Dr. The expansion would involve implementing a new forebay for the additional connection in front of the Oil N Go property and expanding the southeast portion of the wetland. The existing access road would also need to be repositioned.

An underground detention chamber is proposed to detain just the 1-year storm volume (CPv) from the existing Route 7 stormline, via a flow splitter. There is an existing outfall from Shelburne Rd, parallel to the Oil N Go property, that would need to be reset to make room for the chamber. Further analysis needs to be completed to determine if the detention chamber will encroach on the flood plain for the Bartlett Brook culvert or if any other utility conflicts exist.

The percent of the VTrans high-flow target mitigated by these three BMPs was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 267.2% of the VTrans high flow target was met by these three BMPs. The single largest contributor to this target attainment was the existing Post-2002 BBTS BMP, which meets 145% of the VTrans high flow target. This differs from the earlier Post-2002 model summary as the BMPDSS is an aggregate watershed-wide model and proposed BMPs in other sections of the watershed impact flow reductions. The BBTS Expansion and the 1690 Shelburne Rd. projects meet an additional 122.2% of the VTrans high-flow target (100% and 22.2% respectively; Table E6).

The proposed BMPs are summarized in Table E6. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for the 1690 Shelburne Rd project and a section of the BBTS Expansion project can be found in Appendix H-2.

Table E 6 VTrans final proposed BMPs for the Bartlett Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Bartlett Bay Treatment System (BBTS) Expansion	VTrans/ South Burlington	South Burlington	Underground Detention Chamber in ROW	5625-9010, 2-0180, 2-0153	16.1	9.2	57.2%	1.9	20.4%	0.55	100.0%	$378,000
1690 Shelburne Rd	VTrans/ South Burlington	VTrans/ Developer-Pizzagalli	Underground Detention Chamber in ROW	5625-9010	0.8	0.4	51.3%	0.4	100%	0.04	22.2%	$199,000
Existing BBTS (Post-2002) BMP	*Town / City/ VTrans*	*Non-VTrans*	*Detention*	--	--	--		*2.7*		--	145.0%	
Watershed Total:								**5.0**			**267.2%**	**$577,000**

F. Centennial Brook

1. Centennial Brook TMDL Flow Targets

In the effort to restore Centennial Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table F1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table F 1 Centennial Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-63.0%	23.0%

In Table F1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the Pre-2002 condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the Pre-2002 condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the BMP identification for this study.

1.1. Future Growth Target

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, this type of growth is important to account for within the 20 year stormwater management plan.

The original TMDL assumed a non-jurisdictional impervious growth of 50 acres, whereas a 2013 study completed by the Chittenden County Regional Planning Commission (CCPRC) estimated that a more realistic future growth estimate of 5 acres based on the actual non-jurisdictional growth rate. The future growth rate was calculated as follows:

$$\text{Growth Rate} = \left(\left(\frac{Non-Jurisdictional\ Impervious,later\ date}{Non-Jurisdictional\ Impervious,earlier\ date}\right)^{\left(\frac{1}{years}\right)} - 1\right) * 100$$

The revised future growth reduced the high-flow target (Q 0.3%) reduction from 63.0% to 51.1%, which was calculated as shown in the following equation.

Modified Flow Target = $(Target\ \%\ with\ no\ FG) + (\ Target\ \%\ from\ FG) * (\frac{Revised\ FG\ acres}{Original\ FG\ acres})$

The modified flow targets for Centennial Brook were used for this FRP and are shown in Table F2.

Table F 2 Centennial Brook TMDL flow restoration targets with modified future growth

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-51.6%	**23.2%**

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

The majority of the impervious cover in Centennial Brook Watershed is owned by the City of South Burlington (45.7%), though the University of Vermont and the City of Burlington own significant impervious areas (34.1% and 14.3% respectively). The remaining impervious cover is owned by VTrans (4.7%) and the Burlington International Airport (BTV; 1.1%). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where VTrans is responsible for a 2.43% reduction in high flows and the remaining four MS4s are responsible for a 49.07% flow reduction (Table F3).

Table F 3 Centennial Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
BTV	23.4	3.1	1.1%	-0.59%	0.26%
VTrans	56.9	12.7	4.7%	-2.43%	1.08%
Burlington	94.9	38.6	14.3%	-7.37%	3.29%
UVM	298.4	92.1	34.1%	-17.58%	7.85%
South Burlington	405.6	123.2	45.7%	-23.53%	10.51%
Watershed Total	**879.2**	**269.7**		**-51.50%**	**23.00%**

2. Centennial Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Centennial Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Centennial Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 51.5% in the watershed, current BMPs reduced high flows by 16.1%, which equates to 35.4% of the total required flow reduction (Table F4). Of that reduction, 0% of the VTrans allocation was addressed and a required 2.43% high flow reduction remains. As such, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table F 4 Centennial Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
BTV	-0.59%	0.00%	-0.59%	0.0%
VTrans	-2.43%	0.00%	-2.43%	0.0%
Burlington	-7.37%	-3.91%	-3.46%	53.1%
UVM	-17.58%	-10.5%	-7.08%	59.7%
South Burlington	-23.53%	-1.69%	-21.84%	7.2%
Watershed Total	**-51.50%**	**-16.1%**	**-35.40%**	**31.3%**

3. Centennial Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 2 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 100.6% of the modified high-flow target. The Credit condition presented below reflects management of 67% of the impervious cover in the watershed including all potential retrofits identified and evaluated by the MS4s. A low flow increase of 1.8% was modeled, which equates to 8% of the suggested low flow increase target.

The Credit model showed a high flow reduction of -2.30% for the VTrans allocation for the Centennial Brook Watershed, which equates to 94.5% of the VTrans required high flow reduction (Table F5). The high flow reduction for the watershed was 100.6% of the modified high flow reduction target.

Table F 5 Centennial Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
BTV	-0.59%	-0.46%	-0.13%	77.5%
VTrans	-2.43%	-2.30%	-0.13%	94.5%
Burlington	-7.37%	-8.91%	1.54%	120.9%
UVM	-17.58%	-11.95%	-5.63%	68.0%
South Burlington	-23.53%	-28.18%	4.66%	119.8%
Watershed Total	**-51.50%**	-51.80%	0.30%	100.6%

As discussed in section F1.1. Future Growth Target, the modified future growth estimate of 5 acres was utilized for this analysis. However, in the event that the original future growth estimate of 40 acres was proven to be accurate, the original TMDL high flow reduction target of 63.0% would be required. This equates to a high flow reduction of -2.97% for VTrans as opposed to the -2.43% required with the modified future growth assessment.

In order to predict the amount of additional impervious cover that would need to be managed by VTrans, the results from previous Centennial Brook BMPDSS model runs were used to perform a linear regression. The impervious cover managed by VTrans for the proposed BMPs by model scenario were regressed with the unmodified high flow target met (%) by that model run. With this original TMDL high flow reduction target, VTrans will meet 77.28% of the target with the currently proposed BMPs. To meet the full target, management of an additional 5.2 acres of impervious will be needed for a total of 13.2 acres of managed impervious cover (R^2=0.76; Figure F1).

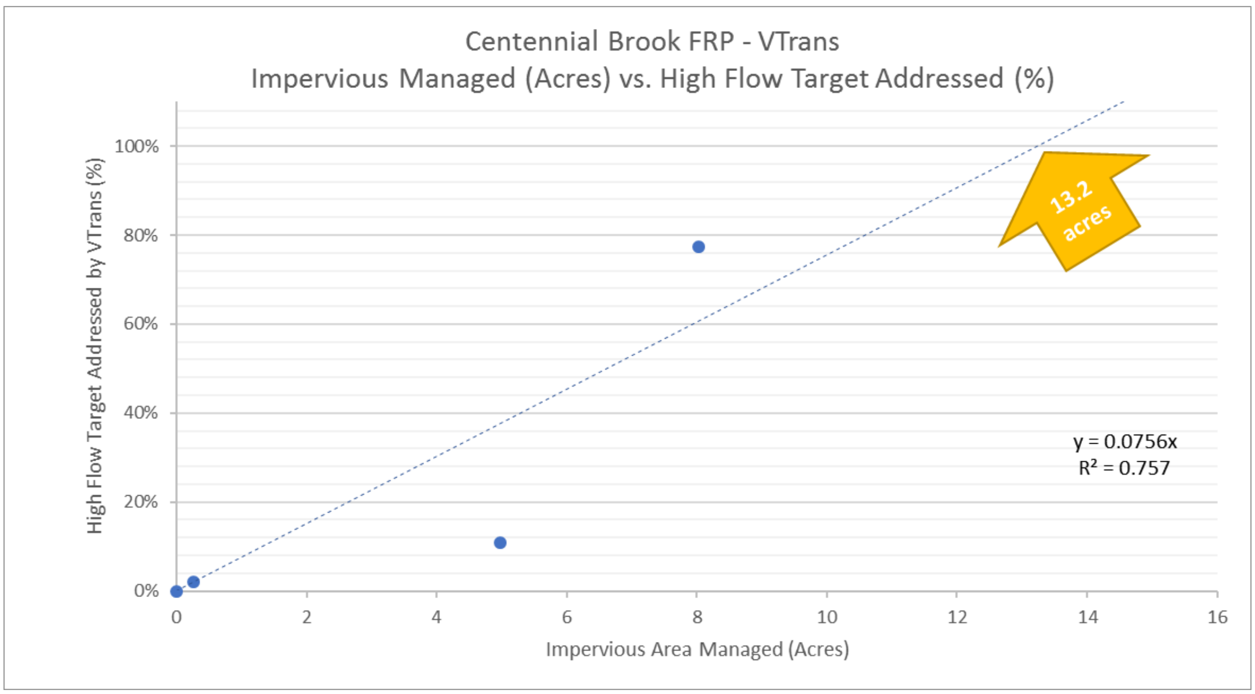

Figure F 2. Regression for predicting required impervious cover managed by VTrans to meet original TMDL high flow reduction targets for Centennial Brook.

Currently, projects will not be developed to manage this additional 5.2 acres of impervious surface as current controls do meet 100.6% of the required high flow reduction with the modified future growth assessment. If this assumption of the modified future growth estimate is proven to be false moving forward, VTrans will identify and construct additional controls. If this is the case, the controls will be identified near the end of the design and construction schedule (Phase 5). Projects would be designed and constructed in the final two phases of the design and construction schedule.

3.2. VTrans Proposed BMPs

There are two proposed VTrans BMPs in the Centennial Brook Watershed, which are summarized in Table F6. These BMPs include one underground detention chamber and one detention basin. The underground detention, I-89 cloverleaf (NE), manages 5 acres of VTrans impervious cover, 36.1% of the total impervious cover managed by the BMP. The detention basin, I-89 Outfall, manages 2.8 acres of VTrans impervious cover, 98.2% of the total impervious cover managed by this BMP.

The proposed I-89 Cloverleaf (NE) underground detention chambers would be located between the I-89 northbound lane and off-ramp. The proposed BMP would require a new control structure to meet CPv storage standards. An existing 48” culvert outlet pipe is easily accessible for construction and maintenance. Additional feasibility analysis is needed to ensure that this project would not impact nearby wetlands.

The I-89 Outfall detention basin location is flexible depending on constraints found during further evaluation. Most downstream locations would be across from the drainage outlet and below the water main, which would be the best location to maximize storage. Some feasibility issues in these locations include impacts to the water main ROW and acquisition of a section of private property. Keeping all of the work within VTrans jurisdiction is an alternative by moving the embankment up gradient to limit the I-89 ROW and reduce available storage.

In addition, one BMP, Patchen Rd. depression, also manages a small amount of VTrans impervious area (0.3 acres). VTrans impervious makes up 4.8% of the impervious area managed by this BMP. The remainder is located in the City of South Burlington. This BMP was determined not to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 94.5% of the VTrans high flow target was met by these BMPs, the majority of which are a result of the I-89 Cloverleaf (NE) and I-89 Outfall BMPs (91.4% cumulatively; Table F6). Although the VTrans high flow reduction target was not met in this watershed, the BMPs proposed were determined to be the most feasible for the watershed-wide scenario. The two proposed VTrans BMPs are summarized in Table F6. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Table F 6 VTrans final proposed BMPs for the Centennial Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
I-89 Cloverleaf (NE)	VTrans	VTrans	Underground Detention Chamber	NP	39.2	13.8	35.2%	5.0	36.1%	2.36	58.7%	$432,000
I-89 Outfall	VTrans	VTrans	Detention Basin	NP	13.1	2.8	21.6%	2.8	98.2%	2.87	32.7%	$1,419,000
Other non-VTrans dominated BMPs	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	--	--	--		*0.3*		--	*3.1%*	
Watershed Total:								**8.0**			**94.5%**	**$1,851,000**

G. Indian Brook

1. Indian Brook TMDL Flow Targets

In the effort to restore Indian Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table G1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table G 1 Indian Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-1.3%	**1.1%**

In Table G1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 18 acres in the watershed based on local development and projected growth for Indian Brook. The approved TMDL flow targets for Indian Brook are shown in Table G1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

Three MS4s own impervious cover within Indian Brook Watershed: the Village of Essex Junction (53.3%), the Town of Essex (39.1%), and VTrans (7.6%). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where the Village of Essex Junction is responsible for a 0.7% flow reduction, the Town of Essex is responsible for a 0.5% flow reduction, and VTrans is responsible for the remaining 0.1% flow reduction (Table G2).

Table G 2 Indian Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Village of Essex Junction	952.6	218.3	53.3%	-0.69%	0.59%
Town of Essex	3492.7	160.1	39.1%	-0.51%	0.43%
VTrans	141.9	31.3	7.6%	-0.10%	0.08%
Watershed Total	**4587.3**	409.7		**-1.30%**	**1.10%**

2. *Indian Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis to determine changes in high and low flows.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Indian Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Indian Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 1.3% in the watershed, current BMPs reduced high flows by 0.54%, which equates to 41.5% of the total required flow reduction (Table G3). Of that reduction, 1.9% of the VTrans allocation was addressed, reducing high flows by 0.002% of the required 0.10% reduction. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table G 3 Indian Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Village of Essex Junction	-0.69%	-0.27%	-0.42%	39.5%
Town of Essex	-0.51%	-0.26%	-0.24%	52.1%
VTrans	-0.10%	-0.002%	-0.10%	1.9%
Watershed Total	**-1.30%**	**-0.54%**	**-0.76%**	**41.5%**

3. *Indian Brook Required Controls Identification*

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 3 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 211.5% of the modified high-flow target, providing a 111.5% factor of safety (Table G4). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. A low flow increase of 0.64% was modeled, which equates to 58% of the suggested low flow increase target.

The Credit model showed a high flow reduction of 0.06% for the VTrans allocation for the Indian Brook Watershed, which equates to 56.6% of the total VTrans required high flow reduction (Table G4). Although this plan does not address 100% of the VTrans high flow allocation, the proposed scenario was determined to be the most feasible watershed-wide plan.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table G4.

Table G 4 Indian Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Village of Essex Junction	-0.69%	-1.55%	0.86%	223.5%
Town of Essex	-0.51%	-1.15%	0.64%	225.6%
VTrans	-0.10%	-0.06%	-0.04%	56.6%
Watershed Total	**-1.30%**	**-2.75%**	**1.45%**	**211.5%**

3.2. VTrans Proposed BMPs

There are three proposed VTrans BMPs in the Indian Brook Watershed, which are summarized in Table G5. These BMPs include one retrofit of an existing natural detention area into a terraced detention basin and two sand filter systems. The terraced detention basin, Fairview Dr, manages 0.7 acres of VTrans impervious cover, 17.4% of the total impervious cover managed. The two sand filter systems proposed in the median on the North and South side of the Route 15, manage 0.9 and 0.8 acres of VTrans impervious cover respectively. This impervious cover is entirely owned by VTrans.

The Fairview Dr retrofit proposes to convert a natural depression to a gravel wetland with water quality treatment bays. This retrofit will benefit the high flow target and provide water quality treatment. Runoff from the northwest side of Route 15 (Main St.) would be intercepted and directed into the system through a new culvert, represented as the "Fairview Dr Add-on" drainage. This would eliminate most runoff to the highly eroded outfall. Runoff would exit the system back under Route 15 via an upgraded pipe (12" to 30").

The I-289/Route 15 Exit Ramp was identified as a potential opportunity to manage runoff from primarily VTrans owned impervious. Two sand filter systems were proposed in the median on the North and South side of the Route 15 overpass. The proposed practice is an approximately 4' deep sand filter, with a 4" underdrain, and 1.5' surface ponding depth before passing over a weir. The system is designed to provide CPv storage. The low-flow orifice and sand filter provide extended filtration and thus water quality benefit.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

The proposed BMPs are summarized in Table G5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for the three proposed projects can be found in Appendix H-3.

Table G 5 VTrans final proposed BMPs for the Indian Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Fairview Dr/Fairview Dr Add-on	Village/ VTrans/ Town	Village	Gravel Wetland	1-1074 SN002	29.4	4.1	14.0%	0.7	17.4%	0.67	17.4%	$290,000
I-289/Route 15 North	VTrans	VTrans ROW	Median Filter	NP	2.8	0.9	30.6%	0.9	100%	0.12	20.7%	$34,000
I-289/Route 15 South	VTrans	VTrans ROW	Median Filter	NP	2.2	0.8	35.3%	0.8	100%	0.10	18.5%	$29,000
Watershed Total:								**2.3**			**56.6%**	**$353,000**

H. Moon Brook

1. Moon Brook TMDL Flow Targets

In the effort to restore Moon Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table H1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table H 1 Moon Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-11.9%	23.9%

In Table H1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 25 acres in the watershed based on local development and projected growth for Moon Brook. The approved TMDL flow targets for Moon Brook are shown in Table H1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas. Additionally, the Town of Mendon owns land within the Moon Brook Watershed, but this town is not designated as an MS4 and is thus not included in the allocation.

Rutland City owns the majority of impervious cover within Moon Brook Watershed (76.8%) while Rutland Town owns 23.7% and VTrans owns the remaining 0.5%. The TMDL flow targets were allocated to each MS4 based on their impervious ownership where Rutland City is responsible for a 9.02% flow reduction, Rutland Town is responsible for a 2.82% flow reduction, and VTrans is responsible for the remaining 0.06% flow reduction (Table H2).

Table H 2 Moon Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Mendon	2041.8	35.8	----	----	----
Rutland City	1415.3	353.8	75.8%	-9.02%	18.12%
Rutland Town	1556.4	110.6	23.7%	-2.82%	5.66%
VTrans	18.7	2.3	0.5%	-0.06%	0.12%
Watershed Total	**2990.4**	**466.7**		**-11.90%**	**23.90%**

2. *Moon Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Moon Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Moon Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 11.9% in the watershed, current BMPs reduced high flows by 0.71%, which equates to 6% of the total required flow reduction (Table H3). Of that reduction, 0% of the VTrans allocation was addressed and a required 0.06% flow reduction remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table H 3 Moon Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Rutland City	-9.02%	-0.52%	-8.50%	5.8%
Rutland Town	-2.82%	-0.19%	-2.63%	6.6%
VTrans	-0.06%	0.00%	-0.06%	0.0%
Watershed Total	**-11.90%**	-0.71%	-11.19%	6.0%

3. Moon Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 1 proposed VTrans BMP. The watershed-wide proposed FRP scenario addresses 25.88% of the modified high-flow target. The minimal high flow reduction is due to the non-participation of the City of Rutland in the FRP process at this time. The Credit model showed a high flow reduction of 0.12% for the VTrans allocation for the Moon Brook Watershed, which equates to 196.87% of the total VTrans required high flow reduction (Table H4). No progress was made towards the suggested increase in low flow.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table H4.

Table H 4 Moon Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Rutland City	-9.02%	-0.74%	-8.28%	8.26%
Rutland Town	-2.82%	-2.22%	-0.60%	78.69%
VTrans	-0.06%	-0.12%	0.06%	196.87%
Watershed Total	**-11.90%**	-3.08%	-8.82%	25.88%

3.2. VTrans Proposed BMPs

The one proposed VTrans BMP in the Moon Brook Watershed, which is summarized in Table H5. This BMP is a gravel wetland collecting runoff from a drainage ditch. The gravel wetland manages 2.3 acres of VTrans impervious cover, 20.9% of the total impervious cover managed by this BMP.

The proposed BMP, located behind the new ALDI Store along Route 7 and Cold River Rd., could potentially be an ideal solution to reduce peak-flows and sediment loading to Moon Brook from a 23-acre drainage area, 47.4% of which is impervious. The proposed gravel wetland will provide flow detention as well as water quality benefits. The Randbury Road site is located on private property, which would need to be acquired by the Town of Rutland in order for this site to be a feasible retrofit location. The site currently consists of a wooded undeveloped area with a highly eroded drainage ditch. The retrofit BMP could collect runoff from this drainage ditch, which has been formed from the high volume of runoff originating from the Route 7 outfall. Based on field observation, the site is underlain by sandy soils so infiltration of runoff may be possible. Additionally, the existing drainage ditch was assessed by the State Fisheries Biologist, and determined to be void of fisheries resources. As such, alterations to the existing ditch would be feasible. This BMP location is of particular interest as the project could align with the Town's re-development goals for the area, which will include a new access road to ease traffic on Route 7. This project would require a new stormwater management system regardless of this FRP (see Appendix H-4 for a design concept plan).

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

$$\% \text{ of high-flow target managed} = (A \div B) \times C$$

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 196.87% of the VTrans high flow target was met by this BMP at the Randbury Rd site. The proposed BMPs are summarized in Table H5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP location is included in Appendix A and details about the proposed BMP is located in Appendix B. A preliminary design has been created for this project and is included in Appendix H-4.

Table H 5 VTrans final proposed BMPs for the Moon Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Randbury Rd	VTrans/ Town of Rutland	VTrans/ Town of Rutland/ Private	Gravel Wetland	NP/ New Road Project (Construction Permit)	23.1	11.0	47.4%	2.3	20.9%	0.83	196.87%	$279,000
Watershed Total:								**2.3**			**196.87%**	**$279,000**

I. Munroe Brook

1. Munroe Brook TMDL Flow Targets

In the effort to restore Munroe Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table I1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table I 1 Munroe Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-5.2%	7.4%

In Table I1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 20 acres in the watershed based on local development and projected growth for Munroe Brook. The approved TMDL flow targets for Munroe Brook are shown in Table I1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

Shelburne owns the majority of impervious cover within the Munroe Brook Watershed (87.9%) while the City of South Burlington owns 7.1% and VTrans owns the remaining 5.0%. The TMDL flow targets were allocated to each MS4 based on their impervious ownership where Shelburne is responsible for a 4.57% flow reduction, the City of South Burlington is responsible for a 0.37% flow reduction, and VTrans is responsible for the remaining 0.26% flow reduction (Table I2).

Table I 2 Munroe Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
Shelburne	3152.3	237.1	87.9%	-4.57%	6.51%
South Burlington	292.4	19.1	7.1%	-0.37%	0.52%
VTrans	23.1	13.5	5.0%	-0.26%	0.37%
Watershed Total	**3467.7**	**268.7**		**-5.20%**	**7.40%**

2. *Munroe Brook BMPDSS Model Assessment*

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Munroe Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Munroe Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 5.2% in the watershed, current BMPs reduced high flows by 2.6%, which equates to 50% of the total required flow reduction (Table I3). Of that reduction, 0.04% of the VTrans allocation was addressed, which equates to 15.1% of the VTrans allocation. A 0.22% flow reduction for VTrans remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table I 3 Munroe Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Shelburne	-4.57%	-1.93%	-2.64%	42.2%
South Burlington	-0.37%	-0.63%	0.26%	170.8%
VTrans	-0.26%	-0.04%	-0.22%	15.1%
Watershed Total	**-5.20%**	**-2.60%**	**-2.60%**	**50.0%**

3. Munroe Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included three proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 100% of the modified high-flow target. The Credit model showed a high flow reduction of 0.36% for the VTrans allocation for the Munroe Brook Watershed, which equates to 137.5% of the total VTrans required high flow reduction (Table I4). The factor of safety is included in the recommended VTrans BMP list to provide for additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for Munroe Brook without seeking out additional projects. No progress was made towards the suggested low flow increase target.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table I4.

Table I 4 Munroe Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Shelburne	-4.57%	-4.15%	-0.42%	90.8%
South Burlington	-0.37%	-0.69%	0.32%	187.5%
VTrans	-0.26%	-0.36%	0.10%	137.5%
Watershed Total	**-5.20%**	**-5.20%**	**0.30%**	**100.0%**

3.2. VTrans Proposed BMPs

There are three proposed VTrans BMPs in the Munroe Brook Watershed, which are summarized in Table I5. These BMPs include an underground detention chamber, a retrofit of an existing detention pond, and a gravel wetland.

The proposed underground detention, by Danform Shoes, manages 2.1 acres of VTrans impervious cover, 74.9% of the total impervious cover managed. This detention area would collect drainage from the west side of Shelburne Rd (Route 7) from the Munroe Brook Watershed boundary to the area in front of Danform Shoes. The underground storage would be located primarily within the VTrans ROW.

A retrofit of an existing pond, the Executive Dr (M08) Detention Pond, would continue to manage 2.7 acres of VTrans impervious cover. However, the retrofit of the pond would increase detention and provide for pre-treatment within a forebay. This pond has a large drainage area (approximately 91 acres) and collects stormwater from over 21 acres of impervious cover, 12.7% of which is owned by VTrans.

The final VTrans BMP proposed for the watershed is across Shelburne Rd (Route 7) from the Tractor Supply building. This proposed gravel wetland would manage 2.8 acres of VTrans impervious cover, 75.6% of the total impervious cover managed, and would be located along Shelburne Rd primarily in the VTrans ROW. In total, this BMP would collect and treat stormwater from 6.8 acres, 3.8 acres of which is impervious cover. The design of this BMP would provide for detention of the CPv as well as significant water quality treatment.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 137.5% of the VTrans high flow target was met by these BMPs. The proposed BMPs are summarized in Table I5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Table I 5 VTrans final proposed BMPs for the Munroe Brook FRP Credit BMPDSS model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
M08 Executive Dr Pond	Town/ VTrans	Non-VTrans	Detention Pond	1-1291	91.1	21.3	23.4%	2.7	12.7%	0.54	49.0%	$25,000
By Danform Shoes	Town/ VTrans	VTrans	Underground Detention	NP	4.9	2.8	58.0%	2.1	74.9%	0.145	38.4%	$102,000
Across from Tractor Supply	Town/ VTrans	VTrans	Gravel Wetland	NP	6.8	3.8	55.5%	2.8	75.6%	0.544	51.5%	$480,000
Watershed Total:								**7.6**			**137.5%**	**$607,000**

J. Potash Brook

1. Potash Brook TMDL Flow Targets

In the effort to restore Potash Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table J1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table J 1 Potash Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-16.5%	11.2%

In Table J1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 30 acres in the watershed based on local development and projected growth for Potash Brook. The approved TMDL flow targets for Potash Brook are shown in Table J1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

The City of South Burlington owns the majority of impervious cover within the Potash Brook Watershed (84.7%) and thus is responsible for the majority of high flow reductions (13.98%). The remaining impervious area is owned by VTrans (8.3%), while BTV owns 3.5%, the City of

Burlington owns 3%, and UVM owns the remaining 0.5%. The TMDL flow targets were allocated to each MS4 based on their impervious ownership where VTrans is responsible for a 1.37% high flow reduction (Table J2). These summaries are representative of the watershed condition following updates to the watershed boundary completed in the Post-2002 and Credit model runs.

Table J 2 Potash Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
South Burlington	3662.1	778.5	84.7%	-13.98%	9.49%
VTrans	317.0	76.3	8.3%	-1.37%	0.93%
BTV	72.1	32.0	3.5%	-0.57%	0.39%
Burlington	105.8	27.3	3.0%	-0.49%	0.33%
UVM	338.2	5.1	0.5%	-0.09%	0.06%
Watershed Total	**4495.2**	919.2		**-16.50%**	**11.20%**

2. Potash Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Potash Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Potash Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 16.5% in the watershed, current BMPs reduced high flows by 4.5%, which equates to 27.3% of the total required high flow reduction (Table J3). Of that reduction, 8% of the VTrans allocation was addressed as a reduction of 0.11% was achieved. A 1.2% VTrans flow reduction remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table J 3 Potash Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
South Burlington	-13.98%	-4.35%	-9.64%	31.1%
VTRANS	-1.37%	-0.11%	-1.25%	8.0%
BTV	-0.57%	0.00%	-0.57%	0.0%
Burlington	-0.49%	-0.04%	-0.45%	8.1%
UVM	-0.09%	0.00%	-0.09%	0.0%
Watershed Total	**-16.50%**	**-4.50%**	**-12.00%**	**27.3%**

3. Potash Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 107 BMPs, 6 of which are the responsibility of VTrans. The watershed-wide proposed FRP scenario addresses 100% of the modified high-flow target. No progress was made towards the suggested low flow increase target.

The Credit model showed a high flow reduction of 0.6% for the VTrans allocation for the Potash Brook Watershed, which equates to 43.7% of the total VTrans required high flow reduction

(Table J4). Although this plan does not address 100% of the VTrans high flow allocation, the proposed scenario was determined to be the most feasible watershed-wide plan.

The ultimate determination for when the watershed has returned to its attainment condition will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table J4.

Table J4 Potash Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
South Burlington	-13.98%	-15.28%	1.31%	109.4%
VTRANS	-1.37%	-0.60%	-0.77%	43.7%
BTV	-0.57%	-0.02%	-0.56%	3.0%
Burlington	-0.49%	-0.56%	0.07%	114.2%
UVM	-0.09%	-0.04%	-0.05%	43.8%
Watershed Total	**-16.50%**	**-16.50%**	**0.00%**	**100.0%**

3.2. VTrans Proposed BMPs

There are six proposed VTrans BMPs in the Potash Brook Watershed, which are summarized in Table J5. These BMPs include one median filter, two gravel wetlands, and three detention basins.

The proposed I-89 Swale median filter would be located between I-89 North and South lanes west of Hinesburg Road in South Burlington. The proposed BMP would be a constructed median filter in the depressed area between the interstate lanes and would manage 1.8 acres of VTrans impervious cover, 100% of the total impervious cover managed. Several existing culverts could be rerouted to this median filter.

Gravel wetlands are proposed at sites Exit 13 and Exit 14 in South Burlington. These wetlands would be constructed in the depressed triangle greenspace between ramps and receive stormwater from several rerouted culverts. The gravel wetlands at Exit 13 and Exit 14, manage 4.8 and 1.8 acres retrospectively, 100% of the total impervious cover managed by these BMPs.

The proposed BMP at the 189 Cloverleaf is a detention pond that will manage 3.5 acres of VTrans impervious cover, 30% of the total impervious cover managed. An outlet structure added to this already depressed area will detain stormwater once stormlines from Shelburne Road are rerouted. Wetlands are the only known feasibility concern for this proposed BMP.

A detention pond is proposed at the Dorset St/189 Ramps site that will detain stormwater from a large section of Dorset Street, managing 1.1 acres of VTrans impervious cover (19.6% of the total impervious cover managed). The stormline near Kennedy Drive can be intercepted to reroute discharge to the area between the 189 ramps. This BMP location will need significant earthwork as the area is currently elevated.

At Queen City Park Rd, a detention basin is proposed to add detention to an exciting depressed area where stormlines already outfall to manage 0.4 acres of VTrans impervious cover, 14.7% of the total impervious cover managed. The drainage from Shelburne Road is assumed to be rerouted to a larger depression to the north at site 189 Cloverleaf because of limiting space.

The remaining 8.2 acres of managed VTrans impervious cover is managed by 18 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 43.7% of the VTrans high flow target was met by these BMPs, the majority of which are a result of the six specific BMPs described in Table J5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Table J 5 VTrans final proposed BMPs for the Potash Brook FRP Credit BMPDSS model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Exit 13	VTrans	VTrans	Gravel Wetland	NP	16.7	4.8	28.6%	4.8	100%	0.567	9.7%	$219,000
189 Cloverleaf	VTrans / Town	VTrans	Detention Basin	NP	21.3	11.5	54.3%	3.5	30%	1.129	7.0%	$59,000
I-89 Swale	VTrans	VTrans	Median Filter	NP	6.3	1.8	28.6%	1.8	100%	0.531	3.6%	$129,000
Exit 14	VTrans	VTrans	Gravel Wetland	NP	4.9	1.8	36.9%	1.8	100%	0.294	3.7%	$131,000
Dorset St / 189 Ramps	VTrans / Town	VTrans	Detention Basin	NP	9.4	5.6	59.5%	1.1	19.6%	0.348	2.2%	$101,000
Queen City Pk Rd	VTrans / Town	VTrans	Detention Basin	NP	6.5	2.9	44.9%	0.4	14.7%	0.452	0.9%	$99,000
Other non-VTrans dominated BMPs	*Town/ VTrans*	*Non-VTrans*	*Assorted*	--				*8.2*		--	*16.6%*	
Watershed Total:								**21.5**			**43.7%**	**$738,000**

K. Rugg Brook

1. Rugg Brook TMDL Flow Targets

In the effort to restore Rugg Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table K1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table K 1 Rugg Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-16.0%	**16.8%**

In Table K1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

The VT DEC added a future growth factor to the TMDL flow targets to account for future non-jurisdictional impervious growth. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, this type of growth is important to account for within the 20 year stormwater management plan.

The original TMDL assumed a non-jurisdictional impervious growth of 15 acres, whereas a 2013 study completed by the Chittenden County Regional Planning Commission (CCPRC) estimated a more likely future growth estimate of 4.54 acres based on the actual non-jurisdictional growth rate from 2003 to 2014. The future growth rate was calculated as follows:

$$\text{Growth Rate} = \left(\left(\frac{Non{-}Jurisdictional\ Impervious{,}2014}{Non{-}Jurisdictional\ Impervious{,}2003}\right)^{\left(\frac{1}{years}\right)} - 1\right) * 100$$

The revised future growth reduced the high-flow target (Q 0.3%) reduction from 16.0% to 15.3%, which was calculated as shown in the following equation.

Modified Flow Target = $(Target\ \%\ with\ no\ FG) + (\,Target\ \%\ from\ FG) * (\frac{Revised\ FG\ acres}{Original\ FG\ acres})$

The modified flow targets for Rugg Brook were used for this FRP and are shown in Table K2.

Table K 2 Rugg Brook TMDL flow restoration targets with modified future growth

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-15.3%	**16.8%**

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

St. Albans Town owns the majority of impervious cover within the Rugg Brook Watershed (73.9%). VTrans and St. Albans City on the remainder of the impervious cover in the watershed (15.7% and 10.4% respectively). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where St. Albans Town is responsible for 11.3% of the flow reduction, VTrans is responsible for 2.4% of the flow reduction, and St. Albans City is responsible for the remaining 1.6% of the flow reduction (Table K3).

Table K 3 Rugg Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
St. Albans Town	1556.4	151.4	73.9%	-11.30%	12.41%
VTrans	131.8	32.2	15.7%	-2.40%	2.64%
St. Albans City	70.5	21.4	10.4%	-1.60%	1.75%
Watershed Total	**1758.8**	**204.9**		**-15.30%**	**16.80%**

2. Rugg Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Rugg Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Rugg Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 15.3% in the watershed, current BMPs reduced high flows by 2.5%, which equates to 16.3% of the total required flow reduction (Table K4). Of that reduction, 12.1% of the VTrans allocation was addressed as a reduction of 0.29% was achieved. A 2.11% flow reduction from the VTrans MS4 remains. Based on the model results, additional CPv stormwater controls will be required to meet the TMDL high-flow target.

Table K 4 Rugg Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
St. Albans Town	-11.30%	-1.19%	-10.11%	10.5%
VTrans	-2.40%	-0.29%	-2.11%	12.1%
St. Albans City	-1.60%	-1.02%	-0.58%	63.9%
Watershed Total	**-15.30%**	**-2.50%**	**-12.80%**	**16.3%**

3. Rugg Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 13 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 114.1% of the modified high-flow target, providing a 14.1% factor of safety. The Credit model showed a high flow reduction of 3.42% for the VTrans allocation for the Rugg Brook Watershed, which equates to 142.4% of the total VTrans required high flow reduction (Table K5). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. No progress was made towards the suggested low flow increase target.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table K5.

Table K 5 Rugg Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
St. Albans Town	-11.30%	-12.41%	1.11%	109.8%
VTrans	-2.40%	-3.42%	1.02%	142.4%
St. Albans City	-1.60%	-1.63%	0.03%	101.9%
Watershed Total	**-15.30%**	**-17.46%**	**2.16%**	**114.1%**

3.2. VTrans Proposed BMPs

There are 13 proposed VTrans BMPs in the Rugg Brook Watershed, which are summarized in Table K6. These BMPs include an infiltration basin, four detention areas, and eight median filters.

The infiltration site, I-89 / Holyoke Farm, manages 0.2 acres of VTrans impervious cover, 49.9% of the total impervious cover managed. The proposed BMP would be located on land owned by an active farm, adjacent to I-89, located off Holyoke Farm Rd. The BMP would be a 15,000 sq-ft infiltration basin that has the potential to increase baseflow to the stream via infiltration, which addresses both the high-flow and low-flow TMDL targets.

The proposed detention basins will treat a total of 7.9 acres of VTrans impervious cover between the four sites. In three of the four locations the BMPs are located on both private and VTrans land. The Exit 19 site is the only detention basin located fully on VTrans land in the center median between the on ramp and the Interstate Access Rd.

Eight median sites were identified that would detain and treat runoff from I-89 in the existing highway median. The structures would be considered equivalent to dry swales as defined in the 2002 Vermont Stormwater Management Manual. The structures would be located in existing vegetated stormwater conveyances in the I-89 median. Key features of the structures include earthen check dams designed to create up to 1.5’ of ponding depth behind each dam, amended soils consisting of a 50/50 blend of sand and native soil at the surface, and a pure sand filter below. A perforated underdrain wrapped in stone would be located below the sand filter, which would be connected to the outlet structure or day lighted.

The remaining 8.1 acres of managed VTrans impervious cover is managed by 12 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 142.4% of the VTrans high flow target was met by these BMPs, the majority of which are a result of thirteen specific BMPs (83.4% cumulatively). The proposed BMPs are summarized in Table K6. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B.

Preliminary design concept plans for the Access Rd East, Access Rd West, Exit 19, I-89 Holyoke Farm, and SDC 280 median filter projects can be found in Appendix H-5.

Table K 6 VTrans final proposed BMPs for the Rugg Brook FRP Credit BMPDSS model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Exit 19 South	VTrans	VTrans	Detention	NP	57.9	3.8	6.5%	3.7	97.2%	2.070	26.7%	$270,000
Access Rd. East	VTrans	VTrans/ Private	Detention	NP	85.1	2.8	3.2%	2.4	87.8%	1.820	17.6%	$410,000
Access Rd. West	VTrans	VTrans/ Private	Detention	Drains Portion of 1-1428	13.7	0.6	4.0%	0.6	100%	0.652	4.0%	$125,000
SASH / Federal St Connector	City/ VTrans	VTrans/ Private	Detention	NP	21.1	4.9	23.1%	1.2	24.5%	0.36	8.7%	$35,000
SDC87	VTrans	VTrans	Median Filter	NP	4.9	0.9	18.8%	0.9	100%	0.128	6.7%	$36,000
SDC83b	VTrans	VTrans	Median Filter	NP	1.8	0.4	20.1%	0.4	100%	0.077	2.6%	$22,000
SDC27	VTrans	VTrans	Median Filter	NP	1.6	0.4	26.4%	0.4	100%	0.063	3.1%	$18,000
SDC280	VTrans	VTrans	Median Filter	NP	2.1	0.4	17.4%	0.4	100%	0.063	2.7%	$18,000
SDC347	VTrans	VTrans	Median Filter	NP	1.4	0.3	21.7%	0.3	100%	0.060	2.2%	$17,000
SDC83a	VTrans	VTrans	Median Filter	NP	1.7	0.3	15.8%	0.3	100%	0.058	2.0%	$16,000
SDC342	VTrans	VTrans	Median Filter	NP	1.6	0.3	19.4%	0.3	100%	0.054	2.3%	$15,000

SDC29	VTrans	VTrans	Median Filter	NP	2.2	0.4	18.2%	0.4	100%	0.054	3.0%	$15,000
I-89 / Holyoke Farm	Town / VTrans	Private	Infiltration	NP	61.8	0.5	0.8%	0.2	49.9%	1.426	1.8%	$185,000
Other non-VTrans dominated BMPs	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	--	*124.1*	*29.9*	*24.1%*	*8.1*	*27.1%*	--	*59.0%*	
Watershed Total:								**19.6**			**142.4%**	**$1,182,000**

L. Stevens Brook

1. Stevens Brook TMDL Flow Targets

In the effort to restore Stevens Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table L1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table L 1 Stevens Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-24.4%	24.3%

In Table L1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 15 acres in the watershed based on local development and projected growth for Stevens Brook. The approved TMDL flow targets for Stevens Brook are shown in Table L1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas.

St. Albans City owns the majority of impervious cover within the Stevens Brook Watershed (70.6%) and thus is responsible for the majority of high flow reductions (17.23%). The remaining impervious area is owned by St. Albans Town (22.7%) and VTrans (6.7%). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where St. Albans Town is responsible for a 5.53% flow reduction and VTrans is responsible for the remaining 1.64% flow reduction (Table L2).

Table L 2 Stevens Brook flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
St. Albans City	585.4	218.0	70.6%	-17.23%	17.16%
St. Albans Town	1081.8	70.0	22.7%	-5.53%	5.51%
VTrans	67.7	20.7	6.7%	-1.64%	1.63%
Watershed Total	**1734.9**	**308.7**		**-24.40%**	**24.30%**

2. Stevens Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Stevens Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Condition Model

The Stevens Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 24.4% in the watershed, current BMPs reduced high flows by 0.92%, which equates to 3.8% of the total required flow reduction (Table L3). Of that reduction, 14.8% of the VTrans allocation of 1.52% was addressed and a required 1.4% flow reduction remains. Based on the model results, additional CPv stormwater controls will be required to meet the required TMDL high-flow target.

Table L 3 Stevens Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
St. Albans City	-17.80%	-0.24%	-16.99%	1.4%
St. Albans Town	-5.09%	-0.44%	-5.09%	8.0%
VTrans	-1.52%	-0.24%	-1.40%	14.8%
Watershed Total	**-24.40%**	**-0.92%**	**-23.48%**	**3.8%**

3. Stevens Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 10 proposed VTrans BMPs. The watershed-wide proposed FRP scenario addresses 115.2% of the modified high-flow target, providing a 15.2% factor of safety. The Credit model showed a high flow reduction of 2.25% for the VTrans allocation for the Stevens Brook Watershed, which equates to 148.5% of the total VTrans required high flow reduction (Table L4). The factor of safety is included in the recommended BMP list to provide the MS4s with additional options in the event the list has to be modified or as conditions in the watershed change from present day. In the event a proposed project becomes infeasible after further design and construction planning or must be downscaled, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. No progress was made towards the suggested low flow increase target.

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table L4.

Table L4 Stevens Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
St. Albans City	-17.80%	-16.52%	-1.28%	92.8%
St. Albans Town	-5.09%	-9.33%	4.25%	183.5%
VTrans	-1.52%	-2.25%	0.74%	148.5%
Watershed Total	**-24.40%**	**-28.10%**	**3.70%**	**115.2%**

3.2. VTrans Proposed BMPs

There are 10 proposed VTrans BMPs in the Stevens Brook Watershed, which are summarized in Table L5. These BMPs include two detention basins and eight median filters.

The proposed location for the Upper Fairfield Hill Rd. retrofit site is off Fairfield Hill Road (VT-36, VTrans-owned) on a private parcel within the Town. It captures approximately 34 acres of drainage from VT-36 as well as neighboring homes and driveways. A water quality treatment/flow control basin is proposed. Private land would need to be acquired in order to implement the BMP. The land, as of November 2013, is advertised for sale. The benefit of the proposed facility location is the ability to control flow at the top of the watershed before stormwater flows enter the main stream channel and gain velocity and erosive strength.

A water quality/flow detention retrofit is proposed at the Fairfield Rd./I-89 retrofit site, designed to capture runoff from a 28.9 acre-area including a portion of Fairfield Road (VT-36) and Town residences along the road. The structure will need to be designed according to Federal Highway Administration (FHWA) guidelines for safety. A new culvert under Fairfield Road would be required to route flow from the north side of VT-36 into the facility. The proposed BMP would treat runoff from VTrans and Town-impervious cover, and therefore a cost-share is recommended.

Eight sites within the VTrans I-89 ROW were identified as potential sites for water quality/flow detention BMPs to detain and treat runoff from I-89. The sites are all located in existing vegetated stormwater conveyances within the I-89 median. Key features of the structures include earthen check dams designed to create up to 1.5 feet of ponding depth behind each dam, amended soils consisting of a 50/50 blend of sand and native soil at the surface, and a pure sand filter below. The structures are designed with a perforated underdrain to be located below the sand filter, connected to the nearest downstream, outlet structure or daylighted. The sites are all on VTrans land. Environmental permitting including primarily potential wetland impacts needs to be considered for each site. Designs are required to comply with FHWA safety standards for the interstate system.

The remaining 2 acres of managed VTrans impervious cover is managed by 4 additional BMPs. While these BMPs manage small amounts of VTrans impervious area, they are not determined to be the responsibility of VTrans to implement.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 148.5% of the VTrans high flow target was met by these BMPs (Table L5).

The proposed BMPs are summarized in Table L5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMPs are located in Appendix B. Preliminary design concept plans for three of the proposed projects can be found in Appendix H-6 (Fairfield Rd I-89, SDC105b, and Upper Fairfield Hill Rd).

Table L 5 VTrans final proposed BMPs for the Stevens Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Upper Fairfield Hill Rd	VTrans	VTrans/ Private	Detention Basin	NP	34.3	3.4	9.8%	1.2	34.4%	1.28	22.7%	$164,000
Fairfield Rd. / I-89	VTrans	VTrans	Detention Basin	NP	28.9	2.1	7.2%	0.8	40.8%	0.68	16.6%	$109,000
SDC118	VTrans	VTrans	Median Filter	NP	1.1	0.5	50.9%	0.5	100%	0.06	10.7%	$28,000
Median A1	VTrans	VTrans	Median Filter	NP	0.9	0.4	46.4%	0.4	100%	0.06	8.2%	$27,000
SDC140b	VTrans	VTrans	Median Filter	NP	1.0	0.5	50.4%	0.5	100%	0.05	9.9%	$26,000
SDC408	VTrans	VTrans	Median Filter	NP	0.9	0.5	50.0%	0.5	100%	0.05	9.2%	$23,000
SDC98b	VTrans	VTrans	Median Filter	NP	0.9	0.4	49.0%	0.4	100%	0.05	8.2%	$22,000
Median A2	VTrans	VTrans	Median Filter	NP	0.7	0.3	45.5%	0.3	100%	0.04	5.8%	$21,000
SDC105b	VTrans	VTrans	Median Filter	NP	1.0	0.5	53.3%	0.5	100%	0.05	10.4%	$26,000

SDC105c	VTrans	VTrans	Median Filter	NP	0.8	0.4	52.1%	0.4	100%	0.04	8.6%	$20,000
Other non-VTrans dominated BMPs	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	--	--	--		*2.0*		--	*38.3%*	
Watershed Total:								**7.6**			**148.5%**	**$466,000**

M. Sunderland Brook

1. Sunderland Brook TMDL Flow Targets

In the effort to restore Sunderland Brook to its attainment condition and lift its impaired designation, a flow-based TMDL was developed for the watershed using flow as a surrogate for pollutant loading. This document outlines required reductions in stream high flows (Q 0.3%) and increases in stream low or base flows (Q 95%). These flow targets (Table M1) serve as the basis for this section of the Flow Restoration Plan (FRP).

Table M 1 Sunderland Brook TMDL flow restoration targets

Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
-3.7%	3.6%

In Table M1, the high flow target is negative (-), indicating there needs to be a reduction in high flow from the baseline condition. Conversely, the low flow target is positive (+), indicating there needs to be an increase in low flow from the baseline condition to meet this goal. While the target low flow increase is an important water quality goal, it is not an actionable requirement in the EPA approved TMDL and thus was not the primary focus of the FRP BMP identification for this study.

1.1. Future Growth Target

A future growth factor was included in the TMDL to account for future non-jurisdictional impervious growth within each watershed. Non-jurisdictional growth is by definition impervious area that does not require a stormwater permit and is not managed by a stormwater BMP. Therefore, the long term stormwater management plan must account for this type of growth as it will be unmanaged impervious area. VT DEC estimated a future growth of 8 acres in the watershed based on local development and projected growth for Sunderland Brook. The approved TMDL flow targets for Sunderland Brook are shown in Table M1.

1.2. MS4 Allocation of Flow Targets

Allocation of the high-flow target by MS4 was approximated based on relative impervious area ownership within the watershed. Impervious cover calculations excluded railroads and agricultural areas. The University of Vermont (UVM) owns land at the Fort Ethan Allen, but as a non-traditional MS4 the VT DEC did not consider UVM to be a jurisdictional MS4 within the Sunderland Brook Watershed. It is thus not included as a contributing MS4 to the Sunderland Brook TMDL.

The Town of Essex and the Town of Colchester own the majority of impervious cover in the Sunderland Brook Watershed (35.7% and 35.6% respectively). The remaining impervious cover is owned by the Village of Essex Junction and VTrans (25.5% and 3.2% respectively). The TMDL flow targets were allocated to each MS4 based on their impervious ownership where the Town of Essex and the Town of Colchester are both responsible for 1.32% flow reductions. The Village of Essex Junction is responsible for 0.94% of the flow reduction, and VTrans is responsible for the remaining 0.12% flow reduction (Table M2).

Table M 2 Sunderland Brook TMDL flow targets allocated by MS4

Owner	Total Watershed Area (acres)	Impervious Cover (acres)	% of Watershed Impervious Cover	Target High Flow Q 0.3 (± %) Reduction	Target Low Flow Q 95 (± %) Increase
University of Vermont	----	----	----	----	----
Town of Essex	318.3	111.8	35.7%	-1.32%	1.28%
Town of Colchester	916.6	111.6	35.6%	-1.32%	1.28%
Village of Essex Junction	173.6	80.1	25.5%	-0.94%	0.9%
VTrans	17.8	10.1	3.2%	-0.12%	0.12%
Watershed Total	**1426.3**	**313.6**		**-3.70%**	**3.60%**

2. Sunderland Brook BMPDSS Model Assessment

The Vermont DEC worked with an external consultant to develop a VT-specific hydrologic model, the VT BMPDSS, to predict progress toward the TMDL flow targets based on proposed BMP implementation scenarios. The BMPDSS model is used to predict peak flows at the watershed outlet for a Pre-2002 (baseline), Post-2002 (existing condition), and a Credit (BMP implementation) scenario. All models are compared to the Pre-2002 model on a percent change basis.

2.1. BMPDSS Pre-2002 Condition Model

The VT DEC developed a Pre-2002 condition model for Sunderland Brook. This model run includes all stormwater BMPs installed prior to the issuance of the 2002 VT Stormwater Standards. The subsequent Post-2002 and Credit model runs are compared to this Pre-2002 condition model. The unadjusted flow is used in the determination of progress towards the TMDL targets to eliminate the effect of watershed area in the percent change comparison.

2.2. BMPDSS Post-2002 Model

The Sunderland Brook Post-2002 model was revised with the most up to date information regarding the BMPs that are currently in place that manage the CPv or 1-year design storm. The Post-2002 model showed that of the target flow reduction of 3.7% in the watershed, current BMPs reduced high flows by 7.91%, which equates to 213.8% of the total required flow reduction (Table M3). Of that reduction, 377.4% of the VTrans allocation of 0.12% was addressed and a no required flow reduction remains. VTrans high flow reductions exceeded the target by 0.33%. Based on the model results, no additional CPv stormwater controls will be required to meet the TMDL high-flow target. However, as noted, even though modeled flow targets exceed TMDL flow targets, additional BMPs were identified in the event that future biomonitoring of the stream reveals non-compliance with Vermont water quality standards.

Table M 3 Sunderland Brook high flow target reduction progress with Post-2002 BMPDSS model run

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Post-2002 Model	High Flow Q 0.3 (± %) Reduction Remaining with Post-2002 Model	High Flow (Q 0.3) Target addressed (%)
Town of Essex	-1.32%	-3.99%	2.67%	302.0%
Town of Colchester	-1.32%	-3.37%	2.06%	256.2%
Village of Essex Junction	-0.94%	-0.10%	-0.84%	10.8%
VTrans	-0.12%	-0.45%	0.33%	377.4%
Watershed Total	**-3.70%**	**-7.91%**	**4.21%**	**213.8%**

3. Sunderland Brook Required Controls Identification

Potential BMP site selection focused on areas with a high-percentage of impervious coverage where stormwater flows were expected to be concentrated. A combination of field assessments and Geographic Information System (GIS) data was used to identify and screen potential BMP locations.

An initial list of retrofits was identified based on BMP feasibility as determined by available space, mapped NRCS soils, existing topographic data, and mapped stormwater and wastewater infrastructure provided by the VT DEC and MS4s. Natural resources were screened, though as part of the final design, an in-depth engineering assessment will still be required at each site to confirm the presence or absence of utilities and other potential impacts. The BMPs were then designed to meet the CPv storage criteria using HydroCAD® software.

3.1. BMPDSS Credit Model Assessment Results

The final recommended BMP list was modeled in the BMPDSS Credit run, which included 1 proposed VTrans BMP. The watershed-wide proposed FRP scenario addresses 482.4% of the modified high-flow target, providing retrofit options for the MS4s well above the required high flow reduction. The factor of safety is included in the recommended BMP list to provide the MS4s with options in the event that biomonitoring of Sunderland Brook reveals non-compliance with Vermont water quality standards. A low flow increase of 8.3% was modeled, which equates to 58% of the suggested target.

The Credit model showed a high flow reduction of 1.01% for the VTrans allocation for the Sunderland Brook Watershed, which equates to 847.3% of the total VTrans required high flow reduction (Table M4).

The ultimate determination for implementation of projects providing benefit beyond the high-flow target (> 100%) will be made by the State of Vermont based on monitoring data or other relevant information (MS4 General Permit Sec. IV.J.3). Progress toward the TMDL flow targets with the proposed FRP scenario was allocated by MS4 based on impervious area coverage to determine the extent to which the proposed BMPs addressed each MS4's allocated responsibility of the flow targets, summarized in Table M4.

Table M 4 Sunderland Brook BMPDSS Credit model results

Owner	Target High Flow Q 0.3 (± %) Reduction	High Flow Q 0.3 (± %) Reduction Achieved with Credit Model	High Flow Q 0.3 (± %) Reduction Remaining with Credit Model	High Flow (Q 0.3) Target addressed (%)
Town of Essex	-1.32%	-10.02%	8.71%	759.6%
Town of Colchester	-1.32%	-5.23%	3.91%	397.1%
Village of Essex Junction	-0.94%	-1.59%	0.64%	168.0%
VTrans	-0.12%	-1.01%	0.89%	847.3%
Watershed Total	**-3.70%**	**-17.85%**	**14.15%**	**482.4%**

3.2. VTrans Proposed BMPs

There is one proposed VTrans BMP in the Sunderland Brook Watershed, which is summarized in Table M5. This BMP includes one infiltration trench that manages 2.3 acres of VTrans impervious cover, 59.4% of the total impervious cover managed.

Tracy Rd. located in the Town of Colchester, was identified as a retrofit opportunity. The BMP retrofit would involve a retrofit of the existing grass swale on the VTrans site along Tracy Road. The existing grass swale and attached stormwater system collects drainage from the VTrans garage site and also from Barnes/Troy Ave. The existing swale would be expanded and a 2-foot-deep stone infiltration gallery would be added under the surface. The surface would remain as grass and riser pipes would connect drainage into the deeper stone gallery for easier maintenance. The existing fence would need to be moved closer to the road. This project would benefit high and low flow targets as well as improve water quality discharge from the site. Since the contributing drainage comes from the Town of Colchester and VTrans impervious, a cost share could be set up to allocate resources. On a runoff volume basis, the Town of Colchester contributes 0.195 ac-ft versus 0.23 ac-ft from VTrans owned land. The split is about 46%/54%.

The Fort Ethan Allen Offset Project manages the remaining 4.5 acres of VTrans impervious cover, 14.2% of the total impervious cover managed in this drainage area. This BMP manages a small amount of VTrans impervious area through the construction of a micropool extended detention pond, it is not determined to be the responsibility of VTrans.

The percent of high-flow target mitigated by each BMP was calculated as a percentage of the total VTrans owned impervious cover managed as shown below.

% of high-flow target managed = (A÷B) x C

A = VTrans impervious managed by individual BMP (acres)
B = total VTrans impervious managed by all BMPs in watershed (acres)
C = VTrans high flow target addressed by all BMPs in watershed (% reduction)

A total of 847.3% of the VTrans high flow target was met by these BMPs, the majority of which are a result of the existing Fort Ethan Allen existing Post-2002 BMP. The proposed Tracy Rd BMP manages the remaining 288% of the high flow target (Table M5).

The proposed BMPs are summarized in Table M5. This table includes the impervious cover managed, drainage area, and CPv volume storage estimated by the HydroCAD® model. A map of the proposed BMP locations is included in Appendix A and details about the proposed BMP is located in Appendix B. A preliminary design concept plans for the Tracy Rd project can be found in Appendix H-7.

Table M 5 VTrans final proposed BMPs for the Sunderland Brook FRP BMPDSS Credit model

Site Name	MS4 Impervious Owner	Ownership of Land where BMP is Located	BMP Type	Permit #	Drainage Area (acres)	Impervious Cover Managed (acres)	Impervious Cover Managed (% of Drainage Area)	VTrans Impervious Cover Managed (acres)	VTrans Impervious Cover Managed (% of Total Impervious Cover)	Runoff Channel Protection Volume (CPv) Storage (ac-ft)	VTrans High-Flow Target Managed (%)	Estimated Cost (Rounded to Nearest $1,000)
Tracy Rd.	VTrans/ Colchester	VTrans/ Colchester	Infiltration Trench	6363-INDS	5.0	3.9	78.3%	2.3	59.4%	0.43	287.9%	$54,000
Existing Fort Ethan Allen (Post-2002) BMP	*Town / City/ VTrans*	*Non-VTrans*	*Assorted*	*5598-INDO*	*46.5*	*31.8*	*68.3%*	*4.5*	*14.2%*	*--*	*559.4%*	
Watershed Total:								**6.8**			**847.3%**	**$54,000**

N. Design and Construction Schedule

A design and construction (D&C) schedule was developed to provide a long term plan for the implementation of the VTrans FRP. The 54 projects were spaced out over a 16-year timeframe in seven separate phases. The timeline provides for design, acquisition of necessary permits, regulatory approvals, acquisition of necessary land, and construction. The flow restoration targets are subject to adjustment by the Secretary based on biological monitoring data or other confounding information concerning high flow reduction progress. Adjustments to the flow targets may impact the schedule and full implementation of the proposed projects. The D&C is a working document and will be revised based on new information regarding the projects and stream conditions. A complete implementation schedule summary can be found in Appendix E. A summary of the number of projects to be constructed and the total cost by implementation phase is included below (Table N1). A workbook has been developed to track these projects (Appendix F).

Table N 1 Summary of project implementation costs and the number of projects to be constructed in each implementation phase

	Phase 1 (2017-2019)	Phase 2 (2020-2022)	Phase 3 (2023-2025)	Phase 4 (2026-2027)	Phase 5 (2028-2029)	Phase 6 (2030-2031)	Phase 7 (2032)	Total
# of Projects	14	18	7	6	3	3	3	**54**
Total Cost (Rounded to Nearest $1,000)	$1,142,000	$729,000	$1,033,000	$1,020,000	$588,000	$607,000	$1,752,000	**$6,871,000**

O. Financial Plan

Planning level costs were estimated for each project using a consistent spreadsheet-based method for all projects. As such, some cost estimates may differ slightly from those presented in other FRP documents. The total estimated implementation cost for all 54 BMPs is $6,871,000. VTrans will request state and federal funding for the appropriate amount to implement the BMPs as outlined in the D&C (see Table N1). For those projects that will require a joint effort with another municipality, VTrans will request funding for their portion of the cost share. In watersheds where VTrans is either not meeting or exceeding their allocated target, there may be cost sharing between MS4s.

a. BMP Cost Estimates

A spreadsheet-based method, originally developed by the Horsley-Witten (HW) Group, was used to develop planning level costs for all proposed BMPs. The methodology was used in the development of the Centennial Brook FRP and provides consistent cost estimates across watersheds (see HW Memo in Appendix G). It is expected that these costs will change as further designs are completed and site conditions and constraints are better understood. Cost estimates are based on limited site investigation, but are useful for planning purposes. All estimates presented are based on 2014 dollars.

The BMP cost estimation is based on the design control volume as determined by HydroCAD models developed for each site, unit costs that take into account the type of BMP, a site adjustment factor that takes into account the difficulty of construction based on present development at a location, a factor for the design and permitting of the BMP, and a land acquisition cost.

Base unit costs were dependent on the type of BMP proposed, as well as the area of the BMP. For example, a detention basin's base cost would be \$2 per ft^3 (Table O1 upper). Depending on the type of site where the BMP will be constructed, a cost multiplier was used with more constricted and developed sites assumed to increase construction complexity and cost (Table O1 lower).

Table O 1 Unit costs and adjustment factors for each BMP type

BMP Type	Base Cost (\$/ft^3)
Detention Basin	\$2
Infiltration Basin	\$4
Underground Chamber (infiltration or detention)	\$12
Bioretention	\$10
Green Infrastructure/ Underground Chamber Combo	\$22
Site Type	**Cost Multiplier**
Existing BMP retrofit	0.25
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Adjustment factor for large aboveground basin projects	0.5

Final costs were also influenced by a number of other factors. These include:

- Base Construction Cost: Calculated as the product of the design control volume, the unit cost, and the site adjustment factor.

- Permits and Engineering Costs: A cost multiplier of either 20% for large storage volume projects, or 35% for small or complex projects was applied.
- Land Acquisition Costs (modified from the HW method): For projects that require the acquisition of private land, a variation from the HW method was applied. An approximate land acquisition cost of $120,000 was used per acre required for the BMP. It should be noted that this value is based on a limited estimate and not necessarily an expected cost per acre.
- Total Project Cost: The total project cost was calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs. This cost was then rounded to the nearest $1,000.
- Minimum Cost Adjustment: This methodology tends to underestimate the cost of small retrofits, so a minimum project cost of $10,000 was applied for a simple, small projects such as an outlet retrofit, and a minimum cost of $25,000 was applied for more complex projects.

Cost estimates are summarized by watershed for VTrans BMPs below (Table O2). Cost estimates by BMP are located in Appendix C.

Table O 2 Cost estimate summary by watershed for all proposed VTrans BMPs

Watershed Name	# of VTrans BMPs	Estimated Cost
Allen Brook	13	$764,000
Bartlett Brook	2	$577,000
Centennial Brook	2	$1,851,000
Indian Brook	3	$353,000
Moon Brook	1	$279,000
Munroe Brook	3	$607,000
Potash Brook	6	$738,000
Rugg Brook	13	$1,182,000
Stevens Brook	10	$466,000
Sunderland Brook	1	$54,000
VTrans Total:	**54**	**$6,871,000**

P. Regulatory Analysis

BMPs presented in this FRP document will be implemented over the 16-year timeframe detailed in D&C. In several watersheds, the proposed BMP implementation scenario manages >100% of the VTrans high flow reduction target and thus includes a robust factor of safety (i.e., Sunderland Brook, Bartlett Brook; Appendix D). This factor of safety is included so that if one or more proposed projects become infeasible after further design and construction planning, VTrans will still be able to meet their allocated target for that watershed without seeking out additional projects. The proposed BMP implementation plan will serve as a guide for VTrans, but is subject to change as more information becomes available. Each of the BMPs is either on land owned by VTrans, on land controlled by VTrans, or on land controlled by another municipality. For the BMPs that fall into the third category, VTrans is prepared to work with the appropriate municipality to implement the BMP.

VTrans currently has one expired permit, the US Route 7, Shelburne-South Burlington (Permit 1-1291), that will be incorporated into the VTrans MS4. VTrans has filed the paperwork to do so. VTrans does not own the Williston Welcome Center (Permit 1-1401) permit. This permit was issued to the Department of Buildings and General Services. VTrans does not intend to take over this permit, although the pond at this rest station will be retrofit as part of the FRP implementation. VTrans does not require any additional regulatory assistance from the DEC at this time.

Q. Glossary of Terms

A glossary of relevant terms is provided below.

Best Management Practice (BMP)- Generally, BMPs are defined as, "schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State and waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage" (MS4 Permit, 2012). In the context of the FRP, BMPs include prescribed stormwater flow control practices as defined in the computer-based BMPDSS model, in which various BMPs scenarios can be assessed.

Best Management Practice Decision Support System (BMPDSS)- A computer-based hydrologic model used to assess the impact of various stormwater BMP scenarios. This tool was developed by a private consultant for the VT DEC to use as the assessment tool for compliance with the Stormwater TMDLs.

Channel Protection Volume (CPv)- The stormwater volume generated from the 1-year, 24-hour rainfall event. The Vermont Stormwater CPv Design Standard requires 24 hours of extended detention storage of the CPv in warm water fish habitat and 12 hours for cold water fish habitat as a means to reduce channel erosion.

Detention BMP- A BMP (e.g. detention pond) which stores stormwater for a defined length of time before it eventually drains to the receiving water body. Stormwater is not retained in the practice long term. The objective with a detention BMP is to reduce the peak discharge (Q_p) from the basin in the effort to reduce channel erosion and settle out pollutants from the stormwater.

Flow Duration Curve (FDC)- An FDC is a curve displaying the percentage of time during a period that flow exceeds a certain value, with the low flow represented by the 95th percentile (Q 95%) of the curve, and the high flow represented by the 5th percentile (Q 0.3%).

Flow Restoration Plan (FRP)- The FRP is a required element of the MS4 General Permit #3-9014, under section IV. C. 1., for stormwater discharges to impaired waters. The FRP is a 20-year implementation plan of stormwater flow control BMPs to meet the TMDL high flow target and return the impaired water to its attainment condition. The FRP is required to include a list of stormwater BMP controls, as well as modeling results from the VT BMPDSS model demonstrating compliance of the approved TMDL flow target with the proposed BMP list.

Infiltration BMP- A BMP that allows for the infiltration of stormwater into the subsurface soil as groundwater, which returns to the stream as baseflow. Mapped soils of Hydrologic group A or B (sandy, well-drained soils) are an indicator of infiltration potential. Infiltration reduces the amount of surface storage required. Typical BMP practices include infiltration basins, underground chamber systems, bioretention practices, and others.

Non-Jurisdictional Impervious- Non-jurisdictional impervious area is impervious cover that does not require a stormwater permit and is not managed by a stormwater BMP (impervious growth < 1 acre).

Residual Designation Authority (RDA)- The RDA permit is separate from the MS4 permit, held by the private landowner.

Stormwater Management Plan (SWMP)- A comprehensive program to manage stormwater discharges from the Municipal Separated Storm Sewer System as mandated by the MS4 General Permit #3-9014.

Stormwater TMDL- Vermont developed stormwater Total Maximum Daily Loads (TMDLs) for impaired watersheds using stormwater flow as a surrogate for pollutants. The basis for the flow-based TMDL is the understanding that stormwater is the source of pollutant loading. Therefore, minimizing stormwater flows will reduce pollutant loading to the streams and Lake Champlain. The approved TMDL requires a reduction in high flows, defined as greater than the 1-year storm event. The TMDL also includes a non-actionable (not enforced) low flow target, which is measured by an increase in stream baseflow (groundwater flow to streams).

Total Maximum Daily Load (TMDL)- A TMDL is a calculation of the maximum pollutant loading that a water body can accommodate and still meet Vermont Water Quality Standards. The term TMDL also refers to the regulated management plan, which defines how the water body will be regulated and returned to its acceptable condition, including the maximum loading, sources of pollution, and criteria for determining if the TMDL is met.

TMDL High Flow Target- The TMDL target defined as the percent change between the Pre-2002 (baseline) condition and the Post-2002 (existing) high flow. The high flow is the flow rate in the stream that is exceeded 0.3% of the time (Q 0.3%) over a 10-year simulation period. The Q 0.3% has been equated to the 1-year design storm runoff.

TMDL Low Flow Target- The non-actionable TMDL target defined as the percent change between the Pre-2002 (baseline) condition and the Post-2002 (existing) low flow. The low flow is the flow rate in the stream that is exceeded 95% of the time (Q 95%), over a 10-year simulation period. The Q 95% is considered baseflow, which is the flow in a stream fed by groundwater.

ATTACHMENT E VTRANS PHOSPHORUS CONTROL PLAN

Lake Champlain Basin Generalized Phosphorus Control Plan for the Vermont Agency of Transportation

STONE
ENVIRONMENTAL

PROJECT NO.

18-008-A

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PC

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Acknowledgements and Disclaimer

This project was undertaken by Stone Environmental, Inc. for the Vermont Agency of Transportation, with funding provided by the Agency.

The intent of this plan is to present the data collected, evaluations, analysis, designs, and cost estimates for the Vermont Agency of Transportation (VTrans). This document provides information for stormwater retrofit projects proposed to meet VTrans phosphorus management obligations in watersheds subject to a Phosphorus Control Plan (PCP) under *National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 for Stormwater Discharges form the State Transportation Separate Storm Sewer System (TS4)* (effective November 29, 2017). This plan is the regulatory document for VTrans to meet PCP obligations under General Permit 3-9007. If VTrans is included in PCPs submitted by any Municipal Separate Storm Sewer System (MS4) permittee, the information contained in this plan should supersede that information. Retrofit projects identified in this plan have not been fully assessed for feasibility or completely designed. The work completed has been done at a planning level and will be subject to change based on site conditions, permitting, budgetary constraints, and other unforeseen issues.

The still-unfolding coronavirus epidemic has, as of March of 2020, radically changed and will continue to affect both how VTrans and Vermont Agency of Natural Resources (ANR) staff members interface, and how work is completed to advance the first four-year implementation plan. VTrans and the consultant team gratefully acknowledge the flexibility provided by the ANR Stormwater Program staff during the preparation and submittal of this draft Generalized PCP.

Executive Summary

The Vermont Agency of Transportation (VTrans), through its Maintenance Bureau and Pollution Prevention and Compliance Section, is committed to maintaining compliance with a swiftly evolving variety of state and federal environmental regulations. The Vermont Agency of Natural Resources (ANR) and VTrans have worked together for several years to develop and implement permitting programs, plans, policies, and designs to comply with the Lake Champlain Phosphorus Total Maximum Daily Load (TMDL), finalized by the United States Environmental Protection Agency (EPA) on June 17, 2016.

This Generalized Phosphorus Control Plan (PCP) documents how VTrans will work towards the reduction of phosphorus (P) loading from roads, rights-of-way, and facilities under the Agency's control by over 20% within the next 20 years (by June 17, 2036). It first summarizes what VTrans has already done to develop the framework for a basin-wide PCP, and then provides a summary of how the agency intends to meet its goals.

The compliance and implementation strategy VTrans will use to achieve its target reductions across the PCP Area in the LCB will continue immediately from submittal of this Generalized PCP into development of the first four-year implementation plan. Work in progress described in this PCP continues into development of the first four-year implementation plan, specifically to refine determinations of what P reduction credit towards VTrans' target reductions can be expected from existing and planned structural stormwater treatment practices (STP)s, existing areas of localized erosion repaired in the last seven years, and areas of hydrologically connected roadway drainage systems recently improved to current standards. Existing application of non-structural practices such as street sweeping and catch basin cleaning is summarized within this document, and while future adjustments to crediting may be applied, the acres and basis for those credits is thoroughly documented in this PCP.

Prior to submittal of the first four-year implementation plan, VTrans will identify additional retrofits and improvement projects using previously compiled datasets and screening criteria enhanced with field verification. This implementation plan will focus on the Missisquoi Bay Lake segment but will opportunistically assess potential major retrofits and opportunities outside that watershed. The plan will include a combination of implementation of localized erosion and hydrologically connected road segment drainage repairs, structural STPs (both new treatment practices and retrofits to existing structural STPs), potential enhancements to non-structural control frequencies, and other projects (particularly floodplain reconnection) with the highest P cost-benefit. Through the execution of the four-year implementation plans, backed by robust tracking and accounting, VTrans expects to achieve its P reduction targets.

After completing the first four-year implementation plan with a Missisquoi Bay Lake segment focus, the focus of the TS4's PCP implementation plans will move south through the Lake Champlain basin as follows:

- 2024-2028: Focus on remaining Lake segments generally north of Main Lake (Isle La Motte, St. Albans Bay, Northeast Arm, Malletts Bay, and Shelburne Bay)
- 2028-2032: Focus on Main Lake and the Winooski River watershed
- 2032-2036: Focus on Lake segments generally south of Main Lake (Otter Creek, Port Henry, South Lake A, and South Lake B).

As envisioned in this Generalized PCP, over a third of the impervious acres anticipated to be managed with structural measures constitute maintenance-level road drainage asset repairs or localized erosion repairs. This application is anticipated to result in two-thirds of the required annual P load target reduction. In Lake segments where these measures coupled with non-structural control application did not appear sufficient to demonstrate P reduction target achievement, areas to be managed with conceptual structural STPs were estimated, preferring infiltration-based practices and those with the highest P reduction cost-benefit.

The Generalized Plan is conservative, demonstrating that VTrans may meet its target P reductions without the benefit of several innovative strategies that are progressing, but for which results are not yet available.

Correction of gullying and large areas of active erosion, as well as corrections at stormwater system outlets, remain areas of active investigation across multiple State agencies, Regional Planning Commissions and municipalities, watershed stewardship organizations, and other partners. As implementation plans are developed, VTrans expects that they will be informed by the progress and findings of the VTrans and ANR research project *Quantifying Nutrient Pollution Reductions Achieved by Erosion Remediation Projects on Vermont's Roads*, which is now underway and will be completed in 2021. VTrans also expects that major upgrades to road embankments and culverts where improvements would address both existing drainage issues and reduce vulnerability to damage from floods, where risk, vulnerability, or criticality have been identified in VTrans's Transportation Resilience Planning Tool will become a possibly substantial factor in prioritization and completion of improvements when those data become available for areas within the Lake Champlain Basin.

Natural resource restoration projects, and particularly floodplain reconnection projects, may be credited as a stormwater treatment practice in the context of the VTrans PCP if the floodplain area to be reconnected is also connected to a TS4 roadway or other VTrans-controlled contributing drainage. Preliminary evaluations of the potential for floodplain reconnection in the VTrans PCP Area will be completed as the first implementation plan is developed. However, more exhaustive evaluation of how to execute and credit floodplain reconnection where VTrans roads and facilities contribute runoff upstream of the restoration practice will be possible through application of results from Vermont's Functioning Floodplains Initiative. While the project outputs will not be complete until 2021, the initiative will develop and apply methodologies for evaluating river reach and watershed-scale restoration of stream, riparian, wetland, and floodplain function. The initiative seeks to track and publicize the natural and socio-economic assets derived from connected and naturally functioning floodplains and wetlands. These and other emerging innovative approaches represent a strong confluence of regulatory priorities, maximizing the opportunity to achieve greater benefits for all compared to a narrow focus on the reduction of P load from VTrans paved roads and facilities.

Generalized Phosphorus Control Plan, Lake Champlain Basin, Vermont Agency of Transportation

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Abbreviations

ANR	Vermont Agency of Natural Resources
BMP	Best Management Practice
DEC	Department of Environmental Conservation
DI	Drop Inlet
EPA	Environmental Protection Agency
HHC	Highly Hydrologically Connected
LHC	Low Hydrologically Connected
MATS	Maintenance Activity Tracking System
MHC	Moderately Hydrologically Connected
MRGP	Municipal Roads General Permit
MSGP	Multi-Sector General Permit
NPDES	National Pollutant Dischrage Elimintation System
PCP	Phosphorus Control Plan
REI	Road Erosion Inventory
SCI	Small Culverts Inventory
STP	Stormwater Treatment Practice
SWMP	Stormwater Management Program
TMDL	Total Maximum Daily Load
TS4	Transportation Sseparate Storm Sewer System
VTrans	Vermont Agency of Transportation

1. Introduction and Background

The Vermont Agency of Transportation (VTrans), through its Maintenance Bureau and Pollution Prevention and Compliance Section, is committed to maintaining compliance with a swiftly evolving variety of state and federal environmental regulations. The Vermont Agency of Natural Resources (ANR) and VTrans have been working together for several years to develop and implement permitting programs, plans, policies, and designs to comply with the Lake Champlain Phosphorus Total Maximum Daily Load (TMDL), finalized by the United States Environmental Protection Agency (EPA) on June 17, 2016.

This Generalized Phosphorus Control Plan (PCP) documents how VTrans will work towards the reduction of phosphorus (P) loading from roads, rights-of-way, and facilities under the Agency's control by over 20% within the next 20 years (by June 17, 2036). It first summarizes what VTrans has already done to develop the framework for a basin-wide PCP, and then provides a summary of how the agency intends to meet its goals.

1.1. VTrans Stormwater Permitting

As part of its Phase 1 Implementation Plan[1] developed in response to the Lake Champlain P TMDL, the ANR, in December 2016, issued the National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System[2] (TS4) to VTrans (effective November 27, 2017). The TS4 General Permit is the primary regulation ensuring that stormwater discharged from VTrans owned or controlled impervious surfaces is managed according to State water quality policy. It combines VTrans' compliance obligations from several permit programs, including the Municipal Separate Storm Sewer System (MS4) General Permit and its associated Flow Restoration Plan and VTrans requirements, Multi-Sector General Permit (MSGP), and Operational (post-construction) Stormwater Permit.

Section 9.2 of the TS4 General Permit requires VTrans to develop and implement a PCP, in phases, that will identify and document a suite of best management practices (BMPs) capable of achieving required reductions in the amount of P in stormwater discharges in each of 11 Lake segments, as required by the TMDL. That plan must, at minimum, estimate the area (acres or road miles) to be treated, and the extent and type of BMPs that will be implemented to meet the entire P load reduction.

VTrans is required to meet a series of interim performance milestones that first culminate in the completion this conceptual PCP for the entire TS4 within the Lake Champlain Basin (LCB) by April 1, 2020, and creation of the first of several four-year implementation plans by October 1, 2020. Below is the compliance schedule from Section 9.2.C of the permit, outlining the Agency's progress in meeting these milestones. Additional information about each of the progress submittals through and including the October 1, 2019 submittal is available at https://arcg.is/0DS4LC0 and in Appendix D.

- January 1, 2018: Submit Notice of Intent and Stormwater Management Program.

[1] https://dec.vermont.gov/watershed/restoring/champlain
[2] https://dec.vermont.gov/watershed/stormwater/transportation-general-permit

- VTrans submitted its Notice of Intent[3] and Stormwater Management Program (SWMP)[4] document, outlining its expected actions and commitments for compliance with Vermont water quality policies and regulations over the next five years, to ANR in December 2017.

- April 1, 2018: Establish the baseline P load and reductions needed.
  - VTrans first developed GIS data defining the spatial extents and geographic coverage of the TS4 within the LCB, then worked with ANR to extract draft developed lands acreages and resulting draft P base loads from ANR's existing land use-land cover dataset (Appendix A and at website above).
- October 1, 2018: Complete GIS inventory of P loading factors.
  - The GIS inventory of loading factors was developed by VTrans in consultation with ANR to first establish the baseline P load, and then to determine other factors to more accurately refine P load allocation for the TS4 across the LCB (Appendix B and at website above).
- April 1, 2019: Complete development of coefficients of loading rates.
  - VTrans and ANR considered the development of loading rate coefficients for each of the four land cover classes and associated P loading factors. Factors adjusting P loading rates by degree of hydrologic connectivity and road slope were developed only for paved roadways, distributing P base load proportionately to VTrans roadways based on each road segment's risk of contributing disproportionate P loads to surface waters (Appendix C and at website above).
- October 1, 2019: Submit progress report on VTrans.
  - The progress submittals above, as well as inventory and assessment work completed through VTrans' other commitments under the TS4 General Permit, were summarized and the groundwork laid for completion of a conceptual PCP for the entire TS4 within the LCB (Appendix D and at website above).
- April 1, 2020: Complete generalized statewide Phosphorus Control Plan.
- October 1, 2020: Submit 1st 4-year implementation plan (Phase I).
- April 1, 2021 and every 6 months thereafter (April 1st and October 1st): Submit semi-annual report on VTrans implementation.
- October 1, 2024: Submit 2nd 4-year implementation plan (Phase II).
- October 1, 2028: Submit 3rd 4-year implementation plan (Phase III).
- October 1, 2032: Submit 4th 4-year implementation plan (Phase IV).
- No later than June 17, 2036: Complete implementation of the approved PCP.

1.2. Summary of Watershed Characteristics

The P-impaired watersheds included in the VTrans PCP Area encompass the entirety of the LCB in Vermont, except for the Burlington Bay direct drainage. A summary of the VTrans PCP area by land cover type (Road/linear facility or Parcel-based facility) and type of land cover (Developed Impervious, Paved Road, Unpaved Road, and Developed Pervious) is provided in Table 1.

[3] https://anrweb.vt.gov/PubDocs/DEC/Stormwater/PublicNotice/7892-9007/TS4%20VTrans%20NOI_Final_signed.pdf
[4] https://anrweb.vt.gov/PubDocs/DEC/Stormwater/PublicNotice/7892-9007/VTrans%20Final%20SWMP%20-%20December%205%202017.pdf

Table 1. Summary of VTrans PCP Area by Land Cover Classification (acres)

	Linear Facilities and Right-of-Way Areas (acres)				Parcel-Based Facility Areas (acres)				
Lake Segment	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Total
South Lake B	16.83	481.54	0.00	775.63	3.98	1.22	0.00	9.74	1,288.94
South Lake A	1.94	69.11	0.00	61.30					132.35
Port Henry	0.75	15.29	0.00	8.10					24.14
Otter Creek	57.93	1,181.20	0.00	1,445.40	43.96	42.53	0.00	269.14	3,040.16
Main Lake	65.38	1,645.12	12.30	3,029.56	41.68	36.57	0.00	223.05	5,053.66
Shelburne Bay	10.15	163.66	0.00	189.58	0.84	2.62	0.00	11.15	378.01
Burlington Bay	--	--	--	--	--	--	--	--	--
Malletts Bay	56.67	1,013.46	0.00	1,604.31	24.13	0.99	0.00	47.44	2,747.00
Northeast Arm	5.86	159.51	0.00	164.01	1.83	0.00	0.00	2.54	333.76
St. Albans Bay	9.90	187.20	0.00	321.73	5.60	0.00	0.00	1.03	525.45
Missisquoi Bay	38.18	910.14	0.00	1,167.43	28.87	26.78	0.44	115.14	2,286.97
Isle La Motte	2.29	46.93	0.00	37.56					86.78
Total	265.89	5,873.17	12.30	8,804.61	150.89	110.71	0.44	679.22	15,897.23

The portion of the Vermont P base load (2001-2010) falling within developed lands source areas as summarized in Table 3 of the 2016 P TMDL[5], as compared to the portion of those developed lands owned and controlled by VTrans, is included in Table 2. The portion of VTrans-managed developed lands by Lake segment varies from 0% in the area draining to the Burlington Bay Lake segment, where VTrans has no land subject to this TMDL, to 8.6% in the watershed draining to the St. Albans Bay Lake segment.

[5] https://ofmpub.epa.gov/waters10/attains_impaired_waters.show_tmdl_document?p_tmdl_doc_blobs_id=79000

Table 2. Summary of Total Developed Land and VTrans Developed Land Base P Loads

Lake Segment	Total Developed Lands Base P Load (mt/yr)	VTrans Base P Load (mt/yr)	Percent of Base P Load Within VTrans PCP Area
South Lake B	9.0	0.66	7.3%
South Lake A	2.3	0.09	3.9%
Port Henry	0.7	0.02	2.7%
Otter Creek	20.2	1.64	8.1%
Main Lake	35.1	2.24	6.4%
Shelburne Bay	3.4	0.17	4.9%
Burlington Bay	1.7	0.00	0.0%
Malletts Bay	17.2	1.19	6.9%
Northeast Arm	3.9	0.19	4.8%
St. Albans Bay	2.6	0.23	8.6%
Missisquoi Bay	17.0	1.19	7.0%
Isle LaMotte	0.9	0.06	7.0%
Total	114.0	7.7	6.7%

The developed lands portion of the P base loads, and target P reductions to be managed under the VTrans PCP, are summarized by Lake segment in Table 3.

Table 3. Phosphorus Base Loads and Reduction Targets by Lake Segment

Lake Segment	P Base Load (kg/yr)			% Reduction Needed to Meet Allocation	Target P Load Reduction (kg/yr)		
	Linear Facilities	Parcel Facilities	Total		Linear Facilities	Parcel Facilities	Total
South Lake B	646.16	8.49	654.66	21.10%	136.34	1.79	138.13
South Lake A	89.46		89.46	18.10%	16.19		16.19
Port Henry	18.69		18.69	7.60%	1.42		1.42
Otter Creek	1,472.19	163.72	1,635.91	15.00%	220.83	24.56	245.39
Main Lake	2,115.80	127.02	2,242.82	20.20%	427.39	25.66	453.05
Shelburne Bay	162.62	4.64	167.26	20.20%	32.85	0.94	33.79
Malletts Bay	1,153.92	36.20	1,190.12	20.50%	236.55	7.42	243.98
Northeast Arm	186.27	2.85	189.11	7.20%	13.41	0.21	13.62
St. Albans Bay	217.58	7.12	224.70	21.70%	47.21	1.55	48.76
Missisquoi Bay	1,101.05	85.96	1,187.02	34.20%	376.56	29.40	405.96
Isle La Motte	63.30		63.30	8.90%	5.63		5.63
Total	**7,227.04**	**436.00**	**7,663.04**		**1,514.40**	**91.52**	**1,605.91**

2. BMPs Considered in Plan Development

Four classes of conceptual stormwater best management practices (BMPs) were considered for development and inclusion in the Generalized Plan:

- Areas of VTrans property treated with structural stormwater BMPs
- Areas of VTrans property treated with non-structural practices
- Areas of localized erosion treated with structural BMPs
- Areas of VTrans roadway and drainage upgraded to meet standards

A process schematic illustrating the framework used to evaluate each class of practices is provided in Figure 1. The practices evaluated included both classes where design, application, treatment, and crediting for P reduction opportunities and constraints are well understood (structural stormwater treatment practices and non-structural controls), and classes where applicability and crediting—at the initiation of plan development—remained areas of active investigation and consideration by both VTrans and ANR.

Implementation plans are anticipated to include combinations of implementation of localized erosion and hydrologically connected road segment drainage repairs, structural STPs (both new treatment practices and retrofits to existing structural STPs), potential enhancements to non-structural control frequencies or extents, and other projects with the highest P cost-benefit. As each class of practices was evaluated, repairs to road drainage assets (Section 2.2) and to areas of localized erosion (Section 2.3) were found to generally be more cost-effective and to have greater co-benefits (for example, regarding flood resilience and the safety of the traveling public) compared to treatment of impervious surfaces with green stormwater infrastructure or other structural stormwater treatment practices (Section 2.1). Although not included in Figure 1, natural resource restoration projects (Section 2.4), and particularly floodplain reconnection projects, represent a critical opportunity for cost-effective P reduction and maximization of co-benefits, and will be an area of continued development and application in the implementation plans.

Details of the evaluations completed and results for each class of conceptual practices are provided in the sections below.

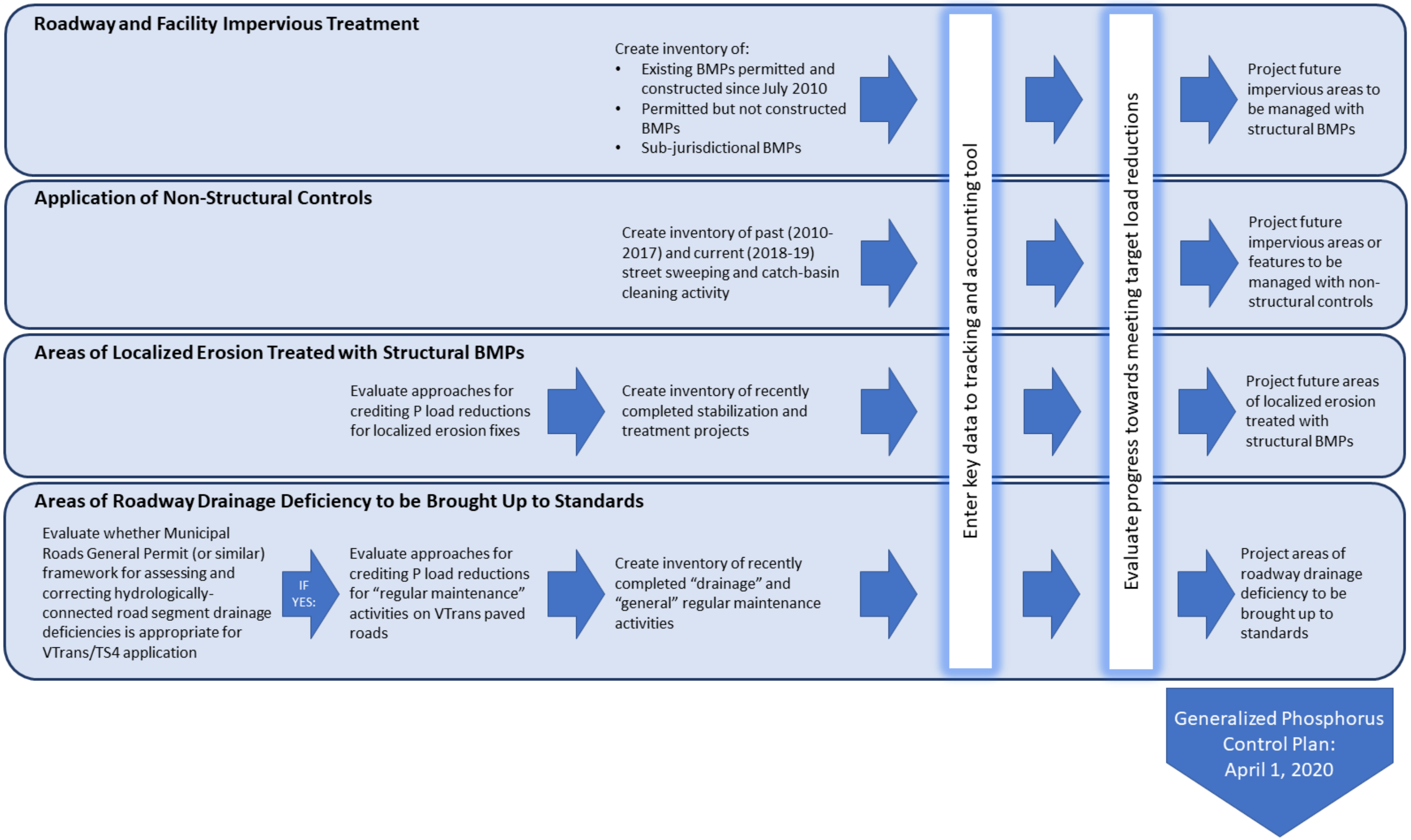

Figure 1. VTrans Generalized Phosphorus Control Plan Framework Schematic

2.1. Structural Stormwater Treatment Practices

Structural stormwater treatment practices (STPs) are one of the measures available to VTrans to meet P reduction targets in accordance with the TS4 General Permit. Structural treatment practices are intended to detain, treat, and better manage runoff from well-defined areas of impervious surface, such as roads, parking lots, or rooftops. These treatment practices range from older detention ponds managing only peak flows to dry swales, gravel wetlands, and other green stormwater infrastructure. Structural stormwater treatment practices historically have been incorporated into VTrans' asset portfolio as transportation projects improving roads and facilities implemented to comply with regulatory requirements.

In developing the Generalized PCP, enhancements to maintenance activities already being performed by VTrans that have quantifiable P reduction benefits were typically preferred over construction of new structural STPs (Sections 2.2 and 2.3). Recognizing that these improvements alone may not be sufficient to achieve the required target P reductions in all Lake segments, structural STP opportunities were evaluated to allow for adaptive management during the development and execution of the four-year implementation plans.

Existing and planned structural STPs throughout the TS4 were first evaluated to determine progress made towards meeting P reduction targets in each Lake segment. Next, a GIS desktop evaluation was completed to screen pervious areas within the VTrans right-of-way for application of conceptual structural STPs. Paved road areas potentially managed by conceptual structural STPs, and P base loads and reductions potentially creditable through construction of the conceptual STPs, were evaluated within each Lake segment, as were feasibility constraints and potential implementation costs. During the development of the first four-year implementation plan, VTrans will more closely evaluate structural STP retrofit feasibility, and will continue to determine acres managed and P reduction credit anticipated from existing and planned structural STPs.

2.1.1. Existing Structural Stormwater Management Practices

VTrans has identified upgrades and retrofits to practices implemented after the adoption of the 2002 Vermont Stormwater Management Manual design standards, including both jurisdictional and sub-jurisdictional improvements. Operational permits and plans issued by the Vermont Department of Environmental Conservation (DEC) Stormwater Program for projects permitted and constructed after July 1, 2010 were reviewed to assess and credit the additional benefit provided by these systems (Map 2). Future VTrans projects that have been issued operational stormwater permits, but which are not constructed as of January 2020, are referred to in this assessment as "planned STPs". For planned STPs, the anticipated acres managed and associated P reductions are included in projections where possible. Treatment practices planned for implementation as part of the Flow Restoration Plans are also included, both as completed (for Allen Brook) and as anticipated in future years where sufficient information existed. Many of the planned FRP projects are anticipated to be adjusted during design to increase P removal efficiency while retaining peak flow mitigation benefits.

As qualifying structural STPs were identified, the P base loads to be managed by each existing and in-process structural STPs were calculated. Phosphorus removal efficiencies and P load reduction benefits expected for existing and planned structural BMPs were calculated consistent with the structural STP types and crediting already established by ANR. VTrans projects in early development stages, such that stormwater requirements are not fully developed, should be reviewed on an annual basis and any newly identified structural STPs should be incorporated into the BMP tracking spreadsheet currently maintained by VTrans.

Nearly 160 structural STPs presently exist and another 64 are planned, which together will manage stormwater from 235.4 acres of impervious area and 814.1 acres of pervious area within the VTrans PCP Area (Figure 1 and Table 4). The majority of existing structural STPs are grass channels that manage stormwater from moderately hydrologically connected paved roads areas with less than 10% slope (Table 5). Most existing structural STPs (93%) manage stormwater from paved roads (Table 5).

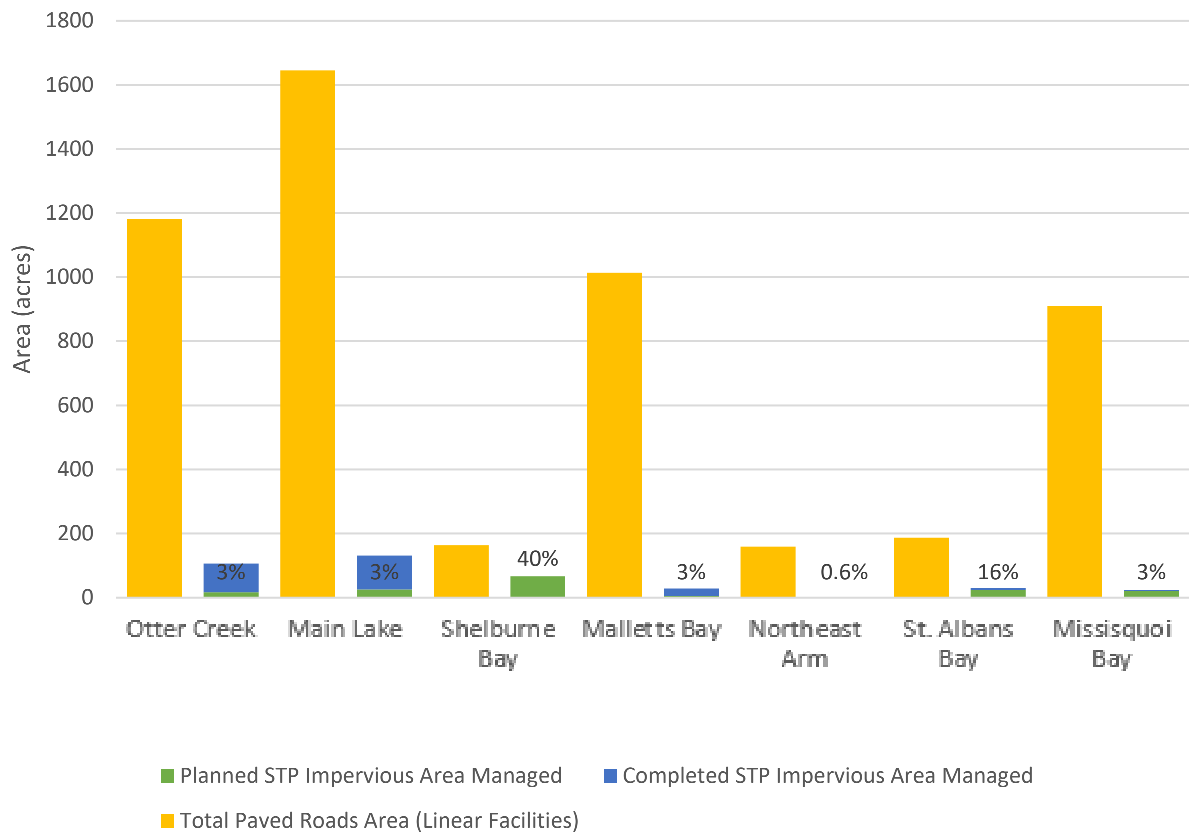

Figure 2. VTrans Impervious Areas Managed by Existing and Planned Structural STPs

Table 4. Summary of Areas Managed by Existing and Planned Structural STPs (ac)

Lake Segment	Completed STP Impervious Area Managed	Completed STP Pervious Area Managed	Planned STP Impervious Area Managed	Planned STP Pervious Area Managed
Otter Creek	17.8	90.0	16.0	28.4
Main Lake	26.3	106.0	25.4	38.7
Shelburne Bay			66.0	118.7
Malletts Bay	22.3	24.0	5.7	28.6
Northeast Arm			0.9	0.2
St. Albans Bay	5.7	8.9	24.9	302.7
Missisquoi Bay	3.8	57.5	20.7	10.5
TOTAL	75.8	286.3	159.6	527.8

Table 5.Summary of Existing and Planned Structural STPs by Land Cover Classification

Land Cover Classification	Total Structural STPs Installed
Developed Impervious	1

Paved Roads - Facilities	14
Paved Roads, 0-10% Slope, High Hydrologic Connectivity	75
Paved Roads, 0-10% Slope, Low Hydrologic Connectivity	9
Paved Roads, 0-10% Slope, Moderate Hydrologic Connectivity	122
Total	221

Table 6: Summary of Existing and Planned STPs by Practice Type

Structural STP Type	Completed	Planned	Total
Bioretention (infiltrating)	0	2	2
Disconnection	23	9	32
Dry Swale (w/ underdrain)	3	2	5
Extended Dry Detention Pond	34	11	45
Grass Channel	81	9	90
Gravel Wetland	1	22	23
Infiltration Chambers	1	0	1
Infiltration Trench	3	2	5
Median Filter	0	3	3
Reduction of existing impervious	1	0	1
Sand filter (infiltrating)	6	0	6
Sand filter (w/ underdrain)	1	0	1
Underground Detention Chamber	0	3	3
Wet pond/ Created Wetland	2	1	3
Wet Swale	1	0	1
Total	157	64	221

Phosphorus load reductions from existing and planned projects account for a small portion of the total required reduction for each Lake segment, ranging from 0.4% (Missisquoi Bay) to 30% (Shelburne Bay), with an average of 5% in Lake segments with existing structural STPs (Figure 2 and Table 7). Many existing structural STPs are either grass swales, which have low P removal efficiency, or were designed primarily to manage the one-year, 24-hour storm event in order to comply with stormwater flow TMDLs (Table 6).

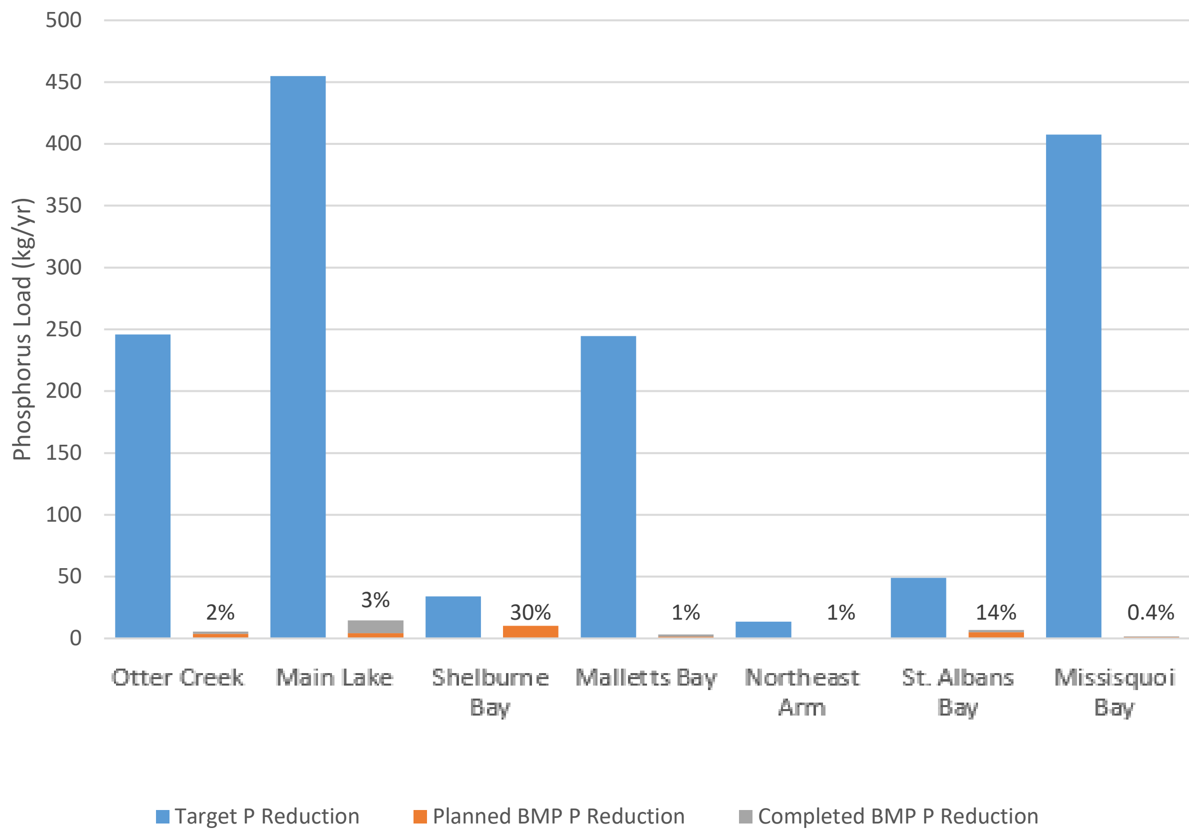

Figure 3.Phosphorus Load Reductions from Existing and Planned Structural STPs by Lake Segment

Table 7. Summary of P Load Reductions from Existing and Planned Structural STPs (kg/yr)

Lake Segment	Completed STP P Load Reduction	Planned STP P Load Reduction	Total P Load Reduction	Target P Load Reduction*	% of Total P Reduction
Otter Creek	1.8	3.8	5.6	246.0	2%
Main Lake	10.3	4.2	14.5	454.9	3%
Shelburne Bay		10.1	10.1	33.9	30%
Malletts Bay	1.9	1.4	3.3	244.6	1%
Northeast Arm		0.2	0.2	13.7	1%
St. Albans Bay	1.8	5.0	6.8	48.9	14%
Missisquoi Bay	0.5	1.1	1.6	407.5	0.4%
Total	16.28	25.83	42.11	795.91	5%

One of the most cost-effective structural STPs available to VTrans is the retrofit of replacement of existing guardrails, where removal of timber curb effectively disconnects runoff from adjacent paved roads areas, allowing unconcentrated flow of runoff into the pervious right-of-way (ROW). Several such disconnections are included in VTrans' BMP tracking table for 'structural' STPs. Where conditions are right (relatively gentle slopes and sufficient pervious area width available in the ROW), the guardrail and timber crib removal may be completed by VTrans personnel, and operation/maintenance of the resulting disconnection practice consists primarily of maintaining the guardrail (if only timber curb is removed and guardrail remains) and mowing –

all of which is part of normal VTrans operations. Opportunities for implementing disconnections through timber curb removal will be evaluated more closely in development of the first four-year implementation plan.

2.1.2. Analysis of Treatment Potential using Structural STPs

A screening analysis was conducted to determine the potential for successfully siting and implementing structural STPs to manage runoff from linear facilities within the VTrans PCP Area. Areas of developed pervious land within the VTrans right-of-way were identified using a desktop GIS analysis, and the drainage areas directing runoff to each pervious area were delineated. Suitable structural STP types were assigned to each pervious potential STP area based on physical and feasibility constraints, as well as cost considerations. Conceptual structural STP were identified by targeting pervious right-of-way areas in proximity to and downslope of large areas of VTrans paved road impervious cover. The resulting comprehensive set of potential structural STP opportunities will be further refined and prioritized based on additional feasibility and cost considerations, through field confirmation, and as the need for structural STP implementation versus other, more cost-effective measures comes into focus during the development and execution of the four-year implementation plans.

The results of this screening analysis are intended to be used only in the context of this Generalized PCP. Further refinement of structural STP siting and sizing, and careful evaluation of feasibility constraints and permitting needs, will be necessary prior to implementation. The assessment results are highly dependent on the assumptions outlined below, which will be adjusted both as the first four-year implementation plan is developed and as the implementation plans are executed.

2.1.2.1. Conceptual Structural STP Opportunity Assessment Methods

Areas of developed pervious land within the VTrans right-of-way greater than 0.1 acres and adjacent to highly hydrologically connected road segments (referred to as "STP areas") were selected. Drainage areas adjacent to and up-slope of the STP areas were calculated using the watershed function within ArcGIS. The resulting drainage areas were categorized based on ownership (VTrans vs. non-VTrans) and surface type (impervious vs. pervious). A processing document describing the steps undertaken to derive the conceptual STP areas and their contributing drainage areas is available upon request.

The desktop GIS analysis only considered developed pervious areas adjacent to impervious roadway surfaces for conceptual STP selection. VTrans parcel-based facilities and associated impervious surfaces constitute a small portion of the total P base load (10%) and are better suited to individual assessment and application of both jurisdictional and sub-jurisdictional structural STPs.

A conceptual STP selection workflow was developed to preferentially select high-performing, low-cost STPs that align with VTrans' needs and operation/maintenance preferences (Figure 3). Where site and soil considerations indicated that multiple STP types could be sited, P removal efficiency, cost, and maintenance impacts were considered. Conceptual STP areas that intersected with a water body or floodplain were removed from consideration as structural STPs and were instead considered as potential floodplain reconnection projects (Section 2.4). Similarly, conceptual STP areas intersecting Vermont Significant Wetlands Inventory areas were flagged as potential wetland restoration projects.

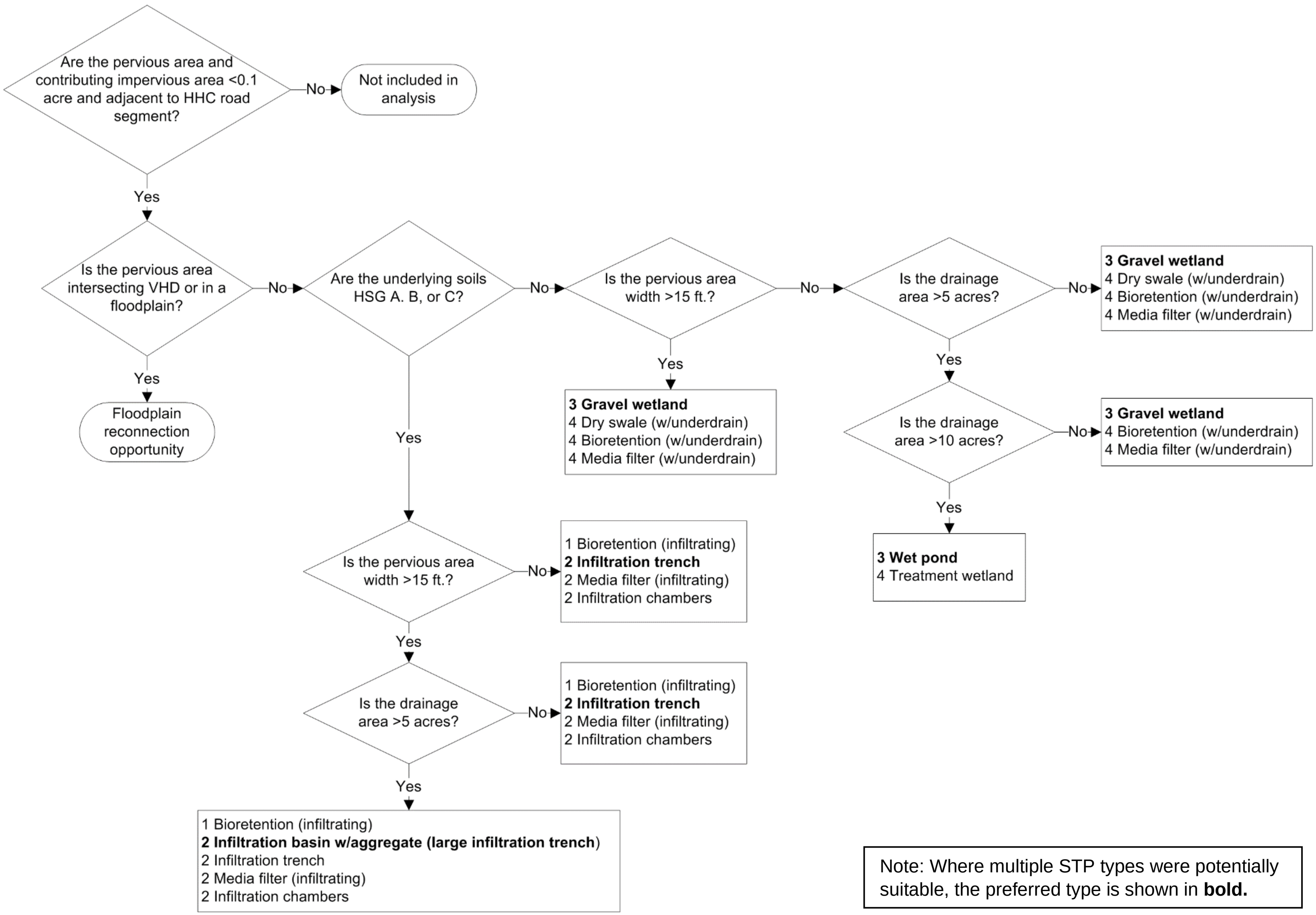

Figure 4. Conceptual STP Selection Decision Logic Flowchart

In addition to performance, implementation cost and long-term maintenance impacts are key factors when selecting structural STPs. Cost estimates per STP type were derived from 2016 Opti-Tool values[6] and refined using implementation costs for recent STP retrofit projects provided by VTrans (Table 8). Each STP unit cost includes construction cost; a 35% allowance for design, engineering, and contingency; and a cost adjustment factor of 1.2, accounting for VTrans project development processes and sometimes-complex permitting situations. In lieu of detailed evaluation of operation and maintenance costs, a maintenance factor was derived from 2016 Opti-Tool estimates of annual labor hours required to maintain each type of STP. The maintenance factor allowed normalization of STPs that may be less costly to construct but expensive to maintain (and vice versa). Once STP types were selected for each conceptual STP area, stormwater treatment volumes, P base loads, P load reductions, and estimated STP implementation costs were calculated for all conceptual STPs.

Table 8. Conceptual STP Implementation Costs and Maintenance Factors

STP Type	STP Implementation Cost ($/CF storage volume)	Maintenance Factor	Implementation and Maintenance Cost ($/CF storage volume)
Wet Pond	$7.90	0.98	$15.63
Gravel Wetland	$10.21	0.70	$17.33
Treatment Wetland	$10.21	0.70	$17.33
Infiltration Trench	$14.52	0.70	$24.65
Bioretention (infiltrating)	$17.97	0.65	$29.71
Dry Swale (infiltrating)	$17.97	0.65	$29.71
Bioretention (w/ underdrain)	$18.14	0.65	$30.00
Dry Swale (w/ underdrain)	$18.14	0.65	$30.00
Media Filter (infiltrating)	$20.85	1.00	$41.70
Media Filter (w/ underdrain)	$20.85	1.00	$41.70
Infiltration Chambers	$78.86	not included	

2.1.2.2. Conceptual Structural STPs: Potential P Reduction Benefits and Costs

Once STP types were assigned to available pervious areas, the conceptual STPs were sized to manage the water quality storm (WQv)[7] using typical design assumptions, so that P load reductions and costs could be estimated for each conceptual STP (Appendix E). Load reductions were calculated using the methodology and calculations embedded in the ANR BMP Tracking Table (3/13/2020 version)[8]. Cost estimates per conceptual STP were calculated using the implementation costs above (Table 8), and cost-benefit metrics ($/acre and $/kg P removed) were calculated.

All results of the conceptual structural STP screening assessment are accessible in a web app, available at https://bit.ly/2WULVJd. As the first four-year implementation plan is developed, refinements to STP characteristics and the STP selection workflow may be made and further prioritization will occur. In addition to the attributes used in the conceptual STP selection workflow (STP area size, drainage area size, proximity to water bodies, hydrologic connectivity of adjacent road segments, soil type, etc.), the variables outlined in Table 9 and others will be considered.

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[6] https://www3.epa.gov/region1/npdes/stormwater/ma/green-infrastructure-stormwater-bmp-cost-estimation.pdf
[7] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf
[8] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/BMPTrackingTable_03132020.xlsx

Table 9. Examples of Conceptual Structural STP Attributes for Prioritization

STP Attribute	Notes
Slope	Higher slope typically leads to higher costs
Existing STP present?	BMP retrofits typically have lower costs
Floodplain permit potentially required?	Mitigation measures can increase cost and slow project delivery
VSWI permit potentially required?	Mitigation measures can increase cost and slow project delivery
RTE or Significant Natural Community present?	Mitigation measures can increase cost and slow project delivery
High crash zone?	BMPs sited in these areas have long-term maintenance concerns
Adjacent to interstate?	BMPs sited in these areas can access Federal funding

Over 8,000 conceptual structural STPs were identified that have the potential capacity to manage stormwater from 2,821 acres of paved roads area and 4,910 acres of developed pervious area within the VTrans PCP Area (Figure 4 and Table 11). The majority of conceptual structural STPs identified were infiltration trenches and gravel wetlands (Figure 5). The inclusion of HSG C soils as potentially suitable for infiltration trenches at a low infiltration rate (0.17 inches/hour) may have resulted in an artificially high preponderance of infiltration trench STPs. This assumption will be revisited through field screening during the development of the first four-year implementation plan. Port Henry was the only Lake segment with no conceptual STP opportunities identified, with the Main Lake, Otter Creek and Malletts Bay Lake segments containing the most opportunities (Table 10).

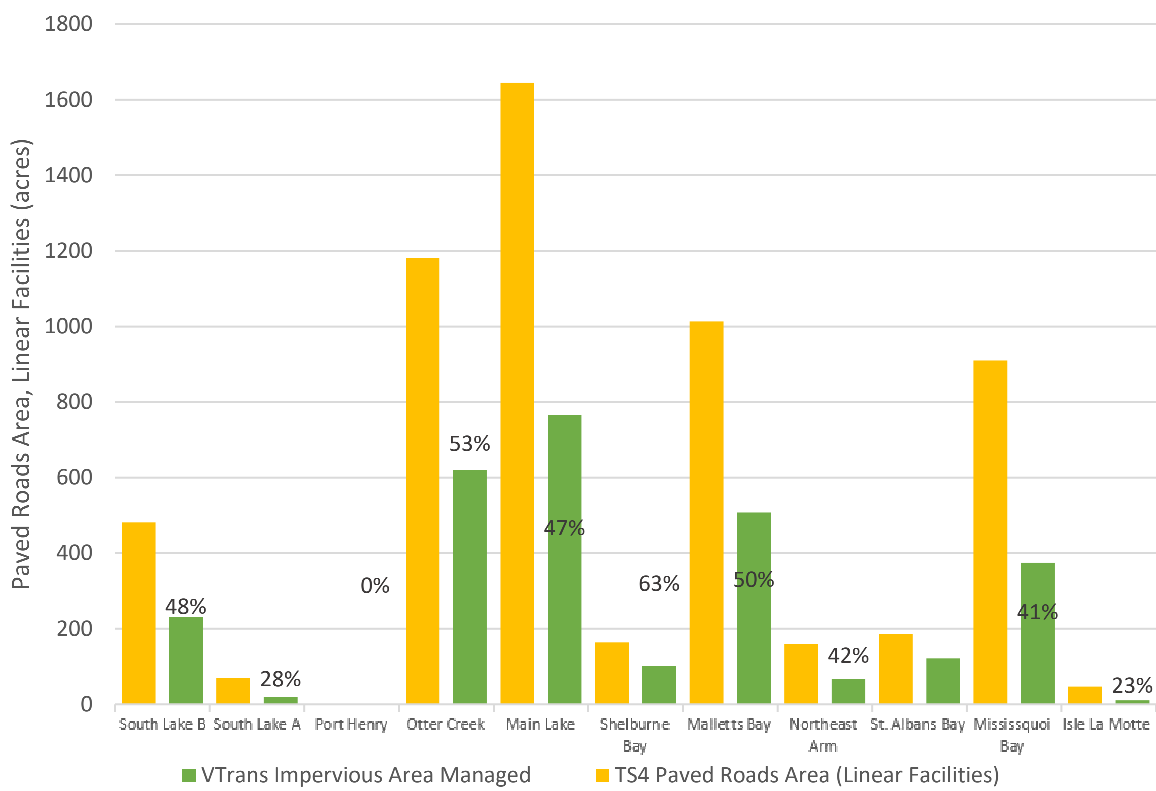


Figure 5. VTrans Paved Roads Area Potentially Managed by Conceptual Structural STPs

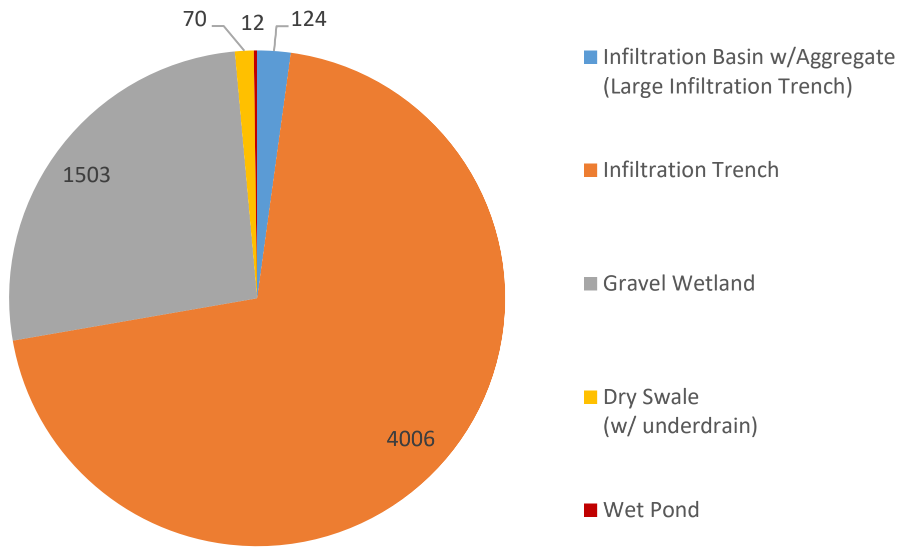


Figure 6. Conceptual Structural STPs by STP Type

Table 10. Summary of Conceptual structural STP Opportunities by Lake Segment

Lake Segment	Infiltration Basin w/Aggregate (Large Infiltration Trench)	Infiltration Trench	Gravel Wetland	Dry Swale (w/ underdrain)	Wet Pond	Floodplain Reconnection	Total
South Lake B	9	360	140	3	1	168	681
South Lake A		6	42	2		18	68
Port Henry							-
Otter Creek	27	779	360	23		473	1,662
Main Lake	36	1,066	393	8	3	780	2,286
Shelburne Bay	4	79	47			52	182
Malletts Bay	22	865	219	7	4	393	1,510
Northeast Arm	1	64	75	12		71	223
St. Albans Bay	7	119	25		2	53	206
Missisquoi Bay	18	656	190	13	2	379	1,258
Isle LaMotte		12	12	2		18	44
Total	124	4,006	1,503	70	12	2,405	8,120

Table 11. Summary of VTrans Paved Roads Area Potentially Managed by Conceptual STPs (acres)

Lake Segment	Conceptual STP Area	Developed Pervious Area Managed	Paved Roads Area Managed	Total VTrans Acres Managed	Total VTrans PCP Paved Roads Area (Linear Facilities)	Total VTrans PCP Area (Linear Facilities)	Paved Roads Area Potentially Managed (%)
South Lake B	8.3	437.6	231.2	677.1	481.5	1,274.0	48%
South Lake A	0.8	22.5	19.5	42.8	69.1	132.4	28%
Port Henry	0.0	0.0	0.0	0.0	15.3	24.1	-
Otter Creek	21.9	951.1	620.1	1,593.2	1,181.2	2,684.5	53%
Main Lake	27.7	1,516.3	766.1	2,310.1	1,645.1	4,752.4	47%
Shelburne Bay	2.6	169.1	102.4	274.1	163.7	363.4	63%
Malletts Bay	17.0	903.6	507.9	1,428.5	1,013.5	2,674.4	50%
Northeast Arm	2.5	69.6	66.3	138.5	159.5	329.4	42%
St. Albans Bay	3.1	167.8	121.7	292.6	187.2	518.8	65%
Missisquoi Bay	13.1	660.8	374.7	1,048.6	910.1	2,115.7	41%
Isle LaMotte	0.4	11.5	11.0	22.9	46.9	86.8	23%
Grand Total	97.4	4,910.0	2,821.0	7,828.4	5,873.2	14,956.0	48%

Conceptual structural STPs have the potential to manage a large portion of the P reduction target in most Lake segments, ranging from 55% (Missisquoi Bay) to 248% (Northeast Arm) (Figure 6). Nearly half of the Lake segments in the VTrans PCP Area could fully reach P reduction targets through application of the conceptual structural STPs (Table 12).

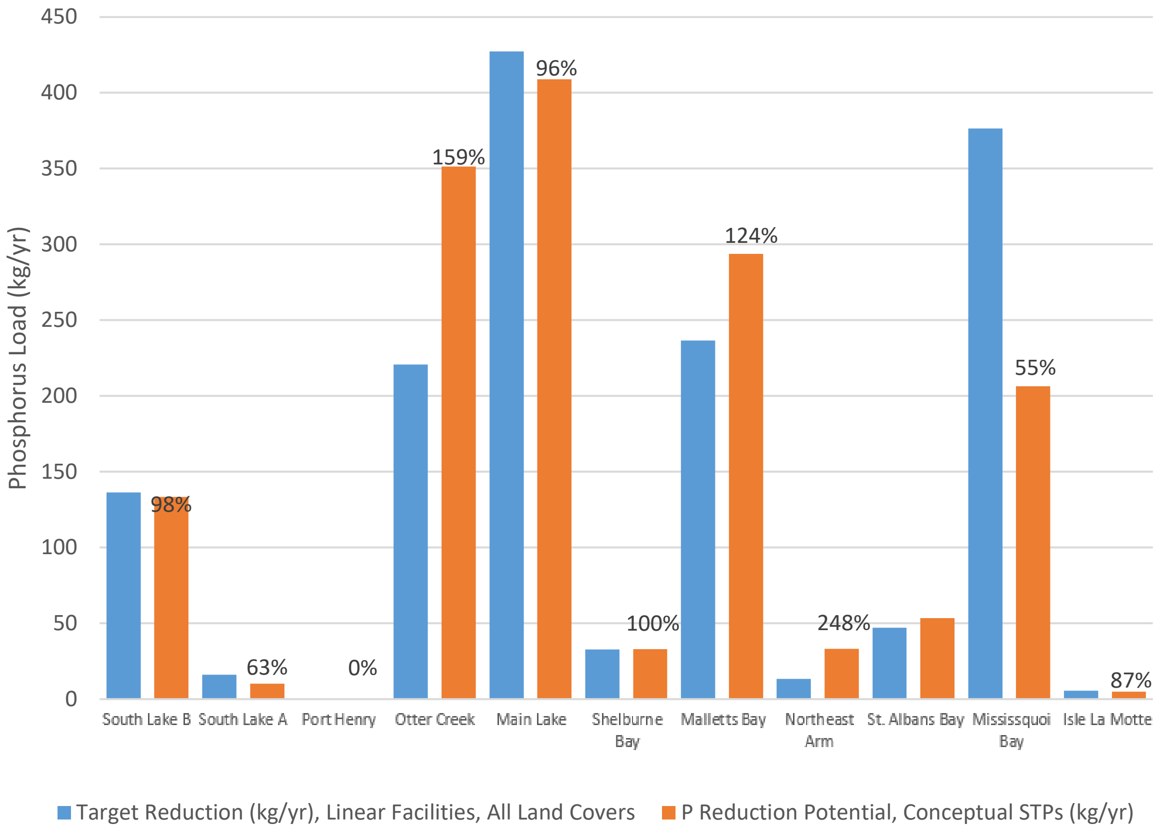


Figure 7. P Load Reductions Possible with Conceptual Structural STPs by Lake Segment

Table 12. Summary of P Reduction Possible from Conceptual Structural STPs

Lake Segment	P Reduction Possible (kg/yr)	Target Reduction (kg/yr)	Total % of Target Reduction Possible
South Lake B	133.4	136.3	98%
South Lake A	10.2	16.2	63%
Port Henry	0.0	0.0	-
Otter Creek	351.5	220.8	159%
Main Lake	409.0	427.4	96%
Shelburne Bay	32.9	32.8	100%
Malletts Bay	293.8	236.6	124%
Northeast Arm	33.2	13.4	248%
St. Albans Bay	53.5	47.2	113%
Missisquoi Bay	206.4	376.6	55%
Isle LaMotte	4.9	5.6	87%
Total	1,528.9	1,513.0	101%

Although conceptual structural STPs have the potential to manage the majority of the required P reduction targets for linear facilities in the VTrans PCP Area, the costs of using these measures alone would be prohibitive. The average cost for each conceptual structural STP type ranges from $18,900 (gravel wetlands) to $151,900 (wet ponds) with an average implementation cost of $24,000 per STP (Table 13). The total cost to implement all the conceptual structural STPs identified in this analysis would be $136,947,800, with an average cost per annual P reduction of $97,100/kg P/yr and an average cost per impervious acre managed of $50,800/acre. These costs are only associated with structural STP implementation and do not account for the life-cycle maintenance and repair costs associated with structural STPs, although these were considered in the initial STP selection process (see Section 2.1.2.1).

Table 13. Summary of Conceptual Structural STP Implementation Costs (2020 dollars)

STP Type	Total Conceptual STP Implementation Cost	Average Cost per STP	Average of Cost per kg P Load Reduced ($/kg/yr)	Average Cost per Impervious Acre Managed ($/ac)
Infiltration Basin w/Aggregate (Large Infiltration Trench)	$18,484,500	$149,100	$119,400	$58,300
Infiltration Trench	$86,394,100	$21,600	$90,900	$54,800
Gravel Wetland	$28,385,700	$18,900	$107,200	$38,900
Dry Swale (w/ underdrain)	$1,860,300	$26,600	$181,600	$64,600
Wet Pond	$1,823,300	$152,000	$183,200	$42,500
Total	$136,947,800	$24,000	$97,100	$50,800

2.2. Structural Correction of Road Drainage Deficiencies

Over the past year, a method has been developed by VTrans in coordination with ANR to assess roadway and drainage deficiencies, and to subsequently quantify P load reductions for improvements that are considered regular maintenance activities on VTrans paved roads. Examples include ditching, guardrail maintenance, or culvert or outfall repair/replacement, where these activities result in a demonstrable P load reduction or improvement in a road segment's condition. This approach is comparable to ANR's requirement for municipalities to compete Road Erosion Inventories (REI) of hydrologically connected road segments under the Municipal Roads General Permit (MRGP)[8] and as incorporated into the MS4 General Permit[9]. This requirement is not part of the TS4 General Permit. VTrans and ANR have worked during the development of this Generalized PCP to determine whether VTrans should develop and maintain a similar Road Erosion Inventory as a component of its PCP.

VTrans continues to work with ANR to more closely define standards and criteria for hydrologically connected road segments within the TS4, where an approach similar to the MRGP standards may be applied. As consensus is reached, a similar workflow may be followed as for the other classes of BMPs included in the Generalized PCP. Existing areas where roadway drainage deficiencies have been brought up to standards since July 2010 are being compiled into a desktop inventory of roadway drainage improvement projects that may be eligible for P reduction credit. Paved road acres or miles where deficiencies have been addressed will be calculated, resulting in estimates of what P load reduction credit may reasonably be granted for existing road drainage projects across the LCB.

This Generalized PCP applies the evaluation and methodology described below to estimate acres of paved roads area where existing drainage deficiencies may be brought up to standards in each Lake segment, the types of conceptual BMPs or drainage improvements that would be best suited in each application, and the P load removal credit achieved for each conceptual application.

2.2.1. Evaluation of VTrans Asset Inventories in PCP Area

The road erosion inventory, scoring, and prioritization system DEC developed for the MRGP was evaluated, acknowledging that the MRGP is targeted to gravel roads and ditches and thus does not always represent conditions within the VTrans highway network. A review of VTrans existing data sources and inventories was conducted to evaluate how existing data could be used to emulate the inventories that are being conducted on a municipal level through the REI. The following VTrans asset inventories and their associated Inventory Field Manuals were considered:

- Small Culverts Inventory (SCI) and SCI Field Manual
- Guardrail Inventory and Guardrail Field Manual (May 2107)
- Ditch/Swale Inventory and the TS4 Drainage Inventory Field Guide

The following fields within these inventories were determined to be most relevant for understanding present road drainage conditions and possible drainage deficiencies:

- SCI – Culvert Condition (Inlet, Outlet and Culvert Barrel) and Treatment
- SCI – Culvert Sediment (Inlet and Outlet)
- SCI – Culvert Erosion (Inlet and Outlet)
- SCI – Sink Hole present

[8] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/MunicipalRoads/sw_MRGP_RoadErosionInventory.pdf

[9] https://dec.vermont.gov/watershed/stormwater/permit-information-applications-fees/ms4-permit

- SCI – Road Settling
- SCI – Presence of Stone Pad at outlet
- Guardrail Inventory – Presence of Curb-board
- Ditch/Swale Inventory – Condition and Material

The guardrail inventory only identifies the presence of curb board and does not provide information regarding erosion or potential drainage deficiencies. Presence of curb board alone is not sufficient to determine whether the removal of curb board and the creation of a disconnection could be a suitable new water quality treatment practice (Section 2.1.2.1). Likewise, assessment of the presence of a stone pad at the culvert outlet within the SCI showed only a small number of culverts with an existing stone pad, such that stone pad presence was not useful as an indicator of either meeting a drainage standard or as indication of drainage deficiency.

The SCI and the TS4 Drainage Inventory (Swale/Ditch) were overlaid with the previously developed GIS inventory of paved road areas, P loading factors, and resulting P base loads to create a desktop inventory of areas located within highly hydrologically connected (HHC) and moderately hydrologically connected (MHC) paved road segments that, based on existing conditions reflected in the asset inventories, may be "brought up to standards" and thus be eligible for P reduction credit throughout the VTrans PCP Area.

The scoring system below (Table 14) was developed to create a unified condition assessment across various asset inventory data fields. The scoring is intended to categorize condition assessments so that segments can be identified as Meeting Standards, Partially Meeting Standards, or Not Meeting Standards based upon a standardized set of scoring criteria. The scoring system was then applied to develop prioritization for addressing identified deficiencies, based on the severity and/or number of conditions identified within any given road segment.

Table 14. Scoring System for Determining Whether Roadway Drainage Infrastructure Meets Drainage Standards

Score	Culvert Condition	Culvert Erosion	Culvert Sediment	Culvert Sink Hole	Road Settling	Swale Condition
5	Critical	Severe	Plugged	Severe	Grade	Critical
4	Poor	Moderate	Heavy	Major	--	Poor
3	Fair	Light	Moderate	Moderate	Repair	Fair
2	--	--	Light	Minor	--	Good
1	Good	None	None	None	None	Excellent
0	Unknown/Null	Unknown/Null	Unknown/Null	Unknown/Null	Unknown/Null	Unknown/Null

2.2.2. Assessment of VTrans Road Drainage Inventory Conditions

A spatial query of the asset inventories was executed using the following datasets:

- VTrans road segments by hydrologic connectivity (High, Moderate, Low)
- Key inventory conditions (Culvert Erosion and Sediment, Sink Hole, Road Settling, Swale Condition)
  - Selection of the worst case within a road segment for that inventory condition (Score 0 to 5 as identified in Table 14)
    - For example, if two culverts in one road segment each have sediment at the inlet, but one is identified as "plugged" and one is "heavy", then the ranking will be 5 for "heavy", which is the most deficient drainage scenario.

- Drainage areas within the LCB, from the determination of PCP Area and P base load by VTDEC and VTrans in March 2018 (Appendix A).

An overall road segment score was assigned using the worst ranking of any of the above conditions found within that road segment. The resulting data and scoring outputs were uploaded to a web map (available at https://bit.ly/2QIPqyy), where users may filter and export the results by Lake segment, degree of hydrologic connectivity, road slope and other criteria. These outputs are intended to be imported into an Excel spreadsheet and tabulated by highly and moderately hydrologically connected road segments within each Lake segment and SWAT drainage basin. An example of an implementation table for the Missisquoi River drainage area is included as Appendix F.

Table 15 summarizes the number of HHC road segments by worst-case ranking in each Lake segment. Of the almost 9,900 HHC paved road segments in the VTrans PCP Area, nearly 40% (3,974) had a condition ranking of 4 or 5, indicating that at least one road drainage asset within that road segment was generally in poor to critical condition.

Table 15. Roadway Drainage Infrastructure Conditions, Count of Highly Hydrologically Connected Road Segments by Lake Segment

	Swale and Culvert Conditions						
	Unknown	Best-->Worst					
Lake Segment	0	1	2	3	4	5	Total
South Lake B	1	72	185	214	100	70	642
South Lake A		9	53	43	17	14	136
Port Henry		1	6	3	3	4	17
Otter Creek	2	211	632	535	352	166	1,898
Main Lake	106	208	685	779	773	313	2,864
Shelburne Bay	7	21	92	56	26	18	220
Malletts Bay	62	89	248	464	708	218	1,789
Northeast Arm		11	29	98	109	32	279
St. Albans Bay		5	43	110	76	27	261
Missisquoi Bay		87	149	541	634	257	1,668
Isle La Motte		4	19	17	46	11	97
Total	178	718	2,141	2,860	2,844	1,130	9,871

Based on these results and the apparent significant number of opportunities to address existing road drainage, road segments with overall segment scores of 4 or 5 are proposed to be considered as "Not Meeting Standards" and thus eligible for credit for fixes that have been made since 2010 or moving forward. A more detailed segmentation of the asset inventory and assessment data into segments that "Partially Meet Standards" as established in the MRGP was not considered in the development of the Generalized PCP, though this concept may be revisited as the implementation plans are developed and executed. Presently, further prioritization is being developed by considering the number of issues located within a road segment, and by including additional prioritization data such as slope (both for the paved road segments and the adjoining swales).

Much of the VTrans road network in the LCB has some level of hydrologic connection (Table 16). The HHC road segments (linear facilities only) represent 2,537 paved road acres (43%) of the 5,873 such acres in the

TS4's PCP area in the LCB, while the MHC road segments represent 2,220 paved road acres (38%). The paved road impervious acres in the PCP Area are summarized in Table 16 and Figure 7 first by whether the areas have any mapped drainage infrastructure assets, and then by whether those areas served by drainage infrastructure 'meet' or 'do not meet' the set of standards/criteria described above. Of the 2,537 acres that are HHC in the PCP Area, 733 acres (29%) have no mapped drainage infrastructure assets, 1,027 acres (40%) "meet standards", and 778 acres (31%) "do not meet standards". The portion of the HHC road segments 'not meeting standards' ranges from 17% (South Lake A) to 43% (Isle La Motte). Similarly, of the 2,220 acres classified as MHC, 552 acres (25%) have no mapped drainage assets, 997 acres (45%) "meet standards", and 671 acres (30%) "do not meet standards". The basin-wide portion of the MHC road segments 'not meeting standards' ranges from 17% (Port Henry) to 59% (Isle La Motte).

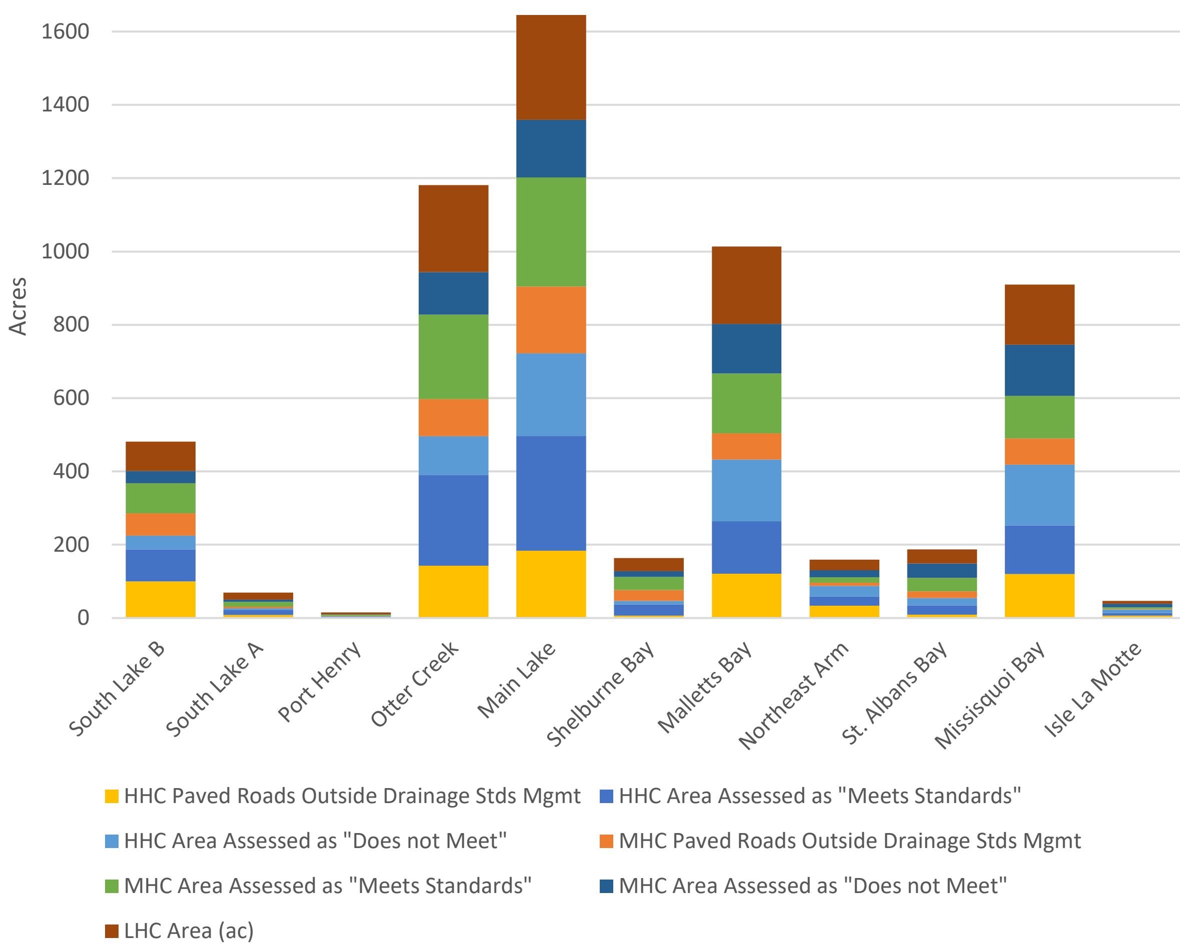


Figure 8. Linear Facilities, Paved Roads Acres by Hydrologic Connectivity and Drainage Standard

Table 16. Summary of Linear Facilities, Paved Roads Area by Hydrologic Connectivity and Asset Drainage Standards Status (acres)

Lake Segment	Total Paved Roads Area	HHC Paved Roads Outside Drainage Stds Mgmt	HHC Area Assessed as "Meets Standards"	HHC Area Assessed as "Does Not Meet"	MHC Paved Roads Outside Drainage Stds Mgmt	MHC Area Assessed as "Meets Standards"	MHC Area Assessed as "Does Not Meet"	LHC Area
South Lake B	481.54	99.62	87.42	37.70	61.05	81.86	33.66	80.23
South Lake A	69.11	8.15	13.42	5.11	4.34	13.12	5.69	19.29
Port Henry	15.29	2.08	1.78	0.93	0.87	3.36	0.89	5.38
Otter Creek	1181.20	142.57	247.67	105.55	101.13	231.12	115.64	237.51
Main Lake	1645.12	183.55	313.12	225.07	183.11	296.75	157.11	286.41
Shelburne Bay	163.66	6.83	30.50	9.77	29.46	35.63	15.82	35.65
Malletts Bay	1013.46	120.67	143.14	168.72	71.27	162.94	135.57	211.15
Northeast Arm	159.51	33.36	25.30	29.36	8.56	14.85	18.80	29.28
St. Albans Bay	187.20	9.10	25.53	20.19	18.54	36.11	39.39	38.35
Missisquoi Bay	910.14	120.37	132.54	165.16	72.11	116.25	139.07	164.65
Isle La Motte	46.93	6.93	6.28	9.99	1.52	4.89	9.16	8.16
Total	5873.17	733.23	1026.70	777.56	551.95	996.88	670.79	1116.06

The assessment returns a higher fraction of roadway areas 'not meeting standards' than what ANR staff have indicated the Road Erosion Inventories submitted by municipalities and RPCs under the MRGP program are returning (~10% or less of hydrologically connected road segments 'not meeting standards'). VTrans expects that further analysis of which TS4 criteria for meeting standards are most representative of erosion and subsequent water quality impacts, and refinement to the criteria and these assessment results, will continue as the first four-year implementation plan is developed. VTrans also acknowledges that the results received by ANR for completed REIs are necessarily incomplete, as the submittal deadline for those inventories is December 31, 2020.

Numeric P target reductions that may be expected if all paved road segments identified as having drainage deficiencies are corrected for linear facilities (roadways and rights-of-way) within the PCP Area are summarized in Table 17. The extent to which addressing all identified road drainage deficiencies on HHC and MHC road segments could be credited towards the TS4's target P reductions, assuming the same crediting schema being applied by ANR to municipal roadway drainage improvements under the MRGP is applied to the TS4's PCP, is summarized in Figure 8. In the MRGP framework, an 80% reduction credit is applied for bringing a hydrologically connected road segment fully up to standards' if its base condition when inventoried did not meet standards. A set of standards that adjusts the MRGP Road Stormwater Management Standards[11] (Part 6 of the MRGP) is in development and will be provided for ANR review when available. VTrans is also developing a ditching Standard Operating Procedure, which may be incorporated into the VTrans standards.

Table 17. Summary of P Target Reductions and Credit Possible for HHC and MHC Road Segments Not Meeting Drainage Standards

Lake Segment	Target P Reduction (Roads Portion Only, All Land Covers) (kg/yr)	HHC P Reduction Possible (kg/yr)*	MHC P Reduction Possible (kg/yr) *	HHC % of Target Reduction Possible	MHC % of Target Reduction Possible
South Lake B	136.34	32.19	18.34	24%	13%
South Lake A	16.19	5.36	4.06	33%	25%
Port Henry	1.42	0.92	0.59	65%	41%
Otter Creek	220.83	93.56	67.14	42%	30%
Main Lake	427.39	188.35	85.61	44%	20%
Shelburne Bay	32.85	7.87	8.72	24%	27%
Malletts Bay	236.55	140.52	72.77	59%	31%
Northeast Arm	13.41	23.69	9.83	177%	73%
St. Albans Bay	47.21	17.62	22.99	37%	49%
Missisquoi Bay	376.56	137.06	74.33	36%	20%
Isle La Motte	5.63	7.30	4.27	130%	76%
Total	1514.40	654.44	368.63	43%	24%

**Assuming 80% credit*

[11] https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/MunicipalRoads/sw_FinalMRGP.pdf

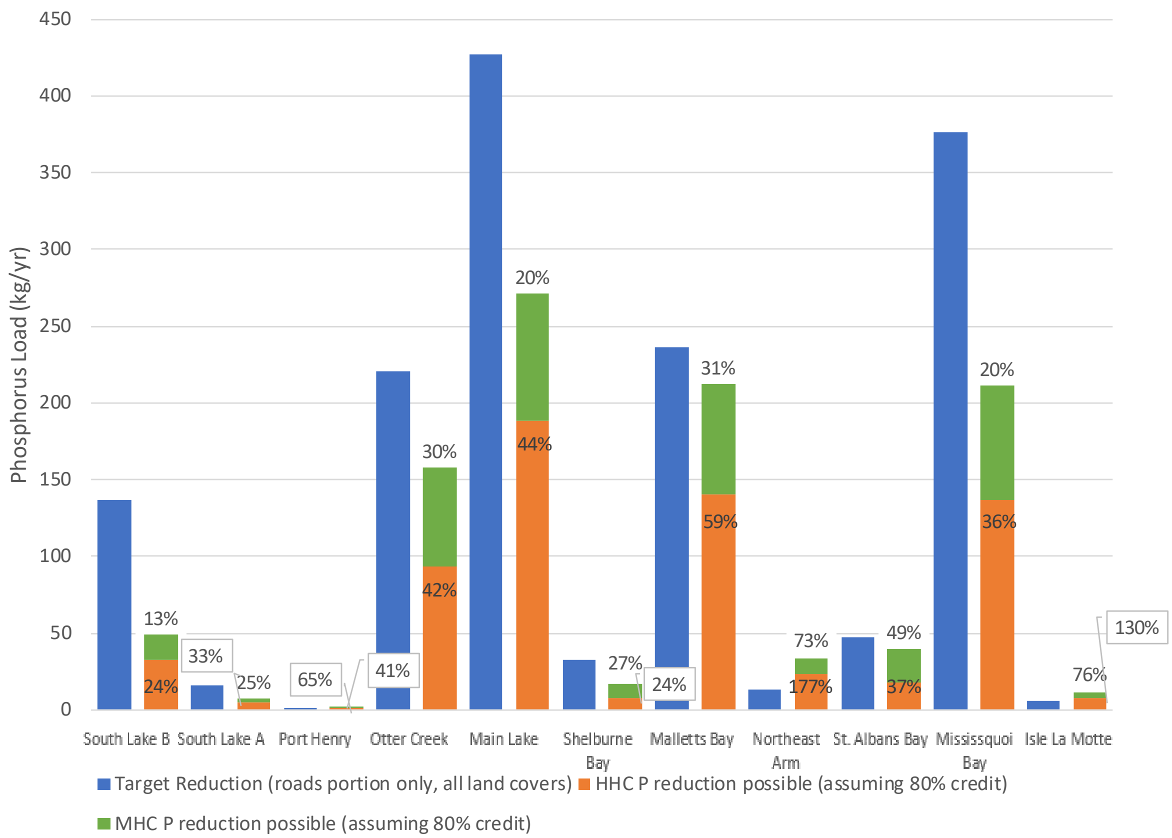


Figure 9. Linear Facilities - P Target Reductions and Credit Possible for HHC and MHC Segments Not Meeting Drainage Standards

In two cases – the Northeast Arm and Isle La Motte Lake segments, both small, low-lying drainages – correction of road drainage conditions on HHC road segments, alone, may be sufficient to meet target P reductions. Across the LCB, however, these corrections can be expected to address up to 43% of the target P reduction (range of 24% in South Lake A and Shelburne Bay, to 177% in the Northeast Arm segment). Adding the MHC road segments for correction of drainage deficiencies, and assuming correction of those drainage deficiencies is feasible and would be eligible for the same P reduction efficiency, would be sufficient to achieve and additional 24% of the target reduction across the LCB but in most cases is still not sufficient to meet the full target P reduction.

The ranking system and prioritization criteria presented above are still under consideration by both VTrans and ANR and may be adjusted as the first four-year implementation plan is developed. The following steps are being advanced in the development of this concept:

- Development of standardized conceptual BMPs and standards that a road segment should meet to be considered “brought up to standards” and receive P reduction credit.
- Confirmation of the P load reduction credit received for bringing a road segment “up to standards”.
- Refinement the prioritization system to help VTrans identify which segments should be “brought up to standards” in a given time frame.

- Identification of existing problems identified in the inventories that have been "brought up to standards" since July 2010 as indicated in the MATS database.
- Development of recommendations for refinement of the asset inventories and MATS database to facilitate tracking and P accounting during PCP implementation.

Additionally, a District Needs Map is under development by VTrans and is anticipated in 2020. As this resource comes online and is populated by District personnel, the identified needs can be spatially assessed in comparison to the road drainage standards inventory developed for the Generalized Plan. The District Needs Map will represent a valuable resource for use in developing and executing the implementation plan(s), particularly in prioritizing and addressing road drainage improvements and localized erosion fixes that can be completed by the Districts and that have distinct and creditable water quality benefits.

2.2.3. Conceptual Cost Information for Correction of Road Drainage Deficiencies

To develop preliminary cost estimates associated with standard fixes to bring road segments "up to standards", costs associated with MATS records of activities consistent with the suite of BMPs associated with correcting roadway drainage deficiencies were reviewed (Table 18).

Table 18. Implementation Cost Ranges for Repairs to Road Drainage Deficiencies

MATS Activity	Number of MATS Entries	Average Cost	Cost Range
Installing Culverts	1822	$4,995	$189 - $545,254
Maintaining Culverts (Repair or Replace)	120	$3,356	$178 - $32,888
Sink Hole Fixes	25	$2,017	$200 - $5,090
Ditching with Stone	106	$4,655	$650 - $10,628
Ditching with Mulch	89	$3,377	$101 - $9171
Ditching without Stone or Mulch	1263	$3,721	$232 - $11,206

Based on this review of standard maintenance items that would be consistent with bringing a road segment "up to standards", a range of average costs of activities that constitute significant improvements was established, using $2,000 for repairing sink holes to approximately $5,000 for ditching with stone or installing culverts. These costs were compared to the VTrans 2018 2-*Year Averaged Price List, 2011 Specifications*[11] and found to be within the same order of magnitude.

To develop an order-of-magnitude cost estimate associated with correcting roadway drainage deficiencies in the context of the Generalized PCP, the estimated per-repair costs were entered into the web app as low and high ranges to fix a structure within a segment that was identified as "not meeting standards" Therefore, a road segment with a larger number of deficient culverts or swales is estimated to have a higher implementation cost to bring the segment up to standards. This method consistently applies broad cost averages across Lake segments and paved road segments with varying degrees of repair intensity needed. Costing methodologies and assumptions described here may be refined and adjusted as the four-year implementation plans are developed and executed.

[11] https://vtrans.vermont.gov/sites/aot/files/estimating/documents/2YearEnglishAveragedPriceList11.pdf

2.3. Structural Correction of Localized Erosion Issues

Stabilization and treatment of areas of localized erosion caused by roadway runoff provides P reduction benefits while protecting VTrans infrastructure. Specific crediting mechanisms are not yet well-established for these and similar transportation-related improvements. VTrans is working with ANR to clarify and come to consensus on a P reduction crediting methodology for existing localized erosion repair projects, which then may reasonably be extended to P reduction crediting for proposed localized erosion repairs under the implementation phase of the PCP. This work will utilize the progress and findings of the VTrans and ANR research project *Quantifying Nutrient Pollution Reductions Achieved by Erosion Remediation Projects on Vermont's Roads,* which is now underway and will be completed in 2021. In this Generalized PCP, road segments with a high risk of localized erosion were identified and a conceptual P reduction credit applied as further described below.

2.3.1. Opportunities for Correction of Minor Areas of Localized Erosion

Localized erosion fixes constitute a demonstrable water quality improvement that can largely be achieved using existing VTrans maintenance practices. A desktop GIS analysis was conducted to identify road segments with risk factors for localized erosion (Appendix C). A road segment was deemed to be at risk for localized erosion if:

- if it was downslope of steep roadway, and/or
- if curb board was present, and/or
- there was evidence of a ditch upslope.

Road segments already included in the road drainage standards analysis, and improvement and crediting framework described in Section 2.2 (road segments with drainage infrastructure such as culverts), were excluded from this analysis. Thus, although paved areas with localized erosion risk exist and have been previously evaluated within paved road segments subject to the asset-based inventory and evaluation framework, those road segments are not 'double-counted' within this assessment. The exclusion results in a very conservative estimate of the acres potentially managed, and P load reduction possible, through application of maintenance-level fixes to areas of localized erosion.

Additionally, in 2017, VTrans field verified a subset of road segments that were identified as having risk factors for localized erosion (Section 2.3.2). The verification work determined that localized erosion was present 30% of the time where the GIS analysis indicates one or more risk factors are present[12]. Therefore, 30% of the acres within paved road segments with one or more localized erosion risk factors were assumed to have active erosion.

Using these criteria, 546 acres of the 5,873 total acres of paved roads in the PCP Area (9%) are outside road segments with drainage infrastructure and associated with one or more localized erosion risk factors (Table 19 and Figure 9), constituting 23% of the 2,401 paved roads acres located outside the asset-based drainage management standards framework. When the assumption of active localized erosion is factored in, the paved road area associated with active localized erosion is 164 acres, or 3% of the total TS4 paved roads area in the LCB (Table 20).

[12] See *VTrans PCP Area Characterization and Results* memo submitted by Stone to VTrans on 10/13/2017 for full results of the localized erosion GIS desktop field verification.

Table 19. Summary of Paved Roads Area with Localized Erosion Potential and No Drainage Infrastructure (acres)

Lake Segment	Paved Road Area Outside Drainage Stds Mgmt	Paved Road Area with Localized Erosion Risk				TS4 Paved Road Area with Localized Erosion Potential (%)
		Total	High HC	Moderate HC	Low HC	
South Lake B	240.9	82.6	37.3	21.4	23.9	17%
South Lake A	31.8	5.2	3.4	0.4	1.4	8%
Port Henry	8.3	0.5	0.2	0.0	0.2	3%
Otter Creek	481.2	113.9	61.3	22.2	30.3	10%
Main Lake	653.1	187.8	84.3	43.9	59.6	11%
Shelburne Bay	71.9	6.0	2.8	1.5	1.7	4%
Malletts Bay	403.1	90.8	54.3	12.0	24.6	9%
Northeast Arm	71.2	16.6	14.4	0.8	1.4	10%
St. Albans Bay	66.0	0.3	0.3	0.0	0.0	0.1%
Missisquoi Bay	357.1	37.5	19.2	7.3	11.0	4%
Isle La Motte	16.6	4.7	3.9	0.3	0.4	10%
Grand Total	2401.2	545.8	281.4	109.9	154.6	9%

Table 20. Summary of Paved Roads Area (Linear Facilities) Assumed to Contain Active Localized Erosion (acres)

Lake Segment	Paved Road Area Outside Drainage Stds Mgmt	Paved Road Area with Assumed Active Erosion				TS4 Paved Road Area with Assumed Active Localized Erosion (%)
		Total	High HC	Moderate HC	Low HC	
South Lake B	240.9	24.8	11.2	6.4	7.2	5%
South Lake A	31.8	1.6	1.0	0.1	0.4	2%
Port Henry	8.3	0.1	0.1	0.0	0.1	1%
Otter Creek	481.2	34.2	18.4	6.7	9.1	3%
Main Lake	653.1	56.4	25.3	13.2	17.9	3%
Shelburne Bay	71.9	1.8	0.8	0.5	0.5	1%
Malletts Bay	403.1	27.2	16.3	3.6	7.4	3%
Northeast Arm	71.2	5.0	4.3	0.2	0.4	3%
St. Albans Bay	66.0	0.1	0.1	0.0	0.0	0%
Missisquoi Bay	357.1	11.3	5.8	2.2	3.3	1%
Isle La Motte	16.6	1.4	1.2	0.1	0.1	3%
Grand Total	2401.2	163.8	84.4	33.0	46.4	3%

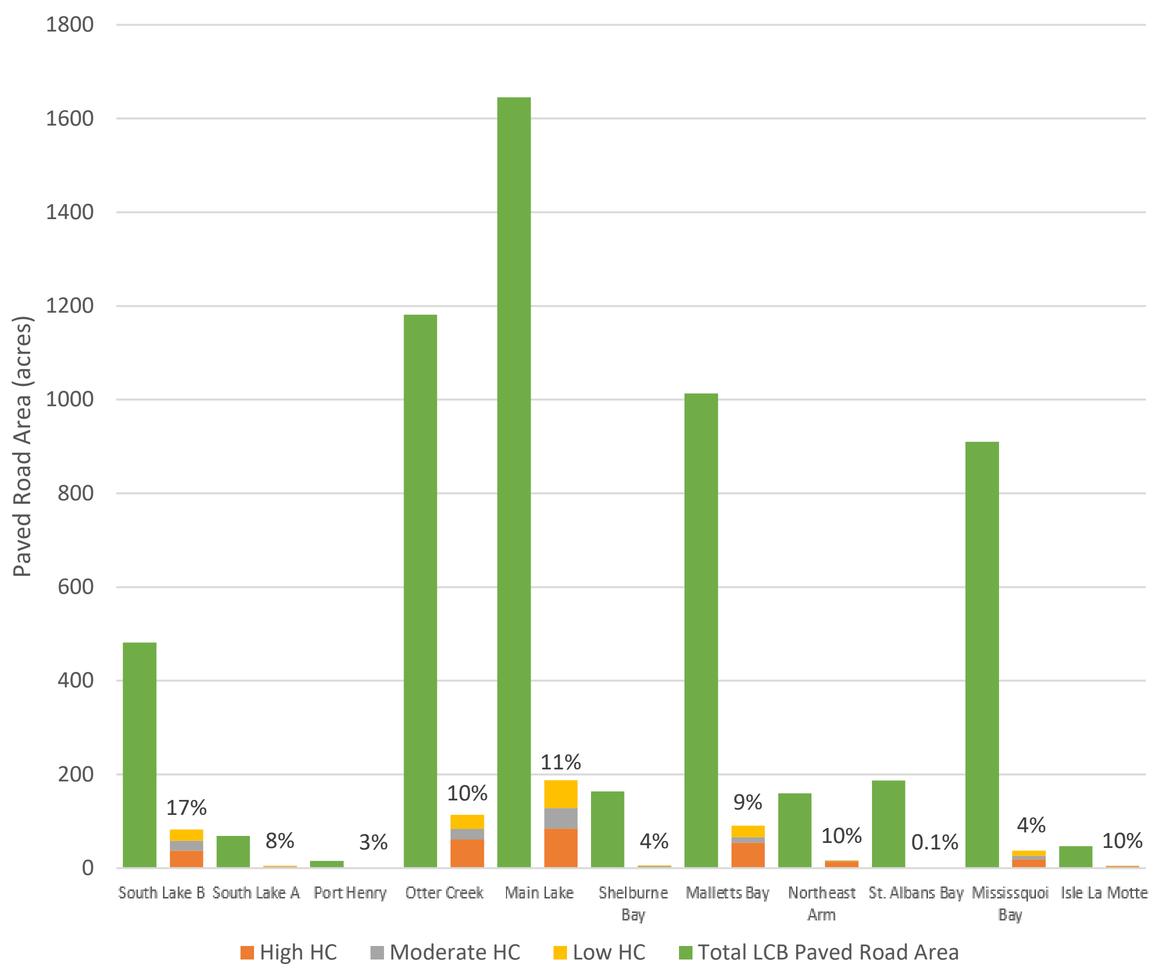


Figure 10. Paved Roads Area (Linear Facilities) with Localized Erosion Risk Outside Drainage Management Standards Area

The P reduction crediting methodology for repairs to areas of localized erosion associated with roadways remains in development and discussion between VTrans, ANR, and other partners in implementing the Lake Champlain P TMDL. A conceptual 50% P reduction credit was assumed for Generalized PCP development, following confirmation of the appropriateness of the assumption by ANR in March 2020. If all areas of localized erosion outside of paved roads areas being considered for application of drainage management standards were corrected, the resulting P load reduction of 67.8 kg/yr would account for 4% of the total P reduction required for VTrans paved roads (linear facilities only, not parcels) (Table 21). As seen in Figure 10, the Northeast Arm and Isle La Motte Lake segments have the highest proportions of P load reductions possible through applying this conceptual management practice (17% and 11%, respectively), with Missisquoi Bay and St. Albans Bay having the smallest P reduction opportunity for crediting through fixes to areas of active localized erosion (1% and 0.1%, respectively).

Table 21. Summary of Estimated P Load Reduction from Roads with Areas of Localized Erosion (kg/yr)

Lake Segment	Target P Reduction*	HHC P Reduction**	MHC P Reduction**	LHC P Reduction**	Total P Reduction**	HHC % of Target Reduction	MHC % of Target Reduction	LHC % of Target Reduction	Total % of Target Reduction
South Lake B	136.3	6.1	2.2	1.8	10.0	4%	2%	1%	7%
South Lake A	16.2	0.6	0.0	0.1	0.8	4%	0.3%	1%	5%
Port Henry	1.4	0.1	0.0	0.0	0.1	4%	0.0%	2%	6%
Otter Creek	220.8	10.1	2.4	2.3	14.8	5%	1%	1%	7%
Main Lake	427.4	13.6	4.4	4.3	22.3	3%	1%	1%	5%
Shelburne Bay	32.9	0.4	0.2	0.1	0.7	1%	1%	0.4%	2%
Malletts Bay	236.6	8.5	1.2	1.8	11.5	4%	1%	1%	5%
Northeast Arm	13.4	2.1	0.1	0.1	2.3	16%	1%	1%	17%
St. Albans Bay	47.2	0.0	0.0	0.0	0.0	0.1%	0.0%	0.0%	0.1%
Missisquoi Bay	376.6	3.0	0.7	0.8	4.6	1%	0.2%	0.2%	1%
Isle La Motte	5.6	0.5	0.0	0.0	0.6	10%	0.5%	0.5%	11%
Grand Total	1514.4	45.2	11.2	11.4	67.8	3%	1%	1%	4%

Load reductions derived from 30% of load totals based on results from field verification of desktop GIS analysis.
**Roads portion of P load only, all land covers*
***Assuming 50% P reduction credit for localized erosion fixes*

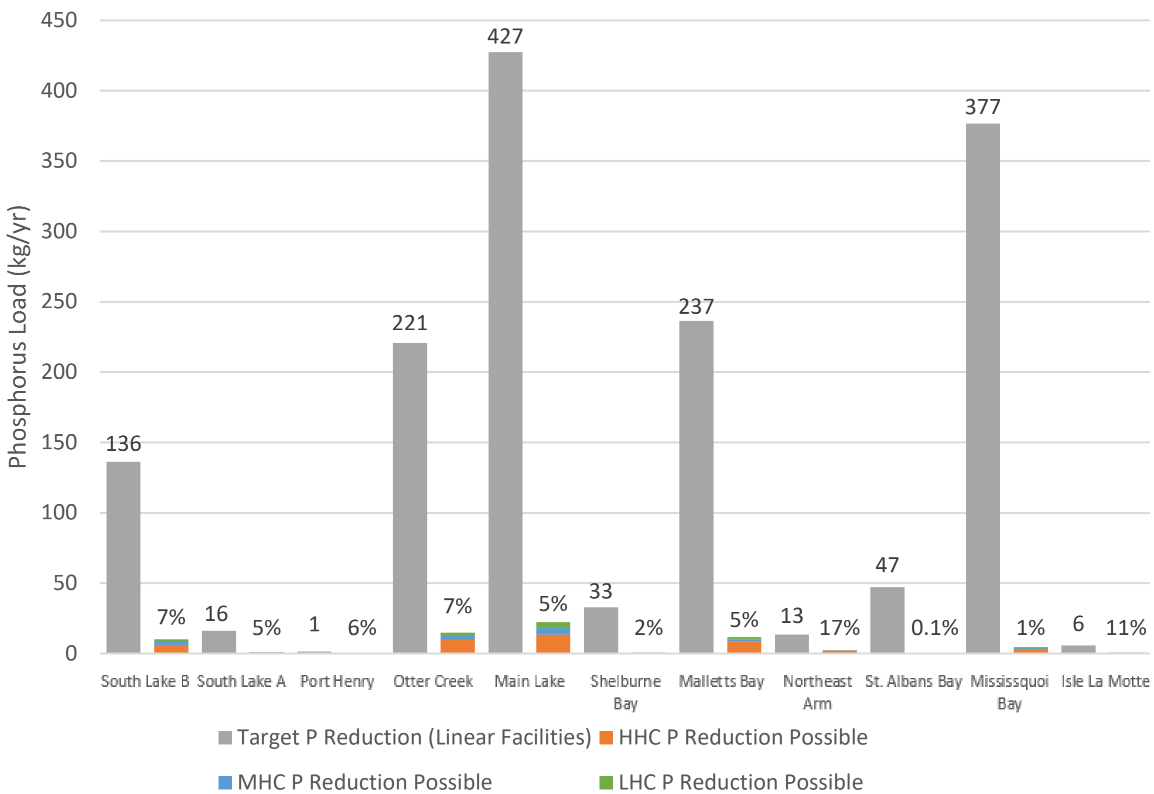


Figure 11. P Target Reductions Summary, Localized Erosion Repairs Outside Drainage Management Standards Areas

2.3.2. Conceptual Cost Information for Regular Maintenance Localized Erosion Repairs

To inform recommendations for future structural controls, a cost analysis was conducted for localized erosion corrections from field verified historic MATS records for the “Protecting Banks and Slopes” MATS activity (from 2017 and 2019 field verification efforts). The average cost (labor and materials) to correct an area of localized ranged from $358 - $22,695 with an average of $2,606. Assuming that each road segment identified with localized erosion would require one repair, the unit cost for removing 1 kg/yr of P with a localized erosion structural BMP is $47,400 (Table 22). The strongest cost-benefit for repairing areas of active localized erosion is, as expected, in HHC road segments ($36,700/kg P/yr).

Table 22. Estimated Costs and Cost Metrics for Small Localized Erosion Repairs Outside Road Drainage Standards Areas

	HHC Roads	MHC Roads	LHC Roads	Total Roads
Number of road segments with localized erosion	637	247	352	1236
Paved roads areas with active localized erosion (acres)	84.4	33.0	46.4	163.8
P load reduction possible through localized erosion fixes (kg/yr)	45.2	11.2	11.4	67.9
Total cost to correct assumed areas of active localized erosion	$1,658,800	$ 644,100	$ 917,700	$ 3,220,700
Cost per impervious acre managed ($/ac)	$ 19,700	$ 19,500	$ 19,800	$ 19,700
Cost per kg P load reduced ($/kg/yr)	$ 36,700	$ 57,400	$ 80,200	$ 47,400

2.3.3. Treatment and Correction of Minor Areas of Localized Erosion

Existing areas of localized erosion that have been repaired or managed with structural BMPs since 2010 are being identified by leveraging asset conditions tracked and maintenance activities reported in the MATS database. These data are being utilized to create a desktop inventory of localized erosion stabilization projects completed since 2010 and which may be eligible for P reduction credit. During the summer of 2019, a sub-set of localized erosion repairs identified in the MATS database completed between January 2017 and May 2019 were field verified. The field verification effort had several goals:

- Understand possible credit for correcting areas of localized erosion
- Gather information to compare the MRGP's REI framework and criteria with VTrans' inventories and maintenance activity records
- Determine applicability for VTrans roadways and erosion problem, such that "fixes" may be credited using a similar strategy between both permit and regulatory programs

Field verification of existing localized erosion repairs was completed in July-August 2019 at over 70 sites identified in the MATS database and returned the following results:

- At 38 sites, (53%) the localized erosion fix was located in good condition.
- At 11 sites, (15%) the fix was located but it was either in need of additional repair or the fix had failed.
- 19 sites (27%) were not found – either the location data were not precise, or the fix was so effective it could not be located.
- 3 records (4%) were related to planning activities rather than localized erosion fixes.

Inventory results, associated P reduction crediting, and recommendations for tracking and accounting will be developed further during creation of the Phase 1 Implementation Plan.

2.3.4. Treatment and Correction of Major Drainage Asset Deficiencies and Areas of Localized Erosion

The costs and P reduction credit opportunities for correction of maintenance-level drainage infrastructure deficiency and small-scale areas of localized erosion are relatively well-understood in the context of the Generalized PCP. Correction of gullying and large areas of active erosion, as well as corrections at stormwater system outlets, remain areas of active investigation across multiple State agencies, Regional Planning Commissions and municipalities, watershed stewardship organizations, and other partners. As implementation plans are developed, VTrans expects that they will be informed by the progress and findings of the VTrans and ANR research project *Quantifying Nutrient Pollution Reductions Achieved by Erosion Remediation Projects on Vermont's Roads*, which is now underway and will be completed in 2021. VTrans also expects that major upgrades to road embankments and culverts where improvements would address both existing drainage issues and reduce vulnerability to damage from floods, where risk, vulnerability, or criticality have been identified in VTrans's Transportation Resilience Planning Tool[13] will become a possibly substantial factor in prioritization and completion of improvements (when and as data become available in the LCB).

2.4. Natural Resource Restoration Projects

Natural resource restoration projects, and particularly floodplain reconnection projects, may be credited as a stormwater treatment practice in the context of the VTrans PCP if some portion of the floodplain area to be reconnected is also connected to a TS4 roadway or parcel-based "developed lands" contributing drainage. A crediting methodology has been developed by ANR that relates the Chesapeake Bay crediting methodology for

[13] https://vtrans.vermont.gov/planning/transportation-resilience

stream restoration projects[14] to Vermont's conditions (Appendix G). Using this method, floodplain cross-sections are created, simulations are run in HEC-RAS, the volume of reconnected floodplain is estimated, and P reduction is apportioned by the fraction of the contributing watershed that is owned and controlled by VTrans or an MS4 permittee.

A test case completed by ANR, using a floodplain reconnection project completed in the Lamoille River watershed in 2007-2008, indicates that the P load reduction, cost-effectiveness, and other co-benefits of broader application of this approach are substantial. The potential for siting floodplain reconnection projects near VTrans roadways is also substantial. The screening analysis for conceptual structural STPs (Section 2.1.2.2) indicated that roughly a quarter of the pervious right-of-way areas identified intersected the Vermont Hydrography Dataset (VHD) – a blue-line stream. As the implementation plans are developed and executed, further evaluation is warranted, possibly utilizing the screening assessment being developed through the VTrans research project described below.

VTrans is aware of at least two potential floodplain reconnection projects that will be further evaluated as the first four-year implementation plan is developed. A series of floodplain reconnection alternatives for a portion of the Lamoille Valley Rail Trail located along VT Route 36 in Fairfield in the Black Creek floodplain are now being evaluated through the VTrans-funded project *Evaluating Effectiveness of Floodplain Reconnection Sites along the Lamoille Valley Rail Trail: A Blueprint for Future Rail/River Projects,* with results expected in mid-2020. A preliminary evaluation of the potential for floodplain reconnection in the Potash Brook watershed was conducted by the South Burlington MS4 in February 2020, identifying a potential reconnection opportunity near the I-89/I-189 interchange.

VTrans also anticipates further investigation of floodplain reconnection where VTrans roads and facilities contribute runoff upstream of the restoration practice through coordination with and application of results from Vermont's Functioning Floodplains Initiative[15]. While the project outputs will not be complete until 2021, the initiative will develop and apply methodologies for evaluating river reach and watershed-scale restoration of stream, riparian, wetland, and floodplain function. The initiative seeks to garner local community support by tracking and publicizing the accumulation of the natural and socio-economic assets derived from connected and naturally functioning floodplains and wetlands, including fish and wildlife habitat, water quality, avoided damage from floods and fluvial erosion, and the storage of carbon affecting the earth's climate.

[14] https://www.chesapeakebay.net/documents/Final_CBP_Approved_Stream_Restoration_Panel_report_LONG_with_appendices_A-G_02062014.pdf

[15] http://www.vermontbusinessregistry.com/bidAttachments/37484/Vermont Functioning Floodplains Initiative White: Paper.pdf

2.5. Non-Structural Controls

As part of its SWMP[16], VTrans has committed to completing a robust suite of maintenance activities under Minimum Control Measure 6.F (Pollution Prevention/ Good Housekeeping for Municipal Operations). In the SWMP, VTrans has committed to conduct street sweeping on 2,000 lane miles of VTrans roads annually, conduct storm drain inspections on 20% of VTrans roads annually, and to properly dispose of materials collected per ANR guidelines during routine street sweeping and storm drain cleaning. Drop inlet (DI) or catch basin cleaning and street sweeping both result in the removal of sediment and P from impervious surfaces—and thus, are of interest in developing the Generalized PCP.

Robust information recorded in the MATS dataset was assessed to review maintenance records and quantify non-structural controls with P reduction benefits: DI cleaning and street sweeping. P reductions for both DI cleaning and street sweeping were calculated using methodology provided by ANR[17]. VTrans will incorporate applicable findings from ongoing research by USGS[18], in cooperation with the Chittenden County Regional Planning Commission, DEC, the University of Vermont, and nine Vermont municipalities, to evaluate P reductions possible through current practices, possible enhancements to those activities, and adjustments to activity frequency and equipment usage as the four-year plans are developed and executed.

Prior to 2010, non-structural controls were not consistently implemented on a significant extent of roads within the LCB as part of VTrans' annual operations. Street sweeping or DI cleaning that can be documented is therefore creditable toward the target P reductions. Review of relevant records in the MATS database was completed, determining that information from 2015 on was reliable enough to quantify lane miles and paved roads areas managed using street sweeping or DI cleaning. Detailed analysis of non-structural controls in the TS4 PCP Area is included in Appendix H.

2.5.1. Street Sweeping

VTrans elected to begin street sweeping with high-efficiency equipment on a limited basis within its MS4 areas in response to requirements within their MS4 permit in 2012. Now across the TS4, VTrans primarily uses mechanical broom sweepers for street sweeping as a regular maintenance practice, particularly along bike routes and for special events such as bike races where the road needs to be clear of debris for safety (Map 3).

Vermont DEC credits street sweeping P reductions based on frequency and type of sweeping equipment used (Table 22). VTrans regularly sweeps some sections of road more than once per year, so a spatial analysis was conducted to determine the appropriate P reduction credit to apply. Very few road segments were swept more than twice annually, and those that were swept more than twice were with a great enough frequency to qualify for the higher P reduction credit applied for monthly or weekly sweeping frequencies. Road segments swept once per year were allocated a 0.5% P reduction, and road segments swept more than once were allocated a 1% P reduction. On average, 15% of road area that is swept is swept more than once per year (Table 23).

[16]https://anrweb.vt.gov/PubDocs/DEC/Stormwater/PublicNotice/7892-9007/VTrans%20Final%20SWMP%20-%20December%205%202017.pdf

[17]https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/Draft%20Annual%20Report%20Workbook_11_2019.xlsx

[18]https://www.ccrpcvt.org/wp-content/uploads/2018/12/CleanStreetsSweepingStudy_Sept4_update.pdf

Table 23. Street Sweeping P Reduction Factors[17]

Equipment Type	Sweeping Frequency			
	2/year (spring and fall)	Monthly	Weekly	4X in the fall
Mechanical Broom	1%	3%	5%	17%
Vacuum Assisted	2%	4%	8%	17%
High Efficiency Regenerative Air-Vacuum	2%	8%	10%	17%

To determine the P base load from streets where sweeping occurred, the P load from each road segment associated with a MATS street sweeping record was calculated using the road segment area, Lake segment identification, slope, and hydrologic connectivity classification of each road segment. The total acres of VTrans roads swept per year ranged from 1,609 to 2,836, with an average of 2180 acres/year, or 37% of the total VTrans road area in the LCB. (Table 24).

Table 24. Summary of Street Sweeping Activity by Paved Roads Areas Swept (acres)

Lake Segment	2015	2016	2017	2018	2019	Average Annual Acres Swept	Total VTrans LCB Road Area (ac)	Average % Total VTrans LCB Road Area Swept
South Lake B	147.4	99.4	294.8	154.6	95.5	158.4	481.5	33%
South Lake A	46.6	18.7	59.7	61.9	22.2	41.8	69.1	61%
Port Henry	15.0	0.3	13.8	15.4	15.0	11.9	15.3	78%
Otter Creek	671.0	653.0	861.5	607.7	756.3	709.9	1181.2	60%
Main Lake	264.2	486.1	441.5	480.6	432.8	421.0	1645.1	26%
Shelburne Bay	60.8	25.2	99.8	85.5	92.1	72.7	163.7	44%
Malletts Bay	215.5	413.9	483.1	421.2	362.8	379.3	1013.5	37%
Northeast Arm	116.3	140.9	61.6	12.4	121.0	90.4	159.5	57%
St. Albans Bay	24.2	53.2	76.6	79.6	56.3	58.0	187.2	31%
Missisquoi Bay	17.1	156.7	427.7	320.0	130.8	210.4	910.1	23%
Isle La Motte	31.4	38.1	16.1	15.2	31.4	26.4	46.9	56%
Total	1609.4	2085.5	2836.0	2254.0	2116.1	2180.2	5873.2	37%

Annual P load reductions ranged from 6.3 - 11.9 kg/yr from 2015 - 2019, with an average of 8.8 kg/yr, translating to roughly 0.6% of the total required P reduction target per year from VTrans roads within the LCB (Table 25). Current street sweeping coverage and frequency accounts for a small portion of the target P reduction, ranging from 0.2% - 3.3%. Annual street sweeping costs averaged $279,200 per year, resulting in an average unit cost of $31,600 per kg P/yr (Table 26).

Table 25.Summary of Annual Sweeping P Load Reduction by Lake Segment (kg/yr)

Lake Segment	2015	2016	2017	2018	2019	Average Annual P Reduction	Target Reduction (kg/yr)*	Average Annual % P Reduction
South Lake B	0.60	0.37	1.30	0.63	0.40	0.66	136.3	0.5%
South Lake A	0.22	0.09	0.28	0.29	0.07	0.19	16.2	1.2%
Port Henry	0.07	0.00	0.03	0.07	0.03	0.04	1.4	2.8%
Otter Creek	2.64	3.00	3.66	2.29	2.42	2.80	220.8	1.3%
Main Lake	1.02	1.75	1.88	2.10	1.79	1.71	427.4	0.4%
Shelburne Bay	0.16	0.16	0.39	0.40	0.44	0.31	32.9	0.9%
Malletts Bay	0.86	1.78	1.99	1.55	0.98	1.43	236.6	0.6%
Northeast Arm	0.48	0.70	0.33	0.04	0.65	0.44	13.4	3.3%
St. Albans Bay	0.09	0.21	0.32	0.41	0.19	0.25	47.2	0.5%
Missisquoi Bay	0.09	0.98	1.64	1.15	0.65	0.90	376.6	0.2%
Isle La Motte	0.11	0.21	0.05	0.06	0.11	0.11	5.6	1.9%
Total	6.3	9.2	11.9	9.0	7.7	8.8	1514.4	0.6%

**Roads portion of P load only, all land covers*

Table 26. Average Annual Unit Costs and Cost-Effectiveness Metrics for Street Sweeping

Metric	2015	2016	2017	2018	2019	Average
Total Area Swept (acres)	1609.4	2085.5	2836.0	2116.1	2180.2	2165.4
Total P Reduction (kg/yr)	6.32	9.24	11.86	8.99	7.73	8.83
Percent of Total VTrans P Reduction Target	0.4%	0.6%	0.8%	0.6%	0.5%	0.6%
Annual Cost	$233,215	$210,775	$414,991	$362,477	$174,631	$279,218
Per-Acre Unit Cost ($/acre/year)	$145	$101	$146	$171	$80	$129
Per-kg P Load Reduction Unit Cost ($/kg/yr)	$36,906	$22,809	$34,979	$40,324	$22,579	$31,623

Current street sweeping activity frequency and coverage (38% of streets swept in the LCB per year) annually manages 0.6% of the total P load reduction required from VTrans roads. Table 27 shows the incremental increase in both P reduction credit and implementation cost that would result from sweeping 2,000 lane miles annually within the VTrans PCP Area.

Table 27. Example Projection of Increased Street Sweeping from 1,055 to 2000 Lane Miles (Ln Mi) Annually

	2015 - 2019 Annual Average	Future Projection
Lane miles swept	1055	2000
Percent of total lane miles swept in PCP Area	38%	73%
P Load Reduction (kg/yr)	8.83	17
P Load Reduction per lane mile swept (kg/yr)	0.01	0.01
Annual Cost	$279,218	$530,000
Percent of VTrans P target reduction (annual)	0.5%	1%

Street sweeping has a modest annual P reduction benefit, and it is a routine maintenance practice that enhances the safety of the traveling public. VTrans may choose to focus future street sweeping programs on sweeping highly hydrologically connected road segments, on increasing the extent and frequency of bridge washing, or to target Lake segments with the most aggressive P target reductions. Further direction of street sweeping may be included in the development of each four-year implementation plan. Results of ongoing research by USGS and others[18] evaluating reductions in nutrient and sediment loads from current street cleaning and leaf litter collection practices, and evaluating P reductions and crediting for current practice and potential enhancements, will further influence decision making regarding VTrans' street sweeping program once those findings are available in 2020.

2.5.2. Drop Inlet Cleaning

In 2012, VTrans elected to begin cleaning DIs with a vac truck in response to requirements within their MS4 permit. A large portion of DI cleaning with a vac truck occurred within VTrans' former MS4 area (Map 4). Since this activity is performed by specialty contractors rather than by VTrans personnel, it is not tracked with a specific activity code in the MATS database. Detailed assessment of individual MATS records was required to determine the areas covered by DI cleaning and thus the P reductions that could be applied. Appendix G includes details of the processes used to estimate P load reductions associated with this non-structural control.

Vermont DEC[17] allows two methods for determining P reduction credit for DI cleaning:

1. *Area-based* – This method allocates a 2% P load reduction from the P base load of streets where DI cleaning occurs (kg/yr).
2. *Volume-based* – Still under development, this method will most likely require a total P (TP) test be conducted on the material collected from cleaned DIs by vac truck so that the amount of P can be determined for the entire volume of material collected and then counted towards P load reduction[17].

The area-based methodology was applied to determine P load reductions from DI cleaning activity between 2015-2019. The paved road areas associated with DI cleaning activity were identified by spatial analysis of the MATS records compared to the VTrans PCP area. The paved road areas with cleaned DIs ranged from 27 acres in 2017 to over 480 acres in 2015 (Table 28), largely due to fluctuations in the annual funding available for VTrans to contract the specialty equipment and operators. Given the limited funding available for 2017 operations, that year was excluded from further analysis. On average, DI cleaning occurred on 339 acres (or 6%) of VTrans paved roads areas in the PCP Area. The Shelburne Bay, Main Lake, and Otter Creek Lake segments contained the highest percentage of roadway where DI cleaning was completed.

Table 28. Summary of Paved Road Areas with DI Cleaning

Lake Segment	DI Cleaning Area (ac) 2015	2016	2017	2018	2019	Annual Average	Total VTrans LCB Road Area (ac)	% Total VTrans LCB Road Area w/ DI Cleaning
South Lake B	0.00	0.00	1.01	0.67	0.00	0.17	481.5	0.03%
South Lake A	10.85	0.00	0.00	0.00	0.00	2.71	69.1	3.92%
Port Henry	0.00	0.00	0.00	0.00	0.00	0.00	15.3	-
Otter Creek	168.18	1.85	18.48	0.37	205.61	94.00	1181.2	7.96%
Main Lake	170.47	229.22	0.85	27.50	39.04	116.56	1645.1	7.09%
Shelburne Bay	20.19	8.69	1.63	5.38	64.94	24.80	163.7	15.15%
Malletts Bay	109.39	50.01	2.13	105.22	46.71	77.83	1013.5	7.68%
Northeast Arm	0.00	0.00	0.00	0.00	4.67	1.17	159.5	0.73%
St. Albans Bay	0.00	0.00	0.00	32.80	0.00	8.20	187.2	4.38%
Missisquoi Bay	3.19	24.71	0.00	21.92	1.65	12.87	910.1	1.41%
Isle La Motte	0.00	0.00	2.95	0.00	3.98	1.00	46.9	2.12%
Total	482.28	314.48	27.04	193.86	366.61	339.31	5873.2	5.78%

Notes: Averages exclude 2017, when DI cleaning received minimal budget consideration.

Annual P load reductions creditable to DI cleaning ranged from 3.16 – 8.07 kg/yr with an average of 6.17 kg/yr, translating to roughly 0.41% of the total P reduction target per year from VTrans roads within the PCP Area. As with street sweeping, DI cleaning accounts for a modest portion of the total required P reduction, ranging from 0.02% in South Lake B to 1.14% in Shelburne Bay (Table 29). Average annual DI cleaning costs were $74,398 total with a unit cost for removing one kg/yr of P with DI cleaning of $12,054 (Table 29).

Table 29. Summary of DI Cleaning P Load Reductions by Lake Segment (kg/yr)

Lake Segment	2015	2016	2017)	2018	2019	Average Annual P Reduction	Target P Reduction*	Average Annual % P Reduction
South Lake B	0.00	0.00	0.02	0.01	0.00	0.00	136.3	0.00%
South Lake A	0.17	0.00	0.00	0.00	0.00	0.04	16.2	0.27%
Port Henry	0.00	0.00	0.00	0.00	0.00	0.00	1.4	-
Otter Creek	3.03	0.03	0.51	0.01	3.78	1.71	220.8	0.77%
Main Lake	2.86	5.29	0.01	0.46	0.53	2.29	427.4	0.53%
Shelburne Bay	0.31	0.12	0.02	0.09	0.98	0.37	32.9	1.14%
Malletts Bay	1.65	1.41	0.04	1.54	0.79	1.35	236.6	0.57%
Northeast Arm	0.00	0.00	0.00	0.00	0.07	0.02	13.4	0.14%
St. Albans Bay	0.00	0.00	0.00	0.59	0.00	0.15	47.2	0.31%
Missisquoi Bay	0.05	0.38	0.00	0.46	0.03	0.23	376.6	0.06%
Isle La Motte	0.00	0.00	0.03	0.00	0.05	0.01	5.6	0.21%
Total	8.07	7.23	0.64	3.16	6.23	6.17	1514.4	0.41%

Notes: Averages exclude 2017, when DI cleaning received minimal budget consideration.
**Roads portion of P load only, all land covers*

Table 30. Average Annual Unit Costs and Cost-Effectiveness Metrics for DI Cleaning

Metric	2015	2016	2017	2018	2019	Average
Total Area with Cleaned DIs (acres)	482.28	314.48	27.04	193.86	366.61	339.31
Total P Reduction (kg/yr)	8.07	7.23	0.64	3.16	6.23	6.17
Percent of Total VTrans P Reduction Target	0.5%	0.4%	0.04%	0.2%	0.4%	0.4%
Annual Cost	$86,687	$59,956	$27,837	$84,179	$66,768	$74,398
Per-Acre Unit Cost ($/acre/year)	$180	$191	$1,029	$434	$182	$219
Per-kg P Load Reduction Unit Cost ($/kg/yr)	$10,740	$8,291	$43,381	$26,672	$10,720	$12,054

Note: Average Annual Percent of Total VTrans P Reduction Target was calculated using the total target P reduction for all VTrans impervious surface within the LCB (1611 kg/yr).
Averages exclude 2017, when DI cleaning received minimal budget consideration.

Current DI cleaning extent and frequency (covering 6% of VTrans roads in the PCP Area) are documented to annually reduce the total P load by an average of 0.4%. The incremental increase that could result from increasing the present effort to instead clean 10% of the DIs in the PCP Area annually is shown in Table 31.

Table 31. Example Projection of Increased DI Cleaning from 6% to 10% Annually

	2015 - 2019 Annual Average	Example Projection
DIs cleaned	376	804
Percent of total DIs cleaned in PCP Area	6%	10%
P load reduction (kg/yr)	6.17	13
P load reduction per acre draining to DI cleaned (kg/yr)	0.02	0.02
Annual Cost	$74,398	$159,152
Percent of VTrans P target reduction (annual)t	0.4%	1%

DI cleaning presently has a modest impact on annual P target reductions. As a routine maintenance practice, DI cleaning has additional benefits, including maintaining DI function and protecting downstream VTrans drainage infrastructure. Without increasing the number of DIs cleaned or the overall budget for DI cleaning, VTrans may choose to prioritize cleaning DIs along highly hydrologically connected road segments or to focus DI cleaning in select Lake segments with aggressive target P reductions. Adjustment to the current DI cleaning program may be considered in the development and execution of each 4-year implementation plan. As discussed above, results from ongoing research by USGS and others[18] evaluating reductions in P loads possible through DI cleaning and street cleaning practices, and evaluating P reductions and crediting for current practice and potential enhancements, will further inform VTrans' DI cleaning program once those findings are available in 2020.

3. Compliance and Implementation Strategy

The compliance and implementation strategy VTrans will use to achieve its target reductions across the PCP Area in the LCB will continue immediately from submittal of this Generalized PCP into development of the first four-year implementation plan. Work in progress described in this PCP continues into development of the first four-year implementation plan, specifically to refine determinations of what P reduction credit towards VTrans' target reductions can be expected from existing and planned structural stormwater STPs, existing areas of localized erosion repaired in the last seven years, and areas of hydrologically connected roadway drainage systems recently improved to current standards. Existing application of non-structural practices such as street sweeping and catch basin cleaning is summarized within this document, and while future adjustments to crediting may be applied, the acres and basis for those credits is thoroughly documented in this PCP.

Prior to submittal of the first four-year implementation plan, VTrans will identify additional retrofits and improvement projects using previously compiled datasets and screening criteria enhanced with field verification. This initial implementation plan will focus on the Missisquoi Bay Lake segment but will opportunistically assess potential major retrofits and opportunities outside that watershed. Field evaluations will be prioritized starting with the largest potential drainage areas and areas of impervious surface, whether on roadways or at facilities, as well as the largest areas of localized erosion associated with roadways and the highest-priority hydrologically connected road segments. As a suite of suitable practices is identified and potential constraints documented, VTrans anticipates continued coordination with ANR, especially if and as environmental resource conflicts related to wetlands and river corridors appear to be substantial.

Retrofit identification, estimation of P reduction credit possible for each retrofit, and updates to PCP tracking tools will be iterative until a suite of BMPs and practices/enhancements is identified that documents 25% net progress towards achievement of the TS4 P reduction targets across the extent of VTrans's PCP Area in the LCB.

The first four-year implementation plan will include a combination of implementation of localized erosion and hydrologically connected road segment drainage repairs, structural STPs (both new treatment practices and retrofits to existing structural STPs), potential enhancements to non-structural control frequencies, and other projects (particularly floodplain reconnection) with the highest P cost-benefit. Through the execution of the four-year implementation plans, and robust tracking and accounting, VTrans expects to achieve its P reduction targets. If and as necessary, the design and implementation schedules included with the four-year plans will include a discussion of any necessary permits or other regulatory approvals needed for implementation of the required practices.

The draft implementation schedule below provides an example of how VTrans anticipates the execution of the four-year plans will be managed. A rough schedule for how the remaining four-year plans are currently anticipated to be executed is also included. Both the schedule below and the implementation model are planning-level documents only and will be subject to revision and adjustment as the implementation plans are developed.

Year 1 of plan implementation (2021):

- Continue to advance priority retrofit designs for FRPs and other VTrans projects in development
- Begin design work for highest-priority structural stormwater practice retrofits identified
- Advance regular maintenance and non-structural control activities basin-wide
- Ensure P reduction credit documented for 2010-2020 activities and retrofits
- Develop and test systems for easy tracking and accounting of progress towards target reductions.

Years 2-3 (2022-2023):

- Deploy tracking and accounting system and apply it to track progress towards target reductions
- Continue to advance priority retrofit designs for FRPs and other VTrans projects in development
- Continue design work for highest-priority structural STP retrofits
- Advance regular maintenance and non-structural control activities basin-wide
- Begin increasing frequency of repairs to roadway drainage and areas of localized erosion
- Begin construction of structural STP retrofits and repairs to major areas of localized erosion

Year 4 (2024):

- Continue to advance priority retrofit designs for FRPs and other VTrans projects in development
- Continue design work for highest-priority structural STP retrofits
- Advance regular maintenance and non-structural control activities basin-wide
- Increase frequency of repairs to roadway drainage and areas of localized erosion
- Continue construction of structural STP retrofits and repairs to major areas of localized erosion
- Develop and submit second four-year implementation plan

After completing the first four-year implementation plan with a Missisquoi Bay Lake segment focus, the focus of the TS4's PCP implementation plans is anticipated to move south through the basin as follows:

- 2024-2028: Focus on remaining Lake segments generally north of Main Lake (Isle La Motte, St. Albans Bay, Northeast Arm, Malletts Bay, and Shelburne Bay)
- 2028-2032: Focus on Main Lake and the Winooski River watershed
- 2032-2036: Focus on Lake segments generally south of Main Lake (Otter Creek, Port Henry, South Lake A, and South Lake B).

3.1. Implementation Unit Cost Assumptions and Metrics

The unit cost estimates and cost metrics presented in Section 2 for each class of practices considered are summarized below in Table 32. While implementation plans will include varying combinations of all the practice types considered, priority for implementation is expected to be directed preferentially to practices that are both implementable and cost-effective. Maintenance-level repairs to road drainage assets along highly and moderately hydrologically connected road segments are the most cost-effective structural practices available for implementation, whether considered on a per-impervious-acre-managed basis ($15,500-$15,800/acre impervious) or on a $/kg P managed basis ($18,800-$28,200/kg P managed) (Table 32). Maintenance-level repairs to areas of localized erosion are estimated to have slightly higher costs on a $/acre impervious basis ($22,200/acre) and markedly higher costs on a $/kg P managed basis—with fixes in highly hydrologically connected road segments being the most cost-effective at $41,700/kg P managed (Table 32). Structural STPs such as infiltration trenches, gravel wetlands, and dry swales generally appear to be the least cost-effective, whether cost-effectiveness is considered in terms of impervious acres managed ($42,400-$64,600/acre) or annual P load managed ($90,800-$183,100/kg P/yr).

Table 32. Summary of Unit Costs and Cost-Effectiveness Metrics (2019 dollars)

BMP Type	$/cf storage volume	$/acre impervious managed	$/kg P managed	Assumptions and Notes
Bioretention (w/ underdrain)[1,5]	$18.14	$64,600	$181,600	
Dry Swale (w/ underdrain)[1,5]	$18.14	$64,600	$181,600	
Gravel Wetland[1,5]	$10.21	$38,800	$107,200	
Infiltration Basin w/Aggregate (Large Infiltration Trench)[1,5]	$14.52	$58,300	$119,300	
Infiltration Trench[1,5]	$14.52	$54,700	$90,800	
Wet pond/ Created Wetland[1,5]	$7.90	$42,400	$183,100	
Floodplain Reconnection[5]			$320	Drawn from Lamoille 2007-08 reconnection project
Road Drainage Repair, Maintenance Project, HHC[2,5]	n/a	$15,800	$18,800	High $/ac and $/kg applied, all Lake segments combined. Cost-effectiveness varies substantially between Lake segments and HC classes, and is affected both by P base loads and target reductions, and by number of issues identified per road segment.
Road Drainage Repair, Maintenance Project, MHC[2,5]	n/a	$15,500	$28,300	
Localized Erosion Repair, Maintenance Project, HHC[3,5]	n/a	$22,200	$41,700	Based on MATS data and average cost per fix, assumed one fix per segment, extrapolated to acre basis
Localized Erosion Repair, Maintenance Project, MHC[3,5]	n/a	$22,200	$65,100	
Localized Erosion Repair, Maintenance Project, LHC[3,5]	n/a	$22,200	$90,600	
Street Sweeping[4,5]	n/a	$130	$31,600	Based on 2015-2019 actuals; annual cost
DI Cleaning[4,5]	n/a	$190	$12,100	

1 Cost estimates for conceptual structural STPs derived from 2016 Opti-Tool values as refined using implementation costs for recent STP retrofit projects provided by VTrans (Section 2.1.2.1, Tables 8 and 13).

2 Cost estimates for road drainage asset repairs derived from 2015-2019 MATS records, related analysis, and VTrans 2018 *2-Year Averaged Price List, 2011 Specifications* (Table 18, Section 2.2.3).

3 Cost estimates for localized erosion repairs derived from 2015-2019 MATS records and related analysis (Table 22, Section 2.3.2).

4 Cost estimates for non-structural controls (street sweeping and DI cleaning) are derived from 2015-2019 MATS activity records and related analysis (Table 26 and Section 2.5.2 for street sweeping, Table 30 and Section 2.5.2 for DI cleaning). Unit costs do not consider any changes in equipment used (mechanical broom vs. vacuum assisted street sweeping), procurement methods (current practice vs. increased contracting or VTrans procurement of Vactor truck for DI cleaning), etc.

5 All cost estimates presented in this table are planning-level, conceptual costs only. Implementation cost for any class of improvements may vary substantially from these planning-level estimates, depending upon access, feasibility, environmental, and other constraints.

3.2. Implementation Model and Schedule

An implementation model was created (Table 35) to both summarize the analyses and findings described in this Generalized PCP, and to develop a draft implementation schedule that includes estimates of the area (acreage) to be treated and the extent and type of treatment strategies that will be applied to meet the entire P load reduction. The model was populated using the following assumptions:

- Existing non-structural control applications continue at present average levels of application and are credited on an annual basis.
- All structural stormwater management strategies, once constructed, are assumed to be maintained at levels sufficient to retain P management benefits and credit towards target P reductions. This includes existing and planned structural STPs, conceptual structural STPs, road drainage asset repairs, localized erosion repairs. The assumption will also apply to natural resource restoration projects, as those are potentially implemented during future implementation plan terms.
- Increased frequency and application of maintenance-level repairs to drainage assets on hydrologically connected road segments, and maintenance-level repairs to areas of localized erosion, were applied preferentially.
- Where full implementation of road drainage asset repairs and localized erosion repairs appeared insufficient to meet target P reductions, conceptual structural STPs were specified, following the selection preferences shown in Figure 3. However, the potential for management using conceptual structural STPs has not been adjusted for the likelihood of feasibility constraints and will be revisited during implementation plan development.
- Costs of operation and maintenance for existing and planned structural STPs, and for conceptual structural STPs, are not yet included in the implementation cost basis. Life-cycle and operational cost considerations for structural STPs are anticipated to be included in a future version of the model.
- The implementation model and schedule includes the opportunity for consideration of project-scale drainage asset repairs and localized erosion fixes, but does not include numeric estimates of acres managed or P load reduction possible. Such projects and credits will be applied as specific projects are identified during implementation plan development and execution.
- Similarly, the model includes the opportunity to record acres managed and P reduction credit applied for natural resource restoration projects but does not yet estimate the costs or benefits of specific floodplain reconnection or wetland restoration projects.

A draft summary of the total acres in the TS4 that are anticipated to be managed in order to meet P load reductions in the VTrans PCP Area is provided in Table 33. A chart summarizing the estimated acres to be managed by structural management strategies is provided as Figure 12. Information about the total P load managed by implementation strategy is summarized in Table 34, and a chart summarizing the estimated P load to be managed by structural management strategy is similarly provided as Figure 13.

Finally, a draft of the implementation model and schedule summarizing the acres and loads to be managed by implementation strategy over the PCP implementation term is provided in Table 35. The timing and the content of this schedule are expected to be adjusted periodically through discussions with ANR, as the implementation plans are developed and executed, and as greater detail regarding critical classes of practices such as natural resource restoration projects becomes available.

A substantial portion of the acres anticipated to be managed with structural measures constitute maintenance-level road drainage asset repairs or localized erosion repairs (1,591 acres or 35%, Table 33 and Figure 12). These structural measures together are anticipated to manage nearly two-thirds of the required annual P load reductions (1,041 kg P/yr or 63%, Table 34 and Figure 13). Of this target P reduction, 638 kg/yr (41%) is estimated to be derived from repairs to road drainage asset deficiencies within highly hydrologically connected road segments. Repairs to areas of localized erosion are currently anticipated to manage a relatively small portion of both paved road area (209 acres and 64.4 kg P/yr).

Existing and planned structural STPs are anticipated to manage 204 impervious acres, or 8% of the total impervious acres managed (963 total acres) within the PCP Area (Table 33 and Figure 12). Collectively, these existing and planned structural STPs are estimated to manage only 55.1 kg P/yr (or 3% of the total P load reduction required (Table 34 and Figure 13). These STPs represent both structural practices required for FRP implementation and STPs anticipated to be constructed on upcoming VTrans projects where operational stormwater permits are required. The model does not presently account for the increase in structural STP application that will likely accompany the lowering of the jurisdictional threshold associated with operational stormwater permit coverage to 0.5 acres of impervious cover following construction beginning in 2022.

In Lake segments where these measures coupled with non-structural control application were not sufficient to demonstrate P reduction target achievement, areas to be managed with conceptual structural STPs were estimated, preferring infiltration-based practices and following the prioritization rubric described in Section 2.1.2.1. Conceptual infiltration trench STPs are proposed to manage 743 impervious acres, or 27% of the total impervious acres managed (1,975 total acres) within the PCP Area (Table 33 and Figure 12); these conceptual STPs are estimated to provide an annual P load reduction of 499 kg P/yr, or 31% of the required target P reduction (Table 34 and Figure 13). Conceptual gravel wetlands were required in limited instances to manage 9.6 acres of impervious surface, for an estimated P load reduction of 4.8 kg P/year . No conceptual under-drained dry swales or wet ponds were required to be applied to meet target P reductions. VTrans expects these assumptions will be revisited often during development and execution of the four-year implementation plans.

The existing, planned, and proposed structural stormwater and P management strategies described above are estimated to manage a total of 2,526 impervious acres (4,818 total acres) within the VTrans PCP Area (Table 34, Table 35, and Figure 12), resulting in a cumulative P load reduction of 1,634 kg P/yr (Table 35 and Figure 13). Though non-structural controls are applied to approximately 2,500 acres of VTrans paved roads area on an annual basis (Table 33), they receive little individual P reduction credit. If current frequencies of street sweeping and DI cleaning continue through 2036, 35.2 kg P/year (1.9%) of the total P target reduction) will be managed (Table 34). Together, over the implementation term of the Vermont Lake Champlain Basin P TMDL, the structural and non-structural measures proposed in this Generalized Plan are estimated to manage 7,317 total acres and result in a total P load reduction of 1,634 kg P/year, exceeding the target P reduction of 1,606 kg P/yr (Table 35).

Table 33. Summary of Acres Managed by Strategy - VTrans Lake Champlain TS4 PCP Area

Treatment Strategy Category	Treatment Type	Land Cover Type	Acres Managed
Structural STP	Existing and Planned Structural STPs	Total Impervious	203.9
Structural STP	Existing and Planned Structural STPs	Developed Pervious	758.7
Conceptual Structural STP	Infiltration Basin w/Aggregate (Large Infiltration Trench)	Total Impervious	259.3
Conceptual Structural STP	Infiltration Basin w/Aggregate (Large Infiltration Trench)	Developed Pervious	717.2
Conceptual Structural STP	Infiltration Trench	Total Impervious	484.4
Conceptual Structural STP	Infiltration Trench	Developed Pervious	778.6
Conceptual Structural STP	Gravel Wetland	Total Impervious	9.6
Conceptual Structural STP	Gravel Wetland	Developed Pervious	11.5
Road Drainage Repair	Road Drainage Repair, Maintenance Project, HHC	Paved Roads	758.9
Road Drainage Repair	Road Drainage Repair, Maintenance Project, MHC	Paved Roads	627.2
Localized Erosion Repair	Localized Erosion Repair, Maintenance Project, HHC	Paved Roads	100.7
Localized Erosion Repair	Localized Erosion Repair, Maintenance Project, MHC	Paved Roads	43.3
Localized Erosion Repair	Localized Erosion Repair, Maintenance Project, LHC	Paved Roads	64.8
Non-Structural Control	Street Sweeping	Paved Roads	2,180.2
Non-Structural Control	DI Cleaning	Paved Roads	338.7
TOTAL IMPERVIOUS ACRES MANAGED (STRUCTURAL)			2,526.4
TOTAL ACRES MANAGED (STRUCTURAL)			4,818.1
ANNUAL ACRES MANAGED (NON-STRUCTURAL)			2,498.9

Table 34. Summary of Treatment Strategies Applied to Meet Target P Reduction

Treatment Strategy Category	Treatment Type	P Load Managed (kg/yr)
Structural STP	All Structural STPs	55.1
Conceptual Structural STP	Infiltration Basin w/Aggregate (Large Infiltration Trench)	139.2
Conceptual Structural STP	Infiltration Trench	360.2
Conceptual Structural STP	Gravel Wetland	4.8
Road Drainage Repair	Road Drainage Repair, Maintenance Project, HHC	640.1
Road Drainage Repair	Road Drainage Repair, Maintenance Project, MHC	339.1
Localized Erosion Repair	Localized Erosion Repair, Maintenance Project, HHC	42.9
Localized Erosion Repair	Localized Erosion Repair, Maintenance Project, MHC	10.7
Localized Erosion Repair	Localized Erosion Repair, Maintenance Project, LHC	10.8
Non-Structural Control	Street Sweeping	19.2
Non-Structural Control	DI Cleaning	13.0
TOTAL P REDUCTION		1,635.6

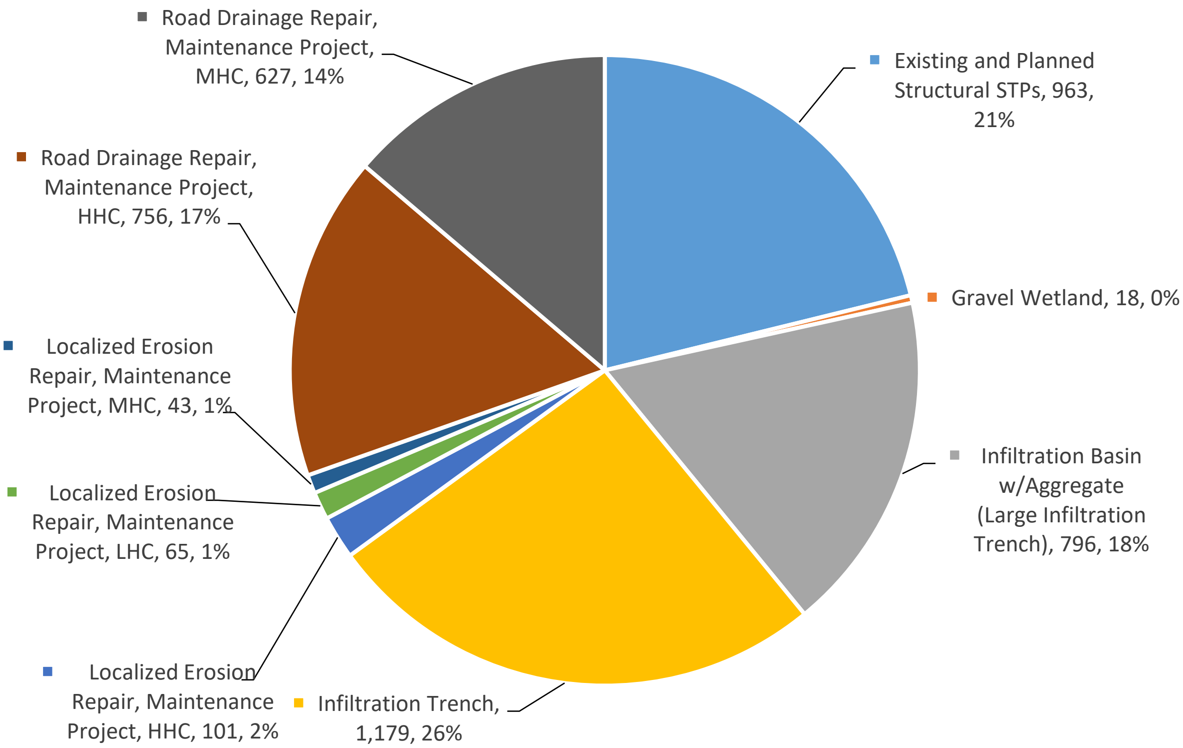


Figure 12. Summary of VTrans PCP Area Acres Managed by Structural Management Strategy

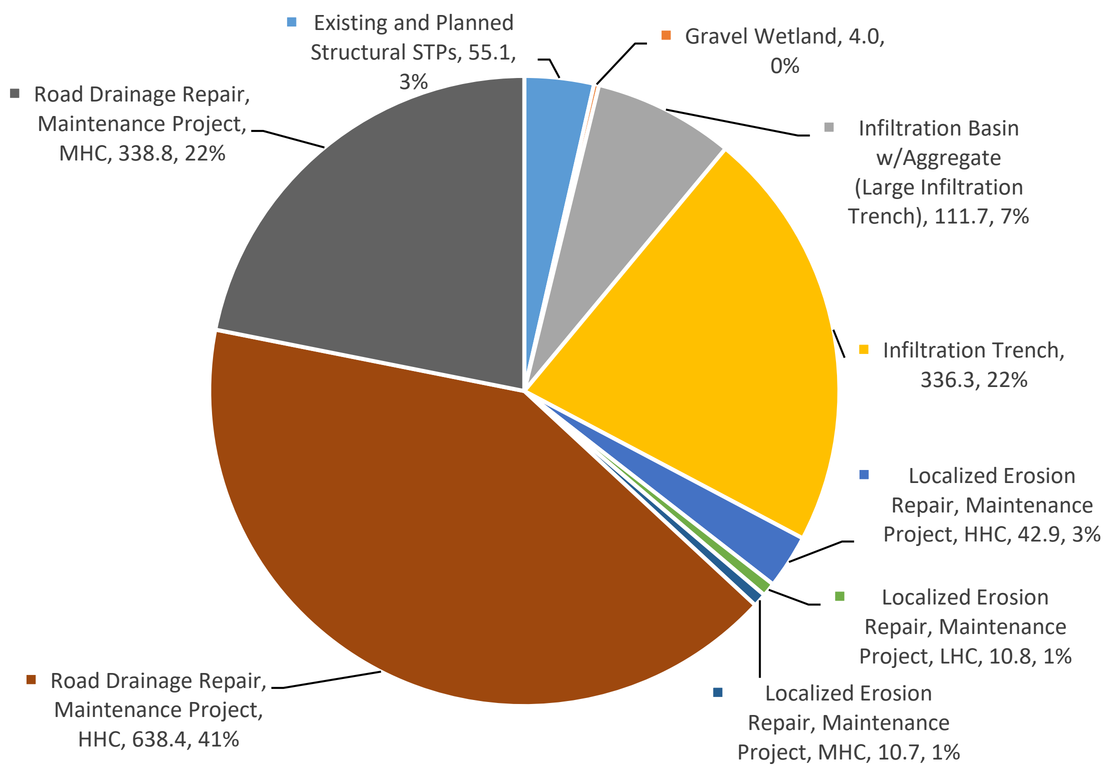


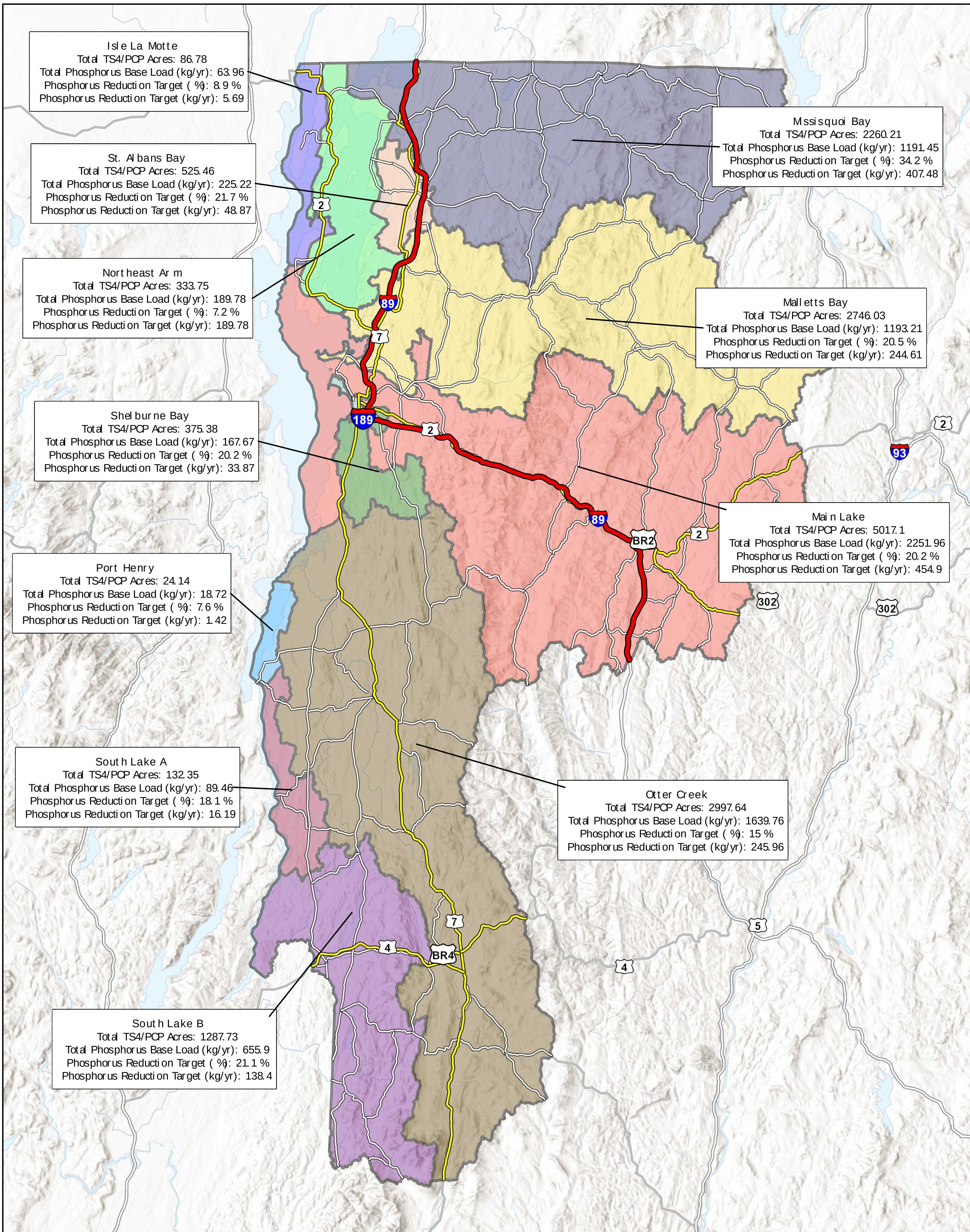
Figure 13. Summary of VTrans P Load (kg/yr) Managed by Structural Management Strategy

Table 35: Draft Generalized Implementation Schedule and Summary of Extent and Type of Measures Anticipated

Lake Segment:	Lake Champlain Basin	Land Cover Type	PCP Area (acres)	P Base Load (kg/yr)	P Target Reduction (kg/yr)	Progress to Target P Reduction Key:
Target Reduction:	20.96%	Developed Impervious	416.78	466.78	97.85	Less than 25%
		Paved Roads	5,983.87	4,836.67	1,014.55	26%-50%
		Unpaved Roads	12.74	28.85	5.96	51%-75%
		Developed Pervious	9,483.84	2,330.74	487.56	76%-99%
		Total	15,897.23	7,663.04	1,605.91	100%+

				Gen PCP, 1st Imp Plan				2nd Imp Plan				3rd Imp Plan				4th Imp Plan				Complete
Metric	**Lake Segment**	**Total Acres Managed**	**2010-2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	South Lake B	**215.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	65.3	65.3	47.3	19.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	South Lake A	**24.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	12.2	6.2	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Port Henry	**1.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Otter Creek	**389.4**	17.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.7	73.3	78.9	78.9	78.9
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Main Lake	**669.7**	28.4	0.0	0.8	0.0	0.0	13.8	2.0	0.0	0.0	73.8	116.3	147.7	147.7	139.3	0.0	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Shelburne Bay	**98.1**	0.0	0.0	9.2	0.0	6.6	11.8	11.8	5.1	16.4	5.9	3.3	9.3	9.3	9.3	0.0	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Malletts Bay	**385.1**	22.3	0.0	0.0	0.0	0.0	35.8	66.2	83.1	82.1	65.2	30.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Northeast Arm	**21.3**	5.7	0.9	0.0	0.0	0.0	0.0	5.9	5.9	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	St. Albans Bay	**105.6**	5.7	0.0	24.9	0.0	0.0	11.9	11.9	17.1	19.6	14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Mississquoi Bay	**609.0**	3.8	0.0	38.1	76.1	191.2	153.2	96.9	49.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	Isle La Motte	**6.0**	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IMPERVIOUS ACRES MANAGED (STRUCTURAL)	**PCP Area**	**2,526.4**	**83.7**	**0.9**	**72.9**	**76.1**	**197.9**	**229.4**	**197.6**	**161.0**	**121.0**	**159.5**	**150.0**	**157.0**	**157.0**	**230.3**	**145.6**	**156.4**	**132.3**	**97.9**
TOTAL ACRES MANAGED (STRUCTURAL)	South Lake B	**441.5**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	154.9	154.9	93.7	19.0
TOTAL ACRES MANAGED (STRUCTURAL)	South Lake A	**38.6**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.1	19.3	6.2	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Port Henry	**1.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.9	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Otter Creek	**762.0**	107.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	73.9	130.2	150.1	150.1	150.1
TOTAL ACRES MANAGED (STRUCTURAL)	Main Lake	**1,343.5**	134.3	0.0	1.3	0.0	0.0	39.2	3.5	0.0	0.0	139.3	278.6	278.6	278.6	190.0	0.0	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Shelburne Bay	**223.7**	0.0	0.0	16.1	0.0	16.4	21.5	21.5	5.1	27.1	5.9	7.3	34.2	34.2	34.2	0.0	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Malletts Bay	**485.1**	46.3	0.0	0.0	0.0	0.0	35.8	66.2	83.1	120.1	103.2	30.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Northeast Arm	**15.7**	0.0	1.0	0.0	0.0	0.0	0.0	5.9	5.9	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	St. Albans Bay	**453.2**	14.7	0.0	327.6	0.0	0.0	11.9	11.9	30.1	36.2	21.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Mississquoi Bay	**1,046.9**	61.2	0.0	38.1	76.1	327.4	289.3	186.9	67.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	Isle La Motte	**6.0**	0.0	0.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL ACRES MANAGED (STRUCTURAL)	**PCP Area**	**4,818.1**	**364.2**	**1.0**	**383.0**	**76.1**	**343.8**	**400.7**	**298.9**	**192.0**	**186.3**	**269.4**	**316.4**	**312.9**	**312.9**	**318.0**	**299.2**	**324.2**	**250.0**	**169.0**
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	South Lake B	**158.7**	158.8	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7	158.7
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	South Lake A	**44.5**	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Port Henry	**11.9**	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Otter Creek	**804.2**	808.5	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9	803.9
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Main Lake	**537.6**	537.8	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6	537.6
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Shelburne Bay	**97.5**	97.9	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Malletts Bay	**457.1**	457.6	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1	457.1
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Northeast Arm	**91.6**	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6	91.6
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	St. Albans Bay	**45.8**	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Mississquoi Bay	**223.3**	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3	223.3
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	Isle La Motte	**26.8**	28.2	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7
ANNUAL ACRES MANAGED (NON-STRUCTURAL)	**PCP Area**	**2,498.9**	**2526.3**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**	**2518.9**
CUMULATIVE TOTAL P REDUCTION	South Lake B	140.2	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	12.9	55.1	97.2	128.1	140.2
CUMULATIVE TOTAL P REDUCTION	South Lake A	16.4	0.2	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3.3	11.3	16.4	16.4
CUMULATIVE TOTAL P REDUCTION	Port Henry	1.6	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.8	1.6	1.6	1.6	1.6
CUMULATIVE TOTAL P REDUCTION	Otter Creek	248.3	5.8	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	48.8	96.4	147.0	197.7	248.3
CUMULATIVE TOTAL P REDUCTION	Main Lake	463.4	15.6	19.6	19.8	19.8	19.8	31.9	33.3	33.3	33.3	81.0	176.6	272.2	367.8	463.4	463.4	463.4	463.4	463.4
CUMULATIVE TOTAL P REDUCTION	Shelburne Bay	34.3	0.7	1.4	3.7	3.7	5.5	10.6	15.7	19.0	26.0	29.7	30.3	31.7	33.0	34.3	34.3	34.3	34.3	34.3
CUMULATIVE TOTAL P REDUCTION	Malletts Bay	247.9	4.6	7.2	7.2	7.2	7.2	30.8	75.8	134.8	187.7	226.6	247.9	247.9	247.9	247.9	247.9	247.9	247.9	247.9
CUMULATIVE TOTAL P REDUCTION	Northeast Arm	13.9	0.9	2.0	2.0	2.0	2.0	2.0	6.7	11.5	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9
CUMULATIVE TOTAL P REDUCTION	St. Albans Bay	49.9	2.2	2.6	7.9	7.9	7.9	16.0	24.2	32.7	42.8	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9	49.9
CUMULATIVE TOTAL P REDUCTION	Mississquoi Bay	412.1	1.6	2.8	24.5	68.1	197.1	304.3	379.6	412.1	412.1	412.1	412.1	412.1	412.1	412.1	412.1	412.1	412.1	412.1
CUMULATIVE TOTAL P REDUCTION	Isle La Motte	5.7	0.1	0.2	0.2	0.2	0.2	3.0	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
CUMULATIVE TOTAL P LOAD REDUCTION	**PCP Area**	**1,633.7**	**32.6**	**47.4**	**77.0**	**120.6**	**251.4**	**410.3**	**552.6**	**660.7**	**733.1**	**830.6**	**948.2**	**1045.1**	**1142.0**	**1290.3**	**1383.6**	**1484.3**	**1571.0**	**1633.7**

Maps



LEGEND

Major Roads Network

- Interstates
- US Highways
- State Highways

Lake Segments

- Burlington Bay
- Isle La Motte
- Main Lake
- Malletts Bay
- Missisquoi Bay
- Northeast Arm
- Otter Creek
- Port Henry
- Shelburne Bay
- South Lake A
- South Lake B
- St. Albans Bay

0 5 10
Miles

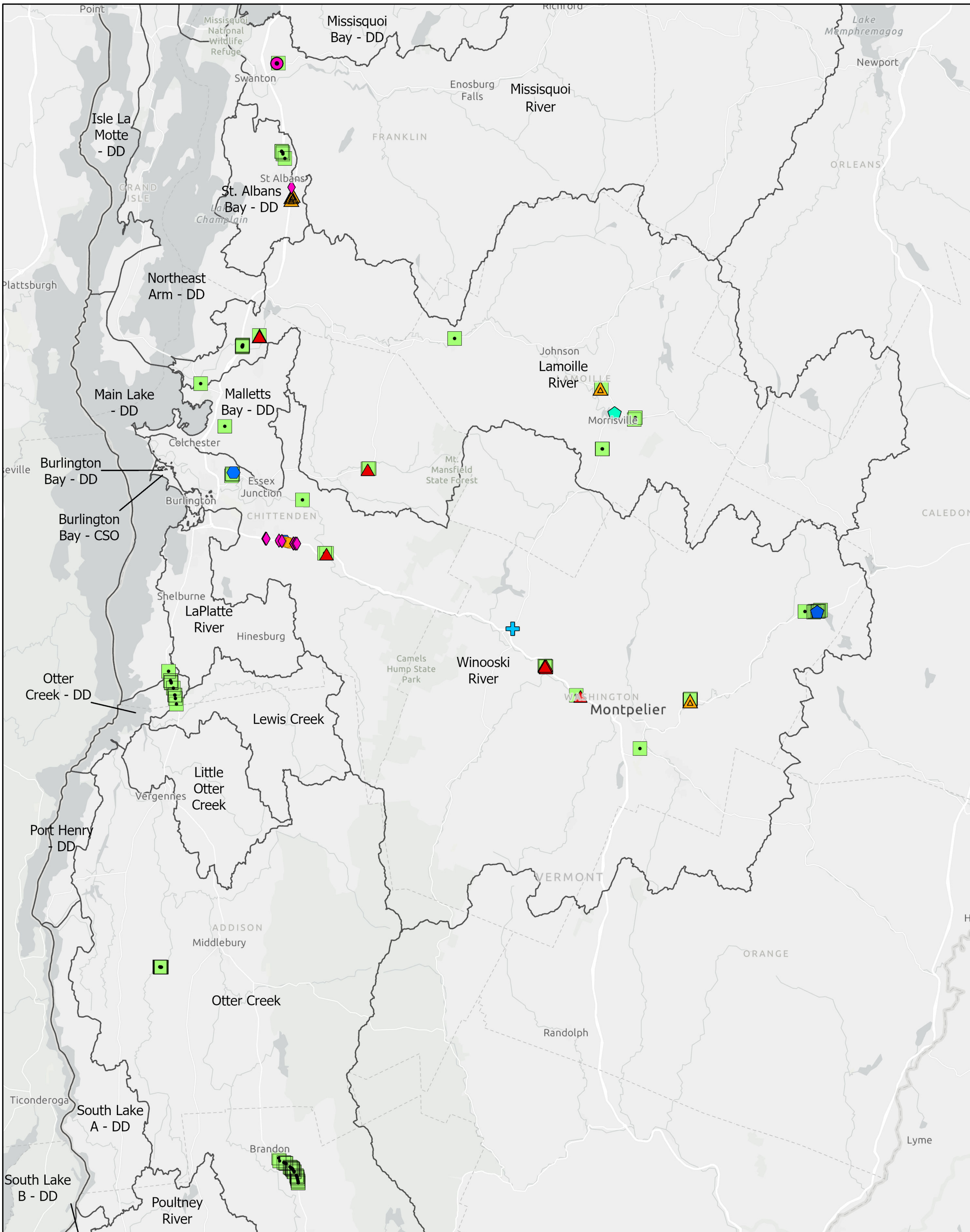
TS4 Phosphorus Control Plan Area

VTrans Phosphorus Control Plan

Prepared for VTrans

STONE ENVIRONMENTAL

Source: Esri World Terrain, VTrans, VCGI, Stone Environmental



LEGEND

Area Treatment Practice

- Disconnection
- Dry Detention Pond
- Gravel Wetland
- Infiltration Basin
- Sand Filter
- Subsurface Infiltration
- Wet Retention Pond

Linear Treatment Practice

- Dry Swale
- Grass Swale
- Infiltration Trench
- Wet Swale
- SWAT Drain Boundary

Source: Esri Basemaps, Vermont Agency of Transportation

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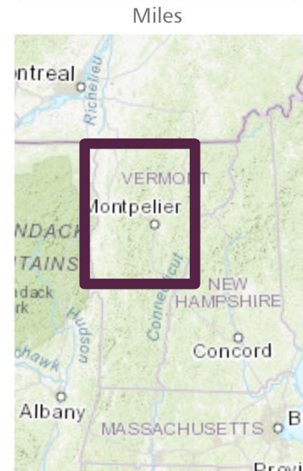
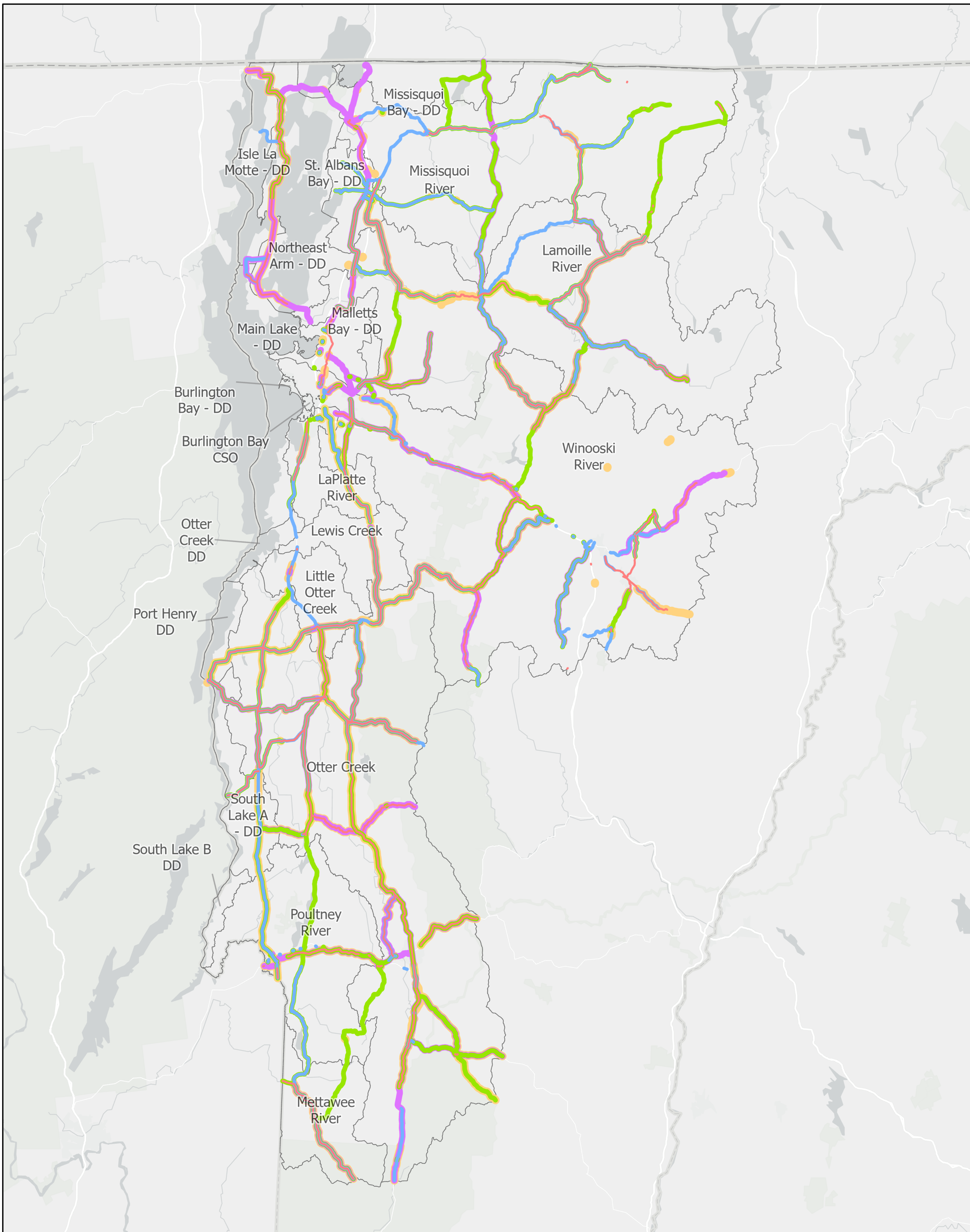


Existing VTrans Strructural BMPs

VTrans Generalized Phosphorous Control Plan

Prepared for Vermont Agency of Transportation - Stormwater Division

STONE ENVIRONMENTAL



MATS Sweeping Activities of Interest: 2015-2019

VTrans Phosphorous Control Plan

Prepared for VTrans and VT DEC

STONE ENVIRONMENTAL

LEGEND

SWAT Drains

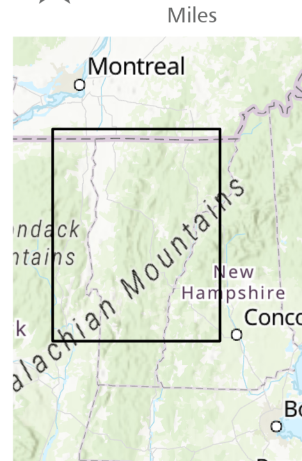
MATS Sweeping of Interest by Year

- 2019
- 2018
- 2017
- 2016
- 2015

N

0 5 10

Miles



Source: Basemap - ESRI; MATS Sweeping Activities - VTrans

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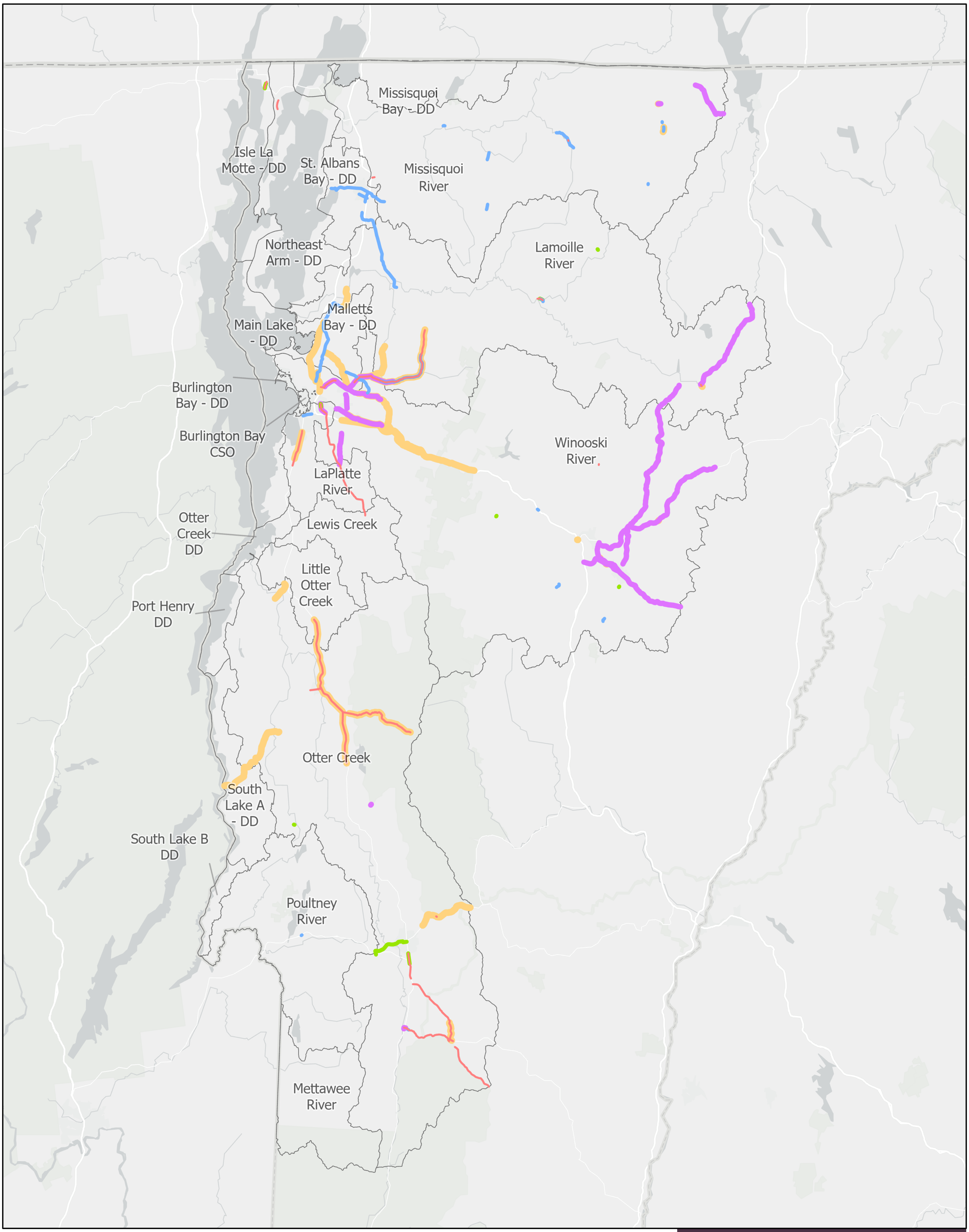
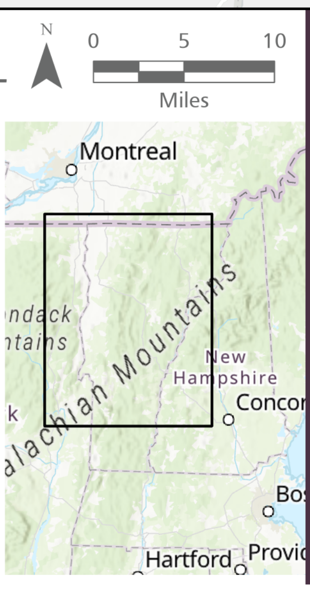


LEGEND

SWAT Drains

MATS DI Cleaning of Interest by Year

- 2019
- 2018
- 2017
- 2016
- 2015



MATS DI Cleaning Activities of Interest: 2015-2019

VTrans Phosphorous Control Plan

Prepared for VTrans and VT DEC

STONE ENVIRONMENTAL

Source: Basemap - ESRI; MATS DI Cleaning Activities - VTrans

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Appendix A: Baseline P Load and Reductions Needed, April 1 2018 Submittal

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

MEMO

March 27, 2018

To: Emily Schelley, VT DEC
Jenn Callahan, VTrans

From: Amy Macrellis, Katie Budreski, Gabe Bolin

Stone Project No. 16-091
Subject: VTrans PCP – Evaluation of draft phosphorus base loads and load reduction numeric targets

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The following narrative summarizes work completed by VTDEC and VTrans, as supported by Stone, to establish the baseline phosphorus load and reductions needed to comply with Lake Champlain Phosphorus Control Plan (PCP) requirements specified in Subpart 9.2.A.1 of the *National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4),* effective November 27, 2017.

In order to establish the baseline phosphorus load and reductions needed, it was first necessary to develop GIS data defining the spatial extents and geographic coverage of the TS4 within the Lake Champlain Basin (LCB). The GIS data for TS4 extents was developed by VTrans and Stone in consultation with VTDEC. The spatial extents of linear facilities were derived based on the VTrans Managing Assets for Transportation Systems (MATS) database and include VTrans owned and maintained roads within the Lake Champlain Basin (LCB). Right of way areas for linear facilities were derived using GIS data from VTrans, buffered road centerlines using minimum ROW widths and standard road class width where gaps existed within the VTrans data, and further manual edits to remove right of way areas maintained by private or municipal entities. The spatial extents for VTrans facilities, including airports, welcome centers, park and rides, gravel pits, and maintenance garages, were developed based on parcel data provided by VTrans. Stone digitized non-road impervious areas using 2011 impervious cover data from the Lake Champlain Basin Program, which was then updated and corrected using aerial imagery.

VTDEC applied the GIS datasets defining the TS4 extents within the LCB to extract draft developed lands acreages and resulting draft phosphorus base loads from VTDEC's existing developed lands dataset. The draft acreages and phosphorus base loads were broken down by lake segment, SWAT model drainage area, type of area (Road/linear facility or Parcel-based facility) and type of land use/land cover (Developed Impervious, Paved Road, Unpaved Road, and Developed Pervious). Draft phosphorus base loads and target reductions were provided in draft form by VTDEC on January 12, 2018.

1. Draft Acreages and Phosphorus Base Loads for VTrans Facilities (Parcels)

Draft acreages and phosphorus base loads for VTrans facilities (parcels) provided by VTDEC are summarized in Table 1. The table is annotated with proposed revisions to the draft acreages and resulting phosphorus base loads, as further described in the narrative below. Proposed revisions in Table 1 are highlighted.

The VTrans/Stone estimate of non-road impervious acres (259 acres) compares favorably with VTDEC's SWAT-model derived impervious acreage for the combined acreage on Parcels for Developed Impervious (151 acres) and Paved Roads (111 acres) – a total of 262 acres. VTrans/Stone generally agree that VTDEC's draft base load allocations for Developed Impervious, Paved Roads, and Developed Pervious are reasonable.

The VTDEC acreages by land use/land cover include 1.38 acres of Unpaved Road, which translates to a base load of 2.85 kg/year. In some cases, this allocation is appropriate, while in other cases, the Unpaved Road acres and allocation should be removed, as described below:

- The 1.07 acres of Unpaved Road in the Missisquoi River drainage area appears to be associated with two VTrans facilities:
    - Approximately 0.46 acres is adjacent to the Franklin County State Airport in Highgate. A section of Hemp Yard Road between Carter Hill Road and the airport is unpaved road and is included in the extents of the VTrans parcel data. This should remain within the VTrans base load allocation.
    - An additional 0.61 acres in the Missisquoi River drainage area is located on Fiddler's Elbow Road off VT Rte. 100 in Lowell, adjacent to a gravel pit that does not appear on VTrans' TS4 Industrial Activities table. While this gravel pit facility appears in VTrans's parcel data, it is owned by Dale E. Percy Inc. The unpaved road is not owned or maintained by VTrans, and so it should be removed from the VTrans acreage and phosphorus base load.
- In the LaPlatte River drainage area, 0.19 acres of unpaved roadway appears to be associated with unpaved municipal road crossings of a railroad right-of-way parcel that runs parallel to US 7 in South Burlington between that highway and Shelburne Bay. We recommend that these areas be removed from the base load allocation.
- A similar situation occurs in the Main Lake – DD drainage area, where less than 0.01 acres of unpaved road municipal road-railroad crossings and unpaved municipal roads are located within the

same railroad right-of-way parcel described above (between US 7 and Lake Champlain, but south of Shelburne Bay).

- 0.14 acres of unpaved road in the Otter Creek drainage area are associated with the Middlebury State Airport. These polygons are in the middle of the taxiway and runway, and should be classified as Paved Road.
- In the Winooski River drainage area, less than 0.01 acres of unpaved road is associated with the Waterbury Park and Ride, where the parcel boundary overlaps with Lincoln St. – however, this road is paved where it passes the park-and-ride entrance. This should either be classified as paved road or removed from VTrans's base load allocation.
- Also in the Winooski River drainage area, less than 0.01 acres of unpaved road is associated with a large, undeveloped parcel in East Montpelier, north of US 2 and near the intersection of US 2 and Coburn Rd. Coburn Rd. is unpaved, and the parcel boundary captures the curb cut. This Unpaved Road fraction should be removed from the base load, as it is more likely to be managed by the municipality. In addition, DEC's mapping shows 0.99 acres of paved road on this parcel, but current orthophotos indicate that no road is present. Historical orthophotos indicate an unpaved road or access was present through roughly 2013, but that now only pedestrian or bicycle trails remain. In this case it is not clear whether the Paved Road base allocation should be removed, or whether de-paving and a resulting land cover change should be later credited towards targets in the PCP.

2. Draft Acreages and Phosphorus Base Loads for VTrans Linear Facilities and Rights-of-Way (Roads)

Draft acreages and phosphorus base loads for VTrans linear facilities (roads) provided by VTDEC are summarized in Table 2. The table is annotated with minor proposed revisions to the draft acreages and resulting phosphorus base loads, as further described in the narrative below. Proposed revisions in Table 2 are highlighted.

2.1 Paved Roads

VTDEC's estimated impervious acreage for Paved Roads (5,904 acres) is higher than the VTrans/Stone estimate (4,830 acres). The VTrans/Stone estimate was derived by buffering road centerlines based on VTrans data and reported roadway widths. This approach, while generally accurate along the roadway, often excludes impervious area at intersections where turning lanes and the intersections themselves are often wider than the reported roadway width. The VTrans/Stone estimate is likely under-estimating the actual paved road impervious acreage. However, VTDEC's estimated impervious acreage sometimes captures portions of municipal roads that are located in the VTrans ROW, particularly at bridge crossings or running parallel to interstate highways, and in villages can misclassify developed impervious as paved road within the VTrans right-of-way. While efforts were made to exclude these non-VTrans-managed roadways, VTDEC's acreage for VTrans Paved Roads is likely an over-estimate. All parties acknowledge this uncertainty, and agree to use VTDEC's estimate of Paved Roads acres for overall consistency with other VTDEC Phase I implementation work (Municipal Roads General Permit, MS4 PCPs, etc.). It is also acknowledged that the VTDEC acreage, and thus the phosphorus base load resulting from that acreage, represents a conservative assumption and may need to be revisited periodically as progress is made towards developing and implementing the specific PCPs. The next opportunity to revisit these estimates of road-related impervious cover will be with the release of updated land use/land cover data which is now under development by the Lake Champlain Basin Program and the UVM Spatial Analysis Lab; delivery of this dataset is currently estimated to be in the fall of 2018.

In addition to the above, the method that will be used to assign the road-related phosphorus base load to various portions of the roadway based on hydrologic connectivity, slope class, or localized erosion caused by highway runoff within each lake segment remains under development.

2.2 Roadway –Related Developed Impervious

VTDEC's estimate of impervious cover within the TS4 right-of-way, which should cover only Paved Road impervious acreage, includes 266 acres of Developed Impervious area. This impervious acreage is generally associated with curb cuts, accesses, or pre-existing developed rooftops, parking, or other impervious cover located within the VTrans ROW but associated with municipal, private or other development. Figure 1 illustrates the breakdown of the draft phosphorus base load for VTrans linear facilities and developed lands within the VTrans ROW, and includes notes about the largest lake segments, draft phosphorus base loads, and target reductions. It was used in consideration of whether the Developed Impervious contribution to the phosphorus base load within the VTrans ROW was cause for substantial concern, and is offered as a visual representation of how the most substantial portions of the draft phosphorus base load and reductions required are distributed across the LCB.

Basin-wide, VTDEC's acreage and phosphorus base load estimates indicate that this developed impervious area accounts for 2.2% of the total acres (range of 1.1-4% across all drainage areas) and 4.4% of the total phosphorus base load(range of 2.6-7.1%) within the TS4 ROW. In contrast, the Paved Roads area (DEC's estimate of 4,472 acres basin-wide) accounts for 43% of the total acres (range of 26-63% across all drainage areas) and 66% of the total base load (range of 45-91%) within the TS4 ROW (Figure 1 and Table 2). These Developed Impervious areas are therefore a relatively minor portion of the overall base load allocation. VTrans' ability to directly control these areas is extremely limited – treatment or improvement of existing accesses can only be required through the 1111 permit process. However, since these Developed Impervious areas are located within the VTrans ROW, VTrans should be able to take credit for treating any incidental, directly connected curb cuts and accesses as part of stormwater improvement projects that otherwise and primarily treat Paved Road impervious. The Developed Impervious areas located within VTrans right-of-way are currently proposed to remain as part of the VTrans phosphorus base load, although this assumption may be re-visited in the future.

2.3 Unpaved Roads

VTDEC's estimate of impervious cover within the VTrans ROW also includes 25 acres of unpaved roads. However, VTrans only has records of owning and controlling two areas of unpaved road described below, both of which are located in the Winooski River drainage area. We recommend that the other areas, which are nearly all associated with municipal Unpaved Road areas crossing into VTrans ROW at intersections, be removed from the VTrans base load allocation (Table 2).

- A 150' section of Dog River Road in the Winooski River drainage area in Berlin does not appear in the GIS dataset for the PCP Area delivered to VTDEC; however, this 0.05-acre section of road is owned and maintained by VTrans and should be classified as unpaved road under VTrans linear facilities and right-of-way.
- A 12.26-acre portion of VT Rte. 65 in Brookfield, between VT Rte. 12 and the edge of the Winooski River drainage area (the unpaved portion of VT Rte. 65 continues out of the Lake Champlain basin, past I-89 and the Floating Bridge in Brookfield Village). This portion alone represents approximately half of the total Unpaved Road area within VTrans's ROW (Table 2), and represents a base load of 27.06 kg/yr.

3. Revised Baseline Phosphorus Load and Reductions Required

The draft phosphorus base loads and target reductions provided by VTDEC on January 12, 2018 were adjusted to reflect the proposed revisions discussed in Sections 1 and 2 above. Table 3 summarizes the revised phosphorus base load, and target phosphorus reductions, by lake segment.

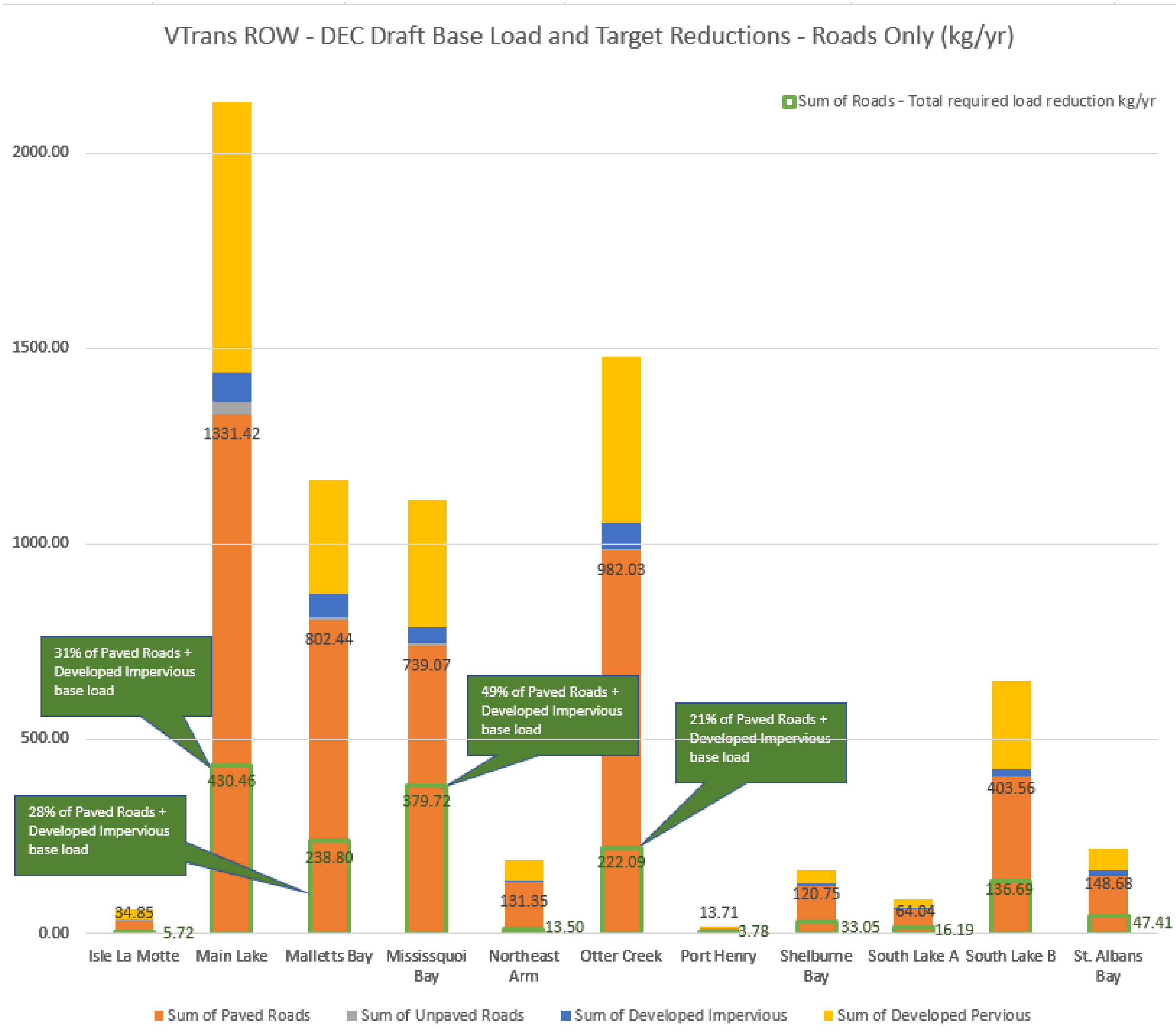

Figure 1. Summary of draft phosphorus base load for VTrans linear facilities (roads and associated ROW areas). Paved roads base loads and draft required load reductions are labeled. This figure shows the VTDEC Jan. 12 draft base loads, before corrections proposed in this memo are applied.

Table 1. Summary of Draft Acres and Phosphorus Base Loads for VTrans Facilities (Parcels)

			Area (acres)				Load (kg/yr)				
Lake Segment	SWAT_drain	Area_Type	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Total
Main Lake	Main Lake - DD	Parcel	1.29	0.14	~~0.000076~~ 0.00	0.45	1.21	0.12	~~0.00016~~ 0.00	0.04	1.37
Main Lake	Winooski River	Parcel	40.39	36.43	~~0.01~~ 0.00	222.60	45.10	29.23	~~0.025~~ 0.000	51.31	~~125.67~~ 125.64
Malletts Bay	Lamoille River	Parcel	20.74	0.98	0.00	39.06	23.60	0.80	0.00	8.90	33.30
Malletts Bay	Malletts Bay - DD	Parcel	3.40	0.01	0.00	8.39	2.80	0.00	0.00	0.10	2.91
Mississquoi Bay	Mississquoi Bay - DD	Parcel	1.17	6.18	0.00	4.58	0.84	5.05	0.00	1.90	7.79
Mississquoi Bay	Mississquoi River	Parcel	27.69	20.60	~~1.05~~ 0.46	110.56	31.83	16.60	~~2.15~~ 0.95	28.83	~~79.42~~ 78.21
Northeast Arm	Northeast Arm - DD	Parcel	1.83	0.00	0.00	2.54	2.09	0.00	0.00	0.76	2.85
Otter Creek	Lewis Creek	Parcel	1.63	0.00	0.00	2.91	1.61	0.00	0.00	0.84	2.46
Otter Creek	Little Otter Creek	Parcel	1.76	0.00	0.00	0.26	2.17	0.00	0.00	0.10	2.27
Otter Creek	Otter Creek	Parcel	40.57	~~42.39~~ 42.53	~~0.14~~ 0.00	265.97	46.65	~~34.68~~ 34.79	~~0.29~~ 0.00	77.55	~~159.17~~ 158.99
Shelburne Bay	LaPlatte River	Parcel	0.84	2.62	~~0.19~~ 0.00	11.15	0.80	1.93	~~0.39~~ 0.00	1.92	~~5.03~~ 4.64
South Lake B	Poultney River	Parcel	3.98	1.22	0.00	9.74	4.66	1.02	0.00	2.81	8.49
St. Albans Bay	St. Albans Bay - DD	Parcel	5.60	0.00	0.00	1.03	6.94	0.00	0.00	0.18	7.12
Total (adjusted to reflect proposed changes)			150.89	110.71	0.46	679.22	170.30	89.55	0.95	175.25	436.04

Table 2. Summary of Draft Acres and Phosphorus Base Loads for VTrans Linear Facilities and Right-of-Way (Roads)

			Area (acres)				Load (kg/yr)				
Lake Segment	SWAT_drain	Area Type	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Total
Isle La Motte	Isle La Motte - DD	Road	2.29	47.83	~~0.17~~ 0.00	37.56	1.74	34.85	~~0.33~~ 0.00	27.37	~~64.29~~ 63.96
Main Lake	Main Lake - DD	Road	1.04	19.73	~~0.14~~ 0.00	35.36	0.97	17.29	~~0.30~~ 0.00	3.35	~~21.91~~ 21.61
Main Lake	Winooski River	Road	64.34	1637.74	~~14.92~~ 12.31	2994.20	71.85	1314.13	~~32.93~~ 27.17	690.19	~~2109.1~~ 2103.34
Malletts Bay	Lamoille River	Road	49.29	854.33	~~3.34~~ 0.00	1264.60	56.08	692.11	~~6.78~~ 0.00	288.31	~~1043.28~~ 1036.49
Malletts Bay	Malletts Bay - DD	Road	7.38	163.06	~~0.55~~ 0.00	339.71	6.09	110.33	~~1.11~~ 0.00	4.09	~~121.62~~ 120.51
Missisquoi Bay	Missisquoi Bay - DD	Road	5.67	104.24	~~0.13~~ 0.00	133.22	4.05	85.21	~~0.26~~ 0.00	55.27	~~144.78~~ 144.52
Missisquoi Bay	Missisquoi River	Road	32.51	811.33	~~2.23~~ 0.00	1034.21	37.37	653.86	~~4.59~~ 0.00	269.70	~~965.52~~ 960.92
Northeast Arm	Northeast Arm - DD	Road	5.86	160.33	~~0.28~~ 0.00	164.01	6.70	131.35	~~0.58~~ 0.00	48.88	~~187.52~~ 186.93
Otter Creek	Lewis Creek	Road	3.58	37.31	~~0.22~~ 0.00	47.81	3.55	31.86	~~0.59~~ 0.00	13.87	~~49.77~~ 49.28
Otter Creek	Little Otter Creek	Road	4.75	72.65	~~0.036~~ 0.00	68.28	5.85	69.53	~~0.08~~ 0.00	24.96	~~100.42~~ 100.34
Otter Creek	Otter Creek	Road	49.06	1068.57	~~1.81~~ 0.00	1308.92	56.42	874.16	~~3.84~~ 0.00	381.66	~~1316.08~~ 1312.24
Otter Creek	Otter Creek - DD	Road	0.54	7.35	~~0.079~~ 0.00	20.40	0.59	6.48	~~0.18~~ 0.00	7.10	~~14.35~~ 14.17
Port Henry	Port Henry - DD	Road	0.75	15.33	0.00	8.10	0.93	13.71	0.00	4.08	18.72
Shelburne Bay	LaPlatte River	Road	10.15	164.23	~~0.28~~ 0.00	189.58	9.66	120.75	~~0.57~~ 0.00	32.61	~~163.6~~ 163.03
South Lake A	South Lake A - DD	Road	1.94	69.11	~~0.0035~~ 0.00	61.30	2.54	64.04	~~0.01~~ 0.00	22.87	~~89.47~~ 89.46
South Lake B	Mettawee River	Road	4.82	102.55	~~0.051~~ 0.00	87.60	5.77	84.43	~~0.12~~ 0.00	25.35	~~115.67~~ 115.55
South Lake B	Poultney River	Road	12.01	380.48	~~0.13~~ 0.00	688.04	14.04	319.13	~~0.29~~ 0.00	198.69	~~532.15~~ 531.86
St. Albans Bay	St. Albans Bay - DD	Road	9.90	187.85	~~0.18~~ 0.00	321.73	12.28	148.68	~~0.37~~ 0.00	57.14	~~218.46~~ 218.1
Total (adjusted to reflect proposed changes)			265.89	5904.03	12.31	8804.61	296.49	4771.90	27.17	2155.49	7251.04

Table 3. Revised Phosphorus Base Loads and Target Reductions

Lake Segment	Phosphorus Base Load (kg/yr)	TMDL Target	Target Phosphorus Reduction (kg/yr)
Isle La Motte	63.96	8.9%	5.69
Main Lake	2251.96	20.2%	454.90
Malletts Bay	1193.21	20.5%	244.61
Mississquoi Bay	1191.45	34.2%	407.48
Northeast Arm	189.78	7.2%	13.66
Otter Creek	1639.76	15.0%	245.96
Port Henry	18.72	7.6%	1.42
Shelburne Bay	167.67	20.2%	33.87
South Lake A	89.46	18.1%	16.19
South Lake B	655.90	21.1%	138.40
St. Albans Bay	225.22	21.7%	48.87
Total	7687.09		1611.05

Appendix B: GIS inventory of phosphorus loading factors, October 1 2018 Submittal

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MEMO

October 1, 2018

To: Emily Schelley, VT DEC
Jenn Callahan, VTrans

From: Amy Macrellis, Katie Budreski, Gabe Bolin

Stone Project No. 16-091
Subject: VTrans PCP – Submission of GIS Files of Loading Factors

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The following narrative summarizes work completed by VTDEC and VTrans, as supported by Stone, to complete a GIS inventory of phosphorus loading factors to comply with Lake Champlain Phosphorus Control Plan (PCP) requirements specified in Subpart 9.2.C. of the *National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4),* effective November 27, 2017.

The loading factors that are being considered to allocate load across the TS4 include the following:

1) Developed Impervious TS4 extents
2) Paved Road TS4 extents, further distributed by:
    a. slope class
    b. hydrologic connectivity
    c. localized erosion potential
3) Unpaved Road TS4 extents
4) Developed Pervious TS4 extents

The GIS inventory of loading factors was developed by VTrans and Stone in consultation with VTDEC to first establish baseline phosphorus load (see Memo titled *VTrans PCP – Evaluation of draft phosphorus base loads and load reduction numeric targets* submitted on March 27, 2018 to VTDEC) and next to determine other factors to refine load allocation across the Lake Champlain Basin (LCB). The spatial extents of loading factors are based on land use data compiled by VTDEC using 2011 Land Cover Data from the Lake Champlain Basin Program (LCBP), VTrans right of way data (ROW), the VTrans Managing Assets for Transportation Systems (MATS) database, VTrans parcel and facility data, VTrans Small Culverts Inventory (SCI) data, and basin-wide LiDAR-based elevation data available through VCGI.

The Lake Champlain Basin Program and the UVM Spatial Analysis Lab are completing an updated land cover dataset based on 2016 orthoimagery that may also be used to define loading factors in the PCP implementation process. The dataset is anticipated to be available in the fall of 2018.

1. GIS Inventory of Loading Factors

The GIS inventory of loading factors is being delivered as an Esri File Geodatabase (v.10.5.1) with feature classes representing loading factors within the TS4. The geodatabase can be downloaded from: https://www.dropbox.com/s/0g7f7lr8zw2h7zu/VTrans_TS4_LoadFactors_20180919.gdb.zip?dl=1.

The following sections outline the included feature classes by loading factor.

1.1 Developed Impervious

Developed impervious areas are associated with non-road VTrans properties including airports, welcome centers, park and rides, gravel pits, and maintenance garages. The full spatial extents for VTrans facilities were developed based on parcel data provided by VTrans. The impervious portions of these areas were defined using 2011 land cover data from the LCBP and provided to VTrans by VTDEC. These data will be used to allocate load across the TS4 for Developed Impervious areas and are included in the following feature class and associated attribute:

- VTrans_landuses (Attribute: LU_Class = “Developed Impervious”)

Impervious areas were further refined by Stone using aerial imagery. These data may be used as a refined dataset to calculate load reduction for PCP implementation activities. The data are provided in the following feature class:

- VTrans_NonRoad_Impervious_Surface_Segment

1.2 Paved Roads

Paved roads include roads that have paved surfaces. Paved road areas were provided to VTrans by VTDEC and were defined by combining the 2011 land cover from LCBP with VTrans Right of Way (ROW) areas. These data will be used to allocate load across the TS4 for Paved Road areas and are included in the following feature class and associated attribute:

- VTrans_landuses (Attribute: LU_Class = “Paved Roads”)

Two additional datasets have been developed to further refine paved road areas. First, a dataset has been developed by buffering VTrans road centerlines by widths specified in GIS data attributes and standard road class width where gaps existed within the VTrans data. These data may be used as a refined dataset to calculate load reductions for PCP implementation activities. The refined paved road area dataset is provided in the following feature class:

- VTrans_Roads_Impervious_Surface_Soil_Segment

A road centerline dataset was derived to further classify road segments by road slope class, hydrologic connectivity class, and localized erosion potential. These data will be used to further refine load for paved road areas within the TS4. This version of the VTrans road segment dataset was developed using a combination of data sources and manual editing. First, MATS roads data from VTrans was obtained. The MATS road segments were intersected with soil polygons and then divided into ~100m (or less) segments.

Each road segment was assigned hydrologic connectivity based on the following criteria with the first being the most hydrologically connected and with the last being the least hydrologically connected:

1) Intersecting NHD Stream, Pond, or VSWI Wetland (attribute: HydroBisect_Criteria) – considered as highly hydrologically connected
2) Within 100 ft of NHD Stream, Pond, or VSWI Wetland (attribute: HydroParallel_Criteria) – considered as highly hydrologically connected
3) Within River Corridor (attribute: HydroRiverCorr_Criteria) – considered as highly hydrologically connected
4) Intersecting Additional Intermittent Streams (used LiDAR-based Enhanced Hydro Network) (attribute: HydroBisectLidar3_Criteria) – considered as highly hydrologically connected
5) Within 100 ft of Additional Intermittent Streams (used LiDAR-based Enhanced Hydro Network) (attribute: HydroParallelLidar3_Criteria) – considered as moderately hydrologically connected
6) Within 50 ft of Piped Stormwater Infrastructure that is Connected to Outfalls within 500 ft of NHD or VSWI (attribute: HydroStorm_Criteria) – considered as moderately hydrologically connected
7) Within 50 ft of a culvert in the Small Culvert Inventory (SCI) (attribute: HydroSCI_Criteria_50ft) – considered as moderately hydrologically connected

If none of the above conditions applied, the road segment was considered to have low hydrologic connectivity.

An attribute was added to provide an single overall 'hydrologic connectivity ranking' called 'HydroConnectCriteria', which assigns the highest connectivity class to the road segment, when multiple criteria are met (of the seven criteria outlined above). Another attribute called 'HydroConnectClass' was included to indicate the general level of hydrologic connectivity (High, Moderate, Low).

Additional analyses were conducted to determine the potential for localized erosion with results added to the line segment, based on the following criteria:

1) Downslope & Steep ROW & Road Runoff (attribute: LE1_DownslpSteepRdRunoff)

    a. Downslope = "Yes" (Meets 2 of the following criteria)

        i. If the nearest road segment has a higher average elevation

        ii. If the nearest road segment has a higher maximum elevation

        iii. If there is 'runoff' or flow accumulation from the road

    b. Steep Slope in ROW (Meets either of the following criteria)

        i. Ave Slope in adjacent ROW > 15% and Max Slope > 40%

        ii. Ave Slope in adjacent ROW > 20% and Max Slope > 25%

    c. Road Runoff

        i. Max flow accumulation of > 5 road segment pixels (45 m2)

2) Potential Culvert Erosion (based on SCI - yes if any of the following) (attribute: LE2_CulvertErosion)

    a. Culvert condition = Light, Moderate or Severe erosion

    b. Culvert type = Concrete

    c. Separation = Minor, Moderate or Major OR Proj_End = Yes

    d. Sink Hole = Minor, Moderate, or Major

    e. Connected to DI or Elbow (Elbows (Yes); then Both In_Treat = DI and Drain_Type = Slope)

3) Presence of Curb Board (Guardrail Dataset) (attribute: LE3_CurbBoard)

4) Evidence of Ditch (upslope along road) (attribute: LE4_PotentialDitch)

    a. Downslope = "No" (Does NOT meet at least 2 of the following criteria)

        i. If the nearest road segment has a higher average elevation

        ii. If the nearest road segment has a higher maximum elevation

        iii. If there is 'runoff" or flow accumulation from the road

b. Road Runoff

   i. Max flow accumulation of > 10 road segment pixels (90 m2)

Lastly, road slope was calculated based on LiDAR (attribute: Line_Slope_Mean). An attribute was added to indicate whether the slope of the road segment fell above or below 10% (attribute: SlopeClass).

The linear paved road features are provided in the following feature class:

- VTrans_MATS_PCP_RdSegments

1.3 Unpaved Road

Unpaved roads include roads that have gravel surfaces. Unpaved road areas were defined by VTDEC using the 2011 land cover data from LCBP and VTrans ROW areas. These data will be used to allocate load across the TS4 for Unpaved Road areas and are included in the following feature class and associated attribute:

- VTrans_landuses (Attribute: LU_Class = "Unpaved Roads")

1.4 Developed Pervious

Developed pervious areas include non-impervious, developed portions of both road ROW areas and VTrans parcels. The data were prepared by VTDEC using VTrans ROW, VTrans parcels, and the 2011 Land Cover from LCBP. These data will be used to allocate load across the TS4 for Developed Pervious areas and are included in the following feature class and associated attribute:

- VTrans_landuses (Attribute: LU_Class = "Developed Pervious")

2. Supplemental GIS Files

There are three GIS data layers that are included in the inventory that were used to develop the loading factor GIS files outlined above in Section 1. These supplemental GIS data layers are described below.

2.1 VTrans Parcels within the LCB

A dataset of VTrans owned or managed parcels was compiled to determine the extent of TS4 property within the Lake Champlain Basin (LCB). The data are included in the following feature class:

- VTrans_Parcels_LCB

2.2 VTrans Right of Way within the LCB

In addition to facility-based TS4 property, ROW extents were extracted for the LCB. This version of the VTrans (ROW) data was developed using a combination of data sources and manual editing. First, ROW data from VTrans was obtained. The dataset was incomplete in some areas. To supplement the VTrans

ROW dataset, the MATS road centerline data was buffered by 50 feet for interstates and 25 feet for other VTrans roads, and added to the overall ROW dataset.

We recognized that some ROW areas within the master dataset were included as 'access' areas versus areas that VTrans owns and maintains. Only ROW areas maintained and owned by VTrans are of interest for purposes of stormwater management and improvement through the TS4 permit and PCP development and implementation processes. For this reason, any ROW areas on municipally or privately owned property, with a focus on impervious surface areas, were removed from the final dataset where feasible.

The ROW data are included in the following feature class:

- VTrans_RDS_ROW_Updated_SWOnly

2.3 All VTrans-owned property within the LCB

The VTrans parcel data and ROW data were combined to represent the full extent of VTrans-owned properties – the extents of the TS4 within the LCB. The combined parcel and ROW data are included in the following feature class:

- VTrans_ROW_parcel_union

Appendix C: Development of coefficients of loading rates, April 1 2019 Submittal

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April 1, 2019

MEMO

To: Emily Schelley, VT DEC
Jenn Callahan, VTrans

From: Amy Macrellis, Barb Patterson, Jody Stryker, and Warren Rich

Stone Project No. 16-091
Subject: VTrans PCP – Submission of Coefficients for Phosphorus Loading Rates

The following narrative summarizes the work completed by VTDEC and VTrans, as supported by Stone, to develop coefficients for phosphorus loading rates across the various transportation land uses included in the VTrans Phosphorus Control Plan (PCP) Area. Our submittal complies with the requirements specified in Subpart 9.2.C. of the *National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4),* effective November 27, 2017.

A GIS inventory of loading factors was developed by VTrans and Stone in consultation with VTDEC to first establish baseline phosphorus load[1] and next to determine other factors to refine load allocation[2]. The spatial extents of loading factors were based on land use data compiled by VTDEC using 2011 Land Cover Data from the Lake Champlain Basin Program (LCBP), VTrans right of way data (ROW), the VTrans Managing Assets for Transportation Systems (MATS) database, VTrans parcel and facility data, VTrans Small Culverts Inventory (SCI) data, and basin-wide LiDAR-based elevation data available through VCGI[2].

The allocation of P base load across the TS4 includes loading rates and factors for four transportation-related land use classes:

1. Developed Impervious TS4 extents
2. Paved Road TS4 extents, further distributed by:
    a. slope class
    b. hydrologic connectivity
    c. localized erosion potential
3. Unpaved Road TS4 extents
4. Developed Pervious TS4 extents

[1] See technical memo titled *VTrans PCP – Evaluation of draft phosphorus base loads and load reduction numeric targets*, dated March 27, 2018
[2] See technical memo titled *VTrans PCP – Submission of GIS Files of Loading Factors*, dated October 1, 2018

For each of the four land use classes and associated factors, VTrans and VTDEC considered the development of loading rate coefficients. The intent of the loading rate coefficients is to refine allocation of the P base load within each classification such that critical source areas – portions of the TS4 with the highest risk of contributing disproportionate P load to surface waters – were assigned a proportionately higher portion of the P base load within each Lake segment.

Following completion of the GIS inventory of loading factors, the acres and P base loads falling into each land use classification and set of loading factors were further evaluated to understand the best opportunities for coefficient development. Figure 1 summarizes the acres and P base load distribution by each of the four transportation-related land use classes across the entire Lake Champlain basin and PCP area.

Nearly 60% (8,804 acres) of the TS4 area included in the PCP is classified as developed pervious, but this area only constitutes 30% of the phosphorus base load (2,155 kg/yr). This is a substantial portion of acreage, but compared to paved roads (which, though only about 40% of the total acres, constitute 66% of the P base load) it is a relatively minor and hard to treat portion of the P base load. Substantial uncertainty remains about how improvements to developed pervious, especially related to localized erosion fixes that also treat paved road runoff, would be credited. Ultimately, the group decided to retain the localized erosion potential factors, but at this time did not elect to develop coefficients to re-distribute P base load according to risk of localized erosion. This decision may be revisited as development of the basin-wide generalized PCP and lake segment-specific PCPs proceed.

Developed impervious areas and unpaved roads both represent small portions of the TS4 Phosphorus Control Plan area, both in terms of acreage and P base load (Figure 1). Thus, no coefficients were developed to refine distribution of these portions of the P base load.

Paved roads represent the highest proportion of the P base load as discussed above and as shown in Figure 1. As demonstrated in the GIS inventory of loading factors, there is substantial variability between both slope class and level of hydrologic connectivity across the TS4 paved road network within the Lake Champlain basin. The following sections outline the methods used to develop loading coefficients for the paved roads portion of the P base load, and to assign that load to paved roads areas within each Lake segment and drainage area based on the slope class and degree of hydrologic connectivity of individual paved road segments.

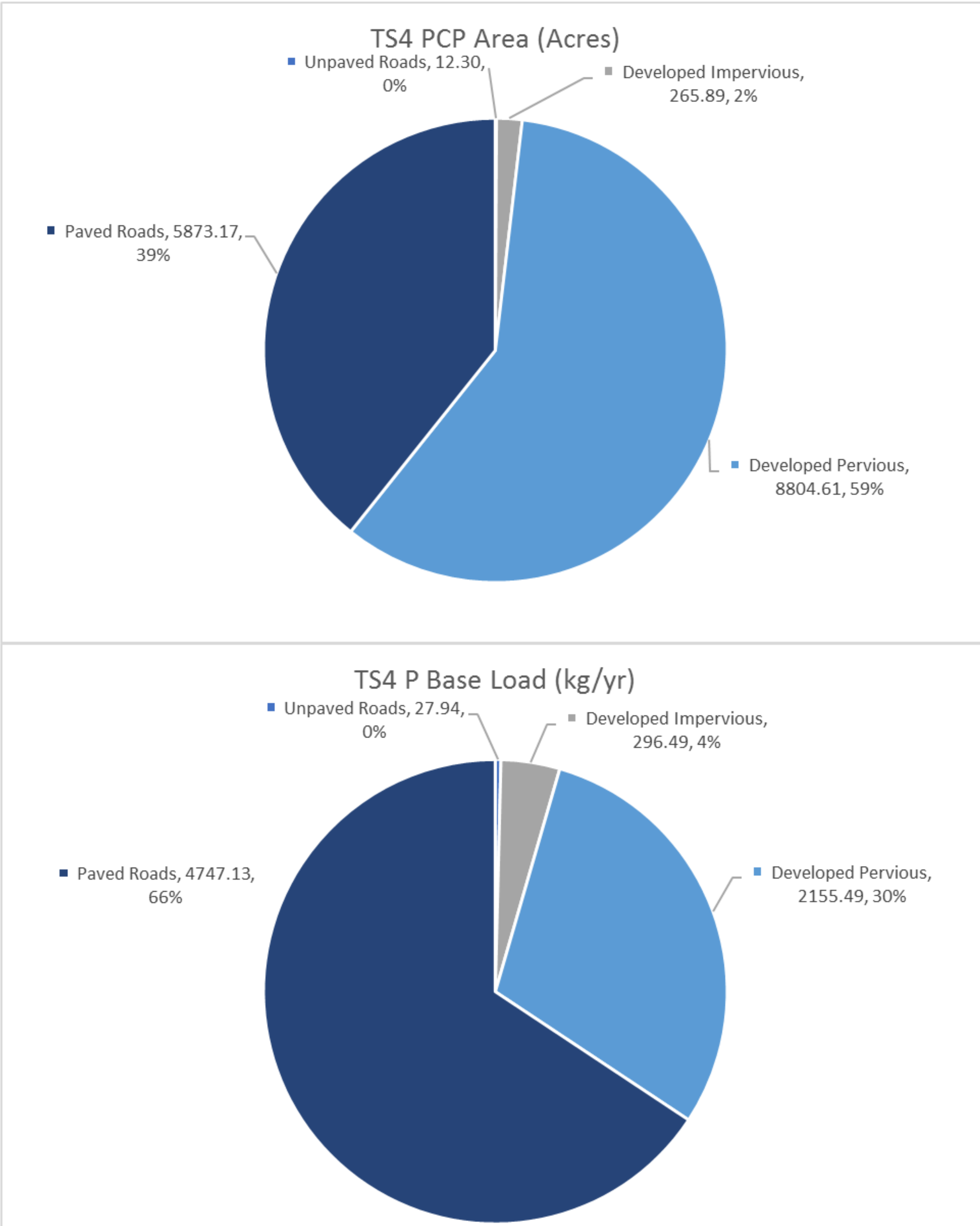


Figure 1. Summary of TS4 acres and P base load by transportation-related land use classification within the Lake Champlain Basin

1. Development of Coefficients for Paved Road P Loading Rates

As discussed in our October 1, 2018 submittal, a road centerline dataset was derived to further classify road segments by road slope class, hydrologic connectivity (HC) class, and localized erosion potential. The road slope class and HC class data, developed using the linear MATS road segment centerline dataset, were used to further refine load allocation for paved road areas within the TS4. A Microsoft Excel spreadsheet model was developed to summarize the TS4 paved roads miles and P base loads, and then to re-allocate the P base load first by roadway slope class (0 – 10% and >10%), then by high, moderate, or low degrees of hydrologic connectivity as reflected in the GIS inventory of loading factors and in frequent consultation with VTrans and VTDEC (Table 1).

The refinement of P base load assignment was completed by first converting the P loading rates from kg/acre-year to kg/mile-year to match the MATS road segment centerline dataset, then by using the Solver add-in functionality in Microsoft Excel. Solver finds an optimal (maximum or minimum) value for a formula in one cell—called the objective cell—subject to constraints, or limits, on the values of other formula cells on a worksheet. Solver works with a group of cells, called decision variables or simply variable cells, which are used in computing the formulas in the objective and constraint cells. Solver adjusts the values in the decision variable cells to satisfy the limits on constraint cells and produce the desired result for the objective cell.

Loading rates for each slope class were determined by applying Solver to each SWAT drainage basin independently. The objective function was the difference between the total load per drainage basin calculated using the solved loading rates and the TS4 paved roads base load, where the goal was that this difference be 0. This resulted in optimal slope class loading rates that ensured the resulting calculated loads matched the total paved roads P loads for each SWAT drainage basin that were agreed upon by VTrans and VTDEC in March 2018. It was expected, and proved to be true, that >10% slope segments received a higher loading rate than 0-10% slope segments.

Loading coefficients were then applied to the calculated slope class loading rates for each of three HC classes, such that slope class loading rates were multiplied by the HC-specific loading coefficient to account for the impact of connectivity. Loading coefficients were set to 1.0 originally, then optimal values were solved for by using a similar objective function as for slope class. This was done first at the Lake Champlain Basin level, such that a single set of loading coefficeints was obtained which could be applied across all Lake segments and SWAT drainage areas. The resulting coefficients were 1.30 for highly hydrologically connected road segments, 0.84 for moderately hydrologically connected segments, and 0.61 for road segments with low hydrologic connectivity. While this method resulted in equivalent paved roads P base loads at the Lake Champlain Basin level, the calculated base loads at the SWAT drainage area level did not match those agreed upon by VTrans and VTDEC in March 2018.

The Solver routine was thus run again at the SWAT drainage area level, such that a unique set of loading coefficients was obtained for each drainage basin. The result of solving for unique sets of loading coefficients at the SWAT drainage level is illustrated in a box-and-whiskers plot in Figure 2. The average results for the loading coefficients were very similar to those obtained at the Lake Champlain Basin level. An average loading rate coefficient of 1.31 was derived for the high HC class, 0.87 for the moderate HC class, and 0.63 for the low HC class, respectively. The SWAT drainage area-specific loading coefficients were similar, with limited variation across the basin (Figure 2) – and the drainage area-specific coefficients ensured that again the resulting P base load for paved roads matched the initial base load allocation for each individual SWAT drainage area.

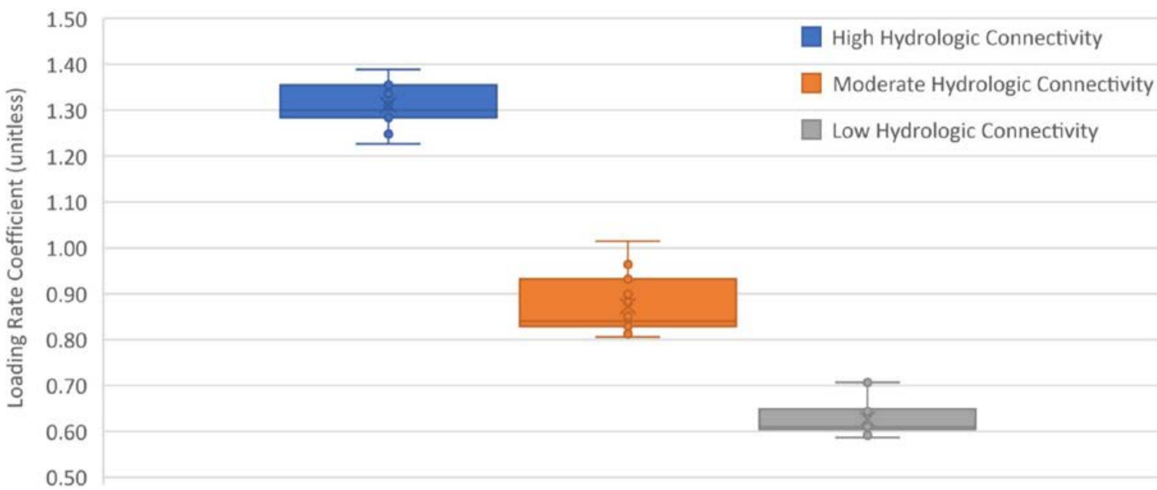


Figure 2.Comparison of paved roads P loading coefficients by SWAT drainage area and hydrologic connectivity class.

The resulting distribution of loading rates for paved roads listed in Table 1 by combined slope class and hydrologic connectivity class is summarized for all drainage areas in the TS4 PCP area using a box-and-whiskers plot in Figure 3. Developed lands P loading rates as provided by VTDEC are shown on the left-hand side of this figure, while the results of application of the paved roads loading rate coefficients are shown on the right-hand side. The resulting distribution maintains the P loading rates for paved roads in a range consistent with the loading rates for developed impervious and paved roads provided by VTDEC, and does not produce artificially low loading rates for paved roads areas that are effectively disconnected (low hydrologic connectivity) when compared to pervious land use loading rates (developed pervious and forest).

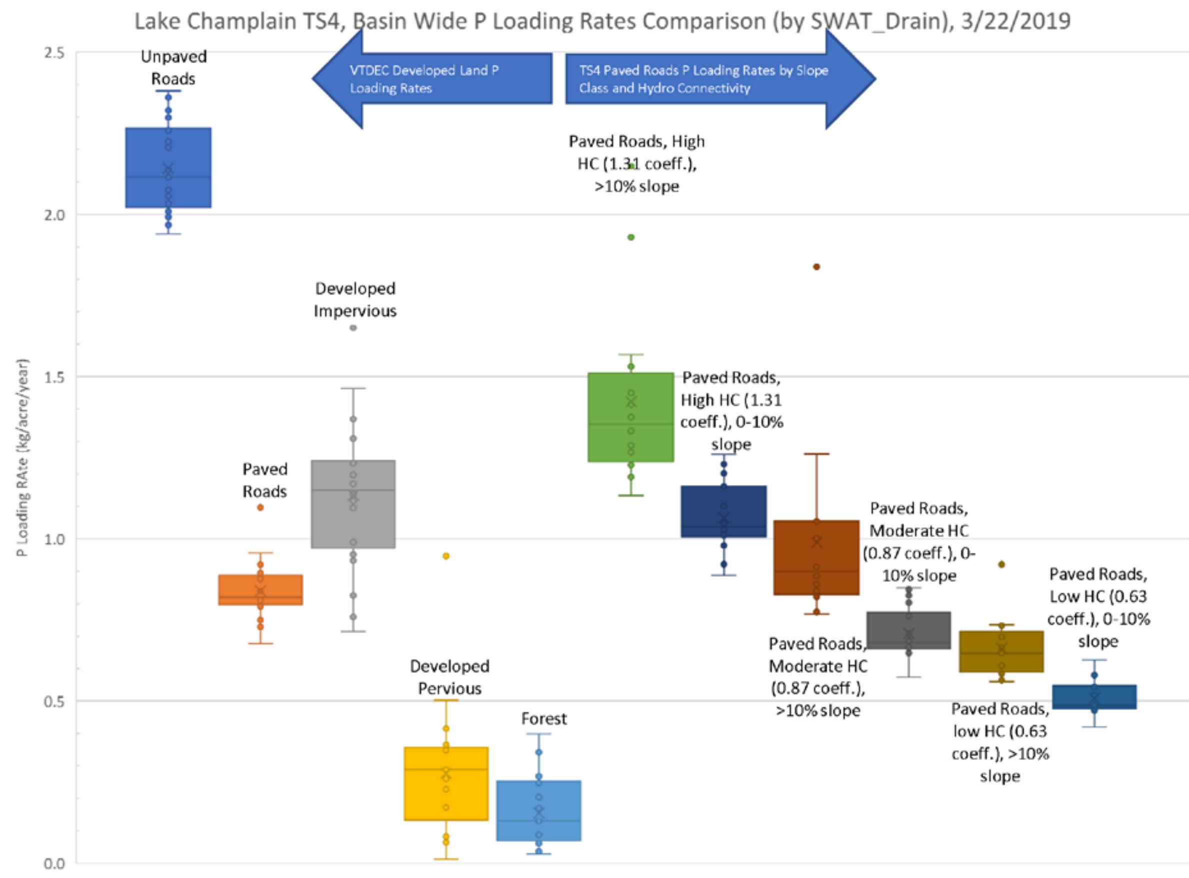


Figure 3. Comparison of VTDEC developed lands loading rates with VTrans paved roads loading rates by slope and hydrologic connectivity class.

Paired bar charts demonstrating the application of the coefficient-weighted P loading rates for paved roads on a Lake segment basis, as compared to the acreage those loading rates are applied to, are provided in Figure 4. As in Figure 3, acres and P base loads by for the entire TS4 PCP area by developed land use class are shown on the left side of each plot, while TS4 paved roads acres and P base loads only, by slope class and hydrologic connectivity class, are summarized on the right. Figure 4 demonstrates that, although relatively high loading rates are assigned to the steeply sloping road segments relative to the low-slope segments, these highest-risk portions of the TS4 road network represent a very small portion of the overall area and resulting P base load.

2. P Base Load Assignment to VTrans Linear Facilities (Paved Roads)

Once consensus was reached on the appropriate coefficients to assign to the paved roads loading rates based on slope class and hydrologic connectivity, the final loading rates from the Excel spreadsheet model, which were necessarily calculated based on the collective mileage of the linear MATS road segment dataset, were attributed to the paved road area polygon dataset originally provided by VTDEC. The MATS road segments were divided in portions ≤100 meters for assignment of loading factors and coefficients, while the VTDEC land use dataset is a polygon feature class dissolved by land use class and drainage area (SWAT drain). The VTDEC paved roads features were thus divided at the extent of each classified paved road segment, in order to assign the hydrologic connectivity and slope class attributes from each paved road line feature to the associated paved road polygon feature. The following steps were taken to complete the assignment of loading factors, rates, and coefficients from the MATS road segments feature dataset to the VTDEC paved roads polygon feature class:

1. Buffer the MATS road segment linear features by 60 feet on each side, with an end type of "FLAT" to divide each buffer at the extent of the divided road segments.
2. Intersect the 60-foot buffer polygon with areas from the VTDEC land cover dataset classified as paved road.
3. Identify and isolate areas of buffer overlap, primarily at the intersections of two or more MATS road segments, in order to remove duplicate paved road polygons.
4. Run custom Python script on overlapping, duplicate paved road areas, comparing the duplicate areas and keeping the highest HydroConnect class first, followed by the highest Slope class.
5. Merge the resulting overlap areas dataset back to the intersected paved roads dataset, with the output representing the MATS linear road segments as converted to TS4 paved road areas within the Lake Champlain basin.

2.1 Assessment of Non-VTrans Managed Paved Road Areas Within the VTrans Right-of-Way

When the paved road polygon features were created using the methodology above, approximately 48 acres classified as paved road and included in the paved roads area and base load submitted to VTDEC on March 27, 2018 were not captured. Some of these locations were a result of the buffering process and could be rectified simply. Larger areas, however, represented locations that were either misclassified as VTrans paved road areas, or areas where MATS road segments were missing from the VTrans paved road areas. The following steps were taken to analyze the discrepancies and determine whether each represented VTrans paved road areas:

1. Isolate the paved road areas located within the TS4, but which had no corresponding MATS linear feature, to a single dataset.
2. Using the VTrans managed "VT_Roads_Centerline" dataset, identify missing paved road areas which did not contain a road centerline designated as a VTrans managed road (US Highway, Interstate Highway, State Highway).
3. Isolate areas identified in Step 2 into a single dataset to retain relevant information and remove from the missing areas dataset.

4. The remaining missing areas represent portions of paved road areas managed by VTrans, but not which are not represented within the MATS road segment dataset.

The remaining paved roads areas were attributed appropriate hydrologic connectivity and slope class attributes as follows:

1. Areas smaller than 10 meters in road length were assigned the attributes of adjoining paved road areas.
2. Areas larger than 10 meters in road length were subjected to the same processing steps used to initially attribute hydrologic connectivity and slope classes to the MATS road segments.
3. The missing areas were merged with the master VTDEC paved road area polygon feature class, resulting in an updated dataset of all VTrans paved road areas containing the necessary attributes to allocate the phosphorus base load for paved roads.

The TS4 paved road area for the Lake Champlain Basin was adjusted to reflect the removal of areas which were previously misclassified. A total of 30.86 acres was removed from paved road areas within the TS4, changing the total acreage of paved road areas from the initial calculation of 5,904.02 acres to 5,873.17 acres. These changes are summarized in Table 1, and an updated version of draft acres and phosphorus base loads originally presented in Tables 1 and 2 of our March 27, 2018 submittal is included as Table 2. Changes to the paved roads acres and base loads for paved roads described in this memo are highlighted, as were changes from the acres and loads originally provided by VTDEC in January 2018.

3. Updates to the GIS Inventory of Loading Factors

Updates to the GIS inventory of loading factors are being delivered as an Esri File Geodatabase (v.10.5.1) with feature classes representing loading factors and loading rate coefficients within the TS4. The geodatabase is available at the following download link:

https://stoneenvironmentalvt-my.sharepoint.com/:u:/g/personal/amym_stone-env_com/EafG_oX7OrVFvTLc8vhvmlMBSdFLKvI437LgHQQRWsFbgQ?e=s3mIMu

Only those feature classes delivered in the October 1, 2018 submittal of the loading factors inventory associated with paved roads were updated and included in this GIS deliverable as described below.

Paved roads polygons used to allocate load across the TS4 are included in the VTrans_landuses feature class and associated attributes:

- Attribute: LU_Class_TS4 = "Paved Roads_LowSlope_HighHC"
- Attribute: LU_Class_TS4 = "Paved Roads_HighSlope_HighHC"
- Attribute: LU_Class_TS4 = "Paved Roads_LowSlope_ModHC"
- Attribute: LU_Class_TS4 = "Paved Roads_HighSlope_ModHC"
- Attribute: LU_Class_TS4 = "Paved Roads_LowSlope_LowHC"
- Attribute: LU_Class_TS4 = "Paved Roads_HighSlope_LowHC"

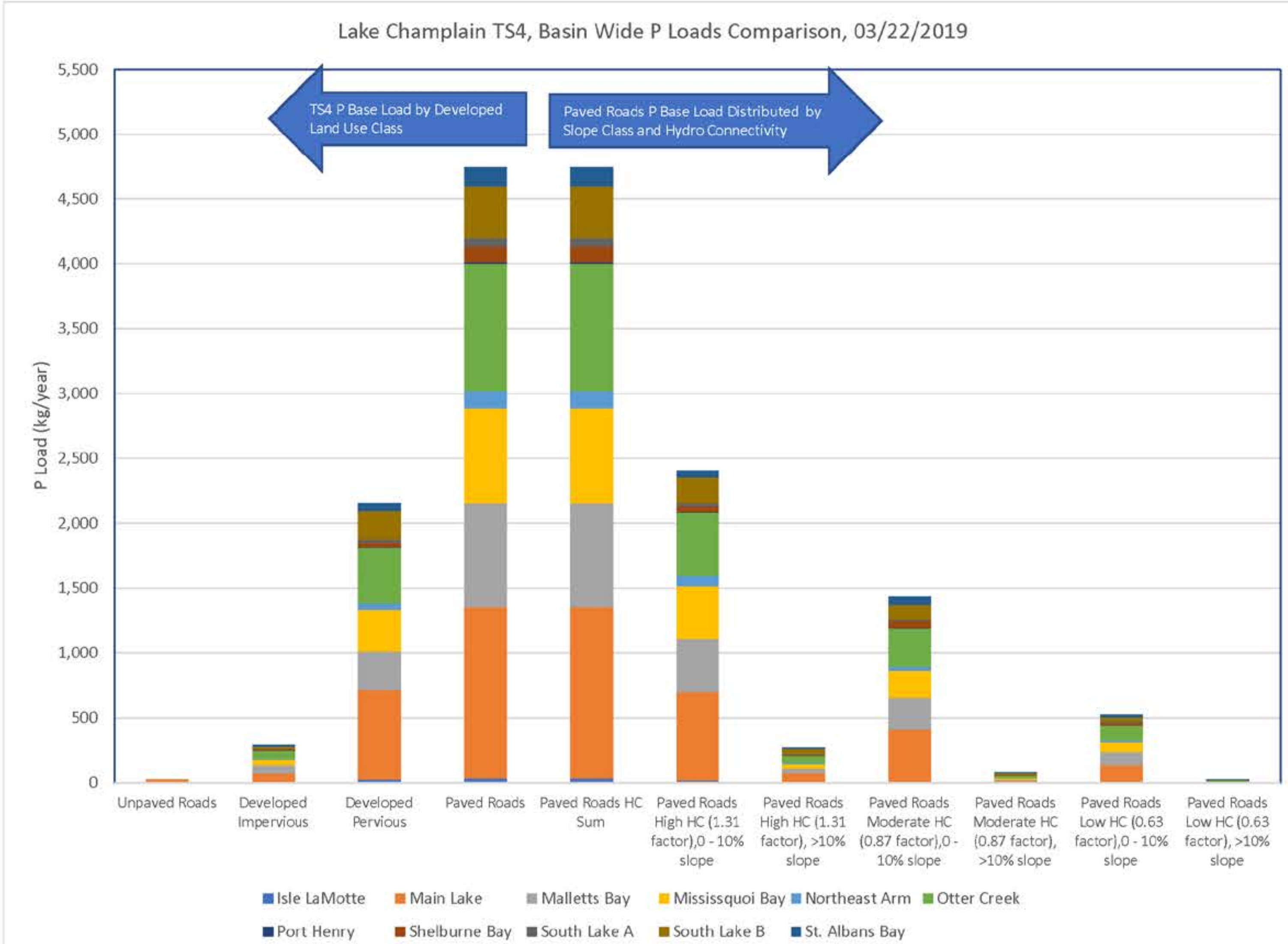
The VTrans_MATS_PCP_RdSegments feature class, as updated during development of the loading coefficients described in this memo, is also included.

Table 1: Phosphorus Load Allocation Spreadsheet Model - Paved Roads Only

														High Hydrologic Connectivity					Moderate Hydrologic Connectivity					Low Hydrologic Connectivity				
		TMDL Base Loads, March 2018		*TMDL Base Loads, March 2019*		*Road Slope*	*Acres and Road Miles by Slope Class*			*Loading Rates and Load by Slope Class*				*Hydro Bisect, Hydro Parallel, River Cooridor, Hydro Intermittent Bisect*					*Hydro Intermittent Parallel, Hydro Storm, Hydro SCI*					*Low Hydrologic Connectivity*				
Lake Segment	**Drainage Area (SWAT_Drain)**	**TS4 Paved Roads Area**	**TS4 Paved Roads Base Load[1] (kg/yr)**	**TS4 Paved Roads Area**	**TS4 Paved Roads Base Load[2] (kg/yr)**	**Slope Class**	**Area per Slope Class**	**Road Miles per Slope Class**	**Total Road Miles**	**Loading Rate for Paved Roads[3]**	**Loading Rate for Paved Roads[4]**	**Load Per Slope Class**	**Calculated TS4 Paved Roads Base Load**	**Acres**	**Miles**	**L.R.[4]**	**L.R.[4]**	**Base Load**	**Acres**	**Miles**	**L.R.[4]**	**L.R.[4]**	**Base Load**	**Acres**	**Miles**	**L.R.[4]**	**L.R.[4]**	**Base Load**
		(acres)	**(kg/yr)**	**(acres)**	**(kg/yr)**	**(%)**	**(ac)**	**(mi)**	**(mi)**	**(kg/mi-yr)**	**(kg/ac-yr)**	**(kg/yr)**	**(kg/yr)**	**(ac)**	**(mi)**	**(kg/mi-yr)**	**(kg/ac-yr)**	**(kg/yr)**	**(ac)**	**(mi)**	**(kg/mi-yr)**	**(kg/ac-yr)**	**(kg/yr)**	**(ac)**	**(mi)**	**(kg/mi-yr)**	**(kg/ac-yr)**	**(kg/yr)**
Isle LaMotte	Isle La Motte Direct Drainage	47.83	34.85	46.93	34.19	SC 1: 0 - 10%	43.20	11.3	12.3	2.698	0.703	30.39	34.19	20.9	6.0	3.41	0.89	18.53	15.0	3.4	2.20	0.57	8.59	7.4	1.8	1.61	0.42	3.09
						SC 2: >10%	3.73	1.0		3.650	1.020	3.80		2.3	0.7	4.61	1.29	3.00	0.6	0.2	2.98	0.83	0.50	0.8	0.2	2.18	0.61	0.49
Main Lake	Main Lake Direct Drainage	19.73	17.29	19.61	17.19	SC 1: 0 - 10%	19.59	3.8	3.8	4.522	0.876	17.15	17.19	3.2	0.9	6.00	1.16	3.76	15.0	2.6	4.36	0.84	12.65	1.4	0.2	2.81	0.54	0.74
						SC 2: >10%	0.02	0.005		6.874	1.908	0.03		0.0	0.0	9.12	2.53	0.00	0.02	0.005	6.63	1.84	0.03	0.0	0.0	4.27	1.18	0.00
Main Lake	Winooski River	1,637.74	1,314.13	1,625.51	1,304.31	SC 1: 0 - 10%	1,543.20	346.2	365.8	3.521	0.787	1,214.26	1304.31	665.3	151.2	4.56	1.02	677.30	600.2	130.2	2.94	0.66	394.18	277.7	64.9	2.14	0.48	132.77
						SC 2: >10%	82.31	19.6		4.695	1.094	90.06		53.2	11.7	6.07	1.42	75.29	21.8	5.5	3.92	0.91	19.89	7.3	2.4	2.85	0.66	4.88
Malletts Bay	Lamoille River	854.33	692.11	851.18	689.56	SC 1: 0 - 10%	814.64	196.6	205.8	3.338	0.805	655.67	689.56	371.3	90.4	4.29	1.03	383.77	280.9	67.7	2.77	0.67	187.40	162.4	38.5	2.01	0.49	78.90
						SC 2: >10%	36.55	9.2		3.690	0.927	33.89		28.3	7.0	4.74	1.19	33.71	5.6	1.5	3.06	0.77	4.32	2.6	0.7	2.23	0.56	1.46
Malletts Bay	Malletts Bay Direct Drainage	163.06	110.33	162.27	109.80	SC 1: 0 - 10%	158.20	32.3	33.1	3.294	0.673	106.43	109.80	31.1	6.3	4.51	0.92	28.69	81.0	16.5	3.34	0.68	55.27	46.1	9.6	2.33	0.48	21.90
						SC 2: >10%	4.07	0.7		4.501	0.828	3.37		1.8	0.3	6.16	1.13	2.04	2.3	0.5	4.57	0.84	1.89	0.0	0.023	3.18	0.58	0.01
Missisquoi Bay	Missisquoi Bay Direct Drainage	104.24	85.21	103.00	84.19	SC 1: 0 - 10%	97.10	28.1	29.5	2.790	0.804	78.11	84.19	43.0	11.6	3.61	1.04	44.73	35.8	10.7	2.33	0.67	24.00	18.3	5.7	1.69	0.49	8.93
						SC 2: >10%	5.90	1.4		4.411	1.031	6.08		3.6	0.8	5.70	1.33	4.83	1.2	0.3	3.68	0.86	1.00	1.1	0.3	2.68	0.63	0.69
Missisquoi Bay	Missisquoi River	811.33	653.86	807.14	650.48	SC 1: 0 - 10%	772.05	187.4	196.2	3.294	0.799	617.00	650.48	349.9	85.9	4.24	1.03	359.76	279.9	67.4	2.73	0.66	185.56	142.2	34.1	1.99	0.48	68.70
						SC 2: >10%	35.09	8.9		3.782	0.954	33.48		21.5	5.5	4.86	1.23	26.35	10.5	2.6	3.14	0.79	8.34	3.1	0.8	2.29	0.58	1.78
Northeast Arm	Northeast Arm Direct Drainage	160.33	131.35	159.51	130.68	SC 1: 0 - 10%	152.76	32.9	34.4	3.730	0.805	122.89	130.68	82.4	17.8	4.57	0.99	81.33	41.7	8.9	3.00	0.65	27.01	28.7	6.3	2.19	0.47	13.51
						SC 2: >10%	6.76	1.4		5.488	1.153	7.79		5.6	1.1	6.73	1.41	7.91	0.5	0.2	4.42	0.93	0.49	0.6	0.1	3.22	0.68	0.42
Otter Creek	Lewis Creek	37.31	31.86	37.30	31.85	SC 1: 0 - 10%	36.93	9.2	9.2	3.440	0.852	31.48	31.85	15.3	3.9	4.45	1.10	16.80	17.6	4.2	2.86	0.71	12.44	4.1	1.1	2.09	0.52	2.14
						SC 2: >10%	0.36	0.1		4.323	1.005	0.37		0.36	0.08	5.59	1.30	0.47	0.0	0.0	3.59	0.84	0.00	0.0	0.0	2.63	0.61	0.00
Otter Creek	Little Otter Creek	72.65	69.53	72.56	69.44	SC 1: 0 - 10%	68.44	14.6	15.7	4.418	0.944	64.60	69.44	20.9	4.7	5.90	1.26	26.38	37.0	7.8	3.97	0.85	31.42	10.5	2.2	2.77	0.59	6.20
						SC 2: >10%	4.12	1.1		4.340	1.174	4.83		2.2	0.6	5.80	1.57	3.44	1.8	0.5	3.90	1.06	1.95	0.1	0.02	2.72	0.73	0.06
Otter Creek	Otter Creek	1,068.57	874.16	1,063.99	870.41	SC 1: 0 - 10%	987.01	227.9	250.9	3.498	0.807	796.13	870.41	414.5	96.1	4.59	1.06	438.79	364.5	82.0	2.98	0.69	250.08	208.1	49.8	2.15	0.50	103.39
						SC 2: >10%	76.98	23.0		3.228	0.965	74.29		40.1	11.8	4.24	1.27	50.74	24.1	7.1	2.75	0.82	19.80	12.8	4.1	1.99	0.59	7.61
Otter Creek	Otter Creek Direct Drainage	7.35	6.48	7.35	6.49	SC 1: 0 - 10%	7.35	2.3	2.3	2.879	0.882	6.49	6.49	2.5	0.8	3.92	1.20	3.05	2.9	0.9	2.62	0.80	2.31	1.9	0.6	1.89	0.58	1.12
						SC 2: >10%	0.00	0.0			0.000	0.00		0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00
Port Henry	Port Henry Direct Drainage	15.33	13.71	15.29	13.68	SC 1: 0 - 10%	15.09	4.1	4.2	3.295	0.886	13.36	13.68	4.6	1.3	4.58	1.23	5.65	5.1	1.4	3.07	0.83	4.22	5.4	1.4	2.33	0.63	3.37
						SC 2: >10%	0.21	0.2		1.998	1.547	0.32		0.2	0.2	2.77	2.15	0.44	0.0	0.0	1.86	1.44	0.00	0.0	0.0	1.41	1.09	0.00
Shelburne Bay	Laplatte River	164.23	120.75	163.66	120.34	SC 1: 0 - 10%	156.66	32.1	33.4	3.520	0.720	112.86	120.34	43.4	8.4	4.78	0.98	42.53	78.6	16.5	3.31	0.68	53.17	34.6	7.2	2.30	0.47	16.30
						SC 2: >10%	7.01	1.3		5.700	1.067	7.48		3.7	0.6	7.75	1.45	5.32	2.3	0.5	5.35	1.00	2.30	1.0	0.2	3.73	0.70	0.73
South Lake A	South Lake A Direct Drainage	69.11	64.04	69.11	64.05	SC 1: 0 - 10%	61.56	18.1	20.4	2.933	0.865	53.23	64.05	23.1	6.9	3.95	1.17	26.94	20.2	6.0	2.59	0.76	15.41	18.2	5.2	1.89	0.56	10.13
						SC 2: >10%	7.56	2.2		4.860	1.431	10.82		3.6	1.0	6.55	1.93	6.89	2.9	0.9	4.28	1.26	3.69	1.1	0.3	3.13	0.92	0.98
South Lake B	Mettawee River	102.55	84.43	102.55	84.43	SC 1: 0 - 10%	93.24	25.3	28.3	2.991	0.810	75.54	84.43	45.9	12.2	3.73	1.01	46.36	28.4	8.0	2.43	0.66	18.71	18.9	5.1	1.77	0.48	9.08
						SC 2: >10%	9.31	3.1		2.896	0.954	8.89		7.7	2.6	3.61	1.19	9.17	0.9	0.3	2.35	0.77	0.73	0.7	0.2	1.71	0.56	0.38
South Lake B	Poultney River	380.48	319.13	378.99	317.88	SC 1: 0 - 10%	332.30	74.9	88.2	3.584	0.806	267.84	317.88	143.8	33.3	4.60	1.03	148.74	134.3	29.0	2.96	0.67	89.41	54.3	12.7	2.17	0.49	26.44
						SC 2: >10%	46.70	13.3		3.811	1.072	50.04		27.4	7.4	4.89	1.38	37.73	12.9	3.9	3.15	0.89	11.46	6.3	2.0	2.30	0.65	4.10
St. Albans Bay	St. Albans Bay Direct Drainage	187.85	148.68	187.20	148.16	SC 1: 0 - 10%	177.46	39.2	40.8	3.529	0.773	137.16	148.16	50.4	11.2	4.78	1.05	52.76	90.6	20.0	3.29	0.72	65.34	36.5	8.0	2.29	0.50	18.28
						SC 2: >10%	9.73	1.6		7.030	1.130	11.00		4.5	0.8	9.53	1.53	6.82	3.4	0.5	6.56	1.05	3.60	1.9	0.3	4.56	0.73	1.36
TOTAL		**5,904.02**	**4,771.90**	**5,873.17**	**4,747.13**		**5,873.17**	**1,374.4**	**1,374.4**			**4,747.13**	**4,747.13**	2,537.5	600.8			2,680.02	2,219.6	507.5			1,517.18	1,116.1	266.1			549.93
														Average Optimized Loading Coefficient:				**1.31**	**Average Optimized Loading Coefficient:**				**0.87**	**Average Optimized Loading Coefficient:**				**0.63**

References/Notes:

1. Columns G-H - Final acres and P base load for paved roads, excluding paved roads areas on VTrans Facilities, 03-27-2018 version.
2. Columns I-J - Acres and P base load for TS4 paved roads, 3-12-2019 update to remove portions of Paved Road area not owned or controlled by VTrans (total of 30.85 ac).
3. P loading rate for paved roads is an area-weighted loading rate for each SWAT_Drain, by slope class, for paved roads only: (loading rate*acres) / total road miles.
4. P loading rate (kg/ac-yr) back-calculated by converting optimized loading rate based on road miles to acres: (kg/mi-yr) * (miles/acres) = kg/ac-yr.



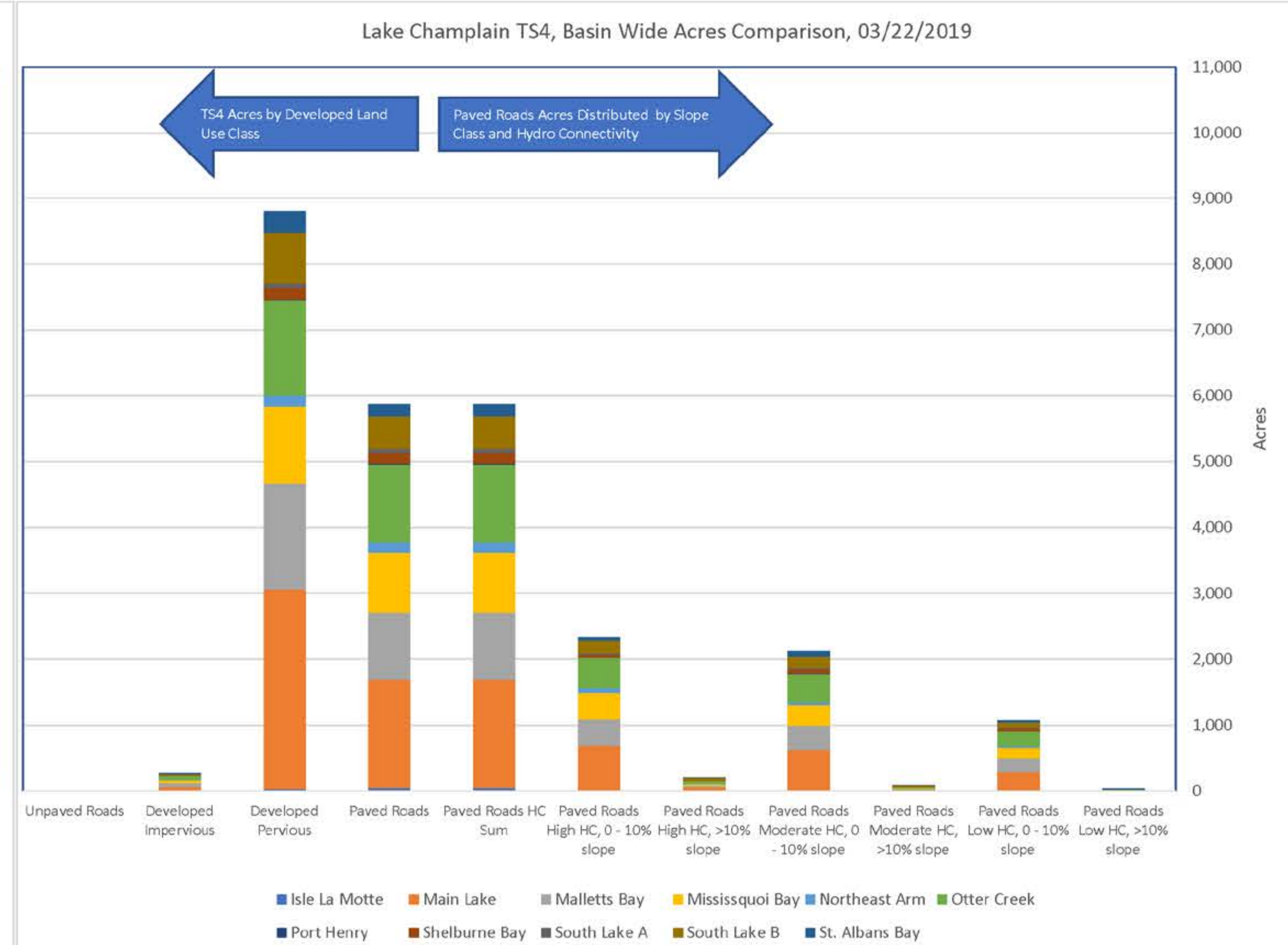


Figure 4. Summary of TS4 Acres and Phosphorus Base Loads by Lake segment

Table 2. Revised Acres and Phosphorus Base Loads for VTrans Linear Facilities and Right-of-Way (Roads)

			Area (acres)				Load (kg/yr)				
Lake Segment	SWAT_drain	Area_Type	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Developed Impervious	Paved Roads	Unpaved Roads	Developed Pervious	Total
Isle La Motte	Isle La Motte - DD	Road	2.29	46.93	0.00	37.56	1.74	34.19	0.00	27.37	63.30
Main Lake	Main Lake - DD	Road	1.04	19.61	0.00	35.36	0.97	17.19	0.00	3.35	21.51
Main Lake	Winooski River	Road	64.34	1625.51	12.30	2994.20	71.85	1304.31	27.94	690.19	2094.29
Malletts Bay	Lamoille River	Road	49.29	851.18	0.00	1264.60	56.08	689.56	0.00	288.31	1033.95
Malletts Bay	Malletts Bay - DD	Road	7.38	162.27	0.00	339.71	6.09	109.80	0.00	4.09	119.98
Mississquoi Bay	Mississquoi Bay - DD	Road	5.67	103.00	0.00	133.22	4.05	84.19	0.00	55.27	143.51
Mississquoi Bay	Mississquoi River	Road	32.51	807.14	0.00	1034.21	37.37	650.48	0.00	269.70	957.54
Northeast Arm	Northeast Arm - DD	Road	5.86	159.51	0.00	164.01	6.70	130.68	0.00	48.88	186.27
Otter Creek	Lewis Creek	Road	3.58	37.30	0.00	47.81	3.55	31.85	0.00	13.87	49.27
Otter Creek	Little Otter Creek	Road	4.75	72.56	0.00	68.28	5.85	69.44	0.00	24.96	100.25
Otter Creek	Otter Creek	Road	49.06	1063.99	0.00	1308.92	56.42	870.41	0.00	381.66	1308.50
Otter Creek	Otter Creek - DD	Road	0.54	7.35	0.00	20.40	0.59	6.49	0.00	7.10	14.18
Port Henry	Port Henry - DD	Road	0.75	15.29	0.00	8.10	0.93	13.68	0.00	4.08	18.69
Shelburne Bay	LaPlatte River	Road	10.15	163.66	0.00	189.58	9.66	120.34	0.00	32.61	162.62
South Lake A	South Lake A - DD	Road	1.94	69.11	0.00	61.30	2.54	64.05	0.00	22.87	89.46
South Lake B	Mettawee River	Road	4.82	102.55	0.00	87.60	5.77	84.43	0.00	25.35	115.55
South Lake B	Poultney River	Road	12.01	378.99	0.00	688.04	14.04	317.88	0.00	198.69	530.61
St. Albans Bay	St. Albans Bay - DD	Road	9.90	187.20	0.00	321.73	12.28	148.16	0.00	57.14	217.58
Total			265.89	5873.17	12.30	8804.61	296.49	4747.13	27.94	2155.49	7227.04

Appendix D: Progress Report on Phosphorus Control Plan, October 1, 2019 submittal

STONE ENVIRONMENTAL

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October 1, 2019

MEMO

To: Emily Schelley, Vermont DEC
Jenn Callahan, VTrans

From: Amy Macrellis, Warren Rich, Barb Patterson, and Peter Lazorchak

Stone Project No. 18-008-A
Subject: VTrans PCP – Submission of Progress Report on the Phosphorus Control Plan

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The story map available at https://arcg.is/0DS4LC0 summarizes the completed by Vermont DEC and VTrans, as supported by Stone, to develop Phosphorus Control Plans for the various transportation land uses included in the VTrans Phosphorus Control Plan (PCP) Area. Our submittal complies with the requirements specified in Subpart 9.2.C. of the *National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4),* effective November 27, 2017.

Previously, a GIS inventory of loading factors was developed by VTrans and Stone in consultation with Vermont DEC to first establish baseline phosphorus load[1] and next to determine other factors to refine load allocation[2]. This inventory and supporting datasets were utilized to develop coefficients of loading rates[3] for the Paved Roads portion of the baseline phosphorus load.

The story map linked above serves as VTrans's Progress Report submittal. It documents how VTrans is developing Phosphorus Control Plans (PCPs) that will result in the reduction of phosphorus loading from roads, rights-of-way, and facilities under the Agency's control by over 20% within the next 20 years (by June 17, 2036). It first summarizes what VTrans has already done to develop the framework for a basin-wide PCP, and then provides a road-map for how the agency intends to meet its goals – beginning with the submittal of a Generalized PCP to Vermont DEC in April 2020.

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[1] See technical memo titled *VTrans PCP – Evaluation of draft phosphorus base loads and load reduction numeric targets*, dated March 27, 2018
[2] See technical memo titled *VTrans PCP – Submission of GIS Files of Loading Factors*, dated October 1, 2018
[3] See technical memo titled *VTrans PCP – Submission of Coefficients for Phosphorus Loading Rates*, dated April 1, 2019

VTrans Lake Champlain Basin Phosphorus Control Plan

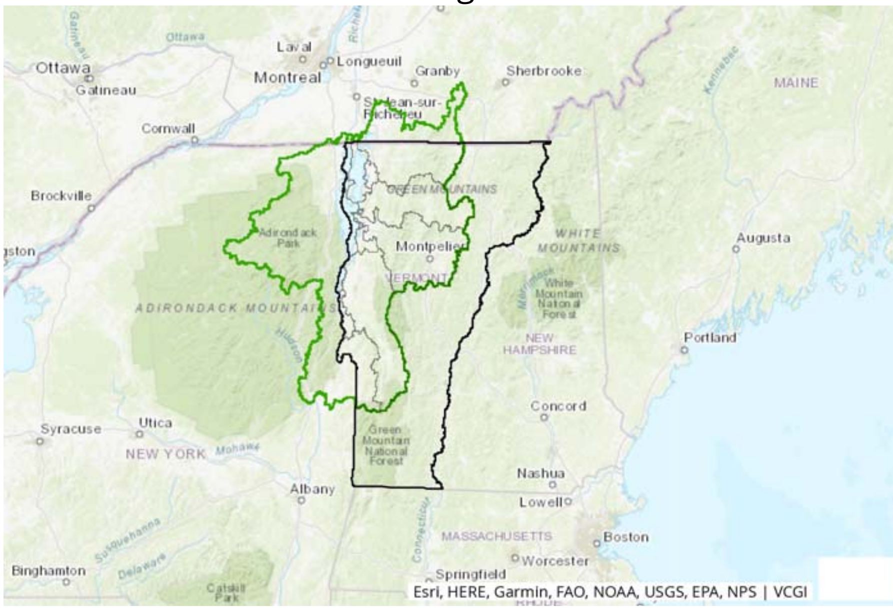
*This story was made with **Esri's Story Map Journal**.*
*Read the interactive version on the web at **https://arcg.is/0DS4LC0**.*

The Vermont Agency of Transportation (VTrans), through its **Maintenance Bureau** and **Pollution Prevention and Compliance Section**, is committed to maintaining compliance with a swiftly evolving variety of state and federal environmental regulations. The Vermont Agencies of Natural Resources (ANR) and Transportation have been working together for several years to develop and implement permitting programs, plans, policies, and designs to comply with the **Lake Champlain Phosphorus Total Maximum Daily Load (TMDL)**, finalized by the U.S. EPA on June 17, 2016.

This story map documents how VTrans is developing Phosphorus Control Plans (PCPs) that will result in the reduction of phosphorus loading from roads, rights-of-way, and facilities under the Agency's control by over 20% within the next 20 years (by June 17, 2036). It first summarizes what VTrans has already done to develop the framework for a basin-wide PCP, and then provides a road-map for how the agency intends to meet its goals – beginning with the submittal of a Generalized PCP to ANR in the spring of 2020.

[Tips for navigation: Scrolling down on left brings new panel; clicking on a map on right will provide information about that feature.]

VTrans Stormwater Permitting



Lake Segments

TS4 Extent - State of Vermont

Lake Champlain Basin Boundary

As part of its **Phase 1 Implementation Plan** developed in response to the Lake Champlain Phosphorus TMDL, the Vermont ANR, in December 2016, issued the **National Pollutant Discharge Elimination System (NPDES) General Permit 3-9007 for Stormwater Discharges from the State Transportation Separate Storm Sewer System (TS4)** to VTrans. The permit was effective November 27, 2017. The TS4 General Permit is the primary regulation ensuring that stormwater discharged from VTrans owned or controlled impervious surfaces is managed according to State water quality policy. It combines VTrans's compliance obligations from several permit programs, including the Municipal Separate Storm Sewer System (MS4) General Permit and its associated Flow Restoration Plan and Phosphorus Control Plan requirements, Multi-Sector General Permit (MSGP), and Operational (post-construction) Stormwater Permit.

TS4 Permit Requirements for Phosphorus Control Planning

Section 9.2 of the TS4 permit requires VTrans to develop and implement Phosphorus Control Plans (PCPs), in phases, that will identify and document a suite of best management practices (BMPs) that will be able to achieve reductions in the amount of phosphorus in stormwater discharges in each of 11 Lake segments, as required by the TMDL. That plan must, at minimum, estimate the area (acres or road miles) to be treated, and the extent and type of BMPs that will be implemented to meet the entire P load reduction.

VTrans is required to meet a series of interim performance milestones that first culminate in the completion of a conceptual PCP for the entire TS4 within the Lake Champlain Basin by April 1, 2020, and creation of the first of several four-year implementation plans by October 1, 2020. Below is the compliance schedule from Section 9.2.C of the permit, outlining the Agency's progress in meeting these milestones. The results of each of the milestone submittals are described below.

- **January 1, 2018: Submit NOI and SWMP. (link available only in online story)**
- **April 1, 2018: Establish the baseline phosphorus load and reductions needed. (link available only in online story)**
- **October 1, 2018: Complete GIS inventory of phosphorus loading factors. (link available only in online story)**
- **April 1, 2019: Complete development of coefficients of loading rates. (link available only in online story)**
- **October 1, 2019: Submit progress report on Phosphorus Control Plan. (link available only in online story)**
- *April 1, 2020: Complete generalized statewide Phosphorus Control Plan.*
- *October 1, 2020: Submit 1st 4-year implementation plan (Phase I).*
- *April 1, 2021 and every 6 months thereafter (April 1st and October 1st): Submit semi-*

annual report on Phosphorus Control Plan implementation.

- *October 1, 2024: Submit 2nd 4-year implementation plan (Phase II).*
- *October 1, 2028: Submit 3rd 4-year implementation plan (Phase III).*
- *October 1, 2032: Submit 4th 4-year implementation plan (Phase IV).*
- *No later than June 17, 2036 Complete implementation of the approved PCP.*

Progress submittal: TS4 Permit Notice of Intent and Stormwater Management Plan (January 1, 2018)

VERMONT AGENCY OF TRANSPORTATION TS4 STORMWATER MANAGEMENT PROGRAM (SWMP)

Attachment F Incorporation of Previously Permitted Stormwater Systems
December 5, 2017

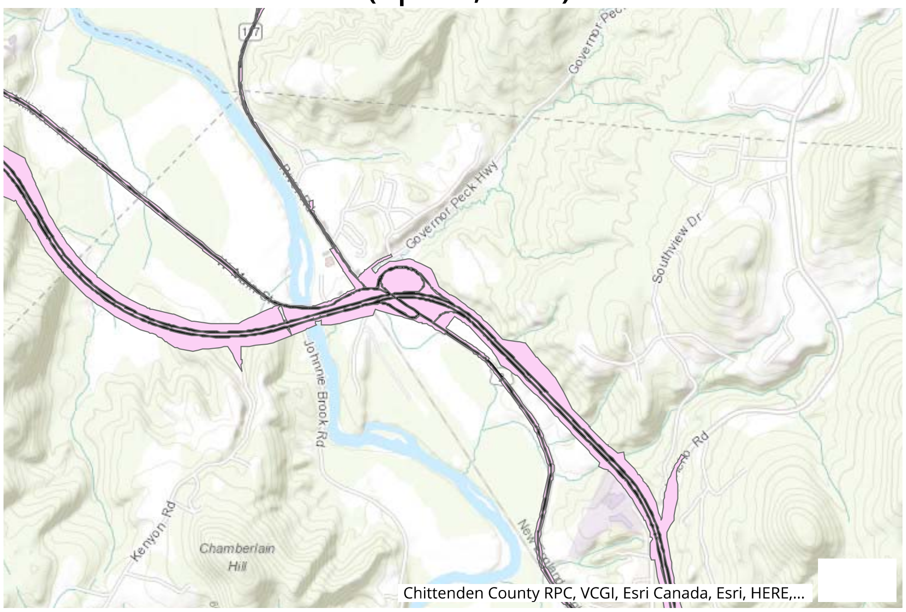
Project Name	Location	Stormwater Permit	BMP Type(s)
Alburg-Swanton Missisquoi Bay Bridge	Alburg-Swanton	6070-9010	grass/stone swales, scuppers
Barre Town HES 026-1(38) (roundabout)	Barre Town	4969-9010	catch basins, culverts, dry swale, flow splitter
Berlin STPG SGNL(40)	Berlin	7066-INDS	grass/stone swales
Bennington D1 Garage (TRANSFERRED TO VTrans)	Bennington	3361-9010	culverts, detention basins, swales
Bennington-Hoosick DPI 0146(1) C/3 & C/4	Bennington-Hoosick	3156-9010.R	vegetated/stone swales, stone check dams, sedementation trap, culverts, deten basins,
Brandon D3 Maint Garage (Arnold Rd)	Brandon	3768-9010.R	vegetated swales, detention basin
Bristol STP BRF 021-1(15)	Bristol	5221-9010	grass treatment channels, disconnection
Burke RS 0269(3) Bridge Replacement	Burke	3906-9010.R	grass/stone swales, DIs, culverts
Cabot-Danville FEGC F028-3(26) C1	Cabot-Danville	4022-INDS.R	grass channels
Cambridge BRF 027-1(4) & STP 030-2(27)	Cambridge	4765-9010	grass channels, site balancing
Cambridge BRF 030-2(12)	Cambridge	3885-9010.R	DI, stone lined swale, sheet flow
Chester BRF-F 016-1(3)	Chester	3905-9010.R	catch basins, culverts
Colchester D5 "Fort" Site Redevelopement	Colchester	6363-INDS.R	grass channels, micropool extended-detention pond, culverts
Colchester HES 0281(28)	Colchester	7427-INDS	sheet flow, grass channel
Colchester Park & Ride and Maintenance Facility	Colchester	3012-9010.R	wet detention basin, rain garden (not part of permit)
Cornwall [illegible]	Cornwall	[illegible]	sheet flow, stone lined swales, pre-treatment chamber, grass treatment channe

VTrans submitted its <u>Notice of Intent</u> and <u>Stormwater Management Program (SWMP)</u> document, outlining its expected actions and commitments for compliance with Vermont water quality policies and regulations over the next five years, to ANR in December 2017.

VTrans Lake Champlain Basin Phosphorus Control Plan

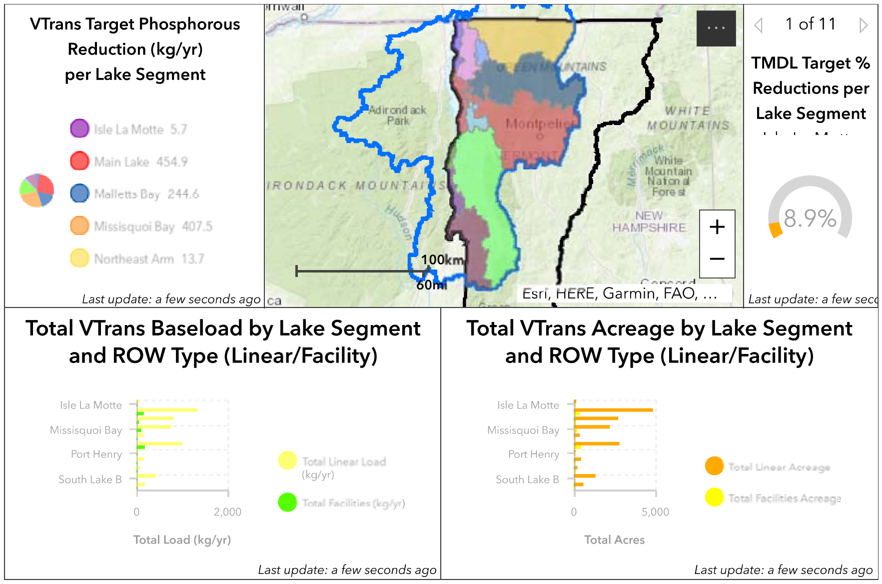
This story was made with ***Esri's Story Map Journal****.*
Read the interactive version on the web at ***https://arcg.is/0DS4LC0****.*

Progress Submittal: Establish the baseline phosphorus load and reductions needed. (April 1, 2018)



In order to establish the baseline phosphorus load and reductions needed, it was first necessary to develop GIS data defining the spatial extents and geographic coverage of the TS4 within the Lake Champlain Basin (LCB). The GIS data for TS4 extents were developed by VTrans and Stone in consultation with VTDEC. The spatial extents of linear facilities were derived based on the VTrans Managing Assets for Transportation Systems (MATS) database and include VTrans owned and maintained roads within the LCB. Right of way areas for linear facilities were derived using GIS data from VTrans, buffered road centerlines using minimum ROW widths and standard road class width where gaps existed within the VTrans data, and further manual edits to remove right of way areas maintained by private or municipal entities. The spatial extents for VTrans facilities, including airports, welcome centers, park and rides, gravel pits, and maintenance garages, were developed based on parcel data provided by VTrans. Stone digitized non-road impervious areas using 2011 impervious cover data from the Lake Champlain Basin Program, which was then updated and corrected using aerial imagery.

Base load and target reductions submittal continued



Once the extents of the TS4 within the LCB were determined, Vermont DEC extracted draft developed lands acreages and resulting draft phosphorus base loads from their existing land use-land cover dataset. The draft acreages and phosphorus base loads were broken down by lake segment, SWAT model drainage area, type of area (Road/linear facility or Parcel-based facility) and type of land use/land cover (Developed Impervious, Paved Road, Unpaved Road, and Developed Pervious).

Following detailed review of the draft acreages and base loads by both VTrans and Vermont DEC, the draft phosphorus base loads and target reductions provided by Vermont were adjusted to reflect the consensus revisions. The table below summarizes the resulting VTrans phosphorus base load and target reductions by Lake segment.

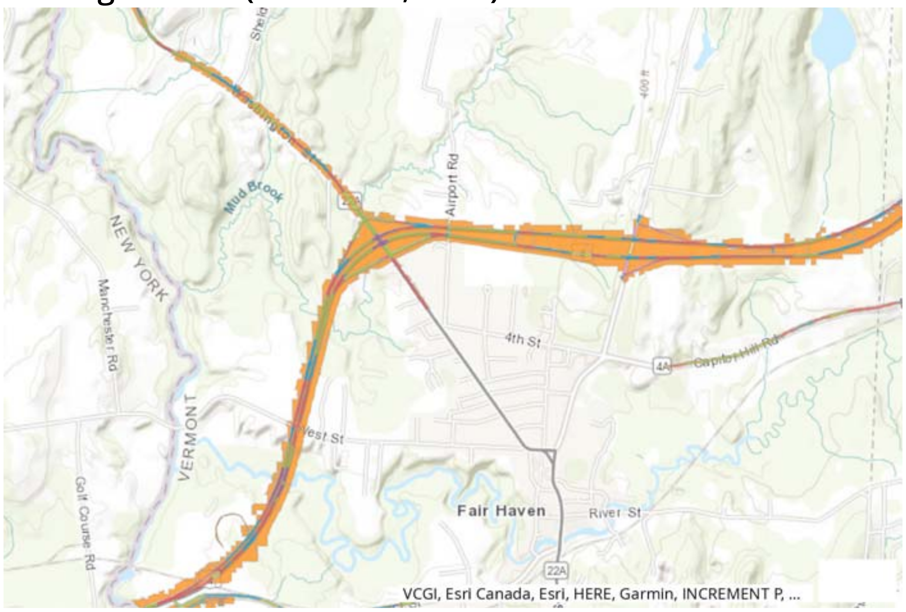
Click here to view the full dashboard

Lake Segment	Phosphorus Base Load (kg/yr)	TMDL Reduction Target	Target Phosphorus Reduction (kg/yr)
Isle La Motte	63.96	8.9%	5.69
Main Lake	2,251.96	20.2%	454.90
Malletts Bay	1,193.21	20.5%	244.61
Missisquoi Bay	1,191.45	34.2%	407.48
Northeast Arm	189.78	7.2%	13.66
Otter Creek	1,639.76	15.0%	245.96
Port Henry	18.72	7.6%	1.42
Shelburne Bay	167.67	20.2%	33.87
South Lake A	89.46	18.1%	16.19
South Lake B	655.90	21.1%	138.40
St. Albans Bay	225.22	21.7%	48.87
Total	7,687.09		1,611.05

VTrans Lake Champlain Basin Phosphorus Control Plan

*This story was made with **Esri's Story Map Journal**.*
*Read the interactive version on the web at **https://arcg.is/0DS4LC0**.*

Progress Submittal: Complete GIS inventory of phosphorus loading factors. (October 1, 2018)



VTrans Land Use with Total Load

- 3 - Paved Roads Moderate HC - Low Slope
- 5 - Paved Roads Low HC - Low Slope
- 1 - Paved Roads High HC - Low Slope
- 2 - Paved Roads High HC - High Slope
- Developed Pervious
- 4 - Paved Roads Moderate HC - High Slope
- 6 - Paved Roads Low HC - High Slope
- Developed Impervious
- Paved Roads - Facilities
- Unpaved Roads

The GIS inventory of loading factors was developed by VTrans in consultation with Vermont DEC to first establish the **baseline phosphorus load (link available only in online story)** and then to determine other factors to more accurately refine P load allocation for the TS4 across the Lake Champlain Basin (LCB). The loading factors that were considered to allocate load across the TS4 included:

- **Developed Impervious TS4 Extents (link available only in online story)**
  - Developed impervious areas are associated with non-road VTrans properties including airports, welcome centers, park and rides, gravel pits, and maintenance garages. These data are used to allocate P baseline load across the TS4 for Developed Impervious areas.
- **Paved Road TS4 Extents (link available only in online story)**
  - Paved roads include VTrans roads that have paved surfaces. Paved road areas were initially provided to VTrans by Vermont DEC. The Vermont DEC paved roads areas were used to allocate load across the TS4 for Paved Road areas. A road centerline dataset was derived to further classify VTrans road segments and to more closely refine allocation of the P baseline load for paved road areas within the TS4. MATS roads segments from VTrans were intersected with soil polygons and then divided into ~100m (or smaller) segments, and

each of these smaller segments was classified by road slope class, hydrologic connectivity class, and localized erosion potential.

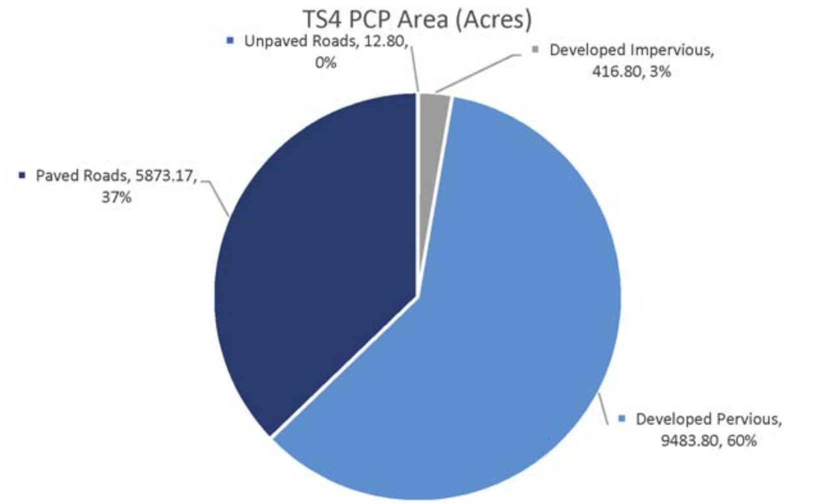
- **Slope Class (link available only in online story)**
  - Road slope was calculated based on LiDAR and classified based on whether the slope of the road segment fell above or below 10%.
- **Hydrologic Connectivity (link available only in online story)**
  - Each road segment was assigned hydrologic connectivity based on seven evaluation criteria:
    - Highly hydrologically connected: road segment intersects or is within 100 feet of an NHD Stream, Pond, or VSWI Wetland, or within a mapped River Corridor
    - Moderately hydrologically connected: Road segment intersects or is within 100 feet of additional intermittent streams (identified using a LiDAR-based Enhanced Hydrology Network); within 50 feet of piped stormwater infrastructure connected to an outfall within 500 feet of an NHD stream, pond, or VSWI wetland; or within 50 feet of any culvert in the Small Culvert Inventory (SCI)
    - Low hydrologic connectivity: If none of the above conditions applied, the road segment was considered to have low hydrologic connectivity.
- **Localized Erosion Potential (link available only in online story)**
  - The potential for localized erosion at each paved road segment was assessed and results were added to the line segment based on the following four criteria:
    - Road segment has steep slopes in the adjacent right-of way, and flow accumulation is mapped downslope of the road segment
    - Potential culvert erosion is recorded in the Small Culverts Inventory dataset
    - The guardrail inventory indicates curb board is present
    - There is evidence of a ditch upslope along the road segment.

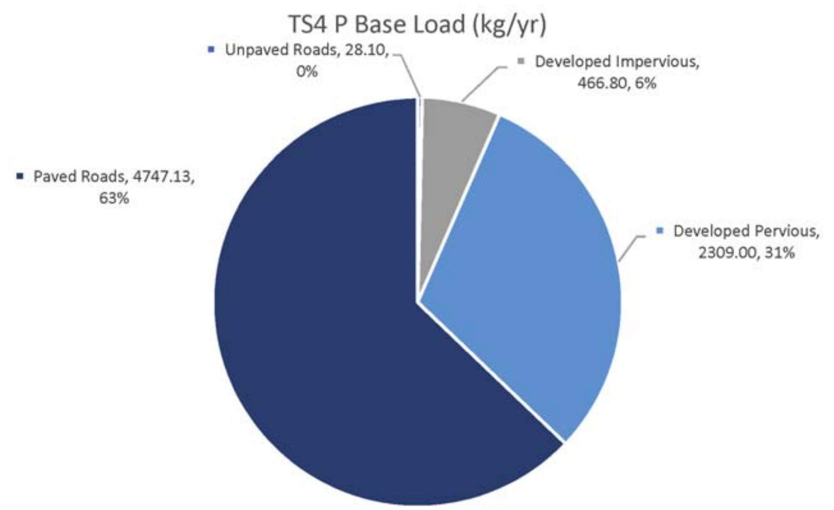
- **Unpaved Road TS4 Extents (link available only in online story)**
  - Unpaved roads include roads that have gravel surfaces. Unpaved road areas were defined by VTDEC using the 2011 land cover data from LCBP and VTrans ROW areas. These data are used to allocate the baseline P load across the TS4 for Unpaved Road areas.
- **Developed Pervious TS4 Extents (link available only in online story)**
  - Developed pervious areas include non-impervious, developed portions of both road ROW areas and VTrans parcels. The data were prepared by VTDEC using VTrans ROW, VTrans parcels, and 2011 Land Cover data. These data are used to allocate load across the TS4 for Developed Pervious areas.

VTrans Lake Champlain Basin Phosphorus Control Plan

*This story was made with **Esri's Story Map Journal**.*
*Read the interactive version on the web at **https://arcg.is/0DS4LC0**.*

Progress Submittal: Complete development of coefficients of loading rates (Subpart 9.2.A.3 - April 1, 2019)





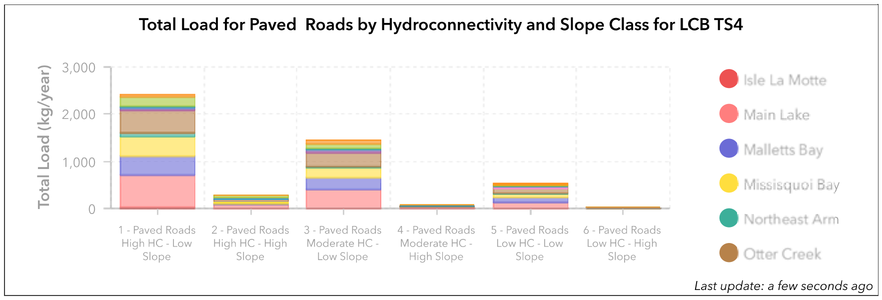
Following the development of the **GIS inventory of loading factors (link available only in online story)**, VTrans and Vermont DEC considered the development of loading rate coefficients for each of the four land use classes and associated P loading factors. The intent of the loading rate coefficients is to refine allocation of the P base load such that critical source areas – portions of the TS4 with the highest risk of contributing disproportionate P loads to surface waters – were assigned a proportionately higher portion of the P base load within each Lake segment. The chart at the right summarizes acres and P base load distribution by each of the four transportation-related land use classes across the entire Lake Champlain basin and PCP area.

60% (9,843 acres) of the TS4 area included in the PCP is classified as developed pervious, but this area only constitutes 31% of the phosphorus base load (2,309 kg/yr). This is substantial acreage, but compared to paved roads (which, though only about 40% of the total acres, constitute 63% of the P base load) it is a relatively minor and hard to treat portion of the P base load. Substantial uncertainty remains about how improvements to developed pervious, especially related to localized erosion fixes that also treat paved road runoff, would be credited. Ultimately, the localized erosion potential factors were retained, but coefficients were not developed to re-distribute P base load according to risk of localized erosion. This decision may be revisited as development of the basin-wide generalized PCP and lake segment-specific PCPs proceed.

Developed impervious areas and unpaved roads both represent small portions of the TS4 Phosphorus Control Plan area, both in terms of acreage and P base load. Thus, no coefficients were developed to refine distribution of these portions of the P base load.

Paved roads represent the highest proportion of the P base load. As demonstrated in the GIS inventory of loading factors, there is substantial variability between both slope class and level of hydrologic connectivity across the TS4 paved road network within the Lake Champlain basin. Loading coefficients were developed for the paved roads portion of the P base load, and that load was assigned to paved roads areas within each Lake segment and drainage area based on the slope class and degree of hydrologic connectivity of individual paved road segments.

Development of coefficients of loading rates continued



Click here to view the full dashboard

The paved roads inventory as refined by **road slope class, hydrologic connectivity class, and localized erosion potential (link available only in online story)** was used to further refine load allocation for paved road areas within the TS4. A spreadsheet model was developed to summarize the TS4 paved roads miles and P base loads, and then to re-allocate the P base load first by roadway slope class (0 – 10% and >10%), then by high, moderate, or low degrees of hydrologic connectivity in frequent consultation between VTrans and Vermont DEC.

Loading rates for each slope class were determined by applying the model to each SWAT drainage basin independently. This resulted in optimal slope class loading rates that ensured the resulting calculated loads matched the total paved roads P loads for each SWAT drainage basin that were agreed upon by VTrans and Vermont DEC in March 2018. The >10% slope segments received a higher loading rate than 0-10% slope segments.

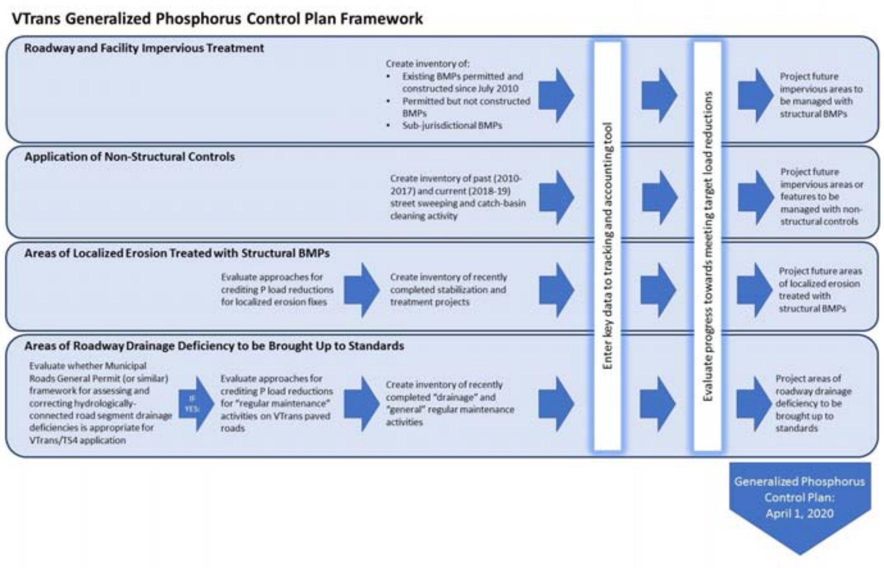
Loading coefficients were then applied to the calculated slope class loading rates for each of the three hydrologic connectivity classes, such that slope class loading rates were multiplied by the hydrologic-connectivity-class-specific loading coefficient to account for the impact of connectivity. Loading coefficients were set to 1.0 originally, then optimal values were solved for using the spreadsheet model. This was done first at the Lake Champlain Basin level, such that a single set of loading coefficients was obtained which could be applied across all Lake segments and SWAT drainage areas. While this method resulted in equivalent paved roads P base loads at the Lake Champlain Basin level, the calculated base loads at the SWAT drainage area level did not match those agreed upon by VTrans and Vermont DEC in March 2018. The model routine was thus run again at the SWAT drainage area level, such that a unique set of loading coefficients was obtained for each drainage basin. The average results for the loading coefficients were very similar to those obtained at the Lake Champlain Basin level. Average loading rate coefficients of 1.31 were derived for the high hydrologic connectivity class, 0.87 for the moderate hydrologic connectivity class, and 0.63 for the low hydrologic connectivity class, respectively.

Once consensus was reached on the appropriate coefficients to assign to the paved roads loading rates based on slope class and hydrologic connectivity, the final loading rates from the spreadsheet model, which were necessarily calculated based on the collective mileage of the linear MATS road segment dataset, were attributed to the paved road area polygon dataset originally provided by Vermont DEC.

VTrans Lake Champlain Basin Phosphorus Control Plan

This story was made with ***Esri's Story Map Journal****.*
Read the interactive version on the web at ***https://arcg.is/0DS4LC0****.*

Progress Submittal: Progress report on the Phosphorus Control Plan (October 1, 2019)

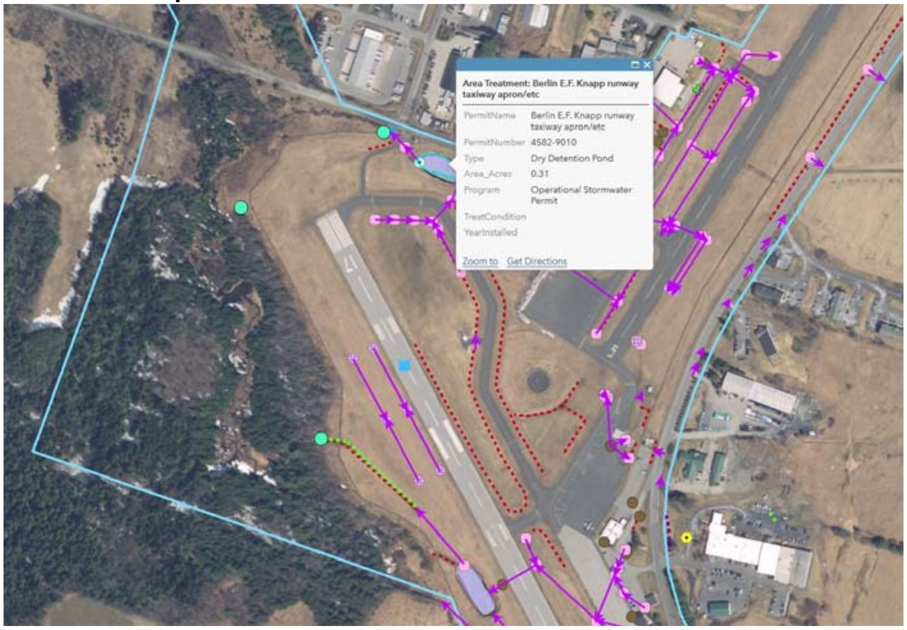


The progress submittals described above, as well as inventory and assessment work completed through VTrans' other commitments under the TS4 General Permit, lay the groundwork for completion of a conceptual PCP for the entire TS4 within the Lake Champlain Basin, as required by April 1, 2020. The generalized PCP must, at minimum, estimate the area (acres or road miles) to be treated, and the extent and type of BMPs that will be implemented to meet the entire P load reduction.

Four classes of conceptual BMPs are under consideration and development for inclusion in the Generalized PCP:

- **Areas of VTrans property treated with structural stormwater BMPs (link available only in online story)**
- **Areas of VTrans property treated with non-structural practices (link available only in online story)**
- **Areas of localized erosion treated with structural BMPs (link available only in online story)**
- **Areas of VTrans roadway and drainage upgraded to meet standards (link available only in online story)**

Areas of impervious surface treated with structural BMPs



Structural best management practices (BMPs) are intended to detain, treat, and better manage runoff from well-defined ares of impervious surface, such as roads, parking lots, or rooftops. These treatment practices range from older detention ponds managing only peak flows, to dry swales, gravel wetlands, and other **green stormwater infrastructure**.

VTrans is identifying upgrades and retrofits to practices implemented after the adoption of the 2002 Vermont Stormwater Management Manual design standards, including both jurisdictional and sub-jurisdictional improvements. Operational permits and plans issued by the Vermont DEC Stormwater Program for projects permitted after July 1, 2010 are under review to assess and credit the additional benefit provided by these systems.

As qualifying BMPs are identified, the P base loads to be managed by each existing and in-process BMP are calculated. Next, P removal efficiencies and P load reduction benefits expected for existing and planned structural BMPs are calculated, generally consistent with **BMP types and crediting already established by DEC**. Upon completion of these updates, VTrans will have an indication of progress already made towards meeting P reduction targets in each Lake segment.

Once an indication of progress towards meeting targets already achieved is in hand, GIS analysis will be used to refine areas for application of conceptual BMPs. Large areas of highly hydrologically connected roadway and moderately connected roadway will be the primary targets for structural BMP retrofits. Structural BMP locations will be identified by targeting large, low-slope right-of-way areas in proximity and downslope of large areas of roadway impervious cover. The results of this analysis will be used to estimate acres of paved road managed with structural BMPs in each Lake segment, the types of BMPs that would be best suited in each application, and the P load removal credit achieved for each conceptual BMP application.

VTrans Lake Champlain Basin Phosphorus Control Plan

This story was made with ***Esri's Story Map Journal****.*
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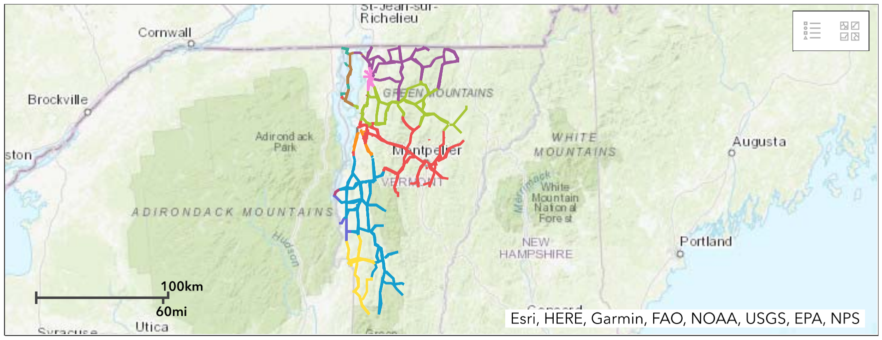
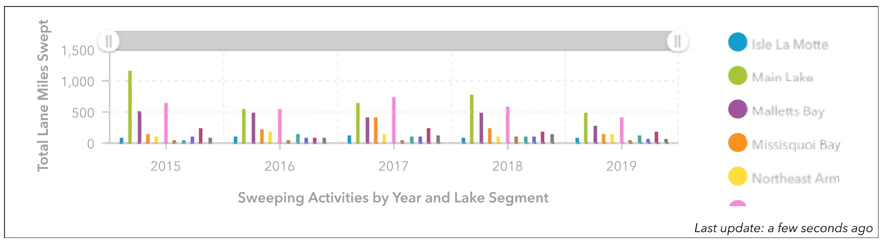
Areas treated with non-structural practices





As part of its **SWMP**, VTrans has committed to completing a robust suite of maintenance activities under Minimum Control Measure 6.F (Pollution Prevention/ Good Housekeeping for Municipal Operations). The ultimate goal of this control measure, as stated in Subpart 6.3.F of the **TS4 Permit**, is "preventing or reducing pollutant runoff from all VTrans' operations related to the TS4". Two of the maintenance activities, drop inlet (DI) or catch basin cleaning and street sweeping, can directly result in the removal of sediment and phosphorus from impervious surfaces—and thus, are of particular interest in developing VTrans's PCP.

It is generally not feasible to summarize VTrans' application of non-structural controls prior to July 2010 outside of areas included in operational stormwater permit drainage areas or stormwater flow-impaired watersheds, where VTrans was previously a non-traditional MS4 permittee. Exploration of maintenance records from VTrans's Managing Assets for Transportation Systems (MATS) database from 2010-July 2018 indicates that it is possible to estimate road miles swept, annual frequency of street sweeping operations, and frequency of drop inlet/catch basin cleaning for at least some VTrans Maintenance Districts within the LCB. The lack of reliable data prior to July 2010 complicates assessment of enhancements to non-structural controls implemented since then. However, the MATS data provide a baseline condition against which enhancements to equipment used or frequency of application may be measured and credited in the development and implementation of Lake-segment-specific PCPs.

Application of non-structural practices (street sweeping and DI cleaning) by Lake segment and drainage basin between 2010 and 2018 is now being summarized to the extent practicable to evaluate opportunities to improve maintenance and provide phosphorus reduction credits. VTrans will incorporate applicable findings from **ongoing research** by USGS, in cooperation with the Chittenden County Regional Planning Commission, Vermont DEC, the University of Vermont, and nine Vermont municipalities, to evaluate potential reductions in nutrient and sediment loads possible through current street cleaning practices, and possible enhancements to those activities.

Ultimately, P load reduction credits anticipated from each type and application of non-structural control on an annual basis will be developed or applied as appropriate. For the Generalized Phosphorus Control Plan, generalized recommendations will be provided by Lake segment for targeting of increased frequency of lane miles swept (2,000 lane miles annually) in line with VTrans' commitment made under the TS4 General Permit and resulting Stormwater Management Program (SWMP). Generalized recommendations will also be made for enhanced DI cleaning, consistent with VTrans' commitment to inspect 20% of DIs on an annual basis under its SWMP.

VTrans Lake Champlain Basin Phosphorus Control Plan

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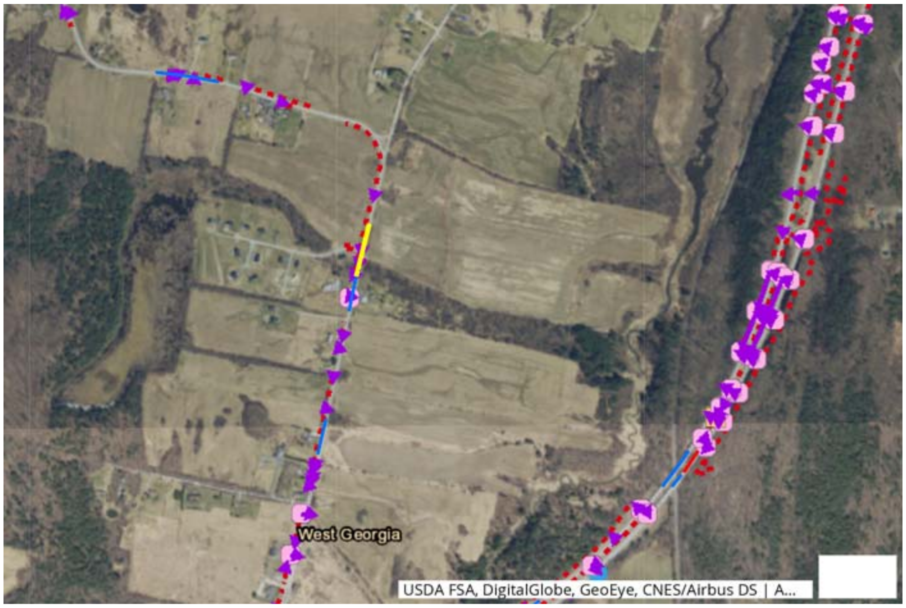
Areas of Localized Erosion Treated with Structural BMPs



Editable - Erosion Validation Segments August 2019

Editable - Erosion Area

Editable - Other Points of Interest

Editable - Erosion Validation Segments July 2019

High HydroConnectivity and High Slope

High HydroConnectivity and Low Slope

VTRC 19(2) - Candidate sites

AMP_SmallCulvertInventory

SCI Culverts

SCI DropInlets

- Unknown
- Drop Inlet
- Dry Sump
- Junction Box
- Stand Pipe

SCI Access Holes

MOB_EPWQ_TS4_Inventory

Swales

Outfall

Stabilization and treatment of areas of localized erosion caused by roadway drainage infrastructure has utility in both the VTrans PCP and in crediting for "meeting standards" under the **Municipal Roads General Permit (MRGP)**. However, specific crediting mechanisms are not well-established for these and similar transportation-related improvements. VTrans is working with Vermont DEC to clarify and come to consensus on a crediting methodology for existing localized erosion repair projects, which then may reasonably be extended to crediting for proposed localized erosion repairs under either the VTrans PCP or the MRGP implementation efforts. Crediting options being explored include NRCS or other area-based approaches, as well as alternative options. For example, the Virginia Department of Transportation has successfully utilized stream restoration and stabilization practices with phosphorus reduction credit for the stabilization of outfalls associated with their roadway network, applying the same **credits offered for stream restoration/stabilization** in the Chesapeake Bay nutrient TMDL. A similar approach could apply both for improvements to areas of localized erosion, and to correction of some areas of **existing roadway drainage deficiency (link available only in online story)**. This work will utilize the progress and findings of the VTrans and Vermont DEC research project *Quantifying Nutrient Pollution Reductions Achieved by Erosion Remediation Projects on Vermont's Roads,* which is now underway.

Existing areas of localized erosion that have been repaired or managed with structural BMPs since July 2010 are being identified by leveraging asset conditions tracked and maintenance activities reported in VTrans electronic data management systems including the MATS database, the Small Culverts Inventory (SCI), and the TS4 infrastructure and operational stormwater permits inventories. These data sources are being coupled with the **GIS inventory of areas of localized erosion (link available only in online story)** to create a desktop inventory of recently-completed localized erosion stabilization projects that may be eligible for P reduction credit.

A sub-set of localized erosion repairs identified in the MATS database and completed between January 2017 and May 2019 were field verified in the summer of 2019. The field verification effort had several goals:

- Understand possible credit for correcting areas of localized erosion with structural BMPs
- Gather information to compare the MRGP's Road Erosion Inventory framework and criteria with VTrans's inventories and maintenance activity records
- Determine applicability for VTrans roadways and erosion problem, such that "fixes" may be credited using a similar strategy between both permit and regulatory programs

Field verification of existing localized erosion repairs was attempted in July-August 2019 at over 70 sites identified in the MATS database (see map at right).

- At 38 sites (53%) a localized erosion fix was located in good condition.
- At 11 sites, (15%) a fix was located but it was either in need of additional repair or the fix had failed.
- 19 sites (27%) were not found – either the location data were not precise, or the fix was so effective it could not be located.
- 3 records (4%) were related to planning activities rather than localized erosion fixes.

Given the positive field verification results, a simple calculation was completed to evaluate the basin-wide scale and potential for P reduction resulting from repairing areas of localized erosion using structural BMPs. It appears that approximately 8% of the PCP area's paved road base load (383 kg/yr) is likely associated with active or recently-repaired localized erosion areas. If a conceptual 50% P load reduction credit was applied for these fixes over the term of PCP implementation, the associated P load reduction of 191 kg/yr constitutes roughly 19% of VTrans's total required target reduction across the LCB.

Erosion Fix, US Route 4 in Proctor, VT

In the coming months, VTrans will be using the MATS data and field verification results to extrapolate the frequency of localized erosion fixes by Lake segment, VTrans Maintenance District, and year. Localized erosion fixes constitute a demonstrable water quality improvement and should be a component of the Generalized Plan – but better prediction is needed of both acres anticipated to be treated and time domain.

As with **structural (link available only in online story)** and **non-structural BMPs (link available only in online story)**, once an indication of progress towards meeting targets already achieved is clear, GIS analysis will be used to refine areas for application of conceptual BMPs. In this assessment, large areas of hydrologically connected paved road adjacent to areas of potential localized erosion identified in the inventory will be targeted, where structural BMPs may be applied to both manage runoff from paved road areas and repair erosion problems. The results of this analysis will be used to estimate acres of paved road and localized erosion managed with structural BMPs in each Lake segment, the types of BMPs that would be best suited in each application, and the P load reduction credit achieved for each conceptual BMP application.

VTrans Lake Champlain Basin Phosphorus Control Plan

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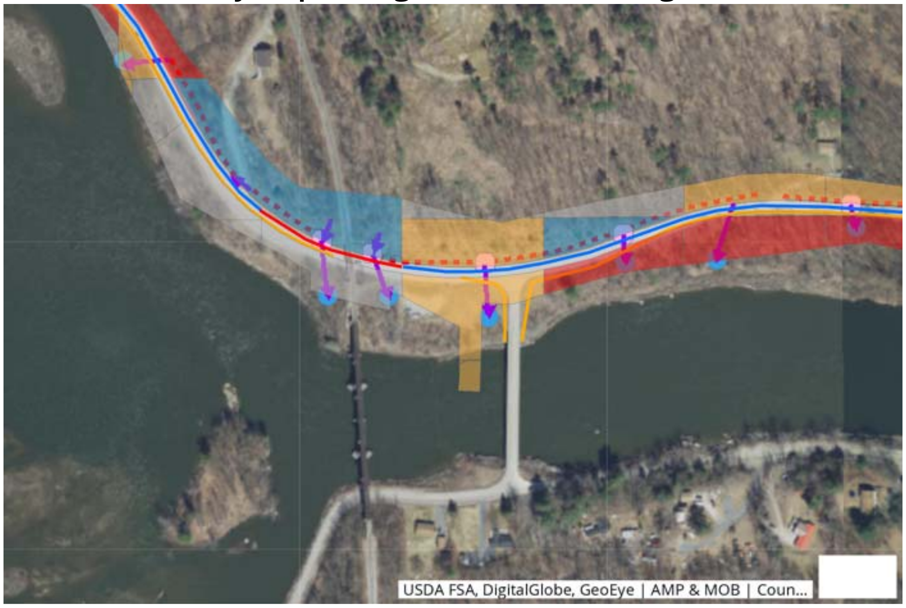
Areas treated by improving road and drainage conditions



High HydroConnectivity and High Slope

High HydroConnectivity and Low Slope

ROW_ActiveErosionClassification_FullBasin

- <Null>
- LE1_DownSteepRdRunoff
- LE2_CulvertErosion
- LE3_CurbBoard
- LE4_PotentialDitch

Maintenance_Inventory_Guard

- Excellent
- Good
- Fair
- Poor
- Very Poor
- Unknown
- No Value Assigned

AMP_SmallCulvertInventory

SCI Culverts

SCI DropInlets

- Unknown
- Drop Inlet
- Dry Sump
- Junction Box
- Stand Pipe

SCI Access Holes

MOB_EPWQ_TS4_Inventory

Swales

Outfall

As with repairs to areas of localized erosion with **structural BMPs (link available only in online story)**, further work is underway to define approaches for quantifying or crediting P load reductions for BMPs that are considered as regular maintenance activities on VTrans paved roads. Examples include guardrail maintenance and culvert or outfall repair/replacement, where these activities result in a demonstrable P load reduction or improvement in a road segment's condition when compared to DEC's 'hydrologically-connected road segments' **inventory requirement** under the MRGP and as incorporated into the MS4 General Permit. This requirement is not part of the TS4 permit, and VTrans and DEC have not reached consensus regarding whether VTrans should develop and maintain a similar Road Erosion Inventory as a component of its PCP.

VTrans is working with Vermont DEC to more closely define standards and criteria for hydrologically connected road segments within the TS4, where an approach similar to the **MRGP standards** may be warranted. If and as consensus is reached, a similar workflow will be followed as for the other classes of BMPs described above. Existing areas where roadway drainage deficiencies have been brought up to standards since July 2010 will be compiled into a desktop inventory of roadway drainage improvement projects that may be eligible for P reduction credit. Road miles or acres where deficiencies have been addressed will be calculated, resulting in estimates of what P load reduction credit may reasonably be granted for existing projects across the LCB.

Once an indication of progress towards meeting targets already achieved is clear, GIS analysis will be used to refine areas for application of conceptual BMPs. Analysis results will estimate acres or miles where existing drainage deficiencies may be brought up to standards in each Lake segment, the types of conceptual BMPs or drainage improvements that would be best suited in each application, and the P load removal credit achieved for each conceptual application.

Appendix E: Design Basis Assumptions for Conceptual Structural STPs

BMP Type	Design Element	Design Element Code	Design Criteria	Unit	Standard Reference	Notes
Bioretention (infiltrating)						
Bioretention (infiltrating)	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = Ponding water storage volume and void space volumes of soil filter media. Example: DSV = (Apond x Dpond) + (Asoil x Dsoil x nsoil mix)	cubic feet	(3)	
Bioretention (infiltrating)	CF storage per SF BMP area	Dv	1.38	cf/sf		
Bioretention (infiltrating)	Bioretention soil mix media minimum depth (Dbio_soil)	Dbio_soil	2	feet	(1)	
Bioretention (infiltrating)	Pea gravel choker course depth (Dpea_gravel)	Dpea_gravel	0.25	feet	(1)	
Bioretention (infiltrating)	Stone reservoir minimum depth (Ddrain_rock)	Ddrain_rock	0.75	feet	(1)	
Bioretention (infiltrating)	Max ponding depth (Dponding)	Dponding	0.5	foot	(1)	
Bioretention (infiltrating)	Porosity of pea gravel	npea_gravel	0.32		(4)	
Bioretention (infiltrating)	Porosity of drain rock	ndrain_rock	0.40		(5)	
Bioretention (infiltrating)	Porosity of bioretention soil	nbio_soil	0.25		(12) - NY DEC porosity value	
Bioretention (infiltrating)	Pre-treatment volume	PTv			(1)	Forebay sized for 25% of WQv or other per section 4.1 of VSMM
Bioretention (infiltrating)	Treatment volume	Tv			(1)	Treatment volume, including ponding, media and pre-treatment storage, must be 75% of WQv to avoid premature bypass
Bioretention (w/ underdrain)						
Bioretention (w/ underdrain)	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = Ponding water storage volume and void space volumes of soil filter media. Example: DSV = (Apond x Dpond) + (Asoil x Dsoil x nsoil mix)	cubic feet	(3)	Same calculation as infiltrative bioretention. Sizing of underdrained facilities should be increased for poorly drained soils.
Bioretention (w/ underdrain)	CF storage per SF BMP area	Dv	1.38	cf/sf		
Bioretention (w/ underdrain)	Bioretention soil mix media minimum depth (Dbio_soil)	Dbio_soil	2	feet	(1)	
Bioretention (w/ underdrain)	Pea gravel choker course depth (Dpea_gravel)	Dpea_gravel	0.25	feet	(1)	
Bioretention (w/ underdrain)	Stone reservoir minimum depth	Ddrain_rock	0.75	feet	(1)	
Bioretention (w/ underdrain)	Ponding depth	Dponding	0.5	foot	(1)	
Bioretention (w/ underdrain)	Porosity of pea gravel	npea_gravel	0.32		(4)	
Bioretention (w/ underdrain)	Porosity of drain rock	ndrain_rock	0.40		(5)	
Bioretention (w/ underdrain)	Porosity of bioretention soil	nbio_soil	0.25		(12) - NY DEC porosity value	
Gravel Wetland						A liner is required if underlying soils have an infiltration rate >0.05 inches per hour.
Gravel Wetland	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = pretreatment volume + ponding volume + void space volume of gravel ISR. DSV = (A pretreatment x DpreTreatment)+ (A wetland x Dponding)+ (AISR x Dgravel x ngravel) Pretreatment	cubic feet	(3)	
Gravel Wetland	Minimum Length (L)	L	15	feet	(1)	Minimum length to width ratio of 1:1 (L:W) for each treatment cell, with a minimum flow path (L) within the gravel substrate of 15 feet.
Gravel Wetland	CF storage per SF BMP area	Dv	2.03	cf/sf		
Gravel Wetland	Ponding depth above gravel (Dponding)	Dponding	1	feet	(2)	(3:1 side slopes and 0.5 feet freeboard)
Gravel Wetland	Topsoil depth (Dtsoil)	Dtsoil	0.33	feet	(2)	
Gravel Wetland	3/4" stone depth (Dstone)	Dstone	0.33	feet	(2)	
Gravel Wetland	Gravel treatment area depth (Dgravel)	Dgravel	2	feet	(2)	
Gravel Wetland	Porosity of topsoil (ntsoil)	ntsoil	0.32		(12) - NY DEC porosity value	topsoil per reference (2), but used bioretention soil porosity for estimation purposes due to high variability of topsoi porosity
Gravel Wetland	Porosity of 3/4" stone	nstone	0.38		(5)	3/8 in crushed stone per reference (2)
Gravel Wetland	Porosity of gravel (ngravel)	ngravel	0.40		(5)	1.5 in crushed stone per reference (2)
Gravel Wetland	Pre-treatment volume	PTv			(1)	At least 10% of the WQV shall be provided in a sediment forebay if used for pre-treatment.
Gravel Wetland	Treatment volume	Tv			(1)	The remaining 90% of the WQV shall be provided through a combination of one or more basins or chambers filled with a minimum 24-inch gravel layer
Infiltration Chambers						Max longitudinal slope is 1%
Infiltration Chambers	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = void space volumes of stone and sand layers. DSV = (Atrench x Dstone x nstone)+ (Atrench x Dsand x nsand)	cubic feet	(3)	
Infiltration Chambers	CF storage per SF BMP area	Dv	2.90	cf/sf		
Infiltration Chambers	Chamber depth	Dchamber	2.5	feet	(8)	
Infiltration Chambers	Gravel cover depth min	DgravelC	0.5	feet	(1)	
Infiltration Chambers	Gravel foundation depth min	DgravelF	0.5	feet	(1)	
Infiltration Chambers	Porosity of gravel	ngravel	0.40		(5)	
Infiltration Basin						Max longitudinal slope is 1%

BMP Type	Design Element	Design Element Code	Design Criteria	Unit	Standard Reference	Notes
Infiltration Basin	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = Water volume of storage structure before bypass. Example for rectangular vegetated basin. DSV = (L x W x D)	cubic feet	(3)	MS4 BMP tracking table and performance curve definitions assume surface ponding only - no stone reservoir.
Infiltration Basin	CF storage per SF BMP area	Dv	2.00	cf/sf		
Infiltration Basin	Ponding depth (Dponding)	Dponding	2	feet	(1)	
Infiltration Trench						- Suggested DMA<5ac for this technology (VSMM) - Max longitudinal slope is 1%
Infiltration Trench	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = void space volumes of stone and sand layers. DSV = (Atrench x Dstone x nstone)+ (Atrench x Dsand x nsand)	cubic feet	(3)	
Infiltration Trench	CF storage per SF BMP area	Dv	2.60	cf/sf		
Infiltration Trench	Ponding depth above gravel (Dponding)	Dponding	1	feet	(1)	
Infiltration Trench	Stone reservoir max depth (Dstone)	Dstone	4	feet	(1)	
Infiltration Trench	Porosity of stone (nstone)	nstone	0.40		(5)	
Infiltration Trench	Pre-treatment volume	PTv			(1)	- If the infiltration rate is ≤2 inches per hour, then the min PTv is 25% of WQv - If the infiltration rate is >2 inches per hour, then the min PTv is 50% of WQV
Porous Pavement						- Assumed porous asphalt rather than concrete. - Permeable pavements shall be sited on slopes less than 5%. - Permeable pavements should only be used to manage precipitation that falls directly on the permeable pavement area to protect the surface from clogging
Porous Pavement	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = void space volumes of stone and sand layers. DSV = (Atrench x Dstone x nstone)+ (Atrench x Dsand x nsand)	cubic feet	(3)	
Porous Pavement	CF storage per SF BMP area	Dv	0.96	cf/sf		
Porous Pavement	Choking course depth (Dchoking)	Dchoking	0.5	feet	(1)	
Porous Pavement	Base course depth (Dbase)	Dbase	2	foot	(1)	Minimum depth is 0.5ft
Porous Pavement	Porosity of choking course (nchoking)	nchoking	0.32		(4)	Assumed similar to pea gravel
Porous Pavement	Porosity of base course (nbase)	nbase	0.40		(5)	
Permeable Pavers						- Assumed paver bricks, no underdrain - Permeable pavements shall be sited on slopes less than 5%. - Permeable pavements should only be used to manage precipitation that falls directly on the permeable pavement area to protect the surface from clogging
Permeable Pavers	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = void space volumes of stone and sand layers. DSV = (Atrench x Dstone x nstone)+ (Atrench x Dsand x nsand)	cubic feet	(3)	Difference between porous asphalt and permeable paver is choking course/beddign course depth and material
Permeable Pavers	CF storage per SF BMP area	Dv	0.83	cf/sf		
Permeable Pavers	Stone bedding course depth (Dbedding)	Dbedding	0.17	feet	(7)	
Permeable Pavers	Base course depth (Dbase)	Dbase	2	foot	(7)	Minimum depth is 0.5ft
Permeable Pavers	Porosity of bedding stone layer (nbedding)	nbedding	0.20		(10)	Assumed ASTm No. 8 stone
Permeable Pavers	Porosity of base course (nbase)	nbase	0.40		(5)	
Dry Swale (infiltrating)						Max longitudinal slope is 6%
Dry Swale (infiltrating)	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = Water volume of storage structure before bypass. Example for linear trapazoidal vegetated swale. DSV = (L x ((Wbottom+Wtop@Dmax)/2) x D)	cubic feet	(3)	
Dry Swale (infiltrating)	Minimum width (W)	W	2	feet	(1)	Width of reservoir only, ponding can be trapezoidal above
Dry Swale (infiltrating)	CF storage per SF BMP area	Dv	2.10	cf/sf		
Dry Swale (infiltrating)	Filter bed minimum depth (Dfilter)	Dfilter	2	feet	(1)	
Dry Swale (infiltrating)	Stone reservoir minimum depth (Dstone)	Dstone	1	foot	(1)	
Dry Swale (infiltrating)	Max ponding depth (Dponding)	Dponding	1	foot	(1)	
Dry Swale (infiltrating)	Porosity of stone (nstone)	nstone	0.4		(5)	
Dry Swale (infiltrating)	Porosity of filter bed	nfilter	0.35		(9)	VSMM specified sand or bioretention soil, assumed sand here. Porosity is based on average of coarse sand range from .26-.43
Dry Swale (infiltrating)	Pre-treatment volume	PTv			(1)	Forebay sized for 10% of WQv or other per section 4.1 of VSMM
Dry Swale (infiltrating)	Treatment volume	Tv			(1)	Treatment volume, including ponding, media and pre-treatment storage, must be 75% of WQv to avoid premature bypass
Dry Swale (w/ underdrain)						Max longitudinal slope is 6%
Dry Swale (w/ underdrain)	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = Ponding water storage volume and void space volume of soil filter media. DSV = (Abed x Dponding)+ (Abed x Dsoil x nsoil)	cubic feet	(3)	Currently, this is the same calculation as infiltrative dry swales. Sizing of underdrained facilities should be increased for those sites on poorly draining soils.
Dry Swale (w/ underdrain)	Minimum width (W)	W	2	feet	(1)	Width of reservoir only, ponding can be trapezoidal above
Dry Swale (w/ underdrain)	CF storage per SF BMP area	Dv	2.10	cf/sf		

BMP Type	Design Element	Design Element Code	Design Criteria	Unit	Standard Reference	Notes
Dry Swale (w/ underdrain)	Filter bed minimum depth (Dfilter)	Dfilter	2	feet	(1)	
Dry Swale (w/ underdrain)	Stone reservoir minimum depth (Dstone)	Dstone	1	foot	(1)	
Dry Swale (w/ underdrain)	Max ponding depth (Dponding)	Dponding	1	foot	(1)	
Dry Swale (w/ underdrain)	Porosity of stone (nstone)	nstone	0.4		(5)	
Dry Swale (w/ underdrain)	Porosity of filter bed	nfilter	0.35		(9)	VSMM specified sand or bioretention soil, assumed sand here. Porosity is based on average of coarse sand range from .26-.43
Dry Swale (w/ underdrain)	Pre-treatment volume	PTv			(1)	Forebay sized for 10% of WQv or other per section 4.1 of VSMM
Dry Swale (w/ underdrain)	Treatment volume	Tv			(1)	Treatment volume, including ponding, media and pre-treatment storage, must be 75% of WQv to avoid premature bypass
Wet Pond						- BMP Type is Wet Pond/ Created Wetland in BMP Tracking Sreadsheet - Max slope of 10%
Wet Pond	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV= Pemanant pool volume prior to high flow bypass DSV=Apond x Dpond	cubic feet		- does not include pretreatment volume - The minimum flow path length to practice width ratio is 3:1.
Wet Pond	CF storage per SF BMP area	Dv	4	cf/sf		
Wet Pond	Min ponding depth (Dponding)	Dponding	4	feet	(1)	
Wet Pond	Pre-treatment volume	PTv			(1)	Forebay sized for 10% of WQv or other per section 4.1 of VSMM. If winter traction sanding is prevalent in the contributing drainage area, the forebay size may be increased to 25% of the WQV to accommodate additional sediment loading.
Wet Pond	Treatment volume	Tv			(1)	At least 25% of the WQV shall be provided in "deep water zones" with a depth equal to or greater than 4 feet, but not more than 8 feet. As required above, at least 10% of the WQV shall be provided in a sediment forebay or other pretreatment practice. The remaining 65% of the WQV shall be provided in some combination of shallow permanent pool with depth less than four feet
Treatment Wetland						A liner is required if underlying soils have an infiltration rate >0.05 inches per hour.
Treatment Wetland	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = Ponding water storage volume and void space volume of soil filter media. DSV = (Abed x Dponding)+ (Abed x Dsoil x nsoil)	cubic feet	(3)	Minimum length to width ratio of 2:1 (L:W)
Treatment Wetland	CF storage per SF BMP area	Dv	4	cf/sf		
Treatment Wetland	Max ponding depth (Dponding)	Dponding	4	feet	(1)	
Treatment Wetland	Pre-treatment volume	PTv				Forebay sized for 10% of WQv or other per section 4.1 of VSMM
Treatment Wetland	Treatment volume	Tv				- Minimum 35% of the WQV storage shall be at design depth of less than 6 inches. A minimum of 65% of the WQV storage shall be at design depth of less than 18 inches. - At least 25% of the WQV storage shall be provided in deep water zones at design depths greater than 4 feet. - The remaining WQV shall be provided through a combination of shallow permanent pool with depth less than 4 feet
Media Filter (infiltrating)						Sites with contributing area imperviousness greater than 75%, and sites with high sediment loading (such as aggressive use of traction sand for de-icing), may require more aggressive sedimentation pre-treatment techniques.
Media Filter	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = void space volumes of stone and sand layers. DSV = (A_{trench} x D_{stone} x n_{stone})+ (A_{trench} x D_{sand} x n_{sand})	cubic feet	(3)	
Media Filter	CF storage per SF BMP area	Dv	1.04	cf/sf		
Media Filter	Topsoil depth (Dtsoil)	Dtsoil	0.88	feet	(2)	Typical detail specified 50:50 native soil, but called "topsoil" for consistency with other BMP assumptions. Also, averged soil depth across parabolic layer, 9" at lowest point and 12" at highest depth along the sides of the parabola.
Media Filter	Sand depth (Dsand)	Dsand	2	feet	(2)	
Media Filter	Porosity of topsoil (ntsoil)	ntsoil	0.32		(12) - NY DEC porosity value	Reference (2) specified 50:50 native soil:sand, however used used bioretention soil porosity for estimation purposes due to high variability of native soil porosity
Media Filter	Porosity of sand	nsand	0.38		(9)	Porosity based on average for range of fine sand range from 0.29-0.46
Media Filter	Pre-treatment volume	PTv				

BMP Type	Design Element	Design Element Code	Design Criteria	Unit	Standard Reference	Notes
Media Filter	Treatment volume	Tv				A storage volume of at least 75% of the design TV, including the volume over the top of the filter media and the volume in the sediment forebay as well as within the filter media is required
Media Filter (w/ underdrain)						- Currently, this is the same calculation as infiltrative media filters. Sizing of underdrained facilities should be increased for those sites on poorly draining soils. - Sites with contributing area imperviousness greater than 75%, and sites with high sediment loading (such as aggressive use of traction sand for de-icing), may require more aggressive sedimentation pre-treatment techniques.
Media Filter (w/ underdrain)	MS4 BMP Definition Design Storage Volume (DSV)	DSV	DSV = Ponding water storage volume and void space volume of soil filter media. DSV = (Abed x Dponding)+ (A_{bed} x D_{soil} x n_{soil})	cubic feet	(3)	
Media Filter	CF storage per SF BMP area	Dv	1.04	cf/sf		
Media Filter	Topsoil depth (Dtsoil)	Dtsoil	0.88	feet	(2)	Typical detail specified 50:50 native soil, but called "topsoil" for consistency with other BMP assumptions. Also, averged soil depth across parabolic layer, 9" at lowest point and 12" at highest depth along the sides of the parabola.
Media Filter	Sand depth (Dsand)	Dsand	2	feet	(2)	
Media Filter	Porosity of topsoil (ntsoil)	ntsoil	0.32		(12) - NY DEC porosity value	Reference (2) specified 50:50 native soil:sand, however used used bioretention soil porosity for estimation purposes due to high variability of native soil porosity
Media Filter	Porosity of sand	nsand	0.38		(9)	Porosity based on average for range of fine sand range from 0.29-0.46
Media Filter	Pre-treatment volume	PTv				
Media Filter	Treatment volume	Tv				A storage volume of at least 75% of the design TV, including the volume over the top of the filter media and the volume in the sediment forebay as well as within the filter media is required

References

(1) 2017 Vermont Stormwater Management Manual Rule and Design Guidance. Vermont Agency of Natural Resources, July 2017.
(2) Allen Brook FRP Typical Details, Vtrans 2018
(3) Nov 2019 MS4 BMP Tracking Table
(4) https://www.utoledo.edu/nsm/lec/research/errl/pdfs/Memo_2.pdf
(5) https://www.stormtech.com/download_files/pdf/techsheet1.pdf
(6) https://www.sanjuanco.com/DocumentCenter/View/1609/Bio-Retention-Rain-Gardens-PDF
(7) Great streets manual http://greatstreetsbtv.com/ - Appendix A, reference detail SW-01B
(8) Assumed SC-740 Chambers
(9) https://www.geotechdata.info/parameter/soil-porosity.html
(10) https://www.wgpaver.com/wp-content/uploads/2012/05/PICP_Base_Construction1.pdf
(11)
(12) GI Exchange Modelling Memo

Appendix F: Road Erosion Inventory Implementation Table, Example for the Missisquoi River Drainage Area

Segment ID	SWAT Drain	MRGP Slope Class	Length (m)	Hydroconnect Class	Total Number of Swales and Culverts	Total Structures Not Meeting Standards	Date of Most Recent Culvert Inspection	Culvert Condition	Culvert Sediment	Culvert Erosion	Culvert Sink Hole	Culvert Road Settling	Swale Condition	Status	Priority
400	Missisquoi River	>10%	44	High	1	1	11/3/2016	Does Not Meet	Meets	Meets	Meets	Does Not Meet	N/A	Does Not Meet	Very High
1284	Missisquoi River	>10%	69	High	2	1	7/31/2019	Meets	Meets	Does Not Meet	Meets	Meets	Meets	Does Not Meet	Very High
1285	Missisquoi River	>10%	109	High	2	1	7/31/2019	Meets	Meets	Does Not Meet	Meets	Meets	Meets	Does Not Meet	Very High
1336	Missisquoi River	>10%	119	High	3	1	7/31/2019	Meets	Meets	Meets	Meets	Does Not Meet	N/A	Does Not Meet	Very High
2027	Missisquoi River	>10%	50	High	1	1	9/2/2019	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	Very High
2028	Missisquoi River	>10%	75	High	2	2	9/2/2019	Does Not Meet	Meets	Does Not Meet	Meets	Meets	Does Not Meet	Does Not Meet	Very High
19637	Missisquoi River	>10%	26	High	2	1	9/2/2019	Meets	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	Very High
19639	Missisquoi River	>10%	102	High	4	3	9/2/2019	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	Very High
19743	Missisquoi River	>10%	72	High	2	1	9/2/2019	Does Not Meet	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	Very High
30935	Missisquoi River	>10%	127	High	4	2	10/8/2018	Does Not Meet	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	Very High
32375	Missisquoi River	>10%	103	High	1	1	6/26/2018	Meets	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	Very High
32401	Missisquoi River	>10%	103	High	1	1	7/11/2018	Meets	Meets	Does Not Meet	Meets	Does Not Meet	N/A	Does Not Meet	Very High
32417	Missisquoi River	>10%	24	High	1	1	6/26/2018	Does Not Meet	Meets	Does Not Meet	Meets	Meets	N/A	Does Not Meet	Very High
32438	Missisquoi River	>10%	18	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	Very High
32443	Missisquoi River	>10%	61	High	1	1	10/29/2018	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	Very High
32505	Missisquoi River	>10%	61	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	Very High
32539	Missisquoi River	>10%	60	High	1	1	6/18/2018	Meets	Meets	Does Not Meet	Meets	Meets	N/A	Does Not Meet	Very High
32635	Missisquoi River	>10%	56	High	1	1	6/18/2018	Does Not Meet	Meets	Does Not Meet	Meets	Meets	N/A	Does Not Meet	Very High
33304	Missisquoi River	>10%	74	High	5	4	10/2/2019	Does Not Meet	Does Not Meet	Does Not Meet	Meets	Meets	Does Not Meet	Does Not Meet	Very High
33306	Missisquoi River	>10%	30	High	4	1	10/2/2019	Meets	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	Very High
33398	Missisquoi River	>10%	55	High	3	2	10/2/2013	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	Very High
33623	Missisquoi River	>10%	89	High	5	1	10/10/2019	Does Not Meet	Meets	Meets	Meets	Meets	Meets	Does Not Meet	Very High
36235	Missisquoi River	>10%	72	High	1	1	10/31/2016	Meets	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	Very High
36824	Missisquoi River	>10%	61	High	2	1	10/2/2019	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	Very High
37028	Missisquoi River	>10%	71	High	2	1	7/16/2013	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	Very High
37045	Missisquoi River	>10%	88	High	3	1	7/16/2013	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	Very High
37070	Missisquoi River	>10%	106	High	1	1	11/14/2016	Meets	Meets	Does Not Meet	Meets	Meets	N/A	Does Not Meet	Very High
37489	Missisquoi River	>10%	85	High	2	1	9/20/2017	Does Not Meet	Meets	Does Not Meet	Meets	Meets	Meets	Does Not Meet	Very High
38104	Missisquoi River	>10%	101	High	1	1	8/24/2016	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	Very High
513	Missisquoi River	8-10%	106	High	2	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
579	Missisquoi River	8-10%	65	High	2	1	10/25/2016	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	High
1423	Missisquoi River	8-10%	82	High	1	1	8/22/2016	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
1424	Missisquoi River	8-10%	109	High	3	2	4/16/2019	Does Not Meet	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	High
1425	Missisquoi River	8-10%	55	High	1	1	6/14/2015	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
19504	Missisquoi River	8-10%	53	High	2	1	9/8/2019	Meets	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
19534	Missisquoi River	8-10%	98	High	2	1	7/8/2013	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
19620	Missisquoi River	8-10%	28	High	2	2	9/4/2019	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
19635	Missisquoi River	8-10%	7	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
19636	Missisquoi River	8-10%	126	High	3	3	9/2/2019	Meets	Meets	Does Not Meet	Meets	Meets	Does Not Meet	Does Not Meet	High
19638	Missisquoi River	8-10%	104	High	3	2	9/2/2019	Meets	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
19648	Missisquoi River	8-10%	38	High	1	1	9/4/2019	Does Not Meet	Meets	Does Not Meet	Meets	Meets	N/A	Does Not Meet	High

Segment ID	SWAT Drain	MRGP Slope Class	Length (m)	Hydroconnect Class	Total Number of Swales and Culverts	Total Structures Not Meeting Standards	Date of Most Recent Culvert Inspection	Culvert Condition	Culvert Sediment	Culvert Erosion	Culvert Sink Hole	Culvert Road Settling	Swale Condition	Status	Priority
19649	Missisquoi River	8-10%	100	High	1	1	7/31/2013	Meets	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	High
19651	Missisquoi River	8-10%	10	High	3	1	7/31/2013	Does Not Meet	Meets	Meets	Meets	Meets	Meets	Does Not Meet	High
19656	Missisquoi River	8-10%	76	High	2	2		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
19703	Missisquoi River	8-10%	33	High	4	1	9/4/2019	Does Not Meet	Meets	Meets	Meets	Meets	Meets	Does Not Meet	High
19820	Missisquoi River	8-10%	85	High	4	1	11/4/2013	Meets	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
30943	Missisquoi River	8-10%	78	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
30945	Missisquoi River	8-10%	131	High	4	3	10/29/2018	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	High
30946	Missisquoi River	8-10%	3	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
30962	Missisquoi River	8-10%	49	High	2	2	10/29/2018	Does Not Meet	Meets	Does Not Meet	Meets	Meets	Does Not Meet	Does Not Meet	High
32341	Missisquoi River	8-10%	66	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
32398	Missisquoi River	8-10%	101	High	2	2	7/11/2018	Meets	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	High
32439	Missisquoi River	8-10%	76	High	2	1	9/26/2018	Meets	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
32463	Missisquoi River	8-10%	0	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
32584	Missisquoi River	8-10%	48	High	1	1	6/18/2018	Meets	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	High
32603	Missisquoi River	8-10%	102	High	3	3	6/25/2018	Meets	Does Not Meet	Does Not Meet	Meets	Meets	Does Not Meet	Does Not Meet	High
32616	Missisquoi River	8-10%	53	High	3	3	10/13/2013	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
32681	Missisquoi River	8-10%	69	High	3	3	9/2/2013	Does Not Meet	Meets	Does Not Meet	Meets	Meets	Does Not Meet	Does Not Meet	High
32860	Missisquoi River	8-10%	69	High	2	1	8/11/2013	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	High
32879	Missisquoi River	8-10%	89	High	2	1	12/1/2016	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
32899	Missisquoi River	8-10%	35	High	1	1	8/21/2013	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
32927	Missisquoi River	8-10%	46	High	3	2	6/20/2017	Does Not Meet	Meets	Meets	Meets	Meets	Meets	Does Not Meet	High
32938	Missisquoi River	8-10%	126	High	1	1	11/6/2016	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
32954	Missisquoi River	8-10%	103	High	1	1	10/2/2019	Does Not Meet	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	High
33123	Missisquoi River	8-10%	102	High	2	2	11/7/2016	Does Not Meet	Does Not Meet	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
33124	Missisquoi River	8-10%	12	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
33198	Missisquoi River	8-10%	81	High	1	1	11/7/2016	Does Not Meet	Meets	Does Not Meet	Meets	Meets	N/A	Does Not Meet	High
33350	Missisquoi River	8-10%	101	High	3	2	9/23/2019	Does Not Meet	Meets	Does Not Meet	Meets	Meets	Meets	Does Not Meet	High
33376	Missisquoi River	8-10%	108	High	2	1	6/11/2018	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	High
33407	Missisquoi River	8-10%	60	High	1	1	6/11/2018	Meets	Does Not Meet	Meets	Meets	Meets	N/A	Does Not Meet	High
33416	Missisquoi River	8-10%	67	High	1	1	6/11/2018	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
33579	Missisquoi River	8-10%	59	High	2	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
33588	Missisquoi River	8-10%	66	High	1	1		N/A	N/A	N/A	N/A	N/A	Does Not Meet	Does Not Meet	High
36055	Missisquoi River	8-10%	59	High	3	1	9/4/2013	Meets	Meets	Meets	Meets	Meets	Does Not Meet	Does Not Meet	High
36172	Missisquoi River	8-10%	78	High	2	1	6/11/2017	Meets	Meets	Does Not Meet	Meets	Meets	Meets	Does Not Meet	High
36858	Missisquoi River	8-10%	35	High	2	1	7/17/2013	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	High
37053	Missisquoi River	8-10%	101	High	3	2	11/9/2016	Does Not Meet	Meets	Does Not Meet	Meets	Meets	Meets	Does Not Meet	High
37233	Missisquoi River	8-10%	103	High	5	1	8/1/2016	Meets	Does Not Meet	Meets	Meets	Meets	Meets	Does Not Meet	High
37305	Missisquoi River	8-10%	103	High	2	1	9/13/2017	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
37324	Missisquoi River	8-10%	124	High	1	1	9/14/2017	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
37328	Missisquoi River	8-10%	97	High	1	1	9/14/2017	Does Not Meet	Meets	Meets	Meets	Meets	N/A	Does Not Meet	High
37371	Missisquoi River	8-10%	120	High	4	1	9/13/2017	Does Not Meet	Meets	Meets	Meets	Meets	Meets	Does Not Meet	High

Appendix G: ANR Standard Operating Procedure for Crediting Floodplain Reconnection Projects (DRAFT)

Crediting Stream Restoration for Phosphorus Reductions

February 4, 2020

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION
RIVERS PROGRAM

VERMONT DEPARTMENT OF ENVIRONMENTAL CONSERVATION
WATERSHED MANAGEMENT DIVISION
STORMWATER PROGRAM

1

1

TMDL review

Wasteload Allocation

- Wastewater discharge
- Stormwater from developed lands
- Treated CSOs (Burlington Main facility)
- Agriculture production areas (farmsteads)

Load Allocation

- Forested land
- Agricultural land
- Stream channel instability/erosion

Phosphorus load from **BOTH** need to be reduced to meet the TMDL

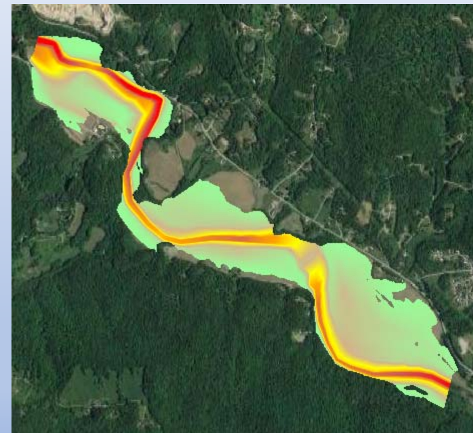
2

2

Crediting Stream Projects

- ~~Stream Bank Erosion~~ → Reductions included in the Load Allocation
- Floodplain Reconnection:

  Increase deposition and adsorption of phosphorus by increasing floodplain storage.

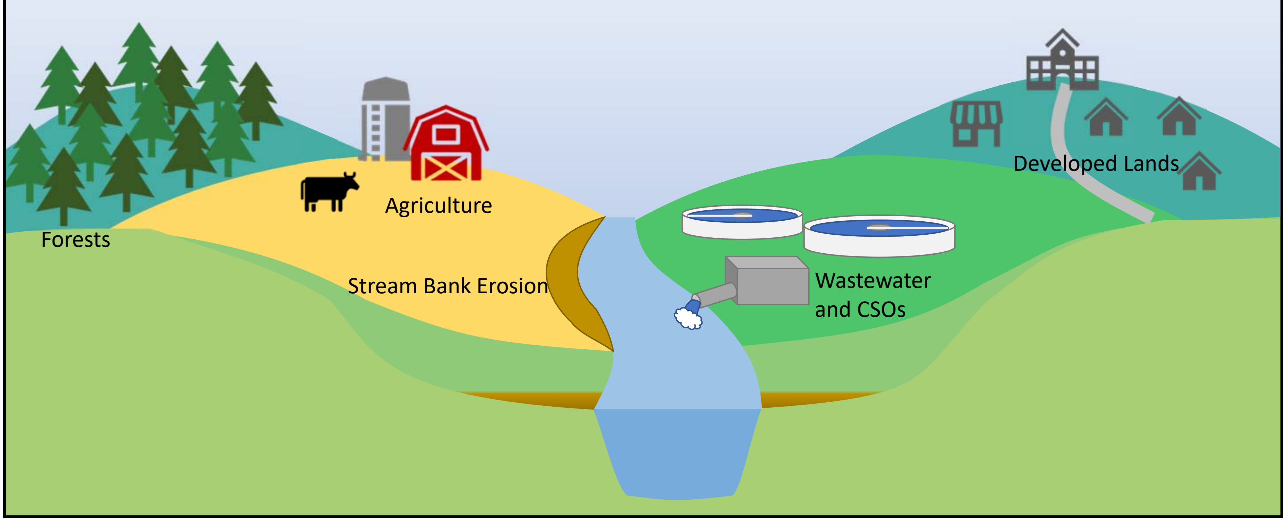


Stream power lbs/ft/s

3

3

Load **Waste load**



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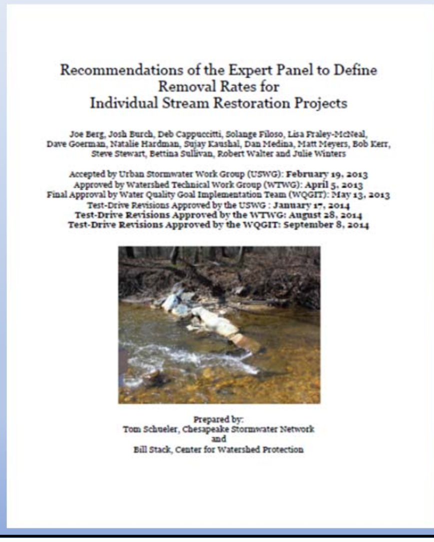
Proposed Method for Crediting Floodplain Reconnection

Expert panel formed to define removal rates for stream restoration



Recommendations of the Expert Panel to Define
Removal Rates for
Individual Stream Restoration Projects

Joe Berg, Josh Burch, Deb Cappuccitti, Solange Filoso, Lisa Fraley-McNeal,
Dave Goerman, Natalie Hardman, Sujay Kaushal, Dan Medina, Matt Meyers, Bob Kerr,
Steve Stewart, Bettina Sullivan, Robert Walter and Julie Winters

Accepted by Urban Stormwater Work Group (USWG): **February 19, 2013**
Approved by Watershed Technical Work Group (WTWG): **April 5, 2013**
Final Approval by Water Quality Goal Implementation Team (WQGIT): May 13, 2013
Test-Drive Revisions Approved by the USWG : January 17, 2014
Test-Drive Revisions Approved by the WTWG: August 28, 2014
Test-Drive Revisions Approved by the WQGIT: September 8, 2014

Prepared by:
Tom Schueler, Chesapeake Stormwater Network
and
Bill Stack, Center for Watershed Protection

5

5

Credit for floodplain reconnection volume

- Calculate volume of runoff that accesses the floodplain on an annual basis before and after reconnection
- Estimate load of TP in reconnected volume by multiplying total pollutant load times the ratio of floodplain runoff to total runoff
- Compute percent of floodplain load that is removed by deposition

6

6

$$TP_{removed} = (Q_{AfterReconnect} - Q_{BeforeRonnect}) \text{ x } TP_{export} \text{ x } TP_{efficiency}$$

$TP_{removed}$ = Phosphorus removed annually due to floodplain reconnection (kg/yr)

$$Q_{AfterReconnect} = \frac{\textit{Annual peak flow volume that accesses floodplain } \textbf{\textit{after}} \textit{ reconnection}}{\textit{Total annual peak flow volume}} \text{ (dimensionless)}$$

$$Q_{BeforeReconnect} = \frac{\textit{Annual peak flow volume that accessesfloodplain } \textbf{\textit{before}} \textit{ reconnection}}{\textit{Total annual peak flow volume}} \text{ (dimensionless)}$$

TP_{export} = Annual TP export from one or more sources (kg/yr)

$TP_{efficiency}$ = TP removal efficiency for floodplain (dimensionless)

7

7

7

Required data and sources

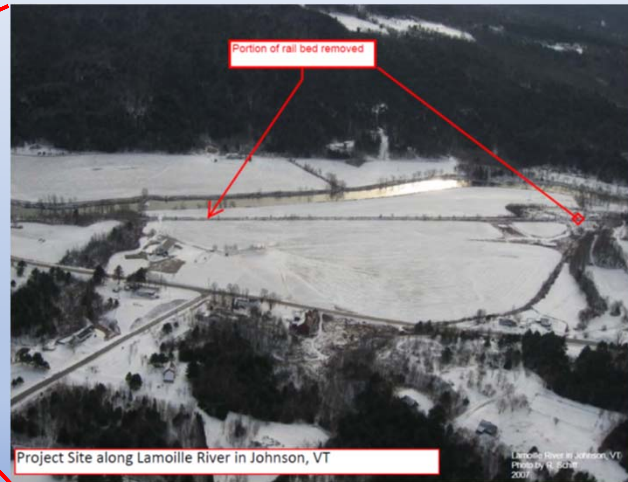
Inputs	Data source
Flow data	Streamstats
Topographic data	LiDAR
Estimate of surface roughness	Professional judgement/literature
Land cover	Existing GIS layers
Export Coefficients	TMDL Modeling
Floodplain efficiency	Default Chesapeake Bay value/best available data

8

8

Site Location: Lamoille River, Johnson VT

~70 Acres



9

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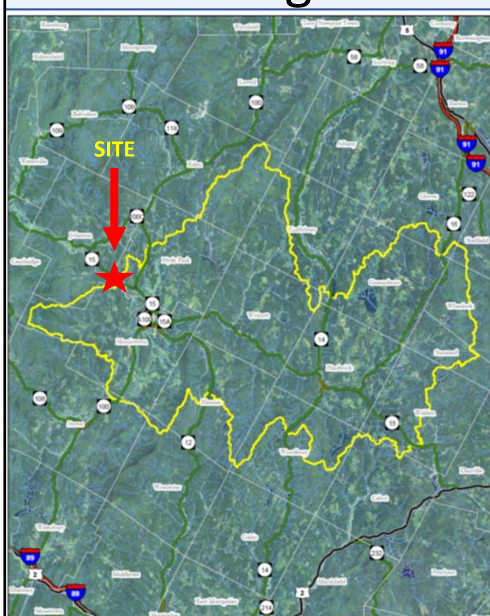
Contributing Watershed



- 190,474 Acres (298 mi^2)

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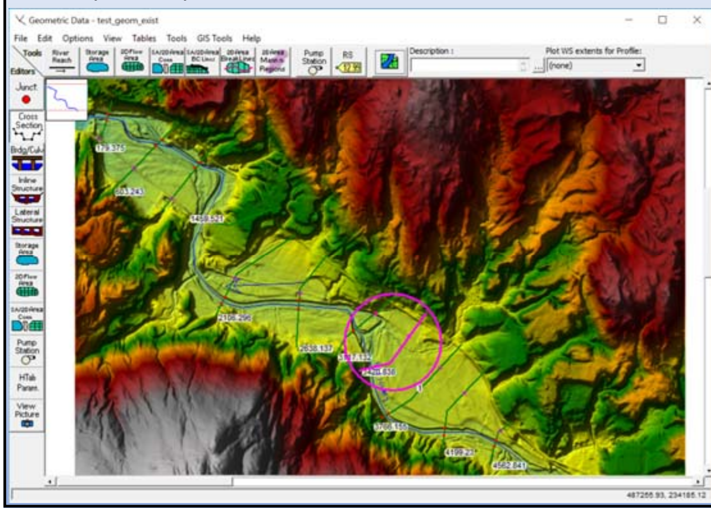
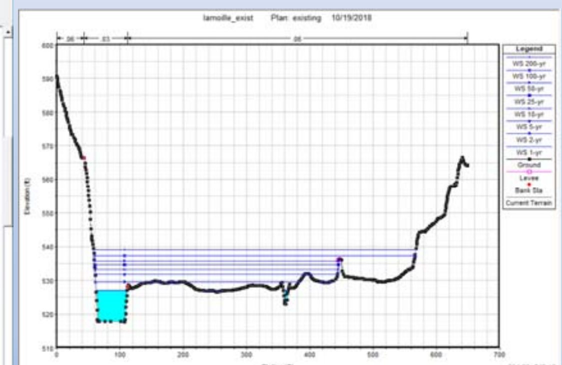
Modeling

Army Corps of Engineers Hydrologic Engineering Center’s (HEC) River Analysis System (RAS)





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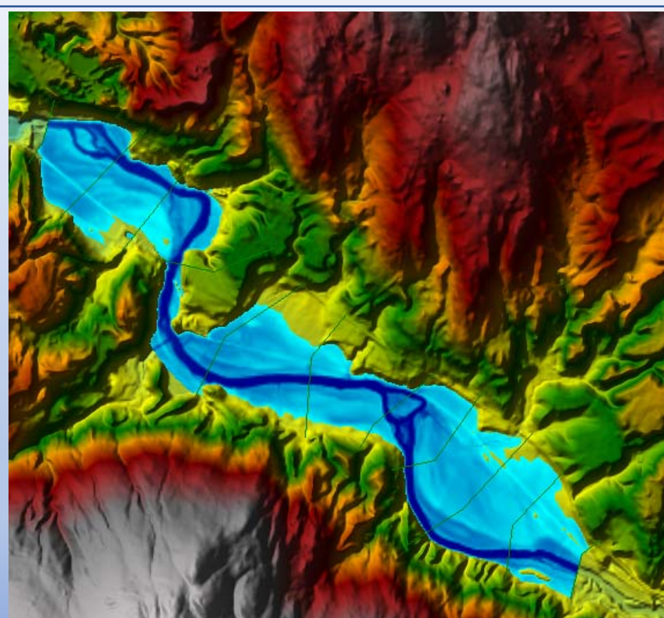
10-Year Flood - Proposed



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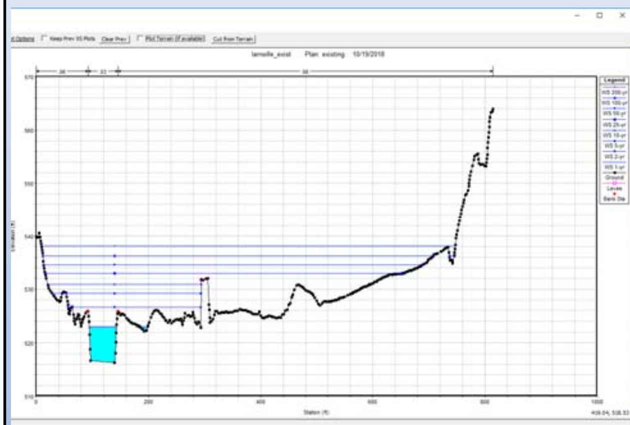
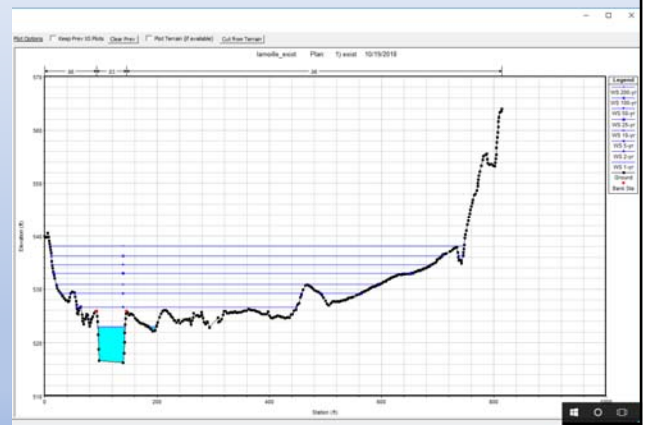
Hydrologic Data: Lamoille River

Existing Condition: Berm	Proposed Conditions: Berm Removed
~20-year storm accesses floodplain	2-year storm accesses floodplain





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Calculations

Credit Calculation

Return Period	Discharge (cfs)	Probability of Event	Integration of Discharge (cfs)	Existing Conditions: Total Runoff (Ac-ft)	Existing Conditions: Floodplain Runoff (Ac-ft)	Existing Conditions: Integration of Total Runoff (Ac-ft)	Existing Conditions: Integration of Floodplain Runoff (Ac-ft)	Proposed Conditions: Total Runoff (Ac-ft)	Proposed Conditions: Floodplain Runoff (Ac-ft)	Proposed Conditions: Integration of Total Runoff (Ac-ft)	Proposed Conditions: Integration of Floodplain Runoff (Ac-ft)
1	480	1		47	3.64			47.29	3.92		
2	1,240	0.5	430.00	90.45	27.68	34.36	7.83	94.63	32.34	35.48	9.07
5	1,860	0.2	465.00	137.94	61.49	34.26	13.38	153.16	77.85	37.17	16.53
10	2,340	0.1	210.00	172.62	87.32	15.53	7.44	197.08	113.56	17.51	9.57
25	3,050	0.04	161.70	241.66	147.07	12.43	7.03	256.89	163.69	13.62	8.32
50	3,630	0.02	66.80	298.92	197.25	5.41	3.44	306.67	205.88	5.64	3.70
100	4,260	0.01	39.45	361.62	251.94	3.30	2.25	363.12	253.82	3.35	2.30
200	5,910	0.005	25.43	426.76	306.51	1.97	1.40	428.52	308.78	1.98	1.41
			1,398			107.26	42.76			114.74	50.88

Existing conditions: % of annual flood flow that accesses the floodplain	39.87%
Proposed conditions: % of annual flood flow that accesses the floodplain	44.34%
Percent increase due to reconnection	4.47%
Floodplain Efficiency Data Source: Chesapeake Bay Protocol	30.00%
Reconnected floodplain efficiency	1.34%

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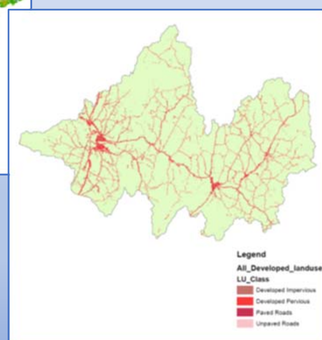
Contributing Load (kg/yr)

All Land Uses (SWAT Inputs)

Developed Lands



- Contributing areas from GIS
- Multiply by loading rates from TMDL to get load

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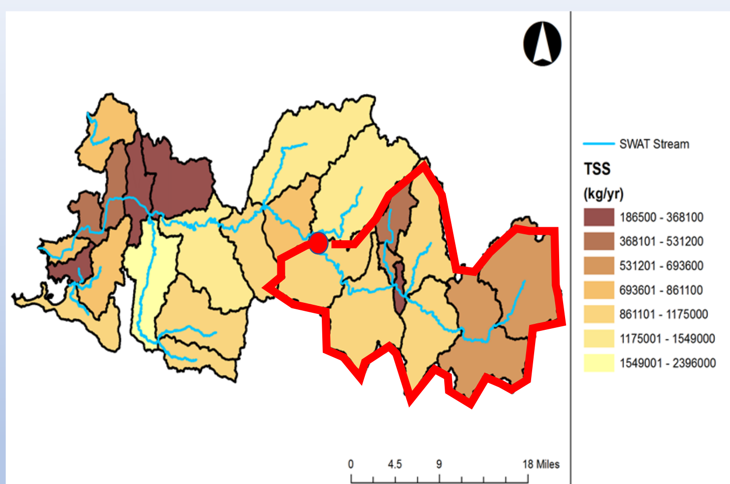
Streambank Load (kg/yr)



$$\frac{Stream\ km\ upstream\ of\ site\ location}{Total\ stream\ km}$$ * Total Stream Bank Loading = Stream Bank Load to Project

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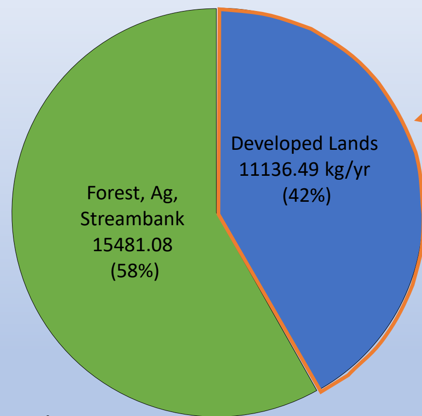
TP Loading (kg/yr)

Loading sources upstream of floodplain reconnection



Reductions to the developed load is creditable to the MS4

Total Load: 26,617.60 kg/yr

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Results (Total Project)

$$(Q_{AfterReconnect} - Q_{BeforeRonnect}) \text{ x } TP_{export} \text{ x } TP_{efficiency} = TP_{removed}$$

4.47% x 26,617 (kg/yr) x 30% = 357 kg/yr (total removed)

- % Increased annual flood volume: 4.47%
- Assumed Floodplain Efficiency: 30%
- Reconnected floodplain efficiency: 1.34%
- Total TP loading from upstream: 26,617 kgs/yr

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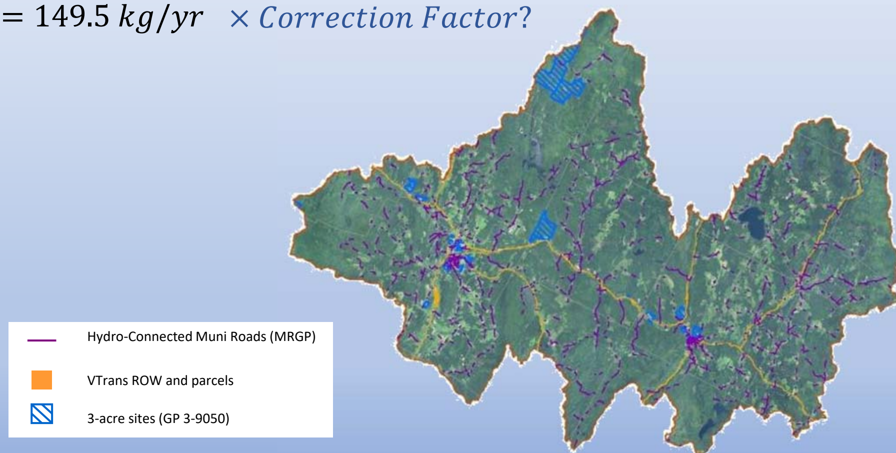
Results (Developed Lands)

$$Total\ P\ Reduction \times \frac{Developed\ Lands\ Load}{Total\ P\ Load} = Developed\ Lands\ Credit$$

$$357\ kg/yr \times 41.9\% = 149.5\ kg/yr \quad \times Correction\ Factor?$$



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Cost Comparison to Stormwater BMPs

Average Stormwater Treatment: $26,000-$95,000 per kg/yr TP

Average Road Erosion Remediation: $14,000 - $67,000 per kg/yr TP

source: 2019 Vermont Clean Water Performance Report, 25th – 75th Percentile

Average floodplain reconnection: $321/kg/yr TP

source: 2007/2008 Lamoille Valley floodplain reconnections

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Summary

- For a proposed floodplain reconnection site, the methodology quantifies how much of the annual TP load from upstream sources would be captured
    - The reductions can be attributed to specific sources
- Costs/benefits suggest relatively high return on investment (ROI)
    - Not just nutrient retention, also habitat, flood resilience
    - Additional tracking of BMP costs would help support comparisons
- Applicability to Wetlands?

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Appendix H: Non-Structural Controls Memo

STONE ENVIRONMENTAL
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MEMO

March 18, 2020

To: Emily Schelley, VT DEC
Jenn Callahan, VTrans

From: Polly Crocker, Amy Macrellis, Warren Rich, Stone Environmental Inc.

Stone Project No. 18-008-A
Subject: VTrans PCP Task 4 – Estimate Areas to be Treated with Non-Structural Practices

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The purpose of this memo is to summarize the baseline condition and potential phosphorus (P) reductions of non-structural controls implemented by the Vermont Agency of Transportation (VTrans) from 2010-2019 and recommend possible future enhancements to those activities with cost estimates for further P reduction for compliance with the Transportation Separate Storm Sewer System (TS4) permit[1]. The Stone Environmental (Stone) team leveraged the VTrans Maintenance Activity Tracking System (MATS) dataset to review maintenance records and quantify the two existing non-structural controls that reduce P: street sweeping and drop inlet (DI)/catch basin cleaning activities (note: for purpose of all PCP analysis DI and catch basins are synonymous and will be referred to as "DI").

P reductions for both DI cleaning and street sweeping were calculated using methodology provided by the Vermont Department of Environmental Conservation (DEC)[2]. VTrans will incorporate applicable findings from ongoing research by USGS[3], in cooperation with the Chittenden County Regional Planning Commission, DEC, the University of Vermont, and nine Vermont municipalities, to evaluate potential reductions in nutrient and sediment loads possible through current street cleaning practices, and possible enhancements to those activities.

Prior to 2010, these non-structural controls were not consistently implemented on a significant extent of roads within the Lake Champlain Basin (LCB) as part of VTrans' annual operations. Therefore, any street sweeping or DI cleaning included in the PCP can count toward the annual P reduction crediting. Upon initial review of the MATS data it was determined that data collected prior to 2015 was sporadic

[1] https://dec.vermont.gov/watershed/stormwater/transportation-general-permit
[2] ANR. (2019) "Draft MS4 Annual Report for Calendar Year 2019" Dec 11, 2019. https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/Draft%20Annual%20Report%20Workbook_11_2019.xlsx
[3] https://www.ccrpcvt.org/wp-content/uploads/2018/12/CleanStreetsSweepingStudy_Sept4_update.pdf

and unreliable, as maintenance crews were getting used to the new maintenance tracking system. Therefore, the general approach for each of the non-structural controls was to analyze data from 2015-2019 to create a baseline of non-structural BMP activities from which average annual P reductions and operational cost could be derived. The baseline, potential P reductions and recommendations for future implementation of each non-structural activity is outlined below.

1. DI Cleaning

VTrans elected to begin cleaning DIs with a vac truck in response to requirements within their Municipal Separate Storm Sewer System (MS4) permit. Therefore, a large portion of DI cleaning with a vac truck happened within VTrans' MS4 area (Figure 1). Additionally, most of the DI cleaning work is contracted out to a vendor with the specialized equipment required and is therefore somewhat limited in scale.

DI cleaning MATS data posed a unique challenge because there is currently no specific activity code for DI cleaning in the MATS database. The activity code "Stormwater Drainage Work" encompasses several activities, including DI cleaning. It was also discovered the DI cleaning can be broken into two categories: 1) clearing debris off the top of a DI so that water can flow into the structure (this activity typically indicates that material is merely being brushed aside and not hauled away) and 2) using a vac truck to vacuum out debris from a DI and hauling it away for disposal. It was determined that the latter DI cleaning would result in P reduction and therefore the data presented in this memo is for vac truck-assisted DI cleaning only.

It should be noted that the baseline estimates presented below may be conservative. Because there is not a specific activity code for DI cleaning, the only way to determine if the Stormwater Drainage Work MATS record was for DI cleaning was if the language included in the comments for that MATS record contained references to DIs. Therefore, blank comments and comments that didn't reference DIs may have been unnecessarily excluded. Refer to Appendix A: Processing Document - MATS Stormwater Drainage Work Baseline Data Analysis for the methods used to create the MATS baseline data set for estimating P reductions of DI Cleaning discussed below.

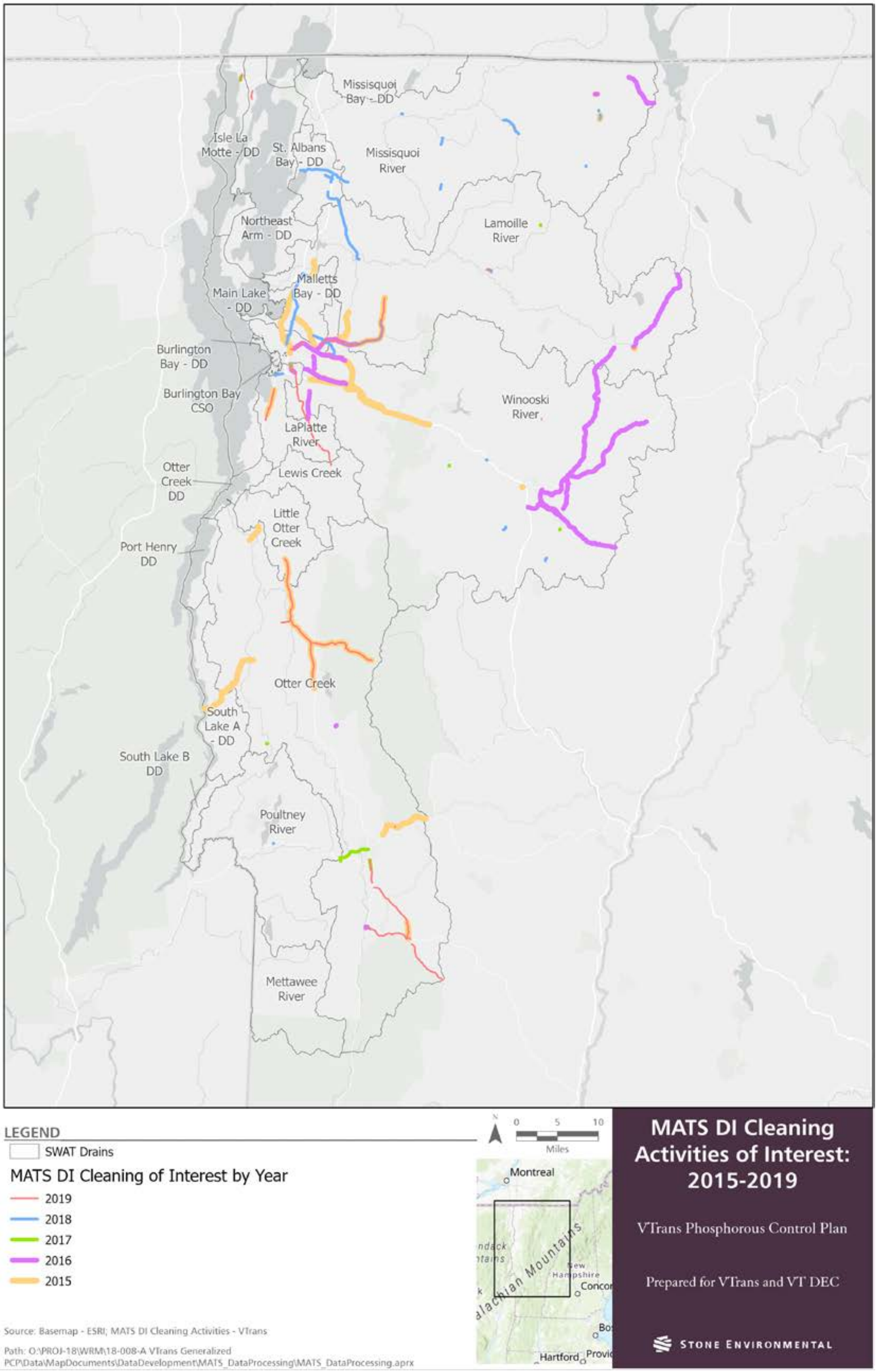


Figure 1. VTrans DI cleaning extent 2015-2019

1.1 DI Cleaning Baseline Analysis

DI Cleaning was analyzed by Soil and Water Assessment Tool (SWAT) drainage area (which is how P reductions will be credited) as well as VTrans District (which is how VTrans manages its maintenance activities). The total number of DIs cleaned per year was somewhat sporadic, ranging from 86 in 2017 to 469 in 2015. Discussions with VTrans staff brought to light that this is largely because of budgeting fluctuations. On average 376 of the 8038 DIs (or 5%) in the LCB area were cleaned each year with a vac truck. Proportional to the total number of DIs per SWAT drainage area, the Isle La Motte – Direct Drainage, LaPlatte River and Malletts Bay – Direct Drainage and Missisquoi River were the SWAT drainage areas with the highest percentage of DIs cleaned (Table 1).

During years with a healthy DI cleaning budget (2015, 2016, 2108, and 2019), annual totals ranged 330-469; whereas the year with a lack of DI cleaning budget (2017) was below 90 per year (Figure 2). Looking at only the volume of DIs cleaned, most DI cleaning occurred in the LaPlatte, Otter Creek and Winooski River SWAT drainage areas which translates to Districts three, five and eight (Table 2, Figure 3).

It should be noted that vac trucks often cross SWAT drainage area boundaries while cleaning DIs. Each MATS record is associated with the SWAT drainage area that represented the majority of cleaned DIs for that record. This results in less precise location data for cleaned DI totals but allows for seamless cost analysis because DI cleaning costs are associated with individual MATS records (see cost analysis below).

Table 1. Total cleaned DIs by SWAT drainage area

SWAT Drainage Area	2015	2016	2017	2018	2019	Grand Total	Average DIs Cleaned Annually	Total # of DIs per SWAT Drain	Average % of DIs Cleaned
Isle La Motte - DD	0	0	1	0	21	22	5	41	13%
Lamoille River	64	14	17	76	27	198	45	1129	4%
LaPlatte River	126	34	1	4	116	281	70	525	13%
Malletts Bay - DD	37	0	0	58	0	95	24	225	11%
Missisquoi River	48	7	0	97	2	154	39	554	7%
Northeast Arm - DD	0	0	0	0	21	21	5	161	3%
Otter Creek	57	8	65	1	108	239	43	1060	4%
Poultney River	0	0	0	2	0	2	1	519	<1%
South Lake A - DD	2	0	0	0	0	2	1	20	3%
St. Albans Bay - DD	0	0	0	37	0	37	9	212	4%
Winooski River	135	258	2	110	35	540	135	3365	4%
Grand Total	469	321	86	385	330	1591	376	8038	5%

Note: Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)

Table 2. Total cleaned DIs by district

District	2015	2016	2017	2018	2019	Grand Total	Average DIs Cleaned Annually
3	18	8	65	3	84	178	28
4	0	0	0	29	0	29	7
5	398	236	2	194	184	1014	253
7	5	70	1	1	7	84	21
8	0	0	18	129	55	202	46
9	48	7	0	29	0	84	21
Grand Total	469	321	86	385	330	1591	376

Note: Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)

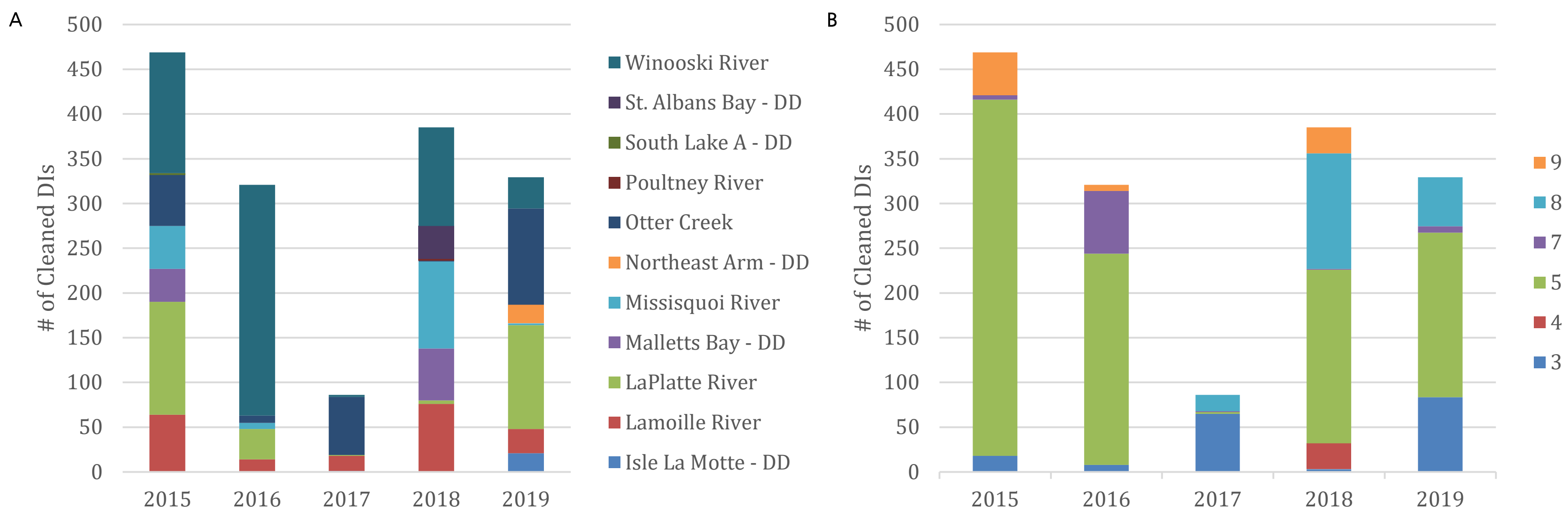


Figure 2. Annual DI cleaning by A) SWAT drainage area, and B) district

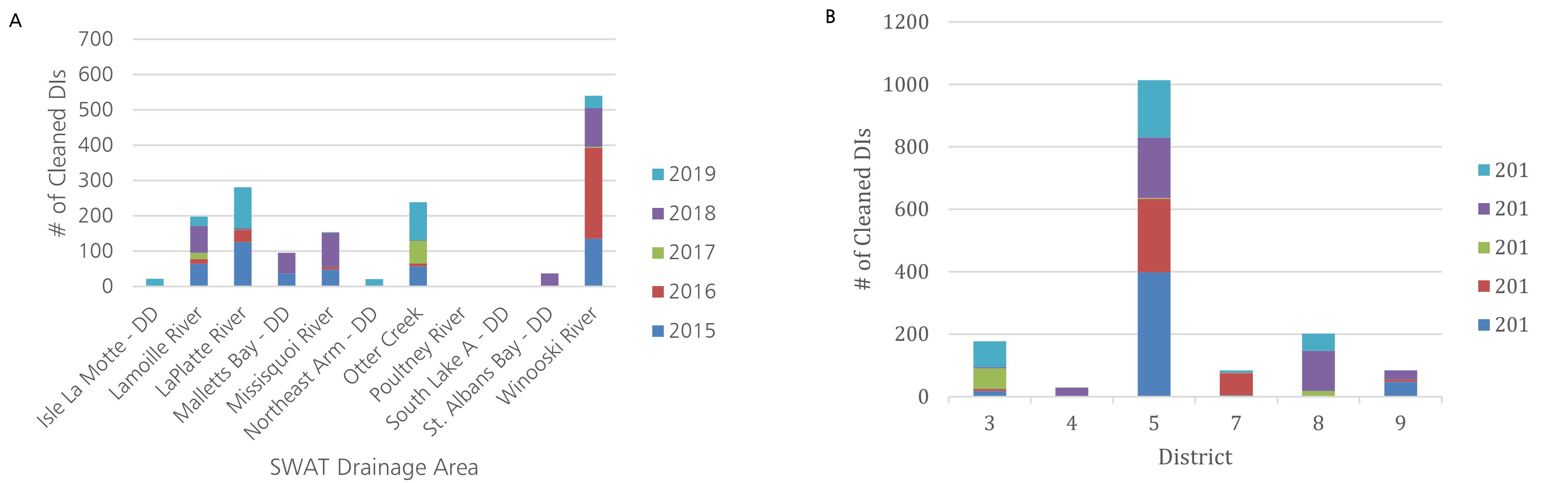


Figure 3. Total cleaned DIs by A) SWAT drainage area, and B) district

DIs are cleaned throughout the year, with a spike of activity later in the year that corresponds to the rainy season (Figure 4).

Figure 4. Total number of DIs cleaned per month 2015-2019

To inform recommendations for future non-structural controls, a cost analysis was conducted for DI cleaning activities from 2015-2019. Total annual costs ranged from $27,837-$86,687 per year, averaging $74,398 (Table 3). The average cost to clean a single DI varied widely between SWAT drainage areas ($81-$851) and was much more consistent across District boundaries ($167-$285). This would be expected due to the data phenomenon outlined above (vac trucks crossing SWAT drainage areas) and Districts sharing a similar contracting mechanism for vac truck work (re: low variability across jurisdictional boundaries). On average, the cost to clean a DI was $198 from 2015-2019 (Table 4).

Costs correlated with where the DI cleaning occurred, with the highest costs attributed to the LaPlatte, Otter Creek and Winooski River SWAT drainage areas, which again correspond to Districts three, five and eight (Figure 5, Figure 6).

Table 3. Annual DI cleaning costs by SWAT drainage area

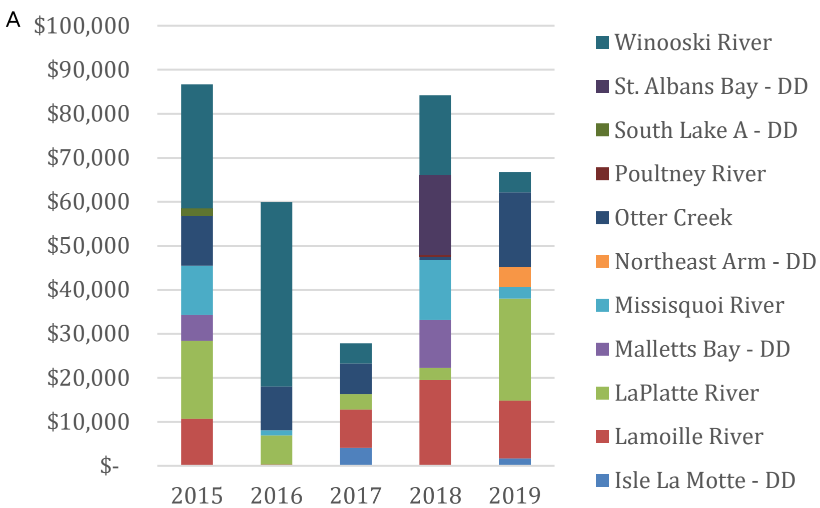
SWAT Drainage Area	2015	2016	2017	2018	2019	Grand Total	Average Annual $	Average DIs Cleaned Annually	Average $ per DI
Isle La Motte - DD	$ -	$ -	$ 4,056	$ -	$ 1,711	$ 5,767	$ 428	5	$ 81
Lamoille River	$10,695	$ 276	$ 8,740	$19,501	$13,145	$ 52,358	$10,904	45	$ 241
LaPlatte River	$17,737	$ 6,679	$ 3,468	$ 2,766	$23,133	$ 53,782	$12,579	70	$ 180
Malletts Bay - DD	$ 5,893	$ -	$ -	$10,847	$ -	$ 16,739	$ 4,185	24	$ 176
Missisquoi River	$11,178	$ 1,093	$ -	$13,577	$ 2,613	$ 28,461	$ 7,115	39	$ 185
Northeast Arm - DD	$ -	$ -	$ -	$ -	$ 4,529	$ 4,529	$ 1,132	5	$ 216
Otter Creek	$11,293	$10,000	$ 6,968	$ 871	$17,011	$ 46,145	$ 9,794	43	$ 226
Poultney River	$ -	$ -	$ -	$ 386	$ -	$ 386	$ 97	1	$ 193
South Lake A - DD	$ 1,701	$ -	$ -	$ -	$ -	$ 1,701	$ 425	1	$ 851
St. Albans Bay - DD	$ -	$ -	$ -	$18,154	$ -	$ 18,154	$ 4,539	9	$ 491
Winooski River	$28,190	$41,908	$ 4,605	$18,076	$ 4,626	$ 97,406	$23,200	135	$ 172
Grand Total	$86,687	$59,956	$27,837	$84,179	$66,768	$ 325,428	$74,398	376	$ 198

Note: Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)

Table 4. Annual DI cleaning costs by District

District	2015	2016	2017	2018	2019	Grand Total	Average Annual $	Average DIs Cleaned Annually	Average $ per DI
3	$ 4,569	$10,000	$ 6,968	$ 1,258	$ 7,463	$ 30,258	$ 5,822	28	$ 207
4	$ -	$ -	$ -	$ 4,844	$ -	$ 4,844	$ 1,211	7	$ 167
5	$64,962	$39,573	$ 4,180	$37,330	$41,464	$ 187,508	$45,832	253	$ 181
7	$ 5,978	$ 9,290	$ 3,893	$ 2,205	$ 6,156	$ 27,522	$ 5,907	21	$ 285
8	$ -	$ -	$12,796	$36,199	$11,686	$ 60,681	$11,971	46	$ 260
9	$11,178	$ 1,093	$ -	$ 2,344	$ -	$ 14,615	$ 3,654	21	$ 174
Grand Total	$86,687	$59,956	$27,837	$84,179	$66,768	$ 325,428	$74,398	376	$ 198

Note: Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)



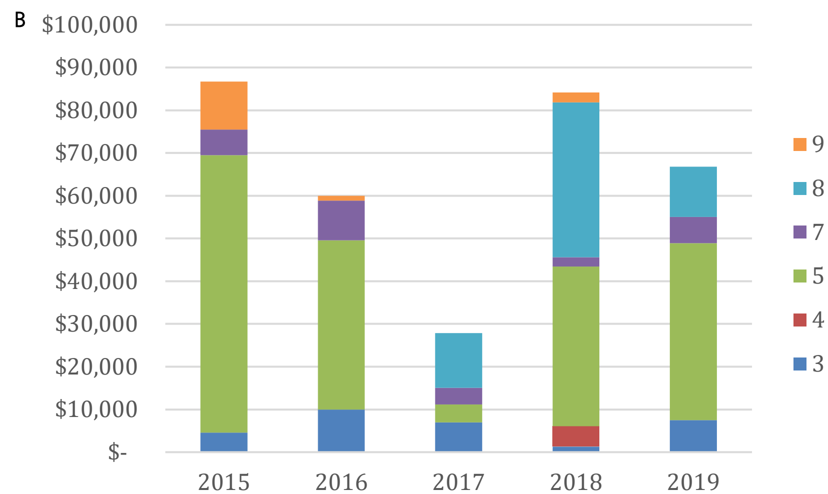
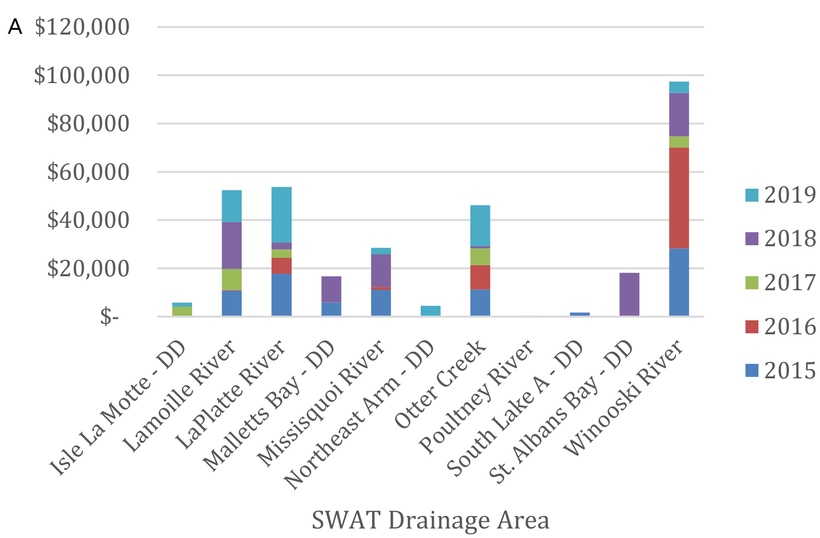


Figure 5. Annual DI cleaning costs by A) SWAT drainage area, and B) district



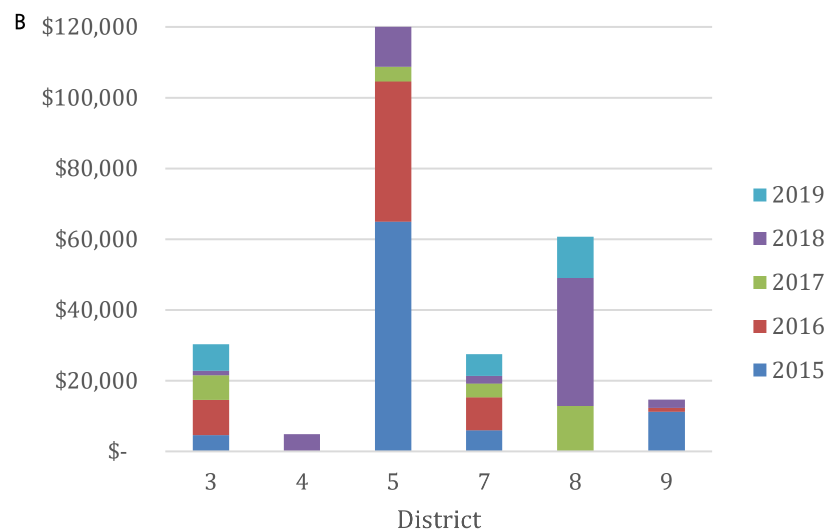


Figure 6. Total DI cleaning costs by A) SWAT drainage area, and B) district

1.2 DI Cleaning Baseline P Load Reduction Credits

The DEC provides two methods for P reduction calculation from DI cleaning:

1. *Area-based* – This method allocates a 2% reduction in P from the P load of streets where DI cleaning occurs (kg/yr).
2. *Volumetric-based* – Still under development, this method will most likely require a total P (TP) test be conducted on the material collected from cleaned DIs by vac truck so that the amount of P can be determined for the entire volume of material collected and then counted towards P load reduction[2].

Samples were not taken from the cleaned DI material from 2015-2019 and TP per volume cannot be determined. Therefore, Stone used the area-based methodology to determine P reductions from 2015-2019. To determine the P load from streets where DI cleaning occurred, the P load from each road segment associated with a DI cleaning MATS record was calculated using the road segment area, SWAT drainage area, slope, and hydrologic class of each road segment (Table 5, Table 6).

Because there are multiple road segments per MATS DI cleaning record and the linear nature of the activity, there were some instances where one MATS record included road segments from multiple SWAT drainage areas (as described above). Therefore, the P loads and associated reduction credits are distributed slightly differently across the SWAT drainage areas than the rest of the data analyzed in this memo (where all data associated with a MATS record as attributed to the single SWAT drainage area that made up the majority of road segments attributed to that MATS record). For example, the Little Otter Creek SWAT drainage area appears in the data analyzed below because there was one MATS record that was previously only associated with the Otter Creek SWAT drainage area, but when broken up into road segments to calculate P load it was discovered the DI cleaning crew also drove through and worked in the Little Otter Creek SWAT drainage area on that trip. Refer to Appendix A: Processing Document - MATS Stormwater Drainage Work Baseline Data Analysis for more detail.

Table 5. Acres of road where DI cleaning occurred by SWAT Drainage Area

SWAT Drainage Area	2015	2016	2017	2018	2019	Annual Average
Isle La Motte - DD	0.0	0.0	2.9	0.0	4.0	1.0
Lamoille River	62.2	44.0	2.1	60.9	40.7	52.0
LaPlatte River	20.2	8.7	1.6	5.4	64.9	24.8
Lewis Creek	0.0	0.0	0.0	0.0	2.0	0.5
Little Otter Creek	12.3	0.0	0.0	0.0	12.3	6.1
Malletts Bay - DD	47.2	6.0	0.0	44.3	6.0	25.8
Missisquoi River	3.2	24.7	0.0	21.9	1.7	12.9
Northeast Arm - DD	0.0	0.0	0.0	0.0	4.7	1.2
Otter Creek	155.9	1.9	18.5	0.4	191.3	87.4
Poultney River	0.0	0.0	1.0	0.7	0.0	0.2
South Lake A - DD	10.8	0.0	0.0	0.0	0.0	2.7
St. Albans Bay - DD	0.0	0.0	0.0	32.8	0.0	8.2
Winooski River	170.5	229.2	0.8	27.5	39.0	116.6
Grand Total	482.3	314.5	27.0	193.9	366.6	339.3

Note: Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)

Table 6. Annual P load from roads where DI cleaning occurs (kg/ac) by SWAT drainage area

SWAT Drainage Area	2015	2016	2017	2018	2019	Annual Average
Isle La Motte - DD	0.00	0.00	1.74	0.00	2.33	0.58
Lamoille River	51.01	66.03	2.02	47.53	34.87	49.86
LaPlatte River	15.64	5.94	1.11	4.42	48.94	18.74
Lewis Creek	0.00	0.00	0.00	0.00	1.74	0.43
Little Otter Creek	11.82	0.00	0.00	0.00	11.82	5.91
Malletts Bay - DD	31.60	4.53	0.00	29.55	4.53	17.55
Missisquoi River	2.36	18.94	0.00	23.25	1.40	11.48
Northeast Arm - DD	0.00	0.00	0.00	0.00	3.68	0.92
Otter Creek	139.46	1.43	25.48	0.39	175.50	79.20
Poultney River	0.00	0.00	1.05	0.58	0.00	0.15
South Lake A - DD	8.66	0.00	0.00	0.00	0.00	2.17
St. Albans Bay - DD	0.00	0.00	0.00	29.31	0.00	7.33
Winooski River	143.03	264.72	0.68	22.77	26.61	114.28
Grand Total	403.58	361.59	32.08	157.81	311.41	308.60

Note: Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)

Annual P load reductions ranged from 0.64 – 8.07 kg/yr with an average of 6.17 kg/yr, which translates to roughly 0.43% of the total required P reduction per year from VTrans roads within the LCB (Figure 7). P load reductions largely corresponded to where DI cleaning happened, although the distribution differed slightly due to the data manipulation discussion above, with the highest P reductions occurring within the Lamoille, Otter Creek and Winooski River SWAT drainage areas (Figure 8). Compared to the total P reduction target of each SWAT drainage area, current DI cleaning regimes account for a relatively small portion of annual P reduction, ranging from 0.003% - 1.43% (Table 7). Looking back at the cost data presented in Section 1.1, the unit cost for removing one kg/yr of P with DI cleaning is $12,054 (Table 8).

Table 7. Annual P load reduction (kg/yr) from DI cleaning activities by SWAT drainage area

SWAT Drainage Area	2015 P Red (kg/yr)	2015 Percent of Total P Red	2016 P Red (kg/yr)	2016 Percent of Total P Red	2017 P Red (kg/yr)	2017 Percent of Total P Red	2018 P Red (kg/yr)	2018 Percent of Total P Red	2019 P Red (kg/yr)	2019 Percent of Total P Red	Average Annual P Red (kg/yr)	Total Target P Red (kg/yr)	Average Annual Percent of Total P Red
Isle La Motte - DD	0.00	-	0.00	-	0.03	1.14%	0.00	-	0.05	1.53%	0.01	5.63	0.21%
Lamoille River	1.02	0.72%	1.32	0.93%	0.04	0.03%	0.95	0.67%	0.70	0.49%	1.00	211.96	0.47%
LaPlatte River	0.31	1.29%	0.12	0.49%	0.02	0.09%	0.09	0.36%	0.98	4.03%	0.37	32.85	1.14%
Lewis Creek	0.00	-	0.00	-	0.00	-	0.00	-	0.03	0.73%	0.01	7.39	0.12%
Little Otter Creek	0.24	2.27%	0.00	-	0.00	-	0.00	-	0.24	2.27%	0.12	15.04	0.79%
Malletts Bay - DD	0.63	2.81%	0.09	0.40%	0.00	-	0.59	2.63%	0.09	0.40%	0.35	24.60	1.43%
Missisquoi River	0.05	0.02%	0.38	0.17%	0.00	-	0.46	0.21%	0.03	0.01%	0.23	327.48	0.07%
Northeast Arm - DD	0.00	-	0.00	-	0.00	-	0.00	-	0.07	0.78%	0.02	13.41	0.14%
Otter Creek	2.79	2.14%	0.03	0.02%	0.51	0.39%	0.01	0.01%	3.51	2.69%	1.58	196.27	0.81%
Poultney River	0.00	-	0.00	-	0.02	0.03%	0.01	0.02%	0.00	-	0.00	111.96	0.00%
South Lake A - DD	0.17	1.49%	0.00	-	0.00	-	0.00	-	0.00	-	0.04	16.19	0.27%
St. Albans Bay - DD	0.00	-	0.00	-	0.00	-	0.59	1.82%	0.00	-	0.15	47.21	0.31%
Winooski River	2.86	1.09%	5.29	2.01%	0.01	0.01%	0.46	0.17%	0.53	0.20%	2.29	423.05	0.54%
Grand Total	8.07	0.86%	7.23	0.77%	0.64	0.07%	3.16	0.33%	6.23	0.66%	6.17	1433.04	0.43%

Notes: - Red = reduction

- Total Target P Reduction is only for SWAT drainage areas which contained roads where DI cleaning occurred. The total target P reduction for all VTrans roads within the LCB is 1514 kg/yr.

- Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)

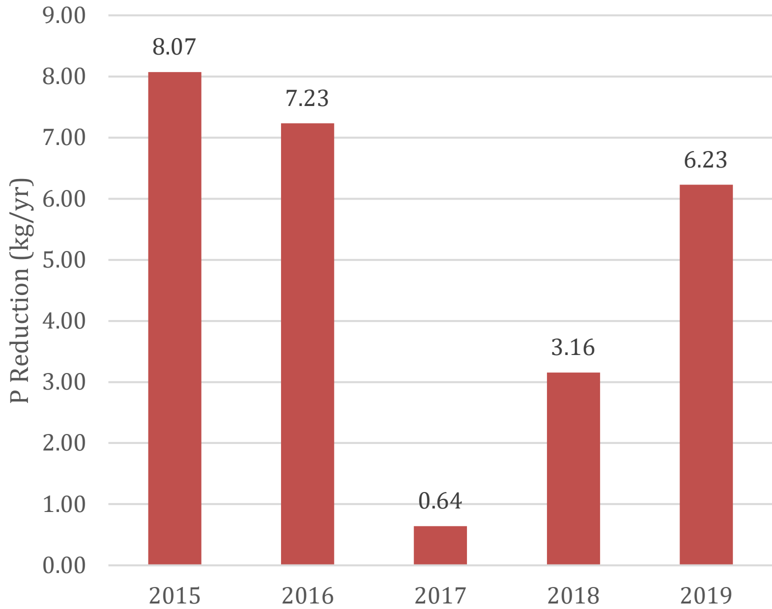


Figure 7. Total P reduction (kg/yr) from streets where DI cleaning occurred 2015-2019

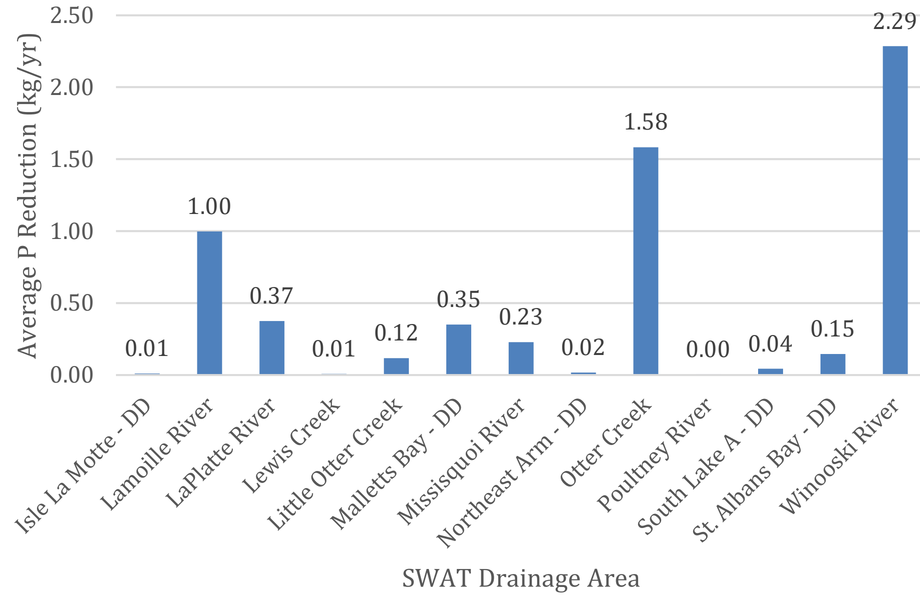


Figure 8. Average annual P reduction (kg/yr) from streets where DI cleaning occurred 2015-2019 by SWAT drainage area

Table 8. Average annual unit cost for removing one kg/yr of P with DI cleaning

	2015	2016	2017	2018	2019	Average
Total P Red (kg/yr)	8.07	7.23	0.64	3.16	6.23	6.17
Percent of Total VTrans P Reduction Target	0.5%	0.4%	0.04%	0.2%	0.4%	0.4%
Total Cost	$ 86,687	$ 59,956	$ 27,837	$ 84,179	$ 66,768	$ 74,398
P Red Unit Cost ($/kg/yr)	$10,740	$ 8,291	$43,381	$26,672	$10,720	$ 12,054

Note: - Average Annual Percent of Total VTrans P Reduction Target was calculated using the total target P reduction for all VTrans roads within the LCB (1514 kg/yr).
- Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)

1.3 Recommendations for Future DI Cleaning Non-Structural Controls

1.3.1 MATS Tracking Improvements

Better tracking will lead to more accurate calculations and potentially greater P reduction estimates; here are a few suggestions for better tracking of street DI cleaning in MATS:

1. Create an activity code for DI Cleaning with vac truck.
2. In order to use the more precise volumetric approach to account for P reductions, begin tracking the volume of material captured and removed per MATS record.
3. Inconsistencies in data entry were identified during this analysis and re-training staff at a regular interval (suggest bi-annually, or as updates to the system are made) may be beneficial to reduce errors.
4. Many DI cleaning MATS records used one MATS record for two different geographic locations. It would be ideal if a truck moves to a different area, a new MATS record be created so area-based P reductions can be calculated more accurately.
5. A field indicating whether or not a vacuum truck was used to clean DIs would be helpful in determining potential credit allocated to each MATS entry.
6. If possible, relating the MATS records to the VTrans Small Culvert Inventory asset would be helpful to provide better spatial context, as well as in tracking changes in DI conditions as a result of a MATS activity.

1.3.2 Extent & Frequency of DI Cleaning

It was determined that current DI cleaning regimes (5% of total DIs in the LCB cleaned per year) could annually reduce the total P required from VTrans roads within the LCB by 0.4% on average. Table 9 shows the incremental increase that would result from doubling ongoing DI cleaning efforts to clean 10% of all DIs in the LCB in a year.

Table 9. Example projections of increased DI cleaning, from 5% of Dis cleaned annually to 10%

	2015 - 2019 Annual Average	Example Projection
DIs cleaned	376	804
Percent of Total DIs in LCB	5%	10%
P Red (kg/yr)	6.17	13
P Red per Cleaned DI (kg/yr/DI)	0.02	0.02
Cost	$74,398	$159,152

Percent of Total VTrans P Red Target	0.4%	1%

DI cleaning presently has a relatively small impact on annual P reductions. As a routine maintenance practice, DI cleaning has additional benefits, including maintaining DI function and protecting downstream VTrans drainage infrastructure. Without increasing the number of DIs cleaned or the overall budget for DI cleaning, VTrans could see increased P reduction benefits from implementing an approach that prioritizes cleaning DIs along highly hydrologically connected road segments. DI sweeping could also be focused in Lake segments with the highest P reduction targets (Table 10).

Further analysis of where to focus DI cleaning efforts will be included in the development of each 4-year Implementation Plan. For example, if structural BMPs have been identified within a 4-year Implementation Plan and marginal P reductions are still required, focused DI cleaning within the planning area could close the P reduction gap. As discussed above, results from ongoing research by USGS and others[3] evaluating reductions in nutrient and sediment loads possible through DI cleaning and street cleaning practices, and evaluating P reductions and crediting for current practice and potential enhancements, will further influence decision making regarding VTrans' DI cleaning program once those findings are available in 2020.

Table 10. Comparison of DI cleaning metrics by SWAT drainage area

SWAT Drainage Area	Average DIs Cleaned Annually	Average Annual P Red (kg/yr)	Total Target P Red (kg/yr)	Average Annual Percent of Total P Red
Isle La Motte - DD	5	0.01	5.63	0.21%
Lamoille River	45	1.00	211.96	0.47%
LaPlatte River	70	0.37	32.85	1.14%
Lewis Creek	N/A	0.01	7.39	0.12%
Little Otter Creek	N/A	0.12	15.04	0.79%
Malletts Bay - DD	24	0.35	24.60	1.43%
Missisquoi River	39	0.23	327.48	0.07%
Northeast Arm - DD	5	0.02	13.41	0.14%
Otter Creek	43	1.58	196.27	0.81%
Poultney River	1	0.00	111.96	0.003%
South Lake A - DD	1	0.04	16.19	0.27%
St. Albans Bay - DD	9	0.15	47.21	0.31%
Winooski River	135	2.29	423.05	0.54%
Grand Total	376	6.17	1433.04	0.43%

Notes: - Red = reduction
- Total Target P Reduction is only for SWAT drainage areas which contained roads where DI cleaning occurred. The total target P reduction
for all VTrans roads within the LCB is 1514 kg/yr.
- Averages are for years with healthy DI cleaning budgets (2015, 2016, 2018, 2019)
- Lewis Creek and Little Otter Creek do not have number of DIs cleaned because of the data phenomenon described in the above section
that results from vac trucks driving across SWAT drainage areas.

1.3.3 DI Cleaning P Reduction Calculation Methodology

The area-based methodology for calculation P reductions from DI cleaning could be underestimating the actual P reductions from streets where DI cleaning. There are two particular instances where this could be happening:

1. when multiple DIs are located along a road segment, and
2. if a DI has been cleaned multiple times in one year.

In both cases, the prescribed 2% P reduction may underestimate the P load removed. Conducting a pilot study to test the volumetric-based methodology or partnering with other municipalities or agencies similarly exploring this methodology, would help determine if there are P reduction benefits that outweigh the expense of lab testing material collected from cleaned DIs.

2. Sweeping

VTrans elected to begin street sweeping with high-efficiency equipment on a limited basis within its MS4 areas in response to requirements within their MS4 permit in 2012. Now across the TS4, VTrans primarily uses mechanical broom sweepers for street sweeping as a regular maintenance practice, particularly along bike routes and for special events such as bike races where the road needs to be clear of debris for safety (Figure 9). A mechanical broom sweeper primarily pushes dirt and debris aside to clear the road, and often does not collect material to be removed. Therefore, current VTrans sweeping provides the least amount of P removal compared to other sweeping methods such as vacuum assisted and high efficiency regenerative air-vacuum sweeping. The analysis presented in this section sets a baseline for street sweeping which can inform future VTrans non-structural P reduction regimes in the Lake Champlain Basin.

The baseline sweeping values presented below are conservative estimates. A subset of MATS sweeping records (roughly 30%) were excluded from the analysis due to irregularities. Refer to Appendix B: Processing Document - MATS Sweeping Baseline Data Analysis for the methods used to create the MATS baseline data set for estimating P reductions of sweeping discussed below.

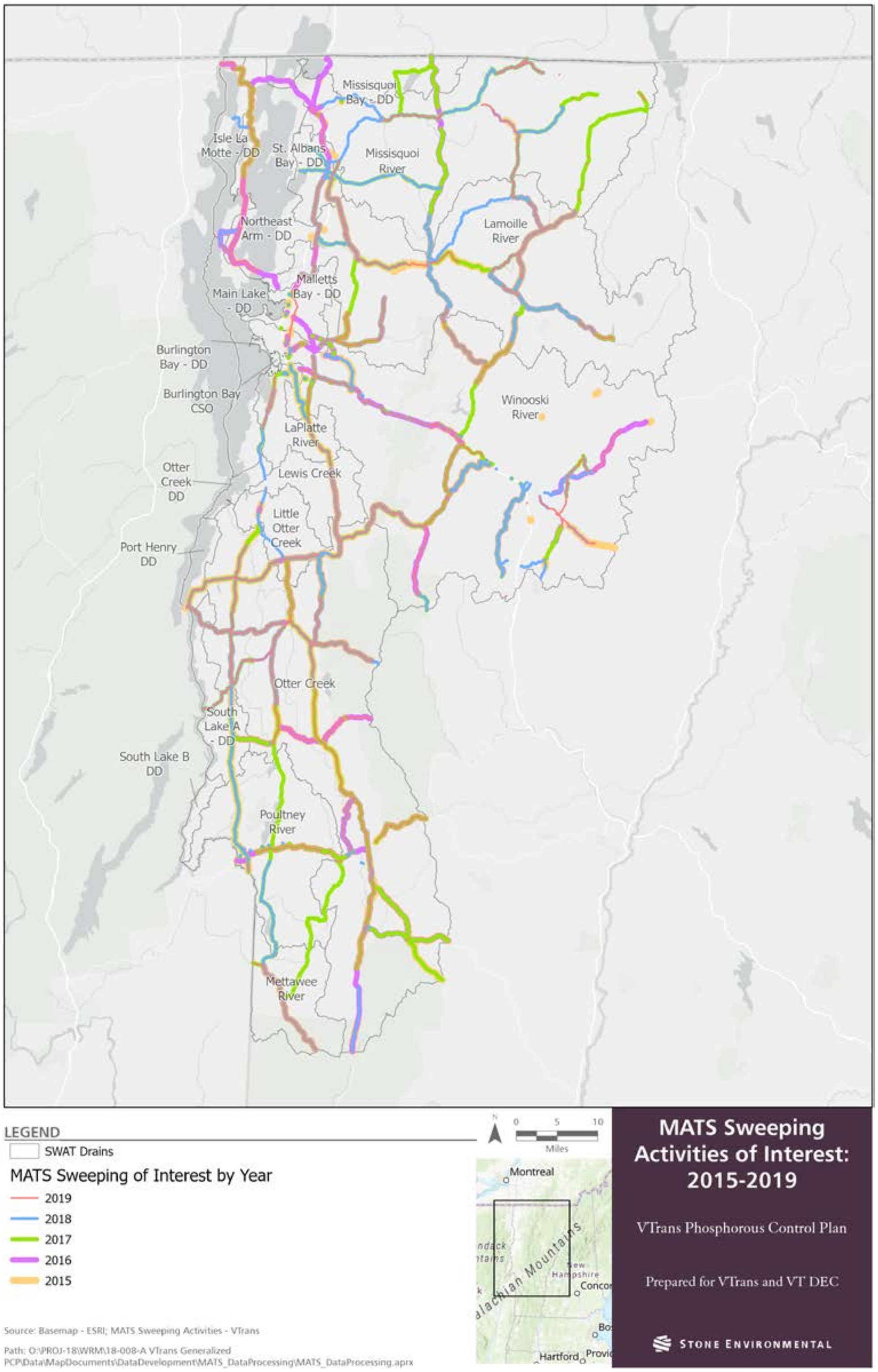


Figure 9. VTrans sweeping extent within the LCB, 2015-2019 (Note that there are overlapping areas of sweeping)

2.1 Sweeping Baseline Analysis

Sweeping was analyzed by SWAT drainage area (which is how P reductions will be credited) as well as VTrans District (which is how VTrans manages its maintenance activities). The total lane miles (Ln Mi) [4] swept per year ranged from 739 to 1430, with an average of 1055/year (Table 11, Table 12).

Table 11. Total lane miles swept by SWAT drainage area

SWAT Drainage Area	2015	2016	2017	2018	2019	Grand Total	Average Ln Mi Swept Annually
Isle La Motte - DD	0	0	0	6	0	6	1
Lamoille River	106	127	254	194	106	787	157
LaPlatte River	22	8	25	65	33	154	31
Lewis Creek	0.2	0	29	0	0	30	6
Little Otter Creek	32	28	6	59	21	146	29
Main Lake - DD	0.0	0	5	0	0	5	1
Malletts Bay - DD	2	18	4	2	0	26	5
Mettawee River	26	20	34	26	29	135	27
Missisquoi Bay - DD	0.2	0	14	0	0	14	3
Missisquoi River	5	96	175	94	63	433	87
Northeast Arm - DD	65	119	39	11	89	322	64
Otter Creek	265	258	422	236	273	1454	291
Port Henry - DD	0	0	0	27	0	27	5
Poultney River	31	29	94	33	21	209	42
South Lake A - DD	60	69	69	50	0	248	50
St. Albans Bay - DD	1	72	77	94	24	268	54
Winooski River	125	250	185	188	264	1012	202
Grand Total	739	1095	1430	1085	924	5274	1055

[4] A lane mile equals 12' by 1 mile, or one single lane of a roadway. It includes passing lanes, two lanes, truck lanes, etc.

Table 12. Total lane miles swept by District

District	2015	2016	2017	2018	2019	Grand Total	Average Ln Mi Swept Annually
1	36	44	35	45	29	188	38
3	203	200	336	104	175	1018	204
4	1	1	9	18	1	30	6
5	269	410	489	461	368	1995	399
7	23	36	30	53	63	204	41
8	208	405	465	404	287	1769	354
9	0	0	67	0	2	69	14
Grand Total	739	1095	1430	1085	924	5274	1055

The most sweeping occurred in Lamoille River, Otter Creek and Winooski SWAT drainage areas (the largest of the SWAT drainage areas with more roads for sweeping) which translates to Districts five and eight (Figure 11, Figure 12). Sweeping occurred most frequently in the spring and summer, which corresponds with when sweepers can get back out to clear debris post-snowmelt (Figure 10).

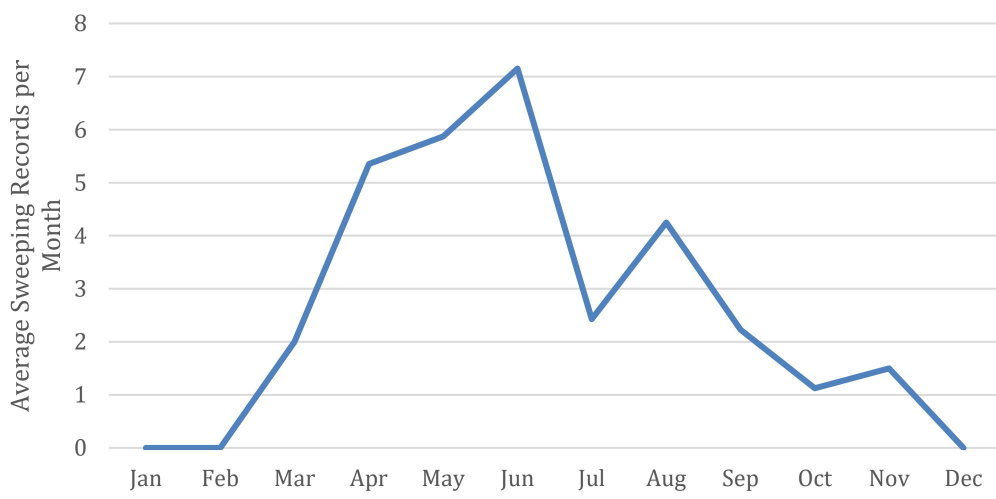


Figure 10. Average monthly frequency of sweeping.

From 2015-2019 an average of 38% (1055 Ln Mi) of the 2749 mi in the LCB were swept per year. However, these totals include re-sweeping the same stretches of road multiple times, as can easily be seen in Table 13 where the percent of LCB swept per SWAT drainage area exceeds 100%. It should also be noted that sweepers often cross SWAT drainage area boundaries while sweeping. Each MATS record is associated with the SWAT drainage area that represented the majority of swept lane miles for that record. This results in less precise location data for lane mile totals but allows for seamless cost analysis because sweeping costs are associated with individual MATS records.

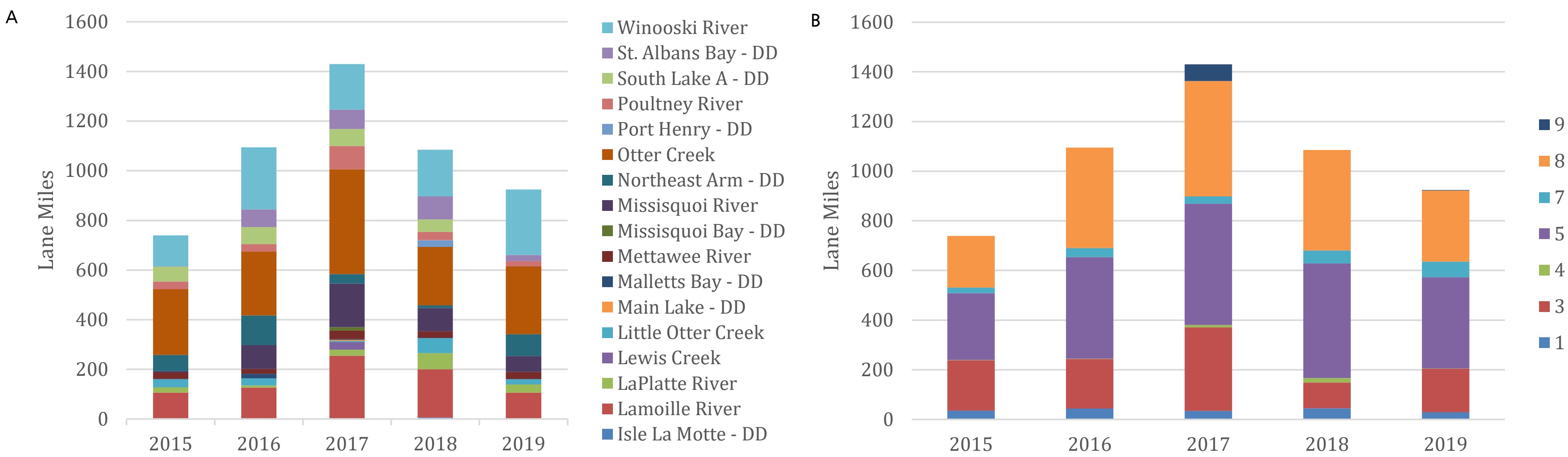


Figure 11. Annual sweeping by A) SWAT drainage area, and B) district

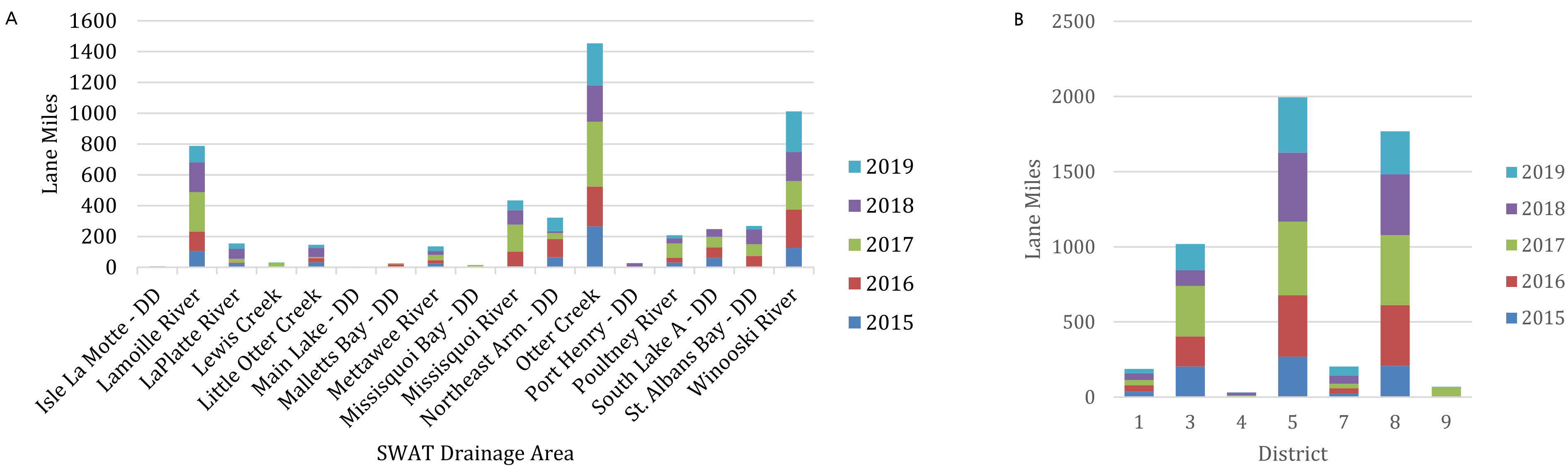


Figure 12. Total sweeping by A) SWAT drainage area, and B) district

Table 13. Annual lane miles swept by SWAT drainage area from 2015-2019

SWAT Drainage Area	2015		2016		2017		2018		2019		Average Annual Sweeping (Ln Mi)	Total Ln Mi in LCB	% LCB Swept on Average
	Sweeping (Ln Mi)	% LCB Swept	Sweeping (Ln Mi)	% LCB Swept	Sweeping (Ln Mi)	% LCB Swept	Sweeping (Ln Mi)	% LCB Swept	Sweeping (Ln Mi)	% LCB Swept			
Isle La Motte - DD	0	-	0	-	0	-	6	26%	0	-6%	1	25	5%
Lamoille River	106	26%	127	31%	254	62%	194	47%	106	26%	157	412	38%
LaPlatte River	22	33%	8	13%	25	37%	65	98%	33	50%	31	67	46%
Lewis Creek	0.2	1%	0	-	29	160%	0	-	0.1	1%	6	18	32%
Little Otter Creek	32	102%	28	90%	6	18%	59	189%	21	66%	29	31	93%
Main Lake - DD	0	-	0	-	5	59%	0	-	0	-	1	8	12%
Malletts Bay - DD	2	3%	18	27%	4	6%	2	3%	0	-	5	66	8%
Mettawee River	26	45%	20	35%	34	60%	26	46%	29	52%	27	57	48%
Missisquoi Bay - DD	0	-	0	-	14	23%	0	-	0	-	3	59	5%
Missisquoi River	5	3%	96	49%	175	89%	94	48%	63	32%	87	196	44%
Northeast Arm - DD	65	94%	119	173%	39	56%	11	16%	89	129%	64	69	93%
Otter Creek	265	53%	258	51%	422	84%	236	47%	273	54%	291	502	58%
Port Henry - DD	0	-	0	-	0	-	27	317%	0	-	5	8	63%
Poultney River	31	18%	29	17%	94	53%	33	19%	21	12%	42	176	24%
South Lake A - DD	60	147%	69	168%	69	169%	50	123%	0	-	50	41	121%
St. Albans Bay - DD	1	1%	72	88%	77	95%	94	115%	24	30%	54	82	66%
Winooski River	125	17%	250	34%	185	25%	188	26%	264	36%	202	732	28%
Grand Total	739	27%	1095	40%	1430	52%	1085	39%	924	34%	1055	2749	38%

To inform recommendations for future sweeping activities, a cost analysis was conducted for sweeping from 2015-2019. Total annual costs ranged from $174,631 to $414,991 per year, averaging $279,218 (Table 14). The average annual cost to sweep varied widely between districts, from $3,157 to $172,361, with an average of $39,888 (Table 15). This variability is likely attributed to different districts having varying equipment (rent vs. own) and the data phenomenon discussed above (sweepers crossing SWAT drainage areas, but MATS record data only being associated with one SWAT drainage area). On average, it cost $265 to sweep one lane mile from 2015-2019.

As would be expected, costs correlated with where sweeping occurred, with the highest costs attributed to the Lamoille River, Otter Creek, and Winooski River SWAT drainage areas, which again correspond to Districts five and eight (Figure 13, Figure 14).

Table 14. Annual sweeping costs by SWAT drainage area

SWAT Drainage Area	2015	2016	2017	2018	2019	Grand Total	Average Annual $	Average Ln Mi Swept Annually	Average $ per Ln Mi
Isle La Motte - DD	$ -	$ -	$ -	$ 567	$ -	$ 567	$ 113	1	$ 90
Lamoille River	$ 21,615	$ 21,022	$ 39,799	$ 30,791	$ 9,963	$ 123,190	$ 24,638	157	$ 156
LaPlatte River	$ 14,254	$ 9,192	$ 43,641	$ 28,418	$ 14,025	$ 109,530	$ 21,906	31	$ 711
Lewis Creek	$ 614	$ -	$ 6,125	$ -	$ 2,265	$ 9,005	$ 1,801	6	$ 303
Little Otter Creek	$ 3,018	$ 10,902	$ 5,568	$ 5,553	$ 12,455	$ 37,497	$ 7,499	29	$ 257
Main Lake - DD	$ -	$ -	$ 2,272	$ -	$ -	$ 2,272	$ 454	1	$ 505
Malletts Bay - DD	$ 10,757	$ 11,689	$ 27,545	$ 13,490	$ -	$ 63,480	$ 12,696	5	$ 2,475
Mettawee River	$ 1,761	$ 2,194	$ 3,323	$ 1,022	$ 2,556	$ 10,856	$ 2,171	27	$ 80
Missisquoi Bay - DD	$ 561	$ -	$ 406	$ -	$ -	$ 967	$ 193	3	$ 69
Missisquoi River	$ 41,786	$ 8,830	$ 10,902	$ 8,114	$ 20,624	$ 90,256	$ 18,051	87	$ 208
Northeast Arm - DD	$ 3,859	$ 4,451	$ 2,215	$ 567	$ 4,685	$ 15,776	$ 3,155	64	$ 49
Otter Creek	$ 37,751	$ 55,803	$ 80,606	$ 49,798	$ 27,608	$ 251,567	$ 50,313	291	$ 173
Port Henry - DD	$ -	$ -	$ -	$ 856	$ -	$ 856	$ 171	5	$ 32
Poultney River	$ 10,493	$ 20,250	$ 29,813	$ 31,592	$ 11,122	$ 103,269	$ 20,654	42	$ 495
South Lake A - DD	$ 1,856	$ 4,628	$ 2,706	$ 2,318	$ -	$ 11,508	$ 2,302	50	$ 46
St. Albans Bay - DD	$ 10,864	$ 3,308	$ 4,004	$ 3,611	$ 1,966	$ 23,752	$ 4,750	54	$ 89
Winooski River	$ 74,026	$ 58,504	$ 156,067	$ 185,781	$ 67,362	$ 541,741	$108,348	202	$ 535
Grand Total	$ 233,215	$ 210,775	$ 414,991	$ 362,477	$ 174,631	$ 1,396,089	$279,218	1055	$ 265

Table 15. Annual sweeping costs by District

District	2015	2016	2017	2018	2019	Grand Total	Average Annual $	Average Ln Mi Swept Annually	Average $ per Ln Mi
1	$ 2,736	$ 4,389	$ 4,059	$ 2,045	$ 2,556	$ 15,784	$ 3,157	38	$ 84
3	$ 33,026	$ 50,666	$ 78,737	$ 64,872	$ 23,249	$ 250,550	$ 50,110	204	$ 246
4	$ 2,249	$ 1,371	$ 3,784	$ 6,184	$ 4,482	$ 18,071	$ 3,614	6	$ 600
5	$ 100,164	$ 120,655	$ 288,319	$ 255,105	$ 97,562	$ 861,806	$172,361	399	$ 432
7	$ 14,453	$ 12,287	$ 9,973	$ 14,197	$ 8,436	$ 59,347	$ 11,869	41	$ 290
8	$ 80,586	$ 21,408	$ 26,193	$ 20,074	$ 23,938	$ 172,198	$ 34,440	354	$ 97
9	$ -	$ -	$ 3,926	$ -	$ 14,408	$ 18,334	$ 3,667	14	$ 264
Grand Total	$ 233,215	$ 210,775	$ 414,991	$ 362,477	$ 174,631	$ 1,396,089	$279,218	1055	$ 265

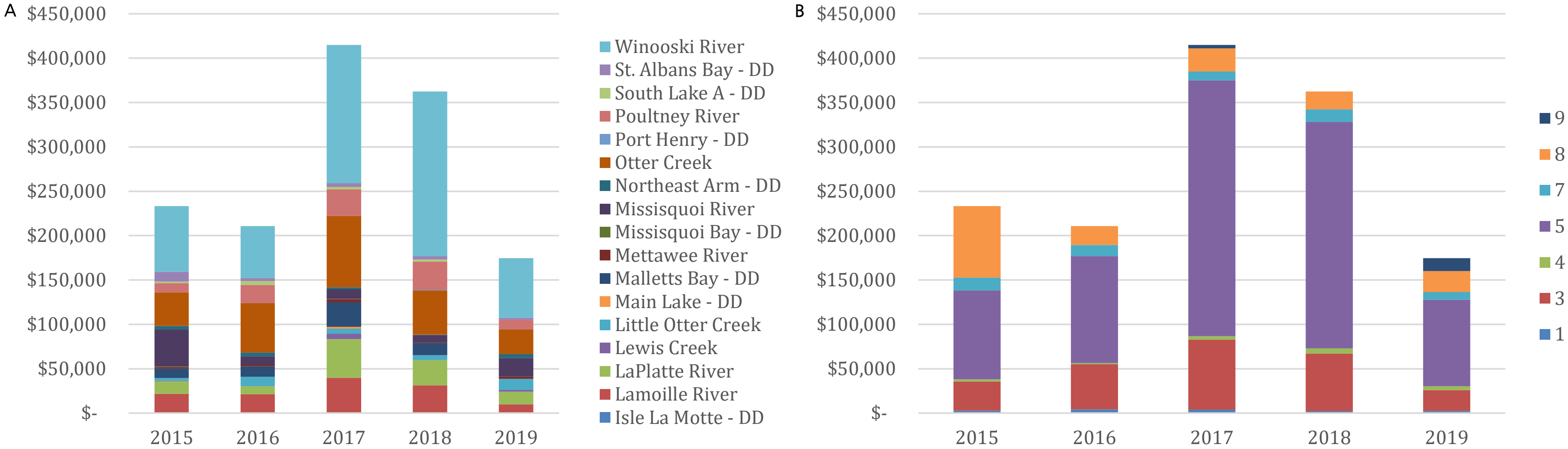


Figure 13. Annual sweeping costs by A) SWAT drainage area, and B) district

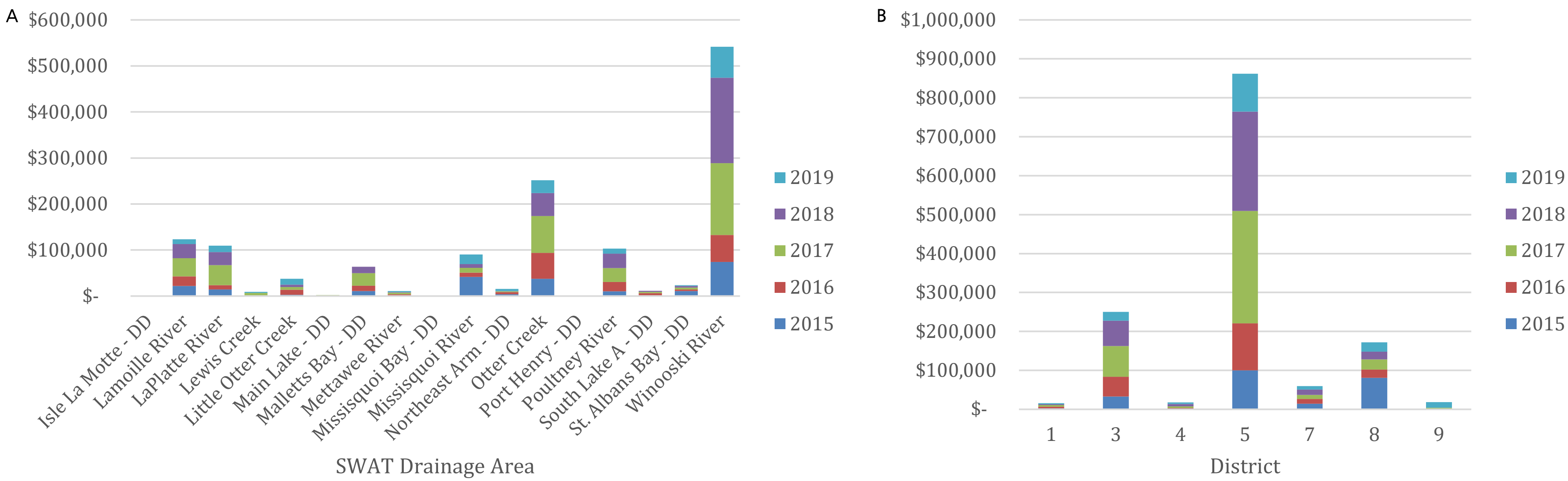


Figure 14. Total sweeping costs by a) SWAT drainage area, and B) district

2.2 Sweeping Baseline P Load Reduction Credits

The DEC credits sweeping based on frequency and type of sweeping equipment used (Table 16). As mentioned previously in Section 2.1, VTrans did sweep some sections of road more than once so a spatial analysis was conducted to determine which appropriate potential P reduction credits could be applied. Preliminary results indicated that very few road segments were swept more than twice and those that were swept more than twice were with not enough regularity to gain larger P reduction credits (re: monthly or weekly). Therefore, road segments that were swept once per year were allocated a 0.5% P reduction and road segments that were visited more than once were allocated a 1% P reduction.

Table 16. P reduction factors[5]

	Sweeping Frequency			
Equipment Type	2/year (spring and fall)	Monthly	Weekly	4X in the fall
Mechanical Broom	1%	3%	5%	17%
Vacuum Assisted	2%	4%	8%	17%
High Efficiency Regenerative Air-Vacuum	2%	8%	10%	17%

To determine the P load from streets where sweeping occurred, the P load from each road segment associated with a sweeping MATS record was calculated using the road segment area, SWAT drainage area, slope, and hydrologic class of each road segment (Table 17, Table 18). Because there are multiple road segments per MATS sweeping record and the linear nature of the activity, there were some instances where one MATS record included road segments from multiple SWAT drainage areas. Therefore, the P load reduction credits are distributed slightly differently across the SWAT drainage areas than the rest of the data analyzed in this memo (where all data associated with a MATS record as attributed to the single SWAT drainage area that made up the majority of road segments attributed to that MATS record). For example, the Otter Creek - DD SWAT drainage area appears in the data analyzed below because there was one MATS record that was previously only associated with the LaPlatte River SWAT drainage area, but when broken up into road segments to calculate P load it was discovered the sweeping crew also drove through and worked in the Otter

[5] MS4 Operational Tracking and Accounting Interim SOP (https://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/MS4/MS4%20Operational%20Tracking%20and%20Accounting%20SOPs_excerpt_08062019.pdf)

Creek - DD SWAT drainage area on that trip. Refer to Appendix B: Processing Document - MATS Sweeping Baseline Data Analysis for more detail.

Table 17. Acres of road where sweeping occurred by SWAT Drainage Area

SWAT Drainage Area	2015 Acres Swept			2016 Acres Swept			2017 Acres Swept			2018 Acres Swept			2019 Acres Swept			Average Annual Acres Swept
	Once	> Once	Total	Once	> Once	Total	Once	> Once	Total	Once	> Once	Total	Once	> Once	Total	
Isle La Motte - DD	31.4	0.0	31.4	6.7	31.4	38.1	16.1	0.0	16.1	15.2	0.0	15.2	30.3	1.2	31.4	26.4
Lamoille River	201.9	6.9	208.8	299.7	65.0	364.6	441.6	25.1	466.7	389.8	19.3	409.2	312.0	13.7	325.7	355.0
LaPlatte River	54.9	5.9	60.8	8.7	16.5	25.2	55.4	44.4	99.8	62.4	23.1	85.5	44.5	47.6	92.1	72.7
Lewis Creek	25.3	0.8	26.1	23.6	0.0	23.6	23.5	2.3	25.8	28.5	0.0	28.5	24.0	0.0	24.0	25.6
Little Otter Creek	32.8	6.7	39.5	33.6	1.5	35.1	27.3	3.4	30.7	39.5	21.2	60.7	28.0	11.2	39.2	41.0
Main Lake - DD	0.0	0.0	0.0	4.7	0.0	4.7	10.2	0.0	10.2	19.2	0.0	19.2	1.6	0.0	1.6	7.1
Malletts Bay - DD	6.7	0.0	6.7	34.8	14.4	49.2	14.9	1.5	16.4	12.0	0.0	12.0	37.1	0.0	37.1	24.3
Mettawee River	51.2	0.0	51.2	51.2	0.0	51.2	83.5	6.6	90.1	59.5	0.0	59.5	57.1	0.4	57.5	61.9
Missisquoi Bay - DD	0.5	0.0	0.5	27.6	12.0	39.5	38.4	0.0	38.4	6.7	0.0	6.7	0.0	0.0	0.0	17.0
Missisquoi River	9.5	7.2	16.6	56.6	60.5	117.1	375.0	14.2	389.3	275.1	38.2	313.2	75.2	55.6	130.8	193.4
Northeast Arm - DD	116.0	0.3	116.3	21.1	119.8	140.9	40.5	21.1	61.6	9.3	3.1	12.4	79.4	41.6	121.0	90.4
Otter Creek	564.6	40.8	605.4	497.8	96.5	594.3	698.9	106.1	805.0	379.9	131.3	511.1	615.2	77.8	693.1	641.8
Otter Creek - DD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.3	0.0	7.3	0.0	0.0	0.0	1.5
Port Henry - DD	15.0	0.0	15.0	0.3	0.0	0.3	13.8	0.0	13.8	0.3	15.1	15.4	15.0	0.0	15.0	11.9
Poultney River	95.2	1.0	96.2	47.7	0.5	48.2	204.2	0.5	204.7	95.1	0.0	95.1	38.0	0.0	38.0	96.4
South Lake A - DD	46.6	0.0	46.6	18.7	0.0	18.7	59.7	0.0	59.7	61.6	0.3	61.9	11.3	10.8	22.2	41.8
St. Albans Bay - DD	24.2	0.0	24.2	52.9	0.4	53.2	75.5	1.1	76.6	38.9	40.7	79.6	28.4	27.9	56.3	58.0
Winooski River	247.7	16.5	264.2	413.7	67.7	481.4	339.3	92.0	431.3	396.3	65.1	461.4	342.2	89.0	431.2	413.9
Grand Total	1523.4	86.1	1609.4	1599.4	486.2	2085.5	2517.7	318.3	2836.0	1896.5	357.4	2254.0	1739.3	376.8	2116.1	2180.2

Table 18. Annual P load from roads where sweeping occurred (kg/ac), based on frequency of sweeping by SWAT drainage area

SWAT Drainage Area	2015 P Load by Sweeping Frequency (kg/ac)			2016 P Load by Sweeping Frequency (kg/ac			2017 P Load by Sweeping Frequency (kg/ac)			2018 P Load by Sweeping Frequency (kg/ac)			2019 P Load by Sweeping Frequency (kg/ac)			Average Annual P Load (kg/ac)
	Once	> Once	Total	Once	> Once	Total	Once	> Once	Total	Once	> Once	Total	Once	> Once	Total	
Isle La Motte - DD	21.7	0.0	21.7	4.7	18.6	23.2	10.6	0.0	10.6	12.2	0.0	12.2	20.7	1.1	21.7	17.9
Lamoille River	153.5	6.6	160.1	238.5	37.5	276.0	355.6	14.8	370.4	290.9	6.7	297.6	171.7	5.5	177.3	256.3
LaPlatte River	26.3	3.2	29.5	5.9	12.6	18.5	31.3	22.9	54.2	45.1	17.7	62.8	19.3	33.9	53.2	43.6
Lewis Creek	21.2	0.6	21.8	20.4	0.0	20.4	10.3	1.5	11.8	13.3	0.0	13.3	10.5	0.0	10.5	15.6
Little Otter Creek	32.0	7.0	38.9	31.7	1.3	33.0	20.0	1.7	21.7	18.2	10.8	29.1	14.1	5.5	19.6	28.5
Main Lake - DD	0.0	0.0	0.0	4.3	0.0	4.3	4.2	0.0	4.2	16.8	0.0	16.8	0.7	0.0	0.7	5.2
Malletts Bay - DD	4.5	0.0	4.5	22.5	9.7	32.2	9.9	1.4	11.3	6.3	0.0	6.3	12.8	0.0	12.8	13.4
Mettawee River	42.7	0.0	42.7	33.7	0.0	33.7	67.7	5.5	73.1	48.4	0.0	48.4	47.7	0.4	48.1	49.2
Missisquoi Bay - DD	0.5	0.0	0.5	25.3	9.6	34.9	30.7	0.0	30.7	4.7	0.0	4.7	0.0	0.0	0.0	14.2
Missisquoi River	8.4	4.1	12.5	50.7	50.3	101.0	274.1	11.8	285.9	168.2	28.1	196.2	43.3	43.1	86.4	136.4
Northeast Arm - DD	94.3	0.3	94.7	17.2	61.0	78.2	28.9	18.6	47.5	7.2	0.9	8.0	61.5	34.2	95.8	64.8
Otter Creek	412.0	23.5	435.5	383.4	81.0	464.4	515.9	89.2	605.1	256.5	70.9	327.5	377.1	36.1	413.2	449.1
Otter Creek - DD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	0.0	6.5	0.0	0.0	0.0	1.3
Port Henry - DD	13.3	0.0	13.3	0.2	0.0	0.2	6.4	0.0	6.4	0.2	6.7	7.0	6.7	0.0	6.7	6.7
Poultney River	75.8	1.0	76.8	40.2	0.4	40.6	179.2	0.6	179.8	77.0	0.0	77.0	31.6	0.0	31.6	81.2
South Lake A - DD	43.0	0.0	43.0	18.1	0.0	18.1	56.0	0.0	56.0	57.5	0.2	57.7	6.0	4.3	10.3	37.0
St. Albans Bay - DD	18.7	0.0	18.7	41.1	0.2	41.3	62.8	0.9	63.7	29.8	26.3	56.1	11.0	13.6	24.6	40.9
Winooski River	186.7	8.2	195.0	258.1	44.0	302.1	245.7	62.9	308.6	322.2	40.0	362.2	235.4	60.7	296.1	292.8
Grand Total	1155	55	1209	1196	326	1522	1909	232	2141	1381	208	1589	1070	238	1308	1554

To accurately account for potential P load reductions, P load from roads where street sweeping occurred was broken into P load from streets swept once and streets swept more than once (Figure 15). On average, 15% of swept road segments were swept more than once annually, which accounted for 4% of the P load.

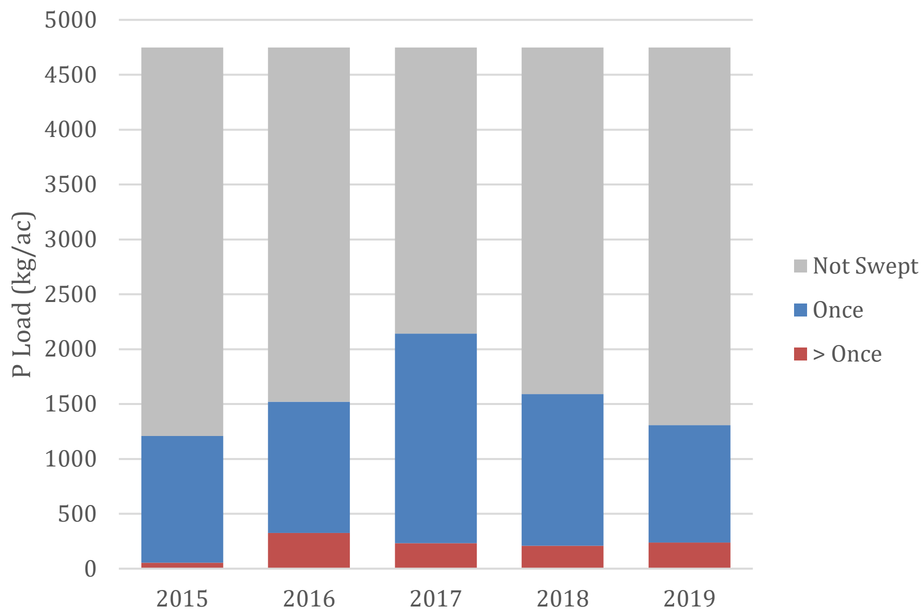


Figure 15. Annual P load from roads where sweeping occurred (kg/ac) by frequency of sweeping

Annual P load reductions ranged from 6.32- 11.86 kg/yr, with an average of 8.83 kg/yr, which translates to roughly 0.6% of the total required P reduction target per year from VTrans roads within the LCB (Figure 16). P load reductions corresponded to where sweeping happened and as would be expected and the highest P reductions occurred within the Lamoille River, Otter Creek and Winooski SWAT drainage areas (Figure 17). Compared to the total P reduction target of each SWAT drainage area, current sweeping regimes account for a relatively small portion of the annual P reduction, ranging from 0.3% - 3.3% (Table 19). Higher percentages of total P reduction targets were typically found in smaller SWAT drainage areas with relatively low P loads. Looking back at the cost data presented in Section 2.1, the unit cost for removing one kg/yr of P with sweeping is $31,623 (Table 20).

Table 19. Annual P load reduction (kg/yr) from sweeping by SWAT drainage area

SWAT Drainage Area	2015 P Red (kg/yr)	2015 Percent of Total P Red	2016 P Red (kg/yr)	2016 Percent of Total P Red	2017 P Red (kg/yr)	2017 Percent of Total P Red	2018 P Red (kg/yr)	2018 Percent of Total P Red	2019 P Red (kg/yr)	2019 Percent of Total P Red	Average Annual P Red	Total Target P Red (kg/yr)	Average Annual Percent P Red
Isle La Motte - DD	0.11	4%	0.21	7%	0.05	2%	0.06	2%	0.11	4%	0.11	5.63	1.9%
Lamoille River	0.83	1%	1.57	1%	1.93	1%	1.52	1%	0.91	1%	1.35	211.96	0.6%
LaPlatte River	0.16	1%	0.16	1%	0.39	2%	0.40	2%	0.44	2%	0.31	32.85	0.9%
Lewis Creek	0.11	2%	0.10	2%	0.07	1%	0.07	1%	0.05	1%	0.08	7.39	1.1%
Little Otter Creek	0.23	2%	0.17	2%	0.12	1%	0.20	2%	0.13	1%	0.17	15.04	1.1%
Main Lake - DD	0.00	-	0.02	1%	0.02	1%	0.08	2%	0.00	0%	0.03	4.34	0.6%
Malletts Bay - DD	0.02	0.1%	0.21	1%	0.06	0.3%	0.03	0.1%	0.06	0%	0.08	24.60	0.3%
Mettawee River	0.21	1%	0.17	1%	0.39	2%	0.24	1%	0.24	1%	0.25	24.38	1.0%
Missisquoi Bay - DD	0.00	0%	0.22	1%	0.15	1%	0.02	0.1%	0.00	0%	0.08	49.08	0.2%
Missisquoi River	0.08	0%	0.76	0%	1.49	1%	1.12	1%	0.65	0%	0.82	327.48	0.3%
Northeast Arm - DD	0.48	5%	0.70	7%	0.33	4%	0.04	0.5%	0.65	7%	0.44	13.41	3.3%
Otter Creek	2.29	2%	2.73	2%	3.47	3%	1.99	2%	2.25	2%	2.55	196.27	1.3%
Otter Creek - DD	0.00	-	0.00	-	0.00	-	0.03	3%	0.00	0%	0.01	2.13	0.3%
Port Henry - DD	0.07	6%	0.00	-	0.03	3%	0.07	7%	0.03	3%	0.04	1.42	2.8%
Poultney River	0.39	1%	0.20	0.3%	0.90	1%	0.38	1%	0.16	0%	0.41	111.96	0.4%
South Lake A - DD	0.22	2%	0.09	1%	0.28	2%	0.29	2%	0.07	1%	0.19	16.19	1.2%
St. Albans Bay - DD	0.09	0.3%	0.21	1%	0.32	1%	0.41	1%	0.19	1%	0.25	47.21	0.5%
Winooski River	1.02	0.4%	1.73	1%	1.86	1%	2.01	1%	1.78	1%	1.68	423.05	0.4%
Grand Total	6.32	0.6%	9.24	0.9%	11.86	1.2%	8.99	0.9%	7.73	0.8%	8.83	1514.4	0.6%

Notes: - Red = reduction

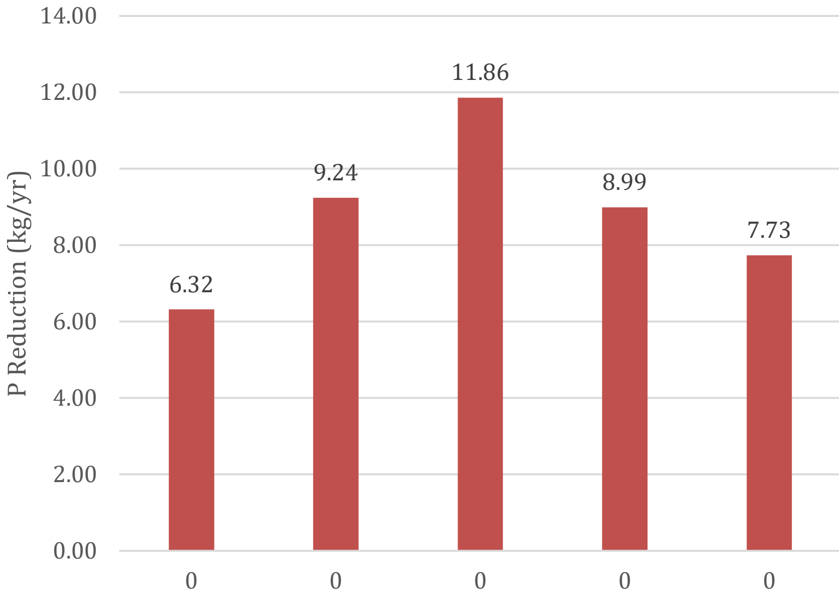


Figure 16. Total P reduction (kg/yr) from roads where sweeping occurred 2015-2019

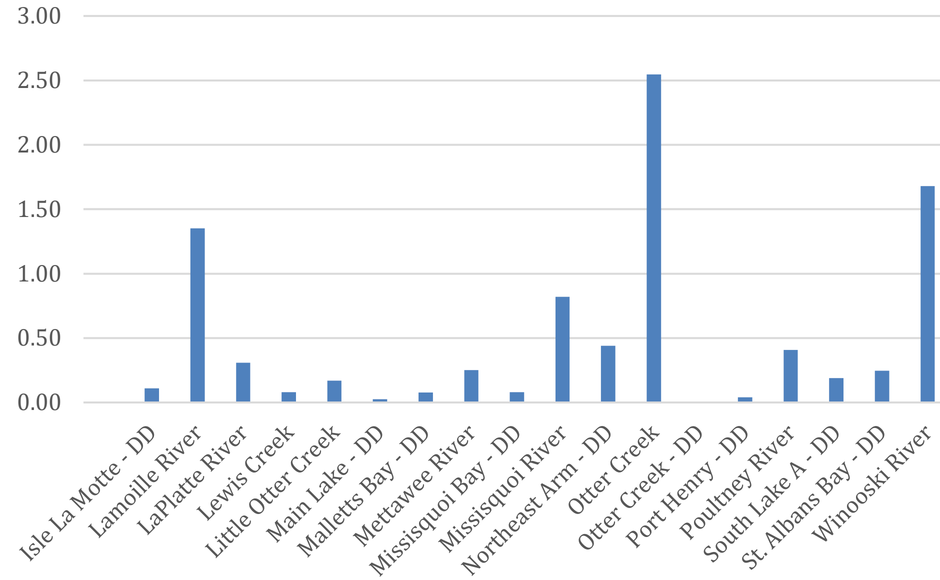


Figure 17. Average annual P reduction (kg/yr) from roads where sweeping occurred by SWAT drainage area

Table 20. Average annual unit cost for removing one kg/yr of P with sweeping

	2015	2016	2017	2018	2019	Average
Total P Red (kg/yr)	6.32	9.24	11.86	8.99	7.73	8.83
Percent of Total VTrans P Reduction Target	0.4%	0.6%	0.7%	0.6%	0.5%	0.5%
Total Cost	$ 233,215	$ 210,775	$ 414,991	$ 362,477	$ 174,631	$ 279,218
P Red Unit Cost ($/kg/yr)	$ 36,906	$ 22,809	$ 34,979	$ 40,324	$ 22,579	$ 31,623

Note: Average Annual Percent of Total VTrans P Reduction Target was calculated using the total target P reduction for all VTrans roads within the LCB (1514 kg/yr).

2.3 Recommendations for Future Street Sweeping Non-Structural Controls

2.3.1 MATS Tracking Improvements

Better tracking will lead to more accurate calculations and greater P reduction estimates; here are a few suggestions for better tracking of street sweeping in MATS:

1. Many sweeping MATS records used a single MATS record for two different geographic sweeping locations. It would be ideal if a truck moves to a different area, a new MATS record be created so P reductions can be calculated more accurately.
2. The length of the MATS record and the Accomplishment value should be more relevant to one another, to aid in determining the potential credit for the linear area swept.
3. It would be helpful to indicate the number of lanes swept per MATS record to better understand when the length and Accomplishment values do not match.
4. A field indicating the type of sweeping that occurred (i.e. broom vs. vac truck) would be helpful in determining potential credit allocated to each MATS entry.

2.3.2 Extent & Frequency of Street Sweeping

It was determined that current sweeping regimes (38% of streets wept in the LCB per year) could annually reduce the total P required from VTrans roads within the LCB by 0.5% on average. Table 21 shows the incremental increase that would result from almost doubling existing street sweeping efforts from roughly 1,000 to 2,000 Ln Mi in a year.

Table 21. Example projection of increased street sweeping from 1,055 to 2000 Ln Mi annually

	2015 - 2019 Annual Average	Future Projection
Ln Mi Swept	1055	2000
Percent of Total Ln Mi in LCB	38%	73%
P Red (kg/yr)	8.83	17
P Red per Ln Mi Swept (kg/yr/Ln Mi)	0.01	0.01
Cost	$279,218	$530,000
Percent of Total VTrans P Red Target	0.5%	1%

Street sweeping has a modest annual P reduction benefit at this time, and it is a routine maintenance practice that enhances the safety of the traveling public. VTrans could see increased P reduction benefits from a sweeping approach that focuses, for instance, on preferentially sweeping highly hydrologically connected road segments, increasing the extent and frequency of bridge washing, or targets Lake segments with the most aggressive P target reductions. For example, the Missisquoi Bay Lake segment (Missisquoi Bay – DD and Missisquoi River) has some of the highest P load reduction targets, but some of the lowest annual P reductions from sweeping (Table 22).

Further analysis of where sweeping efforts could be focused will be included in the development of each 4-year Implementation Plan. Results of ongoing research by USGS and others[3] evaluating reductions in nutrient and sediment loads from current street cleaning and leaf litter collection practices, and evaluating P reductions and crediting for current practice and potential enhancements, will further influence decision making regarding VTrans' street sweeping program once those findings are available in 2020.

Table 22. Comparison of street sweeping metrics by SWAT drainage area

SWAT Drainage Area	Average Ln Mi Swept Annually	Average Annual P Red (kg/yr)	Total Target P Red (kg/yr)	Average Annual Percent P Red
Isle La Motte - DD	1	0.11	5.63	1.9%
Lamoille River	157	1.35	211.96	0.6%
LaPlatte River	31	0.31	32.85	0.9%
Lewis Creek	6	0.08	7.39	1.1%
Little Otter Creek	29	0.17	15.04	1.1%
Main Lake - DD	1	0.03	4.34	0.6%
Malletts Bay - DD	5	0.08	24.60	0.3%
Mettawee River	27	0.25	24.38	1.0%
Missisquoi Bay - DD	3	0.08	49.08	0.2%
Missisquoi River	87	0.82	327.48	0.3%
Northeast Arm - DD	64	0.44	13.41	3.3%
Otter Creek	291	2.55	196.27	1.3%
Otter Creek - DD	N/A	0.01	2.13	0.3%
Port Henry - DD	5	0.04	1.42	2.8%
Poultney River	42	0.41	111.96	0.4%
South Lake A - DD	50	0.19	16.19	1.2%
St. Albans Bay - DD	54	0.25	47.21	0.5%
Winooski River	202	1.68	423.05	0.4%
Grand Total	1055	8.83	1514.40	0.6%

Notes: - Red = reduction
- Otter Creek - DD does not have average Ln Mi swept annual because of the data phenomenon described in the above sections that results from sweeping trucks driving across SWAT drainage areas.

ATTACHMENT F INCORPORATION OF PREVIOUSLY PERMITTED STORMWATER SYSTEMS

VTrans Incorporation of Previously Permitted Stormwater Sysytems

Permit Name	Location	Permit Number	BMP Type(s)
Colchester Chimney Corners Park & Ride and Maintenance Facility	Colchester	3012-9010.R1	wet detention basin
Derby Salt and Sand Shed	Derby	3076-9010	revegetation
Ferrisburgh Park & Ride	Ferrisburgh	3127-9010.R	extended detention pond
Ferrisburgh-Vergennes PLAT (Ferrisburgh park and ride)	Ferrisburgh	3127-9015	disconnection
Sharon I-89 S Salt Shed	Sharon	3141-9015.1	grass channel
Bennington-Hoosick DPI 0146(1) C/3 &C/4	Bennington	3156-9010.R	9 wet retention ponds/swales
Bennington D1 Garage	Bennington	3361-9010	swales/basin
Ferrisburgh Maint. Facility	Ferrisburgh	3399-9010.A1	sheet flow, grass swales, sedement forebay, detention pond, catchbasins
Charlotte F EGC 019-4(20)	Charlotte	3438-9010	grass channels
Pittsford-Brandon Seg 5	Pittsford-Brandon	3628-9010	grass channels, culverts, hydrodynamic/swirl concentrator device
Sheldon HES 034-1(17) Reconstruction	Sheldon	3661-9010.R1	grass channel
Danville F 028-3(17) US2 Reconstruction/ Relocation	Danville	3743-9010.R1	grass swales
Westminster-Rockingham BRS 0113(15)	Westminster-Rockingham	3763-9010.R	sheet flow, grass swales, disconnection
Ferrisburgh F 019-4(16) US7	Ferrisburgh	3764-9010.R1	swale
Vergennes-Ferrisburgh F 017-1(5) 22A	Vergennes-Ferrisburgh	3765-9010.R	sheet flow, grass/stone lined swales
Wilmington F 010-1(19)	Wilmington	3766-9010.R	sheet flow, disconnection, stone swale
Newfane STP-HES 015-1(15) Northern	Newfane	3767-9010.R	grass swale/stone ditch
Brandon D3 Maint Garage (Arnold Rd)	Brandon	3768-9010.R	pond/veg swales
Troy RS 0311(1)	Troy	3772-9010.R1	swales
Coventry - Newport Air	Coventry	3836-INDS.A1	dry pond/ swale/ disconnection
Randolph CMG Park (21) SC Park & Ride	Randolph	3850-9010	grass&stone swales/pocket pond
Cambridge BRF 030-2(12)	Cambridge	3885-9010.R1	sheet flow and stone ditch
Lyndon - Caledonia Cnty Airport (new building & parking)	Lyndon	3896-9010	sheet/grass channel
Hartland BRS 0113(21) US5	Hartland	3903-9010.R1	catch basin to River
Groton F 026-11(27) & BRF 026-11(27)S	Groton	3904-9010.R	grass swales/stone fill
Chester BRF-F 016-1(3)	Chester	3905-9010.R	grass swale, DI, Culverts
Burke RS 0269(3) Bridge Replacement	Burke	3906-9010.R	swales
Cabot-Danville FEGC F028-3(26) C2	Cabot-Danville	4022-9010	grass swales/ disconnection
Cabot-Danville FEGC F028-3(26) C1	Cabot-Danville	4022-9010.1	grass swales, wet swale
Danville FEGC 028-3(32) Downtown	Danville	4144-9010	grass swales/ pond
Colchester Park & Ride (CMG PARK(47))	Colchester	4146-9010	pocket pond
Lyndon - Caledonia Cnty Airport (hangers/taxiway)	Lyndon	4199-9010	sheet flow - disconnection
Stockbridge BRF 022-1(20)	Stockbridge	4233-9010	infiltration basin, grass channel
East Montpelier BRF 037-1(7) (VT14 Br intersect)	East Montpelier	4251-9010	infiltration basin & buried sand filter
Morristown - Morrisville/Stowe Airport	Morristown	4272-9050	vegetated buffer, simple disconnection, subsurface infltration system, drip edge infiltration system, infiltration trench, grass channel, underground infiltration trench,
Moretown-Middlesex BRS0284(14)	Moretown-Middlesex	4278-9010	grass channels, disconnection, infiltration trench
Searsburg-Wilmington F010-0(18) (VT Rte 9)	Searsburg-Wilmington	4301-9010.R	sheet flow
Highgate D8 Highway Maintenance Facility	Highgate	4302-9010.R1	grass swales/2 infiltration basins
Middlesex D6 garage expansion	Middlesex	4578-9010	disconnection
Hartness State Airport- Proposed Hangers	Hartness	4580-9015.A	Grass channels, infiltration basin, infiltration trench
Middlebury State Airport Safety Area Buyouts	Middlebury	4581-INDS	sheet flow, vegetated disconnection, infiltration basin, culverts, grass broadcrested weir
Berlin E.F. Knapp runway taxiway apron/etc	Berlin	4582-9010	grass channel, detention pond
Cambridge BRF 027-1(4) & STP 030-2(27)	Cambridge	4765-9010	grass swale
Barre Town HES 026-1(38) Roundabout	Barre	4969-9010	flow splitter/ Dry Swale
Colchester STP 5600(9) S	Colchester	5132-9010	grass swale(wetland)
Bristol STP BRF 021-1(15)	Bristol	5221-9010	grass swales/ disconnection
Waitsfield D6 Maintenance Garage	Waitsfield	5334-9010.R	sheet/veg.swale/rock spreader
Middlebury Air Hangar Exp & Maintenance Bldg	Middlebury	5453-9015.A	grass channel, sheet flow, plunge pool, stone diaphram, level spreader
Windsor Garage Site Improvements	Windsor	5499-9015.A	disconnection/grass channel
Richmond STP RS 0284(11) Checkerhouse truss	Richmond	5526-9010	grass channel, disconnection
Cornwall BRS0172(6)	Cornwall	5606-9010	grass swales
Milton STP 5800 (2)	Milton	6019-9010	grass swales
Alburg-Swanton Missisquoi Bay Bridge	Alburg-Swanton	6070-9010.R	sheet flow / grass&stone swale
Hyde Park HES 030-2(23) roundabout	Hyde Park	6263-9010	dry swales, grass chan discon
Essex Town STP 5400(5) (VT117/ sand hill rd inter)	Essex	6300-9010	grass channels
Colchester D5 ":Fort" Site Redevelopement	Colchester	6363-INDS.R	grass swale, detention pond
Johnson STP 030-2(21)(25) Streetscape	Johnson	6531-9015	hydrodynamic separator
Richmond CMG Park (31) and STP 0284(17)	Richmond	6797-9010	dry swales
Putney CMG PARK(26)	Putney	6923-9015.A	grass swales and micropool pond
Jericho STP HES 030-1(21) (VT15/ Browns trace)	Jericho	6947-9010	grass swales/ disconnection
Windsor IM 091-1(64) Bridges 33N & S	Windsor	6972-INDS	dry swales
Guilford Weigh Station	Guilford	6989-9015	wet swale
Milton IM 089-3(66)	Milton	7016-INDS.A	Grass Channel
Springfield CMG PARK(32)	Springfield	7034-9015	grass channel
Brattleboro 091-1(65)	Brattleboro	7054-INDS.A	grass channels
Berlin STPG SGNL(40)	Berlin	7066-9010	grass channel
Middlesex 089-2(41) (US2 over I-89)	Middlesex	7145-9010	grass swale/ disconnection
Colchester HES 0281(28)	Colchester	7427-INDS	grass channel
Dummerston Garage	Dummerston	7758-9015	grass swale
White River Junction Office Building	White River	7839-INDS	grass channel
Bethel BHF 0241(38)	Bethel	7719-INDS	grass channels, dry swale
Bakersfield STP SCPR(11)	Bakersfield	7737-INDS	grass channels
Colchester-Essex NH 030-1(34) shared use path along vt15	Colchester-Essex	7757-INDS	disconnection

ATTACHMENT G STORMWATER PROGRAM EVALUATION TOP 13 ACTIONS

Action #		Action	Implementation Track (TS4, LEAN, Other)	Urgency or Timeline*	Agency Lead	Status
1		Integrate Stormwater Management With Project Development Give explicit consideration to stormwater management during each phase of the project development process, starting with scoping. This should include regulatory requirements outside of the need to obtain permits, such as potential retrofit projects to support flow restoration plan or phosphorus control plan implementation. To be as efficient as possible, it is important that stormwater needs are fully considered before projects are handed off to ROW/Utilities. Possible implementation efforts include:				
	a.	Develop a checklist or SOP for stormwater considerations that designers can use to identify opportunities early in the project development process for all Bureaus. Utilize the Resource ID process to identify and evaluate stormwater considerations early on during scoping and other phases. In addition to the existing VTrans PDB-OPS protocol, develop specific guidance on what to assess and consider when a project is located in a drainage area subject to either a flow restoration plan or phosphorus control plan.	TS4	2	PDB Env. MOB Env.	Draft in progress from 2015
	b.	Ensure VTrans Project Definition Guidance Document sufficiently addresses the need to identify and evaluate stormwater considerations early in scoping.	Other	3	AMP, PPAID(?)	Current review cycle is nearly complete; comments have been submitted.
	c.	Develop guidance to demonstrate that many of the issues reviewed as part of design development are integral to stormwater management (e.g., culvert size, placement, fill material, grading, stabilization, run-on, stormwater system connections and close out activities). Use the guidance to provide training to internal designers/project managers and external consultants and municipalities (also see action 7 below). Consider how to address turnover in both internal and external realms.	TS4	3	MOB Env., coordinate with PDB Env.	
	d.	Form inter- and intra-Agency work groups, as well as technical focus groups, to discuss stormwater issues, including reviewing projects and identifying concerns.	TS4/Other	2	MOB Env., coordinate with PDB Env.	
	e.	Require all designers to fill out a Project Data Form or other data form and impact plan early in the design process, which provides information on area of disturbance, redevelopment, expansion, new impervious surface, and de-paved areas.	TS4	2-3	PDB Env.	
	f.	Require evaluation of stormwater management opportunities as part of any municipal project that receives funding from VTrans. Develop a checklist or other tool that grant applicants must use to evaluate stormwater management opportunities as part of scoping potential projects; timing should be such that opportunities can be included in funding applications.	Other	1	MAB	
	g.	Develop a consistent approach for reviewing projects at facilities (including maintenance garages, park & ride facilities, airports, and rest areas) for stormwater management opportunities.	TS4	2	MOB Env.	
2		Codify Expectations for Assessing Runoff-Related Opportunities Define explicit and consistent expectations for how stormwater management opportunities will be evaluated as part of intra-Agency project review. Possible implementation efforts include:	LEAN	3		Some or all sub-actions may then be outcomes of the event. Could be a sub-task of Action 1.f. (a task for an inter-agency work group).
	a.	Make clear how, when, and by whom stormwater opportunities will be considered utilizing the Agency's existing systems for project review (e.g., on-line shared; NERD) (also see Action 1.a above)				
	b.	Task an individual from the Agency with identifying and evaluating stormwater management opportunities for each project (may be combined with Action 1.a).				
	c.	Designate and train internal stormwater experts within each Bureau or Section in order to support stormwater management efforts.				
	d.	Ensure relevant parties attend ROW Acquisition's "acquisition review meetings" to ensure that the Agency is obtaining the right level of control for each project, including within areas designated for stormwater management.				Occurring more frequently now, but invites are not completely consistent.

** 1 = 0-6 months; 2 = within 1 year; 3 = within 3 years; 4 = within 5 years*

Action #		Action	Implementation Track (TS4, LEAN, Other)	Urgency or Timeline*	Agency Lead	Status
3		Track Stormwater Commitments and Assets Implement a centralized tracking system for stormwater commitments, from project development through design and construction and into operation and maintenance. Possible implementation efforts include:	TS4 / other	2-3	PDB, MOB, Construction, 4 Pillars	
	a.	Integrate stormwater considerations explicitly into AMP's asset management activities and the Agency's capital program.	Other	3		Likely part of a larger discussion regarding cross-agency software
	b.	Develop and implement a system/tools for tracking compliance-related activities under the TS4 permit.	TS4			
	c.	Improve communication, documentation, and ROW acquisition planning in order to better identify the location/footprint of jurisdictional impervious surfaces and stormwater practices within VTrans' landholdings, with particular attention to non-structural practices such as disconnection areas.				
	d.	Standardize ROW Maintenance Agreements and develop a consistent approach for tracking responsibilities for drainage features and other stormwater infrastructure, with particular attention to areas with shared or co-mingled obligations.				
	e.	Improve reporting of and feedback on maintenance needs and post-construction operation of stormwater management practices, in order to inform future design.				
4		Optimize Use of 1111 Permits to Protect VTrans Systems Expand and improve the use of Section 1111 Permits to track outside activity in VTrans' right-of-way in order to protect the VTrans system. Possible implementation efforts include:	Other	2	MOB	
	a.	Clarify and enforce that an 1111 permit is required for entities that wish to connect to VTrans' drainage system or discharge into VTrans' ROW. A formal maintenance agreement may be required in addition to the 1111 permit. Clarify that discharges to the ROW not comprised entirely of stormwater ("illicit discharges") are not permissible under VTrans TS4.				
	b.	Develop a formal process for considering requests for run-on, alterations of natural surface drainage, and non-stormwater connections (e.g., foundation drains) that will directly impact VTrans' ROW.				
	c.	Continue to support the Letter of Intent requirement, which became effective July 1, 2015 and serves to confirm that VTrans has reviewed a proposed site plan and is prepared to issue an 1111 permit as a prerequisite for municipal issuance of local zoning permits.				
	d.	Document maintenance responsibilities by incorporating them explicitly into the 1111 permit.				
5		Streamline ANR Stormwater Permitting Work with ANR to identify opportunities to administratively simplify the stormwater permitting process. Possible implementation efforts include:	Other	3		Ideal action for an intra-agency work group (see Action 1.f).
	a.	Designate a single ANR stormwater analyst responsible for reviewing all VTrans projects under all stormwater programs (Operational, Construction, Industrial, TMDL, TS4).				
	b.	Develop a streamlined process for obtaining minor stormwater permit amendments, particularly when an amendment is needed to incorporate as-builts as the drawings of reference for the permit.				
	c.	Develop a two-step permit review process for projects with long development timelines, which would provide early, conditional approvals for a proposed approach in order to limit uncertainty as projects move through the project development process.				
	d.	Pursue a tiered, risk-based approach for post-construction stormwater management permitting similar to that provided for construction phase stormwater permitting under the Construction General Permit. The approach would establish the level of ANR review required for different types of projects as part of the Agency's TS4 permit, and create opportunities for VTrans to self-certify compliance with the stormwater manual for low-risk projects.				
	e.	Identify and implement opportunities to improve designer certifications of permitted stormwater facilities.				

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Action #		Action	Implementation Track (TS4, LEAN, Other)	Urgency or Timeline*	Agency Lead	Status
6		Implement Agency-Wide Stormwater Training Develop broad-based stormwater training for staff at all levels within the Agency and its consultant community. Possible implementation efforts include:	TS4 / Other	1	PDB Env.	
	a.	Provide opportunities for training on written guidelines and checklists to support issue identification and evaluation of stormwater alternatives.				
	b.	Provide opportunities for training specific to ANR's Stormwater Manual. Training emphasis on engineering, implementing, and maintaining green stormwater infrastructure for linear projects and transportation facilities is strongly encouraged.				
	c.	Provide opportunities for training specific to the TS4 permit.				
	d.	Provide training for both in-house designers and consultants on the Agency's (preferred) approach to stormwater treatment design under the TS4.				
	e.	Offer stormwater training targeted to consultants who work on transportation project design (may be combined with 6.a above).				
	f.	Develop stormwater guidance that is specifically targeted to RPCs/MPO.				
	g.	Evaluate options for tracking training course offerings and completion of training activities by VTrans staff and consultants for reporting under TS4				
7		Institutionalize Maintenance and Good Housekeeping Practices Evaluate, develop plans for, and properly resource Agency asset maintenance and good housekeeping activities (e.g., street sweeping, catch basin cleaning, repair, etc.). Possible implementation efforts include:	TS4	1	MOB	
	a.	Develop good housekeeping activity plans (e.g., street sweeping, catch basin inspection and cleaning, slope and ditch maintenance and repair, etc.) as part of facility SWPPPs.				
	b.	Maintain "Operations and Maintenance Binders" at each district, which include maintenance plans for each stormwater permit, estimated operation and maintenance costs, and information relevant to inspections.				
	c.	Ensure that Districts have adequate resources and access to equipment needed to fully implement the Agency's water quality best management practices.				
8		Clarify Jurisdictional Decision-Making for Stormwater Management Develop guidance to clarify the process for making jurisdictional determinations. Possible implementation efforts include:	TS4	1	PDB Env.	
	a.	Standardize the process for when and where to submit permit applications, to ensure that PDB Environmental has an opportunity to review a project before an application is submitted to ANR.				
	b.	Work with ANR to clarify jurisdictional triggers, both for transportation-related projects and for projects that affect the VTrans ROW. This could be in the form of an SOP or guidance tied to the TS4 permit.				
9		Track Stormwater Investments Develop a system for tracking the total investment made each year – including capital costs, operations & maintenance needs, and staff hours – by the Agency in stormwater management. Possible implementation efforts include:	Other	1	Business office, MOB	
	a.	Develop key performance measures and a results-based accountability framework.				
	b.	Separately track up-front capital expenditures for stormwater management and costs associated with on-going maintenance and operations.				
	c.	Update MATS to support better tracking of stormwater-related maintenance activities.				
	d.	Estimate capacity required to fulfill current and anticipated stormwater commitments; evaluate efficacy of different scenarios (in-house vs. consultant-led) for meeting obligations.				

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Action #		Action	Implementation Track (TS4, LEAN, Other)	Urgency or Timeline*	Agency Lead	Status
10		**Integrate Stormwater With Agency Documents and Practices** Incorporate stormwater management considerations into Agency policies, procedures, guidance, MOUs, and handbooks as they are developed/revised. Possible implementation efforts include:	TS4	3	Four Pillars? Dan? PPAID?	
	a.	Incorporate stormwater language into the Agency's Strategic Plan (policy planning chapter) and stormwater performance measures.				
	b.	Look for opportunities to clarify definitions of key terms that directly impact stormwater management in order to alleviate uncertainty in the permitting process.				
	c.	Incorporate Section 652 Special Provisions into the *Standard Specifications for Construction Book* as related protocols are updated.				Comments were also recently provided on Section 100.
	d.	Collaborate across the Agency about how the *Standard Specifications for Construction Book* can address stormwater considerations.				
11		Develop clear guidance documents concerning comingled designs and projects where VTrans may have shared responsibilities with a municipality for both obtaining permits and on-going operations and maintenance. Possible implementation efforts include:	TS4	2	MOB	
	a.	Support municipal outreach and training to clarify roles and responsibilities relative to operations and maintenance obligations for projects with regulated stormwater on Town Highways where comingling occurs.				
	b.	Standardize permitting and maintenance agreements for projects with comingled stormwater.				
	c.	Identify scenarios where it may make sense to divide state and local responsibilities, in order to minimize instances where VTrans will be a co-permittee.				Must be done for TS4 NOI
12		Expand efforts to improve management of outside contributing sources (e.g., run-on, illegal connections (IC), illicit discharges (ID)). Possible implementation efforts include:	Other	1	PDB Env.	
	a.	Develop legislation and/or an IC/ID/run-on policy, with supporting procedure or guidance and training.				
	b.	Develop checklist for identifying and addressing outside contributing sources to VTrans' drainage system to be used during the project planning process.				
	c.	As part of the TS4 SWMP, implement a program to systematically detect and eliminate IC/ID throughout the VTrans drainage network.				
	d.	Offer training to VTrans staff and municipal officials on identifying and correcting outside contributing sources.				
13		Explicitly address stormwater in written standards and guidance relied on during construction. Possible implementation efforts include:	Other	1	PDB Env.	
	a.	Ensure environmental commitments are clearly documented in contract documents (Environmental Special Provisions) and project plans.				
	b.	Require designers and contractors to complete Project Close-Out forms, certifying how and where stormwater practices were constructed.				
	c.	Consider approach for stormwater management similar to that which the Agency currently employs for erosion prevention plans and specification, where plans are developed and included in construction documents regardless of whether an ANR permit is triggered. Contractors are required to either accept or modify these plans as part of the contract.				

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ATTACHMENT H GAP PROCEDURE

VTrans Stormwater GAP Procedure

(July 2021)

The "GAP Procedure" is the process of managing stormwater on projects that involve greater than 1 acre of earth disturbance (and therefore require a construction stormwater permit), but do not trigger jurisdiction under the State's operational stormwater permit program. The requirement to manage these projects is part of the Minimum Control Measures, identified within the Agency's TS4 Stormwater Management Program (SWMP).

The following steps outline the process to comply with the GAP procedure.

Project Manager (PM)	1. Submits the project for Environmental Permits through VPINS with a completed Project Information Data Form (PIDF).
Stormwater Engineer/Green Infrastructure Engineer (SWE/GIE)	2. Assesses if GAP Procedure applies to the project.
	3. Adds "GAP" to VPINS under the OSW tab.
	4. Notifies PM and Maintenance Water Quality Unit (MWQU) Stormwater Technician via email that GAP Procedure applies and schedules meeting to review/discuss.
	5. Updates Shared Tracking Workbook to include project.
	6. Begins filling out the GAP Worksheet. • Assess Level 1/2/3 Practice required • Review plans to identify potential practices & locations
	7. Meets with PM (and designer/consultant) to review practices.
PM	8. Designs treatment practices and incorporates into plans.
SWE/GIE	9. Completes GAP Worksheet.
	10. Prepares GAP Documentation (one combined PDF): • Memo with brief description • Completed GAP Worksheet • Plan/map showing location(s) of treatment practices
	11. Distributes completed GAP document to: • PM • Environmental Specialist • Construction Environmental Engineer • MWQU Stormwater Technician.
	12. Updates VPINS with date of distribution. ("GAPmmddyy")

MWQU SW Tech	13. Tracks, inspects, and maintains (as needed) stormwater treatment practices as assets