CENTRAL VERMONT – STORMWATER MASTER PLAN

BARRE TOWN, BARRE CITY, AND PLAINFIELD, VERMONT

FINAL REPORT
February 1, 2018

CVRPC
CENTRAL VERMONT REGIONAL PLANNING COMMISSION

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I. Disclaimer

The intent of this report is to present the data collected, evaluations, analyses, designs, and cost estimates for subwatersheds in Barre City, Barre Town, and Plainfield under a contract between the Central Vermont Regional Planning Commission and Watershed Consulting Associates, LLC. Funding for the project was provided by the Vermont Department of Environmental Conservation's Clean Water Fund Grant. The plan presented is intended to provide the watershed's stakeholders a means by which to identify and prioritize future stormwater management efforts. This planning study presents a recommended collection of Best Management Practices (BMPs) that would address specific concerns that have been raised for these areas. In particular, there is great need to reduce stormwater impacts including phosphorus and sediment from stormwater runoff to receiving waters within the municipalities and the greater Lake Champlain Basin in light of future regulation under the Lake Champlain Total Maximum Daily Load requirements. Although there are other BMP strategies that could be implemented in the watershed, these are the sites and practices that project stakeholders believe will have the greatest impact and probability of implementation. These practices do not represent a regulatory obligation at this time, nor is any property owner within the watershed obligated to implement them. However, it should be noted that for properties with three or more acres of impervious cover without a current State stormwater permit, forthcoming regulations will require management of existing impervious areas. This stormwater master plan, and therefore its resultant strategies, will be one of the actions in the upcoming Winooski Tactical Basin Plan. This will put the BMP strategies in queue for state funding for implementation.

II. Glossary of Terms

Best Management Practice (BMP)- BMPs are practices that manage stormwater runoff to improve water quality and reduce stormwater volume and velocity. Examples of BMPs include detention ponds, gravel wetlands, infiltration trenches, and bioretention practices.

Buffers- Protective vegetated areas (variable width) along stream banks that stabilize stream banks, filter sediment, slow stormwater runoff velocity, and shade streams to keep waters cool in the summer months.

Channel Protection Volume (CPv)- The stormwater volume generated from the one-year, 24-hour rainfall event. Management of this event targets preventing stream channel erosion.

Check Dam- A small dam, often constructed in a swale, that decreases the velocity of stormwater and encourages the settling and deposition of sediment. They are often constructed from wood, stone, or earth.

Detention BMP- A BMP that stores stormwater for a defined length of time before it eventually drains to the receiving water body. Stormwater is not retained in the practice. The objective of a detention BMP is to reduce the peak discharge from the BMP to reduce channel erosion and settle out pollutants from the stormwater. Some of these practices also include additional water quality benefits. Examples include gravel wetlands, detention ponds, and non-infiltration-dependent bioretention practices.

Drainage Area- The area contributing runoff to a specific point. Generally, this term is used for the area that drains to a BMP or other feature like a stormwater pipe.

Hydrologic Soil Group- A Natural Resource Conservation Service classification system for soils. They are categorized into four groups (A, B, C, and D) with "A" having the highest permeability and "D" having the lowest.

Infiltration/Infiltration Rate- Stormwater percolating into the ground surface. The rate at which this occurs (infiltration rate) is generally presented as inches per hour.

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 Infiltration BMP practices include infiltration trenches, bioretention practices, subsurface infiltration chambers, infiltration basins, and others.

Outfall- The point where stormwater discharges from a system like a pipe.

Sheet Flow- Stormwater runoff flowing over the ground surface in a thin layer.

Stabilization- Vegetated or structural practices that prevent erosion from occurring.

Stormwater/Stormwater Runoff- Precipitation and snowmelt that runs off the ground surface.

Stormwater Master Plan (SWMP)- A comprehensive plan to identify and prioritize stormwater management opportunities to address current, and prevent future, stormwater related problems.

Stormwater Permit- A permit issued by the State for the regulated discharge of stormwater.

Swale- An open vegetated channel used to convey runoff and to provide pre-treatment by filtering out pollutants and sediments.

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. This includes the maximum loading, sources of pollution, and criteria for determining if the TMDL is met.

Total Phosphorus (TP)- The total phosphorus present in stormwater. This value is the sum of particulate and dissolved phosphorus. It includes both organic and inorganic forms.
Total Suspended Solids (TSS)- The total soil particulate matter suspended in the water column.

Watershed- The area contributing runoff to a specific point. For watersheds like the Dog River, this includes all of the area draining to the point where the river discharges to the Winooski River.

Water Quality Volume (WQv)- The stormwater volume generated from the first inch of runoff. This runoff is known as the 90th percentile rainfall event and contains the majority of pollutants.

1 Introduction

1.1 The Problem with Stormwater

Stormwater runoff is any precipitation including melting snow and ice that runs off the land. In undeveloped areas, much of the precipitation is soaked into the ground, taken up by plants, or evaporated back into the atmosphere. However, when human development limits or completely prevents this natural sponge-like effect of the land, generally through the introduction of impervious areas such as roads, parking lots, or buildings, the volume of stormwater runoff increases, sometimes dramatically. In addition to the increased volume of stormwater runoff, the runoff is also frequently laden with pollutants such as sediment, nutrients, oils, and pathogens. These stormwater runoff related issues decrease aquatic habitat health, increase flooding and erosion, threaten infrastructure, and prevent use and enjoyment of our water resources. Traditionally, stormwater management techniques have relied heavily upon gray infrastructure, where stormwater is collected and conveyed in a network of catchbasins and pipes, prior to discharging to surface waters (i.e. streams, rivers, ponds, lakes, and coastal waters). Although this approach is effective in removing stormwater from developed areas, it does not eliminate the problem and has proved to worsen negative stormwater effects such as erosion, flooding, and nutrient pollution. It is clear that something has to change. This is where stormwater master planning comes into play. Funding is limited to implement projects that will improve water quality and reduce the negative impacts of uncontrolled stormwater runoff. As such, creating a plan of where and how to best use these funds to provide the greatest benefit to our water resources is key.

1.2 What is Stormwater Master Planning

In the wake of rapid urban development and increasing rainfall intensity, stormwater management that seeks to mimic the undeveloped environment and treat stormwater runoff as close to the source as possible has become the focus of efforts to mitigate urban flooding and maintain the health of our waterways. Given the complexity of current stormwater issues, the development of the Stormwater Master Planning process provides communities with a range of possibilities for stormwater mitigation from small-scale (i.e. individual parcels), to large-scale (i.e. community-wide). Stormwater rarely follows political or parcel boundaries and tackling this problem from a strategic perspective is key to preventing future problems and addressing current sources of water quality degradation. This process was developed because much of the urban area within the State of Vermont predates regulatory requirements for stormwater management, but these distributed and unmanaged areas are contributing to the impairments of our surface waters including Lake Champlain. These unmanaged stormwater discharges can be identified and addressed through this Stormwater Master Planning process. The process allows for assessment and prioritization of the areas most in need of mitigation while acknowledging that, for many areas, these types of stormwater retrofits are voluntary. Public awareness of both stormwater problems and stormwater management practices are critical to the Stormwater Master Planning process. As such, working with municipal officials, project stakeholders, and community members is key to implementation of and support for these plans. Stormwater Master Planning involves analysis of current and anticipated future conditions, and seeks to prioritize stormwater solutions, maximizing the potential for water quality improvement, flood mitigation, erosion reduction, and pollution prevention using a variety of best management practices (BMPs) and allocating limited funds in a planned and methodical way.

2 Project Overview

In May 2013, the State of Vermont Department of Environmental Conservation (VT DEC) issued a document titled *Vermont Stormwater Master Planning Guidelines*, designed to provide VT communities with a standardized guideline and series of templates. The document assists communities in planning for future stormwater management practices and programs. Our Plan is a combination of Templates 2A: Hybrid site & community retrofit approach with green stormwater infrastructure (GSI) stormwater management, and 3A: Large watershed or regional approach with planned build out analysis and traditional (end of pipe or centralized) stormwater management.

Vermont has had stormwater regulations in place since 1978, with updates concerning unified sizing criteria made in 2002, and again in 2017. Recognizing that stormwater management can be a costly endeavor, the new guidelines are written to help identify the appropriate practices for each watershed, community, and site, in order to maximize the use of funds.

The guidelines encourage each stormwater master plan (SWMP) to follow the same procedures, and include:

- Problem Definition
- Collection of Existing Data
- Development of New Data
- Existing and Proposed Program, Procedure, or Practice Evaluation
- Summary and Recommendations

In keeping with these guidelines, we have prepared the following report. The report is broken up into three chapters, one for each municipality covered by this plan. The chapters are titled with the municipality name: Barre City, Barre Town, and Plainfield.

A. Chapter 1: Barre City

1 Background

1.1 Problem Definition

Barre City is located in Washington County primarily within the Stevens Branch watershed, though small portions fall within the Stevens Branch Headwaters and the Jail Branch watersheds. All three watersheds are tributaries of the Winooski River (Figure A1). The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development.

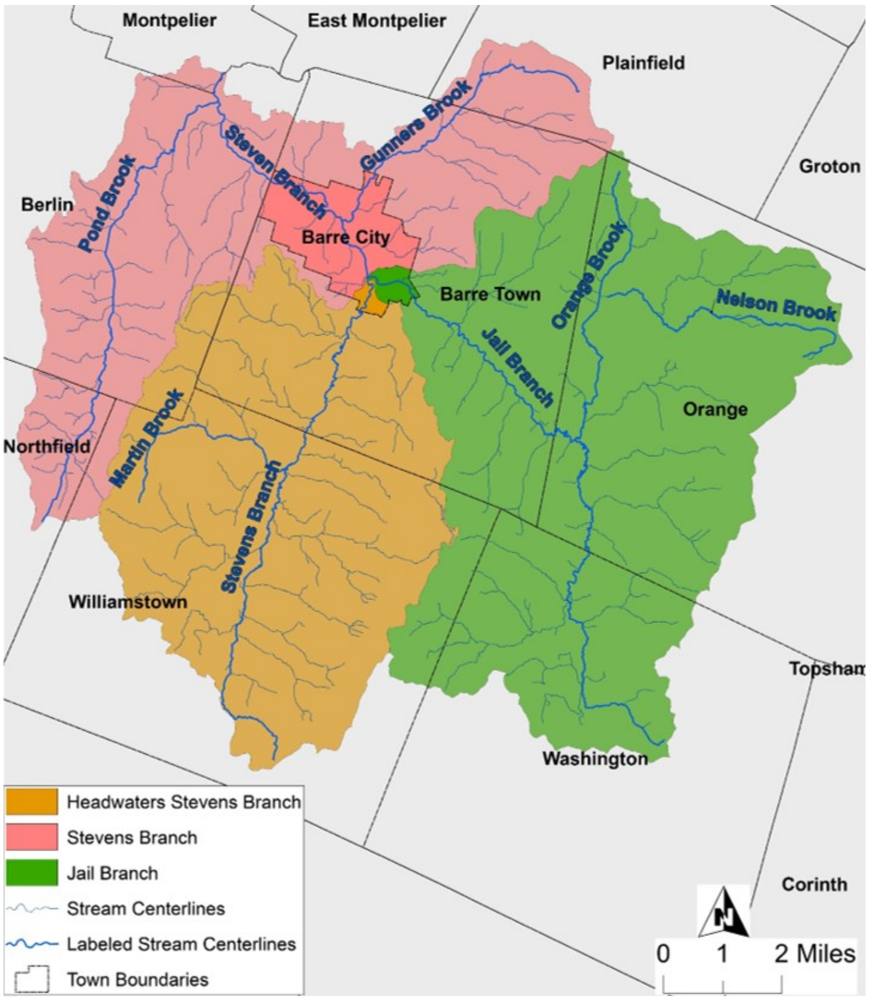

Figure A1. The City of Barre is located primarily within the Stevens Branch watershed with portions in the Gunners Brook and Jail Branch watersheds.

The Stevens Branch frequently floods both currently and historically. As the river passes through the City, it is subject to multiple constrictions, often lacks a sufficient riparian buffer, and has been channelized in some locations historically. Areas of erosion and sediment deposition have been noted within the City. Two sections of the Stevens Branch are on the 2016 stressed waters list due to streambank erosion, channel instability, road runoff, elevated *E. coli*, and urban runoff.

The Jail Branch, near confluence with the Stevens Branch, has flooded downtown Barre City. As the river flows into the City, it is subject to multiple constrictions that limit the stream's ability to adjust its planform. The stream often lacks a riparian buffer, which is critical for stream health and stability. Sections of the river have been channelized in the past, so the river is out of dynamic equilibrium. Areas of erosion and deposition have also been noted. Two sections of the Jail Branch are on the 2016 stressed waters list due to land development, erosion and sedimentation, urban runoff, nutrients, and elevated *E. coli*.

Barry City has experienced significant development along Routes 302, 62, and 14, with expanding areas of impervious surfaces. Route 302 closely parallels Stevens Branch, and Jail Branch, with significant development falling in or close to the river corridors. This development has constrained the rivers along both banks. In addition to expanding development along these corridors, Barre City experiences significant erosion as a result of steep slopes and poor soils, further contributing to sediment and nutrient loading in surface waters.

The human-influenced stressors in the watersheds include commercial development and associated parking areas, construction of roads, residential development, and clearing of previously forested areas. Additionally, in part due to historic straightening of rivers in the area, associated incision of stream channels, and limited floodplain access, both nuisance flooding and more extreme flood events can and do occur. Unmanaged stormwater runoff, particularly from impervious surfaces and landscaped pervious areas, exacerbate flooding. The Winooski River watershed and its tributaries have experienced extreme flooding in the past, and these flood events are expected to occur more frequently due to the predicted increased frequency and intensity of extreme weather events associated with climate change. These heavy rains and easily erodible soils have contributed to erosion issues throughout the area. The stormwater management practices investigated seek to protect local river resources as well as the larger Lake Champlain Basin, which currently has a Total Maximum Daily Load (TMDL) in place, requiring reductions in phosphorus loading to Lake Champlain via its tributaries though reductions in stormwater and agricultural runoff pollution.

1.2 Existing Conditions

The City of Barre spans approximately 2,577 acres in Washington County, VT and is primarily urban (55%), though nearly 26% of the City is classified as forested (Figure A2). Of that area, there are 652 acres (25%) of impervious cover. Much of the development in Barre City parallels Stevens Branch, with many commercial areas falling within the River Corridor. Route 62 and Route 302, two of the more densely developed routes in the City, closely follow Stevens Branch with Route 62 along the southern bank and Route 302 along the northern bank.

Many of the older developments within the City were constructed before current stormwater standards were developed, and they were constructed without any or with only minimal stormwater management. This has resulted in significant amounts of untreated stormwater draining from large portions of developed lands discharging directly to surface waters.

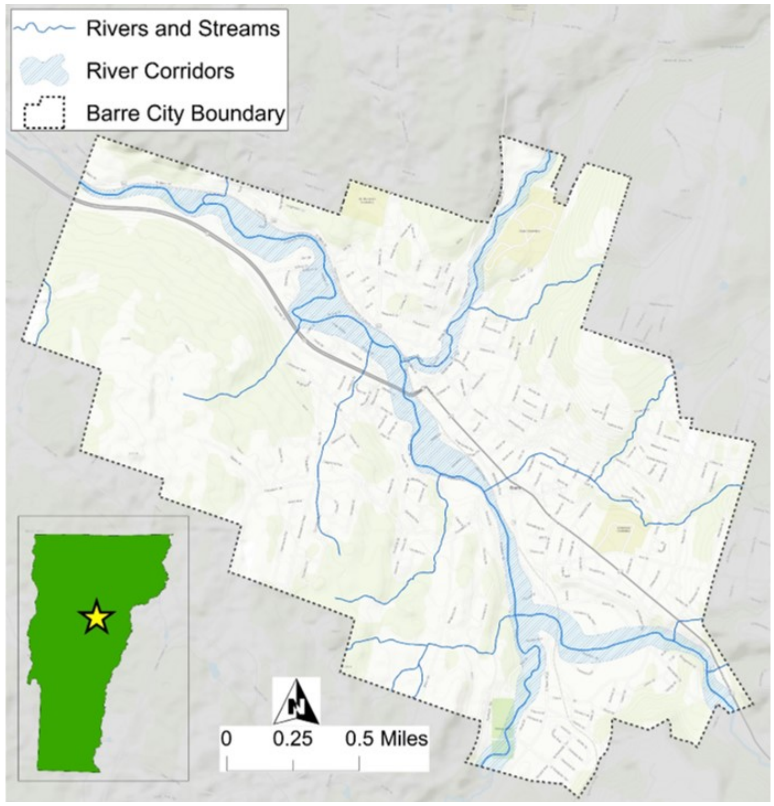

Figure A2. The Barre City is located in Washington County, VT.

Soils analyses indicate that of the 2,577 total acres in the City, 83% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the City, the majority of areas belong to either Hydrologic Soil Group C (30.5%) or D (32.5%), while only 2.5% are in group A, and 18.2% are in group B. The remainder is not classified or comprised of water. This combination of steep slopes with limited infiltration capacity and a highly erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed conditions can be found in Appendix A1 – Map Atlas. Maps include:

- river corridors and wetlands including wetlands advisory layer and hydric soils,
- soil infiltration potential,
- soil erodibility,
- slope,
- stormwater infrastructure and stormwater permits,
- land cover,
- impervious cover,
- and parcel boundaries including parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this SWMP study. These reports include the

Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2017). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix A2 – Data Review.

The project team met with the City of Barre stakeholders and the Central Vermont Regional Planning Commission (CVRPC) on March 29th, 2017 to discuss the SWMP and solicit information on problem areas from the City. Following this meeting, a list of 22 potentially important sites was provided to the project team. This list included particular parcels as well as general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 *Desktop Assessment*

A desktop assessment was completed in order to identify additional potential sites for stormwater BMP implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. Barre City opted to include these private sites with ≥3 acres of impervious cover in the plan despite the upcoming regulations for these areas as they are important sources of stormwater in the City. A point location was created for each identified site or area for assessment in the field.

A 'green streets' assessment was also conducted to identify any road segments in the City potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the "Promoting Green Streets" report published by the River Network (July 2016; included as Appendix A3).

The methodology was modified to better fit specific conditions found in the study area. The analysis utilized two prerequisites and one secondary consideration.
Prerequisites:

1. Road Slope
   - 1-5% Slope = Ideal (Score: 2 points)
   - 5-7.5% Slope = Potential (Score: 1 point)
   - > 7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)
2. Road Right-of-Way Width
   - ≥ 50 ft = Ideal (Score: 2 points)
   - 46-50 ft = Potential (Score: 1 point)
   - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

1. Hydrologic Soil Group (indication of infiltration potential)
   - A/B (highest infiltration potential) = Ideal (Score: 2 points)
   - B/C (moderate infiltration potential) = Potential (Score: 1 point)
   - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

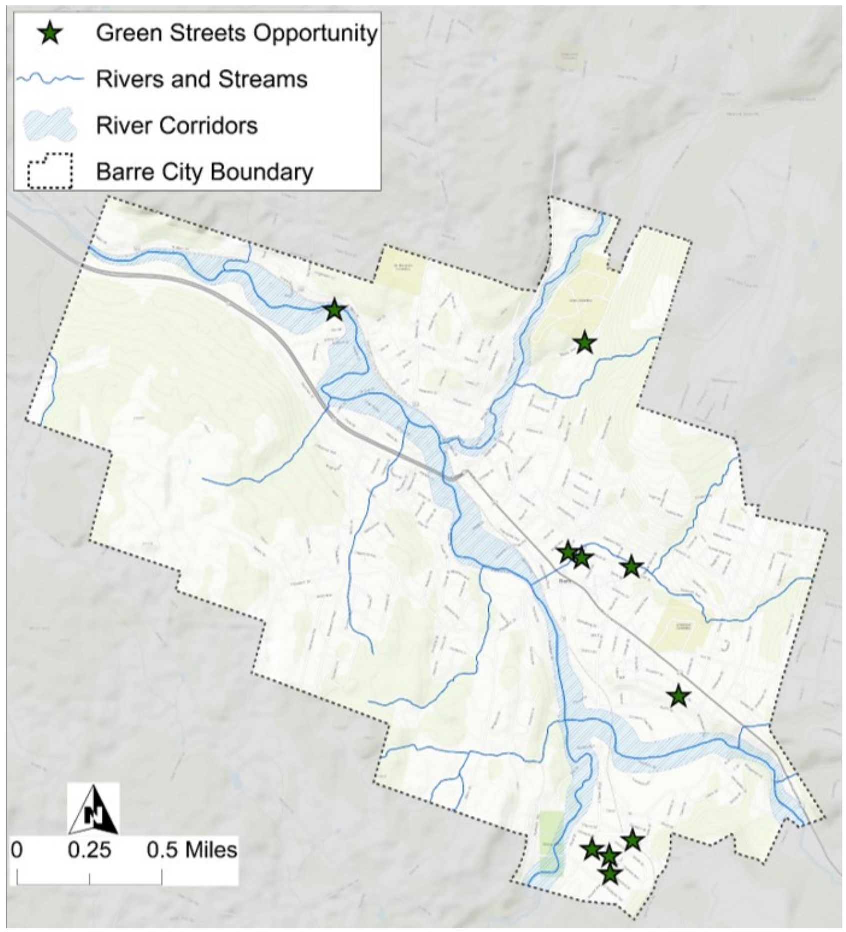

Figure A3. The 10 locations identified as potential green streets opportunities are shown with green stars.

The scores from each of the three criteria were added, and a score was assigned for each road segment where higher scores indicated a greater potential for GSI suitability. In total, 10 sites with potential were noted for assessment in the field (Figure A3). These sites included South Main Street, Treatment Plant Drive, Jefferson Street, Elm Street, East Street, Maple Avenue, Orange Street, Sunrise Avenue, North Parkside Terrace, and Quarry Street.

A total of 72 locations, including the Green Streets sites, were identified for stormwater retrofit potential.

2.1.2.2 Basemap and Mobile App Creation

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the City. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 72 point locations for the potential BMP sites, which included both general City-wide sites and green streets locations. These points allowed for easy site location and data collection in the field (Figure A4).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data. All collected data was securely uploaded to the Cloud for later use.

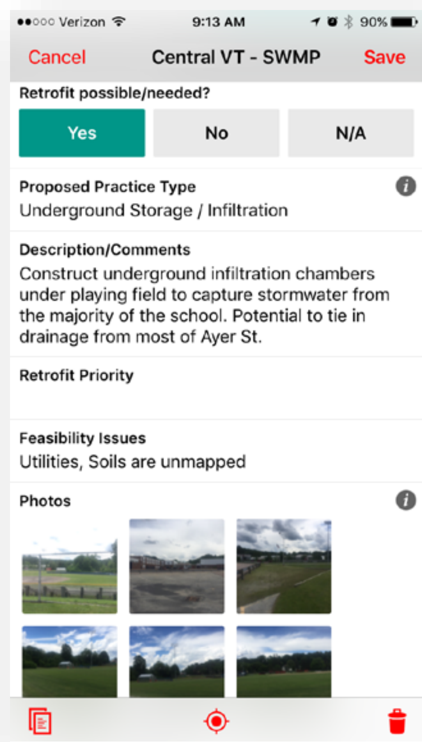

Figure A4. Example screen from data collection app.

2.1.3 Field Data Collection:

Each of the 72 previously identified potential BMP locations were evaluated in the field during the Summer and Fall of 2017 (Figure A5). Data was collected about each site in the mobile app. A large map of these sites with associated site names, and a list of these sites including potential BMP options and site notes can be found in Appendix A4 - Initial Site Identification.

Through the course of these field visits, 9 additional stormwater retrofit sites were identified that had not been included in the initial desktop assessment. Conversely, some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific site conditions. A total of 11 sites were removed from this plan for site-specific reasons.

Following these refinements, the list of potential BMPs in Barre City was refined to 70 (Figure A6). A memo detailing this site refinement and associated maps and tables are included as Appendix A5 - Site Refinements.

Figure A5. 72 potential sites for BMP implementation were identified for field investigation.

2.2 Preliminary BMP Ranking

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 70 projects (Figure A6). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix A6 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix A6 is the completed ranking for each

Figure A6. Following field investigations, the list of potential BMP sites was refined to 70. Point locations are shown for each site.

potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

The draft Top 20 list was distributed to Barre City stakeholders and the CVRPC. As part of this process, the project team met with the stakeholders on August 10th, 2017 to discuss the proposed Top 20 project sites. Following feedback from the City, the list was refined to reflect the City's knowledge of potentially unwilling landowners and the City's priorities. These Top 20 sites are listed in Table A1. Point locations are shown in Figure A7.

Table A1. Top 20 BMPs selected for the Barer City SWMP.

Site ID	Proposed Practice Type
Elmwood Cemetery	Subsurface infiltration chambers
Currier Park	Subsurface infiltration chambers
Auditorium and Ice Rink	Subsurface sand filter
Barre Municipal Swimming Pool	Subsurface sand filter
Spaulding High School	Subsurface sand filter
Camp St Town Parking Lot	Subsurface sand filter
VT City Park	Subsurface sand filter
Foss Street and Rte 62	Gravel Wetland
Boynton St Parking Lot	Subsurface sand filter
Nativi Playground	Subsurface sand filter
DMS Machining and Bellavance Trucking	Subsurface sand filter
Highgate Apts	Gravel Wetland
Foss St	Infiltration Basin
Department of Labor - SW Parking	Subsurface infiltration chambers
Barre City DPW	Hydrodynamic Separator, site stabilization, cistern for roof drainage
Town Parking	Subsurface sand filter
S Main St by Health Center	Infiltration Basin
Sherwin Williams	Reduce impervious cover, revegetate stream buffer, direct runoff from stormline to subsurface sand filter
S Vine St Industrial Area	Reduce impervious cover, revegetate stream buffer, direct runoff from stormline to subsurface sand filter
Allen Lumber Co	Hydrodynamic Separator, vegetated buffer, cistern for roof drainage

2.3 Modeling and Concept Refinement for Top 20 BMPs

Modeling was completed for each of the Top 20 sites. This modeling allowed for accurate sizing of the proposed practices as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and landuse/landcover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations (see Appendix A7 – Top 20 Sites for drainage area delineations). Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix A8 - Top 20 Sites Modeling for modeling reports).

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site's current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table A2. Complete modeling results are provided in Appendix A8 - Top 20 Sites Modeling.

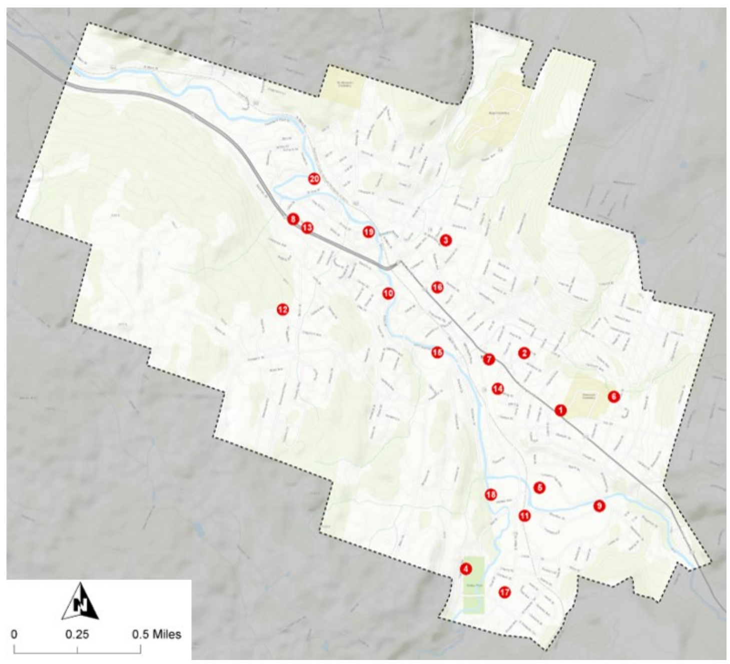

Figure A7. The Top 20 project locations are shown.

Table A2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Elmwood Cemetery	1.514	1.514	17,620	98%	13.93	97%
Currier Park	0.850	0.85	8,072	97%	6.52	97%
Auditorium and Ice Rink	1.267	--	24,164	51%	8.66	33%
Barre Municipal Swimming Pool	0.864	--	4,335	51%	7.89	33%
Spaulding High School	1.500	--	6,632	51%	4.37	33%
Camp St Town Parking Lot	1.176	--	8,198	51%	4.76	33%
VT City Park	0.634	--	54,842	51%	42.62	33%
Foss Street and Rte 62	0.553	--	18,645	96%	9.82	58%
Boynton St Parking Lot	1.298	--	17,822	51%	11.31	33%
Nativi Playground	0.237	--	12,634	51%	9.66	33%
DMS Machining and Bellavance Trucking	0.392	--	9,012	51%	8.19	33%
Highgate Apts	1.050	--	28,944	96%	21.22	58%
Foss St	0.089	0.089	1,167	99%	0.83	99%
Department of Labor - SW Parking	0.058	0.058	975	99%	0.41	98%
Barre City DPW	0.036	--	4,063	42% Hydrodynamic Separator / 100% Cistern	0.08	0% Hydrodynamic Separator / 100% Cistern
Town Parking	0.216	--	3,060	51%	1.54	33%
S Main St by Health Center	0.110	0.11	2,060	97%	1.40	97%
Sherwin Williams	0.497	--	6,736	51%	2.44	33%
S Vine St Industrial Area	0.239	--	2,507	51%	0.52	33%
Allen Lumber Co	0.028	--	2,164	42% Hydrodynamic Separator / 100% Cistern / 60% Filter Strip	0.11	0% Hydrodynamic Separator / 100% Cistern / 20% Filter Strip

2.4 Final Ranking Methodology

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix A9 - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix A10. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix A9 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or GSI-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[1] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table A3 below.

Table A3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	Base Cost ($/ft^3)
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large above-ground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

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

Permits and Engineering Costs: Used either 20% for large above-ground projects, or 35% for smaller or complex projects.

[1] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Land Acquisition Costs *(Modified)*: A variation from the HW method was applied. Based on prior studies completed by Watershed Consulting Associates (WCA), the land acquisition cost was calculated as $120,000 per acre required for the BMP when located on private land. It should be noted that this value is based on a limited estimate and not necessarily an expected cost per acre. At this time, no land acquisition costs were built into the costs provided. It is assumed at this time that sites not owned by the Town will retain ownership of the stormwater management sites.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix A9 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices and their assigned rank are shown in Table A4. The comprehensive matrix used to rank the proposed BMP projects is provided in Appendix A9 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table A4. Top 20 potential BMP sites for Barre City.

Rank	Site ID	Address	Proposed Practice Type
1	Elmwood Cemetery	Washington St	Subsurface infiltration chambers
2	Currier Park	Currier Park	Subsurface infiltration chambers
3	Auditorium and Ice Rink	Auditorium and Ice Rink	Subsurface sand filter
4	Barre Municipal Swimming Pool	59 Parkside Terr	Subsurface sand filter
5	Spaulding High School	155 Ayers St	Subsurface sand filter
6	Camp St Town Parking Lot	75 Camp St	Subsurface sand filter
7	VT City Park	Prospect St and N Main St	Subsurface sand filter
8	Foss Street and Rte 62	Foss St and Rte 62	Gravel Wetland
9	Boynton St Parking Lot	Boynton and Batchelder	Subsurface sand filter
10	Nativi Playground	197 River St	Subsurface sand filter
11	DMS Machining and Bellavance Trucking	DMS Machining and Bellavance Trucking	Subsurface sand filter
12	Highgate Apts	121 Highgate Dr	Gravel Wetland
13	Foss St	Foss St	Infiltration Basin
14	Department of Labor - SW Parking	5 Perry St #200	Subsurface infiltration chambers
15	Barre City DPW	7 Burnham St	Hydrodynamic Separator, site stabilization, cistern for roof drainage
16	Town Parking	N Main St and Seminary St	Subsurface sand filter
17	S Main St by Health Center	S Main St	Infiltration Basin
18	Sherwin Williams	Leonardo's, 131 S Main St	Reduce impervious cover, revegetate stream buffer, direct runoff from stormline to subsurface sand filter
19	S Vine St Industrial Area	S Vine St	Reduce impervious cover, revegetate stream buffer, direct runoff from stormline to subsurface sand filter
20	Allen Lumber Co	502 N Main St	Hydrodynamic Separator, vegetated buffer, cistern for roof drainage

A map of each project showing the drainage areas and BMP locations can be found in Appendix A7 - Top 20 Sites, and project locations within the watershed can be found in Appendix A9 - Top 20 Site Final Ranking.

2.6 *Selection of Top 5 Potential BMPs*

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking as well as input from municipal officials concerning project priorities. The location of the sites within the City are shown in Figure A8. In the final ranking (2.4 Final Ranking Methodology), these 5 sites were awarded additional points in the site scoring to reflect the City's priorities and the high probability for implementation. The Top 5 sites are listed in Table A5 in order of rank.

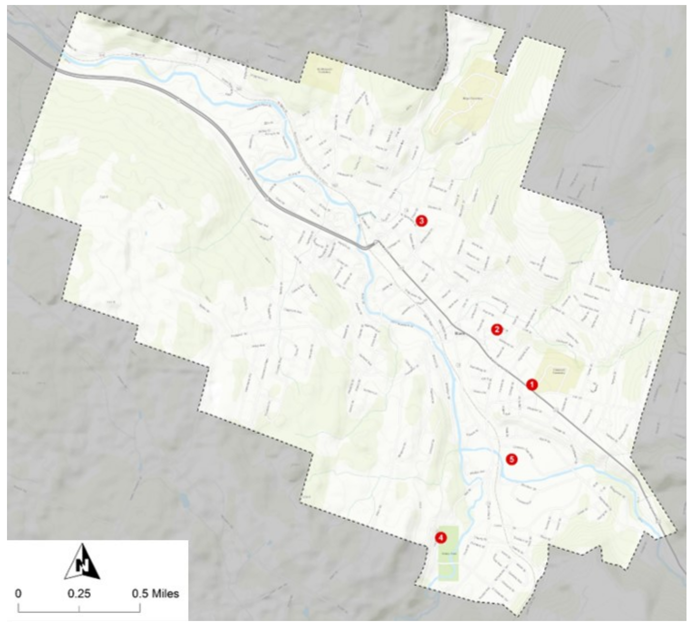

Figure A8. Top 5 sites for the Barre City SWMP.

Table A5. Top 5 BMP sites for Barre City.

Rank	Site ID	Address	Proposed Practice Type
1	Elmwood Cemetery	Washington St	Subsurface infiltration chambers
2	Currier Park	Currier Park	Subsurface infiltration chambers
3	Auditorium and Ice Rink	Auditorium and Ice Rink	Subsurface sand filter
4	Barre Municipal Swimming Pool	59 Parkside Terr	Subsurface sand filter
5	Spaulding High School	155 Ayers St	Subsurface sand filter

3 Priority BMPs

The selected Top 5 BMP implementation sites are briefly described below. These opportunities are located on City property. Individual drainage area maps and an overview map are provided in Appendix A11.

Site: 1
Project Name: Elmwood Cemetery
Description: The site includes a portion of Elmwood Cemetery and a stormline on Washington Street. Stormwater is currently collected in a series of stormlines between Hill St and Washington St, including Charles St, Camp St, and Patterson St. The eastern portion of the cemetery drains to the stormline on Hill St, and the western to Washington St. This stormline outlets at Stevens Branch, west of the cemetery. The concept for this site includes redirecting the stormline on Washington St to an underground storage and infiltration chamber system located in the lawn to the west of the cemetery driveway on Washington St (see Figure A9). Soils are mapped as being good at this site (Hydrologic Group B), so soils and infiltration testing were conducted to evaluate the potential for an infiltration practice. Soils were found to be a mix of sand and silt, and a high infiltration rate was measured.


Figure A9. Grass lawn of Elmwood Cemetery where infiltration practice would be located.

Outreach: This site is owned by the City, and as such, no additional outreach was carried out.

Site: 2
Project Name: Currier Park
Description: The site includes Currier Park and the stormlines that run along the park boundaries. Stormwater is currently collected in a series of stormlines draining road and residential land uses from Terrace Ave, Mount St, Academy St, North St, Andrews Ct, and parts of Highland Ave, East St, and Park St. This stormline outlets at a tributary between Averill St and Eastern Ave. The concept for this site includes rerouting the stormlines to an underground storage and infiltration chamber system located in the northwestern corner of the park (Figure A10). This system would outlet to the existing stormline on Park St. Soils are mapped as being good at this site (Hydrologic Group B), so soils and infiltration testing was completed. Soils were found to be generally silty, and a moderate infiltration rate was measured.


Figure A10. Location in Currier Park where subsurface infiltration chambers would be located.

Outreach: This site is owned by the City, and as such, no additional outreach was carried out.

Site: 3

Project Name: Auditorium and Ice Rink

Description: The site includes the Barre City Auditorium, Barre Civic Center, B.O.R. Ice Arena, and associated parking lots. Stormwater is currently collected in a series of stormlines that outlet to Gunners Brook on Seminary St, west of the site. This drainage area includes Maplewood Ave, Burns St, half of Johnson St, and parts of Sheridan St and Merchant St. The concept for this site includes rerouting the stormline behind the ice rink and the stormline draining the auditorium and civic center to an underground sand filter system located in the northwestern corner of the parking lot (Figure A11). Although soils are mapped as being good at this site (Hydrologic Group B), pursuing an infiltration practice was not an option due to location and potential contamination.

Figure A11. The subsurface sand filter is proposed under the auditorium's large parking lot.

Outreach: This site is owned by the City, and as such, no additional outreach was carried out.

Site: 4

Project Name: Barre Municipal Swimming Pool

Description: The site includes the Barre City Elementary and Middle School, a portion of Parkside Terrace, and Rotary Park's recreational complex parking lot. Stormwater is currently captured in a series of stormlines located throughout this area, and outlets to Stevens Branch. The concept for this site includes redirecting the stormline between the basketball courts and playground to an underground sand filter system in the parking lot by the pool (Figure A12). The feature would outlet to the parking lot's existing stormline. Although soils are mapped as being good at this site (Hydrologic Group B), pursuing an infiltration practice was not an option due to the presence of high groundwater and poor soils. Soils were found to be generally silty.

Figure A12. Recreational complex parking lot and location of proposed subsurface sand filter.

Outreach: This site is owned by the City, and as such, no additional outreach was carried out.

Site: 5
Project Name: Spaulding High School
Description: The site includes a stormline which collects drainage from much of the School's grounds including the building, parking lots, Crimson Tide Way, and some of the athletic fields. It also includes a nearby residential area. The stormline outlets between the baseball field and the track to the Jail Branch. The concept for this site includes rerouting the stormline to an underground sand filter system in the athletic fields (Figure A13). Although soils are mapped as being good at this site (Hydrologic Group B), pursuing an infiltration practice was not an option due to the presence of high groundwater and silty soils.

Figure A13. A subsurface sand filter is proposed under the playing fields at the school

Outreach: Contact was made with Jamie Evans (School Facility Manager) prior to advancing concept designs at this site. The school allowed further design to be completed at the site.

When implemented, these five BMPs would treat approximately 108.4 acres, 47.4 acres (44%) of which is impervious. Modeled pollutant reductions for each of the projects, shown below in Table A6, indicate that these BMPs will prevent nearly 70,000 lbs of total suspended solids and more than 41 lbs of total phosphorus from reaching receiving waters annually.

Table A6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Elmwood Cemetery	1.514	1.514	17,620	98%	13.93	97%
Currier Park	0.850	0.85	8,072	97%	6.52	97%
Auditorium and Ice Rink	1.267	--	24,164	51%	8.66	33%
Barre Municipal Swimming Pool	0.864	--	4,335	51%	7.89	33%
Spaulding High School	1.500	--	6,632	51%	4.37	33%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were created for each site. See Appendix A12 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix A13 - 30% Designs.

A geotechnical analysis was carried out for four of the five sites: Elmwood Cemetery, Currier Park, the Barre Municipal Swimming Pool, and Spaulding High School. The fifth site, the Auditorium and Ice Rink, was not assessed as infiltration was not considered for the site.

Infiltration testing was completed for two of the sites: Elmwood Cemetery and Currier Park. Infiltration testing was not completed for the Barre Municipal Swimming Pool or Spaulding High School sites as soils investigations showed that soils were not favorable for infiltration.

Infiltration testing was completed using a falling head borehole test using a 2-inch diameter PVC pipe (Figure A14). The result of this testing is a soil infiltration rate (inches/hour), a measurement of the movement of water through soils.

Figure A14. An example of the Falling-Head Borehole Test in progress.

4.1 Elmwood Cemetery

4.1.1 30% Concept Design Description

Currently, drainage from the primarily residential drainage area including Camp St, Patterson St, Charles St, and sections of Hill St and Washington St drain west in a large stormwater pipe. The stormline continues to pick up additional residential and increasingly commercial drainage until it outfalls to Stevens Branch via Prospect St. This stormwater is currently unmanaged.

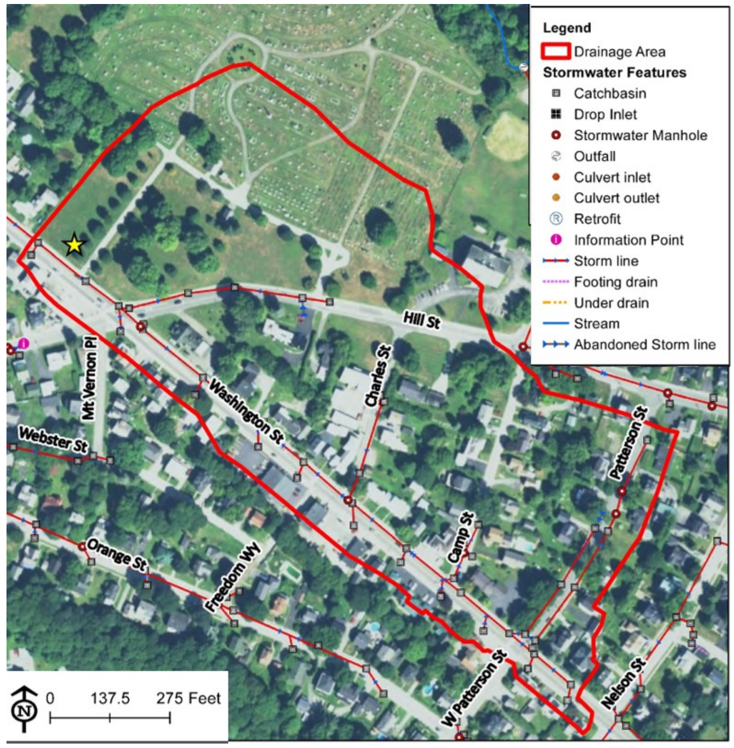

Figure A15. The proposed BMP drainage area is shown in red for Elmwood Cemetery. The recommended BMP location is shown with a star.

The proposed retrofit for this site is a series of subsurface infiltration chambers under the grass entryway to Elmwood Cemetery along Washington St (see starred location in Figure A15). The 23.1-acre drainage area for the proposed BMP is shown with a thick red line in the map to the right. The stormline will be intercepted near the starred location on Washington Street and directed to the chamber system. These open-bottomed chambers allow stormwater to percolate into the soil.

Soils are mapped as being good at this site (Hydrologic Group B), so soils and infiltration testing was conducted to evaluate the potential for an infiltration practice. To complete infiltration testing, a 3.25-inch diameter hole was created using a hand auger (Figure A16). A 2-inch diameter PVC pipe was installed in the augered hole, 41.8 ounces of water was poured into the pipe, and water drop (in inches) was monitored at 10-minute increments. The infiltration rate was measured as 14.76 inches/hour; this is a high infiltration rate. Figure A14 shows the test in progress at the cemetery site.

Figure A16. CVRPC staff assisting with soils testing in the grassy area along Washington Street where the proposed infiltration practice would be located.

Soils were found to be a mix of silt and sand (Figure A17). No evidence of groundwater or seasonal high water table was found. The soil profile with photos and a log of the infiltration testing can be found in Appendix A15.

Once the practice has been installed, the lawn area can be reseeded. There should not be any notable impact either aesthetically or functionally for the area once the new grass has been established.

Figure A17. Soils at Elmwood Cemetery were generally a mix of sand and silt.

The design standard used for this retrofit was full infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 65,950 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent 17,620 lbs of total suspended solids (TSS) and 13.93 lbs of total phosphorus (TP) from entering receiving waters (Table A7). This project will provide a significant benefit to water quality. Additionally, the stormwater line that runs down Washington St can be overwhelmed in high flows, and this project can help to alleviate some of the high-flow related issues.

Table A7. Elmwood Cemetery benefit summary table.

TSS Removed	17,620 lbs
TP Removed	13.93 lbs
Impervious Treated	9.68 acres
Total Drainage Area	23.1 acres

4.1.3 Cost Estimates

The total estimated cost for this project is $162,000. These preliminary costs can be found in Table A8. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $11,628.
- The cost per impervious acre treated is $16,736.
- The cost per cubic foot of runoff treated is $2.46.

Table A8. Elmwood Cemetery project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	400	$1.17	$468.00
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
649.51	Geotextile for silt fence	SY	175	$4.13	$722.75
652.20	Monitoring EPSC Plan	HR	12	$37.22	$446.64
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$4,357.39
Chambers - Costs					
	MC4500	EACH	105	$483.00	$50,715.00
	MC4500 PLAIN END CAP	EACH	6	$494.50	$2,967.00
	MC4500 24B END CAP	EACH	1	$682.81	$682.81
	MC4500 18T END CAP	EACH	5	$682.81	$3,414.06
	18" TEE	EACH	4	$230.01	$920.05
	18" 90 BEND	EACH	1	$144.80	$144.80
	18" COUPLERS	EACH	14	$23.54	$329.57
	18" N12 FOR MANIFOLD (AASHTO)	LF	80	$15.28	$1,222.68
	24" N12 for Isolator Row (AASHTO)	LF	20	$23.06	$461.15
	601TG to wrap system (SY)	SY	2000	$0.67	$1,334.00
	315WTM for scour protection (SY)	SY	500	$0.69	$345.00
	6" INSERTA TEE	EACH	1	$86.32	$86.32
	6" RED HOLE SAW	EACH	1	$132.43	$132.43
	12" INLINE DRAIN	EACH	1	$310.50	$310.50
				Subtotal:	$63,065.37
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	2	$3,387.59	$6,775.18
203.15	Common Excavation	CY	1100	$9.86	$10,846.00
629.54	Crushed Stone Bedding	TON	905	$34.04	$30,806.20
651.15	Seed	LBS	15	$7.66	$114.90
651.35	Topsoil	CY	140	$30.96	$4,334.40
653.20	Temporary Erosion Matting	SY	835	$2.20	$1,837.00
601.0915	18" CPEP	LF	30	$64.04	$1,921.20
				Subtotal:	$56,634.88
Subtotal:					$124,057.64
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$12,405.76
	Incidentals to Construction - 5%**				$6,202.88

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Minor Additional Design Items - 5%**				$6,202.88
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$162,000.00**

4.1.4 Next Steps

As this site is owned and operated by Barre City, it is recommended that the City proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely infiltrated and that larger storms bypass the system safely.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A14 - Permit Review Sheets. In summary:

Stormwater Permit
This site will likely need a stormwater permit under the proposed 3-acre impervious cover rule. The Elmwood Cemetery parcel contains 3.5 acres of impervious cover.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.2 Currier Park

4.2.1 30% Concept Design Description

Stormlines that run along Currier Park currently collect stormwater runoff from residential, commercial, and City roads, and discharge this unmanaged stormwater to a tributary of Stevens Branch between Averill St and Eastern Ave. Drainage is collected from Terrace Ave, Mount St, Academy St, North St, Andrews Court, and parts of Highland Ave, East St, and Park St.

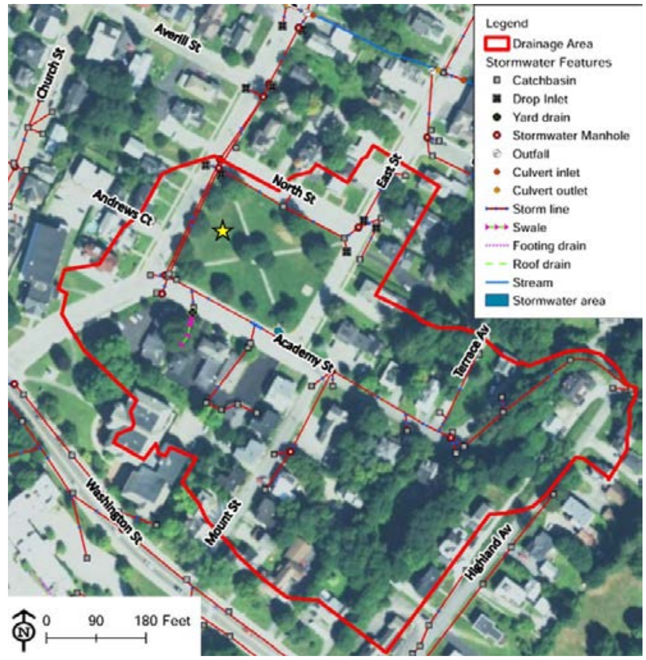

Figure A18. The drainage area for the proposed BMP is shown in red. The recommended location for the subsurface infiltration chambers is shown with a star.

The main concept for this site is to redirect these stormlines to a series of subsurface infiltration chambers under the grassed area of the park (see starred location on the map in Figure A18). Overflow from this system would continue to the existing stormline on Park St. Currier Park itself also has two small rain gardens located on the northwest and southeast corners of the park. These small gardens do not function as designed, and much of the stormwater that is meant to be directed to these areas bypasses them. It is recommended that these rain gardens be made functional such as is depicted in Appendix A-16 – Site Rendering.

Figure A20. A hand auger was used to assess soil conditions and infiltration potential at Currier Park.

Soils are mapped as being good at this site (Hydrologic Group B), so soils and infiltration testing was conducted to evaluate the potential for an infiltration practice. To complete infiltration testing, a 3.25-inch diameter hole was created using a hand auger (Figure A20) to conduct a falling head infiltration test. A 2-inch diameter PVC pipe was installed in the augered hole, 41.8 ounces of water was poured into the pipe, and water drop (in inches) was monitored at 10-minute increments. The infiltration rate was measured as 3.96 inches/hour; this is a moderate infiltration rate. Figure A14 shows an example of this test in progress.

Figure A19. Soils were generally silty.

Soils were found to be generally silty (Figure A19). No evidence of groundwater or seasonal high water table was found. The soil profile with photos and a log of the infiltration testing can be found in Appendix A15.

The design standard used for this retrofit was infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 37,026 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 8,000 lbs of total suspended solids (TSS) and 6.52 lbs of total phosphorus (TP) from entering receiving waters (Table A9). The retrofits also have the potential to raise awareness of stormwater issues in the City as the proposed location for the practice has high visibility. It is recommended that an educational sign be installed in conjunction with the retrofits.

Table A9. Currier Park benefit summary table.

TSS Removed	8,072 lbs
TP Removed	6.52 lbs
Impervious Treated	5.85 acres
Total Drainage Area	11.4 acres

4.2.3 Cost Estimates

The total estimated cost for this project is $192,000. Note that these costs are very preliminary. Cost projections can be found in Table A10. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $29,467.
- The cost per impervious acre treated is $32,821.
- The cost per cubic foot of runoff treated is $5.19.

Table A10. Currier Park project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	750	$1.17	$877.50
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
649.51	Geotextile for silt fence	SY	150	$4.13	$619.50
652.20	Monitoring EPSC Plan	HR	12	$37.22	$446.64
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$4,663.64
Chambers - Costs					
	MC4500	EACH	125	$483.00	$60,375.00
	MC4500 PLAIN END CAP	EACH	7	$494.50	$3,461.50
	MC4500 24B END CAP	EACH	1	$682.81	$682.81
	MC4500 18T END CAP	EACH	6	$682.81	$4,096.88
	18" TEE	EACH	5	$230.01	$1,150.06
	18" 90 BEND	EACH	1	$144.80	$144.80
	18" COUPLERS	EACH	17	$23.54	$400.19
	18" N12 FOR MANIFOLD (AASHTO)	LF	100	$15.28	$1,528.35
	24" N12 for Isolator Row (AASHTO)	LF	20	$23.06	$461.15
	601TG to wrap system (SY)	SY	2500	$0.67	$1,667.50
	315WTM for scour protection (SY)	SY	500	$0.69	$345.00
	6" INSERTA TEE	EACH	1	$86.32	$86.32
	6" RED HOLE SAW	EACH	1	$132.43	$132.43
	12" INLINE DRAIN	EACH	1	$310.50	$310.50
				Subtotal:	$74,842.48
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	2	$3,387.59	$6,775.18
203.15	Common Excavation	CY	1325	$9.86	$13,064.50
629.54	Crushed Stone Bedding	TON	1080	$34.04	$36,763.20
651.15	Seed	LBS	25	$7.66	$191.50
651.35	Topsoil	CY	185	$30.96	$5,727.60
653.20	Temporary Erosion Matting	SY	1200	$2.20	$2,640.00
601.0915	18" CPEP	LF	75	$64.04	$4,803.00
				Subtotal:	$69,964.98
Subtotal:					$149,471.10
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$14,947.11
	Incidentals to Construction - 5%**				$7,473.56

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Minor Additional Design Items - 5%**				$7,473.56
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$192,000.00**

4.2.4 Next Steps

As this site is owned and operated by Barre City, it is recommended that the City proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely infiltrated and that larger storms bypass the system safely.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A14 - Permit Review Sheets. In summary:

Stormwater Permit
It is not anticipated that this site will need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.2.6 Site Rendering

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This graphically engaging rendering visually communicates the plans and can be used by the City and the CVRPC to help advance designs toward implementation. This depiction of the site includes the retrofit of the existing rain gardens at the park. This rendering can be found in Appendix A16 - Site Rendering.

4.3 Auditorium and Ice Rink

4.3.1 30% Concept Design Description

The 27.4-acre drainage area for this site includes the Barre City Auditorium, Barre Civic Center, and B.O.R. Ice Arena. It also includes several residential areas including Maplewood Ave, Burns St, half of Johnson St, and parts of Sheridan St and Merchant St. Stormwater is currently collected in a series of stormlines that outlet to Gunners Brook on Seminary St, west of the auditorium parcel. Currently there is no management for this area.

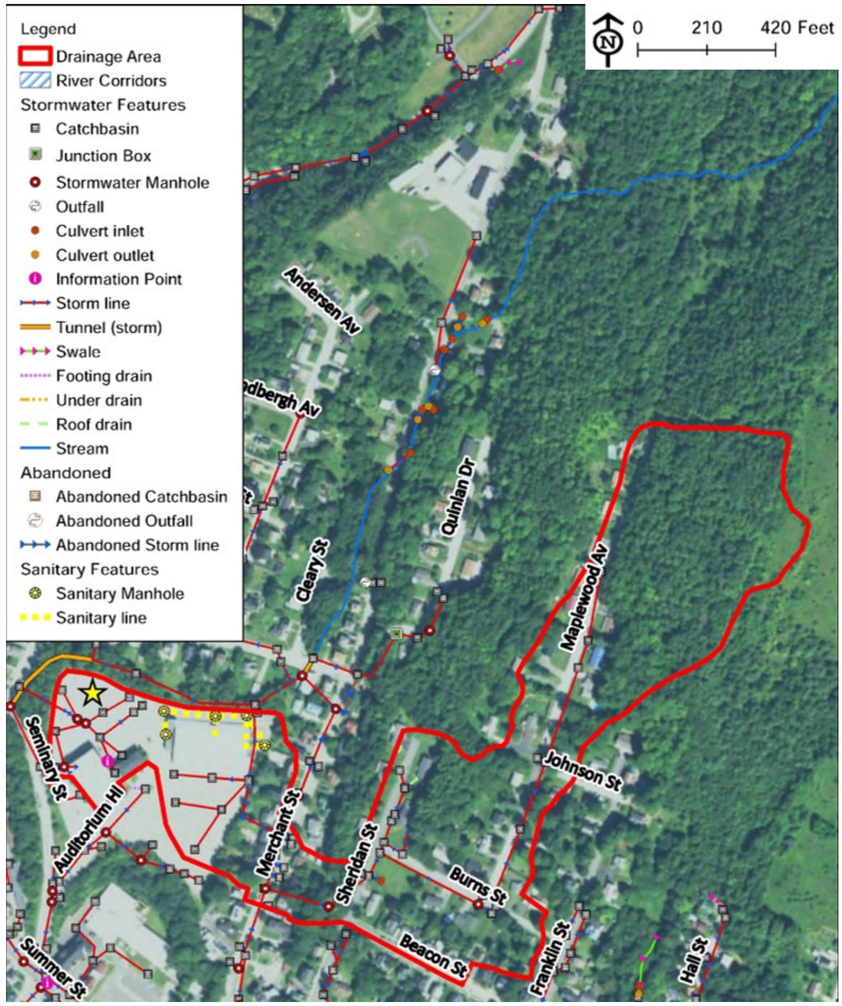

Figure A21. The Auditorium and Ice Rink drainage area includes both residential and commercial areas. The recommended location for the proposed subsurface sand filter is shown with a star.

A subsurface sand filter is recommended to manage the stormwater from the large drainage area. These subsurface chambers would be located in the northwest corner of the auditorium's parking lot (see starred location in Figure A21). Once the chambers are installed and the parking lot is repaved, it can still be used for parking and other normal operations at the site. The stormwater improvements would require rerouting the stormline behind the ice rink and the stormline draining the auditorium and civic center to this filter system.

If future site use changes and the need for the large parking lot at the site decreases, a portion of the parking lot could be removed to implement a surface feature such as a gravel wetland in the same location. This option would likely require a lower cost investment.

Although soils are mapped as having good infiltration potential at this site (Hydrologic Group B), pursuing an infiltration practice was not an option due to topography and potential contamination of underlying soils. As such, soils and infiltration testing were not completed at this site.

The drainage area for this proposed BMP is 27.4 acres, approximately 36.5% of which is classified as impervious. This practice will provide a significant water quality benefit (see Table A11), and is located in a highly visible location in the City. It is recommended that an educational sign be added to the site after construction, perhaps near the entrance to the auditorium. The design standard used for this retrofit was detention and slow release of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 55,190 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 24,000 lbs of total suspended solids (TSS) and 8.7 lbs of total phosphorus (TP) from entering receiving waters annually (Table A11).

Table A11. Auditorium and Ice Rink benefit summary table.

TSS Removed	24,164 lbs
TP Removed	8.66 lbs
Impervious Treated	10 acres
Total Drainage Area	27.4 acres

4.3.3 Cost Estimates

The estimated cost for implementation of this project is $536,000. Note that these costs are very preliminary. Cost projections can be found in Table A12. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $61,914.
- The cost per impervious acre treated is $53,815.
- The cost per cubic foot of runoff treated is $9.71.

Table A12. Auditorium and Ice Rink project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	500	$1.17	$585.00
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
653.20	Temporary Erosion Matting	SY	1500	$2.20	$3,300.00
649.51	Geotextile for silt fence	SY	145	$4.13	$598.85
652.20	Monitoring EPSC Plan	HR	12	$37.22	$446.64
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$7,650.49
Chambers - Costs					
	MC4500	EACH	333	$483.00	$160,839.00
	MC4500 PLAIN END CAP	EACH	19	$494.50	$9,395.50
	MC4500 24B END CAP	EACH	1	$682.81	$682.81
	MC4500 18T END CAP	EACH	6	$682.81	$4,096.88
	18" TEE	EACH	4	$230.01	$920.05
	18" 90 BEND	EACH	2	$144.80	$289.59
	18" COUPLERS	EACH	16	$23.54	$376.65
	18" N12 FOR MANIFOLD (AASHTO)	LF	80	$15.28	$1,222.68
	24" N12 for Isolator Row (AASHTO)	LF	20	$23.06	$461.15
	601TG to wrap system (SY)	SY	4500	$0.67	$3,001.50
	315WTM for scour protection (SY)	SY	500	$0.69	$345.00
	6" INSERTA TEE	EACH	1	$86.32	$86.32
	6" RED HOLE SAW	EACH	1	$132.43	$132.43
	12" INLINE DRAIN	EACH	1	$310.50	$310.50
				Subtotal:	$182,160.06
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	2	$3,387.59	$6,775.18
203.15	Common Excavation	CY	4070	$9.86	$40,130.20
629.54	Crushed Stone Bedding	TON	2650	$34.04	$90,206.00
301.15	Subbase of Gravel	CY	900	$25.88	$23,292.00
301.26	Subbase of Crushed Gravel, Fine Graded	CY	735	$40.01	$29,407.35
605.11	8 Inch Underdrain Pipe	LF	1400	$27.04	$37,856.00
601.0915	18" CPEP	LF	410	$64.04	$26,256.40
				Subtotal:	$253,923.13
Subtotal:					$443,733.68
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$44,373.37

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Incidentals to Construction - 5%**				$22,186.68
	Minor Additional Design Items - 5%**				$22,186.68
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$536,000.00**

4.3.4 Next Steps

As this site is owned and operated by Barre City, it is recommended that the City proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the CPv can be completely filtered and slowly released, and that larger storms bypass the system safely.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix N - Permit Review Sheets. In summary:

Stormwater Permit
This Auditorium and Ice Rink parcel will likely need a stormwater permit under the proposed 3-acre impervious cover rule as it contains 7 acres of impervious cover and does not have a current stormwater permit.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250, Wetlands, or River Corridor permitting is anticipated for this project.

4.4 Barre Municipal Swimming Pool

4.4.1 30% Concept Design Description

This site includes stormwater runoff from the Barre City Elementary and Middle School, a portion of Parkside Terrace, and Rotary Park's parking lot. This stormwater is collected in a series of stormlines located throughout the area. It currently outlets directly to the Stevens Branch to the east of the park. There is no existing water quality management for this stormwater.

The concept for this site includes intercepting and redirecting the Channel Protection volume (CPv) from the stormline between the basketball courts and playground. This stormwater would be directed to a subsurface sand filter system to be located under the recreational complex parking lot (see starred location in Figure A22). The feature would outlet back to the parking lot's existing stormline.

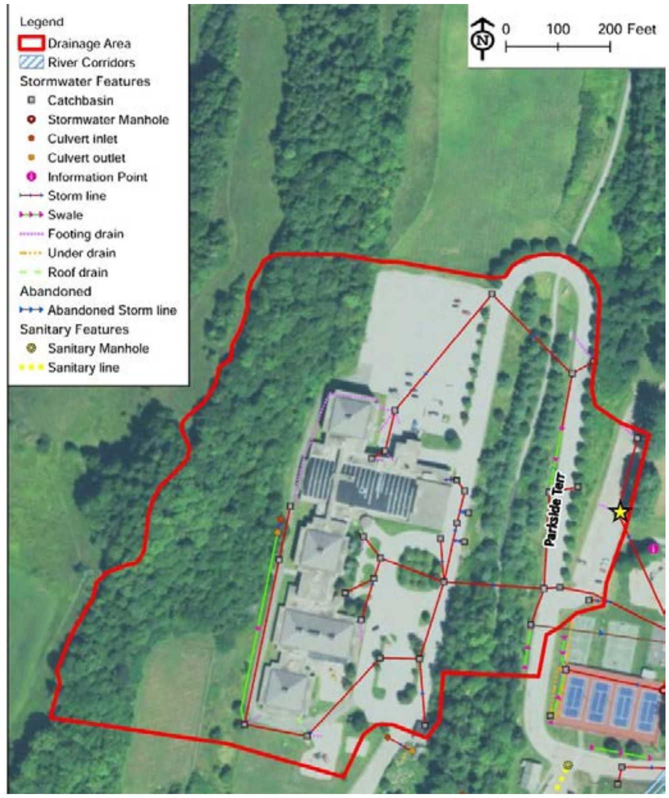

Figure A22. The proposed subsurface sand filter would be located under the parking lot for the recreational park (see starred location). The area that would drain to this practice is shown with a thick red outline.

Soils are mapped as having good infiltration potential (Hydrologic Group B) at the proposed BMP location. As such, soils were investigated to evaluate the potential for an infiltration practice. First, soils were assessed near the starred location in Figure A22. However, soils were found to be very silty and groundwater was encountered. A second location was also assessed to the north of the parking lot to ensure that conditions were not more favorable for infiltration in another area of the park. Unfortunately, soils on site were found to be silty throughout (Figure A23), and groundwater was encountered in the second location as well. As such, no infiltration testing was pursued as this site was not conducive to an infiltration-based practice. The complete soil profile can be found in Appendix A15.

The drainage area for this proposed BMP is 17.3 acres, approximately 45% of which is classified as impervious. This practice will provide a significant water quality benefit (Table A13), but is also a high visibility site within the City. As such, this practice could spur additional retrofits and awareness of stormwater issues in the area. It is recommended that an educational sign be installed in conjunction with the retrofit. The design standard used for this retrofit was filtration and slow release of the CPv (or 2.02 inches of rain in a 24-hour period), equal to 37,636 ft^3 of runoff.

Figure A23. Soils at the Barre Municipal Swimming Pool site were general silty

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 4,335 lbs of total suspended solids (TSS) and 7.89 lbs of total phosphorus (TP) from entering receiving waters annually (Table A13).

Table A13. Barre Municipal Swimming Pool benefit summary table.

TSS Removed	4,335 lbs
TP Removed	7.89 lbs
Impervious Treated	7.8 acres
Total Drainage Area	17.3 acres

4.4.3 Cost Estimates

The estimated cost for implementation of this project is $467,000. Note that these costs are very preliminary. Cost projections can be found in Table A14. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $59,181.
- The cost per impervious acre treated is $60,180.
- The cost per cubic foot of runoff treated is $12.41.

Table A14. Barre Municipal Swimming Pool project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	500	$1.17	$585.00
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
649.51	Geotextile for silt fence	SY	225	$4.13	$929.25
652.20	Monitoring EPSC Plan	HR	12	$37.22	$446.64
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$4,680.89
Chambers - Costs					
	SC740	EACH	453	$224.40	$101,653.20
	SC740 Plain End Cap	EACH	32	$46.20	$1,478.40
	SC740 24B End Cap	EACH	2	$325.11	$650.21
	12" Tee	EACH	14	$104.93	$1,469.01
	12" 90 Bend	EACH	2	$54.62	$109.23
	12" Couplers	EACH	46	$7.93	$364.83
	12" N12 for splicing as needed (AASHTO)	LF	100	$7.58	$757.90
	24" N12 for Isolator Row (AASHTO)	LF	20	$22.06	$441.10
	601TG to wrap system (SY)	SY	5500	$0.64	$3,509.00
	315WTM for scour protection (SY)	SY	1500	$0.66	$990.00
	Inline Drain for Inspection Port	EACH	2	$297.00	$594.00
	Inserta Tee for Inspection Port	EACH	2	$82.57	$165.13
	6" Hole Saw	EACH	1	$126.68	$126.68
				Subtotal:	$112,308.68
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	1	$3,387.59	$3,387.59
203.15	Common Excavation	CY	3118	$9.86	$30,743.48
629.54	Crushed Stone Bedding	TON	3105	$34.04	$105,694.20
301.26	Subbase of Crushed Gravel, Fine Graded	CY	977	$40.01	$39,089.77
605.11	8 Inch Underdrain Pipe	LF	2000	$27.04	$54,080.00
N/A	30 Mil PVC Liner	SY	2000	$5.68	$11,360.00
651.15	Seed	LBS	45	$7.66	$344.70
651.35	Topsoil	CY	410	$30.96	$12,693.60
653.20	Temporary Erosion Matting	SY	2000	$2.20	$4,400.00
				Subtotal:	$261,793.34
Subtotal:					$378,782.91
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$37,878.29

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Incidentals to Construction - 5%**				$18,939.15
	Minor Additional Design Items - 5%**				$18,939.15
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$467,000.00**

4.4.4 Next Steps

As this site is owned and operated by Barre City, it is recommended that the City proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely infiltrated and that larger storms bypass the system safely.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A14 - Permit Review Sheets. In summary:

Stormwater Permit
The recreational complex parcel has more than 3 acres of impervious cover. As such, it will likely need a stormwater permit under the proposed 3-acre impervious cover rule.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Wetlands, or River Corridor permitting is anticipated for this project. This project may require an amendment to the Act 250 permit held by Barre City Elementary and Middle School, but it is possible that this project will be classified as a non-material change to the permit as the permit (5W1160) has no stormwater requirements and this project includes non-permitted drainage.

4.5 Spaulding High School

4.5.1 30% Concept Design Description

Currently stormwater runoff from Spaulding High School and residential Ayers St outlet directly to receiving waters without any water quality improvements. The drainage area includes the school building, parking lots, Crimson Tide Way, and some of the athletic fields. The stormline that drains the school parcel outlets between the baseball field and the track, directly to the Jail Branch. The stormline that runs down Ayers St drains to the west, joins with other stormwater infrastructure, and outlets to Jail Branch slightly more northwest than the drainage for the school.

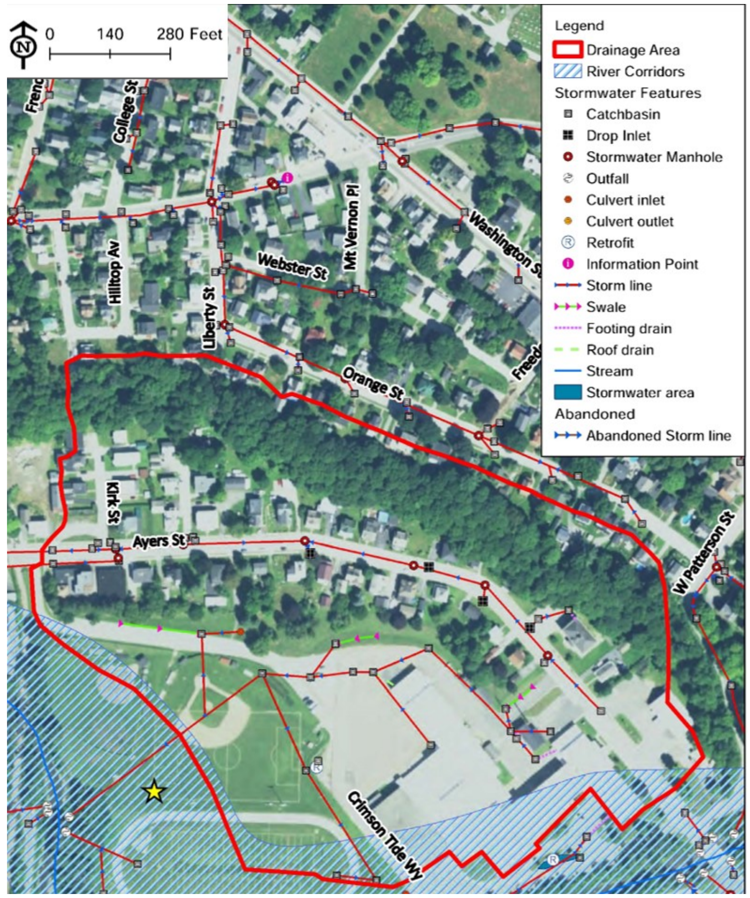

Figure A24. It is proposed that runoff from the residential and school property, shown in red, is directed to a subsurface sand filter.

The proposed stormwater improvements for this site include rerouting these drainages to a subsurface sand filter system to be located under the athletic fields (see starred location in Figure A24). Note that the location of the subsurface sand filter system could be moved to the east, outside of the river corridor. There are plans to renovate or redevelop the school site in the future, and these retrofits could be incorporated into that design.

Soils are mapped as having good infiltration potential (Hydrologic Group B). As such, soils were investigated to evaluate the potential for an infiltration practice. However, soils on site were found to be silty (Figure A25), and groundwater was encountered. As such, an infiltration-based practice was not pursued, and infiltration testing was not completed. The complete soil profile can be found in Appendix A15.

The drainage area for the proposed BMP is 29.2 acres, approximately 49% of which is classified as impervious. This practice will provide a significant water quality benefit (Table A15), but is also a high visibility site within the City. This practice could spur additional retrofits and awareness of stormwater issues in the area. It is recommended that an educational sign be installed in conjunction with the retrofit.

Figure A25. Soils were generally silty.

The design standard used for this retrofit was filtration and slow release of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 65,340 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix A11 - Top 5 Sites. A 30% design plan is provided in Appendix A13 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 6,632 lbs of total suspended solids (TSS) and 4.37 lbs of total phosphorus (TP) from entering receiving waters annually (Table A15).

Table A15. Spaulding High School benefit summary table.

TSS Removed	6,632 lbs
TP Removed	4.37 lbs
Impervious Treated	14.2 acres
Total Drainage Area	29.2 acres

4.5.3 Cost Estimates

The total estimated cost for this project is $808,000. Note that these costs are very preliminary. Cost projections can be found in Table A16. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $185,040.
- The cost per impervious acre treated is $56,982.
- The cost per cubic foot of runoff treated is $12.37.

Table A16. Spaulding High School project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	750	$1.17	$877.50
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
649.51	Geotextile for silt fence	SY	225	$4.13	$929.25
652.20	Monitoring EPSC Plan	HR	12	$37.22	$446.64
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$4,973.39
Chambers - Costs					
	SC740	EACH	832	$224.40	$186,700.80
	SC740 Plain End Cap	EACH	54	$46.20	$2,494.80
	SC740 24B End Cap	EACH	2	$325.11	$650.21
	12" Tee	EACH	12	$104.93	$1,259.15
	12" 90 Bend	EACH	2	$54.62	$109.23
	12" Couplers	EACH	40	$7.93	$317.24
	12" N12 for splicing as needed (AASHTO)	EACH	160	$7.58	$1,212.64
	24" N12 for Isolator Row (AASHTO)	LF	20	$22.06	$441.10
	601TG to wrap system (SY)	LF	8500	$0.64	$5,423.00
	315WTM for scour protection (SY)	SY	1500	$0.66	$990.00
	Inline Drain for Inspection Port	SY	2	$297.00	$594.00
	Inserta Tee for Inspection Port	EACH	2	$82.57	$165.13
	6" Hole Saw	EACH	1	$126.68	$126.68
				Subtotal:	$200,483.98
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	2	$3,387.59	$6,775.18
203.15	Common Excavation	CY	5420	$9.86	$53,441.20
629.54	Crushed Stone Bedding	TON	5382	$34.04	$183,203.28
301.26	Subbase of Crushed Gravel, Fine Graded	CY	1633	$40.01	$65,336.33
605.11	8 Inch Underdrain Pipe	LF	3500	$27.04	$94,640.00
N/A	30 Mil PVC Liner	SY	4100	$5.68	$23,288.00
651.15	Seed	LBS	72	$7.66	$551.52
651.35	Topsoil	CY	680	$30.96	$21,052.80
653.20	Temporary Erosion Matting	SY	4100	$2.20	$9,020.00
				Subtotal:	$457,308.31
Subtotal:					$662,765.68
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$66,276.57
	Incidentals to Construction - 5%**				$33,138.28

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Minor Additional Design Items - 5%**				$33,138.28
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$808,000.00**

4.5.4 Next Steps

As this site is owned and operated by Barre City, it is recommended that the City proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely filtered and that larger storms bypass the system safely.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix A14 - Permit Review Sheets. In summary:

Stormwater Permit
Spaulding High School will likely need a stormwater permit under the proposed 3-acre impervious cover rule. The parcel contains 9.7 acres of impervious cover and does not have a current stormwater permit.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a River Scientist prior to final design due to the project’s location in the river corridor. However, it should be noted that this project will not result in any net fill within the river corridor, and that the location of the subsurface sand filter system could be moved to the east, with at least the majority located outside of the river corridor. No Act 250 permitting or wetlands concerns are anticipated for this project, though there is an Act 250 permit within the project’s drainage area (5W1583 for reconstruction of an existing building into a respite care home).

B. Chapter 2: Barre Town

1 Background

1.1 Problem Definition

Barre Town is located in Washington County primarily within the Stevens Branch, Gunners Brook, and Jail Branch watersheds. These watersheds are tributaries of the Winooski River, which is located just north of the Town (Figure B1). The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development.

The Stevens Branch frequently overflows its banks and has flooded historically. As the river passes through the Town, it is subject to multiple constrictions, lack of riparian buffer, erosion, historic channelization, and aggradation. Two sections of the Stevens Branch are on the 2016 stressed waters list due to streambank erosion, channel instability, road runoff, elevated *E. coli*, and urban runoff.

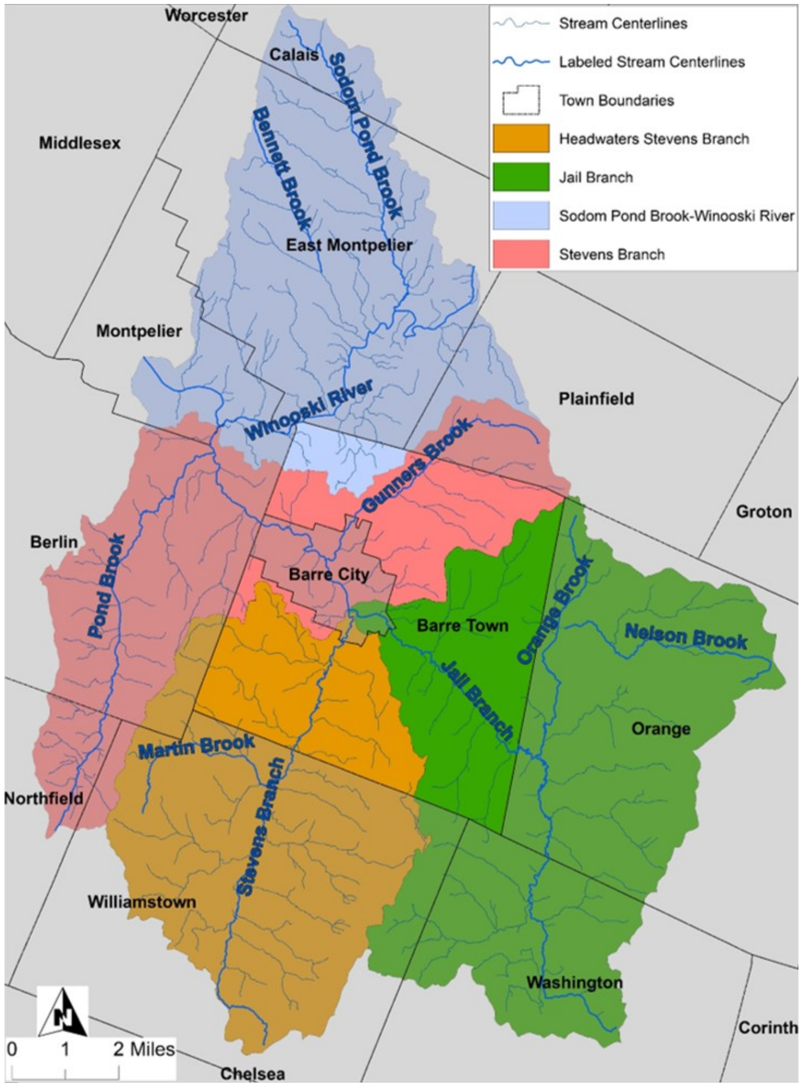

Figure B1. Barre Town is located within the Stevens Branch, Gunners Brook, and Jail Branch watersheds.

Jail Branch has been straightened historically and is currently constrained within the Town. It often lacks an adequate riparian buffer. These stressors have resulted in erosion and depositional areas as it flows through the Town as well as flooding. Two sections of the Jail Branch are on the 2016 stressed waters list due to land development, erosion and sedimentation, urban runoff, nutrients, and elevated *E. coli*.

The Sodom Pond Brook-Winooski River watershed drains directly to the Winooski River and is located in the northwestern corner of the Town. This area is minimally developed with few roads and residential properties. Although there are no stressed sections of the Sodom Pond Brook, this section of the Winooski River is on the 2016 stressed waters list due to streambank erosion, channel instability, road runoff, and elevated *E. coli*.

Barre Town has experienced increased development along Routes 63, 14, and 302, with expanding areas of impervious surfaces. Route 302 closely parallels Jail Branch, and Route 14 closely parallels Stevens Branch. Both of these areas have significant development falling in or close to the river corridors. This development has constrained the Stevens Branch particularly along its eastern bank, and the Jail Branch along both banks. In addition to expanding development along these corridors, Barre Town experiences significant erosion as a result of steep slopes and poor soils, further contributing to sediment and nutrient loading in surface waters.

The human-influenced stressors in the watersheds include commercial development and associated parking areas, construction of roads, residential development, and clearing of previously forested areas. Additionally, in part due to historic straightening of rivers in the area, associated incision of stream channels, and limited floodplain access, both nuisance flooding and more extreme flood events can and do occur. Unmanaged stormwater runoff, particularly from impervious surfaces and landscaped pervious areas, exacerbate flooding. The Winooski River watershed and its tributaries have experienced extreme flooding in the past, and these flood events are only expected to occur more frequently due to the predicted increased frequency and intensity of extreme weather events associated with climate change. These heavy rains and easily erodible soils have contributed to erosion issues throughout the area. The stormwater management practices investigated seek to protect local river resources as well as the larger Lake Champlain Basin, which currently has a Total Maximum Daily Load (TMDL) in place. The TMDL requires reductions in phosphorus loading to Lake Champlain via its tributaries though reductions in stormwater and agricultural runoff pollution.

1.2 Existing Conditions

The Town of Barre spans approximately 19,669 acres in Washington County, VT and is primarily forested (55%), though nearly 13% of the Town is classified as urban (Figure B2). Of that area, there are 1,013 acres (5%) of impervious cover. Barre Town is located to the east of Berlin, southeast of East Montpelier, and is located around the border of Barre City (Figure B2). The Town of Barre is more developed to the south of Barre City, particularly along Route 14. Development is less concentrated and more residential to the northeast.

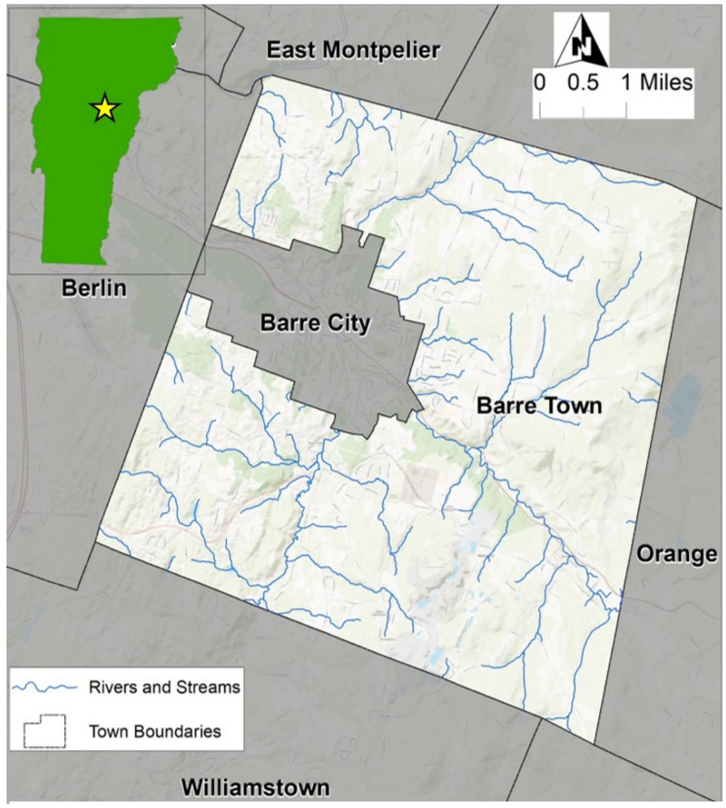

Figure B2. The Town of Barre is located in Washington County, VT.

Many of the older developments within the Town were constructed before current stormwater standards were developed, and they were constructed without any or with only minimal stormwater management. This has resulted in significant amounts of untreated stormwater draining from large portions of developed lands discharging directly to surface waters.

Surrounding the developed lands, areas are more residential and rural. The area contains roads that are generally unpaved with open roadside ditches. Many of these roads have steep slopes and traverse large areas. This predisposes these areas to erosion and sediment transport.

One area within Barre Town was excluded from this stormwater master plan (SWMP) as a separate plan has already been developed for these drainages (Figure B3). This plan is included in Appendix B17.

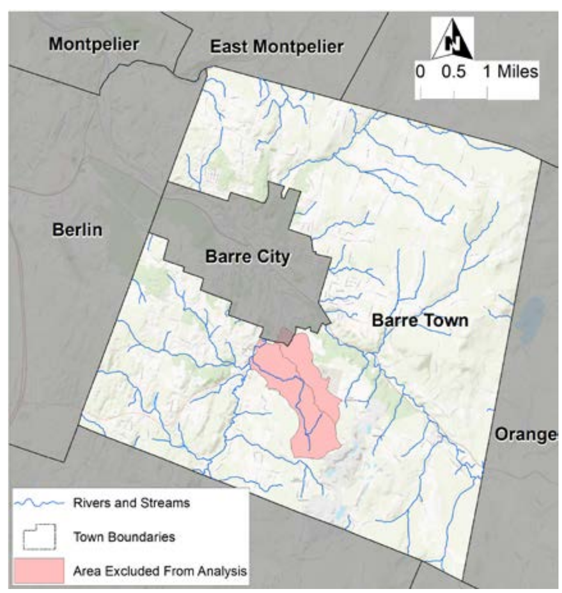

Figure B3. The Quarry Hill / Sterling Hill drainage areas were excluded from analysis as a separate SWMP has already been completed for this area.

Soils analyses indicate that of the 19,669 total acres in the Town, 92.5% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the Town, the majority of areas belong to either Hydrologic Soil Group C (47%) or D (42%), while only 3% are in group A, and 4% are in group B. The remainder is not classified or comprised of water. This combination of steep slopes with limited infiltration capacity and a highly-erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed conditions can be found in Appendix B1 – Map Atlas. Maps include:

- river corridors and wetlands including wetlands advisory layer and hydric soils,
- soil infiltration potential,
- soil erodibility,
- slope,
- stormwater infrastructure and stormwater permits,
- land cover,
- impervious cover,
- and parcel boundaries including parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this SWMP study. These reports include the Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2017). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix B2 – Data Review.

The project team met with the Town of Barre stakeholders and the Central Vermont Regional Planning Commission (CVRPC) on March 28th, 2017 to discuss the SWMP and solicit information on problem areas from the Town. Following this meeting, a list of potentially important sites was provided to the project team by the Town. This list included particular parcels, as well as general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 *Desktop Assessment*

A desktop assessment was completed to identify additional potential sites for stormwater best management practice (BMP) implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. The Town of Barre opted to include these private sites with ≥3 acres of impervious cover in the plan despite the upcoming regulations for these areas as they are important sources of stormwater in the Town. A point location was created for each identified site or area for assessment in the field.

A 'green streets' assessment was also conducted to identify any road segments in the Town potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the "Promoting Green Streets" report published by the River Network (July 2016; included as Appendix B3).

The methodology was modified to better fit specific conditions found in the study area. The analysis utilized two prerequisites and one secondary consideration.
Prerequisites:

3. Road Slope
    - 1-5% Slope = Ideal (Score: 2 points)
    - 5-7.5% Slope = Potential (Score: 1 point)
    - > 7.5% Slope = Unsuitable (Score: 0 points; discarded from further analysis)
4. Road Right-of-Way Width
    - ≥ 50 ft = Ideal (Score: 2 points)
    - 46-50 ft = Potential (Score: 1 point)
    - < 46 ft = Unsuitable (Score: 0 points; discarded from further analysis)

Secondary Consideration:

2. Hydrologic Soil Group (indication of infiltration potential)
    - A/B (highest infiltration potential) = Ideal (Score: 2 points)
    - B/C (moderate infiltration potential) = Potential (Score: 1 point)
    - C/D (lowest infiltration potential) = Unsuitable (Score: 0 points; **not** discarded from further analysis)

The scores from each of the three criteria were added, and a score was assigned for each road segment where higher scores indicated a greater potential for GSI suitability. In total, 7 sites with potential were noted for assessment in the field (Figure B4). These sites included Kings Row, Morin Rd, Deerfield Ave, two sections of South Barre Rd, and two sections of Snowbridge Rd.

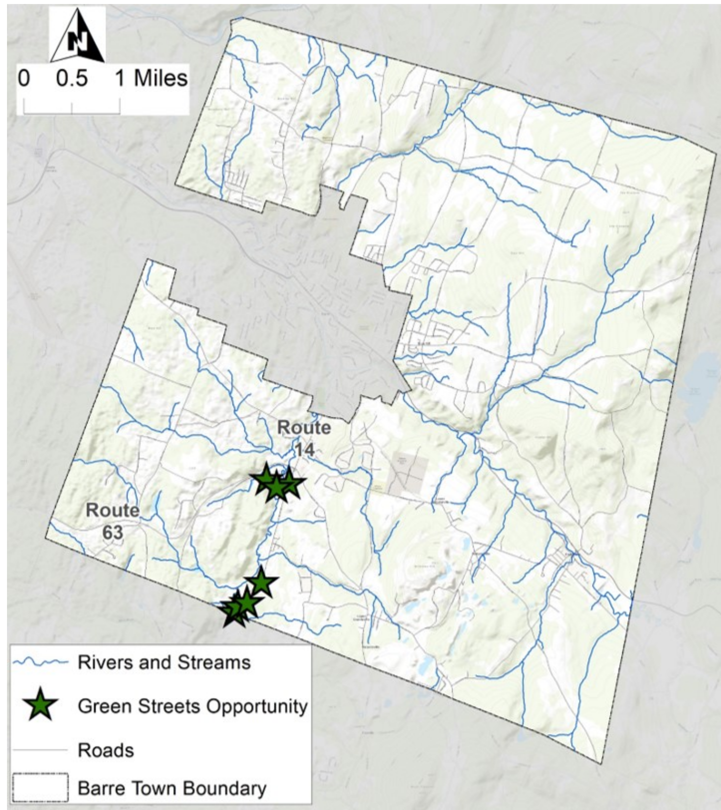

Figure B4. The 7 locations identified as potential green streets opportunities are shown with green stars.

A total of 68 locations, including the Green Streets sites, were identified for stormwater retrofit potential

2.1.2.2 Basemap and Mobile App Creation

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the Town. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 68 point locations for the potential BMP sites, which included Town problem areas, general Town-wide sites, and green streets locations. These points allowed for easy site location and data collection in the field (Figure B5).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data. All collected data was securely uploaded to the Cloud for later use.

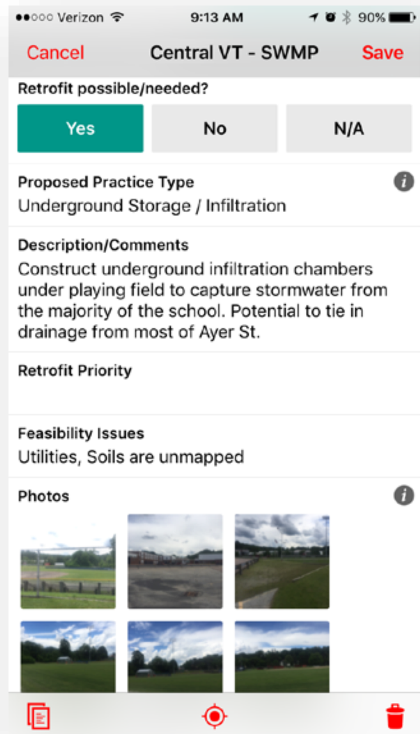

Figure B5. Example screen from data collection app.

2.1.3 Field Data Collection:

Each of the 68 previously identified potential BMP locations were evaluated in the field during the Summer and Fall of 2017 (Figure B6). Data was collected for each site in the mobile app. A large map of these sites with associated site names and a list of these sites including potential BMP options and site notes can be found in Appendix B4 - Initial Site Identification.

Through the course of these field visits, 12 additional stormwater retrofit sites were identified that had not been included in the initial desktop assessment. Conversely, some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific site conditions. A total of 5 sites were removed from this plan due to prohibitive site conditions.

Following these refinements, the list of potential BMPs in the Town of Barre grew to 75 (Figure B7). A memo detailing this site refinement and associated maps and tables are included as Appendix B5 - Site Refinements.

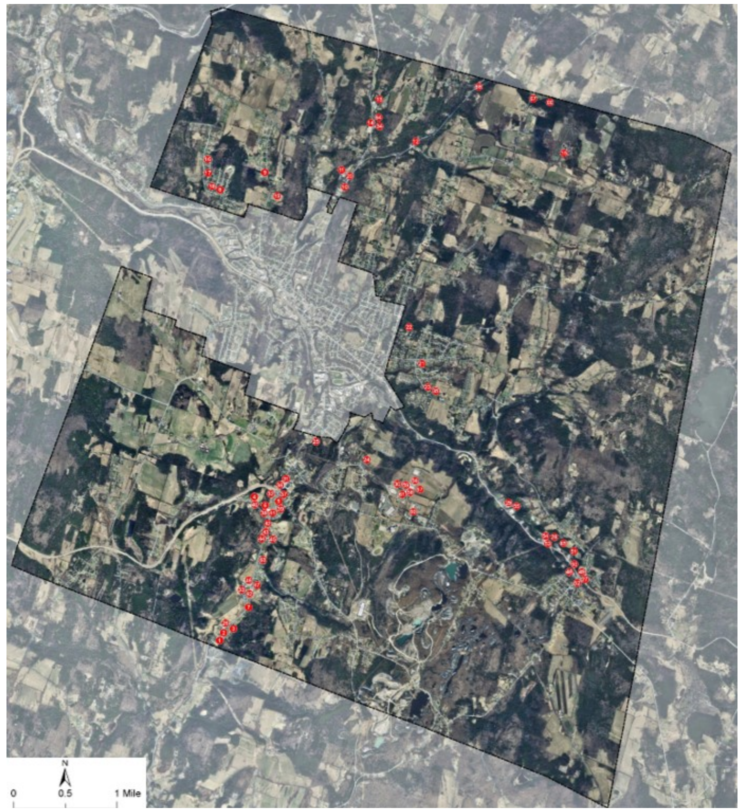

Figure B6. 68 potential sites for BMP implementation were identified for field investigation.

2.2 Preliminary BMP Ranking

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 75 projects (Figure B7). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit, and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix B6 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix B6 is the completed ranking for each potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

The draft Top 20 list was distributed to the Town of Barre and the CVRPC. As part of this process, the project team met with the stakeholders on August 10th, 2017 to discuss the proposed Top 20 project sites. Following feedback from the Town, the list was refined to reflect the Town's knowledge of potentially unwilling landowners and the Town's priorities. Note that one additional site, New Life Assembly Church, was added to the list of Top 20 per the Town's request. A revised list was submitted, and these sites were presented to the Selectboard on September 19th, 2017. Any questions regarding the SWMP itself and specific proposed BMPs were addressed at the Town's Selectboard meeting on October 3rd, 2017. At this time, the Selectboard voted to approve the Top 20 projects. These Top 20 sites are listed in Table B1. As expected, the location of these projects follows development patterns in the Town. Point locations within the Town are shown in Figure B8.

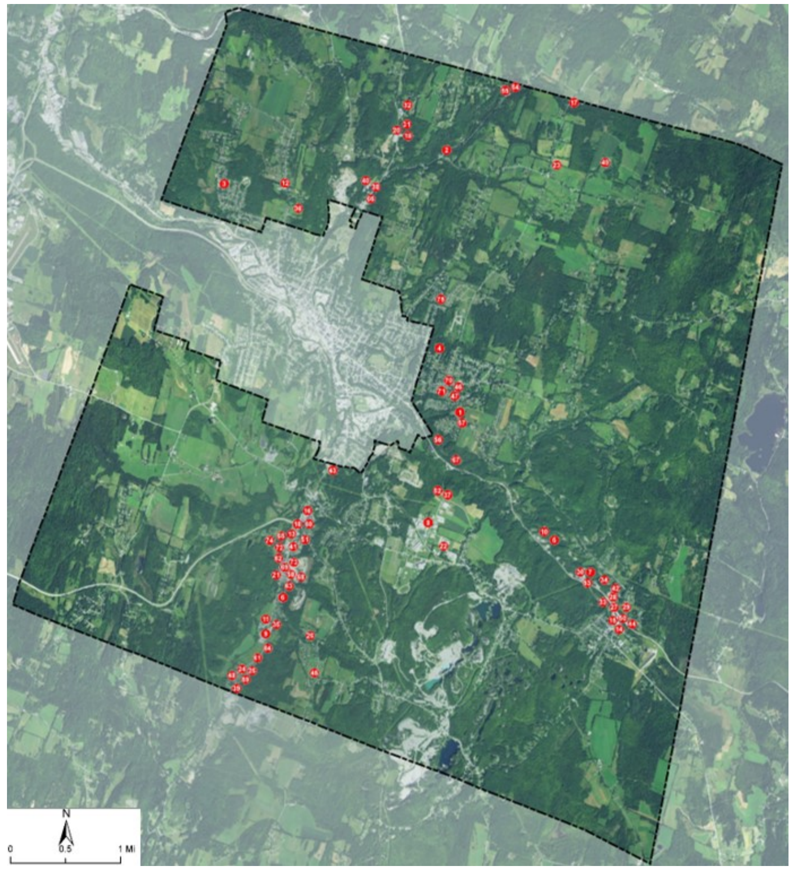

Figure B7. Following field investigations, the list of potential BMP sites grew to 75. Point locations are shown for each site.

Table B1. Top 20 BMPs selected for the Barre Town SWMP.

Site ID	Proposed Practice Type
Smokehouse Lane Infiltration	Subsurface infiltration chambers
Industrial Park Retrofit	Pond expansion, and gully stabilization
Wilkins Harley-Davidson	Subsurface infiltration chambers
New Life Assembly Church	Gravel Wetland
Neddo Family Vineyards	Gravel wetland, site stabilization
Barre Town Park and Ride	Subsurface infiltration chambers
S Barre Rd Field	Infiltration Basin
Trio and Cubesmart Storage	Infiltration Basin
S Barre Rd and Leo Ave	Infiltration Trench
Green Mountain Diesel	Infiltration Trench
796 S Barre Rd	Subsurface infiltration chambers
E Barre Fire Station Parking	Bioretention
Dianne Lane	Swale detention, gully stabilization
Green St	Residential GSI, Sand Filter
W Cobble Hill Rd Multifamily	Subsurface Sand Filter, Roadside GSI
Canadian Club	Subsurface Sand Filter, Swale Detention, Impervious Cover Reduction
E Barre Rd Park and Ride	Subsurface sand filter
E Barre Rd Commercial	Filter Strip, Buffer Enhancement
Barre Tile	Filter Strip, Impervious Cover Reduction
VFW	Filter Strip, Stormwater Planters

2.3 Modeling and Concept Refinement for Top 20 BMPs

Modeling was completed for each of the Top 20 sites. This modeling allowed for accurate sizing of the proposed practices, as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and landuse/landcover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations (see Appendix B7 – Top 20 Sites for drainage area delineations). Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix B8 - Top 20 Sites Modeling for modeling reports).

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site's current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table B2. Complete modeling results are provided in Appendix B8 - Top 20 Sites Modeling.

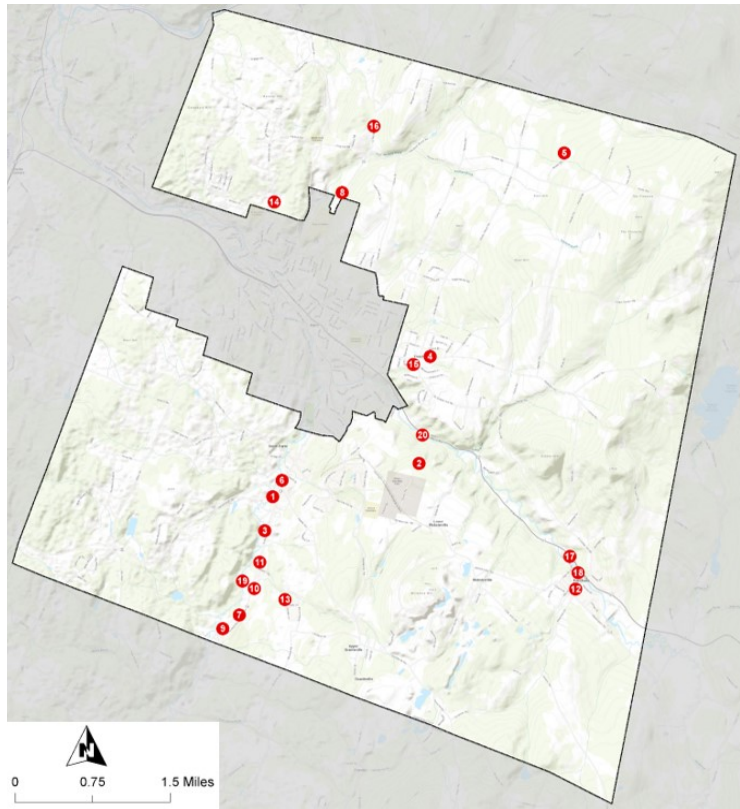

Figure B8. The Top 20 project locations are shown.

Table B2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Smokehouse Lane Infiltration	0.884	0.884	15,426	82.42%	12.23	79.52%
Industrial Park Retrofit	1.084	--	4,020,419	79% (Detention Pond); 50% (Gully Stabilization)	44.86	0% (Swale Detention); 49.9% (Gully Stabilization)
Wilkins Harley-Davidson	0.616	0.616	9,379	99.63%	16.38	99.55%
New Life Assembly Church	0.317	--	11,793	96%	7.06	58%
Neddo Family Vineyards	0.198	--	679	51%	0.78	33%
Barre Town Park and Ride	0.775	0.775	12,708	99.05%	4.59	98.51%
S Barre Rd Field	0.876	0.876	11,333	93.07%	7.18	93.24%
Trio and Cubesmart Storage	0.856	0.856	8,537	100%	4.76	100%
S Barre Rd and Leo Ave	0.25	0.25	4,481	61.86%	2.89	63.66%
Green Mountain Diesel	0.251	0.251	4,597	98.91%	1.25	98.84%
796 S Barre Rd	0.244	0.244	2,259	99.36%	2.01	99.36%
E Barre Fire Station Parking	0.032	--	612	60.32%	0.20	59.92%
Dianne Lane	0.208	--	406,178	79% (Swale Detention); 88.9% (Gully Stabilization)	122.66	0% (Swale Detention); 79.7% (Gully Stabilization)
Green St	0.318	--	8,003	51%	5.16	33%
W Cobble Hill Rd Multifamily	0.957	--	7,362	51%	4.37	33%
Canadian Club	0.28	--	1,817	51%	0.77	33%
E Barre Rd Park and Ride	0.031	--	6,543	51%	1.54	33%
E Barre Rd Commercial	0.106	--	1,842	60%	0.33	20%
Barre Tile	0.12	--	2,929	60%	0.49	20%
VFW	0.097	--	2,208	60%	0.49	20%

2.4 *Final Ranking Methodology*

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix B9 - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix B10. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix B9 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or GSI-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[2] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table B3 below.

Table B3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	Base Cost ($/ft^3)
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large aboveground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

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

[2] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Permits and Engineering Costs: Used either 20% for large aboveground projects or 35% for smaller or complex projects.

Land Acquisition Costs *(Modified)*: A variation from the HW method was applied. Based on prior studies completed by WCA, the land acquisition cost was calculated as $120,000 per acre required for the BMP when located on private land. It should be noted that this value is based on a limited estimate and not necessarily an expected cost per acre. At this time, no land acquisition costs were built into the costs provided except Smokehouse Lane as the landowner indicated he may wish to sell this section of his property to the Town. It is assumed at this time that all other sites not owned by the Town will retain ownership of the stormwater management sites.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix B9 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices with their assigned rank are shown below in Table B4. The comprehensive ranking matrix used to rank the proposed BMP projects is provided in Appendix B9 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table B4. Top 20 potential BMP sites for the Town of Barre.

Rank	Site ID	Address	Proposed Practice Type
1	Smokehouse Lane Infiltration	Smokehouse Ln	Subsurface infiltration chambers
2	Industrial Park Retrofit	Parker Rd	Pond expansion, and gully stabilization
3	Wilkins Harley-Davidson	663 S Barre Rd	Subsurface infiltration chambers
4	New Life Assembly Church	304 Hill St	Gravel Wetland
5	Neddo Family Vineyards	73 Neddo Rd	Gravel wetland, site stabilization
6	Barre Town Park and Ride	Park and Ride, S Barre Rd	Subsurface infiltration chambers
7	S Barre Rd Field	S Barre Rd	Infiltration Basin
8	Trio and Cubesmart Storage	278 E Montpelier Rd	Infiltration Basin
9	S Barre Rd and Leo Ave	1079 S Barre Rd	Infiltration Trench
10	Green Mountain Diesel	894 S Barre Rd	Infiltration Trench
11	796 S Barre Rd	796 S Barre Rd	Subsurface infiltration chambers
12	E Barre Fire Station Parking	122 Mill St and Summer St	Bioretention
13	Dianne Lane	Off Peloquin Rd	Swale detention, gully stabilization
14	Green St	Green St and Beckley Hill Rd	Residential GSI, Sand Filter
15	W Cobble Hill Rd Multifamily	W Cobble Hill Rd and Hill St	Subsurface Sand Filter, Roadside GSI
16	Canadian Club	414 E Montpelier Rd	Subsurface Sand Filter, Swale Detention, Impervious Cover Reduction
17	E Barre Rd Park and Ride	E Barre Rd, south of Old Rt 302	Subsurface sand filter
18	E Barre Rd Commercial	E Barre Rd, north of roundabout	Filter Strip, Buffer Enhancement
19	Barre Tile	889 S Barre Rd	Filter Strip, Impervious Cover Reduction
20	VFW	E Barre Rd	Filter Strip, Stormwater Planters

A map of each project showing the drainage areas and BMP locations can be found in Appendix G - Top 20 Sites, and project locations within the watershed can be found in Appendix I - Top 20 Site Final Ranking.

2.6 Selection of Top 5 Potential BMPs

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking, input from municipal officials concerning project priorities, and the willingness of select private landowners to voluntarily participate in this plan. As part of this process, the project team met with the project stakeholders on August 10th, 2017 to discuss the potential top 5 project sites, and later with the Town's Selectboard on September 19th, and again on October 3rd, 2017. During the final Selectboard meeting, the Top 5 sites were confirmed by Selectboard vote. The location of the sites within the Town are shown in Figure B9. In the final ranking (2.4 Final Ranking Methodology), these 5 sites were awarded additional points in the scoring to reflect the Town's priorities and high probability for implementation. The Top 5 sites are listed in Table B5.

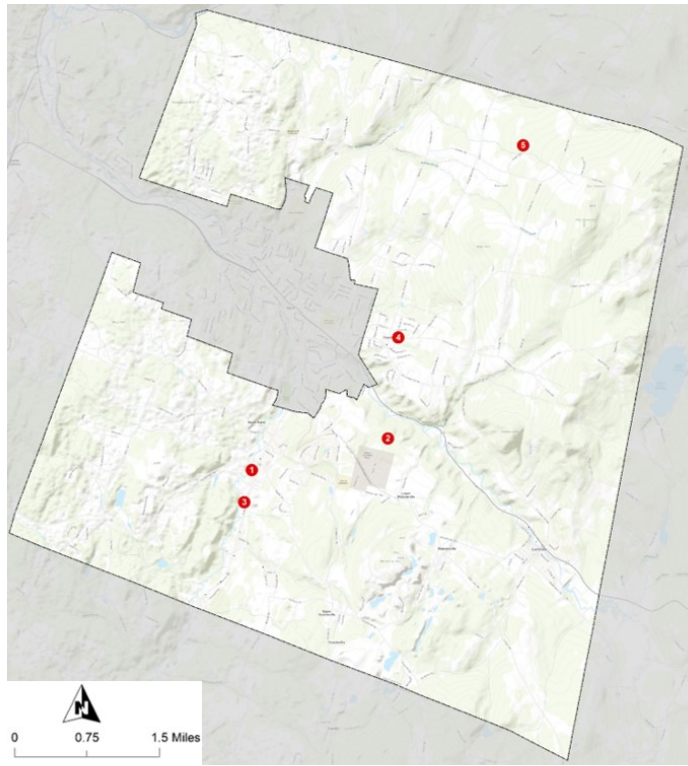

Figure B9. Top 5 sites for the Town of Barre SWMP.

Table B5. Top 5 BMP sites for the Town of Barre.

Rank	Site ID	Address	Proposed Practice Type
1	Smokehouse Lane Infiltration	Smokehouse Ln	Subsurface infiltration chambers
2	Industrial Park Retrofit	Parker Rd	Pond expansion, and gully stabilization
3	Wilkins Harley-Davidson	663 S Barre Rd	Subsurface infiltration chambers
4	New Life Assembly Church	304 Hill St	Gravel Wetland
5	Neddo Family Vineyards	73 Neddo Rd	Gravel wetland, site stabilization

3 Priority BMPs

The selected Top 5 BMP sites are briefly described below. These opportunities are located on Town property and private property. Brief descriptions of each site are provided below. Individual drainage area maps and an overview map of these Top 5 sites are provided in Appendix B11.

Site: 1
Project Name: Smokehouse Lane Infiltration
Description: The site includes a sizeable drainage area with mixed land uses (road, residential, and commercial). Stormwater, fed by stormlines on Middle Rd and S Barre Rd, is currently routed over the bank to the west of Smokehouse Ln into Stevens Branch. Figure B10 shows a portion of the drainage area flowing to the proposed project location. The concept for this site includes a long, linear subsurface storage and infiltration chamber system in the grass to the west of Smokehouse Ln across from Bond Auto. The two stormlines would be redirected to this system. Soils are mapped as being very good at this site (Hydrologic Group A), so soils and infiltration testing was completed to evaluate the potential for an infiltration practice. Soils were found to be generally sandy with moderately high permeability.

Figure B10. Stormwater that drains to the pictured greenspace will be infiltrated in subsurface infiltration chambers.

Outreach: Contact was made with property owner, Bill Bond. Mr. Bond expressed his willingness to allow further design to be completed at the site.

Site: 2
Project Name: Industrial Park Retrofit
Description: The site includes Pitman Rd and Parker Rd in the Wilson Industrial Park. Stormwater is currently conveyed via a series of culverts and grass swales down Pitman Rd, and along both sides of Parker Rd. The eastern swale flows to a pond (Figure B11). Drainage from the pond outlet and the western swale flow through two separate level spreaders located prior to the tree line. Although the flow is initially dispersed through the level spreaders, it re-concentrates past the tree line and is actively eroding, contributing to a large existing gulley. The concept for this site includes a retrofit of the existing pond, and a pond expansion to accommodate drainage from the western swale. The outlet would direct flow away from the gulley. Soils are mapped as being poor at this site (Hydrologic Group C), so soils and infiltration testing was not conducted to pursue an infiltration practice.

Figure B11. The existing detention pond is located in a field at the end of Parker Ln.

Outreach: The area where the proposed retrofits are located is owned by the Town of Barre and as such no additional outreach was conducted.

Site: 3
Project Name: Wilkins Harley-Davidson
Description: The site includes a stormline on S Barre Rd. The stormline passes under the parking lot to the south of the Wilkins Harley-Davidson building, and into the Stevens Branch. The concept for this site includes redirecting the stormline to an underground storage and infiltration chamber system under the Wilkins Harley parking lot (just to the right of where soils were tested as shown in Figure B12). Soils are mapped as being good at this site (Hydrologic Group B), so soils and infiltration testing were conducted to evaluate the potential for an infiltration practice. Soils were found to be generally sandy with a moderately-high infiltration rate.

Figure B12. Soil testing was completed adjacent to the Wilkins Harley Davidson parking lot to confirm soil infiltration potential.

Outreach: Contact was made with property owner John Lyon (Wilkins Manager) and Ron Lyon (brother and engineer at DuBois & King). Mr. Lyon expressed his interest in advancing a design for his property.

Site: 4
Project Name: New Life Assembly Church
Description: The site includes the church building, driveway, and parking lot, and the stormline on Hill St. Stormwater from the church property currently sheet flows to a stormline west of the parking lot via a swale. The stormline on Hill St collects road and residential drainage from Balsam Dr, Osborne Rd, and Sierra Lavin Rd. The concept for this site includes rerouting the Hill St stormline to a gravel wetland in the lawn to the west of the church parking lot (Figure B13). This feature would also manage onsite runoff, and could incorporate an educational aspect for churchgoers and the general public. Soils are mapped as being very poor at this site (Hydrologic Group D), so soils and infiltration testing was not conducted to pursue an infiltration practice.

Figure B13. A gravel wetland is proposed in the grassy area west of the large parking lot.

Outreach: Contact was made with Gordy Wells and Brian LaCount, the Pastors for the New Life Assembly Church. They are in favor of the project, and the church's board voted to allow further design for the project.

Site: 5
Project Name: Neddo Family Vineyards
Description: The site includes the buildings and grounds associated with the farming operation at Neddo Family Vineyards. Stormwater currently sheet flows through this area, some of which drains to the manure pond, some to the corn field west of the buildings, and some to the small tributary south of the farm. The concept for this site includes construction of a contained feed lot along the south side of the barn (see Figure B14), regrading the driveways to the south and east of the barn, adding a series of catchbasins, and managing the drainage in a gravel wetland feature located in the vegetated area between the house and the cornfield. Soils are mapped as being poor at this site (Hydrologic Group C), so soils and infiltration testing was not conducted to pursue an infiltration practice.


Figure B14. Dairy cow feeding area at Neddo Farm.

Outreach: Contact was made with property owner Chris Neddo. Mr. Neddo expressed his interest in advancing a design for his property.

When implemented, these five BMPs would treat approximately 109.7 acres, 28.8 acres (26%) of which is impervious. Modeled pollutant reductions for each of the projects, shown below in Table B6, indicate that these BMPs will prevent nearly 4,058,000 lbs of TSS and more than 81 lbs of TP from reaching receiving waters annually.

Table B6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Smokehouse Lane Infiltration	0.884	0.884	15,426	82.42%	12.23	79.52%
Industrial Park Retrofit	1.084	--	4,020,419	79% (Detention Pond); 50% (Gully Stabilization)	44.86	0% (Swale Detention); 49.9% (Gully Stabilization)
Wilkins Harley-Davidson	0.616	0.616	9,379	99.63%	16.38	99.55%
New Life Assembly Church	0.317	--	11,793	96%	7.06	58%
Neddo Family Vineyards	0.198	--	679	51%	0.78	33%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were created for each site. See Appendix B12 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix B13 - 30% Designs.

A geotechnical analysis was carried out for both the Smokehouse Lane and Wilkins Harley-Davidson sites as the proposed practices are infiltration-based. Infiltration testing at the Smokehouse Lane site was completed using a Constant-Head Borehole Permeameter Test (USBR 7300-89 Condition I, Deep Water Table or Impermeable layer) using a Johnson Meter (see Figure B15 for a photo of the Johnson Meter in use). The result of this testing is a value for the saturated hydraulic conductivity (K_{sat}) of soils on site. This value measures the movement of water through saturated soils, and yields a conservative estimate of infiltration. See Table B7 for typical permeability classes and ranges for K_{sat}.

Figure B15. An example of the Constant-Head Borehole Permeameter Test in progress using a Johnson Meter.

Table B7. Typical permeability classes and ranges for Ksat.

Permeability Class	Permeability Class Range					
	(cm/sec)		(cm/day)		(in/hr)	
	High end	Low end	High end	Low end	High end	Low end
Very Low	1×10^{-6}	$< 1 \times 10^{-6}$	0.0864	< 0.0864	0.0014	< 0.0014
Low	1×10^{-5}	1×10^{-6}	0.864	0.0864	0.014	0.0014
Moderately Low	1×10^{-4}	1×10^{-5}	8.64	0.864	0.14	0.014
Moderately High	1×10^{-3}	1×10^{-4}	86.4	8.64	1.4	0.14
High	1×10^{-2}	1×10^{-3}	864.0	86.4	14.0	1.4
Very high	$> 1 \times 10^{-2}$	1×10^{-2}	> 864.0	864.0	> 14.0	14.0

Infiltration testing at the Wilkins Harley-Davidson site was carried out using a falling head borehole test using a 2-inch diameter PVC pipe (Figure B16). The result of this testing is a soil infiltration rate (inches/hour), a measurement of the movement of water through soil.

Two different methods were used because the Johnson Meter was acquired after infiltration testing at the Wilkins Harley-Davidson site was completed. As the Johnson Meter is the preferred testing method, it was used for all remaining infiltration testing once the unit was acquired.

Figure B16. Infiltration testing using the falling head method in progress at the Wilkins Harley-Davidson site.

4.1 Smokehouse Lane

4.1.1 30% Concept Design Description

The proposed BMP for this site would manage a large (47.4-acre) drainage area with mixed land uses (road, residential, and commercial). Stormwater is currently collected along Middle Road and South Barre Road and routed over the bank to the west of Smokehouse Lane into the Stevens Branch.

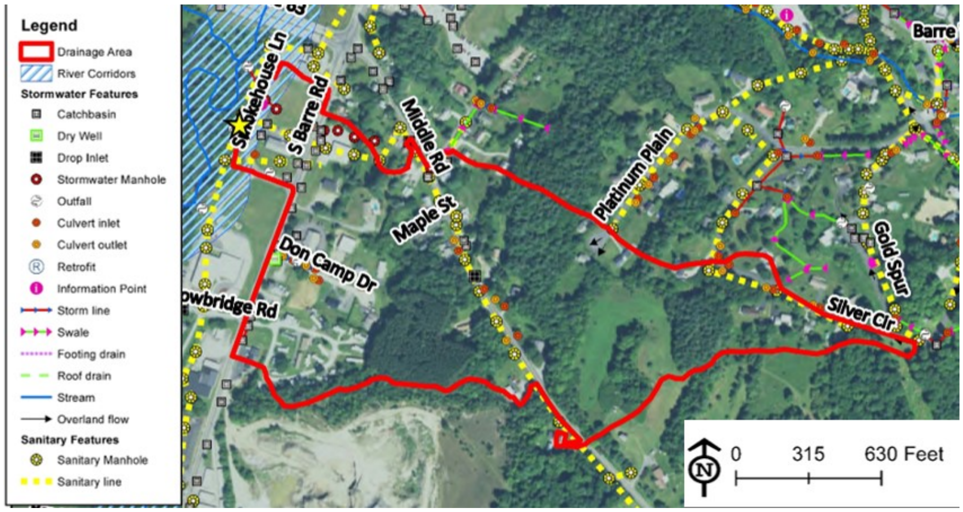

Figure B17. The proposed BMP drainage area is shown in red for the Smokehouse Lane site. The BMP location is shown with a star.

The proposed retrofit for this site includes a series of subsurface infiltration chambers along the west side of Smokehouse Lane. These chambers would be arranged in a linear configuration that parallels the road (see starred location in Figure B17). The two stormlines would be redirected to this system.

Soils are mapped as having very good infiltration potential (Hydrologic Group A), so soils and infiltration testing were conducted to evaluate the potential for an infiltration practice. To complete infiltration testing, a Constant-Head Borehole Permeameter Test (USBR 7300-89 Condition I, Deep Water Table or Impermeable layer) was completed using a Johnson Meter. The K_{sat} value was measured at 0.67 in/hr. This value is classified within the moderately-high permeability class.

Figure B18. Soils at the Smokehouse Lane site are generally sandy.

Soils were generally found to be sandy (Figure B18). No evidence of groundwater or seasonal high water table was found. See Appendix B15 - Soils Investigations for a complete soil log and completed K_{sat} workbook.

The design standard used for this retrofit was full infiltration of the Water Quality volume (or 1 inch of rain in a 24-hour period), equal to 38,507 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent 15,426 lbs of total suspended solids (TSS) and 12.23 lbs of total phosphorus (TP) from entering receiving waters (Table B8).

Table B8. Smokehouse Lane benefit summary table.

TSS Removed	15,426 lbs
TP Removed	12.23 lbs
Impervious Treated	11 acres
Total Drainage Area	47.4 acres

4.1.3 Cost Estimates

The total estimate cost for this project is $206,000. Note that these costs are very preliminary. Cost projections can be found in Table B9.

- The cost per pound of phosphorus treated is $16,837.
- The cost per impervious acre treated is $18,778.
- The cost per cubic foot of runoff treated is $5.35.

Table B9. Smokehouse Lane project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$500.00	$500.00
653.55	Project Demarcation Fencing	LF	400	$1.17	$468.00
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
649.51	Geotextile for silt fence	SY	155	$4.13	$640.15
652.20	Monitoring EPSC Plan	HR	10	$37.22	$372.20
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$3,700.35
Chambers - Costs					
	MC4500	EACH	202	$462.00	$93,324.00
	MC4500 Plain End Cap	EACH	3	$473.00	$1,419.00
	MC4500 24B End Cap	EACH	2	$653.13	$1,306.25
	MC4500 18T End Cap	EACH	3	$653.13	$1,959.39
	18" 90 BEND	EACH	1	$138.50	$138.50
	18" Tee	EACH	2	$220.01	$440.02
	18" Couplers	EACH	8	$22.52	$180.14
	18" N12 FOR MANIFOLD (AASHTO)	LF	40	$14.62	$584.80
	24" N12 for Isolator Row (AASHTO)	LF	20	$22.06	$441.10
	601TG to wrap system (SY)	SY	3000	$0.64	$1,914.00
	315WTM for scour protection (SY)	SY	1000	$0.66	$660.00
	6" INSERTA TEE	EACH	2	$82.50	$165.00
	6" RED HOLE SAW	EACH	1	$126.68	$126.68
	12" INLINE DRAIN	EACH	2	$297.00	$594.00
				Subtotal:	$103,252.88
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	2	$3,387.59	$6,775.18
203.15	Common Excavation	CY	655	$9.86	$6,458.30
629.54	Crushed Stone Bedding	TON	575	$34.04	$19,573.00
601.0920	24" CPEP	LF	150	$61.37	$9,205.50
651.35	Topsoil	CY	305	$30.96	$9,442.80
653.20	Temporary Erosion Matting	SY	1900	$2.20	$4,180.00
651.15	Seed	LBS	30	$7.66	$229.80
				Subtotal:	$55,864.58
Subtotal:					$162,817.81
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$16,281.78
	Incidentals to Construction - 5%**				$8,140.89
	Minor Additional Design Items - 5%**				$8,140.89

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Final Design	HR	60	$100.00	$6,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$206,000.00**

4.1.4 Next Steps

Preliminary outreach has been conducted with property owner Bill Bond. Mr. Bond expressed his willingness to allow further design to be completed at the site, and also noted that he would likely be willing to sell the part of his property where the BMP is proposed to the Town. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the WQv can be completely infiltrated, and larger storms passed through the system safely. A formal agreement will need to be reached with the landowner prior to final design.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B14 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by the River Scientist prior to final design due to the project’s location in the river corridor. However, it should be noted that this project will not result in any net fill within the river corridor. No Act 250 permitting or wetlands concerns are anticipated for this project.

4.2 Industrial Park Retrofit

4.2.1 30% Concept Design Description

The site includes drainage from Pitman Rd and Parker Rd in the Wilson Industrial Park. Stormwater is currently conveyed via a series of culverts and grass swales down Pitman Rd to the west, and along both sides of Parker Rd flowing north. Stormwater from the eastern side of Parker Rd is collected in a swale and outfalls to an existing detention pond. The outlet of the pond discharges to a level spreader. Stormwater from the western side of Parker Rd flows in a swale to a separate level spreader located prior to the tree line.

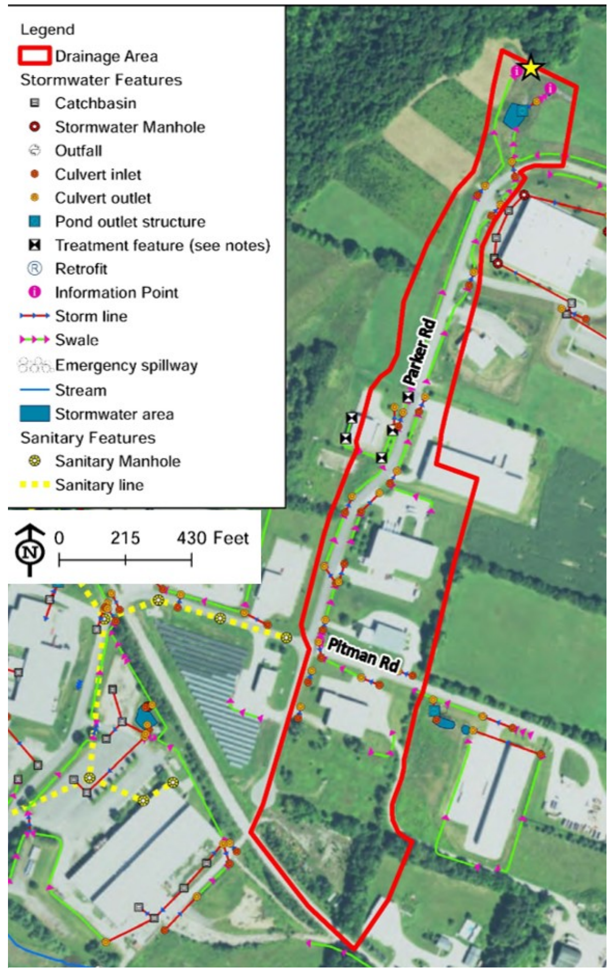

Figure B19. The drainage area for the proposed pond expansion is shown in red for the Industrial Park Retrofit. The location where the flow re-concentrates currently is just north of the starred location. The existing pond is shown with a blue polygon.

Although the stormwater flow is initially dispersed through the level spreaders, it re-concentrates just past the tree line (see starred location in Figure B19). This concentrated flow is entering a large gully that is actively eroding. Historical imagery shows that this gully began forming in, or prior to, 2003 (Figure B20).

Figure B20. Progression of gully formation from 2003 to 2015.

The retrofit for this site includes an expansion of the existing pond, so that it is large enough to capture all of the drainage contained in the drainage area shown in Figure B19. The outlet would direct flow away from the gully and provide better attenuation of peak flows into the eroded area. Additionally, stabilization of the gully is proposed to prevent continued erosion.

Soils are mapped as having poor infiltration potential at this site (Hydrologic Group C), so soils and infiltration testing was not conducted.

The design standard used for this retrofit was detention and slow release of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period) for the detention pond feature, equal to 47,219 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13- 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent more than 4,020,000 lbs of total suspended solids (TSS) and 44.86 lbs of total phosphorus (TP) from entering receiving waters (Table B10). These very large pollutant reductions are due primarily to preventing significant erosion in a highly-erosive gully to the north of the existing detention pond at the end of Parker Rd.

Table B10. Industrial Park Retrofit benefit summary table.

TSS Removed	4,020,419 lbs
TP Removed	44.86 lbs
Impervious Treated	8.8 acres
Total Drainage Area	25.6 acres

4.2.3 Cost Estimates

The total estimated cost for this retrofit is $399,000. Note that these costs are very preliminary. Cost projections can be found in Table B11.

- The cost per pound of phosphorus treated is $8,894.
- The cost per impervious acre treated is $45,392.
- The cost per cubic foot of runoff treated is $8.45.

Table B11. Industrial Park Retrofit project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	500	$1.17	$585.00
649.51	Geotextile for silt fence	SY	300	$4.13	$1,239.00
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
652.20	Monitoring EPSC Plan	HR	10	$37.22	$372.20
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$4,916.20
Detention Pond					
203.15	Common Excavation	CY	2555	$9.86	$25,192.30
613.11	Type II Stone (splash pad)	CY	28	$42.49	$1,189.72
653.20	Temporary Erosion Matting	SY	2100	$2.20	$4,620.00
651.15	Seed	LBS	45	$7.66	$344.70
				Subtotal:	$31,346.72
Swale Regrading					
203.15	Common Excavation	CY	130	$9.86	$1,281.80
613.10	Type I Stone	CY	65	$43.91	$2,854.15
653.20	Temporary Erosion Matting	SY	350	$2.20	$770.00
651.15	Seed	LBS	7	$7.66	$53.62
				Subtotal:	$4,959.57
Headcut Stabilization					
	Gully Stabilization	FT	400	$700.00	$280,000.00
				Subtotal:	$280,000.00
Subtotal:					$321,222.49
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$32,122.25
	Incidentals to Construction - 5%**				$16,061.12
	Minor Additional Design Items - 5%**				$16,061.12
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	24	$100.00	$2,400.00
Total (Rounded)					**$399,000.00**

4.2.4 Next Steps

As this site is owned and operated by Barre Town, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely managed, and larger storms passed through the system safely. Additional design will also be required to ensure that gully stabilization efforts will be effective long-term.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B14 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time as parcels with ≥3 acres of impervious cover in the drainage area have current stormwater permits and are thus expected to be exempt from the proposed 3-acre impervious cover rule.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Wetlands, or River Corridor permitting is anticipated for this project. An Act 250 amendment (permit number 5W0308) will likely be required for this site.

4.3 Wilkins Harley-Davidson

4.3.1 30% Concept Design Description

Drainage from South Barre Rd is collected in a stormline that passes under the parking lot of the Wilkins Harley-Davidson site and into the Stevens Branch without any water quality treatment.

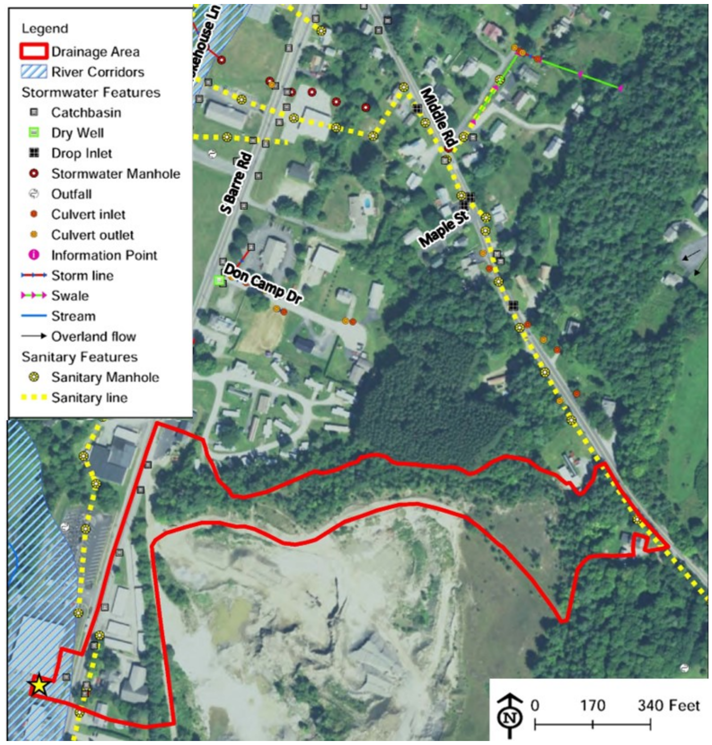

Figure B21. The drainage area for the Wilkins Harley-Davidson proposed stormwater retrofit is outlined in red. The proposed location of the subsurface infiltration chambers is shown with a star.

The concept for this site includes intercepting the existing stormline with a series of subsurface infiltration chambers. The chambers are proposed to be located under the parking lot to the south of the Harley-Davidson building (see starred location in Figure B21).

Soils are mapped as having good infiltration potential at this site (Hydrologic Group B), so soils and infiltration testing was completed to evaluate the potential for an infiltration practice. To complete infiltration testing, a 3.25-inch diameter hole was created using a hand auger to conduct a falling head infiltration test. A 2-inch diameter PVC pipe was installed in the augered hole, 41.8 ounces of water was poured into the pipe, and water drop (in inches) was monitored at 10-minute increments. The infiltration rate was measured as 15.24 inches/hour; this is a moderately-high infiltration rate. Soils were found to be generally sandy (Figure B22).

Figure B22. Soils at the Wilkins Harley-Davidson site were generally sandy.

The drainage area for this proposed BMP is 9.9 acres, approximately 28% of which is classified as impervious. This practice will provide a significant water quality benefit (see Table B12). The design standard used for this retrofit was infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 26,833 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 9,379 lbs of total suspended solids (TSS) and 16.38 lbs of total phosphorus (TP) from entering receiving waters annually (Table B12).

Table B12. Wilkins Harley-Davidson benefit summary table.

TSS Removed	9,379 lbs
TP Removed	16.38 lbs
Impervious Treated	2.8 acres
Total Drainage Area	9.9 acres

4.3.3 Cost Estimates

The total estimated cost for this project is $87,000. Note that these costs are very preliminary. Cost projections can be found in Table B13. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $5,311.
- The cost per impervious acre treated is $31,183.
- The cost per cubic foot of runoff treated is $3.24.

Table B13. Wilkins Harley-Davidson project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$500.00	$500.00
653.55	Project Demarcation Fencing	LF	325	$1.17	$380.25
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
649.51	Geotextile for silt fence	SY	70	$4.13	$289.10
652.20	Monitoring EPSC Plan	HR	10	$37.22	$372.20
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$3,261.55
Chambers - Costs					
	MC3500	EACH	38	$382.80	$14,546.40
	MC3500 PLAIN END CAP	EACH	2	$287.10	$574.20
	MC3500 12T END CAP	EACH	4	$346.50	$1,386.00
	MC3500 24B END CAP	EACH	2	$386.65	$773.30
	12" TEE	EACH	2	$104.93	$209.86
	12" 90 BEND	EACH	2	$54.62	$109.23
	12" COUPLERS	EACH	10	$7.93	$79.31
	12" N12 FOR MANIFOLD (AASHTO)	LF	40	$7.58	$303.16
	24" N12 for Isolator Row (AASHTO)	LF	20	$22.06	$441.10
	601TG to wrap system (SY)	SY	1500	$0.64	$957.00
	315WTM for scour protection (SY)	SY	500	$0.66	$330.00
	6" INSERTA TEE	EACH	2	$82.57	$165.13
	6" RED HOLE SAW	EACH	1	$126.68	$126.68
	12" INLINE DRAIN	EACH	1	$297.00	$297.00
				Subtotal:	$20,298.37
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	2	$3,387.59	$6,775.18
203.15	Common Excavation	CY	500	$9.86	$4,930.00
629.54	Crushed Stone Bedding	TON	420	$34.04	$14,296.80
601.0920	24" CPEP	LF	10	$61.37	$613.70
651.35	Topsoil	CY	75	$30.96	$2,322.00
653.20	Temporary Erosion Matting	SY	4300	$2.20	$9,460.00
651.15	Seed	LBS	10	$7.66	$76.60
				Subtotal:	$38,474.28
Subtotal:					$62,034.20
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$6,203.42
	Incidentals to Construction - 5%**				$3,101.71
	Minor Additional Design Items - 5%**				$3,101.71

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$87,000.00**

4.3.4 Next Steps

Landowner outreach was completed with property owner John Lyon (Wilkins Manager) and Ron Lyon (brother and engineer at DuBois & King). Mr. Lyon expressed his interest in advancing a design for his property. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that the CPv can be fully infiltrated, and larger storms passed through the system safely. A formal agreement will need to be reached with the landowner prior to final design, and construction should be scheduled outside of peak business times for the Harley-Davidson store.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B14 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This site should be reviewed by a State River Scientist prior to final design. However, it should be noted that since this proposed BMP is subsurface, there will be no net fill within the river corridor. No Act 250 permitting or wetlands concerns are anticipated for this project.

4.4 New Life Assembly Church

4.4.1 30% Concept Design Description

Stormwater runoff from residential development along Balsam Dr, Osborne Rd, Sierra Lavin Rd, and Hill St is currently collected in a piped system and conveyed west along Hill St. The drainage passes along the front of the New Life Assembly Church property and discharges without any water quality improvements to a tributary of Stevens Branch.

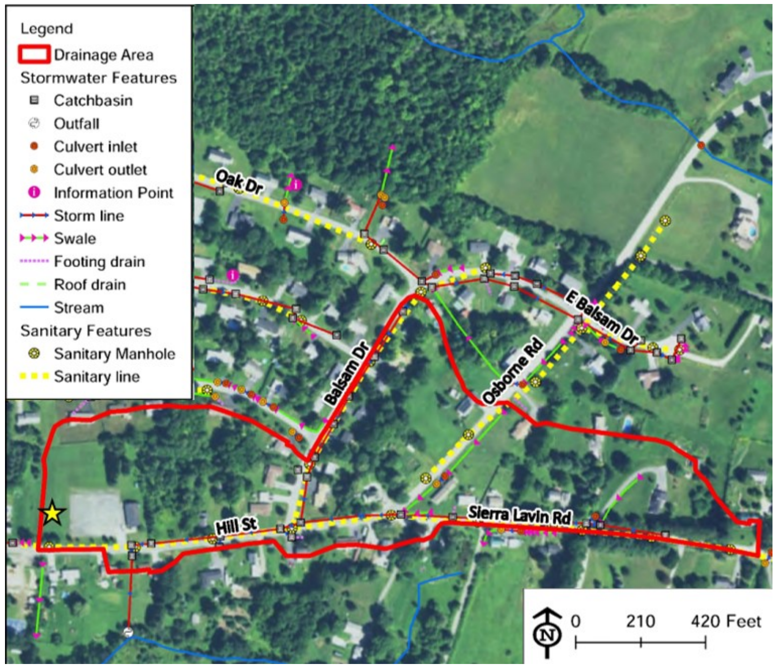

Figure B23. The proposed gravel wetland is located to the west of the church's parking lot (see starred location).

The proposed retrofit for this area includes rerouting the stormwater pipe to a gravel wetland in the grass area to the west of the church's parking lot (see starred location in Figure B23). The design for the gravel wetland includes horizontal flow-through treatment cells and a sedimentation forebay. Stormwater passes through a gravel substrate in a microbe-rich environment, which results in better phosphorus reductions from stormwater leaving the system than many other surface treatment features. This feature would also manage onsite runoff from the church, and could incorporate an educational aspect for churchgoers and the general public. Contact persons at the New Life Assembly Church noted that their lawn area often has ponding water. As part of the design of this practice, a yard drain is included to reduce this surface ponding. The drain will direct this water to the gravel wetland feature for water quality treatment.

Soils are mapped as having very poor infiltration potential at this site (Hydrologic Group D). As such, an infiltration-based practice was not considered, and soils and infiltration testing were not conducted.

The drainage area for this proposed BMP is 22.1 acres, approximately 23% of which is classified as impervious. This practice will provide a significant water quality benefit (Table B14), but is also a high visibility site within the Town, and this practice could spur additional retrofits and awareness of stormwater issues in the area. It is recommended that an educational sign be installed in conjunction with the retrofit. The design standard used for this retrofit was full filtration and slow release of the Water Quality volume (WQv, or 1 inch of rain in a 24-hour period), equal to 13,809 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 11,793 lbs of total suspended solids (TSS) and 7.06 lbs of total phosphorus (TP) from entering receiving waters annually (Table B14).

Table B14. New Life Assembly Church benefit summary table.

TSS Removed	11,793 lbs
TP Removed	7.06 lbs
Impervious Treated	5 acres
Total Drainage Area	22.1 acres

4.4.3 Cost Estimates

Note that two separate cost estimates are provided. The first, which totals $197,000, includes plant plugs while the second cost, $153,000, includes only seeds for planting of the gravel wetland practice. Plant plugs are recommended as they have a higher survival rate and provide ground cover much faster. However, seeds are also an option if funding is limited. Note that these costs estimates are very preliminary. Cost projections can be found in Table B15. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $27,909 for the plant plugs and $21,676 for the seeds.
- The cost per impervious acre treated is $39,558 for the plant plugs and $30,723 for the seeds.
- The cost per cubic foot of runoff treated is $14.27 for the plant plugs and $11.08 for the seeds.

Table B15. New Life Assembly Church project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	500	$1.17	$585.00
649.51	Geotextile for silt fence	SY	105	$4.13	$433.65
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
652.20	Monitoring EPSC Plan	HR	8	$37.22	$297.76
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$4,036.41
Gravel Wetland					
203.15	Common Excavation	CY	2285	$9.86	$22,530.10
651.35	Muck Soil (Topsoil)	CY	115	$30.96	$3,560.40
629.54	3/4" to 1 1/2" Crushed Stone (Crushed Stone Bedding)	TON	750	$34.04	$25,530.00
629.54	Pea Stone (Crushed Stone Bedding)	TON	115	$34.04	$3,914.60
613.10	Type I Stone (Inlet and weirs)	CY	60	$43.91	$2,634.60
613.11	Type II Stone (overflow)	CY	30	$42.49	$1,274.70
301.26	Sand (Subbase of Gravel, Fine Graded)	CY	220	$40.03	$8,806.60
649.31	Geotextile Under Stone Fill	SY	1350	$2.51	$3,388.50
656.41	Plants* (Perennials)	EACH	5000	$8.77	$43,850.00
N/A	Wetland Plant Seeds	LBS	10	$125.00	$1,250.00
651.15	Seed	LBS	10	$7.66	$76.60
653.20	Temporary Erosion Matting	SY	250	$2.20	$550.00
605.11	8" Underdrain Piping	LF	50	$27.04	$1,352.00
601.0915	18" CPEP Outlet Works	LF	6	$64.04	$384.24
N/A	18" Anti-Seep Collar	EACH	1	$250.00	$250.00
N/A	18" Beehive Grate with Anti-Vortex Baffle	EACH	1	$615.00	$615.00
N/A	30 Mil PVC Liner	SY	1500	$5.68	$8,520.00
				Subtotal:	$128,487.34
New Infrastructure					
604.20	New Catch Basin	EACH	1	$3,387.59	$3,387.59
601.0915	18" CPEP	LF	275	$64.04	$17,611.00
				Subtotal:	$20,998.59
Subtotal:					$153,522.34
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$15,352.23
	Incidentals to Construction - 5%**				$7,676.12
	Minor Additional Design Items - 5%**				$7,676.12

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total - Plugs Option (Rounded)					**$197,000.00**
Total - Seed Option (Rounded)					**$153,000.00**

4.4.4 Next Steps

Contact was made with Pastors Gordy Wells and Brian LaCount regarding this project. Both Pastors were amenable to the project, particularly if it would improve the previously noted ponding experienced on the church's lawn area. The church's board voted to allow advancement of the design for this site. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that WQv can be completely managed and that larger storms bypass the system safely. A formal agreement will need to be reached with the landowner prior to final design.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B14 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a wetland ecologist prior to final design due to the presence of hydric soils. No Act 250 permitting or River Corridor concerns are anticipated for this project.

4.4.6 Site Rendering

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This rendering is one possible configuration for this site. This graphically engaging rendering visually communicates the plans and can be used by the Town and the CVRPC to help advance designs toward implementation. This rendering can be found in Appendix B16 - Site Rendering.

4.5 Neddo Family Vineyards

4.5.1 30% Concept Design Description

The site includes the stormwater runoff resulting from the buildings and grounds associated with the farming operation at Neddo Family Vineyards. The farm has a mix of agricultural fields, livestock (dairy cow) holding and feeding areas, farm equipment storage areas, and a residential building. Stormwater currently sheet flows through this area, some of which drains to the manure pond, some to the cornfield west of the buildings, and some to the small tributary, south of the farm. The farm has had trouble with stormwater drainage in the past, and currently the front farm area is unstable and eroding (Figure B25).

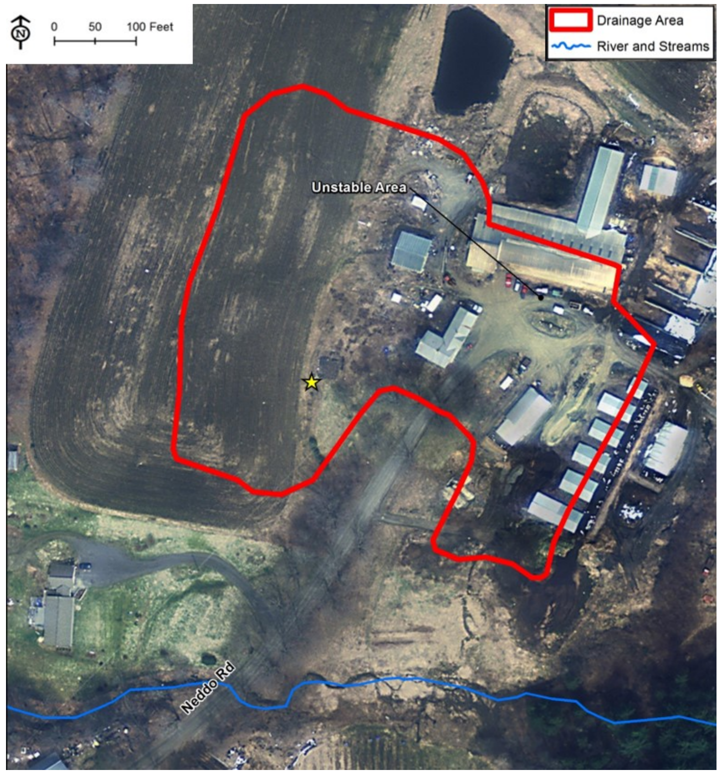

Figure B24. It is recommended that runoff from Neddo Family Vineyards be directed to a gravel wetland.

The concept for this site includes construction of a contained feed lot along the south side of the barn (see photo), regrading the driveways to the south and east of the barn, adding a series of catchbasins, and managing the drainage in a gravel wetland feature located in the vegetated area between the house and the cornfield (see starred location in Figure B24).

Figure B25. Unstable area at Neddo Farm.

Although this site would likely not be eligible for funding through the Clean Water Fund, it may be a good candidate for a grant that targets agricultural areas, particularly small farms.

Soils have low infiltration potental at this site (Hydrologic Group C), so soils and infiltration testing was not conducted, and an infiltration-based practice was not pursued.

The drainage area for these proposed BMPs is 4.7 acres, approximately 28% of which is classified as impervious. The design standard used for this retrofit was detention and slow release of the

Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 8,625 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix B11 - Top 5 Sites. A 30% design plan is provided in Appendix B13 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 679 lbs of total suspended solids (TSS) and 4.93 lbs of total phosphorus (TP) from entering receiving waters annually (Table B16). The TP reduction shown in the table below includes a 33% reduction from the gravel wetland practice and a 100% reduction from covering the dairy cow feeding area as it is anticipated that phosphorus will no longer be leeched from the feed. Total phosphorus runoff concentration from the feeding area was obtained by taking the mean runoff values reported in Wunderlin et al. (2016)[3]. The landowner at this site, Mr. Neddo, has previously attempted to improve water quality from his site, but these practices have not held up over time. He is interested in implementing BMPs on his property that will improve stormwater runoff, and the Town recognizes the importance of landowner interest and enthusiasm. Without such landowner interest, projects have a low likelihood of implementation.

Table B16. Neddo Family Vineyard benefit summary table.

TSS Removed	679 lbs
TP Removed	4.93 lbs
Impervious Treated	1.3 acres
Total Drainage Area	4.7 acres

4.5.3 Cost Estimates

Note that two separate cost estimates are provided. The first, which totals $108,000, includes plant plugs while the second cost, $102,000, includes only seeds for planting of the gravel wetland practice. Plant plugs are recommended as they have a higher survival rate and provide ground cover much faster. However, seeds are also an option if funding is limited. Note that these costs are very preliminary. Cost projections can be found in Table B17. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $21,907 for the plant plugs and $20,090 for the seeds.
- The cost per impervious acre treated is $83,077 for the plant plugs and $79,688 for the seeds.
- The cost per cubic foot of runoff treated is $12.52 for the plant plugs and $11.83 for the seeds.

[3] Wunderlin et al. 2016. Evaluation of Silage Leachate and Runoff Collection Systems on Three Wisconsin Dairy Farms. Discovery Farms Wisconsin, University of Wisconsin Extension.

Table B17. Neddo Family Vineyards project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	250	$1.17	$292.50
649.51	Geotextile for silt fence	SY	110	$4.13	$454.30
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
652.20	Monitoring EPSC Plan	HR	8	$37.22	$297.76
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$3,764.56
Gravel Wetland					
203.15	Common Excavation	CY	500	$9.86	$4,930.00
651.35	Muck Soil (Topsoil)	CY	15	$30.96	$464.40
629.54	3/4" to 1 1/2" Crushed Stone (Crushed Stone Bedding)	TON	125	$34.04	$4,255.00
629.54	Pea Stone (Crushed Stone Bedding)	TON	21	$34.04	$714.84
613.10	Type I Stone (Inlet and weirs)	CY	55	$43.91	$2,415.05
613.11	Type II Stone (overflow)	CY	15	$42.49	$637.35
301.26	Sand (Subbase of Gravel, Fine Graded)	CY	50	$40.03	$2,001.50
649.31	Geotextile Under Stone Fill	SY	150	$2.51	$376.50
656.41	Plants* (Perennials)	EACH	600	$8.77	$5,262.00
N/A	Wetland Plant Seeds	LBS	6	$125.00	$750.00
651.15	Seed	LBS	10	$7.66	$76.60
653.20	Temporary Erosion Matting	SY	195	$2.20	$429.00
605.11	8" Underdrain Piping	LF	60	$27.04	$1,622.40
601.0915	18" CPEP Outlet Works	LF	25	$64.04	$1,601.00
N/A	18" Anti-Seep Collar	EACH	1	$250.00	$250.00
N/A	18" Beehive Grate with Anti-Vortex Baffle	EACH	1	$615.00	$615.00
N/A	30 Mil PVC Liner	SY	400	$5.68	$2,272.00
				Subtotal:	$28,672.64
New Infrastructure					
604.20	New Catch Basin	EACH	3	$3,387.59	$10,162.77
601.0915	18" CPEP	LF	400	$64.04	$25,616.00
301.15	Subbase of Gravel (yard re-grading)	CY	150	$25.11	$3,766.50
605.10	6" Underdrain Piping	LF	324	$21.86	$7,082.64
				Subtotal:	$46,627.91
New Swale					
651.15	Seed	LBS	5	$7.66	$38.30
653.20	Temporary Erosion Matting	SY	230	$2.20	$506.00
613.10	Type I Stone	CY	60	$43.91	$2,634.60

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
653.30	Timber Check Dams (Prefabricated Check Dam)	EACH	4	$295.79	$1,183.16
				Subtotal:	$4,362.06
Subtotal:					$79,065.11
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$7,906.51
	Incidentals to Construction - 5%**				$3,953.26
	Minor Additional Design Items - 5%**				$3,953.26
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total - Plugs Option (Rounded)					**$108,000.00**
Total - Seed Option (Rounded)					**$102,000.00**

4.5.4 Next Steps

Contact was made with property owner Chris Neddo. Mr. Neddo expressed his interest in advancing a design for his property. He also indicated his willingness to assist in construction of retrofits as possible. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely managed, and larger storms passed through the system safely. Additionally, site stabilization strategies should be finalized. A formal agreement will need to be reached with the landowner prior to final design.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix B14 - Permit Review Sheets. In summary:

Stormwater Permit
This site will likely need a stormwater permit under the proposed 3-acre impervious cover rule. The parcel as a whole contains more than 3 acres of impervious cover, so this site would necessitate a permit.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250 permitting, wetlands, or river corridor concerns are anticipated for this project.

C. Chapter 3: Plainfield

1 Background

1.1 Problem Definition

Plainfield is located in Washington County within Great Brook, a tributary included in the Nasmith Brook – Winooski River watershed, and the Gunners Brook watershed, a tributary of Stevens Branch (Figure C1). All of these watersheds are tributaries of the Winooski River, which runs through the northwest corner of Plainfield. See Appendix C1 – Map Atlas for additional maps of the Town. The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development. The section of the Winooski River that lies in Plainfield is on the 2016 stressed waters list due to streambank erosion, channel instability, road runoff, and elevated *E. coli*.

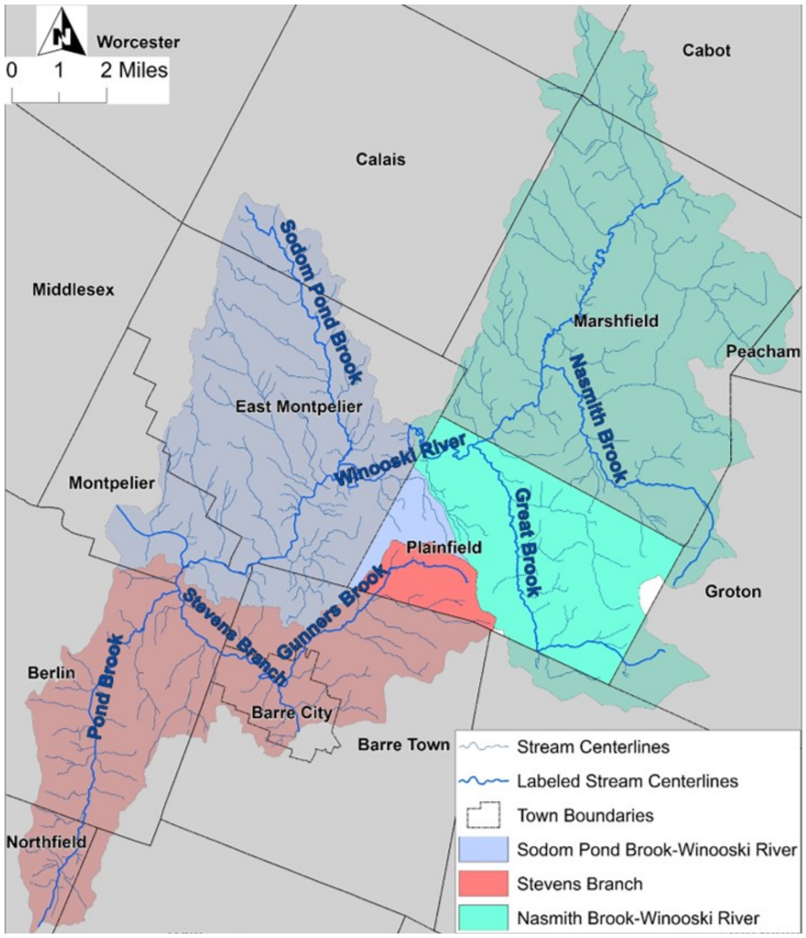

Figure C1. The Town of Plainfield is located primarily within the Great Brook watershed, a tributary of the Winooski River.

Great Brook, a tributary of the Winooski River, has experienced repeated flooding, and has shown significant in-stream erosion and many mass failures. One such flooding event occurred after a heavy rain event on July 19, 2015. Data collected by the University of Vermont Spatial Analysis Lab (Figure C2) shows some of this damage at the Brook Road Bridge in Plainfield. Most of the flooding and erosion is concentrated to the lower reaches, in the more populated areas of Plainfield, and few are in the headwaters. Many gullies of varying sizes have been noted along the length of the brook. Great Brook is confined by a narrow valley, has multiple grade controls, and is in a state of adjustment. According to the 2014 Great Brook River Corridor Plan developed by Bear Creek Environmental, the majority of reaches in the Brook are in fair to poor geomorphic condition, with conditions being rated increasingly poor as the Brook approaches Route 2. Stream habitat condition is likewise rated as primarily fair within Plainfield. The Corridor Plan notes that the main stressors for Great Brook are channelization, bank armoring, floodplain encroachment, removal of woody riparian vegetation, and undersized stream crossings.

Figure C2. Flooding-related damage in Great Brook following a high intensity rain event. Imagery collected by the University of Vermont Spatial Analysis Lab (2015).

Gunners Brook, within the Stevens Branch watershed, has few constrictions within this area as it is minimally developed with primarily only rural roads and residential properties. Gunners Brook has overflowed its banks and caused flooding within the Town. Although there are no stressed sections of Gunners Brook, there are two sections of the Stevens Branch on the 2016 stressed waters list due to streambank erosion, channel instability, road runoff, elevated *E. coli*, and urban runoff.

Plainfield has experienced increased urban development along Route 2, and agricultural lands throughout. Route 2 parallels the Winooski River, with moderately developed areas within or close to the river corridor. This development has constrained the rivers along both banks in some locations. In addition to development along this corridor, Plainfield experiences significant erosion as a result of steep slopes and poor soils, further contributing to sediment and nutrient loading in surface waters.

The human-influenced stressors in the watersheds include commercial development and associated parking areas, construction of roads, residential development, and clearing of previously forested areas. Additionally, in part due to historic straightening of rivers in the area, associated incision of stream channels, and limited floodplain access, both nuisance flooding and more extreme flood events can and do occur. Unmanaged stormwater runoff, particularly from impervious surfaces and landscaped pervious areas, exacerbate flooding. The Winooski River watershed and its tributaries have experienced extreme flooding in the past, and these flood events are only expected to occur more frequently due to the predicted increased frequency and intensity of extreme weather events associated with climate change. These heavy rains and easily erodible soils have contributed to erosion issues throughout the area. The stormwater management practices investigated seek to protect local river resources as well as the larger Lake Champlain Basin, which currently has a Total Maximum Daily Load (TMDL) in place. This TMDL requires reductions in phosphorus loading to Lake Champlain via its tributaries though reductions in stormwater and agricultural runoff pollution.

1.2 Existing Conditions

The Town of Plainfield spans approximately 13,495 acres in Washington County, VT and is primarily forested (73%), though nearly 7% of the Town is classified as urban. Of that area, there are 213 acres (2%) of impervious cover. Plainfield lies to the east of moderately developed East Montpelier, to the north of more residential sections of Barre Town and Orange, to the west of rural Groton, and to the south of rural Marshfield. Development in the Town is concentrated along the Route 2 corridor, which parallels the Winooski River (Figure C3). The remainder of the Town is primarily rural-residential.

Many of the older developments within the Town were constructed before current stormwater standards were developed, and they were constructed without any or with only minimal stormwater management. This has resulted in significant amounts of untreated stormwater draining from large portions of developed lands discharging directly to surface waters.

Surrounding the developed lands, rural roads are generally unpaved, with open roadside ditches, and cross culverts. Many of these roads have steep slopes, and traverse large areas. Furthermore, the rural roads access residential driveways which often convey drainage into, and through the Town road drainage system. This is a problem because runoff from private lands is negatively impacting the Town's overall drainage system.

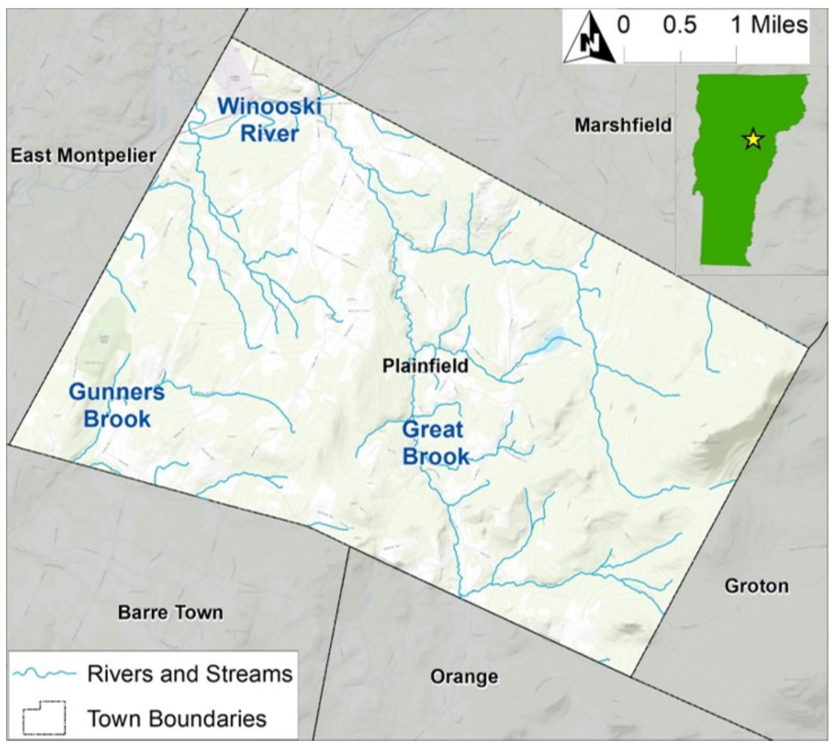

Figure C3. The Town of Plainfield is located in Washington County, VT.

Soils analyses indicate that of the 13,495 total acres in the Town, 96.4% are classified as either potentially highly-erodible, or highly-erodible by the latest Natural Resources Conservation Service (NRCS) soil mapping data. Additionally, the majority of the soils in the watershed have very low infiltration potential as indicated by NRCS Hydrologic Soil Group classifications where soils are classified from group A (highest infiltration potential) to group D (lowest infiltration potential). In the Town, the majority of areas belong to either Hydrologic Soil Group C (38.8%) or D (30.7%), while only 2% are in group A, and 28% are in group B. The remainder is not classified or comprised of water. This combination of steep slopes with limited infiltration capacity and a highly-erodible surface make the area particularly susceptible to erosion. Maps depicting existing watershed conditions can be found in Appendix C1 – Map Atlas. Maps include:

- river corridors and wetlands including wetlands advisory layer and hydric soils,
- soil infiltration potential,
- soil erodibility,
- slope,
- stormwater infrastructure and stormwater permits,
- land cover,
- impervious cover,
- and parcel boundaries including parcels with ≥3 acres of impervious cover.

2 Methodology

2.1 Identification of All Opportunities

2.1.1 Initial Data Collection and Review:

All relevant prior watershed studies and any studies that could inform planning in the project area were assembled and reviewed in the context of this stormwater master plan (SWMP) study. These reports include the Water Quality Management Plan, geomorphic studies including the River Corridor Management Plan, aquatic life studies, and stormwater infrastructure mapping and prioritization.

Relevant Geographic Information System (GIS) data was drawn from a variety of public resources including the Agency of Natural Resource's Atlas, Vermont Center for Geographic Information Open Geodata Portal, and data created by the University of Vermont's Spatial Analysis Lab. A file geodatabase was created to ensure organization and for ease of use. These data represent the "best available" data at the time of data collection (2017). The information collected and reviewed for the creation of this SWMP as well as a summary memo are included as Appendix C2 – Data Review.

The project team met with the Town of Plainfield stakeholders and the Central Vermont Regional Planning Commission (CVRPC) on April 11th, 2017 to discuss the SWMP and solicit information on problem areas from the Town. Following this meeting, a list of potentially important sites was provided to the project team by the Town. This list included particular parcels, as well as general areas of importance. These areas were noted and added to the list of sites identified during the desktop assessment (see section 2.1.2).

2.1.2 Desktop Assessment and Digital Map Preparation

2.1.2.1 Desktop Assessment

A desktop assessment was completed to identify additional potential sites for stormwater best management practice (BMP) implementation. This process involved a thorough review of existing GIS resources and associated attribute data. Data included, but was not limited to, storm sewer infrastructure, soils classifications, parcel data, wetlands, and river corridors. This data was used to identify and map stormwater subwatersheds with particularly high impervious cover, stormwater subwatersheds that are more directly connected to water bodies (direct pipes to streams or via overland flow), areas where infill development may occur, areas that may have worsening stormwater impacts in the future, and parcels with ≥3 acres of impervious cover without a current stormwater permit as these areas will be subject to a permit in the future. As there are only two such parcels in the Town, both of which are privately owned, The Town of Plainfield opted to include these private sites in the plan. However, they were not given priority in the plan in light of the upcoming regulations for these sites. A point location was created for each identified site or area for assessment in the field.

A 'green streets' assessment was also conducted to identify any road segments in the Town potentially appropriate for green stormwater infrastructure (GSI) retrofit opportunities. Streets were evaluated and scored according to width, slope, and soil permeability utilizing a methodology adapted from the "Promoting Green Streets" report published by the River Network (July 2016). However, due primarily to steep slopes, no green streets opportunities were identified in the Town.

A total of 57 locations were identified for field investigation.

2.1.2.2 Basemap and Mobile App Creation

In order to maximize efficiency in the field and better understand site-specific conditions, digital base maps were created for the Town. The maps show parcel boundaries, public parcels, stormwater infrastructure, hydrologic soils groups, river corridors, hydric soils, and wetlands. This information was used in the field to assess potential feasibility issues for proposed practices and to better identify preliminary BMP locations.

The base layers were pre-loaded into a project-specific mobile app that was customized for this project using the Fulcrum platform. The app was also pre-loaded with the 57 point locations for the potential BMP sites. These points allowed for easy site location and data collection in the field (Figure C5).

The app was used to collect information including site suitability, photographic documentation, follow-up notes, and other pertinent data (Figure C4). All collected data was securely uploaded to the Cloud for later use.

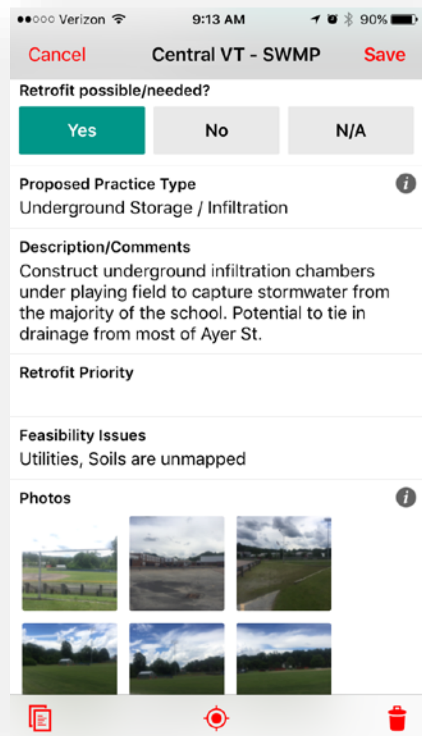

Figure C4. Example screen from data collection app.

2.1.3 Field Data Collection:

Each of the 57 previously identified potential BMP locations were evaluated in the field during the Summer and Fall of 2017 (Figure C5). Data was collected about each site in the mobile app. A large map of these sites with associated site names and a list of these sites including potential BMP options and site notes can be found in Appendix C3 - Initial Site Identification.

Through the course of these field visits, 14 additional stormwater retrofit sites were identified that had not been included in the initial desktop assessment. Conversely, some site locations that seemed like potential opportunities for BMP implementation were excluded from further analysis due to specific site conditions. A total of 21 sites were removed from this plan, primarily because upon visiting these sites in the field, they were found to be sites where in-stream erosion was occurring. Although these areas are problematic and should be addressed in the future, they did not fall under the scope of this plan. In cases where it was possible to address stormwater runoff that is contributing to the in-stream erosion, additional sites were added to the list of potential BMPs.

Figure C5. 57 potential sites for BMP implementation were identified for field investigation.

Following these refinements, the list of potential BMPs in the Town of Plainfield numbered 50 (Figure C6). A memo detailing this site refinement and associated maps and tables are included as Appendix C4 - Site Refinements.

2.2 Preliminary BMP Ranking

After the initial field visits were completed and the project list was updated, a preliminary ranking system was utilized to prioritize these 50 projects (Figure C6). The goal of this ranking was to identify the 20 sites that would provide the greatest water quality benefit and have a high likelihood of implementation. This prioritization was accomplished by completing an assessment of project feasibility and benefits including drainage area size, pollutant load reduction potential, proximity to water, land ownership, and feasibility issues. See Appendix C5 - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix C5 is the completed ranking for each potential site, one-page field data summary sheets with initial ranking information, and a memo detailing this ranking process.

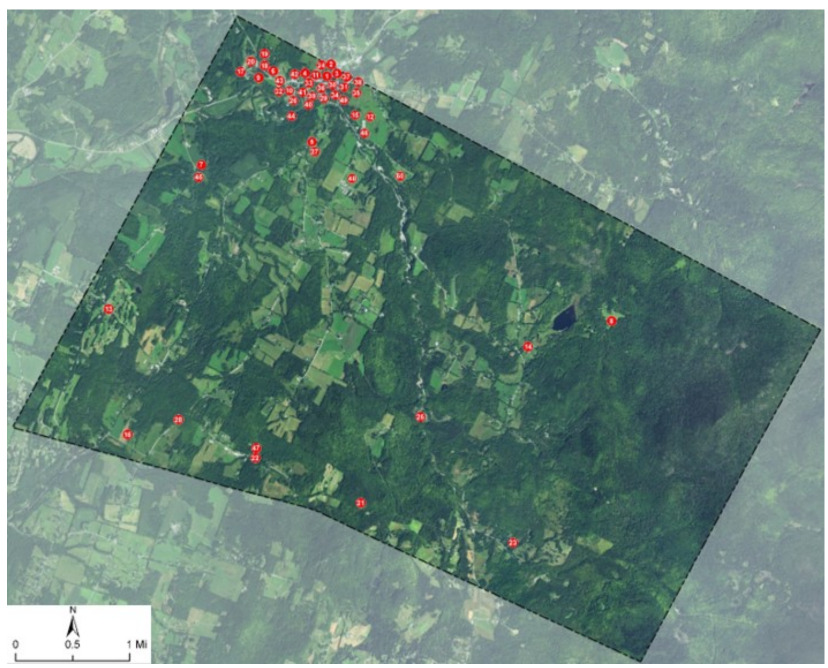

Figure C6. Following field investigations, the list of potential BMP sites was refined to 50. Point locations are shown for each site.

The draft Top 20 list was distributed to the Town of Plainfield and the CVRPC. As part of this process, the project team met with the stakeholders on September 5th, 2017 to discuss the proposed Top 20 project sites. Following feedback from the Town, the list was refined to reflect the Town's knowledge of potentially unwilling landowners, and the Town's priorities. Note that one additional site, Middle Road Ditch N, was added to the list of Top 20 per the Town's request. These Top 20 sites are listed in Table C1. Point locations are shown in Figure C7.

Table C1. Top 20 BMPs selected for the Plainfield SWMP.

Site ID	Proposed Practice Type
Plainfield Health Center	Detention Step Pools and Gully Stabilization
Plainfield Park & Ride	Gravel Wetland
Route 2 from Robert Ln to Horse Farm	Gravel Wetland
123 School Street Front Yard	Subsurface Infiltration Chambers
Middle Road Ditch N	Ditch improvements (check dams, turnouts)
Middle Rd Ditch S	Ditch improvements (check dams, turnouts)
Lee Road	Ditch improvements (check dams, turnouts)
Flood Rd Swale	Ditch improvements (check dams, turnouts)
Brook Rd Step Pools	Outlet control, retrofit of existing step pools, and improve roadside ditching across street
Middle Rd and Lower Rd	Ditch improvements (check dams, turnouts)
2 Lower Rd	Infiltration Basin
Gonyeau Rd	Road stabilization, ditch improvements
Plainfield Town Offices	Infiltration Trench
Martin Meadow Loop	Subsurface Infiltration Chambers
Upper Rd and Brook Rd	Ditch improvements (check dams, turnouts)
Plainfield Main St GSI	Bioretention, curb bump outs, rain barrels, etc.
Brook Rd Swale	Ditch improvements (check dams, turnouts)
High St	Subsurface infiltration chambers or dry wells
Upper Rd near Gonyeau Rd	Ditch improvements (check dams, turnouts)
Plainfield Library	Bioretention

2.3 Modeling and Concept Refinement for Top 20 BMPs

Modeling was completed for each of the Top 20 sites. This modeling allowed for accurate sizing of the proposed practices, as well as an understanding of the water quality and quantity benefits. The contributing drainage area of each of the BMPs was defined and landuse/landcover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations (see Appendix C6 – Top 20 Sites for drainage area delineations). Each of the sites was modeled in HydroCAD to determine the appropriate BMP size and resultant stormwater volume reductions (see Appendix C7 - Top 20 Sites Modeling for modeling reports).

Each of these sites was also modeled using the Source Loading and Management Model for Windows (WinSLAMM) to determine the annual total suspended solids (TSS) and total phosphorus (TP) loading from the drainage area of each site. Pollutant load reductions from each of the BMPs were then calculated using one of two sources, depending on the practice type. WinSLAMM was used when possible, and, for those practices that WinSLAMM does not model well (generally non-infiltration based practices; based on experience and literature), pollutant removal rates published by the University of New Hampshire Stormwater Center were applied to the initial pollutant loading modeled with WinSLAMM for the site's current conditions. This yielded expected pollutant removal loads (lbs) and rates (%). The modeled volume and pollutant loading reductions are shown in Table C2. Complete modeling results are provided in Appendix C7 - Top 20 Sites Modeling.

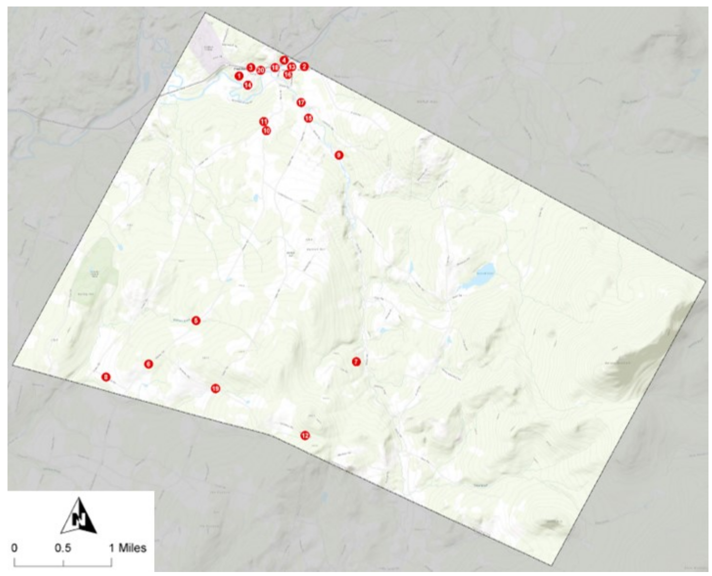

Figure C7. The Top 20 project locations are shown.

Table C2. Modeled volume and pollutant load reductions for the Top 20 BMPs.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Plainfield Health Center	1.406	0.716	552,410	79% (Detention Pond); 88.5% (Gully Stabilization)	163.5	0% (Detention); 76.9% (Gully Stabilization)
Plainfield Park & Ride	0.120	--	1,102	96%	0.66	58%
Route 2 from Robert Ln to Horse Farm	0.439	--	5,904	96%	3.30	58%
123 School Street Front Yard	0.100	0.100	1,936	96.07%	1.36	95.87%
Middle Road Ditch N	0.16	--	1,275	65%	0.34	20%
Middle Rd Ditch S	0.731	--	6,564	65%	1.47	20%
Lee Road	0.50	--	5,323	65%	1.39	20%
Flood Rd Swale	0.812	--	4,761	65%	1.74	20%
Brook Rd Step Pools	0.05	--	4,092	65%	1.03	20%
Middle Rd and Lower Rd	0.17	--	1,401	65%	0.31	20%
2 Lower Rd	0.198	0.354	4,312	77.84%	4.09	74.98%
Gonyeau Rd	1.530	--	13,530	65%	3.60	20%
Plainfield Town Offices	0.087	0.087	928	86.28%	0.51	86.21%
Martin Meadow Loop	0.186	0.186	2,503	99.44%	1.99	99.42%
Upper Rd and Brook Rd	0.68	--	5,107	65%	1.47	20%
Plainfield Main St GSI	0.187	0.100	2,180	87%	0.57	34%
Brook Rd Swale	0.087	0.087	1,006	65%	0.35	20%
High St	0.134	0.134	1,509	99%	1.09	98.65%
Upper Rd near Gonyeau Rd	0.230	--	2,404	65%	0.57	20%
Plainfield Library	0.001	--	252	87%	0.04	34%

2.4 Final Ranking Methodology

A prioritization matrix was utilized to quantitatively rank each of the Top 20 projects. Considerations that factored into the ranking of BMP projects included:

- Impervious area managed
- Ease of operation and maintenance
- Volume managed
- Volume infiltrated
- Permitting restrictions
- Land availability
- Flood mitigation
- TSS removed
- TP removed
- Other project benefits
- Project cost

Each of these criteria are listed and explained in Appendix I - Top 20 Site Final Ranking. The scores associated with each of the categories are also provided in this table.

2.4.1 Project Cost Estimation

Project cost, listed as one of the criteria considered, was calculated for each project using a spreadsheet-based method. The methodology for determining these planning level costs was first developed for the City of South Burlington by the Horsley Witten (HW) Group as part of the Centennial Brook Flow Restoration Plan development. The HW Memorandum describing this methodology is provided in Appendix C9. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix C8 - Top 20 Site Final Ranking. This methodology provides consistent budgetary cost estimates across BMPs.

Cost estimates are based on average costs for conceptual level projects and deviation from these estimates are expected as projects move forward with engineering design. There are differences between project cost estimates presented in the plan and actual project bid costs. The BMP cost estimates presented in the plan are based on limited site investigation. This methodology, while providing consistency in budget cost estimating, may fail to accurately reflect project cost impacts associated with actual site conditions and constraints. Therefore, the BMP cost estimates presented are suitable for planning purposes only, and not detailed program budgeting. The BMP cost estimates were developed based on the following assumptions:

Design Control Volumes: Design control volumes were based on the estimated runoff volume associated with the Channel Protection volume (CPv) or Water Quality volume (WQv) storm events for off-line, underground, or green stormwater infrastructure (GSI)-type practices. Off-line stormwater management systems are designed to manage storm events by diverting a percentage of stormwater from a storm drainage system. Underground systems and GSI-type practices were conceptually designed as offline practices that only accept runoff from the target storm event. Runoff volumes for all storm events were determined based on HydroCAD model results that rely on the Soil Conservation Service (SCS) TR-55 and TR-20 hydrologic methods.

Unit Costs and Site Adjustment Factors: Unit cost for each BMP and site adjustment factors were derived from research by the Charles River Watershed Association and Center for Watershed Protection, as well as from experience with actual construction[4] and modified for this project to reflect the newest cost estimates available. Underground filtration chamber systems were typically designed using Stormtech MC-4500™ chamber systems. Cost adjustment factors were used to account for site-specific differences typically related to project size, location, and complexity. The values used to estimate BMP costs are summarized in Table C3 below.

Table C3. BMP unit costs and adjustment factors modified to reflect newer information.

BMP Type	Base Cost ($/ft^3)
Porous Asphalt	$5.32
Infiltration Basin	$6.24
Underground Chamber (infiltration or detention)	$6.25
Detention Basin / Dry Pond	$6.80
Gravel Wetland	$8.78
Infiltration Trench	$12.49
Bioretention	$15.46
Sand Filter	$17.94
Porous Concrete	$18.07
Site Type	**Cost Multiplier**
Existing BMP retrofit or simple BMP	0.25
Large aboveground basin projects	0.5
New BMP in undeveloped area	1
New BMP in partially developed area	1.5
New BMP in developed area	2
Difficult installation in highly urban settings	3

Site-Specific Costs: Cost of significant utility or other work related to the construction of the BMP itself. Site-specific costs are variable based on past experience.

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

[4] Horsley Witten Group, Inc. 2014. Centennial Brook Watershed: Flow Restoration VTBMPDSS Modeling Analysis and BMP Supporting Information. Memorandum dated January 9th, 2014.

Permits and Engineering Costs: Used either 20% for large aboveground projects or 35% for smaller or complex projects.

Land Acquisition Costs *(Modified)*: A variation from the HW method was applied. Based on prior studies completed by WCA, the land acquisition cost was calculated as $120,000 per acre required for the BMP when located on private land. It should be noted that this value is based on a limited estimate, and not necessarily an expected cost per acre. At this time, no land acquisition costs were built into the costs provided. It is assumed at this time that sites not owned by the Town will retain ownership of the stormwater management sites.

Total Project Cost: Calculated as the sum of the base construction cost, permitting and engineering costs, and land acquisition costs.

Cost per Impervious Acre: Calculated as the construction costs plus the permitting and engineering costs, divided by the impervious acres managed by the BMP.

Operation and Maintenance: The annual operation and maintenance (O&M) was calculated as 3% of the base construction costs, with a maximum of $10,000.

Minimum Cost Adjustment: After total project costs were determined for each proposed BMP based on the HW methodology, costs were reviewed and adjusted so that projects involving a simple BMP such as a small rain garden were assigned a minimum cost of $10,000 and more complex projects were assigned a minimum cost of $25,000.

Road Improvement Projects: A separate cost estimation methodology was used for road improvement projects for the Town of Plainfield. Cost estimates for these improvements are dependent on the road length to be improved, the number of check dams, the number of turnouts, and the number of step pools proposed. A base unit cost was determined for each of these factors based on previous design and implementation experience for similar projects. See Appendix C8 for a full description of each of these factors.

2.4.2 Final Ranking Scoring

Each of the factors noted in Appendix C8 - Top 20 Site Final Ranking were scored, and scores were totaled for each of the criteria. Projects were assigned a rank from 1 to 20 with those projects receiving the highest scores assigned the highest rank. In the case of a tie between two projects, the TP removed (lbs) by the practice was used as a tiebreaker.

2.5 Final Modeling and Prioritization

A summary of the practices and ranks are shown below in Table C4. The comprehensive ranking matrix used to rank the proposed BMP projects is provided in Appendix C8 - Top 20 Site Final Ranking. If future funding becomes available for further implementation, this prioritization matrix can be utilized in selecting additional projects for implementation.

Table C4. Top 20 potential BMP sites for the Town of Plainfield.

Rank	Site ID	Address	Proposed Practice Type
1	Plainfield Health Center	157 Towne Ave	Detention Step Pools and Gully Stabilization
2	Plainfield Park & Ride	165 Main St	Gravel Wetland
3	Route 2 from Robert Ln to Horse Farm	268 High Street / Roberts lane	Gravel Wetland
4	123 School Street Front Yard	123 School Street	Subsurface Infiltration Chambers
5	Middle Road Ditch N	2084 Middle Rd	Ditch improvements (check dams, turnouts)
6	Middle Rd Ditch S	3000 Middle Rd	Ditch improvements (check dams, turnouts)
7	Lee Road	Lee Road	Ditch improvements (check dams, turnouts)
8	Flood Rd Swale	Flood Rd, east of intersection with Lower Rd	Ditch improvements (check dams, turnouts)
9	Brook Rd Step Pools	Brook Rd	Outlet control, retrofit of existing step pools
10	Middle Rd and Lower Rd	Middle Rd and Lower Rd	Ditch improvements (check dams, turnouts)
11	2 Lower Rd	2 Lower Rd	Infiltration Basin
12	Gonyeau Rd	Gonyeau Rd	Road stabilization, ditch improvements
13	Plainfield Town Offices	169 Main St	Infiltration Trench
14	Martin Meadow Loop	150 Martin Meadow Rd	Subsurface Infiltration Chambers
15	Upper Rd and Brook Rd	Upper Rd and Brook Rd	Ditch improvements (check dams, turnouts)
16	Plainfield Main St GSI	Main St	Bioretention, curb bump outs, rain barrels, etc.
17	Brook Rd Swale	Brook Rd, north of Camron Rd	Ditch improvements (check dams, turnouts)
18	High St	High St and Harvey Hill	Subsurface infiltration chambers or dry wells
19	Upper Rd near Gonyeau Rd	Gonyeau Rd and Upper Rd	Ditch improvements (check dams, turnouts)
20	Plainfield Library	High St, west of Towne Ave	Bioretention

A map of each project showing the drainage areas and BMP locations can be found in Appendix C6 - Top 20 Sites, and project locations within the watershed can be found in Appendix C8 - Top 20 Site Final Ranking.

2.6 Selection of Top 5 Potential BMPs

Figure C8. Top 5 sites for the Town of Plainfield SWMP.

Selection of the Town's Top 5 sites considered the results from initial site investigations and preliminary modeling and ranking, input from municipal officials concerning project priorities, and the willingness of select private landowners to voluntarily participate in this plan. As part of this process, the project team met with the project stakeholders on September 5th, 2017 to discuss potential Top 5 project sites. While the preferred Top 5 list was selected, it was not confirmed until appropriate landowner permission was acquired for the BMPs located on private property (Plainfield Health Center, Route 2 from Robert Ln to Horse Farm, and 123 School Street Front Yard). The location of these sites within the Town of Plainfield is shown in Figure C8. In the final ranking (2.4 Final Ranking Methodology), these 5 sites were awarded additional points in the site scoring to reflect the Town's priorities and high-probability for implementation. The Top 5 sites are listed in Table C5.

Table C5. Top 5 BMP sites for the Town of Plainfield.

Rank	Site ID	Address	Proposed Practice Type
1	Plainfield Health Center	157 Towne Ave	Detention Step Pools and Gully Stabilization
2	Plainfield Park & Ride	165 Main St	Gravel Wetland
3	Route 2 from Robert Ln to Horse Farm	268 High Street / Roberts lane	Gravel Wetland
4	123 School Street Front Yard	123 School Street	Subsurface Infiltration Chambers
5	Middle Road Ditch N	2084 Middle Rd	Ditch improvements (check dams, turnouts)

3 Priority BMPs

The selected Top 5 BMP implementation sites are briefly described below. These opportunities are located on Town property (two projects), State property (one project), and private property (two projects). Descriptions of each site are provided below. Individual drainage area maps and an overview map of these Top 5 sites are provided in Appendix C10.

Site: 1

Project Name: Plainfield Health Center

Description: The site includes the Plainfield Health Center and associated parking lots and driveway, and drainage collected from High St and Towne Ave. Drainage from the Health Center, part of Towne Ave, and the Post Office is collected onsite and managed, per their State stormwater permit requirements, in a wet pond located to the south of the main facility. Stormwater from Route 214 is conveyed as overland flow and through vegetated swales to High St where it enters the storm system by the horse farm. Although the stormline from High St bypasses the Health Center's treatment practice, it outlets to the same location as the Health Center's pond. Due to poor soils and concentrated stormwater flow, the outlets have formed an eroded gully down to the Winooski River (Figure C9). This gully also threatens the integrity of the pond. The concept for this site includes a series of step pools separated by gabion weirs below the outlets. Regrading and bioengineered slope stabilization is proposed to stabilize the rest of the gulley. Soils are mapped as being poor, and very poor at this site (Hydrologic Groups C and D), therefore soils and infiltration testing was not conducted to pursue an infiltration practice.

Figure C9. Stormwater that drains to the pictured gully from both the Health Center's detention pond outlet and from an unmanaged stormwater outfall. Significant erosion has occurred.

Outreach: Contact was made with Plainfield Health Center practitioner, Dr. John Matthew Sr., and Jonathan Matthew Jr., the property owner for the lower property where the gully has formed. Both landowners have expressed willingness to allow further design to be completed at the site.

Site: 2
Project Name: Plainfield Park and Ride
Description: The site includes the Park and Ride located on Main St. Stormwater currently sheet flows through this area. The concept for this site includes the implementation of a vegetated swale along the western edge of the park and ride, and a gravel wetland at the eastern end of the park and ride, across from the existing solar panels (Figure C10). The gravel wetland would outlet to the existing swale. Soils are mapped as being poor at this site (Hydrologic Group C), therefore soils and infiltration testing was not conducted to pursue an infiltration practice.
Outreach: This site is owned by the Town of Plainfield and as such, no additional outreach was conducted.

Figure C10. The location of the proposed gravel wetland abutting the paved Park and Ride parking lot.

Site: 3
Project Name: Route 2 from Robert Ln to Horse Farm
Description: The site includes the area between Black Bear Biodiesel and the house at the corner of Robert Ln. Stormwater from the upper extent of the drainage area is collected and conveyed as overland flow in vegetated swales, one by the horse farm, and the other to the west of Black Bear biodiesel. Currently, water ponds in between the horse farm and Route 2. The concept for this site includes a gravel wetland in the vegetated area to the west of Black Bear Biodiesel's parking lot (Figure C11), and rerouting the High St swale into the feature. This would outlet to the existing stormline which discharges to the Winooski River. Soils are mapped as being very poor at this site (Hydrologic Group D), therefore soils and infiltration testing was not conducted to pursue an infiltration practice.
Outreach: Contact was made with property owner Paul Rose. Mr. Rose expressed his interest in advancing a design for his property.

Figure C11. Depressed area adjacent to Robert Lane where the proposed gravel wetland would be located.

Site: 4
Project Name: 123 School Street Front Yard
Description: The site includes the School House Apartment building and associated driveway and parking lot as well as a stormline on School St. Stormwater from the School House property and a portion of School St is collected in a stormline that outlets to the Winooski River, southwest of the site. The concept for this site includes rerouting the stormline on School St and the stormline from the apartment parcel to an underground storage and infiltration chamber system to the west of the walkway in the front lawn of the School House building (Figure C12). This system could also incorporate discharge from the building's sump pump, and would outlet to the existing stormline on School St. Soils are mapped as being good at this site (Hydrologic Group B), therefore soils and infiltration testing was conducted to evaluate the potential for an infiltration practice. Soils were found to be generally sandy, with a moderately-high infiltration rate.

Figure C12. Grass lawn area between the apartment building and School Street where the proposed subsurface infiltration chambers would be located.

Outreach: Contact was made with Nikki Ariste of the Vermont State Housing Authority, and she expressed interest in advancing a design for this property.

Site: 5
Project Name: Middle Road Ditch N
Description: The site includes a section of roadside ditching along Middle Rd between a farmhouse and a small tributary. Stormwater is currently conveyed via roadside ditching to the tributary. The combination of poor soils and steep slopes has degraded the quality and stability of the road surface, prompting extensive erosion throughout this area during storm events. The concept for this site includes the removal of existing grader berms and failing check dams, regrading, improvements to ditching, reducing road width, adding strategic turnouts, and adding level spreaders at the end of the ditching on both sides of the road prior to confluence with the tributary. Soils are mapped as being very poor at this site (Hydrologic Group D), therefore soils and infiltration testing was not conducted to pursue an infiltration practice.
Outreach: This site is owned by the Town of Plainfield and as such, no additional outreach was conducted.

Figure C13. A section of Middle Road where roadside ditches are filled with sediment.

When implemented, these five BMPs would treat approximately 85.6 acres, 8.6 acres (10%) of which are impervious. Modeled pollutant reductions for each of the projects, shown below in Table C6, indicate that these BMPs will prevent nearly 563,000 lbs of TSS and more than 169 lbs of TP from reaching receiving waters annually.

Table C6. Pollutant reductions and select ranking criteria for Top 5 projects.

Site ID	Volume Managed (ac-ft)	Volume Infiltrated (ac-ft)	Total Suspended Solids Removal (lbs)	Total Suspended Solids Removal (%)	Total Phosphorus Removal (lbs)	Total Phosphorus Removal (%)
Plainfield Health Center	1.406	0.716	552,410	79% (Detention Pond); 88.5% (Gully Stabilization)	163.5	0% (Detention); 76.9% (Gully Stabilization)
Plainfield Park & Ride	0.120	--	1,102	96%	0.66	58%
Route 2 from Robert Ln to Horse Farm	0.439	--	5,904	96%	3.30	58%
123 School Street Front Yard	0.100	0.100	1,936	96.07%	1.36	95.87%
Middle Road Ditch N	0.16	--	1,275	65%	0.34	20%

Site surveys were completed for each of the Top 5 sites, and existing conditions plans were developed. These plans were used as the basis for the 30% proposed condition plans that were developed for each site. See Appendix C11 - Existing Conditions Plans for these plans.

4 30% Designs

30% engineering designs were completed for each of the Top 5 sites. Site-specific concepts are discussed in the following sections. All 30% designs can be found in Appendix C12 - 30% Designs.

A geotechnical analysis was carried out for the 123 School Street Front Yard site as the proposed practice is infiltration-based. Infiltration testing was not completed for the remaining sites as infiltration-based practices were not recommended based on field-observed conditions and mapped soil types.

Infiltration testing was completed using a falling head borehole test using a 2-inch diameter PVC pipe (Figure C14). The result of this testing is a soil infiltration rate (inches/hour), a measurement of the movement of water through soils.

Figure C14. The falling head infiltration test in progress at the School Street apartment site.

4.1 Plainfield Health Center

4.1.1 30% Concept Design Description

Drainage from the Plainfield Health Center is currently managed by a stormwater detention pond that outfalls to the south of the property. This wet pond manages stormwater from the Health Center and associated parking lots and driveway, part of Towne Avenue, and the Post Office, per State stormwater permit requirements.

Stormwater from High Street, Towne Avenue, and a stretch of Route 214 is included in this proposed BMP drainage area as stormwater from the north and east of Route 214 travels via overland flow and via vegetated swales to High St where it enters the storm system by the horse farm. This stormline bypasses the Health Center's wet pond, but outfalls in the same location as the pond outlet pipe.

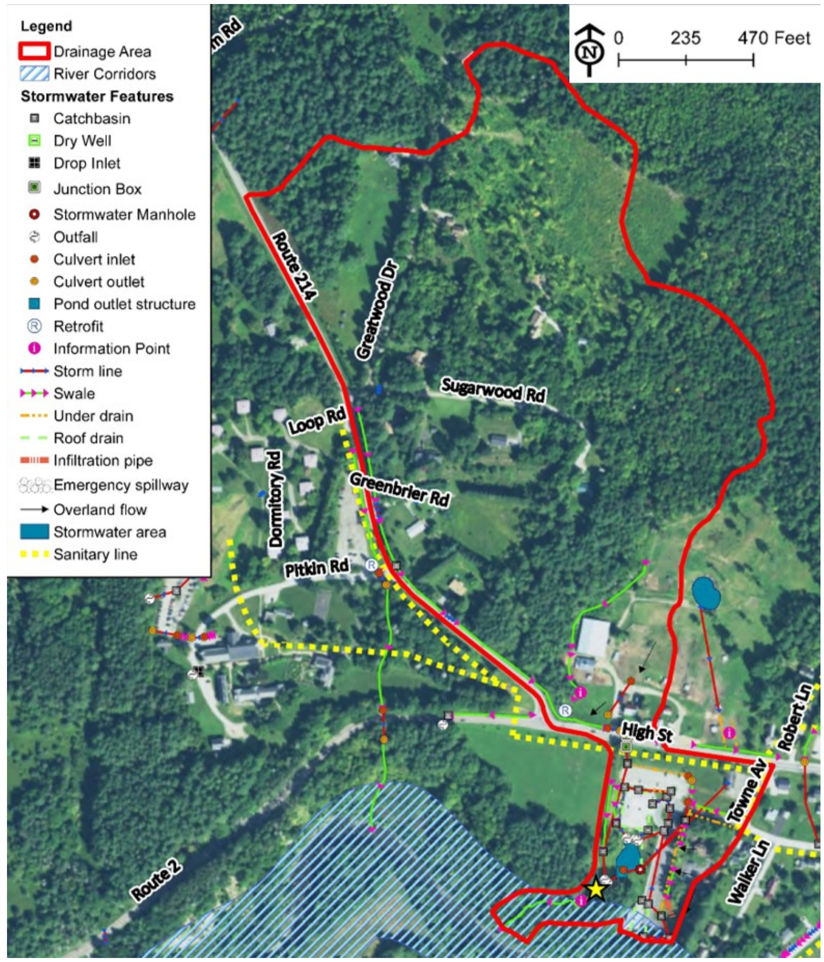

Figure C15. The drainage area is shown outlined in red for the Plainfield Health Center site. The location of the proposed gully stabilization is shown with a star.

Due to concentrated stormwater flows, poor soils, and a large contributing drainage area, the outlets have formed an eroded gulley down to the Winooski River. This gulley also threatens the integrity of the pond as it is actively head cutting.

The concept for this site includes a series of step pools separated by gabion weirs below the two outlets. Regrading and bioengineered slope stabilization is proposed to stabilize the rest of the gulley (see starred location in Figure C15).

Soils are mapped as being poor, to very poor in terms of infiltration potential at this site (Hydrologic Groups C and D), so soils and infiltration testing was not completed.

The design standard used for this retrofit was management of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 61,245 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C10 - Top 5 Sites. A 30% design plan is provided in Appendix C12 - 30% Designs.

4.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent more than 552,000 lbs of total suspended solids (TSS) and 163.5 lbs of total phosphorus (TP) from entering receiving waters (Table C7).

Table C7. Plainfield Health Center benefit summary table.

TSS Removed	552,410 lbs
TP Removed	163.5 lbs
Impervious Treated	5.3 acres
Total Drainage Area	63.6 acres

4.1.3 Cost Estimates

The estimated cost for this project is $206,000. Note that these costs are very preliminary. Costs are shown in Table C8. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $1,260.
- The cost per impervious acre treated is $38,868.
- The cost per cubic foot of runoff treated is $3.36.

Table C8. Plainfield Health Center project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	250	$1.17	$292.50
649.51	Geotextile for silt fence	SY	250	$4.13	$1,032.50
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
652.20	Monitoring EPSC Plan	HR	10	$37.22	$372.20
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$4,417.20
Step Pools					
203.15	Common Excavation	CY	4125	$9.86	$40,672.50
613.25	Gabion Wall	CY	215	$188.55	$40,538.25
613.10	Type I Stone (splash pad)	CY	60	$43.91	$2,634.60
653.20	Temporary Erosion Matting	SY	1200	$2.20	$2,640.00
651.15	Seed	LBS	60	$7.66	$459.60
				Subtotal:	$86,944.95
Swale Regrading and Bioengineering					
203.15	Common Excavation	CY	700	$9.86	$6,902.00
613.10	Type I Stone	CY	225	$43.91	$9,879.75
613.11	Type II Stone	CY	110	$42.49	$4,673.90
656.41	Plants* (Perennials)	EACH	5000	$8.77	$43,850.00
653.20	Temporary Erosion Matting	SY	1200	$2.20	$2,640.00
651.15	Seed	LBS	60	$7.66	$459.60
649.51	Geotextile for silt fence	SY	250	$4.13	$1,032.50
				Subtotal:	$69,437.75
Subtotal:					$160,799.90
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$16,079.99
	Incidentals to Construction - 5%**				$8,040.00
	Minor Additional Design Items - 5%**				$8,040.00
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$206,000.00**

4.1.4 Next Steps

Contact was made with Plainfield Health Center practitioner, Dr. John Matthew Sr., and Jonathan Matthew Jr., the property owner for the lower property where the gully has formed. Both landowners have expressed willingness to allow further design to be completed at the site. Further design will involve refinement of the retrofit design with respect to size and design to ensure that all storms can be passed through the system safely, and that the severe gully erosion is mitigated.

4.1.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C13 - Permit Review Sheets. In summary:

Stormwater Permit
The Health Center site already has an existing permit (4655-9015.A) for the detention pond on their property. It is not anticipated that the proposed retrofits would require an additional stormwater permit.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by the River Scientist prior to final design due to the gully stabilization required within the river corridor and FEMA Flood Hazard Area. However, the structural step pools are located outside of the river corridor. An Act 250 permit for the one-story health center building (5W0427) exists, and as such this project should be reviewed to determine if an amendment to this permit would be required. There are no wetlands concerns anticipated for this project.

4.2 Plainfield Park and Ride

4.2.1 30% Concept Design Description

The Plainfield Park and Ride site is located on Main Street. The recently paved parking lot currently sheet flows through this area and does not have any formal water quality management.

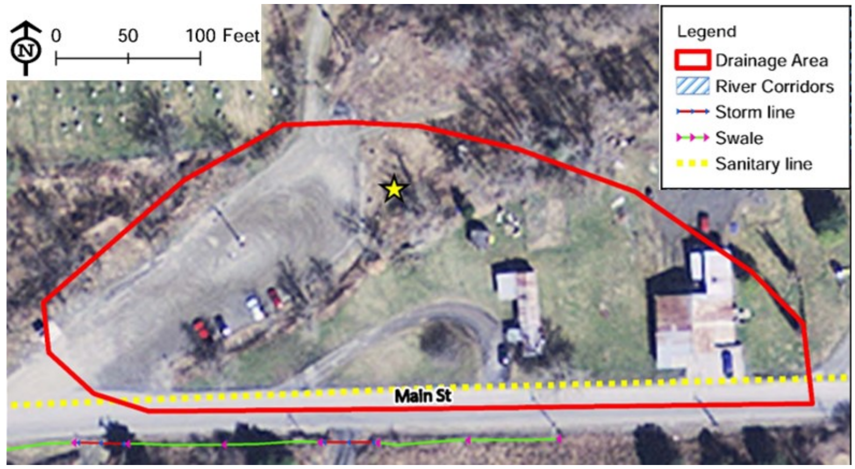

Figure C16. A gravel wetland is proposed to manage drainage from the Plainfield Park and Ride and surrounding area. The recommended location is shown with a star.

The proposed stormwater improvements for this site include the creation of a vegetated swale along the western edge of the park and ride to direct flow to the northeast. The swale would pass under the Town Well Access Road in a culvert and be directed to a gravel wetland at the eastern end of the park and ride, across from the existing solar panels (Figure C16). The gravel wetland would outlet to the existing swale.

Soils are mapped as having poor infiltration potential at this site (Hydrologic Group C), so soils and infiltration testing was not conducted to pursue an infiltration practice.

The design standard used for this retrofit was detention and slow release of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period) for the gravel wetland feature, equal to 5,227 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C10 - Top 5 Sites. A 30% design plan is provided in Appendix C12 - 30% Designs.

4.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent nearly 2,000 lbs of total suspended solids (TSS) and 0.75 lbs of total phosphorus (TP) from entering receiving waters (Table C9). The retrofits in this location also have the potential to raise awareness of stormwater issues in the Town, as the proposed location for the practice has high visibility. It is recommended that an educational sign be installed in conjunction with the retrofits.

Table C9. Plainfield Park and Ride benefit summary table.

TSS Removed	1,906 lbs
TP Removed	0.75 lbs
Impervious Treated	0.9 acres
Total Drainage Area	1.8 acres

4.2.3 Cost Estimates

Note that two separate cost estimates are provided. The first, which totals $73,000, includes plant plugs while the second cost, $69,000, includes only seeds for planting of the gravel wetland practice. Plant plugs are recommended as they have a higher survival rate and provide ground cover much faster. However, seeds are also an option if funding is limited. Note that these costs estimates are very preliminary. Costs are described in Table C10. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $97,333 for the plant plugs and $92,000 for the seeds.
- The cost per impervious acre treated is $81,111 for the plant plugs and $76,667 for the seeds.
- The cost per cubic foot of runoff treated is $13.97 for the plant plugs and $13.20 for the seeds.

Table C10. Plainfield Park and Ride project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	250	$1.17	$292.50
649.51	Geotextile for silt fence	SY	45	$4.13	$185.85
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
652.20	Monitoring EPSC Plan	HR	12	$37.22	$446.64
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$3,644.99
Gravel Wetland					
203.15	Common Excavation	CY	300	$9.86	$2,958.00
651.35	Muck Soil (Topsoil)	CY	5	$30.96	$154.80
629.54	3/4" to 1 1/2" Crushed Stone (Crushed Stone Bedding)	TON	40	$34.04	$1,361.60
629.54	Pea Stone (Crushed Stone Bedding)	TON	5	$34.04	$170.20
613.10	Type I Stone (hydraulic inlet)	CY	12	$43.91	$526.92
613.11	Type II Stone (overflow)	CY	30	$42.49	$1,274.70
301.26	Sand (Subbase of Gravel, Fine Graded)	CY	52	$40.03	$2,081.56
649.31	Geotextile Under Stone Fill	SY		$2.51	$0.00
656.41	Plants* (Perennials)	EACH	450	$8.77	$3,946.50
N/A	Wetland Plant Seeds	LBS	6	$125.00	$750.00
651.15	Seed	LBS	5	$7.66	$38.30
653.20	Temporary Erosion Matting	SY	250	$2.20	$550.00
605.11	8" Underdrain Piping	LF	20	$27.04	$540.80
601.0915	18" CPEP Outlet Works	LF	10	$64.04	$640.40
N/A	18" Anti-Seep Collar	EACH	1	$250.00	$250.00
N/A	18" Beehive Grate with Anti-Vortex Baffle	EACH	1	$615.00	$615.00
N/A	30 Mil PVC Liner	SY	315	$5.68	$1,789.20
604.20	New Catch Basin	EACH	1	$3,387.59	$3,387.59
601.0915	18" CPEP	LF	75	$64.04	$4,803.00
				Subtotal:	$17,647.98
Dry Swale					
203.15	Common Excavation	CY	260	$9.86	$2,563.60
651.15	Seed	LBS	5	$7.66	$38.30
653.20	Temporary Erosion Matting	SY	225	$2.20	$495.00
				Subtotal:	$28,935.47
Subtotal:					$50,228.44
	Construction Oversight**	HR	32	$100.00	$3,200.00
	Construction Contingency - 10%**				$5,022.84
	Incidentals to Construction - 5%**				$2,511.42
	Minor Additional Design Items - 5%**				$2,511.42

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total Plugs Option (Rounded)					**$73,000.00**
Total Seed Option (Rounded)					**$69,000.00**

4.2.4 Next Steps

As this site is owned and operated by Plainfield, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely managed, and larger storms passed through the system safely.

4.2.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C13 - Permit Review Sheets. In summary:

Stormwater Permit
This site is not anticipated to need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250 permitting, river corridor concerns, or wetlands issues are anticipated for this project. It should be noted that this project falls within the primary recharge area for the Plainfield Town water source. However, it is not expected that this will be a concern with final design or implementation as it will not adversely impact groundwater. The project will improve runoff water quality in the source protection area. The site should still be reviewed by the Drinking Water and Groundwater Division prior to final design.

4.2.6 Site Rendering

A rendering of the proposed stormwater improvements was created to bring a concept to life in ways that engineering plans cannot. This graphically engaging rendering visually communicates the plans and can be used by the Town and the CVRPC to help advance designs toward implementation. This rendering can be found in Appendix C15 - Site Rendering.

4.3 Route 2 from Robert Ln to Horse Farm

4.3.1 30% Concept Design Description

Currently, drainage from a large hillslope travels via overland flow to a shallow swale along High Street. There is routinely-ponded water in this swale along High Street. While neither the Town nor property owners have noticed that the water floods up onto High Street, it has come close to doing so. This is worsened as the cross-culvert beneath Robert Lane (draining the swale to a depressed area to the east of Robert Lane), and the culvert beneath High Street are not functioning well. Stormwater is also conveyed via overland flow in a vegetated swale to the north and west of Black Bear biodiesel to this same location (see starred location in Figure C17).

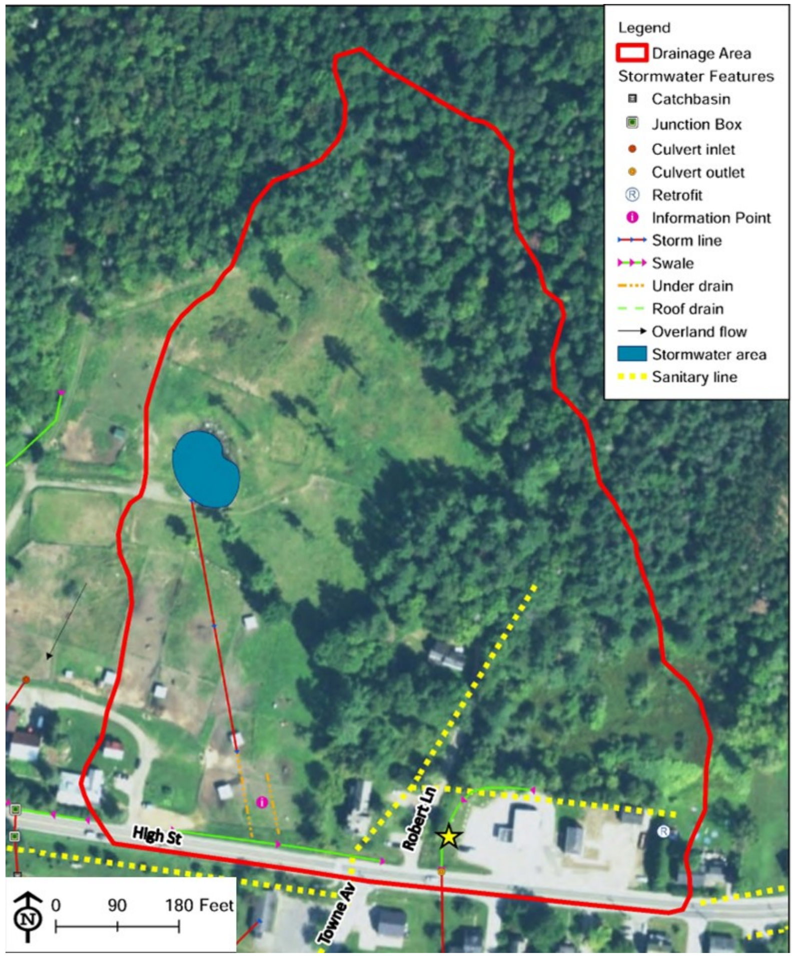

Figure C17. The Route 2 from Robert Ln to Horse Farm drainage area includes private commercial, residential, and agricultural properties as well as a section of High Street. The location of the proposed gravel wetland is shown with a star.

The proposed solution for this site includes improved conveyance of stormwater from the swale in front of the horse farm to the depressed area between Robert Lane and Black Bear Biodiesel (see starred location in Figure C17), and the implementation of a gravel wetland in this area. The treated stormwater would outlet to the existing stormline under High Street. However, it should be noted that there is a suspected illicit discharge to the existing stormline where this practice would discharge, and sections of the pipe appear to be failing. These issues should be repaired as soon as possible.

Soils are mapped as being very poor for infiltration at this site (Hydrologic Group D), so soils and infiltration testing were not conducted to pursue an infiltration practice.

The drainage area for this proposed BMP is 17 acres, about 8% of which is classified as impervious. However, much of the drainage area is agricultural, located on a fairly-steep hillslope, and underlain with poor soils. As such, significant water quality benefits are expected from this project (see Table C11). The design standard used for this retrofit was detention and slow release of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 19,123 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C10 - Top 5 Sites. A 30% design plan is provided in Appendix C12 - 30% Designs.

4.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 5,904 lbs of total suspended solids (TSS) and 3.3 lbs of total phosphorus (TP) from entering receiving waters annually (Table C11).

Table C11. Route 2 from Robert Ln to Horse Farm benefit summary table.

TSS Removed	5,904 lbs
TP Removed	3.3 lbs
Impervious Treated	1.4 acres
Total Drainage Area	17 acres

4.3.3 Cost Estimates

Note that two separate cost estimates are provided. The first, which totals $80,000, includes plant plugs while the second cost, $71,000, includes only seeds for planting of the gravel wetland practice. Plant plugs are recommended as they have a higher survival rate and provide ground cover much faster. However, seeds are also an option if funding is limited. Initial cost projections can be found in Table C12. Note that these costs are very preliminary. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $24,242 for the plant plugs and $21,515 for the seeds.
- The cost per impervious acre treated is $57,143 for the plant plugs and $50,714 for the seeds.
- The cost per cubic foot of runoff treated is $4.18 for the plant plugs and $3.71 for the seeds.

Table C12. Route 2 from Robert Ln to Horse Farm project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	350	$1.17	$409.50
653.20	Temporary Erosion Matting	SY	600	$2.20	$1,320.00
649.51	Geotextile for silt fence	SY	115	$4.13	$474.95
652.10	EPSC Plan	LS	1	$1,000.00	$1,000.00
652.20	Monitoring EPSC Plan	HR	8	$37.22	$297.76
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$5,222.21
Gravel Wetland					
203.15	Common Excavation	CY	850	$9.86	$8,381.00
651.35	Muck Soil (Topsoil)	CY	50	$30.96	$1,548.00
629.54	3/4" to 1 1/2" Crushed Stone (Crushed Stone Bedding)	TON	270	$34.04	$9,190.80
629.54	Pea Stone (Crushed Stone Bedding)	TON	25	$34.04	$851.00
613.11	Type II Stone (weirs and overflow)	CY	45	$42.49	$1,912.05
301.26	Sand (Subbase of Gravel, Fine Graded)	CY	60	$40.03	$2,401.80
649.31	Geotextile Under Stone Fill	SY	300	$2.51	$753.00
656.41	Plants* (Perennials)	EACH	1300	$8.77	$11,401.00
N/A	Wetland Plant Seeds	LBS	15	$125.00	$1,875.00
651.15	Seed	LBS	50	$7.66	$383.00
605.11	8" Underdrain Piping	LF	150	$27.04	$4,056.00
601.0915	18" CPEP Outlet Works	LF	20	$64.04	$1,280.80
N/A	18" Anti-Seep Collar	EACH	1	$250.00	$250.00
N/A	18" Beehive Grate with Anti-Vortex Baffle	EACH	1	$615.00	$615.00
N/A	30 Mil PVC Liner	SY	745	$5.68	$4,231.60
				Subtotal:	$49,130.05
New Infrastructure					
604.20	New Catch Basin	EACH	1	$3,387.59	$3,387.59
601.0915	18" CPEP	LF	10	$64.04	$640.40
				Subtotal:	$4,027.99
Subtotal:					$58,380.25
	Construction Oversight**	HR	24	$100.00	$2,400.00
	Construction Contingency - 10%**				$5,838.03
	Incidentals to Construction - 5%**				$2,919.01
	Minor Additional Design Items - 5%**				$2,919.01

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Final Design	HR	80	$100.00	$8,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total Plugs Option (Rounded)					**$80,000.00**
Total Seed Option (Rounded)					**$71,000.00**

4.3.4 Next Steps

Contact was made with property owner Paul Rose. Mr. Rose expressed his interest in advancing a design for his property. Mr. Rose has interfaced with the owners of Black Bear Biodiesel, and indicated that they are also willing to allow further design. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely managed and larger storms passed through the system safely. A formal agreement will need to be reached with the landowners prior to final design.

4.3.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C13 - Permit Review Sheets. In summary:

Stormwater Permit
This site will likely not need a stormwater permit at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
No Act 250 permitting, river corridor issues, or wetlands concerns are anticipated for this project.

4.4 123 School Street Front Yard

4.4.1 30% Concept Design Description

The School Street apartments, located at 123 School Street, are owned by the Vermont Housing Authority. Stormwater runoff from the building, lawn area, parking lot, and driveways, enter a stormline that flows west down School Street and directly into the Winooski River without any water quality improvements. Drainage from several other residential properties, and a section of School Street, are also collected in this stormwater pipe system that flows down School Street.

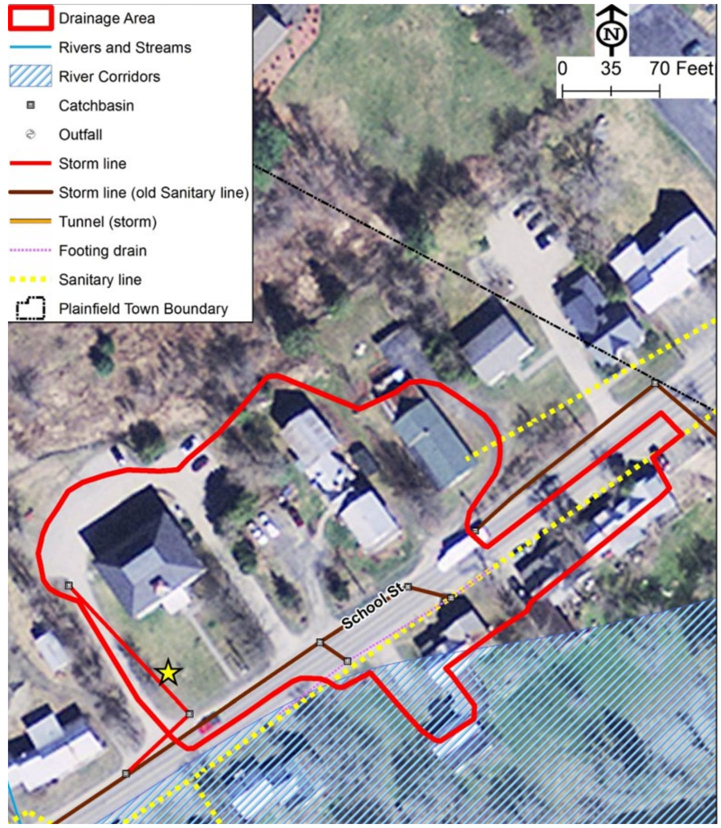

Figure C18. The proposed subsurface infiltration chambers would be located on the front lawn of the School Street apartment building (see starred location).

The stormwater management practice recommended for this site includes rerouting the stormline on School Street, and the stormline that passes through the front lawn area of the apartment building prior to joining the School Street stormline, to a series of subsurface infiltration chambers to the west of the walkway in the front lawn of the apartment building (see starred location in Figure C18). This system would also incorporate discharge from the building's sump pump. The practice would have an overflow that would outlet to the existing stormline on School Street.

Soils are mapped as having good infiltration potential at this site (Hydrologic Group B), so soils and infiltration testing were conducted to evaluate the potential for an infiltration practice. To complete infiltration testing, a 3.25-inch diameter hole was created using a hand auger to conduct a falling head infiltration test. A 2-inch diameter PVC pipe was installed in the augered hole, 41.8 ounces of water was poured into the pipe, and water drop (in inches) was monitored at 10-minute increments. The infiltration rate was measured as 6.24 inches/hour; this is a moderately-high rate. Figure C14 shows the test in progress in the 123 School Street Front Yard site. Soils were generally sandy on site (Figure C19). Complete soil logs and infiltration testing results can be found in Appendix C14 - Soils Investigations.

Figure C19. Soils at the School Street apartments were generally sandy.

The drainage area for this proposed BMP is 1.2 acres, approximately 42% of which is classified as impervious. The design standard used for this retrofit was full infiltration of the Channel Protection volume (CPv, or 2.02 inches of rain in a 24-hour period), equal to 4,356 ft^3 of runoff.

An updated BMP summary sheet is included in Appendix C10 - Top 5 Sites. A 30% design plan is provided in Appendix C12 - 30% Designs.

4.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 1,252 lbs of total suspended solids (TSS) and 0.87 lbs of total phosphorus (TP) from entering receiving waters annually (Table C13).

Table C13. 123 School Street Front Yard benefit summary table.

TSS Removed	1,252 lbs
TP Removed	0.87 lbs
Impervious Treated	0.9 acres
Total Drainage Area	1.6 acres

4.4.3 Cost Estimates

The estimated cost for implementation of this project is $45,000. Note that these costs are very preliminary. Cost projections can be found in Table C14. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used.

- The cost per pound of phosphorus treated is $51,724.
- The cost per impervious acre treated is $50,000.
- The cost per cubic foot of runoff treated is $10.33.

Table C14. 123 School Street Front Yard project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$1,000.00	$1,000.00
653.55	Project Demarcation Fencing	LF	100	$1.17	$117.00
652.10	EPSC Plan	LS	1	$500.00	$500.00
649.51	Geotextile for silt fence	SY	45	$4.13	$185.85
652.20	Monitoring EPSC Plan	HR	8	$37.22	$297.76
	Construction Staking	HR	8	$90.00	$720.00
				Subtotal:	$2,820.61
Chambers - Costs					
	MC3500	EACH	9	$382.80	$3,445.20
	MC3500 PLAIN END CAP	EACH	2	$287.10	$574.20
	MC3500 12T END CAP	EACH	1	$346.50	$346.50
	MC3500 24B END CAP	EACH	1	$386.65	$386.65
	12" 90 BEND	EACH	1	$54.62	$54.62
	12" COUPLERS	EACH	2	$7.93	$15.86
	12" N12 FOR MANIFOLD (AASHTO)	LF	20	$7.58	$151.58
	24" N12 for Isolator Row (AASHTO)	LF	20	$22.06	$441.10
	601TG to wrap system (SY)	SY	1000	$0.64	$638.00
	315WTM for scour protection (SY)	SY	500	$0.66	$330.00
	6" INSERTA TEE	EACH	1	$82.57	$82.57
	6" RED HOLE SAW	EACH	1	$126.68	$126.68
	12" INLINE DRAIN	EACH	1	$297.00	$297.00
				Subtotal:	$6,889.95
Materials and Excavation Costs					
604.20	Concrete Catch Basin	EACH	3	$3,387.59	$10,162.77
203.15	Common Excavation	CY	140	$9.86	$1,380.40
629.54	Crushed Stone Bedding	TON	129	$34.04	$4,391.16
601.0920	24" CPEP	LF	45	$61.37	$2,761.65
651.35	Topsoil	CY	17	$30.96	$526.32
653.20	Temporary Erosion Matting	SY	100	$2.20	$220.00
651.15	Seed	LBS	2	$7.66	$15.32
				Subtotal:	$19,457.62
Subtotal:					$29,168.18
	Construction Oversight**	HR	24	$100.00	$2,400.00
	Construction Contingency - 10%**				$2,916.82
	Incidentals to Construction - 5%**				$1,458.41
	Minor Additional Design Items - 5%**				$1,458.41

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
	Final Design	HR	60	$100.00	$6,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	16	$100.00	$1,600.00
Total (Rounded)					**$45,000.00**

4.4.4 Next Steps

Contact was made with Nikki Ariste of the Vermont State Housing Authority, and she expressed interest in advancing a design for this property. Further design will involve refinement of the retrofit design with respect to size, outlet design, and routing to ensure that CPv can be completely managed and larger storms passed through the system safely. A formal agreement will need to be reached with the Vermont State Housing Authority prior to final design.

4.4.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C13 - Permit Review Sheets. In summary:

Stormwater Permit
It is not expected that a stormwater permit will be required at this time.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50' vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This site has an Act 250 permit issued for renovation of the old high school building into elderly housing units (5W0603). As such, this project should be reviewed to determine if an Act 250 amendment is required. There are no wetlands or river corridor issues anticipated for this project.

4.5 Middle Road Ditch N

4.5.1 30% Concept Design Description

The site includes a section of roadside ditching along unpaved Middle Road between a farmhouse and a small tributary (Figure C20). Stormwater is currently conveyed as overland flow via roadside ditching to the tributary.

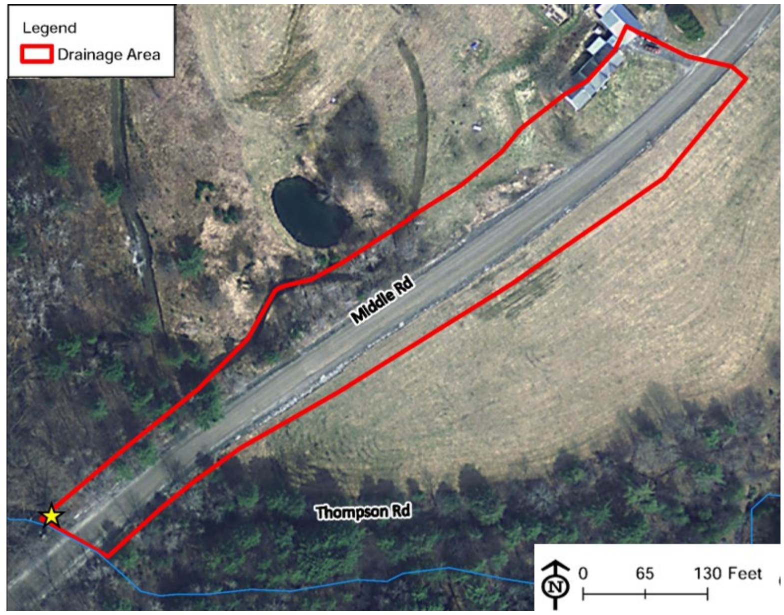

Figure C20. Improvements are proposed along both sides of unpaved Middle Road.

The combination of poor soils and steep slopes have degraded the quality and stability of the road surface, prompting extensive erosion throughout this area during storm events. The roadside ditches are clogged with sediment, and the road has been overwidened (Figure C21).

The concept for this site includes the removal of existing grader berms and failing check dams, regrading, stone lining of ditches to prevent future scour, reducing the road width, adding strategic turnouts to dissipate stormwater volumes as they travel west down Middle Road, and the inclusion of level spreaders at the end of the ditching on both sides of the road, prior to confluence with the tributary. Much of the sediment carried in these ditches makes its way into this tributary (see starred location in Figure C20).

Figure C21. Sediment is clogging the roadside ditch on Middle Road.

Soils are mapped as having very poor infiltration potential at this site (Hydrologic Group D), so soils and infiltration testing were not conducted to pursue an infiltration practice.

The drainage area that flows to the proposed road improvements is 0.5 acres, approximately 25% of which is classified as impervious. During the Channel Protection volume storm (CPV, 2.02 inches of rain in a 24-hour period), 6,970 ft^3 of runoff flows through these ditches.

An updated BMP summary sheet is included in Appendix C10 - Top 5 Sites. A 30% design plan is provided in Appendix C12 - 30% Designs.

4.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 1,275 lbs of total suspended solids (TSS) and 0.34 lbs of total phosphorus (TP) from entering receiving waters annually (Table C15).

Table C15. Middle Road Ditch N benefit summary table.

TSS Removed	1,275 lbs
TP Removed	0.34 lbs
Impervious Treated	0.5 acres
Total Drainage Area	2 acres

4.5.3 Cost Estimates

Cost projections, which are detailed in Table C16, total $35,000. Note that these costs are very preliminary. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used. This project will likely be eligible for a Vermont Better Roads Grant Program Category A grant.

- The cost per pound of phosphorus treated is $101,744.
- The cost per impervious acre treated is $70,000.
- The cost per cubic foot of runoff treated is $5.02.

Table C16. Middle Road Ditch N project initial construction cost projection.

VTrans Code	Description	Unit	Quantity	Unit Price	Amount
Site Preparation					
	Mobilization	LS	1	$250.00	$250.00
649.51	Geotextile for silt fence	SY		$4.13	$ -
				Subtotal:	$250.00
Swale Regrading					
203.15	Common Excavation	CY	260	$9.86	$2,563.60
613.10	Type I Stone (swale armoring)	CY	520	$43.91	$22,833.20
203.40	Shoulder Berm Removal	LF	2800	$0.38	$1,064.00
				Subtotal:	$25,396.80
Turnouts					
203.15	Common Excavation	CY	132	$9.86	$1,301.52
613.10	Type I Stone (swale armoring)	CY	155	$43.91	$6,806.05
				Subtotal:	$8,107.57
Subtotal:					$25,646.80
	Construction Oversight**	HR	16	$100.00	$1,600.00
	Construction Contingency - 10%**				$2,564.68
	Incidentals to Construction - 5%**				$1,282.34
	Minor Additional Design Items - 5%**				$1,282.34
	Final Design	HR	20	$100.00	$2,000.00
	Permit Review and Applications (exclusive of permit fees)	HR	8	$100.00	$800.00
Total (Rounded)					**$35,000.00**

4.5.4 Next Steps

As this site is owned and operated by Plainfield, it is recommended that the Town proceed with further design of this retrofit. Further design will involve refinement of the retrofit design with respect to turnout locations and ditch sizing.

4.5.5 Permit Needs

A project readiness screening worksheet has been completed for this project and is included in Appendix C13 - Permit Review Sheets. In summary:

Stormwater Permit
This site is not expected to need a stormwater permit.

The site should qualify for an Erosion Prevention and Sediment Control permit (3-9020) under the Low Risk categorization if the following guidelines are followed:

- Less than 2 acres of disturbance at any one time.
- All soils must be stabilized (temporary or final) within 7 days.
- Runoff from the site must pass through a 50’ vegetated buffer prior to entering any Water of the State.

Local Permitting
No local permits are anticipated.

Other Permits
This project should be reviewed by a wetland ecologist prior to final design due to the presence of hydric soils. No Act 250 permitting, or river corridor concerns are anticipated for this project.

5 Final Recommendations

The results of this SWMP have identified a number of potential BMP concepts and locations that would have a positive impact on water quality in Barre City, Barre Town, and Plainfield, and their receiving waters. Although designs were only advanced for the top 5 projects per municipality, this plan also serves to highlight other opportunities throughout the study areas. As such, the momentum developed during this study should be strengthened and continued.

The practices proposed in this study all stand to have a substantial impact on abating water pollution and setting a precedent for integrating GSI into the landscape. It is our recommendation that the municipalities, in partnership with the CVRPC, move to implement the Top 5 practices, but also move forward with additional design and implementation of the other projects presented in this plan (see Appendices with Top 20 Site Final Rankings: A9, B9, and C8). As these practices are the result of a stormwater master planning effort under a Clean Water Fund grant, they are well-suited as candidates for an implementation grant from this same source. We recommend the following steps in proceeding with this:

- For priority projects already at the 30% concept level, consider grant request for final design and implementation.

- Following implementation of the priority projects, submit grant funding requests for higher-scoring projects that may include both preliminary and final design.

The Vermont Agency of Transportation (VTrans), as part of their Transportation Separate Storm Sewer System (TS4) General Permit, will be completing their own retrofit assessment of VTrans-owned impervious surfaces throughout the region. Projects determined in this plan should be coordinated with the VTrans TS4 permitting efforts to allow for potential collaboration.