# STORMWATER MASTER PLAN FOR THE TOWN OF BERLIN, VERMONT

**FINAL REPORT**

**January 17, 2018**


**Prepared for:**

*Central Vermont Regional Planning Commission*

29 Main St #4, Montpelier, VT 05602

P: 802.229.0389

**Prepared by:**

*Watershed Consulting Associates, LLC*

208 Flynn Ave P.O. Box 4413

Burlington, VT 05406

P: 802.497.2367

info@watershedca.com

## TABLE OF CONTENTS

List of Tables: ..... ii
List of Figures: ..... ii
I. Disclaimer ..... 1
II. Glossary of Terms ..... 1
Total Maximum Daily Load (TMDL)- ..... 2
1 Introduction ..... 3
1.1 The Problem with Stormwater ..... 3
1.2 What is Stormwater Master Planning ..... 3
2 Project Overview ..... 4
3 Background ..... 5
3.1 Problem Definition ..... 5
3.2 Existing Conditions ..... 6
4 Methodology ..... 7
4.1 Identification of All Opportunities ..... 7
4.1.1 Initial Data Collection and Review: ..... 7
4.1.2 Desktop Assessment and Digital Map Preparation ..... 8
4.1.2.1 Desktop Assessment ..... 8
4.1.2.2 Basemap and Mobile App Creation ..... 10
4.1.3 Field Data Collection: ..... 10
4.2 Preliminary BMP Ranking ..... 12
4.3 Modeling and Concept Refinement for Top 20 BMPs ..... 13
4.4 Final Ranking Methodology ..... 15
4.4.1 Project Cost Estimation ..... 16
4.4.1 Final Ranking Scoring ..... 18
4.5 Final Modeling and Prioritization ..... 18
4.6 Selection of Top 5 Potential BMPs ..... 20
5 Priority BMPs ..... 20
6 30% Designs ..... 24
6.1 Berlin Elementary ..... 25
6.1.1 30% Concept Design Description ..... 25
6.1.2 Pollutant Removal and Other Water Quality Benefits ..... 26
6.1.3 Cost Estimates ..... 26
6.1.4 Next Steps ..... 28
6.1.5 Permit Needs ..... 28
6.1.1 Site Rendering ..... 28
6.2 Berlin Town Offices and Garage ..... 29
6.2.1 30% Concept Design Description ..... 29
6.2.2 Pollutant Removal and Other Water Quality Benefits ..... 29
6.2.3 Cost Estimates ..... 30
6.2.4 Next Steps ..... 32
6.2.5 Permit Needs ..... 32
6.3 Chimney Sweep ..... 33

6.3.1 30% Concept Design Description ..... 33
6.3.2 Pollutant Removal and Other Water Quality Benefits ..... 34
6.3.3 Cost Estimates ..... 34
6.3.4 Next Steps ..... 36
6.3.5 Permit Needs ..... 36
6.4 Berlin Fire Department 1 ..... 37
6.4.1 30% Concept Design Description ..... 37
6.4.2 Pollutant Removal and Other Water Quality Benefits ..... 38
6.4.3 Cost Estimates ..... 38
6.4.4 Next Steps ..... 39
6.4.5 Permit Needs ..... 40
6.5 Berlin Fire Department 2 ..... 41
6.5.1 30% Concept Design Description ..... 41
6.5.2 Pollutant Removal and Other Water Quality Benefits ..... 42
6.5.3 Cost Estimates ..... 42
6.5.4 Next Steps ..... 43
6.5.5 Permit Needs ..... 44
7 Final Recommendations ..... 45

**List of Tables:**

Table 1. Top 20 BMPs selected for the Berlin SWMP. ..... 13
Table 2. Modeled volume and pollutant load reductions for the Top 20 BMPs. ..... 15
Table 3. BMP unit costs and adjustment factors modified to reflect newer information. ..... 17
Table 4. Top 20 potential BMP sites for the Town of Berlin. ..... 19
Table 5. Top 5 BMP sites for the Town of Berlin. ..... 20
Table 6. Pollutant reductions and select ranking criteria for Top 5 projects. ..... 23
Table 7. Typical permeability classes and ranges for Ksat. ..... 24
Table 8. Berlin Elementary benefit summary table. ..... 26
Table 9. Berlin Elementary project initial construction cost projection. ..... 27
Table 10. Berlin Town Offices and Garage benefit summary table. ..... 30
Table 11. Berlin Town Offices and Garage project initial construction cost projection ..... 31
Table 12. Chimney Sweep benefit summary table. ..... 34
Table 13. Chimney Sweep project initial construction cost projection. ..... 35
Table 14. Berlin Fire Department 1 benefit summary table. ..... 38
Table 15. Berlin Fire Department 1 project initial construction cost projection ..... 39
Table 16. Berlin Fire Department 2 benefit summary table. ..... 42
Table 17. Berlin Fire Department 2 project initial construction cost projection ..... 43

**List of Figures:**

Figure 1. The Town of Berlin is located primarily within the Dog River (west) and Stevens Branch (east) watersheds ..... 5
Figure 2. The Town of Berlin is located in Washington County, VT ..... 6
Figure 3. The 7 locations identified as potential green streets opportunities are shown with green stars. ..... 9
Figure 4. Example screen from data collection app. ..... 10

Figure 5. 54 potential sites for BMP implementation were identified for field investigation. .... 11
Figure 6. Following field investigations, the list of potential BMP sites grew to 74. Point locations are shown for each site. .... 12
Figure 7. The Top 20 project locations are shown. .... 14
Figure 8. Top 5 sites for the Town of Berlin SWMP. .... 20
Figure 9. A bioretention is proposed within the vegetated circle at the Berlin Elementary School. .... 21
Figure 10. A gravel wetland and filter strip are proposed at the Berlin Town Offices and Garage site. .... 21
Figure 11. The Chimney Sweep Fireplace Shop parking lot is the proposed location for a subsurface sand filter. .... 22
Figure 12. Berlin Fire Department 1 site. An infiltration trench to capture and infiltrate stormwater on site is proposed along the southwest corner of the site. .... 22
Figure 13. Berlin Fire Department 2 site. It is proposed that runoff from this site be directed to two bioretention practices. .... 23
Figure 14. An example of the Constant-Head Borehole Permeameter Test in progress using a Johnson Meter. .... 24
Figure 15. The BMP drainage area is shown in red for the Berlin Elementary School. The proposed BMP location is shown with a star. .... 25
Figure 16. Soils at the Berlin Elementary School were generally a mix of silt and sandy. .... 25
Figure 18. The Berlin Elementary School parcel boundary is shown in yellow. .... 28
Figure 19. The drainage area for the proposed BMPs are shown in red for the Berlin Town Offices and Garage. The proposed BMP location for the Town Offices (south) is shown with a star. The area that is proposed to be managed with a filter strip to the north is also outlined in red. .... 29
Figure 20. The Chimney Sweep drainage area includes a section of Route 302 and the commercial complex to the west. The location for the proposed subsurface sand filter is shown with a star. .... 33
Figure 21. The proposed infiltration trench is located in the southeast corner (see starred location) of the Berlin Fire Department 1's drainage area, which is shown in red. .... 37
Figure 22. Soils at the Berlin Fire Department 1 site were generally a mix of sand and gravel... 37
Figure 23. Runoff from the Berlin Fire Department 2 drainage area, shown in red, is proposed to be directed to two separate bioretention areas, shown with stars. .... 41

## List of Appendices:

Appendix A - Map Atlas
Appendix B - Data Review
Appendix C - Green Streets Methodology
Appendix D - Initial Site Identification
Appendix E - Site Refinements
Appendix F - Preliminary Site Ranking
Appendix G - Top 20 Sites
Appendix H - Top 20 Sites Modeling
Appendix I - Top 20 Site Final Ranking
Appendix J - Cost Estimation Basis
Appendix K - Top 5 Sites
Appendix L - Existing Conditions Plans
Appendix M - 30% Designs
Appendix N - Permit Review Sheets
Appendix O - Soils Investigations
Appendix P - Site Rendering

# I. Disclaimer

The intent of this report is to present the data collected, evaluations, analyses, designs, and cost estimates for subwatersheds in Berlin under a contract between the Central Vermont Regional Planning Commission and Watershed Consulting Associates, LLC. Funding for the project was provided by a Vermont Department of Environmental Conservation, 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 Town 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, 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 basin 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.

# 3 Background

## *3.1 Problem Definition*

The Town of Berlin is located in Washington County within the Dog River and Stevens Branch watersheds, tributaries of the Winooski River (Figure 1). The Winooski River has numerous reaches that are adversely impacted by stormwater runoff and development. The Dog River has flooded and washed out roads in the Town of Berlin in the past. As the river passes through the Town, it is subject to multiple constrictions, lack of riparian buffer, erosion, historic channelization, and aggradation. As of the 2009 River Corridor Plan completed by Bear Creek Environmental, 9 of the 16 river segments are in overall fair condition, several segments are noted as being very highly sensitive to adjustment, and all segments have only a fair aquatic habitat rating. A section of the Dog River is on the 2016 stressed waters list due to elevated *E. Coli*.

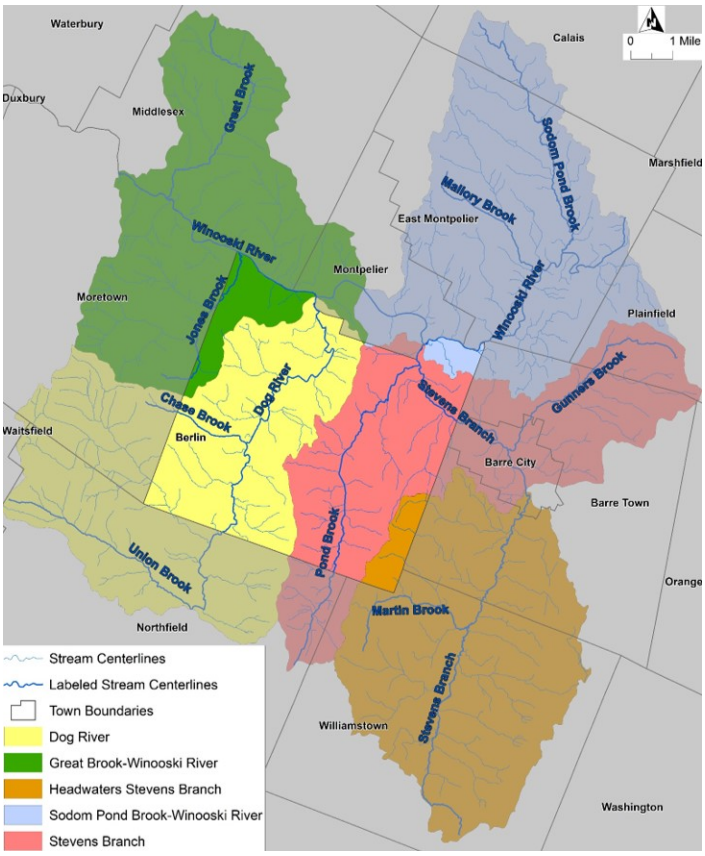


**Figure 1. The Town of Berlin is located primarily within the Dog River (west) and Stevens Branch (east) watersheds.**

Berlin has experienced significant development along Routes 302 and 62, with expanding areas of impervious surfaces. Route 302 closely parallels Stevens Branch, with much of the development falling in or close to the river corridor. This development has constrained Stevens Branch, particularly on its western banks although constrictions along the eastern banks are present farther south in the Town. In addition to expanding development along these corridors, Berlin experiences significant erosion as a result of steep slopes and poor soils, further contributing to sediment and nutrient loading in surface waters. Pond Brook, tributary to Stevens Branch and receiving waters of Berlin Pond, boasts one of the highest cascades in the State, Benjamin Falls, and is threatened by stormwater runoff. Further, two sections of Stevens Branch are on the 2016 stressed waters list due to streambank erosion, channel instability, road runoff, elevated *E. Coli* levels, and urban runoff.

The human-influenced stressors in the watershed 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, which requires reductions in phosphorus loading to Lake Champlain via its tributaries though reductions in stormwater and agricultural runoff pollution.

## *3.2 Existing Conditions*

The Town of Berlin spans approximately 23,495 acres in Washington County, VT and is primarily forested (73%), though nearly 14% of the Town is classified as urban (Figure 2). Of that area, there are 832 acres (3.5%) of impervious cover. Berlin lies to the west of fairly heavily developed Barre City and Barre Town, and to the south of the fairly urbanized Montpelier. To the west of Berlin, land use is more rural in the towns of Moretown and Northfield. Berlin has followed this development pattern, with development concentrated to the north-eastern corner of the Town. The western section of Berlin is more residential, though development does parallel the Dog River.

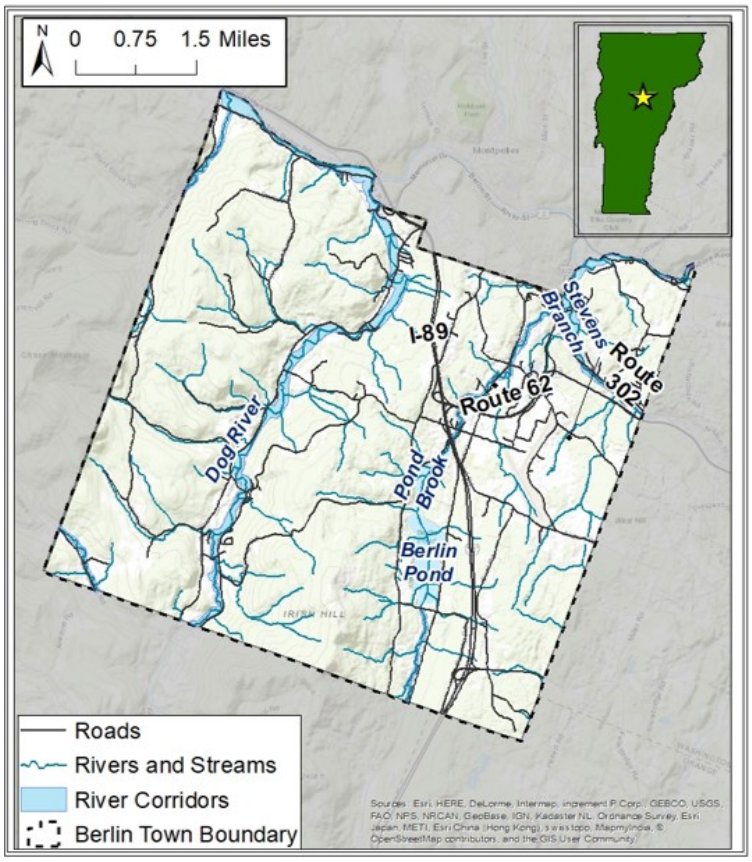


**Figure 2. The Town of Berlin is located in Washington County, VT.**

The majority of developments within these areas were constructed with minimal stormwater management features, which has resulted in significant amounts of untreated stormwater draining large portions of developed lands discharging directly to surface waters, particularly to Stevens Branch along Route 302. Other areas where there are ≥3 acres of unmanaged and unpermitted impervious cover in a parcel, such as the Berlin Elementary School property, are an issue given the large concentration of impervious surfaces, as well as upcoming regulatory requirements under Act 64 that will require management of these sites.

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.

The Berlin Mall area, although a large section of concentrated impervious area, was excluded from this analysis as a major redevelopment of this area is planned for the near future. As such, this plan does not address the current stormwater management issues since it is expected that a redevelopment of this scale will include required stormwater management practices.

Soils analyses indicate that of the 23,495 total acres in the Town, 91% 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 (50%) or D (35%), while only 5% are in group A and 7% 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 A – 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.

# 4 Methodology

## *4.1 Identification of All Opportunities*

### 4.1.1 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 B – Data Review.

The project team met with the Town of Berlin stakeholders and the Central Vermont Regional Planning Commission (CVRPC) on March 31st, 2017 to discuss the stormwater master plan and solicit information on problem areas from the Town. Following this meeting, a list of 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 4.1.2).

### 4.1.2 Desktop Assessment and Digital Map Preparation

#### *4.1.2.1 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. The Town of Berlin 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 C).

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 3. The 7 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, 7 sites with potential were noted for assessment in the field (Figure 3). These sites included Plateau Drive, Partridge Farm Road, Midway Avenue, Industrial Lane (two sections were noted on this road), Junction Road, and Route 12.

During this initial BMP identification and incorporating problem areas identified by the Town, a total of 54 locations were identified for field investigation.

#### *4.1.2.2 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 54 point locations for the potential BMP sites, which included both general Town-wide sites and green streets locations. These points allowed for easy site location and data collection in the field (Figure 4).

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.

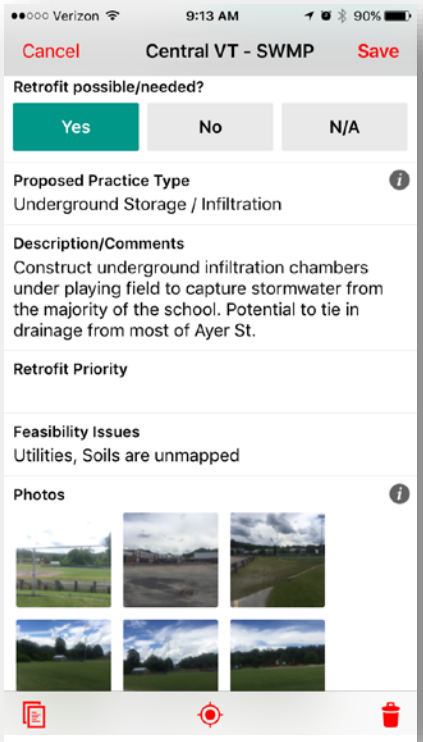


**Figure 4. Example screen from data collection app.**

### 4.1.3 Field Data Collection:

Each of the 54 previously identified potential BMP locations were evaluated in the field during the Summer and Fall of 2017 (Figure 5). 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 D - Initial Site Identification.

Through the course of these field visits, 29 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 9 sites were removed from this plan, primarily because upon visiting these sites in the field, they were found to be adequately managed with existing BMPs. While some improvement was possible for these sites, due to the fact that resources were limited for this project, time and effort were prioritized for sites without any or without adequate stormwater management rather than improving sites with current management.

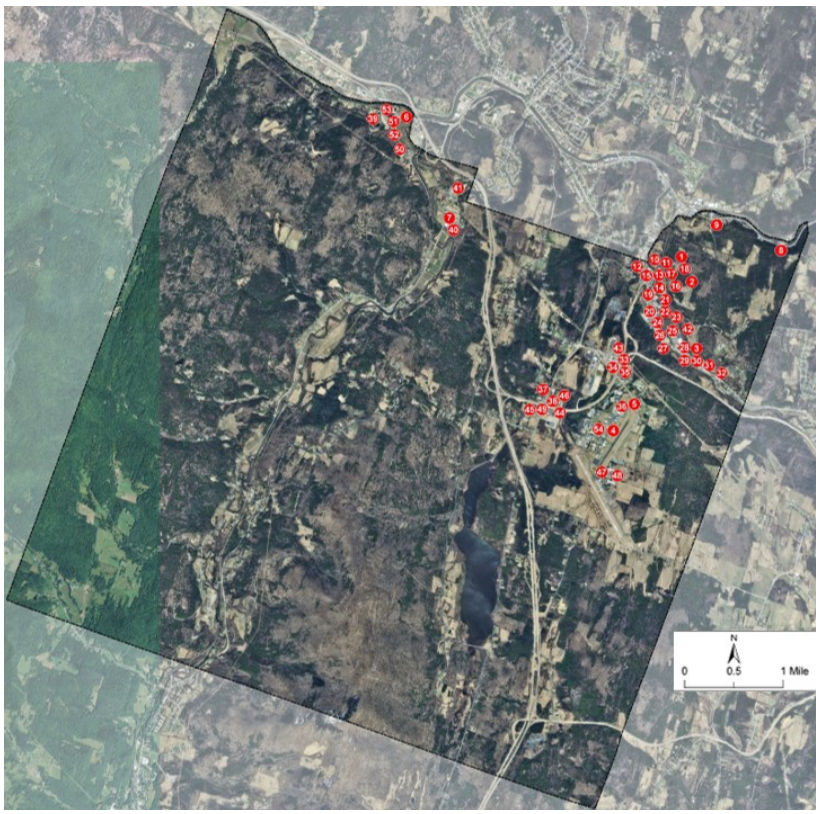


**Figure 5. 54 potential sites for BMP implementation were identified for field investigation.**

Following these refinements, the list of potential BMPs in the Town of Berlin grew to 74 (Figure 6). A memo detailing this site refinement and associated maps and tables are included as Appendix E - Site Refinements.

## 4.2 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 74 projects (Figure 6). 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, ownership, and feasibility issues. See Appendix F - Preliminary Site Ranking for the complete list of factors utilized in the preliminary ranking. Also included in Appendix F 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.

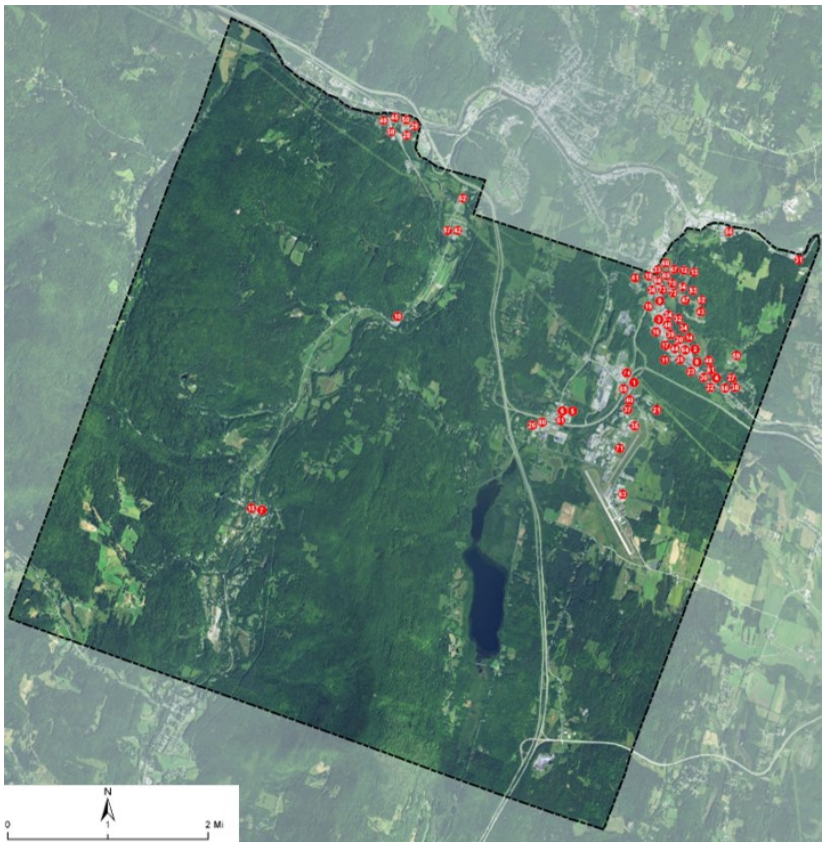


**Figure 6. Following field investigations, the list of potential BMP sites grew to 74. Point locations are shown for each site.**

The draft Top 20 list was distributed to the Town of Berlin and the CVRPC. As part of this process, the project team met with the stakeholders on August 17th, 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. A revised list was submitted, and these sites were presented to the Selectboard by the Town, and any questions regarding the SWMP itself and specific proposed BMPs were addressed at the Town's Selectboard meeting on October 2nd, 2017. These Top 20 sites are listed in Table 1. Point locations are shown in Figure 7.

**Table 1. Top 20 BMPs selected for the Berlin SWMP.**

| Site ID | Proposed Practice Type |
|---|---|
| Berlin Elementary | Bioretention |
| Berlin Town Offices and Garage | Gravel Wetland, Filter Strip |
| Chimney Sweep Fireplace Shop | Subsurface Sand Filter |
| Berlin Fire Department 1 | Infiltration Trench |
| Berlin Fire Department 2 | Bioretention (two) |
| Berlin Price Chopper Plaza | Subsurface sand filter, Buffer Enhancement, Impervious Cover Reduction |
| Paine Turnpike N and VT-62 | Gravel Wetland |
| Partridge Farm Rd East | Infiltration Trench |
| Berlin State Hwy Swale | Gravel Wetland |
| Airport Rd and 302 access road | Sand Filter |
| VSECU Parking Lot and Gas Station | Subsurface sand filter, Buffer Enhancement, Impervious Cover Reduction |
| CVMC East | Subsurface sand filter, bioretention |
| Twin City Family Fun Center | Sand Filter, Impervious Cover Removal |
| Steakhouse | Subsurface sand filter |
| Junction Rd Truck Storage | Filter Strip, Sand Filter, Resurface Parking Lot |
| Berlin Kinney Drugs | Gravel Wetland |
| VTrans Parking Lot | Gravel Wetland |
| Enterprise | Subsurface sand filter, Buffer Enhancement |
| VT Chamber of Commerce | Bioretention |
| 302 Paved Swale | Filter strip, Buffer Enhancement |

## *4.3 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 land use/land cover was digitized using the best available topographic data and aerial imagery. Drainage areas were refined based on field observations (see Appendix G – 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 H - 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 2. Complete modeling results are provided in Appendix H - Top 20 Sites Modeling.

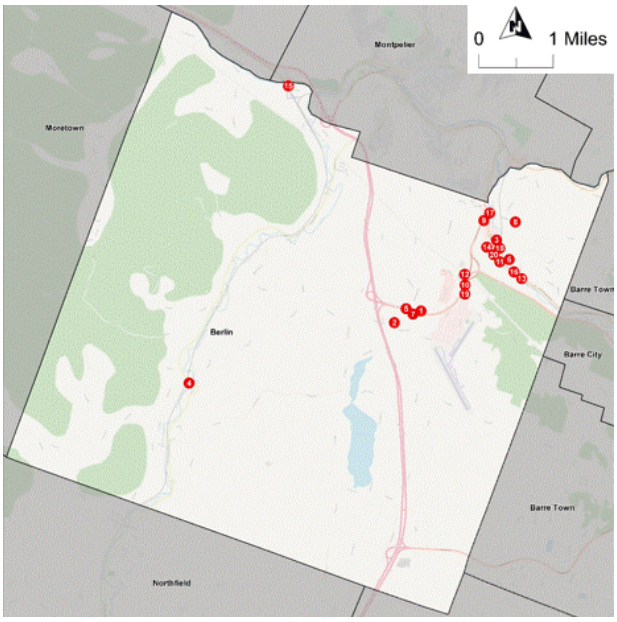


**Figure 7. The Top 20 project locations are shown.**

**Table 2. 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 (%) |
|---|---|---|---|---|---|---|
| Berlin Elementary | 0.21 | 0.21 | 23 | 100% | 0.14 | 100% |
| Berlin Town Offices and Garage | 0.386 | -- | 6,160 | 96% (Gravel Wetland)/60% (Filter Strip) | 1.76 | 58% (Gravel Wetland)/20% (Filter Strip) |
| Chimney Sweep Fireplace Shop | 0.413 | | 5,158 | 51% | 1.90 | 33% |
| Berlin Fire Department 1 | 0.092 | 0.092 | 534 | 72% | 0.41 | 65% |
| Berlin Fire Department 2 | 0.102 | -- | 1,007 | 55% | 0.52 | 55% |
| Berlin Price Chopper Plaza | 1.492 | -- | 22,701 | 51% | 7.19 | 33% |
| Paine Turnpike N and VT-62 | 2.308 | -- | 36,820 | 96% | 18.75 | 58% |
| Partridge Farm Rd East | 0.19 | 0.19 | 1,899 | 80% | 1.47 | 81% |
| Berlin State Hwy Swale | 0.665 | -- | 6,684 | 96% | 3.45 | 58% |
| Airport Rd and 302 access road | 0.439 | -- | 7,306 | 51% | 4.47 | 33% |
| VSECU Parking Lot and Gas Station | 0.588 | -- | 6,919 | 51% | 2.68 | 33% |
| CVMC East | 0.253 | -- | 3,625 | 51% | 1.00 | 33% |
| Twin City Family Fun Center | 0.481 | -- | 2,649 | 51% | 1.11 | 33% |
| Steakhouse | 0.158 | -- | 1,533 | 51% | 1.41 | 33% |
| Junction Rd Truck Storage | 0.16 | -- | 400 | 51% | 0.28 | 33% |
| Berlin Kinney Drugs | 0.449 | -- | 6,263 | 96% | 1.07 | 58% |
| VTrans Parking Lot | 0.233 | -- | 3,366 | 96% | 0.82 | 58% |
| Enterprise | 0.058 | -- | 779 | 51% | 0.20 | 33% |
| VT Chamber of Commerce | 0.017 | -- | 439 | 87% | 0.08 | 34% |
| 302 Paved Swale | 0.066 | -- | 528 | 51% | 0.23 | 33% |

## *4.4 Final Ranking Methodology*

A prioritization matrix was utilized in order 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.

### 4.4.1 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 J. Note that a variation of this method was used for this plan. The criteria used in this cost estimation can be found in Appendix I - 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. Note that costs are not adjusted for inflation. 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 CPv or 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 3 below.

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

**Table 3.** 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.

**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 for the Berlin SWMP. 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.

### 4.4.1 Final Ranking Scoring

Each of the factors noted in Appendix I - 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.

## *4.5 Final Modeling and Prioritization*

A summary of the practices with scores and ranks are shown below in Table 4. The comprehensive ranking matrix used to rank the proposed BMP projects is provided in Appendix I - 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 4. Top 20 potential BMP sites for the Town of Berlin.**

| Rank | Site ID | Address | Proposed Practice Type | Score |
|---|---|---|---|---|
| 1 | Berlin Elementary | 372 Paine Turnpike N | Bioretention | 42 |
| 2 | Berlin Town Offices and Garage | Shed Rd | Gravel Wetland, Filter Strip | 36 |
| 3 | Chimney Sweep Fireplace Shop | 1284 US-302 | Subsurface Sand Filter | 35 |
| 4 | Berlin Fire Department 1 | Route 12, W of Crosstown Rd | Infiltration Trench | 33 |
| 5 | Berlin Fire Department 2 | Paine Turnpike N | Bioretention (two) | 29 |
| 6 | Berlin Price Chopper Plaza | Ames Dr | Subsurface sand filter, Buffer Enhancement, Impervious Cover Reduction | 24 |
| 7 | Paine Turnpike N and VT-62 | Paine Turnpike N and VT-62 | Gravel Wetland | 21 |
| 8 | Partridge Farm Rd East | Partridge Farm Rd | Infiltration Trench | 20 |
| 9 | Berlin State Hwy Swale | Route 302 and Partridge Farm Rd | Gravel Wetland | 19 |
| 10 | Airport Rd and 302 access road | 3336 Airport Rd | Sand Filter | 18 |
| 11 | VSECU Parking Lot and Gas Station | 998 US-302 | Subsurface sand filter, Buffer Enhancement, Impervious Cover Reduction | 17 |
| 12 | CVMC East | 130 Fisher Rd | Subsurface sand filter, bioretention | 17 |
| 13 | Twin City Family Fun Center | 708 US-302 | Sand Filter, Impervious Cover Removal | 16 |
| 14 | Steakhouse | 1239 US-302 | Subsurface sand filter | 14 |
| 15 | Junction Rd Truck Storage | 278 Junction Rd | Filter Strip, Sand Filter, Resurface Parking Lot | 14 |
| 16 | Berlin Kinney Drugs | Midway Ave and Route 302 | Gravel Wetland | 13 |
| 17 | VTrans Parking Lot | Partridge Farm Rd & Route 302 | Gravel Wetland | 13 |
| 18 | Enterprise | Enterprise lawn, 1193 US-302 | Subsurface sand filter, Buffer Enhancement | 13 |
| 19 | VT Chamber of Commerce | Granger Rd and Airport Rd | Bioretention | 12 |
| 20 | 302 Paved Swale | 1104-1162 US-302 | Filter strip, Buffer Enhancement | 10 |

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.

### *4.6 Selection of Top 5 Potential BMPs*

Selection of the Town's Top 5 sites considered the results from WCA's 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, WCA met with the project stakeholders on August 17th, 2017 to discuss potential top 5 project sites, and later with the Town's Selectboard on October 2nd, 2017. During this Selectboard meeting, four of the five were decided upon. The fifth site was determined by the Town following landowner outreach. The location of the sites within the Town of Berlin can be viewed in Figure 8. In the final ranking (4.4 Final Ranking Methodology), these 5 sites were awarded additional points in the site scoring due to reflect the Town's priorities and high probability for implementation. The Top 5 sites are listed in Table 5.

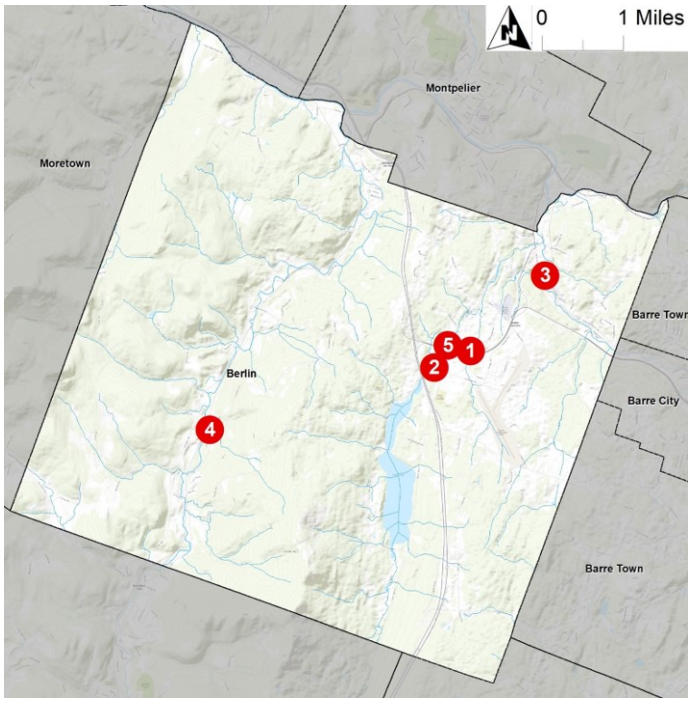


**Figure 8. Top 5 sites for the Town of Berlin SWMP.**

**Table 5. Top 5 BMP sites for the Town of Berlin.**

| Rank | Site ID | Address | Proposed Practice Type |
|---|---|---|---|
| 1 | Berlin Elementary | 372 Paine Turnpike N | Bioretention |
| 2 | Berlin Town Offices and Garage | Shed Rd | Gravel Wetland, Filter Strip |
| 3 | Chimney Sweep Fireplace Shop | 1284 US-302 | Subsurface Sand Filter |
| 4 | Berlin Fire Department 1 | Route 12, W of Crosstown Rd | Infiltration Trench |
| 5 | Berlin Fire Department 2 | Paine Turnpike N | Bioretention (two) |

## 5 Priority BMPs

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

**Site:** 1
**Project Name:** Berlin Elementary School
**Description:** The site includes the School building and associated paved driveway, turnaround, and gravel parking lot. Stormwater currently sheet flows through this area, and off the eastern edge of the parking lot into a small tributary. The concept for this site includes a bioretention basin in the circle by the School's main entrance (Figure 9), check dams along the southern end of the parking lot, and a swale along the eastern edge of the parking lot. Soils are mapped as being very good at this site (Hydrologic Group A), therefore soils and infiltration testing was conducted to evaluate the potential for an infiltration practice. Soils were found to be a mix of silt and sand and have moderately high permeability.

**Figure 9. A bioretention is proposed within the vegetated circle at the Berlin Elementary School.**

**Outreach:** Contact was made with Krista Metivier (Supervisory Union) and Chuck Paquet (School Facility Manager) prior to advancing concept designs at this site. The school board voted to allow further design to be completed at the site.

**Site:** 2
**Project Name:** Berlin Town Offices and Garage
**Description:** The site includes buildings, a gravel access drive between the Town Office and Town Garage (the access road to the site is paved), open storage areas, and a paved parking lot, all associated with the Berlin Town Offices and Town Garage. Stormwater currently sheet flows through this area, and down a bank into Pond Brook. The concept for this site includes impervious reduction and revegetation between the offices and garage, regrading part of the driveway to prompt better drainage, and adding a catchbasin to route flow to a gravel wetland northwest of the Town Offices building (Figure 10). A filter strip is also proposed for the Town Garage site. Soils are mapped as being very poor in terms of infiltration potential at this site (Hydrologic Group D), so soils and infiltration testing were not conducted as an infiltration practice was not proposed.

**Figure 10. A gravel wetland and filter strip are proposed at the Berlin Town Offices and Garage site.**

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

**Site:** 3
**Project Name:** Chimney Sweep Fireplace Shop
**Description:** The site includes the Chimney Sweep building and associated parking and driveways, and a stormline which begins behind the VT Lottery Building across the street. Some stormwater sheet flows by the Chimney Sweep building into the Stevens Branch, the rest is collected in the storm system and outlets behind the building into the Stevens Branch. The concept for this site includes additional catchbasins and rerouting the stormline to a subsurface sand filter system behind the northeastern corner of the Chimney Sweep building (Figure 11). It is recommended that the parking lot and driveways be swept regularly to prevent sediment build-up. Soils are unmapped at this site, so soils and infiltration testing were not conducted to pursue an infiltration practice.

**Figure 11. The Chimney Sweep Fireplace Shop parking lot is the proposed location for a subsurface sand filter.**

**Outreach:** Contact was made with Tim Ayer both by the Town and the project team prior to advancing concept designs at this site. Mr. Ayer has indicated his willingness to allow further design to be completed at the site. Prior to final design, a formal agreement with Mr. Ayer should be reached.

**Site:** 4
**Project Name:** Berlin Fire Department 1
**Description:** The site includes the Fire Department building and associated gravel parking lot. The eastern edge of the parking lot has mailboxes and is an access point for a small park and swimming hole on the Dog River. Stormwater currently sheet flows through this area, and eventually into the river (Figure 12). The concept for this site includes an infiltration trench that wraps around the eastern edge of the parking lot. Soils are mapped as being a mix of good (Hydrologic Group A) and poor at this site (Hydrologic Group C), therefore soils and infiltration testing was conducted to evaluate the potential for an infiltration practice. Soils were found to be a mix of sand and gravel and have moderately high permeability.

**Figure 12. Berlin Fire Department 1 site. An infiltration trench to capture and infiltrate stormwater on site is proposed along the southwest corner of the site.**

**Outreach:** Contact was made with Joe Staab (Berlin Volunteer Fire Department) prior to advancing concept designs at this site. The Fire Department agreed to allow further design to be completed at the site.

**Site:** 5
**Project Name:** Berlin Fire Department 2
**Description:** The site includes the Fire Department building (Figure 13) and paved driveways and parking lots. Stormwater currently sheet flows through this area into a small tributary behind the building. The concept for this site includes two bioretention features, one by the northwestern corner of the station, and one by the southwestern corner of the parking lot. A shallow swale wrapping around the eastern side of the parking lot would direct drainage into the second bioretention. 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.

**Figure 13. Berlin Fire Department 2 site. It is proposed that runoff from this site be directed to two bioretention practices.**

**Outreach:** Contact was made with Joe Staab (Berlin Volunteer Fire Department) prior to advancing concept designs at this site. The Fire Department agreed to allow further design to be completed at the site.

When implemented, these five BMPs would treat approximately 17 acres, 9 acres (56%) of which is impervious. Modeled pollutant reductions for each of the projects, shown below in Table 6, indicate that these BMPs will prevent nearly 13,000 lbs of TSS and 4.7 lbs of TP from reaching receiving waters annually.

**Table 6. 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 (%) |
|---|---|---|---|---|---|---|
| Berlin Elementary | 0.21 | 0.21 | 23 | 100% | 0.14 | 100% |
| Berlin Town Offices and Garage | 0.386 | -- | 6,160 | 96% (Gravel Wetland)/60% (Filter Strip) | 1.76 | 58% (Gravel Wetland)/20% (Filter Strip) |
| Chimney Sweep Fireplace Shop | 0.413 | | 5,158 | 51% | 1.90 | 33% |
| Berlin Fire Department 1 | 0.092 | 0.092 | 534 | 72% | 0.41 | 65% |
| Berlin Fire Department 2 | 0.102 | -- | 1,007 | 55% | 0.52 | 55% |

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 L - Existing Conditions Plans for these plans.

# 6 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 M - 30% Designs.

A geotechnical analysis was carried out for both the Berlin Elementary School and the Berlin Fire Department 1 sites as the proposed practices are infiltration-based. All infiltration testing in the Town of Berlin was completed using a Constant-Head Borehole Permeameter Test (USBR 7300-89 Cond. II, Shallow Water Table or USBR 7300-89 Condition I, Deep Water Table or Impermeable layer) using a Johnson Meter (see Figure 14 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 7 for typical permeability classes and ranges for $K_{sat}$.

**Figure 14. An example of the Constant-Head Borehole Permeameter Test in progress using a Johnson Meter.**

**Table 7. 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 | $1 X 10^{-6}$ | $< 1 X 10^{-6}$ | 0.0864 | < 0.0864 | 0.0014 | < 0.0014 |
| Low | $1 X 10^{-5}$ | $1 X 10^{-6}$ | 0.864 | 0.0864 | 0.014 | 0.0014 |
| Moderately Low | $1 X 10^{-4}$ | $1 X 10^{-5}$ | 8.64 | 0.864 | 0.14 | 0.014 |
| Moderately High | $1 X 10^{-3}$ | $1 X 10^{-4}$ | 86.4 | 8.64 | 1.4 | 0.14 |
| High | $1 X 10^{-2}$ | $1 X 10^{-3}$ | 864.0 | 86.4 | 14.0 | 1.4 |
| Very high | $> 1 X 10^{-2}$ | $1 X 10^{-2}$ | > 864.0 | 864.0 | > 14.0 | 14.0 |

## 6.1 Berlin Elementary

### 6.1.1 30% Concept Design Description

Currently, most drainage from the Berlin Elementary School is unmanaged. Although the roof drains to a series of dry wells, and some of the runoff from the school does naturally infiltrate in pervious areas on site, the majority of the drainage from the large unpaved parking lot flows down a fairly steep slope into an existing swale.

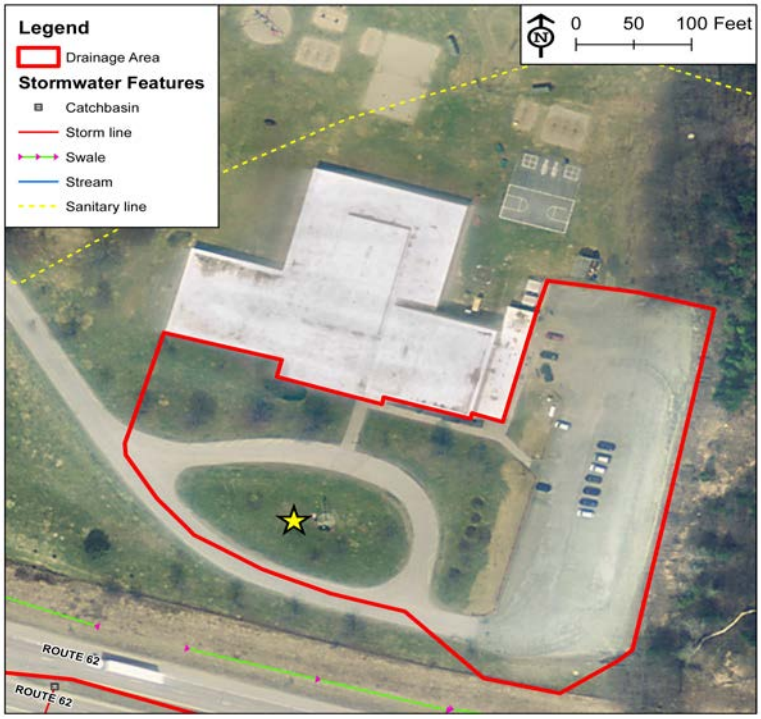


**Figure 15. The BMP drainage area is shown in red for the Berlin Elementary School. The proposed BMP location is shown with a star.**

The unpaved parking lot frequently has issues associated with unmanaged runoff (puddling, pot holes, etc.). It is recommended that parking lot improvements are made to address these issues when the stormwater improvements are implemented on site.

The proposed retrofit for this site is an improved conveyance and pre-treatment swale leading to a bioretention practice in the middle of the access drive circle (see starred location in Figure 15). The swale will contain a series of check dams to slow and filter runoff further.

Soils are mapped as being very good at this site (Hydrologic Group A), so soils and infiltration testing was conducted to evaluate the potential for an infiltration practice. To complete infiltration testing, a Constant-Head Borehole Permeameter Test (USBR 7300-89 Cond. II, Shallow Water Table) was completed using a Johnson Meter. The $K_{sat}$ value was measured at 0.33 in/hr. This value is classified within the moderately high permeability class.

**Figure 16. Soils at the Berlin Elementary School were generally a mix of silt and sandy.**

Soils were found to be a mix of silt and sand (Figure 16), and it was noted that groundwater on site is fairly high. As such, the stormwater improvements on site are designed to be shallow (2.5 ft in depth) so as to avoid impacts to and from groundwater. See Appendix O - Soils Investigations for a complete soil log and completed $K_{sat}$ workbook.

The design standard used for this retrofit was full infiltration of the channel protection volume (CPv, or 2.02" of rain in a 24-hour period), equal to 9,148 $ft^3$ of runoff.

A 30% design plan is provided in Appendix M - 30% Designs.

### 6.1.2 Pollutant Removal and Other Water Quality Benefits

This practice has the potential to prevent 23 lbs of TSS and 0.14 lbs of TP from entering receiving waters (Table 8). These pollutant removal estimates are fairly low due to the fact that the site is situated on sandy Hydrologic Soil Group A soils, which do not have high runoff rates during rainfall events. However, this project would still provide a benefit to water quality and would be a high visibility project that 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 retrofits.

**Table 8.** Berlin Elementary benefit summary table.

| | |
|---|---|
| Total Suspended Solids Removed | 23 lbs |
| Total Phosphorus Removed | 0.14 lbs |
| Impervious Treated | 1.36 acres |
| Total Drainage Area | 2.6 acres |

### 6.1.3 Cost Estimates

The provided costs are very preliminary. Initial cost projections can be found in Table 9. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used. Note that two separate cost estimates are provided. The first, which totals $61,000, includes plant plugs while the second cost, $49,000, includes only seeds for planting of the bioretention 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.

- The cost per pound of phosphorus treated is $435,714 for plant plugs and $350,000 for seeds.
- The cost per impervious acre treated is $44,853 for plant plugs and $36,412 for seeds.
- The cost per cubic foot of runoff treated is $6.67 for plant plugs and $5.36 for seeds.

**Table 9. Berlin Elementary 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 | 300 | $1.59 | $477.00 |
| 653.20 | Temporary Erosion Matting | SY | 200 | $2.34 | $468.00 |
| 649.51 | Geotextile for silt fence | SY | 85 | $4.07 | $345.95 |
| 652.10 | EPSC Plan | LS | 1 | $500.00 | $500.00 |
| | Construction Staking | HR | 8 | $90.00 | $720.00 |
| | | | | *Subtotal:* | $3,010.95 |
| **Bioretention Basin Materials (w/labor and trucking included)** | | | | | |
| 203.15 | Common Excavation | CY | 375 | $9.86 | $3,697.50 |
| 651.35 | Topsoil (Bioretention Soil) | CY | 195 | $31.48 | $6,138.60 |
| 613.11 | Type II Stone (weirs and overflow) | CY | 30 | $42.49 | $1,274.70 |
| 656.41 | Plants* (Perennial Plugs) | EACH | 1315 | $8.77 | $11,532.55 |
| N/A | Perennial Flower Seeds | LBS | 8 | $125.00 | $1,000.00 |
| 651.15 | Seed (grass) | LBS | 10 | $7.79 | $77.90 |
| 601.0910 | 15" CPEP Outlet Works | LF | 6 | $64.04 | $384.24 |
| 601.0915 | 18" CPEP Pipe | EACH | 150 | $64.04 | $9,606.00 |
| | | | | *Subtotal (Seed Option):* | $22,178.94 |
| | | | | *Subtotal (Plugs Option):* | $32,711.49 |
| **Conveyance Swale Materials (w/labor and trucking included)** | | | | | |
| 203.15 | Common Excavation | CY | 180 | $9.86 | $1,774.80 |
| 653.30 | Timber Check Dams (Prefabricated Check Dam) | EACH | 10 | $295.79 | $2,957.90 |
| 651.15 | Seed (grass) | LBS | 10 | $7.79 | $77.90 |
| 653.20 | Temporary Erosion Matting | SY | 400 | $2.34 | $936.00 |
| | | | | *Subtotal:* | $5,746.60 |
| **Subtotal:** | | | | | $41,469.04 |
| | Construction Oversight** | HR | 32 | $100.00 | $3,200.00 |
| | Construction Contingency - 10%** | | | | $4,146.90 |
| | Incidentals to Construction - 5%** | | | | $2,073.45 |
| | Minor Additional Design Items - 5%** | | | | $2,073.45 |
| | 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 Plugs Option (Rounded)** | | | | | **$61,000.00** |
| **Total Seed Option (Rounded)** | | | | | **$49,000.00** |
| * This cost could be eliminated by using seeds instead of perennial plugs. Note different sub-totals. | | | | | |

### 6.1.4 Next Steps

Preliminary outreach has been conducted with the Berlin Elementary School Board. They have indicated their willingness to 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 larger storms passed through the system safely.


**Figure 17. The Berlin Elementary School parcel boundary is shown in yellow.**

### 6.1.5 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 site will likely need a stormwater permit under the proposed 3-acre impervious cover rule. Though the school's drainage area does not exceed 3 acres impervious cover, the school shares a parcel with the Berlin Fire Station (project Berlin Fire Station 2 in this plan). The parcel as a whole contains 3.3 acres of impervious cover. The school separately contains 2.8 acres of impervious cover. However, since the parcel contains more than 3 acres of impervious cover, this site would necessitate a permit (Figure 18).

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*
Although there are no mapped wetlands on site or within 50 feet of the project, there are hydric soils mapped on site. As such, this project should be reviewed by a state Wetlands Ecologist prior to final design. No Act 250 or River Corridor permitting is anticipated for this project.

### 6.1.1 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 P - Site Rendering.

## 6.2 Berlin Town Offices and Garage

### 6.2.1 30% Concept Design Description

Currently, all drainage from the Berlin Town Offices and Town Garage sites is unmanaged. The stormwater primarily drains to the west, over a fairly steep bank, and into Pond Brook. Some of the stormwater also drains to the east and into a swale that runs along the perimeter of the site.

Soils on site are fairly poor with Hydrologic Soil Group D classified as potentially highly erodible. Very little runoff from the site naturally infiltrates and almost all unmanaged runoff is delivered to surface waters. As such, the proposed practices for this site are not dependent upon infiltration.

The proposed retrofit for this site is an improved conveyance and pre-treatment swale leading to a gravel wetland practice to the southwest of the Town Office building (see starred location in Figure 19). The swale will wrap around the parking area to convey runoff to the practice. The design for this site also incorporates a filter strip along the perimeter of the northern drainage area (Figure 19). This filter strip will provide water quality benefit at a fairly low cost.

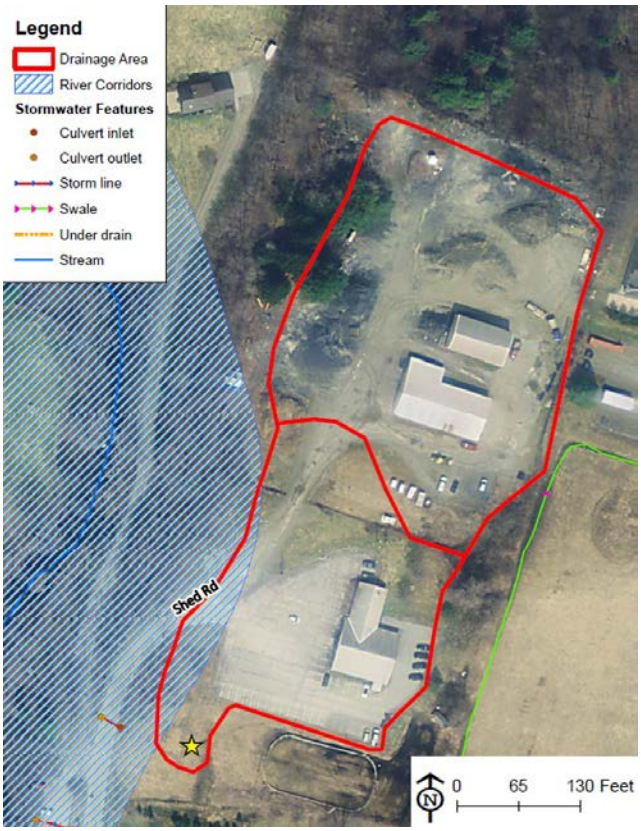


**Figure 18. The drainage area for the proposed BMPs are shown in red for the Berlin Town Offices and Garage. The proposed BMP location for the Town Offices (south) is shown with a star. The area that is proposed to be managed with a filter strip to the north is also outlined in red.**

The design standard used for this retrofit was detention and slow release of the Channel Protection volume (CPv, or 2.02" of rain in a 24-hour period) for the gravel wetland feature, equal to 5,053 $ft^3$ of runoff. An additional 16,553 $ft^3$ of runoff will be directed to the vegetated filter strip. The total volume managed by both practices is 21,606 $ft^3$.

A 30% design plan is provided in Appendix M - 30% Designs.

### 6.2.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 6,160 lbs of TSS and 1.76 lbs of TP from entering receiving waters (Table 10). Different pollutant removal rates were used for the portion of the drainage area that drains to the gravel wetland as opposed to the filter strip. The gravel wetland

has significantly higher pollutant reduction potential, but is also more expensive and requires dedication of a portion of the lawn area for the practice. The retrofits 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 10.** Berlin Town Offices and Garage benefit summary table.

| | |
|---|---|
| Total Suspended Solids Removed | 6,160 lbs |
| Total Phosphorus Removed | 1.76 lbs |
| Impervious Treated | 3.38 acres |
| Total Drainage Area | 4.6 acres |

### 6.2.3 Cost Estimates

Note that these costs and benefits are very preliminary. Initial cost projections can be found in Table 11. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used. Note that two separate cost estimates are provided. The first, which totals $80,000, includes plant plugs while the second cost, $58,000, 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.

- The cost per pound of phosphorus treated is $45,455 for the plant plugs and $32,955 for the seeds.
- The cost per impervious acre treated is $23,669 for the plant plugs and $17,160 for the seeds.
- The cost per cubic foot of runoff treated is $3.70 for the plant plugs and $2.68 for the seeds.

**Table 11. Berlin Town Offices and Garage 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 | 200 | $1.59 | $318.00 |
| 649.51 | Geotextile for silt fence | SY | 290 | $4.07 | $1,180.30 |
| 652.10 | EPSC Plan | LS | 1 | $500.00 | $500.00 |
| 652.20 | Monitoring EPSC Plan | HR | 6 | $40.21 | $241.26 |
| | Construction Staking | HR | 8 | $90.00 | $720.00 |
| | | | | *Subtotal:* | $3,459.56 |
| **Gravel Wetland - Materials (with labor/trucking included)** | | | | | |
| 203.15 | Common Excavation | CY | 460 | $9.50 | $4,370.00 |
| 651.35 | Muck Soil (Topsoil) | CY | 160 | $31.48 | $5,036.80 |
| 629.54 | 3/4" to 1 1/2" Crushed Stone (Crushed Stone Bedding) | TON | 25 | $35.93 | $898.25 |
| 629.54 | Pea Stone (Crushed Stone Bedding) | TON | 25 | $35.93 | $898.25 |
| 613.11 | Type II Stone (weirs and overflow) | CY | 30 | $42.49 | $1,274.70 |
| 613.10 | Type I Stone (Hydraulic Inlet) | CY | 25 | $43.91 | $1,097.75 |
| 649.31 | Geotextile | SY | 1300 | $2.52 | $3,276.00 |
| 656.41 | Plants* (Perennials) | EACH | 2500 | $8.77 | $21,925.00 |
| N/A | Wetland Plant Seeds | LBS | 10 | $125.00 | $1,250.00 |
| 651.15 | Seed | LBS | 50 | $7.79 | $389.50 |
| 605.10 | 6" Underdrain Piping | LF | 120 | $20.86 | $2,503.20 |
| 601.0915 | 18" CPEP Pipe | LF | 30 | $62.94 | $1,888.20 |
| N/A | 18" Beehive Grate with Anti-Vortex Baffle | EACH | 1 | $615.00 | $615.00 |
| N/A | 30 Mil PVC Liner | SY | | $5.68 | $ |
| 604.20 | New Catch Basin | EACH | 1 | $3,478.51 | 3,478.51 |
| 653.20 | Temporary Erosion Matting | SY | 1200 | $2.34 | $2,808.00 |
| 651.35 | Topsoil | CY | 75 | $31.48 | $2,361.00 |
| | | | | *Subtotal:* | $54,070.16 |
| **Subtotal:** | | | | | $57,529.72 |
| | Construction Oversight** | HR | 32 | $100.00 | $3,200.00 |
| | Construction Contingency - 10%** | % | | | $5,752.97 |
| | Incidentals to Construction - 5%** | % | | | $2,876.49 |
| | Minor Additional Design Items - 5%** | % | | | $2,876.49 |
| | 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 - Plugs Option (Rounded)** | | | | | **$80,000.00** |
| **Total - Seed Option (Rounded)** | | | | | **$58,000.00** |
| * This cost could be eliminated by using seeds instead of perennial plugs. Note different sub-totals. | | | | | |

### 6.2.4 Next Steps

As this site is owned and operated by Berlin 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.

### 6.2.5 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 site will likely need a stormwater permit under the proposed 3-acre impervious cover rule. The parcel as a whole contains 3.5 acres of impervious cover, 3.4 acres of which are managed by these proposed retrofits.

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*
Although there are no mapped wetlands on site or within 50 feet of the project, there are hydric soils mapped on site. As such, this project should be reviewed by a state Wetlands Ecologist prior to final design. The gravel wetland BMP is located outside of the river corridor, but the river corridor does extend into the drainage area for the gravel wetland (Figure 19). As such, this site should be reviewed by a State River Scientist prior to final design. No Act 250 permitting is anticipated for this project.

## 6.3 Chimney Sweep

### 6.3.1 30% Concept Design Description

The Chimney Sweep commercial building is located along Route 302 in one of the most heavily developed areas of the Town. Presently in the drainage area to the proposed BMP, runoff is generated from the commercial complex that contains the Vermont Lottery Commission's parking lot and roof, drainage from Route 302, and a vegetated hillslope behind the commercial complex. The runoff is collected via a series of catchbasins and pipes in the commercial complex parking lot. The runoff is conveyed in this piped system under the Chimney Sweep complex's parking lot and into the Stevens Branch without any water quality management.

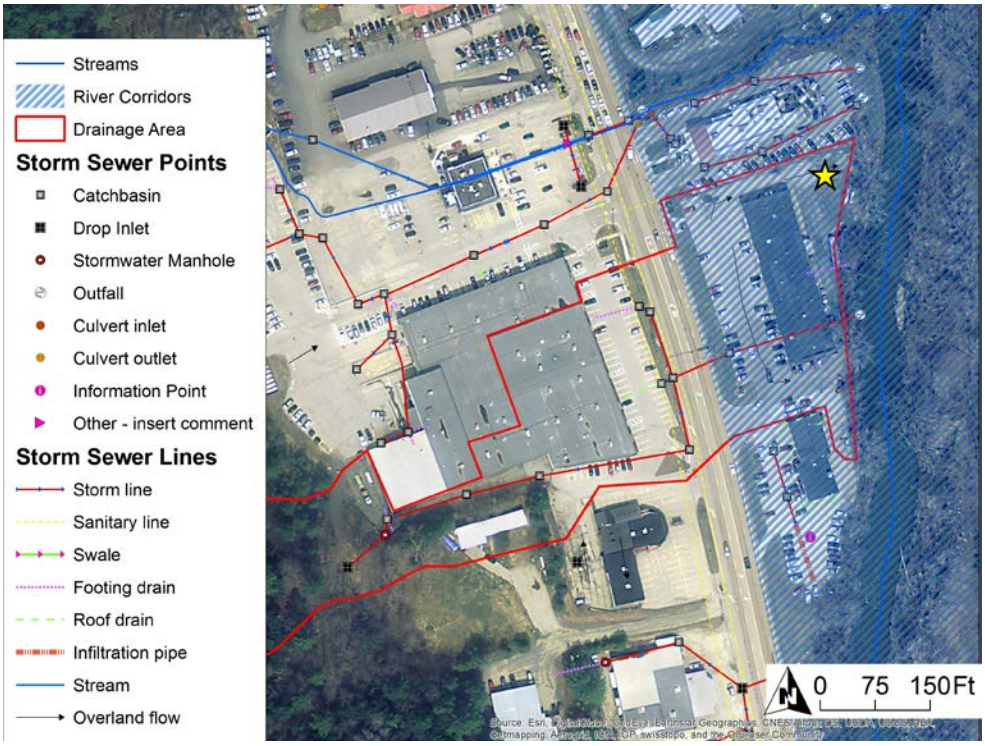


**Figure 19. The Chimney Sweep drainage area includes a section of Route 302 and the commercial complex to the west. The location for the proposed subsurface sand filter is shown with a star.**

At the location proposed for the subsurface sand filter, the Hydrologic Soil Group is unmapped. Soils to the west of the site are classified as Hydrologic Soil Group C. As such, they are expected to have fairly poor infiltration potential and the runoff contributed from this vegetated area and steep area has little opportunity to infiltrate prior to entering the traditional drainage system in the Lottery Commission parking lot despite being undeveloped. An infiltration practice was not considered for this site.

The proposed BMP includes a subsurface sand filter in the back parking lot (adjacent to Stevens Branch; see Figure 20) of the Chimney Sweep parcel. The drainage area for this proposed BMP is nearly 8 acres, approximately 44% of which is classified as impervious. This practice will provide a significant water quality benefit (see Table 12). The design standard used for this retrofit was detention and slow release of the Channel Protection volume (CPv, or 2.02" of rain in a 24-hour period), equal to 17,821 $ft^3$ of runoff.

A 30% design plan is provided in Appendix M - 30% Designs.

### 6.3.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 5,158 lbs of TSS and 1.9 lbs of TP from entering receiving waters annually (Table 12).

**Table 12.** Chimney Sweep benefit summary table.

| | |
|---|---|
| Total Suspended Solids Removed | 5,158 lbs |
| Total Phosphorus Removed | 1.9 lbs |
| Impervious Treated | 3.45 acres |
| Total Drainage Area | 7.9 acres |

### 6.3.3 Cost Estimates

Note that these costs and benefits are very preliminary. Initial cost projections can be found in Table 13. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used. The estimated cost for implementation of this project is $191,000.

- The cost per pound of phosphorus treated is $100,526.
- The cost per impervious acre treated is $55,362.
- The cost per cubic foot of runoff treated is $10.72.

**Table 13. Chimney Sweep 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 | 350 | $1.59 | $556.50 |
| 652.10 | EPSC Plan | LS | 1 | $500.00 | $500.00 |
| 653.20 | Temporary Erosion Matting | SY | 60 | $2.34 | $140.40 |
| 649.51 | Geotextile for silt fence | SY | 100 | $4.07 | $407.00 |
| 652.20 | Monitoring EPSC Plan | HR | 8 | $40.21 | $321.68 |
| | Construction Staking | HR | 8 | $90.00 | $720.00 |
| | | | | *Subtotal:* | $3,145.58 |
| **Chamber Costs** | | | | | |
| | MC4500 | EACH | 99 | $483.00 | $47,817.00 |
| | MC4500 Plain End Cap | EACH | 5 | $494.50 | $2,472.50 |
| | MC4500 18" Top End Cap | EACH | 4 | $682.81 | $2,731.25 |
| | MC4500 24" Bottom End Cap | EACH | 1 | $ 682.81 | $682.81 |
| | 18" 90 Manifold - 1898AN | EACH | 1 | $144.80 | $144.80 |
| | 18" Single Tee Manifold - 1251AN | EACH | 3 | $230.01 | $690.03 |
| | 18" Coupler - 1865AA | EACH | 11 | $23.54 | $258.95 |
| | 18" N12 for splicing as needed (AASHTO) | LF | 60 | $15.28 | $917.01 |
| | 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 |
| | Inline Drain for Inspection Port | EACH | 1 | $310.50 | $310.50 |
| | Inserta Tee for Inspection Port | EACH | 1 | $86.32 | $86.32 |
| | 6" Hole Saw | EACH | 1 | $132.43 | $132.43 |
| | | | | *Subtotal:* | $58,383.75 |
| **Associated Infrastructure and Other Costs** | | | | | |
| 604.20 | Concrete Catch Basin | EACH | 3 | $3,478.51 | $10,435.53 |
| 203.15 | Common Excavation | CY | 1240 | $9.50 | $11,780.00 |
| 629.54 | Crushed Stone Bedding | TON | 670 | $35.93 | $24,073.10 |
| 301.26 | Subbase of Crushed Gravel, Fine Graded (Bedding Sand) | CY | 220 | $40.01 | $8,802.20 |
| 601.0920 | 24" CPEP Pipe | EACH | 225 | $61.37 | $13,808.25 |
| 613.11 | Type II Stone (pipe outlet) | CY | 15 | $42.49 | $637.35 |
| 605.11 | 8-inch underdrain pipe | LF | 500 | $27.04 | $13,520.00 |
| 651.15 | Seed (grass) | LBS | 10 | $7.79 | $77.90 |
| N/A | 30 Mil PVC Liner | SY | 555 | $5.68 | $3,152.40 |
| | | | | *Subtotal:* | $86,286.73 |
| **Subtotal:** | | | | | $147,816.06 |

| VTrans Code | Description | Unit | Quantity | Unit Price | Amount |
|---|---|---|---|---|---|
| | Construction Oversight** | HR | 32 | $100.00 | $3,200.00 |
| | Construction Contingency - 10%** | | | | $14,781.61 |
| | Incidentals to Construction - 5%** | | | | $7,390.80 |
| | Minor Additional Design Items - 5%** | | | | $7,390.80 |
| | Final Design | HR | 80 | $100.00 | $8,000.00 |
| | Permit Review and Applications (exclusive of permit fees) | HR | 20 | $100.00 | $2,000.00 |
| **Total (Rounded)** | | | | | **$191,000.00** |

### 6.3.4 Next Steps

Landowner outreach was completed with Mr. Tim Ayer from Chimney Sweep. He has expressed his interest in the project, and was amenable to allowing completion of further design of this project. 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 landowner prior to final design.

### 6.3.5 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 Lottery Commission site will likely need a stormwater permit under the proposed 3-acre impervious cover rule as this parcel, located to the west of the Chimney Sweep site, contains 3.4 acres of impervious cover. The Chimney Sweep parcel would not be subject to this permit as it does not contain more than 3 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*
The entire Chimney Sweep parcel is located in the river corridor (Figure 20), so 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.

## *6.4 Berlin Fire Department 1*

### 6.4.1 30% Concept Design Description

The Berlin Fire Department is located on Route 12, west of Crosstown Road. At this site, stormwater runoff from the gravel parking lot and rooftop travels overland and enters the Dog River to the southeast of the site (Figure 21).

Soils are mapped as being a mix of good (Hydrologic Group A) and poor at this site (Hydrologic Group C). As such, 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 0.25 in/hr. This value is classified within the moderately high permeability class. Soils were generally found to be a mix of sand and gravel (Figure 22).


**Figure 20. The proposed infiltration trench is located in the southeast corner (see starred location) of the Berlin Fire Department 1's drainage area, which is shown in red.**

An infiltration trench is proposed along the southeast perimeter of the parking lot to intercept and infiltrate the stormwater runoff from the site. While the majority of the drainage area is located within the river corridor (Figure 21), this practice would result in no net fill in the river corridor.

The drainage area for this proposed BMP is 0.6 acres, approximately 80% of which is classified as impervious. This practice will provide a water quality benefit (Table 14), 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

**Figure 21. Soils at the Berlin Fire Department 1 site were generally a mix of sand and gravel.**

be installed in conjunction with the retrofit. The design standard used for this retrofit was full infiltration of the Channel Protection volume (CPv, or 2.02" of rain in a 24-hour period), equal to 4,008 $ft^3$ of runoff.

A 30% design plan is provided in Appendix M - 30% Designs.

### 6.4.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 534 lbs of TSS and 0.41 lbs of TP from entering receiving waters annually (Table 14).

**Table 14. Berlin Fire Department 1 benefit summary table.**

| | |
|---|---|
| Total Suspended Solids Removed | 534 lbs |
| Total Phosphorus Removed | 0.41 lbs |
| Impervious Treated | 0.49 acres |
| Total Drainage Area | 0.6 acres |

### 6.4.3 Cost Estimates

Note that these costs and benefits are very preliminary. Initial cost projections can be found in Table 15. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used. The estimated cost for implementation of this project is $19,000.

- The cost per pound of phosphorus treated is $46,341.
- The cost per impervious acre treated is $38,776.
- The cost per cubic foot of runoff treated is $4.74.

**Table 15. Berlin Fire Department 1 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 | 300 | $1.59 | $477.00 |
| 653.20 | Temporary Erosion Matting | SY | 100 | $2.34 | $234.00 |
| 649.51 | Geotextile for silt fence | SY | 95 | $4.07 | $386.65 |
| 652.10 | EPSC Plan | LS | 1 | $500.00 | $500.00 |
| | Construction Staking | LS | 1 | $500.00 | $500.00 |
| | | | | *Subtotal:* | $2,597.65 |
| **Infiltration Trench and Filter Strip Materials (w/labor and trucking included)** | | | | | |
| 203.15 | Common Excavation | CY | 265 | $9.86 | $2,612.90 |
| 629.54 | Crushed Stone Bedding | TON | 2 | $35.93 | $71.86 |
| 651.35 | Topsoil | CY | 40 | $31.48 | $1,259.20 |
| 613.11 | Type II Stone (overflow) | CY | 15 | $42.49 | $637.35 |
| 651.15 | Seed (grass) | LBS | 10 | $7.79 | $77.90 |
| 653.20 | Temporary Erosion Matting | SY | 500 | $2.34 | $1,170.00 |
| | | | | *Subtotal:* | $5,829.21 |
| **Subtotal:** | | | | | $8,426.86 |
| | Construction Oversight** | HR | 16 | $100.00 | $1,600.00 |
| | Construction Contingency - 10%** | | | | $842.69 |
| | Incidentals to Construction - 5%** | | | | $421.34 |
| | Minor Additional Design Items - 5%** | | | | $421.34 |
| | 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)** | **$19,000.00** |

* This cost could be eliminated by using seeds instead of perennial plugs. Note different sub-totals.

### 6.4.4 Next Steps

Contact was made with Joe Staab (Berlin Volunteer Fire Department) prior to advancing concept designs at this site. The Fire Department agreed to allow further design to be completed at the site. 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 landowner prior to final design.

### 6.4.5 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*
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, and within the FEMA Flood Hazard Area. However, it should be noted that since this proposed BMP is subsurface, there will be no net fill within the river corridor. This project should also be reviewed by a wetland ecologist prior to final design due to the presence of hydric soils. No Act 250 permitting is anticipated for this project.

## 6.5 Berlin Fire Department 2

### 6.5.1 30% Concept Design Description

The site includes the Fire Department building and paved driveways and parking lots located off of Paine Turnpike North across from the intersection with Pike Drive. Stormwater currently sheet flows through this area into a small tributary behind the building (to the east; Figure 23).


**Figure 22. Runoff from the Berlin Fire Department 2 drainage area, shown in red, is proposed to be directed to two separate bioretention areas, shown with stars.**

Soils are mapped as being very poor at this site for infiltration (Hydrologic Group D). As such, an infiltration-based practice was not pursued, so soils and infiltration testing were not completed at this site.

The concept for this site includes two non-infiltration-based bioretention practices. One will be located by the northwestern corner of the station, and the second will be situated by the southwestern corner of the parking lot (see stars in Figure 23 for locations). A shallow swale will wrap around the eastern side of the parking lot to direct drainage into the second bioretention.

The drainage area for these proposed BMPs is 1.1 acres, approximately 65% of which is classified as impervious. This practice will provide a water quality benefit (Table 16), but is also a high visibility site within the Town. 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 detention and slow release of the Channel Protection volume (CPv, or 2.02" of rain in a 24-hour period), equal to 4,443 $ft^3$ of runoff.

A 30% design plan is provided in Appendix M - 30% Designs.

### 6.5.2 Pollutant Removal and Other Water Quality Benefits

A retrofit of this site has the potential to prevent 1,007 lbs of TSS and 0.52 lbs of TP from entering receiving waters annually (Table 16).

**Table 16. Berlin Fire Department 2 benefit summary table.**

| | |
|---|---|
| Total Suspended Solids Removed | 1,007 lbs |
| Total Phosphorus Removed | 0.52 lbs |
| Impervious Treated | 0.68 acres |
| Total Drainage Area | 1.1 acres |

### 6.5.3 Cost Estimates

Note that these costs and benefits are very preliminary. Initial cost projections can be found in Table 17. This amount differs from the amount initially projected for this site as design-specific amounts and costs were used. Note that two separate cost estimates are provided. The first, which totals $40,000, includes plant plugs while the second cost, $31,000, includes only seeds for planting of the bioretention 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.

- The cost per pound of phosphorus treated is $76,923 for the plant plugs and $59,615 for the seeds.
- The cost per impervious acre treated is $58,824 for the plant plugs and $45,588, for the seeds.
- The cost per cubic foot of runoff treated is $9.00 for the plant plugs and $6.98 for the seeds.

**Table 17. Berlin Fire Department 2 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 | 500 | $1.59 | $795.00 |
| 649.51 | Geotextile for silt fence | SY | 240 | $4.07 | $976.80 |
| 652.10 | EPSC Plan | LS | 1 | $500.00 | $500.00 |
| | Construction Staking | HR | 8 | $90.00 | $720.00 |
| | | | | *Subtotal:* | $3,491.80 |
| **Bioretention Materials (w/labor and trucking included)** | | | | | |
| 203.15 | Common Excavation | CY | 390 | $9.86 | $3,845.40 |
| 651.35 | Topsoil | CY | 160 | $31.48 | $5,036.80 |
| 613.11 | Type II Stone (overflow) | CY | 30 | $42.49 | $1,274.70 |
| 656.41 | Plants* (Perennial Plugs) | EACH | 1000 | $8.77 | $8,770.00 |
| N/A | Perennial Flower Seeds | LBS | 4 | $125.00 | $500.00 |
| 651.15 | Seed (grass) | LBS | 15 | $7.79 | $116.85 |
| 601.0910 | 15" CPEP Outlet Works | LF | 12 | $34.05 | $408.60 |
| 601.0910 | 15" CPEP Pipe | EACH | 45 | $34.05 | $1,532.25 |
| 653.20 | Temporary Erosion Matting | SY | 332 | $2.34 | $776.88 |
| | | | | *Subtotal:* | $22,261.48 |
| **Subtotal:** | | | | | $25,753.28 |
| | Construction Oversight** | HR | 32 | $100.00 | $3,200.00 |
| | Construction Contingency - 10%** | | | | $2,575.33 |
| | Incidentals to Construction - 5%** | | | | $1,287.66 |
| | Minor Additional Design Items - 5%** | | | | $1,287.66 |
| | Final Design | HR | 40 | $100.00 | $4,000.00 |
| | Permit Review and Applications (exclusive of permit fees) | HR | 16 | $100.00 | $1,600.00 |
| **Total - Plugs Option (Rounded)** | | | | | **$40,000.00** |
| **Total - Seed Option (Rounded)** | | | | | **$31,000.00** |
| * This cost could be eliminated by using seeds instead of perennial plugs. Note different sub-totals. | | | | | |

### 6.5.4 Next Steps

Contact was made with Joe Staab (Berlin Volunteer Fire Department) prior to advancing concept designs at this site. The Fire Department agreed to allow further design to be completed at the site. 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 landowner prior to final design.

### 6.5.5 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 site will likely need a stormwater permit under the proposed 3-acre impervious cover rule. Though the fire department's drainage area does not exceed 3 acres impervious cover, the Berlin Fire Station shares a parcel with the Berlin Elementary School (project Berlin Elementary School in this plan). The parcel as a whole contains 3.3 acres of impervious cover. The school separately contains 2.8 acres of impervious cover, and the remainder is part of the Berlin Fire Department. However, since the parcel contains more than 3 acres of impervious cover, this site would necessitate a permit (Figure 18).

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.

## 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 the Town of Berlin and receiving waters. Although designs were only advanced for the top 5 projects, this plan also serves to highlight these other opportunities throughout the drainage areas. 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 in Berlin's landscape. It is our recommendation that the Town, in partnership with the CVRPC move to implement the Top 5 practices, but also to move forward with additional design and implementation of other projects presented in this plan (see Appendix I - Top 20 Site Final Ranking). As these practices are the result of a stormwater master planning effort under a VT DEC 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 Town. Projects determined in this plan should be coordinated with the VTrans TS4 permitting efforts to allow for potential collaboration.