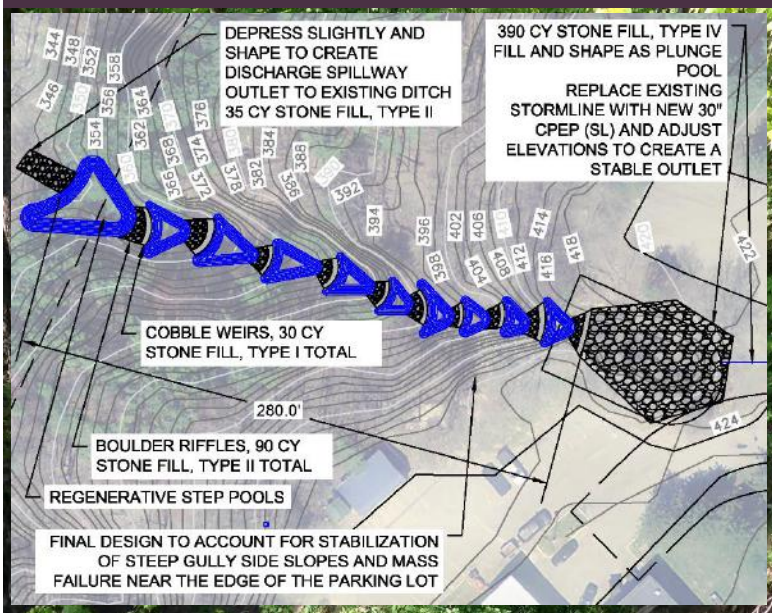
Stormwater Master Plan
Town of Richmond, Vermont

STONE ENVIRONMENTAL



PROJECT NO.

17-061-A

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Cover: Gully erosion identified at the north end of the Richmond Elementary / Camel's Hump Middle School campus; and concept design for a regenerative conveyance retrofit to provide both water quality treatment and safe conveyance for runoff from both the school campus and a portion of I-89.

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Acknowledgements

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1. Introduction

Water knows no political boundaries, and thus evaluations of water quality tend to be undertaken within watershed boundaries and involve land areas in multiple towns. From a water quality perspective, it would be ideal to manage water resources along watershed lines—but the reality is that many decisions, particularly those about land use, are made at the level of towns or individual sites.

A Stormwater Master Plan is responsive to existing landscape characteristics across all watersheds within local political bounds. It connects land use, stormwater management, floodplain management, river management, and public infrastructure needs to more effectively address all of the issues which contribute to water quality impairment or improvement. Within this Plan, localized stormwater problems are examined at a larger scale (e.g., throughout the village core) to determine their relative contributions and aid in setting priorities for addressing challenges related to stormwater runoff. As adjoining municipalities also take increasingly comprehensive views of stormwater management issues and planning, these plans are one-stop resources that can improve coordination and increase opportunities for collaboration in meeting watershed-related needs across political boundaries.

1.1. Project Overview

As precipitation falls on an undisturbed, natural landscape and moves through the hydrologic cycle, it flows through a complex system of vegetation, soil, groundwater, and surface water. Natural events have shaped these components over time to create a system that can efficiently handle stormwater through evaporation, transpiration, infiltration, and runoff. Alterations to the landscape change the way it responds to precipitation events. Management of land use, rainfall, storm runoff, and surface water (streams and lakes) are interrelated, and the management practices chosen all influence water quality and stream health.

Watersheds are interconnected networks in which a change at any location can carry throughout the system. There are many factors that influence exactly how stormwater runoff from a particular site will affect other areas of the watershed. The degree and type of impact varies from location to location, but it can be significant relative to other sources of pollution. Stormwater runoff affects water quality, water quantity, habitat and biological resources, public health, and the aesthetic appearance of the receiving water. Stormwater controls, in contrast, are typically conceived and implemented on a project-by-project basis. These projects are analyzed for their individual stormwater impacts, not in the context of their impact on an interconnected hydrologic and hydraulic system. It is well documented, however, that the cumulative effects of individual land surface changes dramatically influence flooding conditions and contribute to water quality degradation (NRC 2009).

What is a watershed? A watershed is any area of land in which all water runoff from its surface flows to the same drainage point. Watersheds are sometimes referred to as drainage areas. Watersheds are important because they are the basic unit of analysis for all surface water management. They come in all shapes and sizes, and are defined based on the intended study area.

Watershed management practices have direct impacts on water quality both locally (in the Huntington and Winooski Rivers) and in downstream waterbodies (Lake Champlain). Decisions that affect land use have stormwater management ramifications and, in turn, impact all downstream water resources.

Vermont's streams, rivers and lakes are vital economic resources. The quality of local receiving waters affects both economic interests and quality of life in the surrounding areas. Throughout the Winooski River basin, the local economy depends, in part, on the revenue gained from outdoor activities enjoyed in and on the water. Protecting the quality of surface waters is one of the most important commitments communities can make to protect the economic interests of residents.

Taken together, these elements emphasize the need for a holistic planning effort that considers the interconnected nature of land use, stormwater management, and river management in order to achieve overall watershed goals. The Vermont Department of Environmental Conservation (VTDEC) issued Vermont Stormwater Master Planning Guidelines in 2013 (most recently updated in June 2016) to provide a consistent framework for the many communities and stakeholders undertaking stormwater planning efforts—and critically, to make better use of limited dollars by targeting high priority stormwater projects. Richmond's plan generally follows Template #2A from this guidance, "Hybrid site and community retrofit approach with green stormwater infrastructure stormwater management".

1.2. Project Goals

The ultimate objective of this stormwater master planning project is to support the Town in improving stormwater management, by providing a list of high priority water resource concerns and conceptual solutions that support the development and implementation of future restoration projects in an efficient and targeted manner.

This Stormwater Master Plan first incorporates information from existing plans and datasets to create a single, town-specific resource to guide future stormwater management activities. The resulting stormwater management planning information and resources are included in Section 2 of this report.

This Stormwater Master Plan also:

- Provides a means for comparing anticipated benefits of individual stormwater improvement projects;
- Provides recommendations to address stormwater problems, including a prioritized list of problem areas that can assist the Town in directing resources to high priority projects; and
- Presents conceptual solutions for stormwater management measures in select high priority problem areas.

1.3. Problem Definition – Project Area and the Winooski River

The Town of Richmond is located in Chittenden County; the Town has a total area of 32.7 square miles and as of the 2010 census, the population of Richmond was 4,081 (US Census Bureau 2018). The Winooski River flows into town from the west and flows out of town into neighboring Williston. The Huntington River flows into Richmond along its southern border, and flows north and east until it meets the Winooski River mainstem in Jonesville at the Town's eastern border. The areas of interest for this plan are all in the Winooski River watershed and include Richmond's village center in the center of town, and the Richmond Elementary School/Camels Hump Middle School campus, including upland areas contributing runoff from east of the campus and I-89 (Figure 1).

The Winooski River watershed encompasses a watershed area of about 1,080 square miles (11.9 percent of Vermont). The basin occupies all of Washington County, a little less than half of Chittenden County and

small parts of Lamoille and Orange Counties. Almost three quarters of the watershed benefits from forest and wetland cover, most of it located in the higher elevations or upper half of the watershed. The agricultural and urban (developed land and roads) land use comprise only 12% and 9% of the landscape respectively. The developed or urban areas are concentrated in Chittenden County, including in Richmond, but also include small cities and towns located adjacent to the main stem and tributaries. The water quality problems identified in the basin tend to be associated with decreasing amounts of natural landcover (VTDEC 2012). The entire Winooski river basin, including Richmond, is part of the area subject to the Lake Champlain Phosphorus TMDL issued by the U.S. EPA in 2016. The Huntington River is also subject to a state-wide bacteria TMDL issued in 2013, though specific actions to address the bacteria impairment are not within the area of interest for the stormwater management plan.

2. Existing Plans and Data

Numerous and varied groups and individuals have invested considerable effort in evaluating different components of Richmond's water, wastewater, and stormwater infrastructure; water resources; and the important interface between water resources and local land use decisions. At times these evaluations followed watershed boundaries, and at other times they have followed political boundaries. The following sections identify these evaluations and highlight information most relevant to Richmond and most relevant to developing a list of strategic, prioritized projects that could be undertaken to improve water quality and increase resilience. Reference documents, including those described in this section, and pre-existing data used to further inform the development of this Plan are included in Appendix B.

2.1. Watershed-Based Assessments

The ongoing assessments described below are generally led by the State of Vermont's Agency of Natural Resources (ANR). These include basin planning efforts, stream geomorphic assessment and in-stream water quality assessment work, and TMDL development, each of which are briefly described below where applicable information is available for Richmond.

2.1.1. Tactical Basin Planning

The main goal of tactical basin planning is to guide ANR in its own work and in collaborative projects with the public, municipalities, and other state and federal agencies. The basin plans have a five-year scope. The Town of Richmond is located in the Winooski River Basin (Basin #8), where a plan was adopted in May 2012 by the Agency of Natural Resources. The central component of this Tactical Basin Plan is an implementation table with targeted actions to protect high quality waters and to address identified water quality issues identified. One of the top priority actions stated in the plan was to 'assist municipalities in the development and implementation of municipal stormwater management plans as well as overall water quality planning for towns...and present completed IDDE maps for Stowe, Richmond, Waterbury, and Waitsfield to municipal staff and community groups to assist in the identification and implementation of potential stormwater retrofit projects or housekeeping practices' (Item 2.d, Page 18 of the plan) (VTDEC, 2012). The Winooski's Tactical Basin Plan is currently being updated, with a final Plan anticipated late in 2018.

2.1.2. Other Vermont ANR-Sponsored Programs

Additional ANR-based data sources reviewed prior to the start of field visits for the purpose of locating potential stormwater problem areas (Section 3) included:

- Stream Geomorphic Assessments: Recorded in the Vermont ANR Natural Resources Atlas Geomorphic Assessment Viewer (http://anrmaps.vermont.gov/websites/anra5/?LayerTheme=1); in Richmond, Phase II Fluvial Erosion Hazard Assessments and River Corridor Plans are available for: Winooski and Huntington Rivers, Johnnie Brook.
- Water Quality Monitoring Data: Available through the Vermont Integrated Watershed Information System (IWIS), the VTDEC-Watershed Management Division's online data portal for water quality information, at https://anrweb.vt.gov/DEC/IWIS/.

2.2. Town-Wide Assessments and Programs

In addition to the watershed-based assessments, a number of assessments and datasets are developed on a municipality-by-municipality basis. These include direct feedback from the Town; work by the Vermont Agency of Transportation and Vermont Department of Environmental Conservation; and past and current planning initiatives.

- Direct Input from Town Staff: Meetings with Town and School District staff resulted in the identification of several areas of concern and priority project opportunities that were further assessed in the field and included in the stormwater opportunity prioritization and implementation matrix (Section 4.2).
- Vermont Agency of Transportation-Sponsored Programs: The agency's online bridge and culvert inventory for Town-controlled bridges and culverts (available at https://www.vtculverts.org/) was reviewed prior to field screening and evaluation of potential stormwater problem areas (Section 3). The agency's Small Culverts Inventory dataset was also reviewed to assess VTrans-owned and controlled drainage infrastructure crossing I-89 to the north of the elementary/middle school campus (http://vtransmaps.vermont.gov/webmaps.htm).
- Vermont DEC-Sponsored Programs: Much of the Richmond village area and the elementary/middle school campus is served by closed-system stormwater infrastructure, which was mapped by Vermont DEC in 2009. Detailed stormwater infrastructure mapping and state-issued post-construction stormwater permitting records were examined in order to identify additional stormwater management opportunities. The infrastructure mapping data represent an important supplement to VTrans' online bridge and culvert inventories and were invaluable during evaluations of existing problem areas and retrofit opportunities (Section 3 and as further described below).

A stormwater infrastructure mapping project completed by the VTDEC Ecosystem Restoration Program for Richmond's village area identified potential locations for stormwater retrofit sites among priority drainage areas. The identified potential retrofits included:

- A bioretention area or wet pond was proposed to treat runoff from closed drainage systems serving Main Street southeast of the Bridge Street intersection, Bridge Street, Depot Street, Pleasant Street, and Jolina Court.
- A sedimentation basin was proposed to treat runoff from both open and closed drainage systems conveying runoff from the Richmond Elementary/Camel's Hump Middle School parking lot and roadway.
- A wet pond was proposed to treat runoff from closed drainage systems serving Baker Street, Main Street, portions of Railroad and Church Streets, and Borden Street.
- A bioretention area was proposed to treat runoff from buildings and a parking lot east of Bridge Street and south of Jolina Court (US Postal Service and Richmond Free Library).

In addition, the age, style, size, and upkeep of existing facilities permitted by DEC – particularly facilities constructed prior to 2002 – may make them candidates for improvement to enhance stormwater management capabilities. Post-construction stormwater management permits for the planning area (as available from the ANR Atlas at http://anrmaps.vermont.gov/websites/anra5/, "Stormwater Permits – Issued" data layer) were reviewed during field screening of potential stormwater problem areas (Section 3) and development of potential implementation projects (Section 4).

Another resource utilized during the desktop assessment was the Richmond Road Erosion Inventory Assessment. This assessment was conducted in the summer of 2016 by the CCRPC. The assessment was

conducted to help the Town prepare for compliance with the, then pending, Municipal Roads General Permit (MRGP), later issued in early 2018. The assessment looked at how well hydrologically-connected, 100- meter road segments were complying with MRGP standards such as road crown, berm issues, ditches, cross culverts, driveway culverts, outfalls, and presence of rill or gully erosion.

In 2016, of the 629 hydrologically connected, 100-meter road segments in Richmond, the CCRPC found 219 that did not meet current MRGP draft standards. The Town will have until 2036 to bring those 219 segments, totaling 13.29 miles, up to standards. Initially, to comply with the permit, the Town will need to focus its work on 22 non-compliant road segments with drainage ditches scoring "Does Not Meet" on the REI, on slopes greater than 10%, as these are considered by the Permit as "Very High Priority Road Segments" which, "shall be upgraded to meet the MRGP standards listed in Part 6 of this General Permit by December 31, 2025."

The intent of the MRGP is to reduce stormwater-related erosion from municipal roads by stabilizing municipal road drainage systems to basic maintenance standards and taking preventative measures to mitigate erosion when necessary. Table 1 below summarizes these segments by standards compliance and surface type.

In addition to assessing which hydrologically-connected road segments did not meet the MRGP standards, the CCRPC engaged the services of Fitzgerald Environmental Services, LLC (FEA) to determine which segments, not meeting current MRGP standards (both PARTIALLY MEETS and DOES NOT MEET), should be fixed in terms of reducing their negative impacts on water quality. These segments were scored by FEA with a severity rating via a 0 to 10 scoring system in which 0 is the best, and 10 is the worst – in terms of a segment's ability to impact water quality.

After sorting all segments and ranking them from worst to best, the CCRPC further investigated the top 10 segments to detail additional information including pictures and problem/solution identification. The locations of the "top 10" road erosion priority sites can be seen in Figure 2 (Appendix A).

A final resource utilized during the desktop assessment was the Town's 2017 All-Hazards Mitigation Plan, approved by the Selectboard and FEMA as of March 6, 2017. Hazard Mitigation is a sustained effort to permanently reduce or eliminate long-term risks to people and property from the effects of reasonably predictable hazards. The purposes of this updated Local All-Hazards Mitigation Plan are to:

- Identify specific natural, technological and societal hazards that impact the Town of Richmond;
- Prioritize hazards for mitigation planning;
- Recommend town-level goals and strategies to reduce losses from those hazards; and
- Establish a coordinated process to implement the plan, taking advantage of a wide range of resources.

The Town plans to conduct the following mitigation actions during the 5 year period this Plan is in effect (2017-2022):

- CATEGORY A: Complete fluvial geomorphology assessment and address identified vulnerable infrastructure
  - Action A-1: Complete geomorphic assessment and corridor management plan for the Winooski River
  - Action A-2: Flood Hazard Mitigation Project Implementation
- CATEGORY B: Improve capabilities of existing road and stormwater management infrastructure
  - Action B-1: Culvert Upgrades: Upgrade culverts and ditching along roads to mitigate repeated damages from stormwater or spring snowmelt.
  - Action B-2: Drainage Improvement: rebuilding approximately 2 miles of gravel roads each year to ensure good quality of the base and top layers which will improve drainage and reduce the

likelihood of damage in hazard events. Likely roads to be improved are Dugway Road and Kenyon Road.

- Action B-3: Road Improvement: Consider re-engineering certain sections of roads to lower overall maintenance costs and improve overall capability of roads to handle current and projected traffic volumes. Consider paving certain road sections - potential target roads are Cemetery Road and Hillview Road.

- CATEGORY C: Implement Roads Stormwater Management Plan
  - Action C-1: Develop Roads Stormwater Management Plan: Complete an Inventory of Priority Road Segments both currently meeting and not meeting MRGP standards. Apply for MRGP coverage starting in July 2018. After issuance of the permit by the State, use this information to develop a formal Roads Stormwater Management Plan.
  - Action C-2: Begin Roads Stormwater Management Plan implementation: Obtain funding for and complete projects as identified in the Roads Stormwater Management Plan. Submit annual reports to DEC, documenting progress in remediation efforts towards meeting schedule to be in compliance with the MRGP.

Table 1. Top 10 Municipal Roads Erosion Priority Sites

Priority	Road Name	Segment ID	Overall Segment Score	Field Determined Slope	Road Type	Roadway Crown / Travel Lane	Grader Berm / Windrow	Road Drainage	Conveyance Area / Turnout	Erosion Type Present	Driveway & Drainage Culvert
1	Stage Road	171148	Does Not Meet	8.7%	Gravel	Fully Meets (100%)	Partially Meets (65%)	Partially Meets (65%)	Does Not Meet (3 Poor)	Gully and Rill	1 Drainage, 3 Driveway
2	Snipe Ireland Road	169082	Does Not Meet	13.7%	Gravel	Fully Meets (100%)	Partially Meets (50%)	Does Not Meet (0%)	Fully Meets	Rill	1 Drainage
3	Christmas Hill Road	22081	Partially Meets	11.7%	Gravel	Fully Meets (95%)	Partially Meets (70%)	Partially Meets (70%)	Fully Meets	Rill	1 Drainage, 3 Driveway
4	Snipe Ireland Road	169081	Partially Meets	11.8%	Gravel	Partially Meets (50%)	Partially Meets (60%)	Fully Meets (100%)	Fully Meets	Rill	1 Drainage, 1 Driveway
5	Christmas Hill Road	22080	Does Not Meet	8.3%	Gravel	Fully Meets (95%)	Fully Meets (95%)	Fully Meets (90%)	Does Not Meet (1 Poor)	Gully and Rill	1 Drainage, 2 Driveway
6	Williams Hill Road	198895	Partially Meets	9.1%	Gravel	Fully Meets (100%)	Partially Meets (60%)	Partially Meets (60%)	Fully Meets	Rill	1 Drainage
7	Lawrence Road	123630	Does Not Meet	10.1%	Gravel	Fully Meets (100%)	Partially Meets (80%)	Partially Meets (60%)	Does Not Meet (5 Poor)	Rill	1 Drainage, 2 Driveway
8	Stage Road	171136	Does Not Meet	10.9%	Gravel	Partially Meets (75%)	Does Not Meet (40%)	Does Not Meet (35%)	Fully Meets	Rill	None
9	Hillview Road	112587	Does Not Meet	7.2%	Gravel	Fully Meets (100%)	Partially Meets (70%)	Does Not Meet (40%)	Fully Meets	Gully and Rill	1 Driveway
10	Stage Road	171141	Does Not Meet	11.3%	Gravel	Fully Meets (90%)	Partially Meets (75%)	Does Not Meet (40%)	Does Not Meet (1 Poor)	Rill	1 Driveway

3. New Data Collection and Identification of Stormwater Problem Areas

One of the objectives of this plan is to make recommendations to improve the functioning of aging infrastructure, using GSI-type retrofits where appropriate. To achieve this goal, a thorough effort was made to identify existing problem areas, and then to evaluate existing conditions and potential solutions.

3.1. Identification and Initial Evaluation of Stormwater Problem Areas

Initially, we identified the location and nature of existing drainage problems and stormwater management concerns, and gathered field data for further analysis where appropriate. The approach to identifying potential problem areas included the following elements:

- Reviewing existing plans and data, as described in Section 2, and noting the location of any concerns related to stormwater
- Engagement with Town, School District, Friends of the Winooski River, and State of Vermont staff
- Targeted site visits to verify problem areas during the fall of 2017 and spring of 2018
- Documentation (with photos) of existing problem areas

A "problem area data sheet" was developed and used as a guide to ensure that consistent information was collected as site visits were completed. A total of 22 potential problem areas were identified by Stone and geo-located (Figures 3-6, Appendix A). Eleven of these areas were located in the village area, seven were identified on the school campus, and four areas were identified within the I-89 right-of-way to manage runoff from the interstate and upland areas. The data sheets are provided in Appendix C.

3.2. Initial Screening Evaluation of Problem Areas

Working from the list of potential problem areas, Stone staff visited each potential problem area to directly observe the site. Where an unresolved problem was found, photos were taken of any areas of active erosion or observable impact, and observations were recorded regarding the source or cause.

Each problem area was given an initial score with the intent of: 1) generally assessing the severity of existing problems, 2) removing low priority problem areas from the dataset, and 3) providing general guidance on the relative order in which the problems should be addressed when considered across the project area. Scores were assigned as described in Table 2.

The problem areas identified during this initial evaluation were carried forward through a more detailed examination and prioritization process as described in Section 4.

Table 2. Scoring Criteria for Preliminary Evaluation of Stormwater Problem Areas.

Level	Classification
1	Outside of project scope, or infeasible to remedy due to project size.
2	Stable, but problem could escalate with future change in surrounding land use.
3	Limited erosion and/or drainage problems are present; issues may be readily addressed.
4	Moderate erosion and/or drainage problems are present; issues may be readily addressed.
5	Significant erosion and/or drainage problems are present; issues may be readily addressed.
6	Strategic retrofit opportunity.

3.3. Problem Identification for Private Property / Community Areas

In addition to the problems and opportunities identified through the process described above, the Winooski Natural Resources Conservation District (WNRCD) conducted twelve stormwater technical site visits and assessments between November 2017 - April 2018. In contrast to the problem areas and engineered retrofit solutions identified by Stone, those proposed by WNRCD were focused on low-tech opportunities on private properties and in the community. WNRCD ultimately identified eight stormwater project opportunities and one program opportunity (Section 6 and Appendix D).

4. Prioritization of Stormwater Management Opportunities and Decision Matrix

Stone completed a field screening that identified 22 stormwater management opportunities in the Town of Richmond during the fall of 2017 through May of 2018. The following tables build upon the basic problem area descriptions and documentation included in the Stormwater Problem Area Datasheets (PADS) (Appendix C), to include documentation of drainage area characteristics, potential BMPs to be implemented, and the stormwater volume reduction and pollutant removal benefits that may be achieved by implementing the proposed improvements. Finally, an implementation matrix is presented, which ranks each problem area and proposed solution relative to existing environmental concerns, overall environmental priority, constructability, and ease of operation.

4.1. Drainage Area Characteristics and Retrofit Benefits

Key characteristics and assessment results for each identified stormwater problem area or strategic retrofit opportunity within the project area are summarized in Table 4. The following characteristics are included for each identified problem area or retrofit opportunity:

- Site ID (with locations shown on Figures 2-5 in Appendix A)
- Site name
- Drainage area characteristics:
  - Primary Hydrologic Soil Group (HSG), as derived from the Chittenden County Soil Survey for the drainage area
  - Total drainage area (acres)
  - Impervious surfaces within the drainage area (in acres)
  - Percent impervious cover in the drainage area
- Drainage area runoff volumes and phosphorus loading estimates
  - Estimated Water Quality Volume (WQv) (in cubic feet) for the entire area draining to the proposed BMP, based on the 2017 VSMM Water Quality Treatment Standard's required runoff capture and treatment depth of 1 inch (VTDEC, 2017).
  - Estimated Hydrologic Conditions Volume / Channel Protection Volume, in acre-feet and cubic feet, based on the 2017 VSMM Channel Protection Standard's requirement to provide treatment for the difference in runoff volumes between pre-development and post-development site runoff for the one-year, 24-hour storm (VTDEC, 2017). The volumes reported in the table assume that the present condition represents the "post-development" condition.
  - Estimated total phosphorus base load (lbs/year) for the WQv, calculated using the Simple Method approach and based on phosphorus loading rates for developed lands developed by Vermont DEC in 2015 as an interim procedure to guide applicants in meeting phosphorus "Net Zero" requirements for projects that would potentially discharge phosphorus to Lake Champlain before the P TMDL was in place (VTDEC 2015). The average annual pollutant (phosphorus) concentrations provided in the guidance that were applied in Table 1 are 0.441 mg/L for

developed lands, and 0.618 mg/L for paved roads. The developed lands concentration of 0.441 mg/L was applied for most systems in the project area, consistent with DEC guidance for systems that include driveways, access drives, and other transportation surfaces within larger development projects (e.g., residential and commercial subdivisions).

- Estimated total phosphorus load to be removed by proposed improvements on an annual basis (lbs/year), calculated based on the estimated total phosphorus base load, annual runoff volume anticipated to be captured by proposed BMPs, and percent pollutant removal efficiencies for the proposed BMP types as included in the Lake Champlain BMP Scenario Tool (Tetra Tech 2015) (Table 3).

Table 3. Phosphorus Removal Efficiencies by BMP Type, Assuming 1 Inch of Runoff Treated

BMP Type	BMP P Removal Efficiency %
Bioretention	76
Extended Dry Detention pond	12
Grass Swale	21
Gravel Wetland	61
Infiltration Chamber	98
Infiltration Trench	98
Porous Pavement (Asphalt)	75
Sand Filter	60
Surface Infiltration	98
Wet pond/ Created Wetland	52

- Proposed Best Management Practices, cost estimates, and cost-benefit metrics:
  - Proposed BMP type
  - Proposed storage volume, or treatment capacity, estimated to optimize treatment by maximizing the area available for treatment while accounting for various BMP void ratios. Assumptions were made with regard to reasonable storage depths.
  - Proposed BMP implementation cost, estimated on a price per cubic foot of storage basis. Costs for implementing proposed stormwater BMPs were estimated using the cost function employed in Vermont's Best Management Practice Decision Support System (BMPDSS), as well as current installation cost estimates per cubic foot of BMP storage volume provided in 2016 guidance from U.S. EPA Region 1. The costs are calculated based on the following equation:
    - total cost = installation cost (I) + land cost (L) + fixed cost (F), where
    - I = BMP installation cost per cubic foot (CF) of storage volume in 2016 dollars, updated to account for inflation to the year 2018, using a 2.5% inflation rate, specific to the practice type
    - L = $0 as easement or land purchase costs for individual BMPs are not yet known
    - F = project-specific estimate of design/permitting costs, estimated at 25% of construction costs.
    - A cost adjustment factor was applied for each proposed BMP to account for anticipated and site-specific implementation challenges. The assumption made was that it would cost more

to install a new BMP in a developed area (with more site constraints) than it would cost to install the same BMP in a previously undeveloped area. The unit-based BMP installation costs were developed using a cost adjustment factor or 1 (new BMP in undeveloped area). Proposed BMPs in outlying areas of the Village and at the school property were given an adjustment factor of 1.5; BMPs in or near the village core were given a cost adjustment factor of 2.0, and BMPs associated with I-89 were given a cost adjustment factor of 2.5 to account for the complexity of VTrans's project development processes.

- Phosphorus removal cost-benefit: The total implementation cost for each BMP was divided by the estimated total annual phosphorus load reduction, resulting in a cost per pound of P removed.

4.2. Implementation Matrix

Through field screening, development of the problem area datasheets, and desktop evaluation to define and refine drainage areas and their respective characteristics, Stone recorded observations about each site, which were used to develop a draft "implementation score" for each opportunity (Table 2) relative to the following criteria:

- **Existing environmental concerns** – score was assigned based on the type(s) of problems present, with 1 point added for each of the following concerns presented by the site's current condition: water quality concerns; infrastructure vulnerability; localized drainage issues/flooding; gullying resulting from existing drainage systems, and streambank or in-stream erosion. Although sites are generally anticipated to receive between 1 and 3 points, the maximum score a site can receive is 5.
- **Environmental priority –** relative environmental impact on nearest receiving water (e.g., proximity, location) and how "active" the problem area was during the site visit, with 1 being the smallest impact and 5 being the greatest impact.
- **Constructability –** relative ease with which a project could be implemented, including whether the recommended practice(s) could be constructed on publicly-owned land or with a willing landowner-partner, existing access to the site, and the amount of additional assessment and engineering design work that would be required to move the project to implementation. The maximum score a site can receive is 3, indicating a project that should move quickly and easily to implementation.
- **Ease of operation –** operational considerations, including amount and frequency of maintenance likely required, and whether maintenance activities will be straightforward to complete. The maximum score a site can receive is 3, indicating a project with infrequent maintenance needs that are easily completed.
- **Phosphorus removal cost-benefit** – qualitative evaluation of the cost per pound of phosphorus removed by each proposed BMP, where a score of 3 indicates a cost-benefit of <$50,000 / lb P removed, a score of 2 indicates a cost-benefit of $50-200,000 / lb P removed, and a score of 1 indicates a cost-benefit of >$200,000 / lb P removed.

The type of ownership of each project location, an initial indication of project cost, and the amount of additional engineering that will be needed for implementation are also presented in the matrix. These measures are not included currently in the score tabulated for each potential project, but are qualitatively scored as follows:

Project Type "key":

A Private property
B State property or right-of-way
C Public property (town-owned land or right-of-way)
D Hybrid; part public land, part private land

Estimated Implementation Cost "key":

L less than $100,000
M $100-$500,000
MH $500-$1,000,000
H more than $1,000,000

Need for Additional Engineering "key":

L Project can be implemented without formal engineering
M Project requires some amount of engineering design to ensure proper sizing
H Project requires full engineering

Finally, the matrix indicates the subset of projects selected for development of a preliminary design. These projects were selected in consultation with the Town, school district, Friends of the Winooski, CCRPC, and representatives from VT DEC.

Table 4. Summary of Drainage Area Characteristics and Retrofit Benefits

Site ID sort order	Site ID	Site Name	Drainage Area Characteristics, Runoff Volumes, and Phosphorus Base Load Estimates									Proposed BMPs, Storage Volumes, and Phosphorus Load Reduction Estimates					Implementation Cost Estimates and Cost-Benefit Metrics					
			Primary Soil HSG	Drainage Area (acres)	Impervious Area (acres)	% Impervious	Estimated WQv (acre-feet)	Estimated HCv / CPv (acre-feet)	Estimated WQv (CF)	Estimated HCv / CPv (CF)	Estimated Total Base P Load (lbs/year)	Proposed BMP Type	BMP P Removal Efficiency (%)	Proposed Storage Volume (CF)	Estimated Total P Load Reduction (lbs/year)	Estimated Total P Load Post Treatment (lbs/year)	BMP Unit Construction Cost (2018 $/CF)	BMP Construction Cost Estimate (2018 $)	BMP Design / Permitting Costs (2018 $)	Cost Adjustment Factor	Total Implementation Cost (2018 $)	Phophorus Removal Cost-Benefit ($/lb P removed)
1	WR-01	Thompson Road	C / D	0.70	0.47	67	0.038	0.033	1,650	1,440	1.75	Gravel Wetland	61%	7,800	1.07	0.68	$6.00	$47,000	$11,750	1.5	$88,125	$82,360
2	WR-02	Cochran Road	A	2.20	1.76	80	0.14	0.030	6,150	1,310	6.52	Surface infiltration	98%	7,200	6.39	0.13	$4.27	$31,000	$7,750	1.5	$58,125	$9,096
3	WR-03	South Bridge Street	C	2.36	0.92	39	0.079	0.11	3,430	4,840	3.63	Wet pond/ Created Wetland	52%	20,000	1.89	1.74	$4.65	$93,000	$23,250	1.5	$174,375	$92,262
4	WR-04	Volunteers Green Parking Lot	B	1.84	1.19	65	0.097	0.073	4,210	3,180	4.46	Infiltration Chamber	98%	9,000	4.37	0.09	$46.34	$418,000	$104,500	2	$1,045,000	$239,130
5	WR-05	USPS / Richmond Free Library	B	1.89	1.10	58	0.090	0.075	3,910	3,270	4.15	Bioretention	76%	8,000	3.15	1.00	$10.56	$85,000	$21,250	2	$212,500	$67,460
6	WR-06	Richmond Rescue	C	50.63	16.94	33	1.5	2.4	64,330	103,670	68.19	Wet pond/ Created Wetland	52%	65,000	35.46	32.73	$4.65	$303,000	$75,750	2	$757,500	$21,362
7	WR-07	Railroad Tracks	A / D	122.67	13.25	11	1.5	6.1	66,790	265,280	70.81	Gravel Wetland	61%	70,000	43.19	27.62	$6.00	$420,000	$105,000	2	$1,050,000	$24,311
8	WR-08	Our Lady Church	A / D	0.49	0.41	84	0.033	0.024	1,420	1,050	1.51	Bioretention	76%	1,500	1.15	0.36	$10.56	$16,000	$4,000	2	$40,000	$34,855
9	WR-09	Bridge Street Sidewalks	A / D	1.01	0.46	45	0.039	0.050	1,690	2,180	1.79	Infiltration Chamber	98%	1,700	1.75	0.04	$46.34	$79,000	$19,750	2	$197,500	$112,587
10	WR-10	Main Street Water Line Replacement	A / D	0.78	0.78	100	0.062	0.039	2,700	1,700	2.86	Bioretention	76%	2,700	2.17	0.69	$10.56	$29,000	$7,250	2	$72,500	$33,410
11	WR-11	Millet Street	A / D	39.08	3.07	8	0.39	1.9	17,020	84,510	18.05	Bioretention	76%	4,830	13.72	4.33	$10.56	$52,000	$13,000	2	$130,000	$9,475
12	WR-12	School Entrance	A	1.15	0.46	40	0.039	0.016	1,710	700	1.81	Porous Pavement (Asphalt)	75%	840	1.36	0.45	$3.64	$4,000	$1,000	1.5	$7,500	$5,515
13	WR-13	School Parking Island	C/D	0.41	0.08	19	0.0074	0.020	320	870	0.34	Bioretention	76%	2,363	0.26	0.08	$10.56	$25,000	$6,250	1.5	$46,875	$180,288
14	WR-14	School NW Ravine	C/D	5.50	2.47	45	0.21	0.27	8,990	11,890	9.53	Regenerative Conveyance	70%	8,990	6.67	2.86	#N/A	#N/A	#N/A	1.5	#N/A	#N/A
15	WR-15	School Athletic Field	C/D	4.42	2.19	50	0.18	0.22	8,030	9,580	8.51	Wet pond/ Created Wetland	52%	9,100	4.43	4.08	$4.65	$43,000	$10,750	1.5	$80,625	$18,200
16	WR-16	School Drip Edge	A	0.29	0.28	97	0.023	0.0040	980	170	1.04	Infiltration Trench	98%	651	1.02	0.02	$8.53	$6,000	$1,500	1.5	$11,250	$11,029
17	WR-17	School adjacent to Playground	A	1.28	0.49	38	0.043	0.017	1,860	740	1.97	Gravel Wetland	61%	1,350	1.20	0.77	$6.00	$9,000	$2,250	1.5	$16,875	$14,063
18	WR-18	E2 Drainage Area, Interstate and Median	B	5.10	1.31	26	0.119	0.202	5,180	8,800	7.72	Gravel Wetland	61%	20,000	4.71	3.01	$6.00	$120,000	$30,000	2.5	$375,000	$79,618
19	WR-19	D5 Drainage Area, Interstate and Median	B	0.80	0.40	50	0.033	0.032	1,450	1,390	2.16	Gravel Wetland	61%	5,000	1.32	0.84	$6.00	$30,000	$7,500	2.5	$93,750	$71,023
20	WR-20	F3 Drainage Area, Upslope of Interstate	D	37.20	0.90	2	0.217	1.847	9,450	80,460	10.02	Gravel Wetland	61%	25,000	6.11	3.91	$6.00	$150,000	$37,500	2.5	$468,750	$76,718
21	WR-21	F2 Drainage Area, Upslope of Interstate	D	10.90	0.30	3	0.064	0.541	2,770	23,570	2.94	Gravel Wetland	61%	7,500	1.79	1.15	$6.00	$45,000	$11,250	2.5	$140,625	$78,561
22	WR-22	D3 Drainage Area, School Access Drive & D5 Stable Conveyance	C/D	2.41	0.54	23	0.050	0.12	2,190	5,230	2.32	Gravel Wetland	61%	3,640	1.79	0.53	$6.00	$22,000	$5,500	1.5	$41,250	$23,045

Table 5. Stormwater Opportunity Prioritization and Implementation Matrix

Site ID	Site Name	Need	Proposed Approach	Web Soil Survey Mapped HSG	Existing Environmental Concerns (scale 1-5)	Environmental Priority (scale 1-5)	Constructability (scale 1-3)	Ease of Operation (scale 1-3)	P Removal Cost Effectiveness (Scale 1-3)	Implementation Score	Project Type	Estimated Implementation Cost	Green Infrastructure Opportunity (Y or N)	Need for Additional Engineering	Final Implementation Priority	Advance to Concept Design?
WR-01	Thompson Road	Retrofit opportunity	Install gravel wetlands or underdrained bioswales along the shoulders of Thompson Road capturing and treating all roadway runoff, as well as the majority of residential runoff. Soils in the area do not have a high capacity for infiltration, any underdrains should follow existing drainage network. It is important to provide separation between the roadway shoulder and edge of BMP as postal couriers pull off the shoulder to deliver mail.	C / D	1	1	3	2	2	9	C	L	Y	M	Village - 9	★
WR-02	Cochran Road	Retrofit opportunity	Install bioswales along the shoulders of Cochran Road capturing and treating all roadway runoff, as well as the majority of residential runoff from the south side of the road. Soils in the area are conducive to infiltration, so bioswales should be treated as infiltrating bioswales without underdrain. It is important to provide separation between the roadway shoulder and edge of BMP as postal couriers pull off the shoulder to deliver mail.	A	1	2	3	2	1	9	C	L	Y	M	Village - 10	
WR-03	South Bridge Street	Retrofit existing BMP	There is already a pond here, soils are mapped as HSG C but appear to be infiltrating the collected runoff as there is no pond outlet. It is possible to increase the storage capacity of the pond to capture larger storm events.	C	2	2	1	2	2	9	C	M	N	L	Village - 11	
WR-04	Volunteers Green Parking Lot	Retrofit opportunity	Install underground infiltration chambers, or underground storage with controlled outlet to the Winooski River, dependent upon what is discovered about the site's infiltrative capabilities. This would require rerouting the existing drainage network in one location, but would effectively capture and treat all runoff from Bridge Street, and a portion of the neighborhood from the center of the Winooski River north to the railroad tracks. Also install a rain garden in the vacinity of the parking lot to treat surface flows from the lot and demonstrate improved water quality.	B	3	3	2	2	1	11	C	H	Y	H	Village - 5	
WR-05	USPS / Richmond Free Library	Retrofit opportunity	Install a bioretention basin to the southeast of the municipal parking lot. The roughly 1.25 acre drainage area is mostly impervious and already drains to a single collection point in the northeast corner.	B	2	3	2	2	2	11	C	M	Y	M	Village - 6	
WR-06	Richmond Rescue	Retrofit opportunity	Install a wet pond/created wetland at the outlet adjacent to Richmond Rescue within the existing drainage pattern. There is not much capicity for infiltration at the site, though there is also no serious risk associated with overtopping the wet pond/created wetland that will convey stormwater to the Winooski River. The outfall is within the 100 year floodplain, which may preclude BMP implementation.	C	4	4	2	2	3	15	C	H	Y	H	Village - 1	★
WR-07	Railroad Tracks	Retrofit opportunity	Install a gravel wetland to treat stormwater from from a 120+-acre drainage area; even without the ability to fully infiltrate, substantial treatment is feasible. Floodplain and potential wetland constraints may preclude implementation.	A / D	3	5	1	1	3	13	B	H	Y	H	Village - 2	★
WR-08	Our Lady Church	Retrofit opportunity	There is opportunity to utilize green space to the northwest of the parking lot for infiltration/bioretention. The parking lot already slopes that direction so capture and treatment can be achieved with relative ease.	A / D	2	2	2	2	2	10	A	L	Y	M	Village - 8	★

Site ID	Site Name	Need	Proposed Approach	Web Soil Survey Mapped HSG	Existing Environmental Concerns (scale 1-5)	Environmental Priority (scale 1-5)	Constructability (scale 1-3)	Ease of Operation (scale 1-3)	P Removal Cost Effectiveness (Scale 1-3)	Implementation Score	Project Type	Estimated Implementation Cost	Green Infrastructure Opportunity (Y or N)	Need for Additional Engineering	Final Implementation Priority	Advance to Concept Design?
WR-09	Bridge Street Sidewalks	Retrofit opportunity	There is an opportunity to incorporate BMP installation with the planned sidewalk replacement project on Bridge Street. If soils are deemed infiltrative, install bioswale in green space between the roadway and sidewalk contiguous with underdrained bioretention/sand filter beneath the sidewalk. Curb cuts to bioswale should be positioned just up gradient of catch basins so in the event that the bioswale is overwhelmed, overflow to the closed stormwater network may occur.	A / D	2	3	3	2	2	12	C	L	Y	H	Village - 4	★
WR-10	Main Street Water Line Replacement	Retrofit opportunity	There is an opportunity to incorporate BMP installation with the planned water line replacement project along Main Street. If soils are deemed infiltrative, install bioswale along the Main Street cooridor. If infiltration is not possible, consider a grass swale conveyance system to filter stormwater before it enters the closed drainage network.	A / D	3	2	1	2	2	10	A	L	Y	H	Village - 7	
WR-11	Millet Street	Retrofit opportunity	Install an infiltration basin, or other water quality BMP, at the corner of Millet Street and Tilden Avenue. At this location, the existing drainage enters a subsurface closed drainage network that outlets at Richmond Rescue.	A / D	4	3	1	2	3	13	A	M	Y	H	Village - 3	★
WR-12	School Entrance	Retrofit opportunity	Along the north side of the existing campus entrance is a non-paved unvegetated drainage swale, much of which is used for overflow parking. The area could be stabilized with a porous pavement or grass pavers, with a gravel reservoir for infiltration and filtering beneath.	A	2	2	3	2	3	12	C	L	Y	M	School - 5	
WR-13	School Parking Island	Retrofit opportunity	Convert an existing raised parking island to accept runoff, with a bioretention area. The existing drainage lines can be used to connect the BMP and provide for BMP overflow.	C/D	1	1	2	2	1	7	C	L	Y	M	School - 7	
WR-14	School NW Ravine	Stabilize outlet and gully	Repair the failed outlet and stabilize the actively eroding gully; investigate whether existing swale can be retrofit to control and/or treat runoff before reaching the gully.	C/D	4	5	2	3	2	16	C	M	N	H	School - 1	★
WR-15	School Athletic Field	Retrofit opportunity	Create a wet pond, gravel wetland, or emergent wetland to provide storage for upstream areas, including parking and roof drainage. The existing drainage system can be used to connect the BMP, particularly for the parking area and portions of the rooftops.	C/D	2	1	2	2	3	10	C	M	Y	H	School - 2	★
WR-16	School Drip Edge	Infiltration of roof runoff	Disconnect the northeast side of the middle schoool into an infiltration trench along the roof drip edge.	A	1	1	2	3	1	8	C	L	Y	M	School - 6	
WR-17	School adjacent to Playground	Retrofit opportunity	Provide storage and retention for parking and rooftop runoff with a bioretention or wetland area, prior to discharging to the gully to the south of the school.	A	2	1	2	2	3	10	C	L	Y	M	School - 8	
WR-18	E2 Drainage Area, Interstate and Median	Retrofit opportunity	Provide retention and water quality treatment upstream of existing culvert inlet.	B	2	2	2	3	2	11	B	MH	Y	M	Upland - 4	
WR-19	D5 Drainage Area, Interstate and Median	Retrofit opportunity	Provide retention and water quality treatment upstream of existing culvert inlet. Couple with additional retention and water quality treatment downstream of culvert outlet within VTrans ROW. Stabilize gully erosion within ROW and on School property leading to WR-22.	B	2	3	2	3	2	12	B	M	Y	H	Upland - 1	★

Site ID	Site Name	Need	Proposed Approach	Web Soil Survey Mapped HSG	Existing Environmental Concerns (scale 1-5)	Environmental Priority (scale 1-5)	Constructability (scale 1-3)	Ease of Operation (scale 1-3)	P Removal Cost Effectiveness (Scale 1-3)	Implementation Score	Project Type	Estimated Implementation Cost	Green Infrastructure Opportunity (Y or N)	Need for Additional Engineering	Final Implementation Priority	Advance to Concept Design?
WR-20	F3 Drainage Area, Upslope of Interstate	Retrofit opportunity	Provide retention and water quality treatment upstream of existing culvert inlet.	D	3	4	2	3	2	14	B	MH	Y	M	Upland - 2	
WR-21	F2 Drainage Area, Upslope of Interstate	Retrofit opportunity	Provide retention and water quality treatment upstream of existing culvert inlet.	D	2	3	2	2	2	11	B	M	Y	M	Upland - 3	
WR-22	D3 Drainage Area, School Access Drive & D5 Stable Conveyance	Retrofit and stabilization opportunity	Stabilize gully erosion transitioning from VTrans ROW to School property (WR-19). Provide enhanced water quality treatment using gravel wetland or bioswale in area of existing grass channel; provide safe passage for larger storms and run-on prior to discharge at WR-14.	C/D	3	3	2	2	3	13	C	M	Y	H	School - 3	★

Project Type "key":

- **A** Private property
- **B** State property or right-of-way
- **C** Public property (town-owned land or right-of-way)
- **D** Hybrid; part public land, part private land

Estimated Implementation Cost "key":

- **L** less than $20,000
- **M** $20-$50,000
- **MH** $50-$100,000
- **H** more than $100,000

Need for Additional Engineering "key":

- L Project can be implemented without formal engineering
- M Project requires some amount of engineering design to ensure proper sizing
- H Project requires full engineering

5. Conceptual Solutions for High Priority Stormwater Problems and Opportunities

Initially, the prioritization of all of the identified problem areas and opportunities (Section 4) resulted in 13 of the identified problem areas being assigned an implementation score of 11 or higher. In consultation with CCRPC, Town and School District staff, Friends of the Winooski, and Vermont DEC staff, this list was further narrowed to a total of ten projects for development conceptual designs, with final selection based on size of the treatment opportunity, extent to which an existing erosion or water quality treatment problem could be successfully addressed, as well as property owner/stakeholder interest and concurrence of State agencies' staff that the concepts were worthy of advancement.

Originally, six opportunities were intended to be advanced to concept design in the Village area, two on the School campus, and two in the I-89 upland drainage areas where runoff was potentially directed towards the elementary/middle school campus. However, the project stakeholders chose to re-direct one of the upland concept designs to manage runoff from both the I-89 ROW and school campus drainage (opportunity WR-22), allowing development of a holistic, watershed approach to alleviating erosion issues at WR-14.

The six opportunities advanced to concept design in the village area (Appendix E) were:

- WR-06, Richmond Rescue (Wet Pond)
- WR-07, Railroad Tracks (Gravel Wetland)
- WR-11, Millet Street (Bioretention)
- WR-09, Bridge Street Sidewalks (Bioretention)
- WR-08, Our Lady Church (Bioretention)
- WR-01, Thompson Road (Gravel Wetland)

The single location advanced to concept design within the I-89 right-of way draining towards the school campus was:

- WR-19, D5 Drainage Area, Interstate and Median (Gravel Wetland)

The three locations advanced to concept design on the school campus were:

- WR-22, D3 Drainage Area, School Access Drive & D5 Stable Conveyance (Gravel Wetland)
- WR-14, School NW Ravine (Regenerative Storm Conveyance)
- WR-15, School Athletic Field (Wet Pond / Created Wetland)

For each of the proposed concept designs, an opinion of probable cost for implementation of the proposed restoration design is presented in a table following a brief description of the proposed implementation project. Unit costs are based on Vermont Agency of Transportation (VTrans) 5 year average unit prices, ranging from July 2012 to June 2017

(http://vtrans.vermont.gov/sites/aot/files/estimating/documents/5YearEnglishAveragedPriceList11.pdf), and adjusted based on recent construction projects managed by Stone staff.

5.1. Village Concept Designs

5.1.1. WR-06, Richmond Rescue (Wet Pond)

Stormwater runoff from an approximately 90-acre drainage area is conveyed via a closed drainage system and overland flow to a ditch to the southwest of Richmond Rescue. The ditch carries stormwater to the Winooski River, and is actively eroding and filled with sediment. Sufficient open land is present at the outlet of the closed drainage system to construct a sediment forebay and a water quality treatment practice, wet pond or created wetland.

The proposed retrofit for this site is a wet pond at the site of the existing outfall west of Richmond Rescue to provide water quality treatment, with overflow to a newly constructed stable outfall to the existing drainage channel--which, though receiving only inflow from the closed drainage system, is shown in DEC mapping as a blue-line stream. A wet pond was chosen at this site instead of a gravel wetland, in consideration for the historic The design standard used for this retrofit was best-fit treatment of the water quality volume for the portion of the drainage area not captured at the Millet Street bioretention area (50.63 acres of the total 89.71-acre area draining to this point). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period. At this site, it is possible to site a wet pond that will manage 100% of the WQv or 65,000 ft^3 of runoff—however, as initially projected, a pond this large represents such a substantial implementation cost that the project would not be feasible to fund. A smaller wet pond, managing 60% of the WQv or 49,032 ft^3 of runoff was ultimately advanced through concept design. A 30% design plan is provided in Appendix E.

5.1.1.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (Table 6). This amount differs from the amount initially projected for this site (Table 4), as design-specific amounts and costs were developed to support this high-priority retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

The estimated cost for implementation of this project is $80,600.

- The cost per pound of phosphorus treated is $3,125.
- The cost per impervious acre treated is $4,758.
- The cost per cubic foot of runoff treated is $1.64.

Table 6. Richmond Rescue – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT	UNIT COST		TOTAL
	CLEARING AND GRUBBING	1	LS	$5,000.00	$5,000.00
	PROJECT DEMARCATION FENCING	400	LF	$1.25	$500.00
	GEOTEXTILE FOR SILT FENCE	400	SY	$5.00	$2,000.00
	COMMON EXCAVATION	1640	CY	$10.00	$16,400.00
	DEWATERING	1	EA	$10,000.00	$10,000.00
WR-06	PRECAST REINFORCED CONCRETE MANHOLE WITH ORIFICE, TRASH RACK, AND 24" CAST IRON GRATE	1	EA	$6,000.00	$6,000.00
	30" X 42" CPEP (SL)	35	LF	$75.00	$2,625.00
	STONE FILL, TYPE II	20	CY	$45.00	$900.00
	SEED	13	LB	$7.08	$92.04
	MULCH	13	LB	$0.30	$3.93
				CONSTRUCTION TOTAL	***$43,521***
				FINAL DESIGN (25%)	***$8,704***
				PERMITTING (15%)	***$6,528***
				STAKE OUT (5%)	***$2,176***
				MOBILIZATION / DEMOBILIZATION (10%)	***$4,352***
				CONSTRUCTION OVERSIGHT (10%)	***$4,352***
				CONTINGENCY (25%)	***$10,880***
				TOTAL (ROUNDED TO NEAREST $100)	***$80,600***

5.1.1.2. Permitting Needs

Anticipated permitting needs are summarized below.

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

- Less than 2 acres of disturbance at any one time.
- All disturbed 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.
  - If this buffer cannot be maintained due to the immediate down-grade presence of the blue-line drainage channel/stream, risk mitigation factors including minimizing disturbed earth exposure in any location to less than 7 days before implementing stabilization may be employed to maintain a Low Risk categorization.

Operational Stormwater Permit: No operational stormwater permit is anticipated to be required.

Local Permitting: No local permits are anticipated.

Other Permits:

No Act 250 permitting review or actions are anticipated to be required.

No Wetlands permitting is anticipated for this project, but given the retrofit project's landscape position, a site visit with Wetlands program staff to confirm the presence or absence of wetlands is warranted.

River Corridor permitting is anticipated for this project; the proposed retrofit is located partially within the mapped AE flood zone (1-percent annual chance floodplain with elevations). A Stream Alteration Permit may also be necessary, as the channel originating at the drainage system outlet is mapped as a blue-line stream. A site visit with Rivers Program staff is warranted.

5.1.1.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with design work for this retrofit. Further design will involve refinement of the retrofit design with respect to size and layout to maximize water quality treatment and minimize environmental impacts, particularly concerns regarding work in or adjacent to the mapped flood hazard area.

5.1.2. WR-07, Railroad Tracks (Gravel Wetland)

Stormwater from an approximately 122-acre drainage area is conveyed via a closed drainage system and overland flow to a ditch south of the railroad tracks. The ditch is actively eroding and filling with sediment, and carrying stormwater to a natural pond that then drains to the Winooski River. Sufficient area likely exists for construction of end-of-pipe retrofit practices, including gravel wetlands, in at least two separate locations. Both the culvert that carries water beneath the railroad tracks, and the box culvert that carries water beneath the private drive are badly damaged and in need of replacement. Planned waterline replacement on Main Street and replacement of the drainage network between Main Street and the railroad tracks may represent a strategic opportunity to "bundle" needed improvements that benefit this larger drainage area. Constraints on the northern-most of the two sites, however, include proximity to the railroad tracks and right-of-way and active construction of Phase 1 improvements at the Richmond Creamery redevelopment project at 74 Jolina Court, on the parcel just south of the railroad tracks.

The proposed retrofit for this site is a gravel wetland at the site of the existing outfall southeast of 74 Jolina Court provide water quality treatment, with overflow to a newly constructed stable outfall to overland flow and ultimately to the existing natural pond. The design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (122.6 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period. At this site, it is possible to site a gravel wetland that will manage 35% of the WQv or 31,400 ft^3 of runoff. A 30% design plan is provided in Appendix E.

5.1.2.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (

Table 7). This amount differs from the amount initially projected for this site (Table 4), as design-specific amounts and costs were developed to support this high-priority retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

The estimated cost for implementation of this project is $212,900.

- The cost per pound of phosphorus treated is $6,442.
- The cost per impervious acre treated is $16,067.
- The cost per cubic foot of runoff treated is $6.78.

Table 7. Railroad Tracks – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT		UNIT COST	TOTAL
	CLEARING AND GRUBBING	1	LS	$5,000.00	$5,000.00
	PROJECT DEMARCATION FENCING	400	LF	$1.25	$500.00
	GEOTEXTILE FOR SILT FENCE	400	SY	$5.00	$2,000.00
	COMMON EXCAVATION	1631	CY	$10.00	$16,310.00
	DEWATERING	1	EA	$10,000.00	$10,000.00
	PRECAST REINFORCED CONCRETE MANHOLE WITH TRASH RACK, AND 24" CAST IRON GRATE	1	EA	$6,000.00	$6,000.00
	30" CPEP	50	LF	$65.00	$3,250.00
	STONE FILL, TYPE II	6	CY	$45.00	$270.00
WR-07	3/4" DENSE GRADED DOUBLE WASHED CRUSHED STONE	434	CY	$40.00	$17,360.00
	3/8" DOUBLE WASHED PEA STONE	75	CY	$45.00	$3,375.00
	WETLAND SOIL	145	CY	$50.00	$7,250.00
	6" UNDERDRAIN PIPE	420	LF	$25.00	$10,500.00
	6" UNDERDRAIN CLEANOUT WITH CAP	8	EA	$125.00	$1,000.00
	6" PERFORATED RISER WITH CAP	8	EA	$125.00	$1,000.00
	GEOTEXTILE FOR ROADBED SEPARATOR	660	SY	$2.00	$1,320.00
	WETLAND PLANTS	660	SY	$50.00	$33,000.00
	SEED	12	LB	$7.08	$84.96
	MULCH	12	LB	$0.30	$3.63
				CONSTRUCTION TOTAL	***$118,224***
				FINAL DESIGN (25%)	***$29,556***
				PERMITTING (15%)	***$17,734***
				STAKE OUT (5%)	***$5,911***
				MOBILIZATION / DEMOBILIZATION (10%)	***$11,822***
				CONSTRUCTION OVERSIGHT (10%)	***$11,822***
				CONTINGENCY (15%)	***$17,734***
				TOTAL (ROUNDED TO NEAREST $100)	***$212,900***

5.1.2.2. Permitting Needs

Anticipated permitting needs are summarized below.

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

- Less than 2 acres of disturbance at any one time.
- All disturbed 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.
  - If this buffer cannot be maintained due to the immediate down-grade presence of the natural pond, risk mitigation factors including minimizing disturbed earth exposure in any location to less than 7 days before implementing stabilization may be employed to maintain a Low Risk categorization.

Operational Stormwater Permit: No operational stormwater permit is anticipated to be required.

Local Permitting: No local permits are anticipated.

Other Permits:

This site should be reviewed by the Act 250 Coordinator prior to final design as there are Buttermilk, LLC permits (No. 4C0150-1 and 4C0150-2) for demolition of buildings on the former Richmond Creamery site (74 Jolina Ct.) and for construction of a new mixed-use building and associated parking immediately adjacent to the proposed retrofit.

Wetlands permitting is anticipated for this project. Though the concept design avoids siting the gravel wetland in wetland areas as displayed in the ANR Natural Resources Atlas VSWI layer, the plans accompanying the Act 250 permit 4C0150-1 referenced above indicate that at least portions of the proposed retrofit are located in a Class II wetland (delineation by Kristen Rose-Howell, fall 2015). A site visit with Wetlands Program staff to confirm the presence of wetlands and discuss mitigation options is warranted.

River Corridor permitting is anticipated for this project; the proposed retrofit is located partially within the mapped AE flood zone (1-percent annual chance floodplain with elevations). A site visit with Rivers Program staff to discuss design and permitting options is warranted.

5.1.2.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with design work for this retrofit. The property owner was approached and was interested in allowing the design to advance, particularly if the retrofit could be utilized to manage runoff from the development now under construction (which falls below jurisdictional thresholds for operational stormwater permitting). Further work will involve refinement of the retrofit design with respect to size and layout to maximize water quality treatment and minimize environmental impacts, particularly concerns regarding work in or adjacent to wetlands and the mapped flood hazard area.

5.1.3. WR-11, Millet Street (Bioretention)

At this location, runoff from an approximately 39-acre drainage area enters the closed drainage system that outlets southwest of Richmond Rescue (WR-07). Installing a water quality treatment practice, ideally one that can infiltrate some portion of the runoff reaching this location, would reduce the volume and improve quality of runoff currently causing damage at the Richmond Rescue site.

The proposed retrofit for this site is a bioretention area just upstream from the existing inlet to the closed drainage system immediately north of the Millet Street – Tilden Avenue intersection to provide water quality treatment and limited infiltration capacity, with overflow to the existing closed drainage system and ultimately to the outlet at WR-07. The design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (39.1 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period and at full water quality treatment, this practice has the potential to prevent 13.72 lbs/year of total phosphorus from entering receiving waters (Table 4) At this site, it is possible to site a bioretention area that will manage over 100% of the WQv or a total of 20.300 ft^3 of runoff. A 30% design plan is provided in Appendix E.

5.1.3.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (Table 8). This amount differs from the amount initially projected for this site (Table 4), as design-specific amounts and costs were developed to

support this high-priority retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

The estimated cost for implementation of this project is $120,400.

- The cost per pound of phosphorus treated is $5,172.
- The cost per impervious acre treated is $39,218.
- The cost per cubic foot of runoff treated is $5.93.

Table 8. Millet Street – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT		UNIT COST	TOTAL
WR-11	CLEARING AND GRUBBING	1	LS	$5,000.00	$5,000.00
	PROJECT DEMARCATION FENCING	160	LF	$1.25	$200.00
	GEOTEXTILE FOR SILT FENCE	160	SY	$5.00	$800.00
	COMMON EXCAVATION	560	CY	$10.00	$5,600.00
	DEWATERING	1	EA	$10,000.00	$10,000.00
	STONE FILL, TYPE II	14	CY	$45.00	$630.00
	3/8" DOIUBLE WASHED PEA STONE	135	CY	$45.00	$6,075.00
	BIORETENTION PLANTING MEDIA	450	CY	$32.00	$14,400.00
	BIORETENTION PLANTINGS	540	SY	$50.00	$27,000.00
	SEED	12	LB	$7.08	$84.96
	MULCH	12	LB	$0.30	$3.63
	TEMPORARY EROSION MATTING	1600	SY	$2.50	$4,000.00
	6" UNDERDRAIN PIPE (IF NEEDED)	120	LF	$25.00	$3,000.00
	6" UNDERDRAIN CLEANOUT WITH CAP (IF NEEDED)	2	EA	$125.00	$250.00
	6" PERFORATED RISER WITH CAP (IF NEEDED)	2	EA	$125.00	$250.00
				CONSTRUCTION TOTAL	***$68,794***
				FINAL DESIGN (25%)	***$17,198***
				PERMITTING (none anticipated)	***$0***
				STAKE OUT (5%)	***$3,440***
				MOBILIZATION / DEMOBILIZATION (10%)	***$6,879***
				CONSTRUCTION OVERSIGHT (10%)	***$6,879***
				CONTINGENCY (25%)	***$17,198***
				TOTAL (ROUNDED TO NEAREST $100)	***$120,400***

5.1.3.2. Permitting Needs

Anticipated permitting needs are summarized below.

Construction Stormwater Permit: Disturbance at this site is not anticipated to require a construction stormwater permit. Construction activities should still be conducted in accordance with the requirements and guidance of the Vermont DEC's *Low Risk Site Handbook for Erosion Prevention and Sediment Control*.

Operational Stormwater Permit: No operational stormwater permit is anticipated to be required.

Local Permitting: No local permits are anticipated.

Other Permits:

No Act 250 permitting review or actions are anticipated to be required.

Wetlands and river corridor or Stream Alteration permitting are not anticipated for this project.

5.1.3.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with design work for this retrofit. Attempts to reach the property owners (Richard and Jean Smith, parcel code JR0205, SPAN 519-163-11438) were not successful. Further work will involve confirming landowner willingness to proceed with the design, and refinement of the retrofit design with respect to size and layout to maximize water quality treatment.

5.1.4. WR-09, Bridge Street Sidewalks (Subsurface Infiltration)

There is an opportunity to integrate stormwater management improvements with planned sidewalk replacement project on Bridge Street, including into green space and mini-park amenities originally envisioned in the *Bridge Street Bicycle & Pedestrian Feasibility Study* (Broadreach Consulting et. al. 2010). At this location, runoff from an approximately 1-acre drainage area centered on Bridge Street between Railroad Street and Volunteer's Green enters a closed drainage system without treatment, and ultimately is discharged to the Winooski River. Installing water quality treatment retrofits that can ideally infiltrate some portion of the runoff would reduce the volume and improve quality of runoff currently flowing to the river.

Initially, a series of surface bioretention basins were envisioned to manage runoff in the right-of-way. However, the limited space available to site surface practices led the team to instead propose an "invisible green infrastructure" concept consisting of traffic calming bump-outs with surface bioretention only in key locations (primarily at the crosswalk leading from the west side of Bridge Street to the Town Offices). Most water quality treatment is provided by deep-sump catch basins providing pre-treatment, followed by infiltration and water quality treatment in subsurface infiltration chambers with gravel reservoirs sited beneath new sidewalks or the roadway, with overflow to the existing closed drainage system. The design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (1.01 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period; this practice has the potential to prevent 1.36 lbs/year of total phosphorus from entering receiving waters (Table 4) At this site, it is possible to site a series of infiltration chambers that will manage 100% of the WQv or 1,700 ft^3 of runoff. A 30% design plan is provided in Appendix E.

5.1.4.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (

Table 9). This amount differs from the amount initially projected for this site (Table 4), as design-specific amounts and costs were developed to support this high-priority retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

The estimated cost for implementation of this project is $120,800.

- The cost per pound of phosphorus treated is $85,616.
- The cost per impervious acre treated is $262,608.
- The cost per cubic foot of runoff treated is $27.45.

Table 9. Bridge Street Sidewalks – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT	UNIT COST		TOTAL
	PROJECT DEMARCATION FENCING	1300	LF	$1.25	$1,625.00
	GEOTEXTILE FOR SILT FENCE	700	SY	$5.00	$3,500.00
	COMMON EXCAVATION	545	CY	$10.00	$5,450.00
	EXCAVATION OF SURFACES AND PAVEMENTS	52	CY	$25.00	$1,300.00
WR-09	DEEP SUMP CATCH BASIN	3	EA	$5,000.00	$15,000.00
	24" CPEP	160	LF	$60.00	$9,600.00
	STORMTECH MC3500 INFILTRATION CHAMBER SYSTEM	4400	CF	$6.50	$28,600.00
	SEED	25	LB	$7.08	$177.00
	MULCH	25	LB	$0.30	$7.56
				CONSTRUCTION TOTAL	***$65,260***
				FINAL DESIGN (25%)	***$16,315***
				PERMITTING (10%)	***$6,526***
				STAKE OUT (5%)	***$3,263***
				MOBILIZATION / DEMOBILIZATION (10%)	***$6,526***
				CONSTRUCTION OVERSIGHT (10%)	***$6,526***
				CONTINGENCY (25%)	***$16,315***
				TOTAL (ROUNDED TO NEAREST $100)	***$120,800***

5.1.4.2. Permitting Needs

Anticipated permitting needs are summarized below.

Construction Stormwater Permit: Disturbance at this site is not anticipated to require a construction stormwater permit. Construction activities should still be conducted in accordance with the requirements and guidance of the Vermont DEC's *Low Risk Site Handbook for Erosion Prevention and Sediment Control*.

Operational Stormwater Permit: No operational stormwater permit is anticipated to be required.

Local Permitting: No local permits are anticipated.

Other Permits:

No Act 250 permitting review or actions are anticipated to be required.

Wetlands permitting is not anticipated for this project.

River Corridor permitting is anticipated for this project. The proposed retrofits are located partially within the mapped River Corridor, and the portion of the project extents southwest of the crosswalk is within the mapped AE flood zone (1-percent annual chance floodplain with elevations). A site visit with Rivers Program staff to discuss design and permitting options is warranted.

5.1.4.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with design work for this retrofit. This design can be implemented within the Town's right-of-way. Further work will involve refinement of the retrofit design with respect to size and layout to maximize water quality treatment while minimizing utility conflicts and work within the flood hazard area.

Since the improvements proposed are primarily subsurface, no changes to the base flood elevation would result from construction and the improvements would be protected during flooding events, so it is possible that a more detailed discussion with the DEC Basin Planner and Rivers Program staff could result in improved possibilities for implementation project funding through the Ecosystem Restoration Grants program.

5.1.5. WR-08, Our Lady Church (Bioretention)

Stormwater runoff from the parking lot and a portion of the rooftop area at the Our Lady of the Holy Rosary Church, an approximately 0.4-acre drainage area, flows from the impervious surfaces over a narrow strip of lawn and enters the closed drainage system that outlets southwest of Richmond Rescue (WR-07). Though the site is relatively small, installing a water quality treatment practice, ideally one that can infiltrate some portion of the runoff reaching this location, would further reduce the volume and improve quality of runoff currently causing damage at the Richmond Rescue site.

The proposed retrofit for this site is a bioretention area just upstream from the existing inlet to the closed drainage system immediately west of the parking lot to provide water quality treatment and infiltration capacity, with overflow to the existing closed drainage system and ultimately to the outlet at WR-07. The design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (0.41 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period and at full water quality treatment, this practice has the potential to prevent 1.75 lbs/year of total phosphorus from entering receiving waters (Table 4) At this site, it is possible to site a bioretention area that will manage 168% of the WQv or 2,390 ft^3 of runoff. A 30% design plan is provided in Appendix E.

5.1.5.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (

Table 10). This amount differs from the amount initially projected for this site (Table 4), as design-specific amounts and costs were developed to support this high-priority retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

The estimated cost for implementation of this project is $14,800.

- The cost per pound of phosphorus treated is $15,257.
- The cost per impervious acre treated is $36,098.
- The cost per cubic foot of runoff treated is $6.19.

Table 10. Our Lady Church – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT		UNIT COST	TOTAL
WR-08	PROJECT DEMARCATION FENCING	150	LF	$1.25	$187.50
	GEOTEXTILE FOR SILT FENCE	150	SY	$5.00	$750.00
	COMMON EXCAVATION	67	CY	$10.00	$670.00
	STONE FILL, TYPE II	1	CY	$45.00	$45.00
	1" DENSE GRADED DOUBLE WASHED CRUSHED STONE	10	CY	$40.00	$400.00
	3/8" DOUBLE WASHED PEA STONE	3	CY	$45.00	$135.00
	BIORETENTION PLANTING MEDIA	37	CY	$32.00	$1,184.00
	BIORETENTION PLANTINGS	101	SY	$50.00	$5,050.00
	SEED	3	LB	$7.08	$21.24
	MULCH	3	LB	$0.30	$0.91
				CONSTRUCTION TOTAL	***$8,444***
				FINAL DESIGN (25%)	***$2,111***
				PERMITTING (none anticipated)	***$0***
				STAKE OUT (5%)	***$422***
				MOBILIZATION / DEMOBILIZATION (10%)	***$844***
				CONSTRUCTION OVERSIGHT (10%)	***$844***
				CONTINGENCY (25%)	***$2,111***
				TOTAL (ROUNDED TO NEAREST $100)	***$14,800***

5.1.5.2. Permitting Needs

Anticipated permitting needs are summarized below.

Construction Stormwater Permit: Disturbance at this site is not anticipated to require a construction stormwater permit. Construction activities should still be conducted in accordance with the requirements and guidance of the Vermont DEC's *Low Risk Site Handbook for Erosion Prevention and Sediment Control*.

Operational Stormwater Permit: No operational stormwater permit is anticipated to be required.

Local Permitting: No local permits are anticipated.

Other Permits:

No Act 250 permitting review or actions are anticipated to be required.

Wetlands and river corridor or Stream Alteration permitting are not anticipated for this project.

5.1.5.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with design work for this retrofit. Further work will involve refinement of the retrofit design with respect to size and layout to maximize water quality treatment.

5.1.6. WR-01, Thompson Road (Gravel Wetland)

There is currently no treatment, and very little drainage infrastructure, for managing stormwater flow from Thompson Road between the Town Garage and the intersection with Cochran Road. Stormwater from this 0.7-acre drainage area is conveyed via a series of ditches and driveway culverts to an unnamed stream, and

then to the Winooski River. Sufficient area likely exists to site small structural stormwater practices in key, lower-slope locations along the road to enhance water quality treatment.

The proposed retrofit for this site is a series of linear gravel wetlands in key, low-slope portions of the right-of- provide water quality treatment, with overflow to existing stable outfalls to the unnamed stream. The design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (122.6 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period. At this site, it is possible to site a series of gravel wetlands that will manage nearly 200% of the WQv or 3,300 ft^3 of runoff. A 30% design plan is provided in Appendix E.

5.1.6.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (Table 11). This amount differs from the amount initially projected for this site (Table 4), as design-specific amounts and costs were developed to support this high-priority retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

The estimated cost for implementation of this project is $95,300.

- The cost per pound of phosphorus treated is $180,114.
- The cost per impervious acre treated is $202,765.
- The cost per cubic foot of runoff treated is $28.88.

Table 11.Thompson Road – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT	UNIT COST		TOTAL
WR-01	CLEARING AND GRUBBING	1	LS	$2,000.00	$2,000.00
	PROJECT DEMARCATION FENCING	250	LF	$1.25	$312.50
	COMMON EXCAVATION	170	CY	$15.00	$2,550.00
	TRANSPORT EXCAVATED MATERIAL OFF SITE	170	CY	$15.00	$2,550.00
	PRECAST REINFORCED CONCRETE MANHOLE WITH TRASH RACK, AND 24" CAST IRON GRATE	2	EA	$6,000.00	$12,000.00
	30" CPEP	20	LF	$60.55	$1,211.00
	3/4" DENSE GRADED DOUBLE WASHED CRUSHED STONE	104	CY	$40.00	$4,160.00
	3/8" DOUBLE WASHED PEA STONE	18	CY	$45.00	$810.00
	WETLAND SOIL	35	CY	$50.00	$1,750.00
	6" UNDERDRAIN PIPE	215	LF	$25.00	$5,375.00
	6" UNDERDRAIN CLEANOUT WITH CAP	2	EA	$125.00	$250.00
	6" PERFORATED RISER WITH CAP	2	EA	$125.00	$250.00
	GEOTEXTILE FOR ROADBED SEPARATOR	312	SY	$2.00	$624.00
	WETLAND PLANTS	312	SY	$50.00	$15,600.00
	SEED	1.5	LB	$7.08	$10.62
	MULCH	1.5	LB	$0.30	$0.45
	TRAFFIC CONTROL	1	LS	$5,000.00	$5,000.00
				CONSTRUCTION TOTAL	***$54,454***
				FINAL DESIGN (25%)	***$13,613***
				PERMITTING (NONE ANTICIPATED)	***$0***
				STAKE OUT (5%)	***$2,723***
				MOBILIZATION / DEMOBILIZATION (10%)	***$5,445***
				CONSTRUCTION OVERSIGHT (10%)	***$5,445***
				CONTINGENCY (25%)	***$13,613***
				TOTAL (ROUNDED TO NEAREST $100)	***$95,300***

5.1.6.2. Permitting Needs

Anticipated permitting needs are summarized below.

Construction Stormwater Permit: Disturbance at this site is not anticipated to require a construction stormwater permit. Construction activities should still be conducted in accordance with the requirements and guidance of the Vermont DEC's *Low Risk Site Handbook for Erosion Prevention and Sediment Control*.

Operational Stormwater Permit: No operational stormwater permit is anticipated to be required.

Local Permitting: No local permits are anticipated.

Other Permits:

No Act 250 permitting review or actions are anticipated to be required.

Wetlands and river corridor or Stream Alteration permitting are not anticipated for this project. An area of Class II wetlands is shown in the ANR Natural Resources Atlas VSWI layer near the north (downslope) end of the drainage area close to the unnamed stream, but the concept design has been optimized to avoid wetlands conflicts. A site visit with ANR Stormwater Program staff is warranted to ensure any potential wetland impacts are avoided.

5.1.6.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with design work for this retrofit. Further work will involve refinement of the retrofit design with respect to size and layout to maximize water quality treatment and minimize environmental impacts, particularly concerns regarding work in the proximity of mapped wetlands.

5.2. I-89 Right-of-Way and Upland Drainage Concept Design

5.2.1. WR-19, D5 Drainage Area, Interstate and Median (Gravel Wetland)

Runoff from portions of the I-89 northbound and southbound lanes immediately east of the Richmond Elementary School/Camel's Hump Middle School campus collects in the median in the 0.8-acre "D5" drainage area (Figure 5). From a low point in the median, runoff travels through an 18" concrete culvert beneath the I-89 southbound lanes and discharges, via overland flow, onto school property in the D3 drainage. This runoff is causing gully erosion as it flows down-slope out of the VTrans right-of-way, before reaching the existing swale along the northeast edge of the school's access road and parking area, and ultimately reaching the gully at the north end of the school campus (see Figure 5, and Appendix C datasheets for WR-22 and WR-14).There are two opportunities to improve water quality and reduce peak flows: one within the median prior to the culvert inlet, and one within the southbound I-89 right-of-way but upslope of the school property.

The proposed retrofit for this site is a gravel wetland at the site of the existing culvert inlet at the northern end of the D5 drainage area to provide water quality treatment and peak flow attenuation, with overflow the existing concrete culvert and sited entirely within the VTrans right-of-way. At minimum, the culvert outfall and downslope area is proposed to be stabilized where flow leaves the VTrans right-of-way and enters school property. Adequate freeboard will be provided in concept designs for the existing swale along the edge of the School access drive (WR-22, see Section 5.3.1) and at the existing outfall (WR-14, see Section 5.3.2) to allow safe conveyance for runoff from this drainage area during larger storms. The design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (0.8 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period. At this site, it is possible to site a gravel wetland that will manage both 100% of the WQv (or 1,450 ft^3) of runoff and 100% of the channel protection volume—or the additional volume of runoff generated by a one-year, 24-hour storm (1,390 ft^3). The total proposed treatment volume for this practice is 2,840 ft^3. A 30% design plan is provided in Appendix E. This practice has the potential to prevent 1.32 lbs/year of total phosphorus from entering receiving waters (Table 4).

5.2.1.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (Table 12). This amount differs from the amount initially projected for the site (Table 4), as design-specific amounts and costs were developed to support this high-priority retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

The estimated cost for implementation of this project is $68,400.

- The cost per pound of phosphorus treated is $88,645.
- The cost per impervious acre treated is $171,000.
- The cost per cubic foot of runoff treated is $17.37.

Table 12. D5 Drainage Area, Interstate and Median – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT		UNIT COST	TOTAL
WR-19	PROJECT DEMARCATION FENCING	400	LF	$1.25	$500.00
	GEOTEXTILE FOR SILT FENCE	50	SY	$5.00	$250.00
	COMMON EXCAVATION	265	CY	$15.00	$3,975.00
	TRANSPORT EXCAVATED MATERIAL OFFSITE	265	CY	$10.00	$2,650.00
	PRECAST REINFORCED CONCRETE MANHOLE WITH TRASH RACK, AND 24" CAST IRON GRATE	1	EA	$6,000.00	$6,000.00
	24" CPEP (SL)	15	LF	$65.00	$975.00
	STONE FILL, TYPE II	2.5	CY	$45.00	$112.50
	3/4" DENSE GRADED DOUBLE WASHED CRUSHED STONE	65	CY	$40.00	$2,600.00
	3/8" DOUBLE WASHED PEA STONE	12	CY	$45.00	$540.00
	WETLAND SOIL	22	CY	$50.00	$1,100.00
	6" UNDERDRAIN PIPE	110	LF	$25.00	$2,750.00
	6" UNDERDRAIN CLEANOUT WITH CAP	2	EA	$125.00	$250.00
	6" PERFORATED RISER WITH CAP	2	EA	$125.00	$250.00
	WETLAND PLANTS	96	SY	$50.00	$4,800.00
	SEED	4	LB	$7.08	$28.32
	MULCH	4	LB	$0.30	$1.21
	TRAFFIC CONTROL	1	LS	$5,000.00	$5,000.00
				CONSTRUCTION TOTAL	***$31,782***
				FINAL DESIGN (25%)	***$7,946***
				PERMITTING (25%)	***$7,946***
				STAKE OUT (10%)	***$3,178***
				MOBILIZATION / DEMOBILIZATION (15%)	***$4,767***
				CONSTRUCTION OVERSIGHT (15%)	***$4,767***
				CONTINGENCY (25%)	***$7,946***
				TOTAL (ROUNDED TO NEAREST $100)	***$68,400***

5.2.1.2. Permitting Needs

Anticipated permitting needs are summarized below.

Construction Stormwater Permit: Disturbance at this site is not anticipated to require a construction stormwater permit. Construction activities should still be conducted in accordance with the requirements and guidance of the Vermont DEC's *Low Risk Site Handbook for Erosion Prevention and Sediment Control*.

Operational Stormwater Permit: No operational stormwater permit is anticipated to be required for this retrofit. However, an amendment to the existing operational stormwater permit for the school may be needed, since the proposed retrofit discharges into the existing swale which is permitted as the manner of discharge for

6615-9010, S/N 001. In addition, if and as the retrofit moves forward to implementation, VTrans will likely include the retrofit in their Transportation Separate Storm Sewer System (TS4) General Permit to ensure it is credited, tracked, and maintained appropriately under the TS4's Phosphorus Control Plan.

Local Permitting: No local permits are anticipated.

Other Permits:

This site should be reviewed by the Act 250 Coordinator prior to final design, as there are Chittenden East School District (No. 300015) and Richmond School District (No. 300015-1 and 300015-2) permits for construction of and additions to the Elementary and Middle School buildings immediately adjacent to this project area.

No Wetlands or River Corridor permitting is anticipated for this project.

Any work within the VTrans right-of-way will require a State Highway Access and Work Permit (19 VSA 1111), or will be required to be completed by VTrans personnel or contractors.

5.2.1.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with concept design work for this retrofit. This concept design would, if implemented, better manage runoff that is currently impacting School property. School District staff were supportive of this concept design but acknowledged that its implementation is out of their immediate control. Vermont Agency of Transportation staff (Maintenance and Operations Bureau and Project Development Bureau – Environmental) were also consulted and indicated willingness to consider the concept, although their process for developing and implementing Phosphorus Control Plans is still in its early stages and substantial progress towards specific implementation projects is not anticipated in the next 1-2 years. Further work will involve refinement of the retrofit design with respect to size and layout to maximize peak flow minimization and water quality treatment, as well as impacts to the School property. Continued coordination with VTrans (District Office and Maintenance and Operations Bureau staff) is warranted.

5.3. School Campus Concept Designs

5.3.1. WR-22, D3 Drainage Area, School Access Drive & D5 Stable Conveyance (Gravel Wetland)

Runoff from the D5 drainage area immediately upslope of the School property (problem area WR-19 described above) discharges untreated onto the Richmond Elementary School/Camel's Hump Middle School property in the D3 drainage, where it runs into the existing swale along the northeast edge of the school's access road and parking area, and ultimately reaches the gully at the north end of the school campus (problem area WR-14, described below). There is an opportunity to retrofit this swale improve water quality and reduce peak flows. A portion of the School parking lot and access drive draining to this swale is covered under operational stormwater permit 6615-9010; that permit specifies that water quality treatment be provided for 16,096 SF / 0.37 acres of impervious surface. It does not appear that the swale was sized to provide water quality treatment or safe conveyance for VTrans's run-on. The existing swale is filled with sediment and cattails and is minimally maintained.

The proposed retrofit for this site is a sediment forebay and gravel wetland, replacing the existing grass channel on school property, sized appropriately to provide water quality treatment for contributing impervious surfaces and, to the extent reasonable, to provide peak flow attenuation and (at minimum) safe conveyance for larger storms, accounting for existing impervious within the drainage area on the school

property and VTrans run-on. The design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (0.8 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period. At this site, it is possible to site a gravel wetland that will manage 100% of the WQv (or 2,190 ft^3) of runoff and the channel protection volume—or the additional volume of runoff generated by a one-year, 24-hour storm (1,350 ft^3). The total proposed treatment volume for this practice 10,886 ft^3 (enough volume to manage both the school runoff and that from I-89, in the event that the practice at WR-19 is never constructed). A 30% design plan is provided in Appendix E. If implemented as designed, this practice has the potential to manage 1.50 lbs/year of total phosphorus.

5.3.1.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (Table 12). This amount differs from the amount initially projected for the site (Table 4), as design-specific amounts and costs were developed to support this retrofit concept. Cost-benefit metrics were adjusted based on the design-specific cost estimate.

Table 13. D3 Drainage Area, School Access Drive and D5 Stable Conveyance – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT		UNIT COST	TOTAL
WR-22	CLEARING AND GRUBBING	1	LS	$5,000.00	$5,000.00
	PROJECT DEMARCATION FENCING	1260	LF	$1.25	$1,575.00
	GEOTEXTILE FOR SILT FENCE	580	SY	$5.00	$2,900.00
	COMMON EXCAVATION	600	CY	$10.00	$6,000.00
	UNCLASSIFIED CHANNEL EXCAVATION	30	CY	$15.00	$450.00
	TRANSPORT EXCAVATED MATERIAL OFFSITE	630	CY	$10.00	$6,300.00
	PRECAST REINFORCED CONCRETE MANHOLE WITH TRASH RACK, AND 24" CAST IRON GRATE	1	EA	$6,000.00	$6,000.00
	24" CPEP (SL)	25	LF	$60.00	$1,500.00
	STONE FILL, TYPE II	28	CY	$45.00	$1,260.00
	3/4" DENSE GRADED DOUBLE WASHED CRUSHED STONE	200	CY	$40.00	$8,000.00
	3/8" DOUBLE WASHED PEA STONE	35	CY	$45.00	$1,575.00
	WETLAND SOIL	70	CY	$50.00	$3,500.00
	6" UNDERDRAIN PIPE	160	LF	$25.00	$4,000.00
	6" UNDERDRAIN CLEANOUT WITH CAP	5	EA	$125.00	$625.00
	6" PERFORATED RISER WITH CAP	5	EA	$125.00	$625.00
	WETLAND PLANTS	295	SY	$50.00	$14,750.00
	SEED	12	LB	$7.08	$84.96
	MULCH	12	LB	$0.30	$3.63
				CONSTRUCTION TOTAL	***$64,149***
				FINAL DESIGN (25%)	***$16,037***
				PERMITTING (10%)	***$6,415***
				STAKE OUT (5%)	***$3,207***
				MOBILIZATION / DEMOBILIZATION (10%)	***$6,415***
				CONSTRUCTION OVERSIGHT (10%)	***$6,415***
				CONTINGENCY (15%)	***$9,622***
				TOTAL (ROUNDED TO NEAREST $100)	***$112,300***

The estimated cost for implementation of this project is $112,300.

- The cost per pound of phosphorus treated is $74,909.
- The cost per impervious acre treated is $207, 962.
- The cost per cubic foot of runoff treated is $10.32.

5.3.1.2. Permitting Needs

Anticipated permitting needs are summarized below.

Construction Stormwater Permit: Disturbance at this site is not anticipated to require a construction stormwater permit. Construction activities should still be conducted in accordance with the requirements and guidance of the Vermont DEC's *Low Risk Site Handbook for Erosion Prevention and Sediment Control*.

Operational Stormwater Permit: An amendment to the existing operational stormwater permit for the school may be needed, since the proposed retrofit will replace the existing swale, which is permitted as the manner of discharge for S/N 001.

Local Permitting: No local permits are anticipated.

Other Permits:

This site should be reviewed by the Act 250 Coordinator for a preliminary jurisdictional determination prior to final design, as there are Chittenden East School District (No. 300015) and Richmond School District (No. 300015-1 and 300015-2) permits for construction of and additions to the Elementary and Middle School buildings immediately adjacent to this project area.

No Wetlands or River Corridor permitting is anticipated for this project. However, since cattails are present in the existing grass channel, a site visit and discussion with Wetlands Program staff is warranted.

Any work within the VTrans right-of-way will require a State Highway Access and Work Permit (19 VSA 1111). Although this retrofit is not currently anticipated to extend onto the VTrans right-of-way, continued coordination with VTrans staff is warranted as this retrofit progresses through design, especially if participants choose to stabilize the existing gully erosion down-slope of the culvert outlet directing runoff from the VTrans right-of-way onto the school property as part of this implementation project.

5.3.1.3. Next Steps

A meeting was held with the project stakeholders (Town, Friends of the Winooski, CCRPC) and all indicated willingness to proceed with design work for this retrofit. This concept was developed following a meeting at the Richmond Town Offices with VTrans, DEC, FWR, and Town staff on May 30, and was presented to the Richmond Elementary School principal (Mark Carbone) and Jeff Forward, Chittenden East Supervisory Union Facilities Coordinator. School District staff were deeply concerned about the District's level of commitment and obligation to implement the projects if concept designs are approved, and agreed to discuss the topic with the Superintendent, who is the ultimate decision maker regarding the School District's obligations. Following this meeting, the concept design was modified to address comments received. Vermont Agency of Transportation staff (Maintenance and Operations Bureau and Project Development Bureau – Environmental) were consulted and indicated willingness to consider the concept, although their involvement would be limited as the main work is outside their right-of-way. Further work will involve refinement of the retrofit design with respect to size and layout to maximize both peak flow minimization and water quality

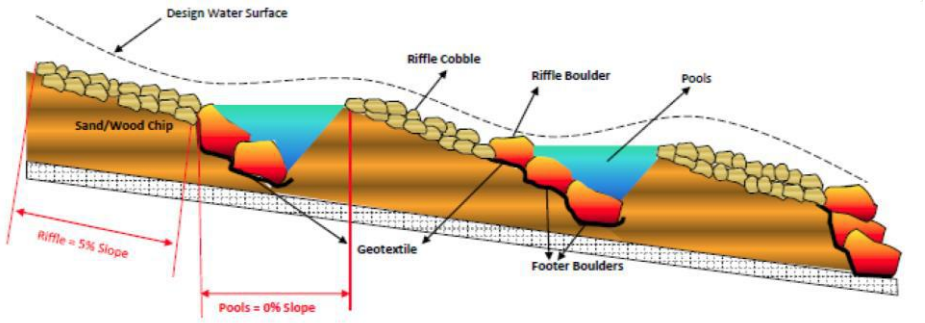
treatment. Continued coordination with School District staff and VTrans (District Office and Maintenance and Operations Bureau staff) is warranted.

5.3.2. WR-14, School NW Ravine (Regenerative Storm Conveyance)

The existing outlet from the open drainage system carrying runoff from I-89 (WR-19), School Street, a portion of the school parking lots and access drives (WR-22), and the bus and overflow parking area—a total drainage area of roughly 5.5 acres--has failed, and there is an actively eroding gully from the system outlet leading down the slope to the west. There is an opportunity to repair the outlet structure, and to stabilize the upper portion of the gully, where steep side slopes and mass failures threaten the adjacent parking areas and other school infrastructure, while providing additional water quality treatment.

The proposed retrofit for this site is a new, stable outlet structure to a plunge pool and step pool storm conveyance, coupled with stabilization measures at the head of the existing gully to protect infrastructure. The conveyance practice will be sized appropriately to provide supplementary water quality treatment for contributing impervious surfaces during small storms and, more critically, to provide safe conveyance for larger storms, accounting for both existing impervious within the drainage area on the school property and VTrans run-on.

This concept of a step pool storm conveyance, also referred to as "regenerative storm conveyance" originated in the mid-Atlantic, and has since spread to and been successfully implemented in other areas of the US, particularly as a strategy for restoring urban drainage channels and eroded outfalls. The schematic cross section below illustrates how these are generally constructed—with a riffle-pool profile, and the riffle-pool structure underlain by a media bed (usually a sand and wood chip mix) to provide water quality treatment in addition to safe conveyance of larger and higher-velocity flows.



Schematic profile for a regenerative storm conveyance system (Anne Arundel County, 2011)

The water quality design standard used for this retrofit was best-fit treatment of the water quality volume for the contributing drainage area (5.5 acres). Full compliance with the WQv treatment standard would manage 1.0" of rain in a 24-hour period. At this site, it is possible to site a regenerative stream conveyance that will manage 100% of the WQv (or 8,990 ft^3) of runoff and provide safe conveyance for the 100-year design storm. A 30% design plan is provided in Appendix E. This practice has the potential to prevent 6.67 lbs/year of total phosphorus from entering receiving waters (Table 4). Depending on the order in which retrofits are implemented in the contributing drainage areas, however, phosphorus removal benefits reported to VTDEC may ultimately be calculated by difference to avoid double-counting.

5.3.2.1. Cost Estimates and Revised Benefit Metrics

A preliminary implementation cost estimate is provided below (Table 14). No cost estimate was initially projected for this site (Table 4), as a per-cubic-foot construction cost basis was not readily available for this

type of management practice. The design-specific amounts and costs below were developed to support this high-priority retrofit concept. Cost-benefit metrics were calculated based on the design-specific cost estimate.

The estimated cost for implementation of this project is $242,400.

- The cost per pound of phosphorus treated is $36,341.
- The cost per impervious acre treated is $98.137.
- The cost per cubic foot of runoff treated is $26.96.

Table 14. School NW Ravine – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT		UNIT COST	TOTAL
	CLEARING AND GRUBBING	1	LS	$15,000.00	$15,000.00
	PROJECT DEMARCATION FENCING	940	LF	$1.25	$1,175.00
	GEOTEXTILE FOR SILT FENCE	400	SY	$5.00	$2,000.00
	COMMON EXCAVATION	500	CY	$25.00	$12,500.00
	TRENCH EXCAVATION	70	CY	$17.00	$1,190.00
	TRANSPORT EXCAVATED MATERIAL OFFSITE	500	CY	$25.00	$12,500.00
	30" HDPE (SL)	80	LF	$60.00	$4,800.00
WR-14	STONE FILL, TYPE I	30	CY	$55.00	$1,650.00
	STONE FILL, TYPE II	125	CY	$45.00	$5,625.00
	STONE FILL, TYPE IV	390	CY	$50.00	$19,500.00
	FILTER MEDIA MIX (70% SAND, 30% WOODCHIP)	40	CY	$50.00	$2,000.00
	GEOTEXTILE UNDER STONE FILL	200	SY	$1.25	$250.00
	SEED	13	LB	$7.08	$92.04
	MULCH	13	LB	$0.30	$3.93
	EROSION PREVENTION AND STABILIZATION MEASURES	1	LS	$25,000.00	$25,000.00
				CONSTRUCTION TOTAL	***$103,286***
				GEOTECHNICAL INVESTIGATION	***$10,000***
				FINAL DESIGN (25%)	***$25,821***
				PERMITTING (10%)	***$10,329***
				STAKE OUT (10%)	***$10,329***
				MOBILIZATION / DEMOBILIZATION (25%)	***$25,821***
				CONSTRUCTION OVERSIGHT (15%)	***$15,493***
				CONTINGENCY (40%)	***$41,314***
				TOTAL (ROUNDED TO NEAREST $100)	***$242,400***

5.3.2.2. Permitting Needs

Anticipated permitting needs are summarized below.

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

- Less than 2 acres of disturbance at any one time.
- All disturbed 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.
  - If this buffer cannot be maintained due to the immediate down-grade presence of the existing gully (and thus a lack of a vegetated buffer), risk mitigation factors including minimizing disturbed earth exposure in any location to less than 7 days before implementing stabilization may be employed to maintain a Low Risk categorization.

Operational Stormwater Permit: An amendment to the existing operational stormwater permit for the school may be needed, since the proposed retrofit will modify the outlet for the existing swale, which is permitted as the manner of discharge for S/N 001.

Local Permitting: No local permits are anticipated.

Other Permits:

This site should be reviewed by the Act 250 Coordinator prior to final design, as there are Chittenden East School District (No. 300015) and Richmond School District (No. 300015-1 and 300015-2) permits for construction of and additions to the Elementary and Middle School buildings immediately adjacent to this project area.

No Wetlands or River Corridor permitting is anticipated for this project.

No work within the VTrans right-of-way requiring a State Highway Access and Work Permit is anticipated.

5.3.2.3. Next Steps

A site meeting was held with the Richmond Elementary School principal (Mark Carbone). Jeff Forward, Chittenden East Supervisory Union Facilities Coordinator, was not able to attend but was consulted. They have indicated their willingness to proceed with concept design of this retrofit. The concept design was presented to the Richmond Elementary School principal (Mark Carbone) and Jeff Forward, Chittenden East Supervisory Union Facilities Coordinator. School District staff were deeply concerned about the District's level of commitment and obligation to implement the projects if concept designs are approved, and agreed to discuss the topic with the Superintendent (the ultimate decision maker regarding the School District's obligations). Continued coordination with School District staff is warranted. Following this meeting, the concept design was modified to address comments received. Vermont Agency of Transportation staff (Maintenance and Operations Bureau and Project Development Bureau – Environmental) were consulted and indicated willingness to consider the concept, although their involvement would be limited as the work is outside their right-of-way. Further work will involve refinement of the retrofit design with respect to size and layout to maximize both peak flow minimization and water quality treatment.

5.3.3. WR-15, School Athletic Field (Wet Pond / Created Wetland)

Stormwater runoff from the Richmond Elementary/Camel's Hump Middle School parking lot is conveyed from a 4.4-acre drainage area via closed drainage between the two school buildings towards the athletic field, then southeast where it discharges at a stable outfall at the bottom of a steep slope. This system has an operational stormwater permit (6615-9010), but runoff entering the closed drainage system receives no water quality treatment prior to discharge.

The proposed retrofit for this site is a surface wet pond or created wetland adjacent to the athletic field to provide water quality treatment, with overflow back to the closed drainage system and existing stable outfall. The design standard used for this retrofit was treatment of the full water quality volume (WQv, or 1.0" of rain in a 24-hour period), equal to 8,030 ft^3 of runoff. A 30% design plan is provided in Appendix E. This practice has the potential to prevent 4.43 lbs/year of total phosphorus from entering receiving waters (Table 4). It is

recommended that, at minimum, an educational sign be installed in conjunction with the retrofit. Ideally, the retrofit would be designed to maximize educational opportunities for students.

5.3.3.1. Cost Estimates and Revised Benefit Metrics

The cost estimate provided below (Table 15) is preliminary. This amount differs from the amount initially projected for this site (Table 4) as design-specific amounts and costs were used. Cost-benefit metrics were also adjusted based on the design-specific cost estimate.

Table 15. School Athletic Field – Opinion of Probable Cost – 30% Design

	ITEM	AMOUNT		UNIT COST	TOTAL
WR-15	PROJECT DEMARCATION FENCING	340	LF	$1.25	$425.00
	GEOTEXTILE FOR SILT FENCE	180	SY	$5.00	$900.00
	COMMON EXCAVATION	533	CY	$15.00	$7,995.00
	TRANSPORT EXCAVATED MATERIAL OFFSITE	543	CY	$10.00	$5,430.00
	STRUCTURE EXCAVATION	10	CY	$25.00	$250.00
	PRECAST REINFORCED CONCRETE MANHOLE WITH ORIFICE, TRASH RACK, AND 24" CAST IRON GRATE	1	EA	$6,000.00	$6,000.00
	18" HDPE (SL)	35	LF	$44.00	$1,540.00
	CONNECTION TO EXISTING 18" HDPE (SL)	1	EA	$500.00	$500.00
	STONE FILL, TYPE II	11	CY	$45.00	$495.00
	CHAIN LINK FENCE, 6 FEET	340	LF	$30.00	$10,200.00
	GATE FOR CHAIN LINK FENCE, 6 FEET	12	LF	$131.00	$1,572.00
	PLANTINGS	45	SY	$50.00	$2,250.00
	SEED	5	LB	$7.08	$35.40
	MULCH	5	LB	$0.30	$1.51
				CONSTRUCTION TOTAL	***$37,594***
				FINAL DESIGN (25%)	***$9,398***
				PERMITTING (10%)	***$3,759***
				STAKE OUT (5%)	***$1,880***
				MOBILIZATION / DEMOBILIZATION (15%)	***$5,639***
				CONSTRUCTION OVERSIGHT (10%)	***$3,759***
				CONTINGENCY (25%)	***$9,398***
				TOTAL (ROUNDED TO NEAREST $100)	***$71,500***

The estimated cost for implementation of this project is $71,500.

- The cost per pound of phosphorus treated is $21,478.
- The cost per impervious acre treated is $32,648.
- The cost per cubic foot of runoff treated is $7.72.

5.3.3.2. Permitting Needs

Anticipated permitting needs are summarized below.

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

- Less than 2 acres of disturbance at any one time.
- All disturbed 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.

Operational Stormwater Permit: An amendment to the existing operational stormwater permit may be needed, since the manner of discharge for S/N 002 is proposed to be modified to add water quality treatment.

Local Permitting: No local permits are anticipated.

Other Permits:

This site should be reviewed by the Act 250 Coordinator prior to final design as there are Chittenden East School District (No. 300015) and Richmond School District (No. 300015-1 and 30001502) permits for construction of and additions to the Elementary and Middle School buildings.

No Wetlands or River Corridor permitting is anticipated for this project.

5.3.3.3. Next Steps

A site meeting was held with the Richmond Elementary School principal (Mark Carbone). Jeff Forward, Chittenden East Supervisory Union Facilities Coordinator, was not able to attend but was consulted. They have indicated their willingness to proceed with concept design of this retrofit. The draft concept design was presented to Mark Carbone and Jeff Forward. School District staff were deeply concerned about the District's level of commitment and obligation to implement the projects if concept designs are approved, and will discuss the topic with the Superintendent (the ultimate decision maker regarding the School District's obligations). Following this meeting, the concept design was modified to address comments received. Further design will involve refinement of the retrofit design with respect to size and layout to maximize both water quality treatment and educational opportunity, with larger storms passed through the system safely.

6. Proposed Practices and Programs for the Wider Community

The WNRCD conducted twelve stormwater technical site visits and assessments between November 2017 - April 2018. They identified eight stormwater project opportunities and one program opportunity, summarized below. Details, including next steps and project funding recommendations, are included in Appendix D.

1. Project: Install simple infiltration water bars, or replace the existing culvert and reconstruct the ditch, along lower drive at 82 Bates Farm Road, to address a driveway drainage ditch that has filled in with sediment and conveys stormwater to failing culvert underneath drive that daylights to a steep ravine and small, perennial tributary to the Huntington River.
2. Project: Install a rain garden in a grassed area east of the house at 82 Bates Farm Road, to reduce the stormwater volume conveyed to the upper driveway and to a grassed area, where it is conveyed to the small tributary above house and has caused rill erosion to form.
3. Project: Construct infiltration water bars and re-grade the upper drive at 82 Bates Farm Road, to address runoff from the upper portion of the drive, barn parking area, and barn roof, which is de-stabilizing a secondary culvert under the driveway, posing a threat of culvert and bank failure.
4. Project: Line an existing ditch with large stone where it conveys stormwater along East Hill Road above 87 and 95 Deer Creek Lane, in order to alleviate the stormwater and sediment volumes being discharged to these properties.
5. Project: Disconnect existing gutters at 138 Rocky Road from direct piping to Johnnie Brook, where a stream bank is actively eroding. The disconnection from the pipe may infiltrate into the lawn or be captured in a rain barrel.
6. Project: Install a rain barrel at to capture a portion of roof runoff at 31 Railroad Street, where water currently is conveyed by a gutter directly to a saturated lawn area.
7. Project: Construct a rain garden in front of One Radish Eatery (1 Esplande Road) to reduce stormwater pooling in low, grassed areas in front of the building and parking lot, and reduce sediment transport from the property to Main Street.
8. Project: Install a larger rain garden in the grassed area between 1 Esplande Road and Main Street to treat and potentially infiltrate stormwater sourced from One Radish Eatery property, Esplande Road, and excess stormwater from Main Street not captured by catch basin above the rain garden site.
9. Program: Create a rain garden adoption program for the Main St. and/or One Radish Eatery rain gardens, in order to care for rain gardens implemented following the recommendations of this report.

7. Recommendations

This document represents an extensive effort to identify and evaluate stormwater problem areas and strategic retrofit opportunities throughout Richmond's village and at the Richmond Elementary School/Camel's Hump Middle School campus, as well as projects and programs for further community engagement and hydrologically connected municipal road segments most in need of repair. A total of six high priority stormwater improvement projects were advanced to concept design in the Village, and an additional four projects were advanced to concept design on the school campus and in an area of the I-89 right-of way that contributes runoff to the school property. These conceptual solutions all represent improvements that the Town or the School District could pursue directly, or could work with partners to pursue funding to address.

The practices, projects, and program identified in this plan individually and collectively can have a substantial benefit for water quality, resilience to larger storm events, and increased awareness and interest in stormwater management generally. While the high-priority concepts stand to provide some of the more substantial benefits, the Town and its partners are encouraged to move forward with the additional retrofits and practices outlined here (Appendix F includes a summary of these projects to be uploaded into VTDEC's Watershed Projects Database for tracking). These potential improvements have been identified through a planning process encouraged and recognized by VTDEC, so they will be good candidates for implementation funding through the VTDEC Clean Water Fund grant program (http://dec.vermont.gov/watershed/cwi/cwf). Alternately, and particularly for lower-cost strategic retrofits, such as the pervious paving retrofit suggested at the Richmond Elementary School, final design and construction funding could be pursued through the Lake Champlain Basin Program's Pollution Prevention grant program (http://www.lcbp.org/about-us/grants-rfps/request-for-proposals-rfps/).

Beyond addressing the specific problem areas identified in this plan, there are often opportunities to improve management of stormwater runoff that arise as part of routine municipal projects, such as the substantial reconstruction of a road surface or intersection. Grant funds may be available to cover the incremental cost of addressing stormwater runoff as part of such projects, if stormwater management is considered early enough in the design process and does not exceed regulatory thresholds for state stormwater permits. Any party choosing to advance one of these priority projects will likely need to consult on a case-by-case basis with the VT DEC Stormwater Program to determine whether or not a specific project will be subject to state jurisdiction. Regardless, it is often significantly more cost-effective and efficient to incorporate stormwater management measures into a planned municipal project as compared to the construction of a stand-alone stormwater management retrofit.

Finally, we recommend that all project partners keep up with "current events" related to implementation of the Lake Champlain Phosphorus TMDLs. The Vermont Agency of Transportation, for instance, is now working to develop its framework for implementing Phosphorus Control Planning across its entire transportation system in the Vermont Lake Champlain Basin through its TS4 General Permit. While implementation is not immediate, in the coming years VTrans will be completing retrofit assessments for its roads and facilities throughout Richmond. Projects in this plan that involve VTrans drainage should continue to be coordinated with that agency and its permitting and compliance efforts, to the benefit of all parties. In

addition, under the forthcoming Developed Lands General Permit, parcels and common plans of development with more than 3 acres of impervious surface that has either never been permitted, or was permitted for operational stormwater before 2002, will be required to obtain permit coverage and develop new retrofits to treat stormwater from their impervious surfaces. The Richmond Elementary School/Camel's Hump Middle School complex is one example of a property that may ultimately be designated. Though its existing operational stormwater permit is in compliance, its stormwater management infrastructure was originally permitted prior to 2002 and provides only minor water quality treatment benefits.

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Vermont Department of Environmental Conservation, Watershed Management Division, 2017. 2017 Vermont Stormwater Management Manual Rule and Design Guidance, effective July 1, 2017. Available at http://dec.vermont.gov/sites/dec/files/wsm/stormwater/docs/Permitinformation/2017%20VSMM_Rule_and_Design_Guidance_04172017.pdf

Appendix A. Maps

ESSEX

North Williston

Jericho Center

JERICHO

Nashville

WILLISTON

Williston

Richmond Elementary School Area

Richmond Elementary School Including Drainage Area

Richmond Village Area

Richmond

Fays Corner

Jonesville

BOLTON

Rhode Island Corner

HINESBURG

HUNTINGTON

Huntington

N

Sources: Streets: VCGI, Streams: VCGI, Watershed Boundaries (WBD): VCGI, Imagery: Esri

0 0.25 0.5 1 Miles

Watershed boundary

- Huntington River
- La Platte River
- Winooski River
- Stormwater Master Plan Area
- River or Stream

STONE ENVIRONMENTAL INC

Watershed Boundaries

Figure 1

Town of Richmond Stormwater Master Planning

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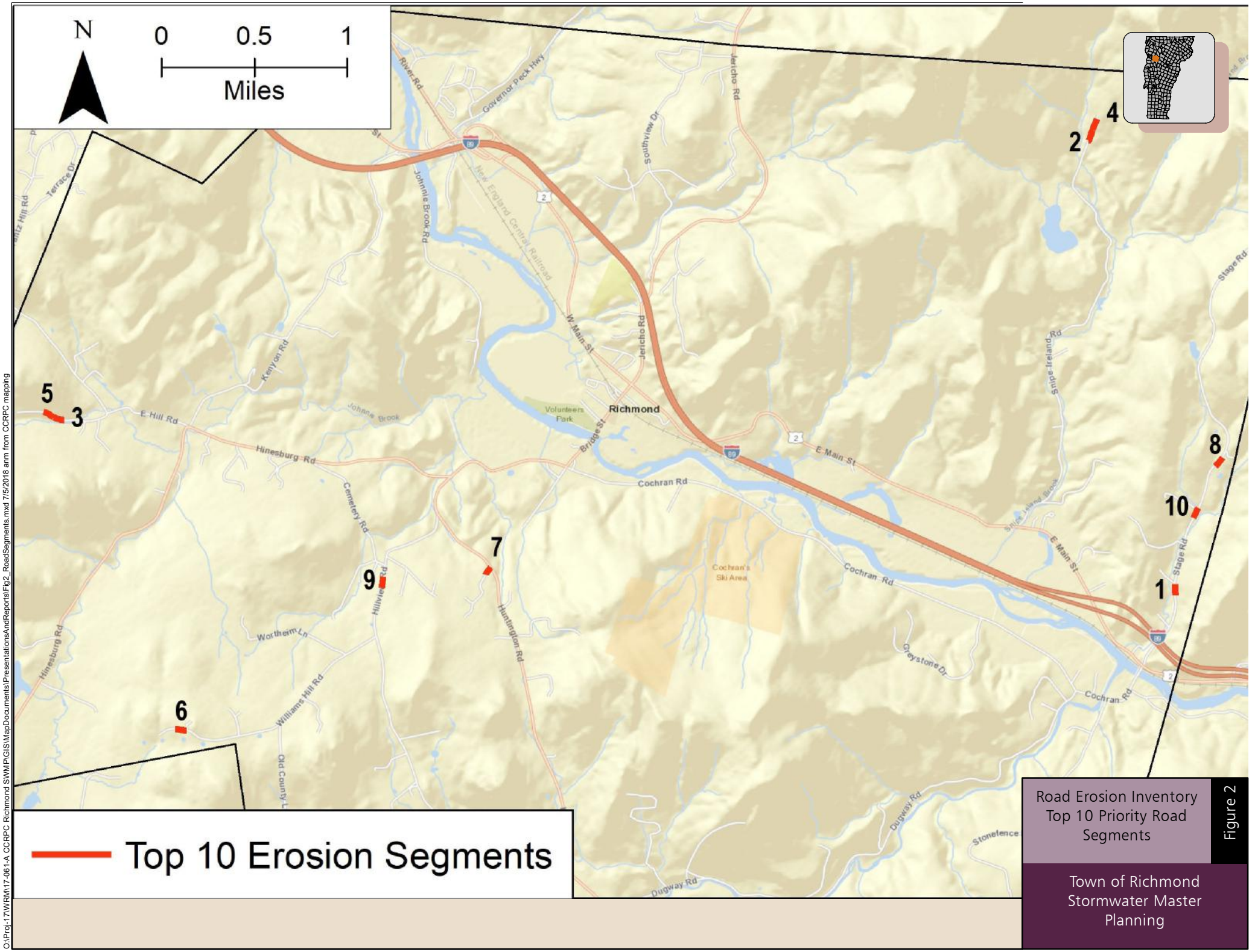

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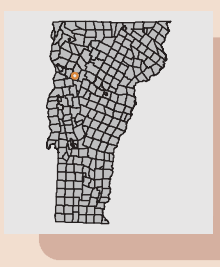
Richmond Village (Winooski River Watershed)

WR-11
WR-08
WR-06
WR-10
WR-07
WR-09
WR-05
WR-04
WR-03
WR-02
WR-01

TILDEN AVE
BAKER ST
MILLET ST
MAIN ST
JERICHO RD
INTERSTATE 89
RAILROAD ST
BORDEN ST
DEPOT ST
CHURCH ST
ESPLANADE
JOLINA CT
PLEASANT ST
LEMROY CT
BRIDGE ST
OLD BROOKLYN CT
ROUND CHURCH RD
HUNTINGTON RD
FARR RD
COCHRAN RD
THOMPSON RD

Level	Classification
1	Infeasible to remedy issue/ outside of project scope
2	Stable, but problem could escalate with future change in surrounding landuse
3	Limited erosion and/or drainage problems are present
4	Moderate erosion and/or drainage problems are present
5	Significant erosion and/or drainage problems are present
6	Strategic retrofit opportunity



N

Existing, Catchbasin
Existing, Culvert inlet
Existing, Culvert outlet
Existing, Dry Well
Existing, Grate/Curb Inlet
Existing, Information Point
Existing, Outfall
Proposed, Catchbasin
Existing, Footing drain
Existing, Sanitary line
Existing, Storm line
Existing, Swale
Proposed, Storm line
River or Stream

Problem Area

3
4
5
6

Sources: Problem Areas: Stone, Streets: VCGI, Streams: VCGI, Stormwater Infrastructure: ANR, Imagery: Esri

0 250 500 Feet

STONE ENVIRONMENTAL INC

Figure 3: Summary of Problem Areas and Strategic Retrofit Opportunities

Richmond Village

Richmond Stormwater Master Plan

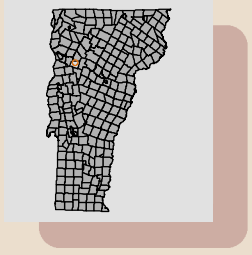
O:\Proj-17WRM\17-061-A CCRPC Richmond SWMP\GIS\MapDocuments\PresentationsAndReports\Fig_Richmond_ProblemAreas_wSWInfrastructure.mxd 12/27/2017 kab/anm

Richmond Elementary School (Winooski River Watershed)

WR-18
WR-14
WR-22
WR-19
WR-20
WR-13
WR-12
WR-15
WR-16
WR-17
WR-21

SOUTHVIEW DR
SCHOOL ST
INTERSTATE 89
JERICHO RD
HILLSIDE LN
BURNETT CT
BROWNS CT

Level	Classification
1	Infeasible to remedy issue/ outside of project scope
2	Stable, but problem could escalate with future change in surrounding landuse
3	Limited erosion and/or drainage problems are present
4	Moderate erosion and/or drainage problems are present
5	Significant erosion and/or drainage problems are present
6	Strategic retrofit opportunity



N

Existing, Catchbasin
Existing, Culvert inlet
Existing, Culvert outlet
Existing, Drop Inlet
Existing, Grate/Curb Inlet
Existing, Information Point
Existing, Outfall
Existing, Footing drain
Existing, Sanitary line
Existing, Storm line
Existing, Swale
River or Stream

Problem Area

3
4
5
6
School Drainage Area

Sources: Problem Areas: Stone, Streets: VCGI, Streams: VCGI, Stormwater Infrastructure: ANR, Imagery: Esri

0 100 200 Feet

STONE ENVIRONMENTAL INC

Figure 4: Summary of Problem Areas and Strategic Retrofit Opportunities

Richmond Elementary School and Camel's Hump Middle School

Richmond Stormwater Master Plan

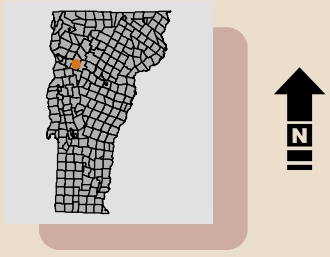
O:\Proj-17\WRM\17-061-A CCRPC Richmond SWMP\GIS\MapDocuments\PresentationsAndReports\Fig_Richmond_ProblemAreas_wSWInfrastructure.mxd 6/11/2018 kab/ann

Richmond Elementary School (Winooski River Watershed)

GOVERNOR PECK RD
BROWNS TRCE
SUNSET RDG
HIDDEN PINES EXT
HIDDEN PINES DR
HIDDEN PINES CIR
MARY DR
PINNACLE VW
BRADFORD TER
JOAN AVE
SOUTHVIEW DR
WESTALL DR
WESTALL EXT
OLD JERICHO RD
JERICHO RD
VALLEY VIEW RD
VALLEY VIEW EXT
BURNETT CT
BROWNS CT
TILDEN AVE
BAKER ST
MILLETT ST
RAILROAD ST
DEPOT ST
MAIN ST
BRIDGE ST
JOLINA CT
LEMROY CT
INTERSTATE 89
MAIN ST

WR-18
WR-14
WR-22
WR-19
WR-20
WR-13
WR-15
WR-12
WR-16
WR-17
WR-21
WR-11
WR-08
WR-10
WR-09
WR-07
WR-05

Level	Classification
1	Infeasible to remedy issue/ outside of project scope
2	Stable, but problem could escalate with future change in surrounding landuse
3	Limited erosion and/or drainage problems are present
4	Moderate erosion and/or drainage problems are present
5	Significant erosion and/or drainage problems are present
6	Strategic retrofit opportunity



N

Sources: Problem Areas: Stone, Streets: VCGI, Streams: VCGI, Stormwater Infrastructure: ANR, Imagery: Esri

0 500 1,000 Feet

- Existing, Catchbasin
- Existing, Culvert inlet
- Existing, Culvert outlet
- Existing, Drop Inlet
- Existing, Grate/Curb Inlet
- Existing, Information Point
- Existing, Outfall
- Proposed, Catchbasin
- Existing, Footing drain
- Existing, Sanitary line
- Existing, Storm line
- Existing, Swale
- Proposed, Storm line
- River or Stream

Problem Area

- 3
- 4
- 5
- 6
- School Drainage Area

STONE ENVIRONMENTAL INC

Figure 5: Summary of Problem Areas and Retrofit Opportunities

Richmond School Campus, Including Upland Drainage Areas

Richmond Stormwater Master Plan

O:\Proj-17\WRM\17-061-A CCRPC Richmond SWMP\GIS\MapDocuments\PresentationsAndReports\Fig_Richmond_ProblemAreas_wSWInfrastructure.mxd 6/11/2018 kab/anm

DRAWING CREDITS

Drawn On:	2-14-2018
Drawn By:	KAM
Checked On:	2-16-2018
Checked By:	ANM
Project No.:	17-061A

REVISIONS

#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE

0 100 200 FT

File:

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

CAMEL'S HUMP MIDDLE SCHOOL
AND RICHMOND ELEMENTARY
REGIONAL WATERSHEDS

Richmond Vermont

FIGURE NO.

6

Appendix B. Inventory of Existing Plans and Data

The inventory of plans and data compiled at the beginning of Richmond's Stormwater Management Plan process includes existing GIS datasets (parcels, stormwater infrastructure, environmental resources, soils data, etc.), as well as previously completed plans, reports, and designs relevant to the stormwater planning work undertaken here.

The complete data library may be downloaded from the following link:

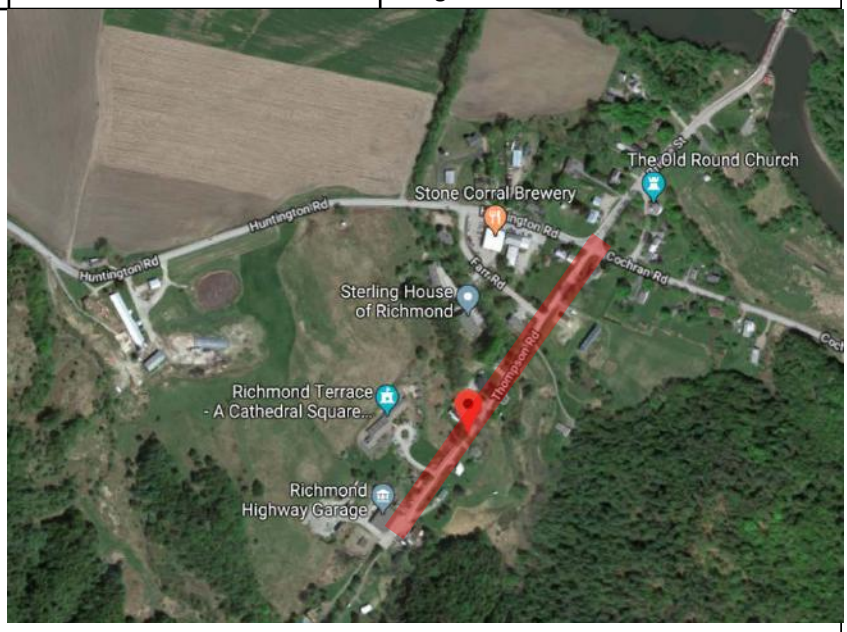
https://www.dropbox.com/sh/0cqb1bv9k2j1rnv/AACriaVtIdZIWo1_gCNEJ5Eja?dl=0

Appendix C. Problem Area Data Sheets

Problem Area Data Sheet

Problem Area ID: WR-01	Latitude: 44.39693°	Longitude: -73.00161°

Watershed:	Winooski River
Location:	Thompson Road
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments
Ownership:	Town of Richmond
Classification:	6
Base P Load:	1.75 lbs/yr
Soil Type	C/D
Feasible BMPs	Gravel wetland, underdrained bioswale, grass swale
Max. P Reduction	1.07 lbs/yr



Date of Field Data Collection: October 5, 2017, May 30, 2018

Description of Observed Conditions:

There is currently no treatment, and very little drainage infrastructure, for managing stormwater flow from Thompson Road. This presents an opportunity to capture and treat stormwater runoff before it enters the Winooski River.

Field Photos

Photo 1. Thompson Road

Photo 2. Thompson Road

Problem Area Data Sheet

Problem Area ID: WR-02	Latitude: 44.39821°	Longitude: -72.99781°

Watershed:	Winooski River
Location:	Cochran Road
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments
Ownership:	Town of Richmond
Classification:	6
Base P Load:	6.52 lbs/yr
Soil Type	A
Feasible BMPs	Bioswale/bioretention, grass swale, surface infiltration
Max. P Reduction	6.39 lbs/yr

Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

There is currently no treatment, and very little drainage infrastructure, for managing stormwater flow from Cochran Road. This presents an opportunity to capture and treat stormwater runoff before it enters the Winooski River.

Field Photos

Photo 1. Cochran Road

Photo 2. Cochran Road

Problem Area Data Sheet

Problem Area ID: WR-03	Latitude: 44.40077°	Longitude: -72.99863°

Watershed:	Winooski River
Location:	Wet Pond
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments
Ownership:	Town of Richmond/Private
Classification:	6
Base P Load:	3.63 lbs/yr
Soil Type	C
Feasible BMPs	Retrofit Existing Wet Pond
Max. P Reduction	1.89 lbs/yr

Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

Stormwater runoff from Bridge Street, Round Barn Road, and portions of Thompson Road and Huntington Road is collected within a closed stormwater drainage network that outlets to an existing wet pond. Soils are mapped as HSG C, but appear to be infiltrating the collected runoff; there is no visible pond outlet. It may be feasible to increase the storage capacity of the pond to capture larger storm events.

Field Photos

Photo 1. Portion of the WR-03 drainage area

Photo 2. Existing wet pond

Problem Area Data Sheet

Problem Area ID: WR-04	Latitude: 44.40203°	Longitude: -72.99649°

Watershed:	Winooski River
Location:	Volunteers Green Parking Lot
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments
Ownership:	Town of Richmond (Volunteers Green)
Classification:	6
Base P Load:	4.46 lbs/yr
Soil Type	B
Feasible BMPs	Underground Infiltration, Underground Storage
Max. P Reduction	4.37 lbs/yr

Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

The existing closed drainage system conveys stormwater from Bridge Street, as well as portions of Esplanade and Church Streets, to the Winooski River. The outlet pipe from this drainage network passes under the recreational fields parking area. It may be possible to access the drainage system in this location and install chambers or underground storage (dependent upon soil infiltrative capacity). It would also be possible to install a rain garden in the vicinity of the parking lot, whether near the entrance or near the gravel road to access the recreational fields.

Field Photos

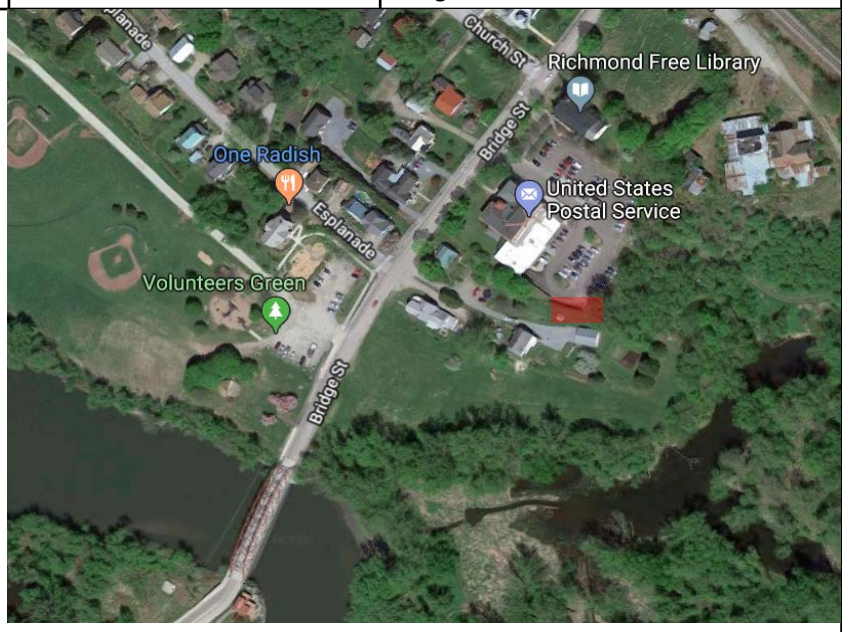
Photo 1. Entrance to the recreational fields parking lot

Photo 2. Recreational fields parking lot

Problem Area Data Sheet

Problem Area ID: WR-05	Latitude: 44.40213°	Longitude: -72.99481°

Watershed:	Winooski River
Location:	USPS / Richmond Free Library
Problem Type:	Water Quality and Erosion
Identification Source:	SWMP Field Assessments
Ownership:	Town of Richmond
Classification:	4
Base P Load:	4.15 lbs/yr
Soil Type	B
Feasible BMPs	Bioretention
Max. P Reduction	3.15 lbs/yr



Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

Stormwater flows overland from the USPS and library roofs and parking lot to a collection point at the southeast corner of the parking lot. From there, drainage is conveyed via a closed pipe and a drainage ditch that outlets to a natural pond, and then to the Winooski River. There is substantial erosion occurring in the drainage ditch; if stormwater flow were reduced by installation of a bioretention basin or bioswale, stabilization of the currently eroding channel may also be possible.

Field Photos

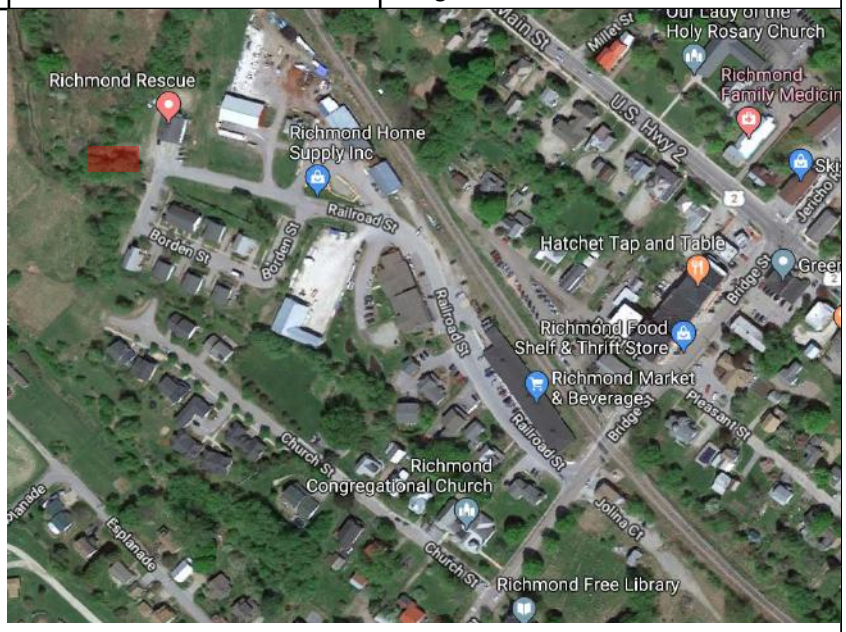
Photo 1. Eroding drainage ditch

Photo 2. Eroding drainage ditch and its junction with the pond

Problem Area Data Sheet

Problem Area ID: WR-06	Latitude: 44.40558°	Longitude: -72.99800°

Watershed:	Winooski River
Location:	Richmond Rescue
Problem Type:	Water Quality and Erosion
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	4
Base P Load:	68.2 lbs/yr
Soil Type	C
Feasible BMPs	Wet Pond / Created Wetland
Max. P Reduction	35.5 lbs/yr



Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

Stormwater runoff from an approximately 90-acre drainage area is conveyed via a closed drainage system and overland flow to a ditch to the southwest of Richmond Rescue. The ditch, which is actively eroding and filled with sediment, carries the stormwater to the Winooski River. Sufficient open land is present at the outlet of the closed drainage system to construct a sediment forebay and a water quality treatment practice, wet pond or created wetland. About 40 acres of the contributing drainage area can be managed by a separate water quality practice at WR-11 (Millet Street).

Field Photos

Photo 1. Eroding drainage ditch down-slope of existing outfalls.

Photo 2. Eroding drainage ditch

Problem Area Data Sheet

Problem Area ID: WR-07	Latitude: 44.40321°	Longitude: -72.99320°

Watershed:	Winooski River
Location:	Railroad Tracks
Problem Type:	Water Quality, Erosion, and Damaged Infrastructure
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	3
Base P Load:	70.8 lbs/yr
Soil Type	A / D
Feasible BMPs	Gravel Wetland
Max. P Reduction	43.19 lbs/yr

Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

Stormwater from an approximately 122-acre drainage area is conveyed via a closed drainage system and overland flow to a ditch south of the railroad tracks. The ditch, which is actively eroding and filling with sediment, carries stormwater to a natural pond that then drains to the Winooski River. Sufficient area likely exists for construction of end-of-pipe retrofit practices, including pre-treatment gravel wetlands, in at least two separate locations. Both the culvert that carries water beneath the railroad tracks, and the box culvert that carries water beneath the private drive are badly damaged and in need of replacement. Planned waterline replacement on Main Street and replacement of the drainage network between Main Street and the railroad tracks may represent a strategic opportunity to "bundle" needed improvements that benefit this larger drainage area.

Field Photos

Photo 1. Eroding drainage ditch and sediment transport

Photo 2. Corroded and undersized culvert

Problem Area Data Sheet

Problem Area ID: WR-08	Latitude: 44.40653°	Longitude: -72.99310°

Watershed:	Winooski River
Location:	Our Lady of the Holy Rosary Church
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	6
Base P Load:	1.51 lbs/yr
Soil Type	A / D
Feasible BMPs	Bioretention, Infiltration Trench
Max. P Reduction	1.15 lbs/yr

Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

Stormwater from the church roof and parking lot flows overland to the northwest, where existing green space could be utilized for stormwater capture and treatment. Opportunity to disconnect runoff from closed drainage system that outfalls at WR-07 project location.

Field Photos

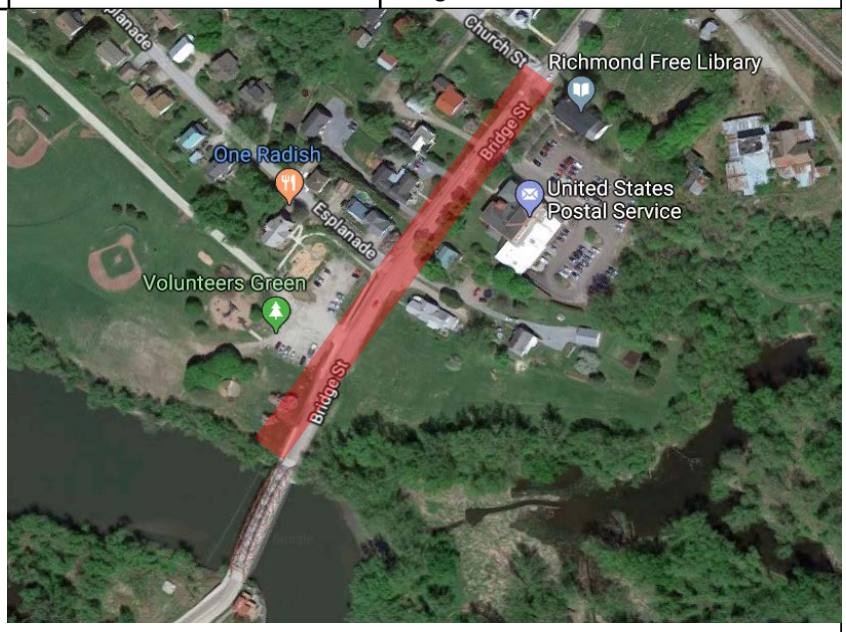
Photo 1. Parking lot and roof currently draining to green space

Photo 2. Existing green space and catch basin

Problem Area Data Sheet

Problem Area ID: WR-09	Latitude: 44.40259°	Longitude: -72.99585°

Watershed:	Winooski River
Location:	Bridge Street Sidewalk
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments
Ownership:	Town of Richmond
Classification:	6
Base P Load:	1.79
Soil Type	A / D
Feasible BMPs	Bioretention, Tree Trench
Max. P Reduction	1.36



Date of Field Data Collection: October 5, 2017, May 30, 2018

Description of Observed Conditions:

There is an opportunity to incorporate BMP installation with the planned sidewalk replacement project on Bridge Street. BMPs may include traffic calming bump-outs with rain gardens, tree wells, and/or underground infiltration beneath the new sidewalk.

Field Photos

Photo 1. Bridge St. looking southwest towards the Town Offices.

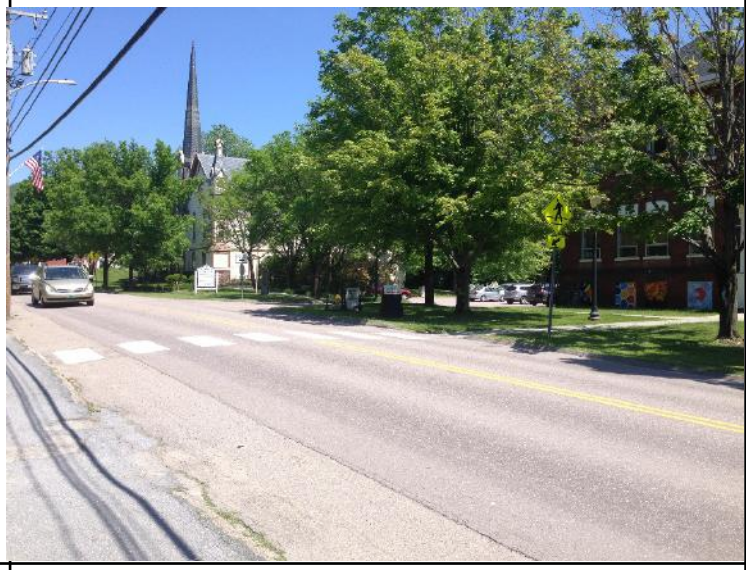
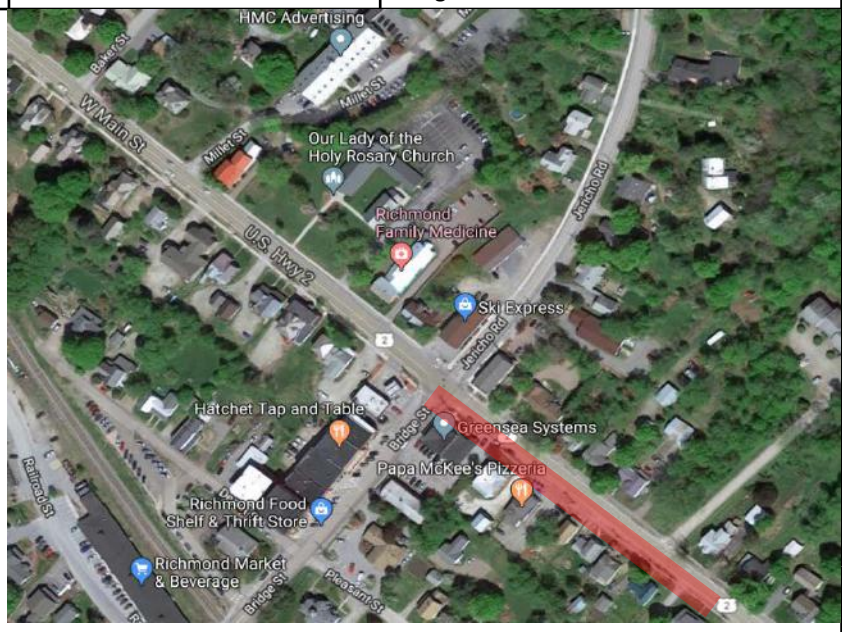


Photo 2. Crosswalk in front of the Town Offices – possible traffic calming bump-out location

Problem Area Data Sheet

Problem Area ID: WR-10	Latitude: 44.40469°	Longitude: -72.99211°

Watershed:	Winooski River
Location:	Main Street Water Line Replacement
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	6
Base P Load:	2.86
Soil Type	A / D
Feasible BMPs	Bioretention
Max. P Reduction	2.17



Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

There is an opportunity to incorporate BMP installation with the planned water line replacement project on Main Street. If soils are deemed infiltrative, reduce the paved width and/or remove one sidewalk and install bioswales along the southern edge of the roadway where space allows. If infiltration is not possible, consider installing grass swales to provide filtration before the stormwater enters the closed drainage network. The same treatment may be applied to the northern edge of the roadway to create additional capacity.

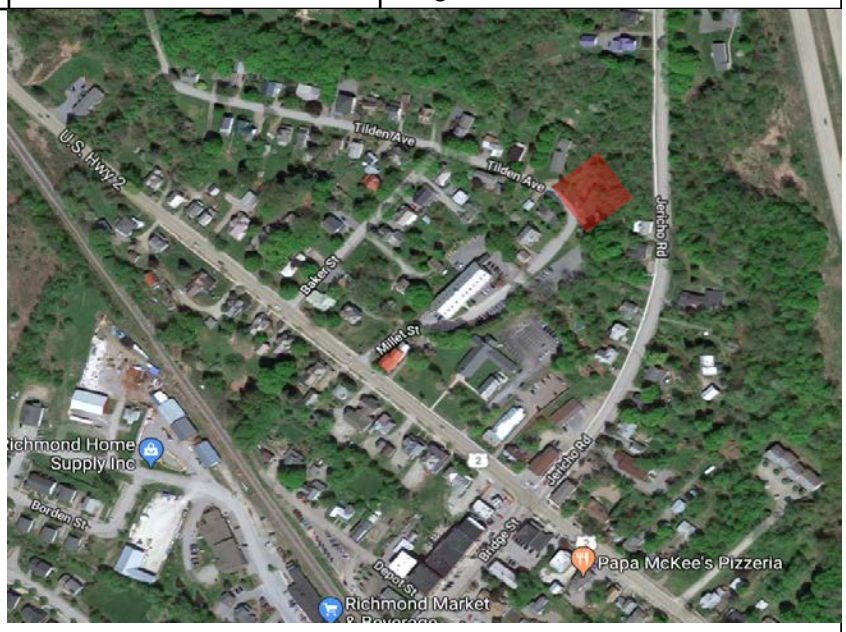
Field Photos

Photo 1. Main Street looking west depicting deteriorating green strips and sidewalks that could be used for stormwater treatment.

Problem Area Data Sheet

Problem Area ID: WR-11	Latitude: 44.40736°	Longitude: -72.99245°

Watershed:	Winooski River
Location:	Millet Street
Problem Type:	Water Quality, Infrastructure Protection
Identification Source:	SWMP Field Assessments
Ownership:	Private
Classification:	6
Base P Load:	18.05 lbs/yr
Soil Type	A / D
Feasible BMPs	Infiltration, Bioretention
Max. P Reduction	13.72 lbs/yr



Date of Field Data Collection: October 5, 2017

Description of Observed Conditions:

At this location, runoff from an approximately 39-acre drainage area enters the closed drainage system that outlets southwest of Richmond Rescue. Installing a water quality treatment practice, ideally one that can infiltrate some portion of the runoff reaching this location, would reduce the volume and improve quality of runoff currently causing damage at WR-07.

Field Photos

Photo 1. Corner of Millet Street and Tilden Avenue where stormwater enters the closed drainage system

Photo 2. Typical bioretention basin

Problem Area Data Sheet

Problem Area ID: WR-12	Latitude: 44.41257°	Longitude: -72.99240°

Watershed:	Winooski River
Location:	School Campus Entrance Road
Problem Type:	Water Quality, Erosion
Identification Source:	SWMP Field Assessments, School Meetings
Ownership:	USD 17
Classification:	4
Base P Load:	1.81 lbs/yr
Soil Type	A
Feasible BMPs	pervious asphalt or grass pavers with infiltration volume beneath
Max. P Reduction	1.36 lbs/yr

Date of Field Data Collection: October 17, 2017, May 30, 2018

Description of Observed Conditions:

Along the north side of the existing campus entrance is a non-paved and unvegetated drainage swale. The swale and a portion of its contributing area is actively used for parking, which exacerbates the movement of material The informal parking area could be stabilized with a porous pavement or grass paver system, with a small gravel reservoir for infiltration and filtering beneath.

Photos

Photo 1. Existing gravel parking area; drainage swale is at left.

Problem Area Data Sheet

Problem Area ID: WR-13	Latitude: 44.41288°	Longitude: -72.99240°

Watershed:	Winooski River
Location:	School Campus Parking Island
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments, School Meetings
Ownership:	USD 17
Classification:	6
Base P Load:	0.34 lbs/yr
Soil Type	C/D
Feasible BMPs	Bioretention with overflow to existing drainage system.
Max. P Reduction	0.26 lbs/yr

Date of Field Data Collection: October 17, 2017, May 30, 2018

Description of Observed Conditions:

Convert an existing raised parking island to accept runoff, creating a bioretention area. The existing drainage lines can be used to provide overflow conveyance for the new BMP.

Photo 1. Existing raised parking island, facing northeast.

Photo 2. Potential overflow location at existing catch basin.

Problem Area Data Sheet

Problem Area ID: WR-14	Latitude: 44.41422°	Longitude: -72.99440°

Watershed:	Winooski River
Location:	School Campus Northwest Ravine
Problem Type:	Water Quality, Erosion, Property Damage
Identification Source:	SWMP Field Assessments, School Meetings
Ownership:	USD 17
Classification:	5
Base P Load:	9.5 lbs/yr
Soil Type	C/D
Feasible BMPs	Stabilize gully and culvert outlet, provide scour protection.
Max. P Reduction	TBD lbs/yr

Date of Field Data Collection: October 17, 2017, May 30, 2018

Description of Observed Conditions:

The existing outlet from the open drainage system carrying runoff from School Street, a portion of the parking lots, and the bus and overflow parking area has failed, and there is an actively eroding gully from the system outlet leading down the slope to the west. Repair the outlet structure, and stabilize the gully. Also consider opportunities to retrofit the existing grass swale that runs southeast to northwest along School St. to slow, treat, and potentially soak in a small portion of the runoff.

Photo 1. Gully wall as viewed from the south edge of the highlighted area above.

Photo 2. Same gully wall as Photo 1, showing recent erosion and a large tree toppled into the gully with leaves still green.

Problem Area Data Sheet

Problem Area ID: WR-15	Latitude: 44.41267°	Longitude: -72.99511°

Watershed:	Winooski River
Location:	School Campus Athletic Fields
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments, School Meetings
Ownership:	USD 17
Classification:	6
Base P Load:	8.51 lbs/yr
Soil Type	C/D
Feasible BMPs	Wet Pond/Created Wetland
Max. P Reduction	4.43 lbs/yr

Date of Field Data Collection: October 17, 2017, May 30, 2018

Description of Observed Conditions:

A wet pond, gravel wetland, or constructed emergent wetland could be constructed adjacent to the athletic fields to provide storage and treatment for runoff from upstream areas, including the main parking lot and roof drainage. The existing drainage system can be used to connect the BMP, particularly for the main parking lot and portions of the rooftop drainage systems. Proximity of the treatment practice to the school buildings may improve opportunities for demonstration and education in connection with design, construction, and operation.

Photo 1. Proposed BMP area, looking northwest.

Photo 2. Proposed BMP area, looking northeast.

Problem Area Data Sheet

Problem Area ID: WR-16	Latitude: 44.41241°	Longitude: -72.99339°

Watershed:	Winooski River
Location:	School Campus Elementary School
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments, School Meetings
Ownership:	USD 17
Classification:	6
Base P Load:	1.04 lbs/yr
Soil Type	A
Feasible BMPs	Infiltration trench along roof drip line
Max. P Reduction	1.03 lbs/yr

Date of Field Data Collection: October 17, 2017

Description of Observed Conditions:

The rooftop on the northeast side of the elementary school could be effectively disconnected into an infiltration trench along the roof's drip edge.

Photo 1. Proposed rooftop disconnection area, also showing existing gutter and drain system for roof fumoff.

Problem Area Data Sheet

Problem Area ID: WR-17	Latitude: 44.41241°	Longitude: -72.99289°

Watershed:	Winooski River
Location:	School Campus Elementary School
Problem Type:	Water Quality
Identification Source:	SWMP Field Assessments, School Meetings
Ownership:	USD 17
Classification:	6
Base P Load:	1.97 lbs/yr
Soil Type	A
Feasible BMPs	Gravel wetland
Max. P Reduction	1.20 lbs/yr

Date of Field Data Collection: October 17, 2017

Description of Observed Conditions:

Provide water quality treatment, and some peak storm flow reduction, prior to discharging into the existing gully to the south of the school property. Depending on soil infiltration capacity, either a bioretention or gravel wetland area may be suitable. Roof drainage from the elementary school could be directed to this BMP instead of to disconnection, as proposed in WR-16.

Photo 1. Paved play area and equipment, southwest of proposed BMP.

Photo 2. Proposed BMP area.

Problem Area Data Sheet

Problem Area ID: WR-18	Latitude:	Longitude:

Watershed:	Winooski River
Location:	I-89 NB ROW, E2 Drainage Area, Interstate and Median
Problem Type:	Water Quality, Erosion
Identification Source:	SWMP Field Assessments
Ownership:	Vermont Agency of Transportation
Classification:	6
Base P Load:	7.72 lb/year
Soil Type	B
Feasible BMPs	Gravel wetland
Max. P Reduction	4.71 lb/year

Date of Field Data Collection: May 30, 2018

Description of Observed Conditions:

Strategic retrofit to treat runoff from I-89 NB and SB, and a limited amount of VTrans-owned pervious surface associated with I-89. The proposed BMP treats and detains runoff that discharges northeast across I-89 north of the school property. Though this portion of I-89 is adjacent to the school property, this runoff is not contributing to the erosion issue at WR-14.

Photo 1. Proposed BMP area as viewed from I-89 NB. (Area was not safe to access during May 2018 site visit, image is from Google Earth, fall 2015).

Problem Area Data Sheet

Problem Area ID: WR-19		Latitude:	Longitude:
Watershed:	Winooski River		
Location:	I-89 ROW, D5 Drainage Area, Interstate and Median		
Problem Type:	Water Quality, Erosion, Property Damage		
Identification Source:	SWMP Field Assessments, School Meetings		
Ownership:	Vermont Agency of Transportation		
Classification:	4		
Base P Load:	2.16 lb./year		
Soil Type	B		
Feasible BMPs	Gravel Wetland, potentially infiltration		
Max. P Reduction	1.32 lb./year		

Date of Field Data Collection: May 30, 2018

Description of Observed Conditions:

Runoff from the D5 drainage area travels through an 18" concrete culvert beneath the I-89 SB lanes and discharges, via overland flow, onto USD 17 property in the D3 drainage, where it causes gully erosion before reaching the existing swale along the northeast edge of the school's access road and parking area, and ultimately reaching the gully at the north end of the school campus (see sheets WR-22 and WR-14).There are two opportunities to improve water quality and reduce peak flows: one within the median prior to the culvert inlet (not pictured below), and one within the SB right-of-way upslope of the school property.

Photo 1. Gully erosion downslope of culvert outlet, leaving I-89 ROW and entering USD 17 property. Note exposed concrete fence footer and chloride-damaged vegetation.

Photo 2. Potential treatment area within the VTrans ROW downslope of culvert outlet. Note erosion in the foreground, which joins gullying from culvert outlet and reaches USD 17 property.

Problem Area Data Sheet

Problem Area ID: WR-20		Latitude:	Longitude:
Watershed:	Winooski River		
Location:	I-89 ROW F3 Drainage Area, Upslope of Interstate		
Problem Type:	Water Quality, Potential Erosion		
Identification Source:	SWMP Field Assessments		
Ownership:	Vermont Agency of Transportation		
Classification:	3		
Base P Load:	10.02 lbs./year		
Soil Type	D		
Feasible BMPs	Gravel Wetland		
Max. P Reduction	6.11 lbs./year		

Date of Field Data Collection: May 30, 2018

Description of Observed Conditions:

Strategic retrofit to treat runoff from upland areas draining to the VTrans right-of-way, and a limited amount of VTrans-owned impervious surface associated with I-89. The area draining to this proposed BMP location is substantial (about 37 acres) but the watershed contains very little impervious surface (~1 acre). The proposed BMP would treat runoff that discharges across I-89 south of the school property, not associated with the erosion issue at WR-14. Historic erosion issues in the drainage channels south of the school campus appeared stable during the May 2018 field visit.

Photo 1. Proposed BMP area, looking south.

Photo 2. Existing inlet structure for the culverts passing beneath I-89.

Problem Area Data Sheet

Problem Area ID: WR-21	Latitude:	Longitude:

Watershed:	Winooski River
Location:	I-89 ROW, F2 Drainage Area, Upslope of Interstate
Problem Type:	3
Identification Source:	SWMP Field Assessments
Ownership:	Vermont Agency of Transportation
Classification:	3
Base P Load:	2.94 lb./year
Soil Type	D
Feasible BMPs	Gravel Wetland
Max. P Reduction	1.79 lb./year

Date of Field Data Collection: May 30, 2018

Description of Observed Conditions:

Strategic retrofit to treat runoff from upland areas draining to the VTrans right-of-way, and VTrans-owned impervious surface associated with I-89 NB. The proposed BMP would treat runoff that discharges across I-89 south of the school property, not associated with the erosion issue at WR-14. Historic erosion issues in the drainage channels south of the school campus appeared stable during the May 2018 field visit.

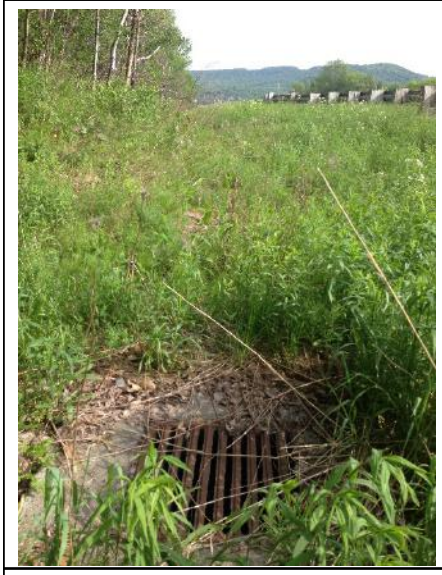


Photo 1. Potential BMP area, looking south.

Photo 2. Culvert inlet intercepting intermittent stream flow and upland runoff from the F2 drainage and conveying it beneath I-89.

Problem Area Data Sheet

Problem Area ID: WR-22	Latitude:	Longitude:

Watershed:	Winooski River
Location:	I-89 ROW, D5 drainage, and School Campus parking and access drive
Problem Type:	Water Quality, Erosion, Property Damage
Identification Source:	SWMP Field Assessments, School Meetings
Ownership:	USD 17
Classification:	4
Base P Load:	2.32 lb./year
Soil Type	C/D
Feasible BMPs	Gravel Wetland, Bioswale
Max. P Reduction	1.79 lb./year

Date of Field Data Collection: May 30, 2018

Description of Observed Conditions:

Runoff from the D5 drainage area (WR-19) discharges, onto USD 17 property in the D3 drainage, runs into the existing swale along the northeast edge of the school's access road and parking area, and ultimately reaches the gully at the north end of the school campus (WR-14). There is an opportunity to retrofit this swale improve water quality and reduce peak flows. A portion of the School parking lot and access drive draining to this swale is covered under operational stormwater permit 6615-9010; water quality treatment provided for 16,096 SF / 0.37 acres of impervious. It does not appear that the swale was sized to provide water quality treatment or safe conveyance for VTrans run-on. The existing swale is filled with sediment and cattails and is minimally maintained.

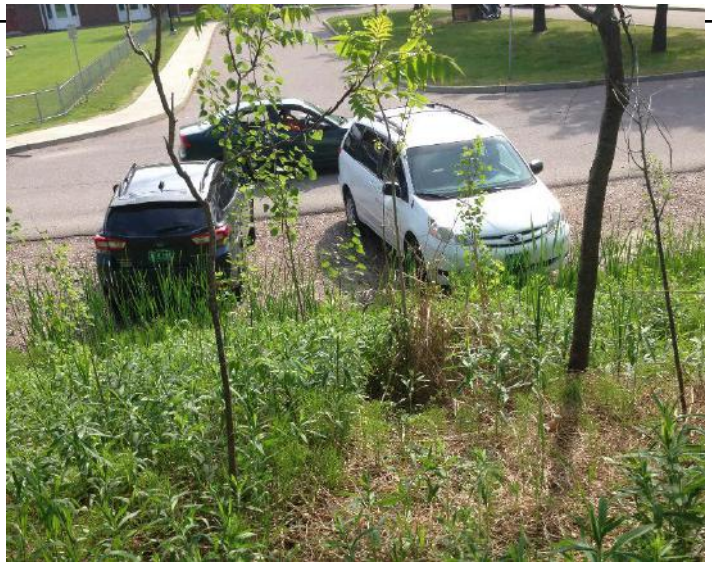


Photo 1. Up-slope end of the proposed BMP, where VTrans runoff enters the D3 drainage. Note chloride-damaged vegetation in foreground.

Photo 2. Proposed BMP location viewed from near the northeast corner of the middle school, looking southeast along the access drive.

Appendix D. WNRCD Project and Program Summary

Winooski Natural Resources Conservation District
"Connecting people to a sustainable landscape"
www.winooskinrcd.org

Memo

To: Dan Albrecht, Chittenden County Regional Planning Commission (CCRPC)
From: Holly Kreiner, Winooski Natural Resources Conservation District (WNRCD)
Re: Richmond SWMP, Summary and Preliminary Scope of Identified Projects and Programs
Date: April 24, 2018

The Winooski Natural Resources Conservation District (WNRCD) conducted twelve stormwater technical site visits and assessments between November 2017 - April 2018. WNRCD identified eight stormwater project opportunities and one program opportunity in Richmond, VT. A summary and preliminary scope of these projects and programs are listed below:

1. **Project:** Waterbars or culvert replacement along lower drive at 82 Bates Farm Road

   Identified concern: The ditch running alongside the driveway of 82 Bates Farm Road has filled in with sediment and conveys stormwater to failing culvert underneath drive that daylights to steep ravine and small, perennial tributary (REACH CODE: 02010003002577). This undermined culvert is causing significant bank erosion and shows signs of impending mass failure that will inevitably cut into driveway. A large fan of sediment extends down to this bank and to mapped tributary of Huntington River. The stormwater is sourced from the house roof, parking area, yard, from lower half of driveway.

   Proposed approach 1: **Infiltration water bars** - The two soil types present in the identified runoff area are Colton gravelly loamy sand and Colton and Stetson soils, both of which are designated as "excessively drained." We propose the drive be regraded, culvert inlet be filled, and several water bars be installed that are directed towards opposite bank (away from decommissioned ditch) to capture and infiltrate stormwater.

   ERP designation: SIMPLE - Requires minimal feasibility analysis and design; One round of ERP funding.

   Proposed approach 2: **Culvert replacement and ditch reconstruction** - If degree of bank erosion is significant enough that stabilization should be considered, an alternative option is to replace failing culvert and re-construct ditch so that this infrastructure is again functional.

   ERP designation: INTERMEDIATE - Feasibility analysis to 30% design - Two rounds of ERP funding.

2. **Project:** Rain garden at 82 Bates Farm Road

   Identified concern: In order to alleviate some of the stormwater volume conveyed to non-functioning ditch, homeowners re-directed downspout from garage to flow towards upper portion of drive and to grassed area that is conveyed to small tributary above house. Rill erosion has formed and further erosion will likely continue.

   Proposed approach: **Rain garden -** In order to address runoff from the house roof and portion parking area, we propose a rain garden be installed in grassed area immediately east of the house. Several downspouts currently discharge water to lawn and are undermining a bankwall along the garage. These downspouts should be connected and conveyed to rain garden. The area of rain garden should be sized to accommodate stormwater from garage roof, southern side of house (north portion goes to opposite side of lawn) and a portion of parking area adjacent to house.

   ERP designation: SIMPLE - Requires minimal feasibility analysis and design; One round of ERP funding.

3. **Project:** Infiltration waterbars along upper drive at 82 Bates Farm Road

   Identified concern: A secondary culvert under driveway was stabilized by old railroad ties and these are becoming undermined by high stormwater volume and pose a threat of culvert and bank failure. Stormwater is sourced from upper portion of drive, barn parking area, and barn roof (runoff from house garage also directed here, but is addressed by rain garden installation above).

   Proposed Approach: **Infiltration water bars -** The two soil types present in the identified runoff area are Colton gravelly loamy sand and Colton and Stetson soils, both of which are designated as "excessively drained." We propose the drive be regraded and several water bars be installed to capture and infiltrate water. These waterbars will divert stormwater away from railroad tie and allow groundwater to slowly discharge into grassed area along barn parking area and drive.

   ERP designation: SIMPLE - Requires minimal feasibility analysis and design; One round of ERP funding.

4. **Project:** Stone lined ditch along East Hill Road above 87 and 95 Deer Creek Lane

   Identified concern: There is significant erosion and bank failure below the culvert that discharges stormwater from East Hill Road onto these properties. Erosion control below the culvert has been inadequate, resulting in the undercutting and wash out of the bank near the outflow. Significant sediment deposition has filled in the ditch on 87 Deer Creek Lane and a fan of sediment was observed adjacent to ephemeral stream (REACH CODE: 02010003002225).

   Proposed Approach: **Stone-lined ditch -** The ditch conveying stormwater to this location should be lined with large stone to alleviate the stormwater volume being discharged to these properties.

   ERP designation: INTERMEDIATE - Feasibility analysis to 30% design - Two rounds of ERP funding.

5. **Project:** Downspout disconnection at 138 Rocky Road

   Identified concern: This property runs along Johnnie Brook, which displayed an actively eroding stream bank due to encroachment of adjacent driveway. Gutter runoff from house is currently piped directly to eroding stream bank.

   Proposed Approach: **Gutter Disconnection -** Disconnect gutter from pipe to infiltrate into lawn or be captured by rain barrel.

   ERP designation: SIMPLE - Requires minimal feasibility analysis and design; ERP funding not needed (project not listed in attached table for Winooski Tactical Basin Plan).

6. **Project:** Rain barrel at 31 Railroad Street

   Identified concern: Stormwater from Railroad Street does not adequately shed water to surrounding catch basins or infiltration areas, and as such water currently pools in front of 31 Railroad Street.

   Proposed Approach: **Rain barrel** - A portion of roof runoff is conveyed by a gutter directly to saturated lawn area. We propose a rain barrel be installed to alleviate some for the stormwater pooling at this site.

   ERP designation: SIMPLE - Requires minimal feasibility analysis and design; ERP funding not needed (project not listed in attached table for Winooski Tactical Basin Plan).

7. **Project:** Rain garden at 1 Esplande Road

   Identified concern: Stormwater from One Radish Eatery pools at various locations on the property due to a lack of stormwater infrastructure. The absence of roof gutters result in stormwater pooling in the low, grassed area in front of the building and parking lot. Flow paths and sediment deposition were observed nearby to Main Street that appear to be sourced from this property.

   Proposed Approach: **Rain garden -** To alleviate some of the stormwater conveyed to Main Street from this property, we propose a rain garden be installed in front of One Radish Eatery. This rain garden should be sized to accommodate stormwater from the eastern portion of the building's roof and sidewalks on this property.

   ERP designation: SIMPLE - Requires minimal feasibility analysis and design; One round of ERP funding.

8. **Project:** Rain garden between 1 Esplande Road and Main Street

   Identified concern: Flow paths and sediment deposition were observed in the grassed area between One Radish Eatery parking lot and Main Street. This stormwater appears to be sourced from One Radish Eatery property, Esplande Road, and excess stormwater from Main Street not captured by catch basin above this site.

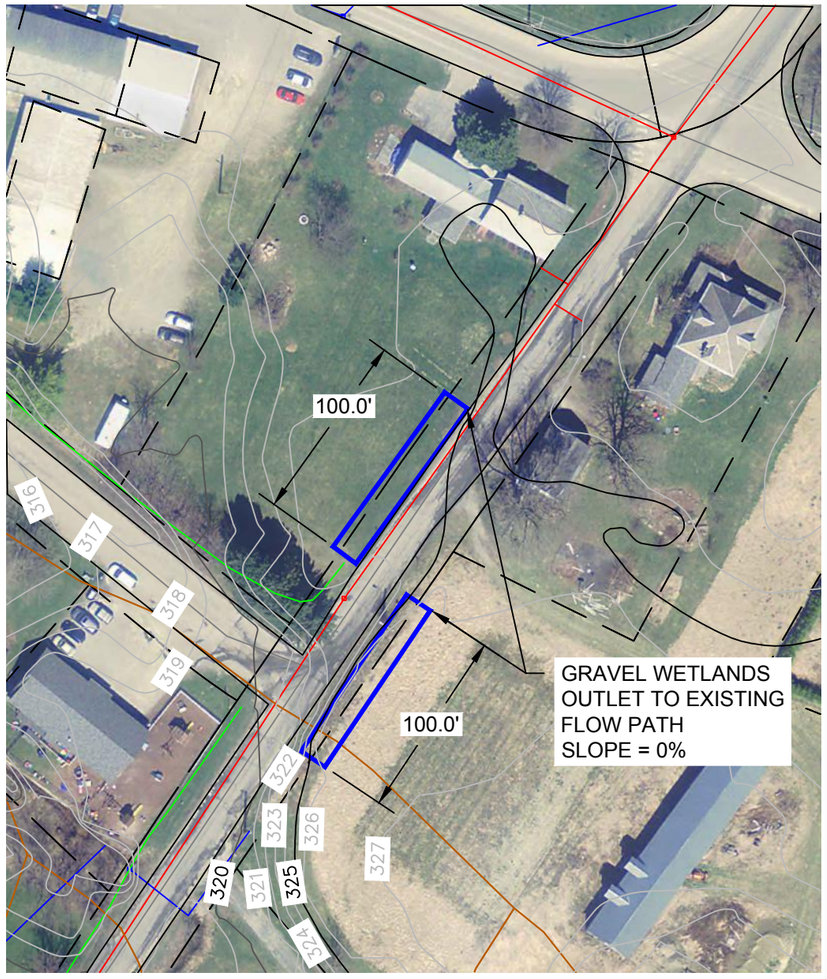
   Proposed Approach: **Rain garden -** We propose a rain garden be installed in this grassed area to infiltrate some of the stormwater being captured by nearby catch basins. This large rain garden would be sized to accommodate all the sources listed above.

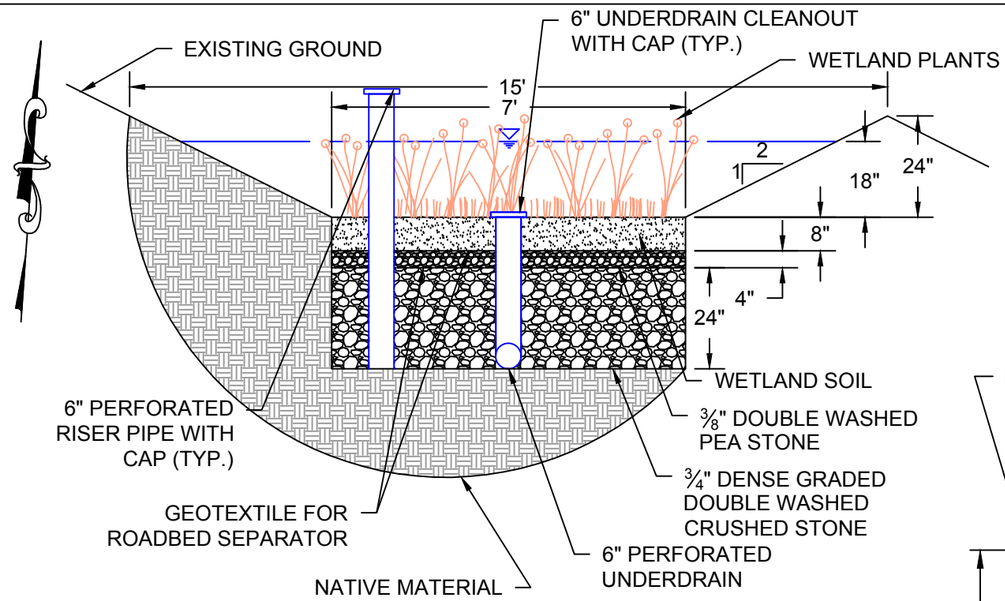
   ERP designation: INTERMEDIATE - Feasibility analysis to 30% design - Two rounds of ERP funding.

9. **Program:** Rain garden adoption of Main St. and/or One Radish Eatery rain garden

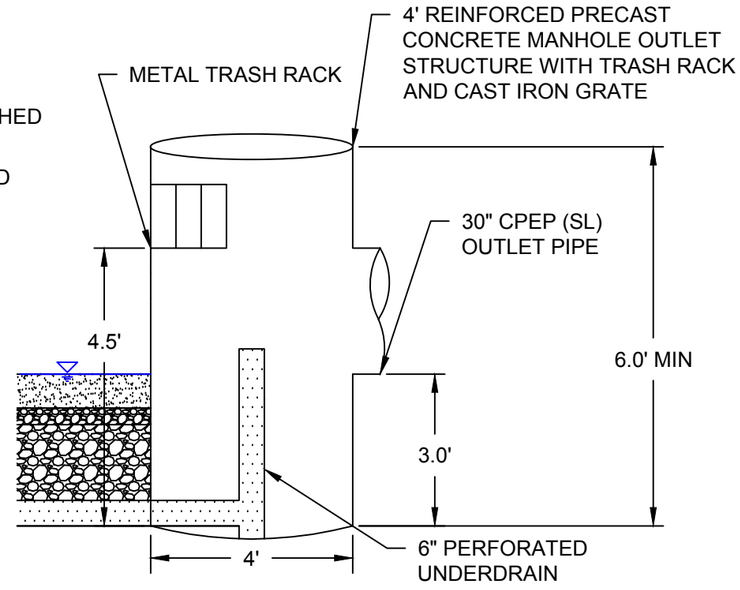
   We propose the adoption of a community program to care for the rain gardens installed at One Radish Eatery or the rain garden project identified by Stone Environmental at this location. WNRCD will provide Richmond Conservation Commission with resources and materials from the Rethink Runoff Adopt-A-Rain Garden program so they are equipped to initiate this program if interested.

Appendix E. Concept Designs for Priority Stormwater Problem Areas





GRAVEL WETLAND DETAIL (CROSS SECTION)
NOT TO SCALE



GRAVEL WETLAND OUTLET STRUCTURE DETAIL
NOT TO SCALE

LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING STORMWATER SYSTEM*
- *EXISTING DITCH*
- *EXISTING SANITARY SEWER LINE*
- *PROPOSED GRAVEL WETLAND FOOTPRINT*
- *EXISTING SANITARY MANHOLE*

NOTES

1. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
2. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
3. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
4. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
5. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
6. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED ARES.
7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. GRAVEL WETLAND AREA SIDE SLOPES SHALL NOT EXCEED 2:1 UNLESS OTHERWISE NOTED.
10. NATIVE SUB-SOIL SHALL REMAIN UNCOMPACTED. EXCAVATORS OR BACKHOES SHALL WORK FROM THE SIDES TO EXCAVATE, SHAPE, AND FILL THE GRAVEL WETLAND. EXCAVATING EQUIPMENT MUST HAVE BOOMS WITH ADEQUATE REACH SO THEY DO NOT HAVE TO SIT INSIDE THE FOOTPRINT OF THE GRAVEL WETLAND.
11. INSTALL CLEANOUTS AND OBSERVATION/INLET RISER EVERY 50'.
12. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
13. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
14. PLANTING OF THE GRAVEL WETLAND SHALL BE COMPLETED USING WETLAND VEGETATION.
15. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
16. EXISTING CONTOURS REPRESENT LIDAR PROVIDED BY THE STATE OF VERMONT.

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DRAWING CREDITS
Drawn On: 06/12/2018
Drawn By: BAM
Checked On: 06/13/2018
Checked By: ANM
Project No.: 17-061-A

REVISIONS

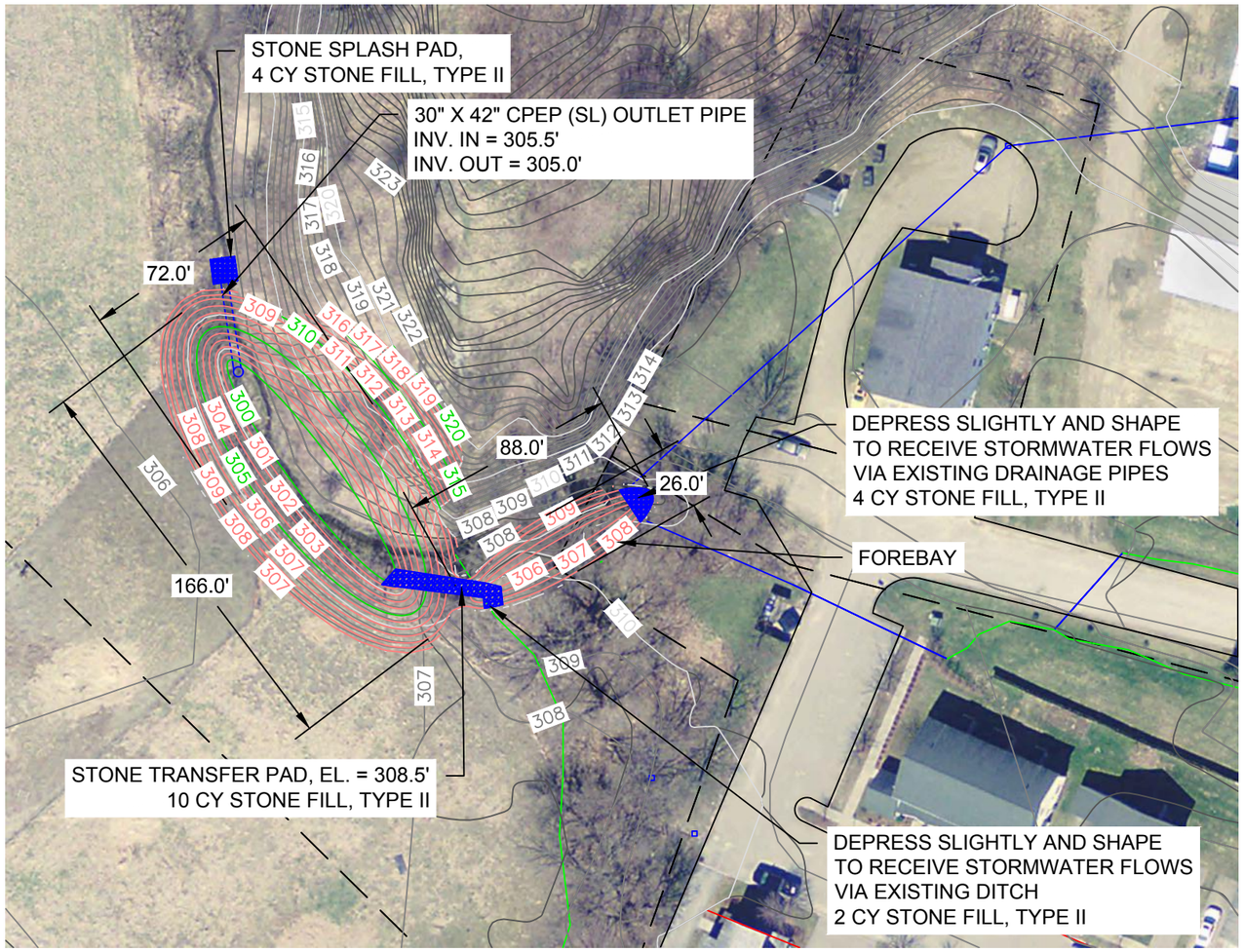
#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE
0 80 160 Feet
1 INCH = 80 FEET

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

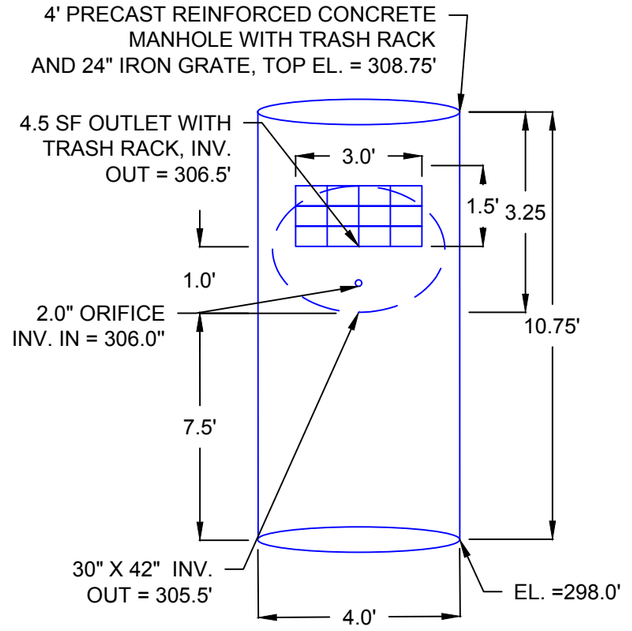
RICHMOND STORMWATER MASTER PLAN
WR-01
THOMPSON ROAD GRAVEL WETLANDS
RICHMOND VERMONT

FIGURE NO. 1



LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PROPOSED MAJOR CONTOUR*
- *PROPOSED MINOR CONTOUR*
- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING STORMWATER SYSTEM*
- *EXISTING SANITARY SEWER SYSTEM*
- *EXISTING DITCH*
- *EXISTING STORMWATER CATCH BASIN*



STORMWATER POND OUTLET STRUCTURE DETAIL
NOT TO SCALE

NOTES

1. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
2. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
3. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
4. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
5. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
6. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED AREAS.
7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. INTERIOR STORMWATER POND SIDE SLOPES SHALL NOT EXCEED 3:1 UNLESS OTHERWISE NOTED, EXTERIOR STORMWATER POND SIDE SLOPES SHALL NOT EXCEED 2:1 UNLESS OTHERWISE NOTED.
10. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
11. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
12. STONE TRANSFER PAD SHALL BE CONSTRUCTED USING A 6" THICK LAYER OF COMPACTED STONE FILL, TYPE II.
13. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
14. EXISTING CONTOURS REPRESENT LIDAR PROVIDED BY THE STATE OF VERMONT.
15. FINAL DESIGN MAY INCORPORATE USE OF A GRAVEL TRENCH OUTLET.

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DRAWING CREDITS
Drawn On: 06/12/2018
Drawn By: BAM
Checked On: 06/13/2018
Checked By: ANM
Project No.: 17-061-A

REVISIONS

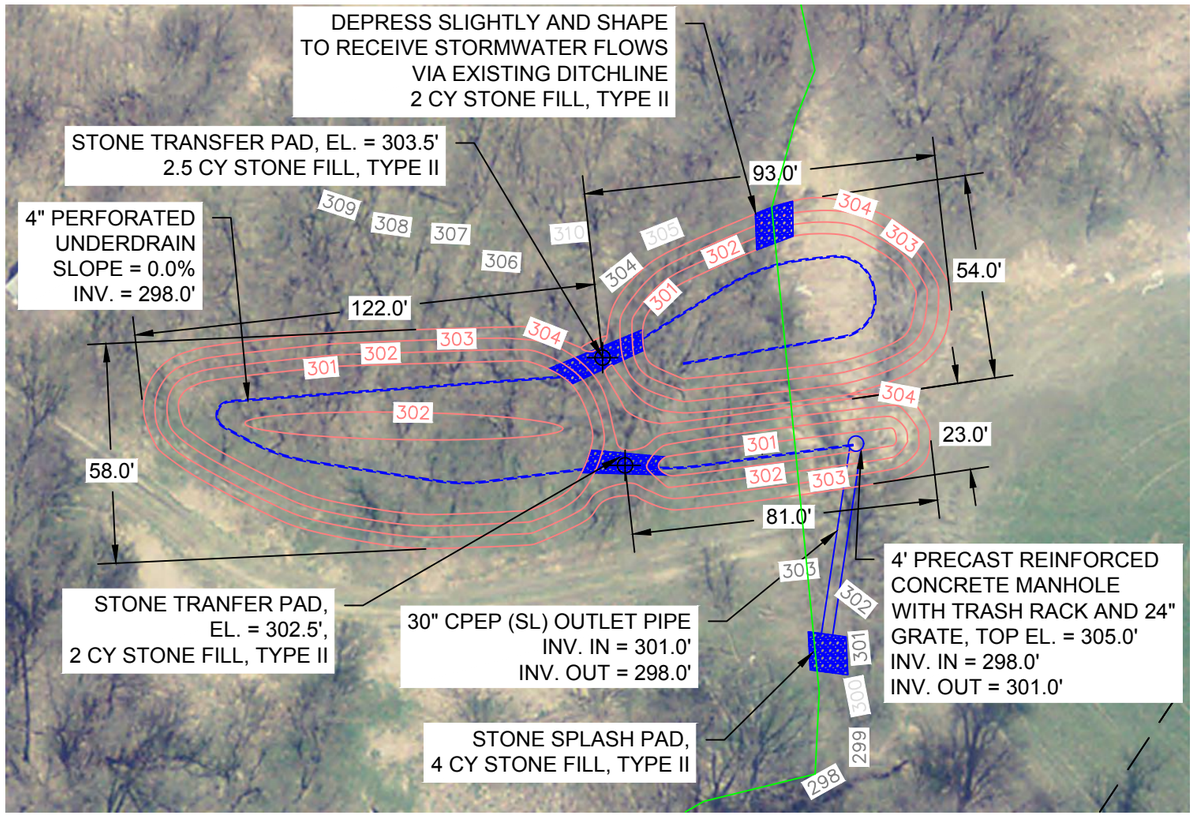
#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE
0 60 120 Feet
1 INCH = 60 FEET

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

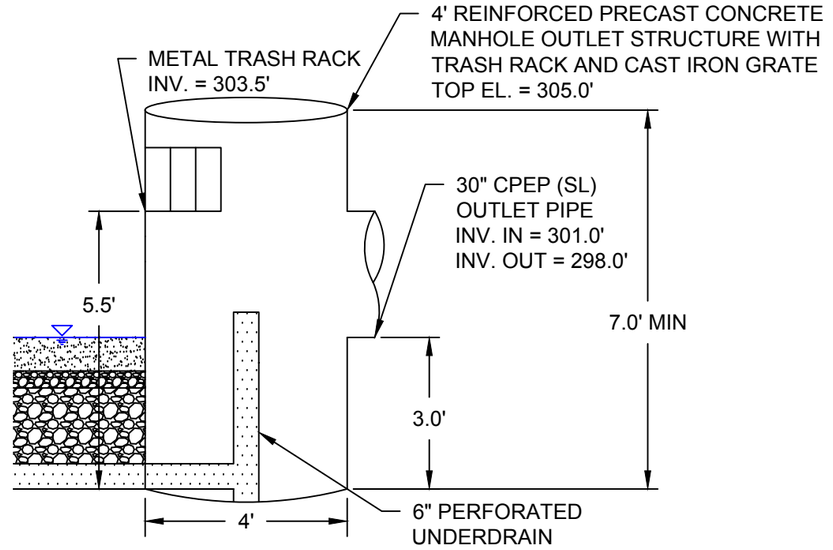
RICHMOND STORMWATER MASTER PLAN
WR-06
RICHMOND RESCUE STORMWATER POND
RICHMOND VERMONT

FIGURE NO. 2

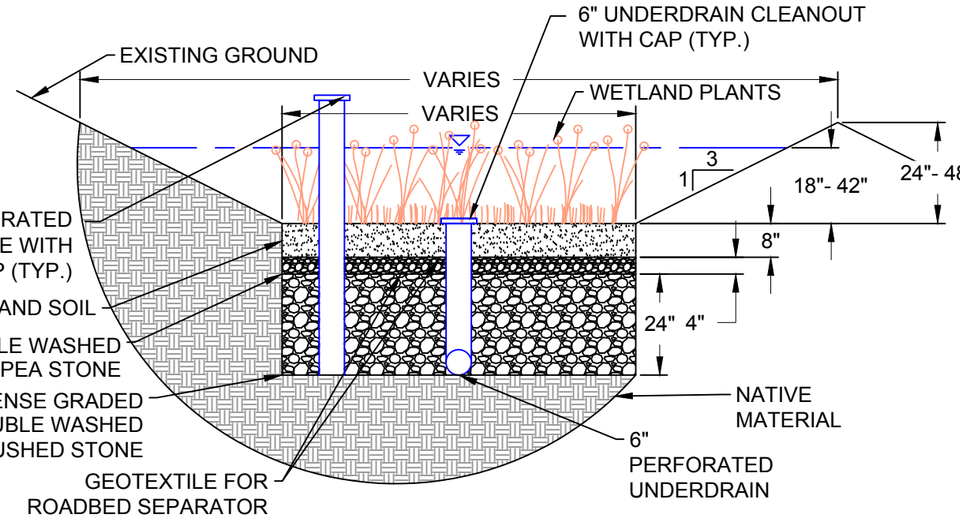


LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PROPOSED MINOR CONTOUR*
- *EXISTING DITCH*
- *30" CPEP (SL) OUTLET PIPE*
- *UNDERDRAIN*



GRAVEL WETLAND OUTLET STRUCTURE DETAIL
NOT TO SCALE



GRAVEL WETLAND DETAIL (NOT TO SCALE)
NOT TO SCALE

NOTES

1. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
2. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
3. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
4. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
5. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
6. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED ARES.
7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. STONE TRANSFER PADS SHALL BE CONSTRUCTED USING A 6" THICK LAYER OF COMPACTED STONE FILL, TYPE II.
10. GRAVEL WETLAND AREA SIDE SLOPES SHALL NOT EXCEED 3:1 UNLESS OTHERWISE NOTED.
11. NATIVE SUB-SOIL SHALL REMAIN UNCOMPACTED AS MUCH AS POSSIBLE. EXCAVATORS OR BACKHOES SHALL WORK FROM THE SIDES TO EXCAVATE, SHAPE, AND FILL THE GRAVEL WETLAND.
12. INSTALL CLEANOUTS AND OBSERVATION/INLET RISER EVERY 50'
13. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
14. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
15. PLANTING OF THE GRAVEL WETLAND SHALL BE COMPLETED USING WETLAND VEGETATION.
16. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
17. EXISTING CONTOURS REPRESENT LIDAR PROVIDED BY THE STATE OF VERMONT.

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Drawn By: BAM
Checked On: 06/13/2018
Checked By: ANM
Project No.: 17-061-A

REVISIONS

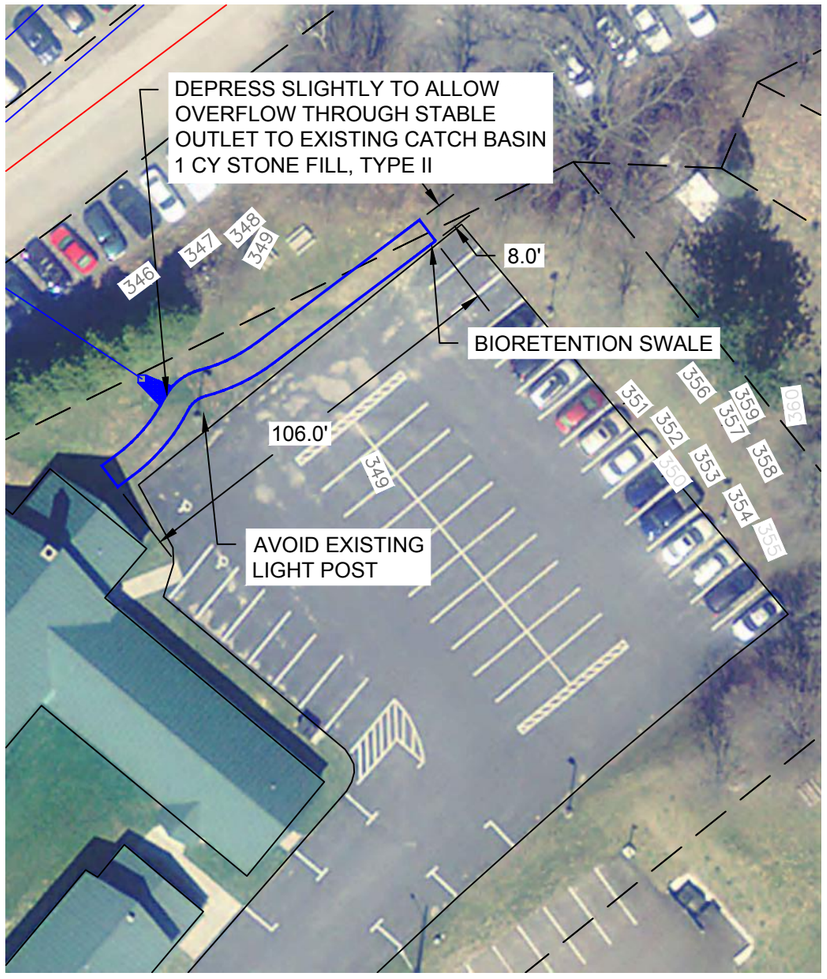
#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE
0 40 80 Feet
1 INCH = 40 FEET

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

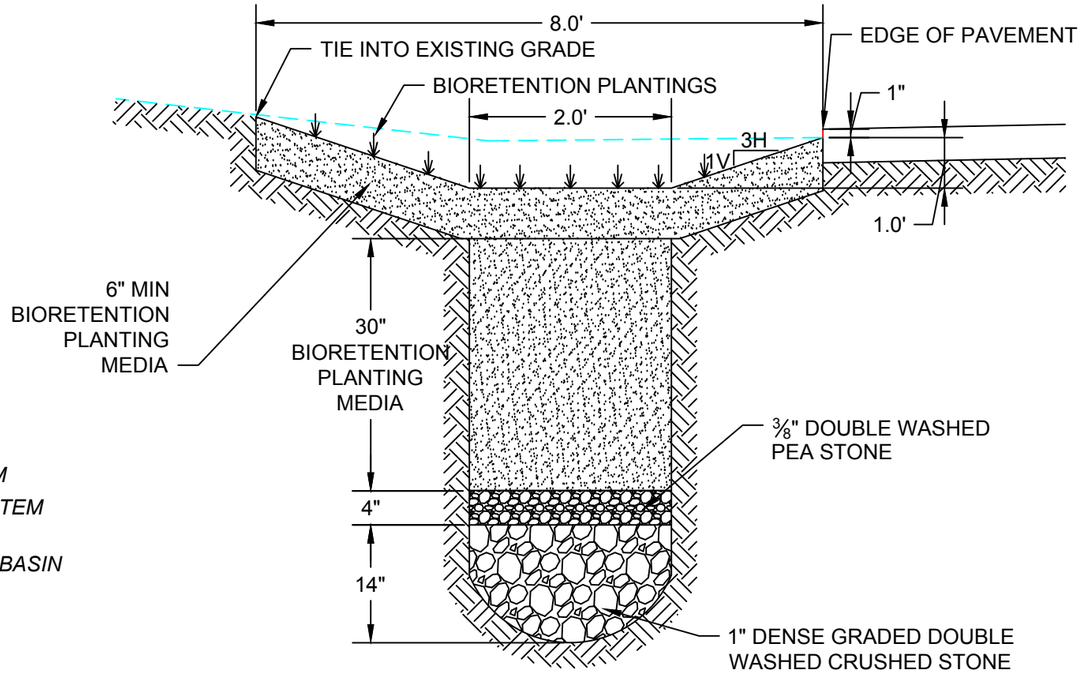
RICHMOND STORMWATER MASTER PLAN
WR-07
RAILROAD TRACKS GRAVEL WETLAND
RICHMOND VERMONT

FIGURE NO. 3



LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING STORMWATER SYSTEM*
- *EXISTING SANITARY SEWER SYSTEM*
- *BIORETENTION SWALE*
- *EXISTING STORMWATER CATCH BASIN*



BIORETENTION SWALE DETAIL
NOT TO SCALE

NOTE:
1. SIDE SLOPES FOR FINISHED GRADE OF SWALE TO TIE INTO EXISTING DRIVEWAYS OR SIDEWALKS SHALL NOT EXCEED 1V:3H.
2. SHOULD UNSUITABLE MATERIALS BE FOUND DURING INSTALLATION OF SWALE, UNDER DRAIN MAY BE ADDED AS DIRECTED BY THE ENGINEER.

NOTES

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2. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
3. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
4. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
5. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
6. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED ARES.
7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. BIORETENTION SWALE SIDE SLOPES SHALL NOT EXCEED 3:1 UNLESS OTHERWISE NOTED.
10. NATIVE SUB-SOIL SHALL REMAIN UNCOMPACTED. EXCAVATORS OR BACKHOES SHALL WORK FROM THE SIDES TO EXCAVATE, SHAPE, AND FILL THE BIORETENTION SWALE. EXCAVATING EQUIPMENT MUST HAVE BOOMS WITH ADEQUATE REACH SO THEY DO NOT HAVE TO SIT INSIDE THE FOOTPRINT OF THE SWALE.
11. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
12. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
13. VEGETATION OF THE BIORETENTION SWALE SHALL BE COMPLETED USING APPROPRIATE PLANTINGS (NATIVE OR NATURALIZED CULTIVARS PREFERRED). SEEDING WITH A CONSERVATION MIX IS AN OPTION IF PREFERRED MAINTENANCE IS MOWING.
14. BIORETENTION SOIL MEDIA SHALL BE COMPACTED BY SATURATING WITH WATER. DO NOT COMPACT MEDIA WITH MACHINERY.
15. BIORETETNION SOIL MEDIA TO BE COMPRISED OF 90% SAND (ASTM C33 FINE) AND 10% TOPSOIL (USDA TEXTURAL CLASSIFICATION OF SANDY LOAM OR LOAMY SAND.
16. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.

File: O:\Proj-17\WRM\17-061-A CCRPC Richmond SWMP\CAD\RICHMOND_CONCEPTS.DGW

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DRAWING SCALE
0 40 80 Feet
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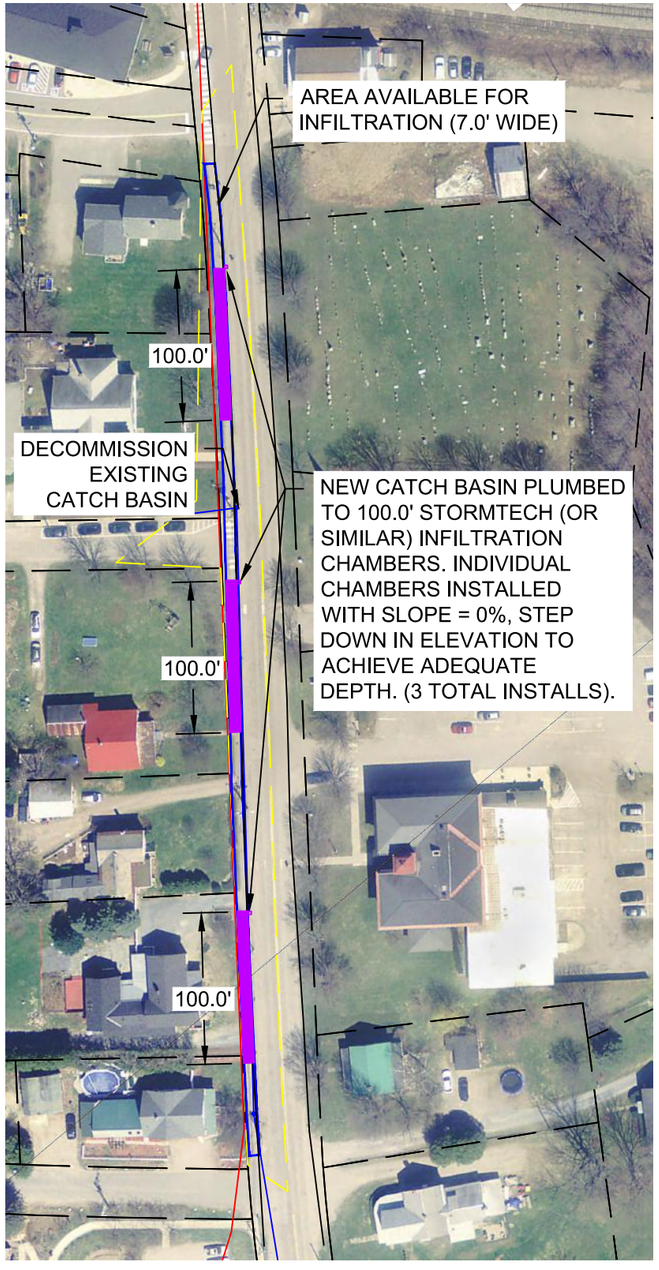
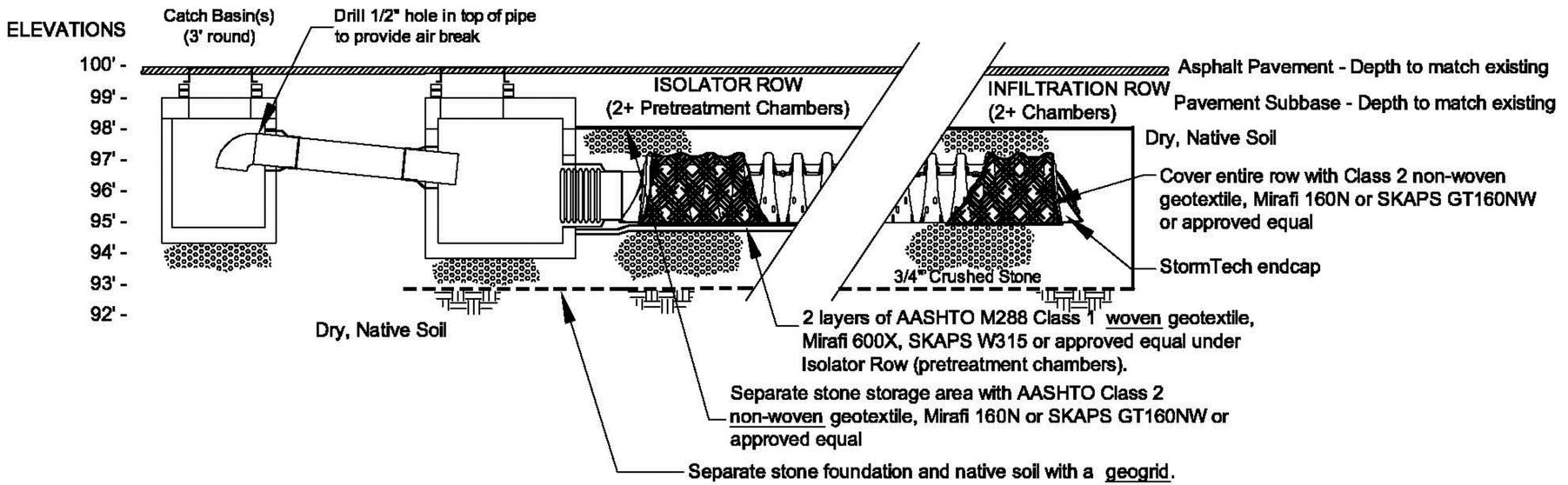
RICHMOND STORMWATER MASTER PLAN
WR-08
OUR LADY OF THE ROSARY CHURCH BIOSWALE
RICHMOND VERMONT

FIGURE NO. 4





STORMTECH INFILTRATION CHAMBERS (TYP.)

NOT TO SCALE

SOURCE: CITY OF BURLINGTON DEPARTMENT OF PUBLIC WORKS

LEGEND

- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING STORMWATER SYSTEM*
- *PROPOSED STORMWATER SYSTEM*
- *DRAINAGE AREA*
- *EXISTING SANITARY SEWER LINE*
- *AVAILABLE TREATMENT FOOTPRINT*
- *PROPOSED INFILTRATION CHAMBERS*
- *EXISTING STORMWATER CATCH BASIN*
- *EXISTING SANITARY MANHOLE*
- *PROPOSED DEEP-SUMP STORMWATER CATCH BASIN*

NOTES

1. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
2. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
3. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
4. ADDITIONAL INVESTIGATION OF POTENTIAL UTILITY CONFLICTS WILL FURTHER DEFINE FEASIBILITY.
5. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
6. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
10. INFILTRATION BENEATH SIDEWALK OR ROADWAY ARE BOTH OPTIONS AND MAY BE FURTHER INVESTIGATED WITH RESPECT TO UTILITY CONFLICTS.
11. STORMTECH INFILTRATION CHAMBERS SHALL UTILIZE AN OVERFLOW TO CLOSED STORMWATER INFRASTRUCTURE.

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DRAWING SCALE

0 100 200 Feet

1 INCH = 100 FEET

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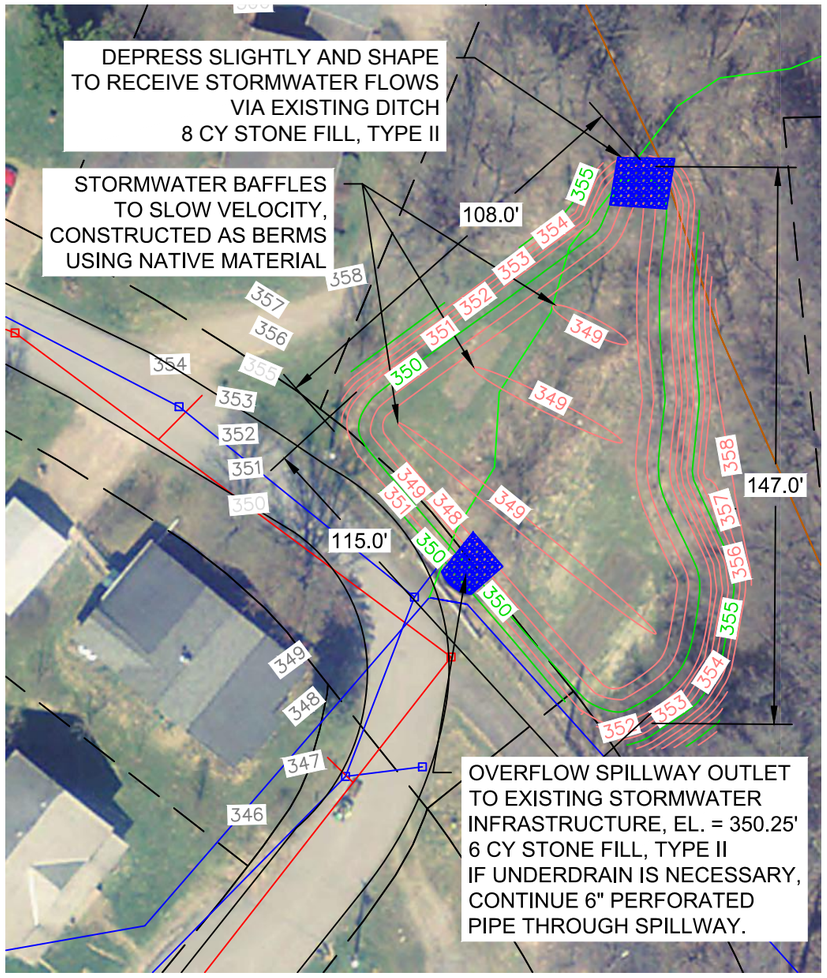
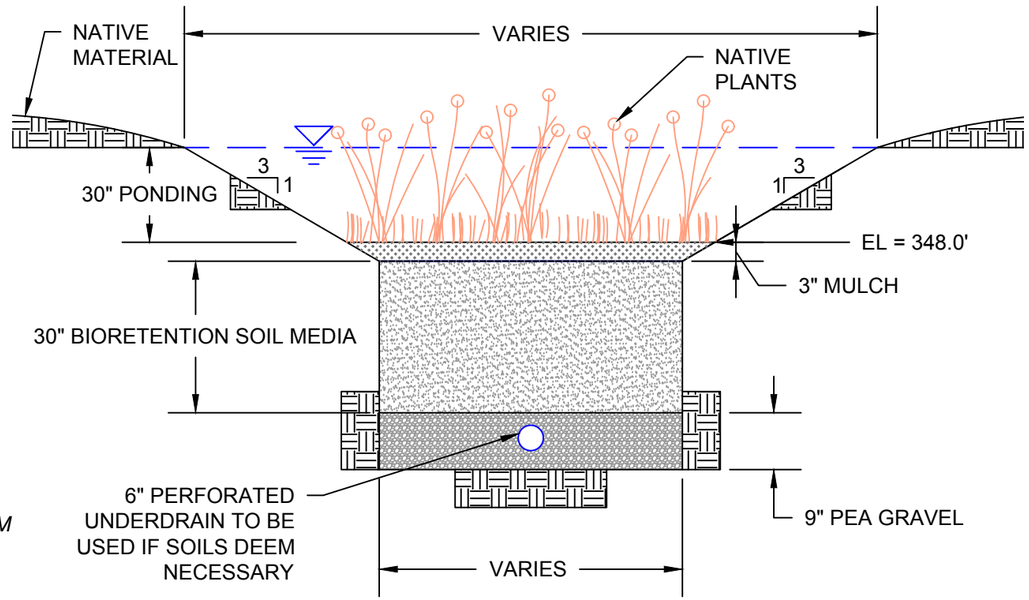
RICHMOND STORMWATER MASTER PLAN
WR-09
BRIDGE STREET SIDEWALK INFILTRATION
RICHMOND VERMONT

FIGURE NO. 5



LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PROPOSED MAJOR CONTOUR*
- *PROPOSED MINOR CONTOUR*
- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING SANITARY SEWER SYSTEM*
- *EXISTING STORMWATER SYSTEM*
- *EXISTING DITCH*
- *EXISTING STORMWATER CATCH BASIN*
- *EXISTING SANITARY SEWER MANHOLE*



TYPICAL UNDERDRAINED BIORETENTION AREA DETAIL
NOT TO SCALE

NOTES

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4. CONTRACTOR SHOULD NOTE THAT DEWATERING AND BYPASS MAY BE NECESSARY TO CONSTRUCT THE BIORETENTION BASIN.
5. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
6. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
7. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED ARES.
8. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
9. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
10. BIORETENTION BASIN SIDE SLOPES SHALL NOT EXCEED 3:1 UNLESS OTHERWISE NOTED. SIDE SLOPES ABOVE EL = 351.0' SHALL BE CONSTRUCTED TO 1.5:1.
11. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
12. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
13. VEGETATION OF THE BIORETENTION BASIN SHALL BE COMPLETED USING APPROPRIATE PLANTINGS (NATIVE OR NATURALIZED CULTIVARS PREFERRED).
14. BIORETENTION SOIL MEDIA SHALL BE COMPACTED BY SATURATING WITH WATER. DO NOT COMPACT MEDIA WITH MACHINERY.
15. BIORETENTION SOIL MEDIA TO BE COMPRISED OF 90% SAND (ASTM C33 FINE) AND 10% TOPSOIL (USDA TEXTURAL CLASSIFICATION OF SANDY LOAM OR LOAMY SAND).
16. “PEA GRAVEL” SHALL CONSIST OF 3/8" SCREENED, DOUBLE WASHED STONE.
17. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
18. EXISTING CONTOURS REPRESENT LIDAR PROVIDED BY THE STATE OF VERMONT.

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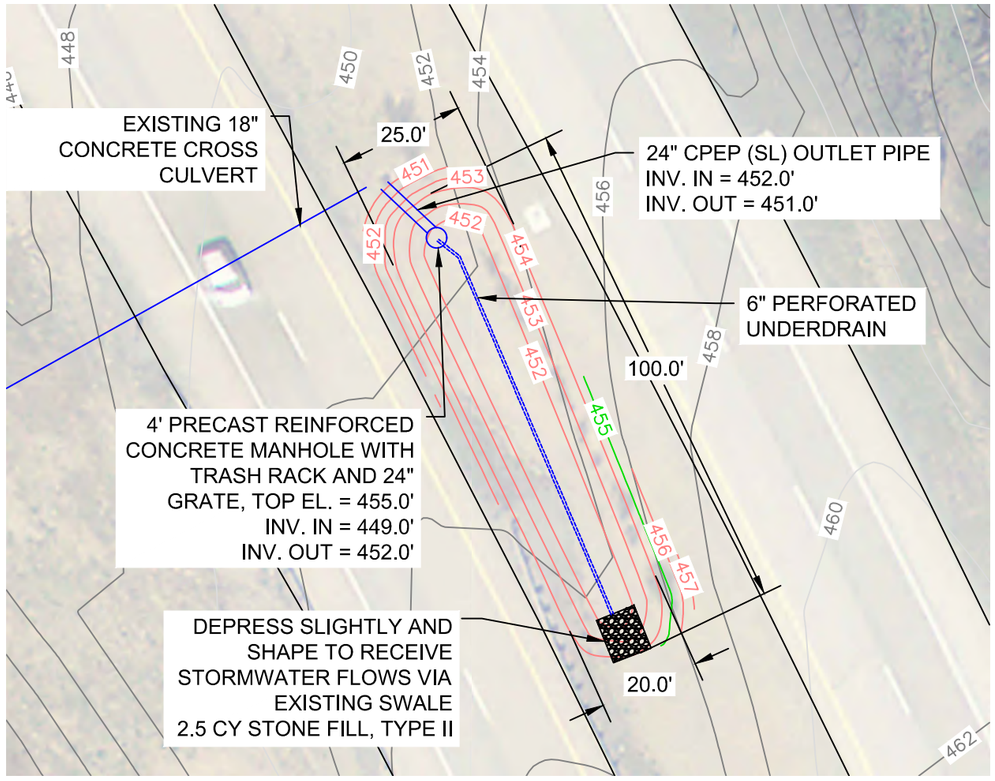
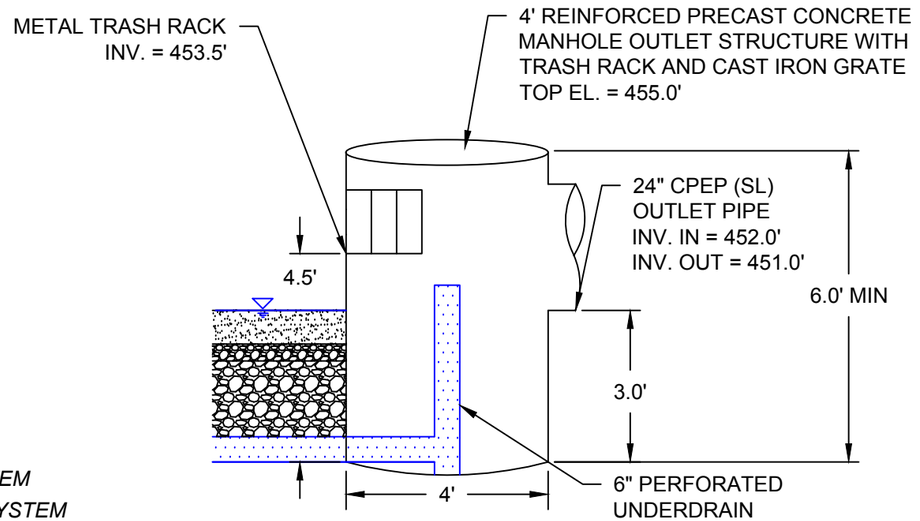
RICHMOND STORMWATER MASTER PLAN
WR-11
MILLET STREET BIORETENTION BASIN
RICHMOND VERMONT

FIGURE NO. 6

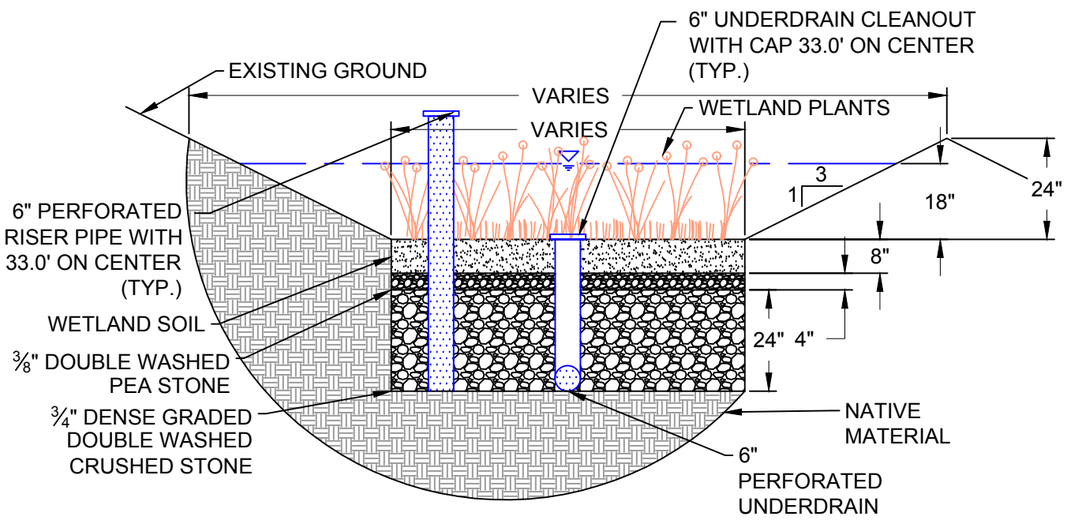


LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PROPOSED MAJOR CONTOUR*
- *PROPOSED MINOR CONTOUR*
- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING STORMWATER SYSTEM*
- *EXISTING SANITARY SEWER SYSTEM*



GRAVEL WETLAND OUTLET STRUCTURE DETAIL
NOT TO SCALE



GRAVEL WETLAND DETAIL (CROSS SECTION)
NOT TO SCALE

NOTES

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7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. STONE TRANSFER PADS SHALL BE CONSTRUCTED USING A 6" THICK LAYER OF COMPACTED STONE FILL, TYPE II.
10. GRAVEL WETLAND AREA SIDE SLOPES SHALL NOT EXCEED 3:1 UNLESS OTHERWISE NOTED.
11. NATIVE SUB-SOIL SHALL REMAIN UNCOMPACTED AS MUCH AS POSSIBLE. EXCAVATORS OR BACKHOES SHALL WORK FROM THE SIDES TO EXCAVATE, SHAPE, AND FILL THE GRAVEL WETLAND.
12. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
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Checked By: ANM
Project No.: 17-061-A

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DRAWING SCALE
0 30 60 Feet
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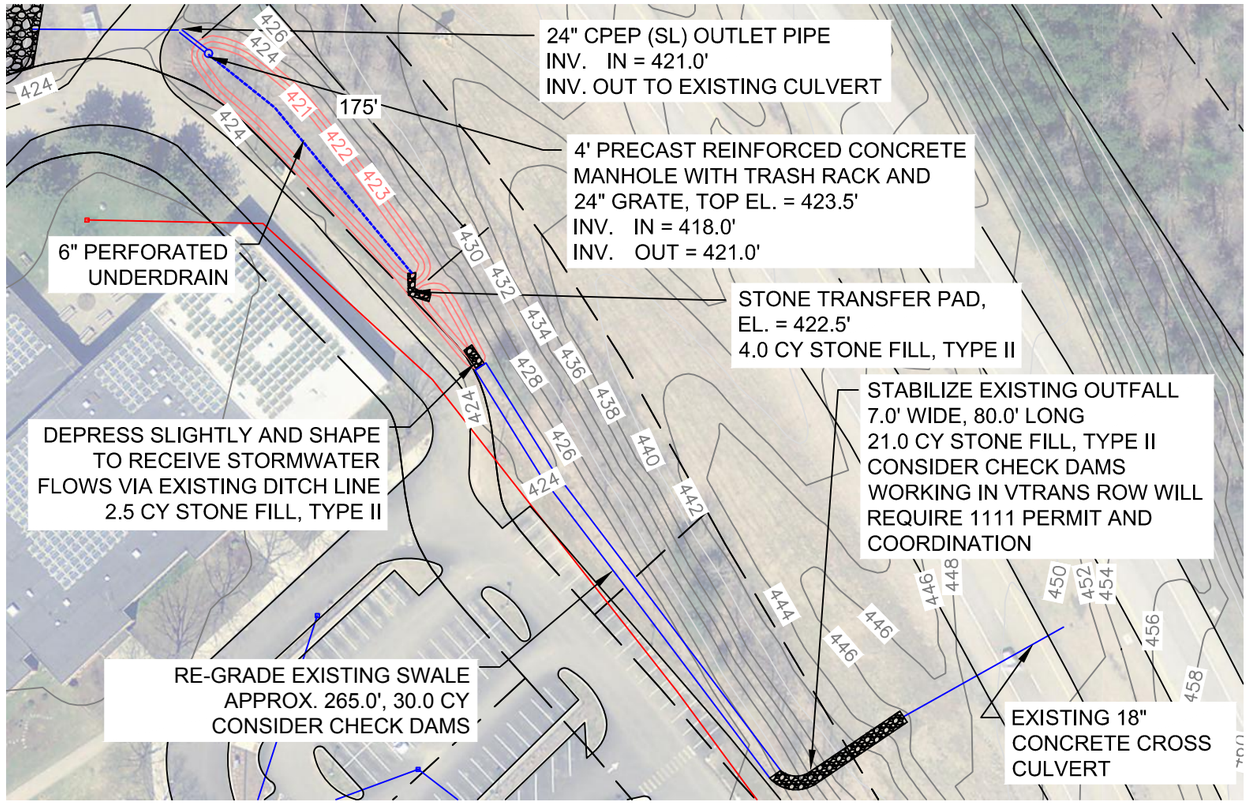
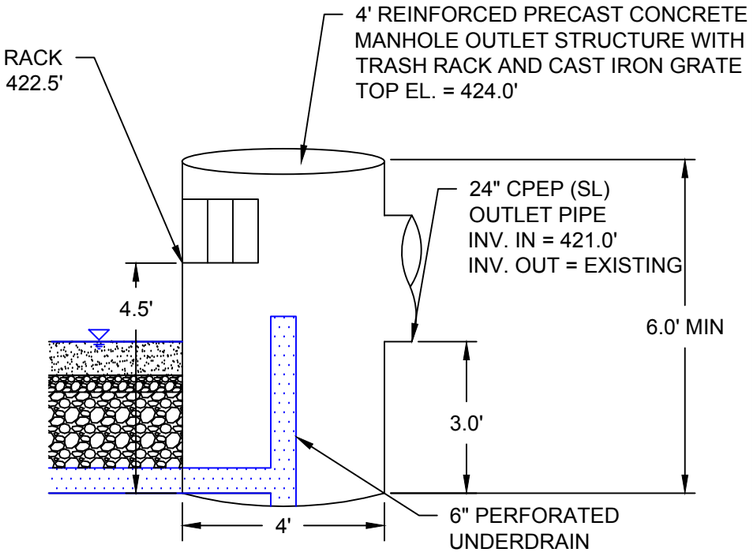
RICHMOND STORMWATER MASTER PLAN
WR-19
VTRANS I-89 RIGHT-OF-WAY GRAVEL WETLAND
RICHMOND VERMONT

FIGURE NO. 7

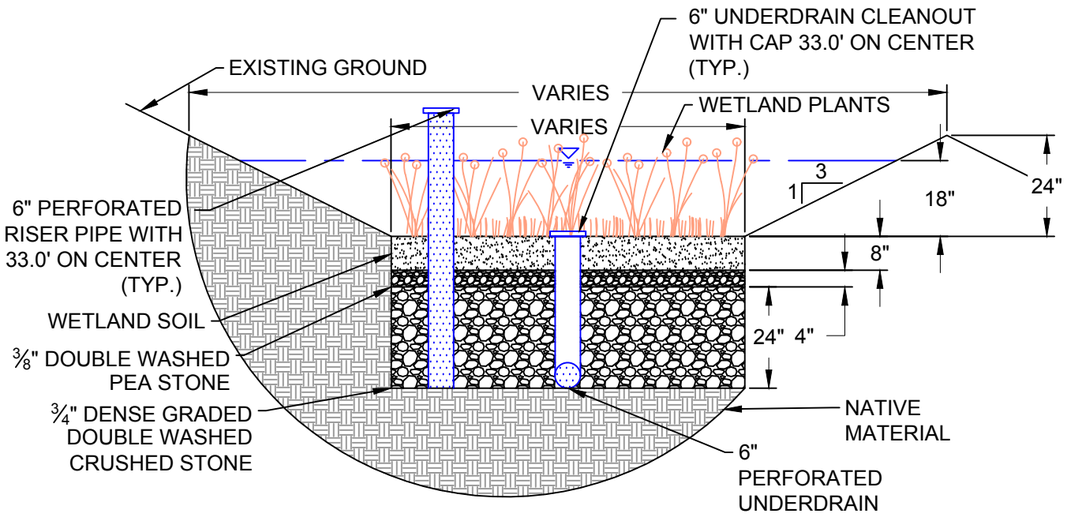


LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PROPOSED MAJOR CONTOUR*
- *PROPOSED MINOR CONTOUR*
- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING STORMWATER SYSTEM*
- *EXISTING SANITARY SEWER SYSTEM*
- *EXISTING STORMWATER CATCH BASIN*
- *EXISTING SANITARY SEWER MANHOLE*



GRAVEL WETLAND OUTLET STRUCTURE DETAIL
NOT TO SCALE



GRAVEL WETLAND DETAIL (CROSS SECTION)
NOT TO SCALE

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10. GRAVEL WETLAND AREA SIDE SLOPES SHALL NOT EXCEED 3:1 UNLESS OTHERWISE NOTED.
11. NATIVE SUB-SOIL SHALL REMAIN UNCOMPACTED AS MUCH AS POSSIBLE. EXCAVATORS OR BACKHOES SHALL WORK FROM THE SIDES TO EXCAVATE, SHAPE, AND FILL THE GRAVEL WETLAND.
12. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
13. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25 LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
14. PLANTING OF THE GRAVEL WETLAND SHALL BE COMPLETED USING WETLAND VEGETATION.
15. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
16. EXISTING CONTOURS REPRESENT LIDAR PROVIDED BY THE STATE OF VERMONT.

File: O:\Proj-17\WRM\17-061-A CCRPC Richmond SWMP\CAD\RICHMOND_CONCEPTS_SCHOOL.DGW

DRAWING CREDITS
Drawn On: 06/15/2018
Drawn By: BAM
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Project No.: 17-061-A

REVISIONS

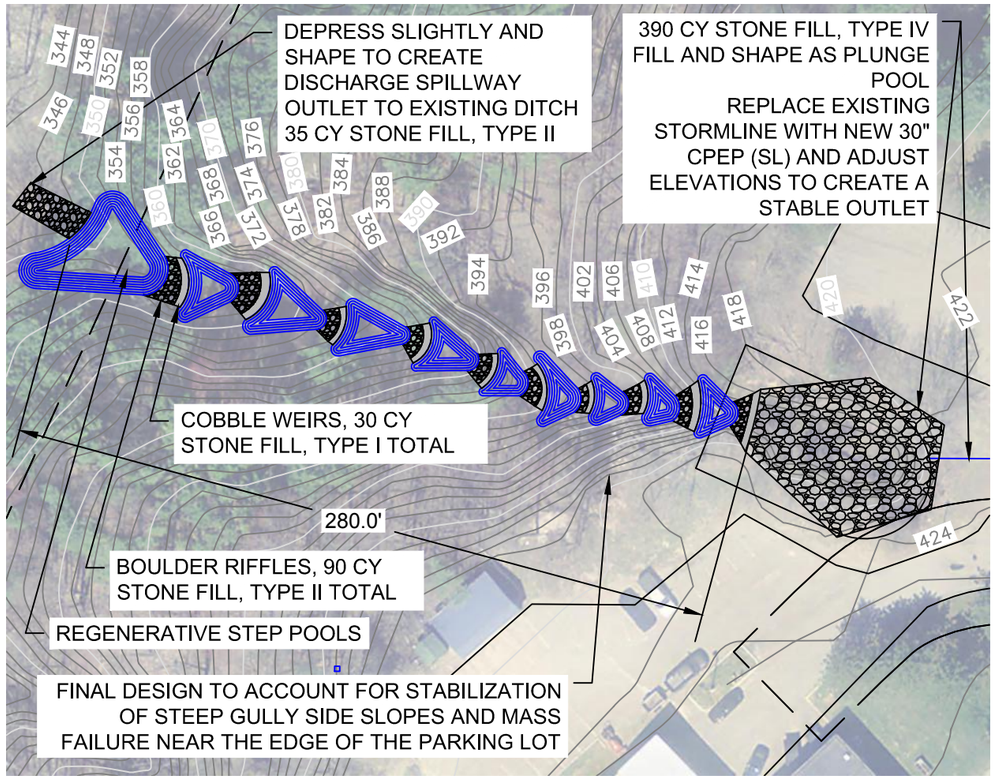
#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE
0 80 160 Feet
1 INCH = 80 FEET

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

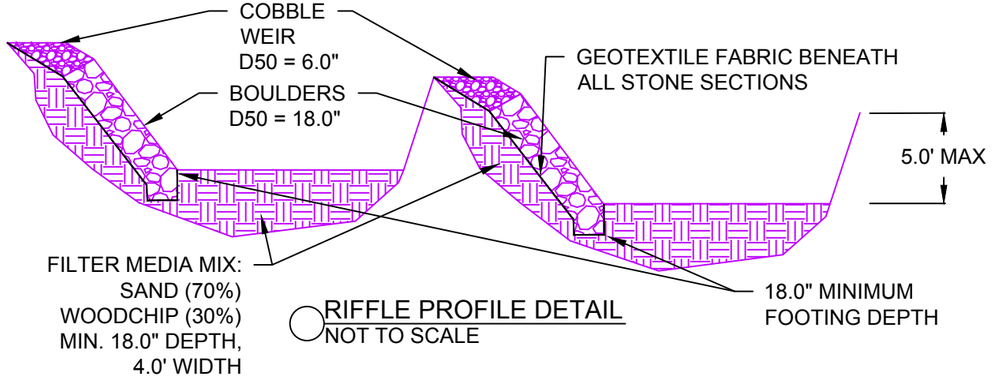
RICHMOND STORMWATER MASTER PLAN
WR-22
CAMELS HUMP MIDDLE SCHOOL GRAVEL WETLAND
RICHMOND VERMONT

FIGURE NO. 8

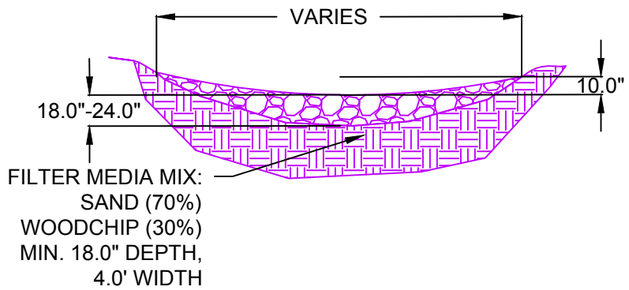


LEGEND

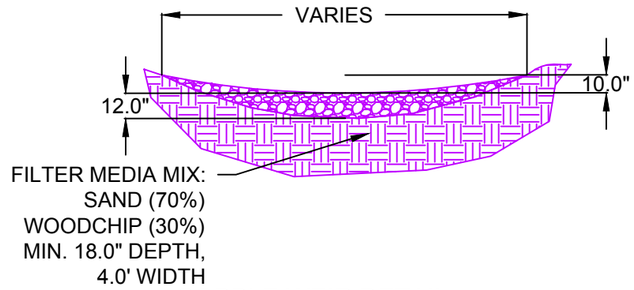
- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PROPOSED MAJOR CONTOUR*
- *PROPOSED MINOR CONTOUR*
- *PARCELS*
- *EDGE OF PAVEMENT*
- *EXISTING STORMWATER SYSTEM*



RIFFLE PROFILE DETAIL
NOT TO SCALE



BOULDER RIFFLE DETAIL
NOT TO SCALE



COBBLE WEIR DETAIL
NOT TO SCALE

NOTES

1. THE RIFFLES, WEIRS, AND POOL CHANNELS SHALL BE PARABOLIC IN SHAPE.
2. THE MINIMUM FREEBOARD FOR LINED WATERWAYS OR OUTLETS SHALL BE 0.25' ABOVE DESIGN HIGH WATER IN AREAS WHERE EROSION RESISTANT VEGETATION CANNOT BE GROWN AND MAINTAINED. NO FREEBOARD IS REQUIRED IF VEGETATION CAN BE GROWN AND MAINTAINED.
3. COBBLE WEIR SECTIONS WILL UTILIZE ON SITE MATERIALS, WHEN EXISTING MATERIAL IS AVAILABLE. EXISTING COBBLE MATERIAL SHALL BE REMOVED OF EXCESS FINE SEDIMENT BEFORE PLACEMENT. DEPTH OF COBBLE IS EQUAL TO 2XD50, WHERE D50 IS EQUAL TO THE MEDIAN STONE SIZE.
4. THE CONSTRUCTED DEPTH OF TYPICAL POOLS SHALL NOT BE LESS THAN 18.0" AND SHALL NOT EXCEED 5.0'.
5. THE SAND/WOOD CHIP FILTER MEDIA SHALL MEET AASHTO-M-6 OR ASTM-C-33, 0.02" TO 0.04" IN SIZE. SAND SUBSTITUTIONS SUCH AS DIABASE AND GRAYSTONE (AASHTO) #10 ARE NOT ACCEPTABLE. NO CALCIUM CARBONATE OR DOLOMITIC SAND SUBSTITUTIONS ARE ACCEPTABLE. NO "ROCK DUST" CAN BE USED FOR SAND. THE WOOD CHIPS SHALL BE HARDWOOD CHIPS AND BE ADDED TO THE SAND MIX, APPROXIMATELY 30% BY VOLUME TO INCREASE ORGANIC CONTENT AND PROMOTE PLANT GROWTH AND SUSTAINABILITY.
6. FILTER FABRIC SHALL BE PLACED UNDER ALL STONES. REFER TO DESIGN FIGURES FOR PLACEMENT LOCATION. TO PREVENT UNDERCUTTING, A CONTINUOUS SHEET OF FILTER FABRIC SHALL BE USED ALONG THE CROSS-SECTION. FILTER FABRIC SHALL NOT BE PLACED IN POOLS SO AS NOT TO IMPEDE FILTRATION.
7. THE BOULDERS SHOULD BE AT LEAST THREE TO FOUR TIMES HEAVIER THAN THE RIFFLE CHANNEL COBBLE.
8. THE SAND/WOODCHIP MIX FILTER BED SHALL HAVE A MINIMUM DEPTH OF 18.0" UNDER THE RIFFLE CHANNEL, A MINIMUM WIDTH OF 4.0', AND SHALL BE PLACED AS THE SUBSTRATE DRAINAGE MATERIAL ALONG THE ENTIRE PROJECT LENGTH.
9. FOOTER BOULDERS SHALL BE PLACED AT THE INTERFACE OF THE POOLS AND RIFFLES AS SHOWN. ADDITIONAL BOULDERS SHALL BE PLACED ON TOP OF THE FOOTER BOULDERS AT THE WEIR ELEVATION UPSTREAM OF THE FOOTER BOULDERS TO FORM THE RIFFLE CHANNEL PARABOLIC SHAPE.
10. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
11. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
12. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
13. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
14. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
15. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED ARES.
16. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
17. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
18. BARE OR DISTURBED SOIL ADJACENT TO NEW CONVEYANCE SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25 LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
19. FURTHER EROSION PREVENTION MEASURES SUCH AS LIVE STAKES AND COMPOST BLANKETS MAY BE CONSIDERED DURING FINAL DESIGN.
20. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
21. EXISTING CONTOURS REPRESENT LIDAR PROVIDED BY THE STATE OF VERMONT.

File: O:\Proj-17\WRM\17-061-A CCRPC Richmond SWMP\CAD\RICHMOND_CONCEPTS_SCHOOL.DGW

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REVISIONS

#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE
0 60 120 Feet
1 INCH = 60 FEET

STONE ENVIRONMENTAL
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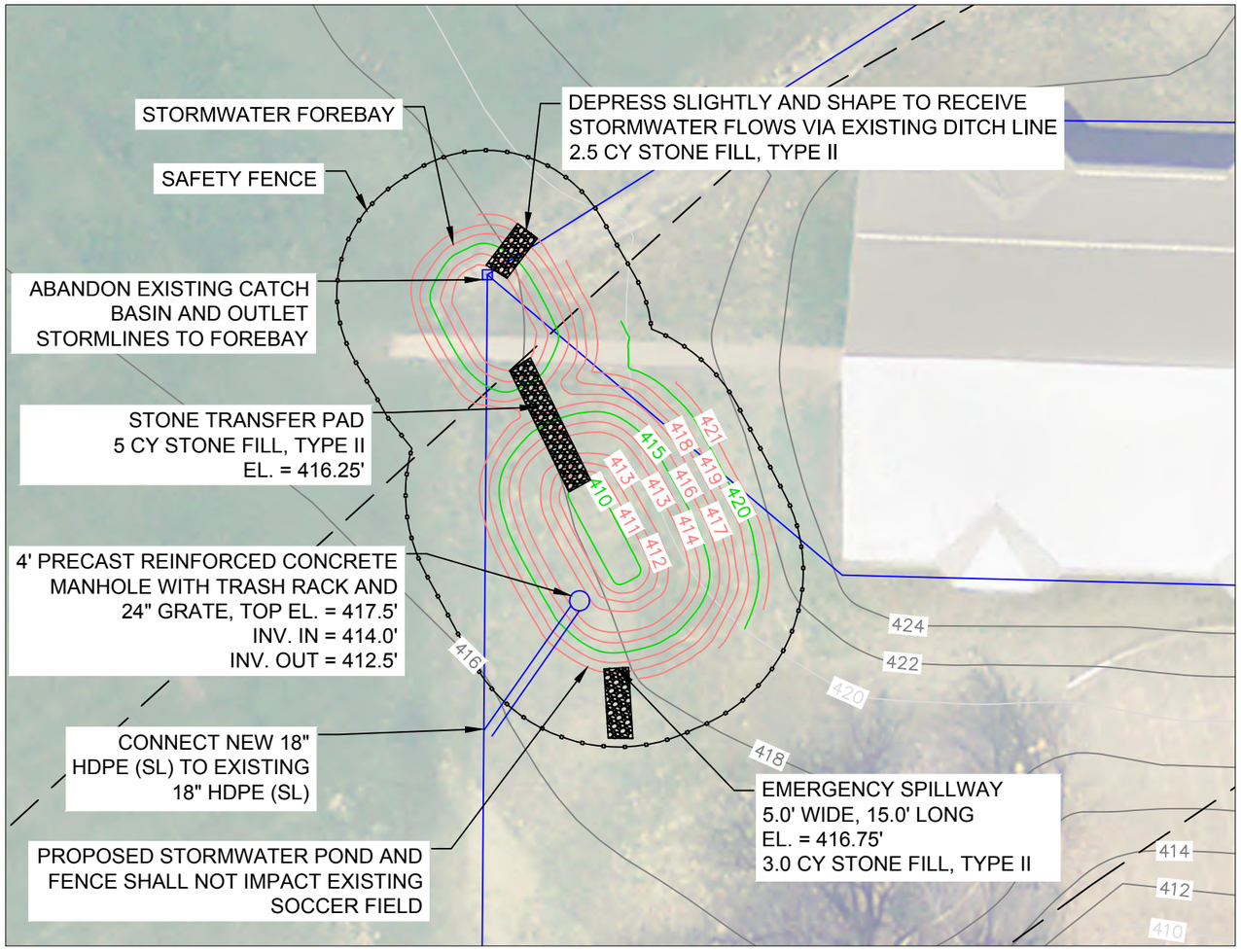
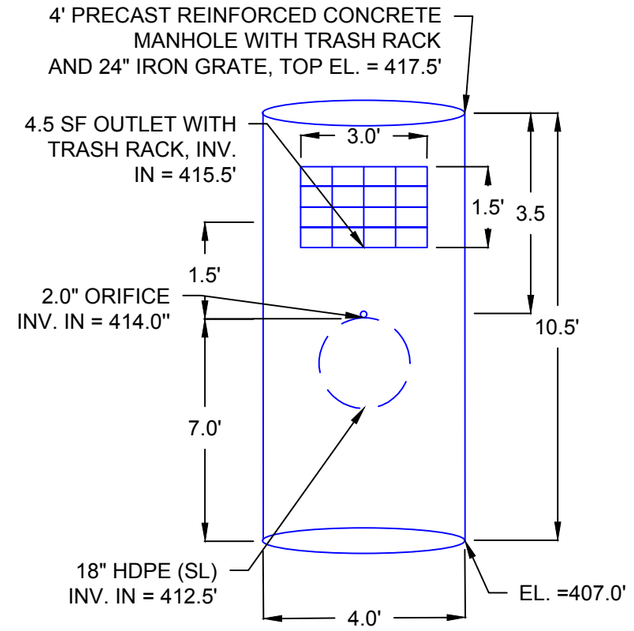
RICHMOND STORMWATER MASTER PLAN
WR-14
CHMS NORTH GULLY - REGENERATIVE STORM CONVEYANCE
RICHMOND VERMONT

FIGURE NO. 9



LEGEND

- *EXISTING MAJOR CONTOUR*
- *EXISTING MINOR CONTOUR*
- *PROPOSED MAJOR CONTOUR*
- *PROPOSED MINOR CONTOUR*
- *PARCELS*
- *EXISTING STORMWATER SYSTEM*
- *EXISTING STORMWATER CATCH BASIN*



STORMWATER POND OUTLET STRUCTURE DETAIL
NOT TO SCALE

NOTES

1. ALL PERMITS, EASEMENTS, AND RIGHTS OF WAY ARE THE RESPONSIBILITY OF THE LAND OWNER.
2. IT IS THE EXCAVATION CONTRACTOR'S RESPONSIBILITY TO CALL "DIG SAFE" AND TO COMPLY WITH ALL VERMONT LAWS AND REGULATIONS REGARDING THE LOCATION AND WORK AROUND UNDERGROUND UTILITIES. DIG SAFE: (888) 344-7233.
3. ALL CONSTRUCTION ACTIVITIES SHALL BE COMPLETED IN A MANNER THAT MINIMIZES THE POTENTIAL FOR SEDIMENT TO ENTER ANY WATER BODY, INCLUDING WATERWAYS. SEE D.E.C. SEDIMENT AND EROSION CONTROL HANDBOOKS.
4. ALL ITEMS SHALL BE CONSTRUCTED TO THE DIMENSIONS SHOWN ON THE DRAWINGS. ANY CHANGES REQUIRE APPROVAL BY STONE ENVIRONMENTAL, INC.
5. STONE ENVIRONMENTAL, INC. SHALL BE NOTIFIED AT THE START OF CONSTRUCTION AND BEFORE ANY FILL MATERIAL IS PLACED.
6. WHERE RELEVANT, TOPSOIL SHALL BE STRIPPED AND STOCKPILED TO BE USED TO RESTORE DISTURBED AREAS.
7. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO NOTIFY STONE ENVIRONMENTAL, INC. IMMEDIATELY IF PROBLEMS OR UNFORESEEN CIRCUMSTANCES ARISE DURING CONSTRUCTION.
8. ALL DIMENSIONS ARE MEASURED HORIZONTALLY AND VERTICALLY UNLESS OTHERWISE NOTED.
9. INTERIOR STORMWATER POND SIDE SLOPES SHALL NOT EXCEED 2:1 UNLESS OTHERWISE NOTED, EXTERIOR STORMWATER POND SIDE SLOPES SHALL NOT EXCEED 2:1 UNLESS OTHERWISE NOTED.
10. EMBANKMENTS SHALL BE CONSTRUCTED BY REMOVING AND STOCKPILING TOPSOIL, SCARIFYING NATIVE, INORGANIC SOIL, AND THEN PLACING AND COMPACTING SUITABLE EXCAVATED MATERIAL IN 8-INCH LIFTS.
11. EMBANKMENTS SHALL BE SEEDED WITH A CONSERVATION MIX AT AN APPLICATION RATE OF 25 LBS/ACRE OR PER SEED MANUFACTURER'S REQUIREMENTS. PLACEMENT OF SEED MUST BE COMPLETED PRIOR TO PLACEMENT OF EROSION CONTROL MATTING.
12. STONE TRANSFER PAD SHALL BE CONSTRUCTED USING A 6" THICK LAYER OF COMPACTED STONE FILL, TYPE II.
13. PARCEL LINES PROVIDED ON THIS SHEET ARE FROM SHAPEFILES PROVIDED BY THE STATE OF VERMONT, DO NOT REPRESENT A BOUNDARY SURVEY, AND SHOULD BE CONSIDERED APPROXIMATE.
14. EXISTING CONTOURS REPRESENT LIDAR PROVIDED BY THE STATE OF VERMONT.
15. FINAL DESIGN MAY INCORPORATE USE OF A GRAVEL TRENCH OUTLET.

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REVISIONS

#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE
0 30 60 Feet
1 INCH = 30 FEET

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RICHMOND STORMWATER MASTER PLAN
WR-15
CAMEL'S HUMP MIDDLE SCHOOL WET POND
RICHMOND VERMONT

FIGURE NO. 10

Appendix F. Batch Input File for VTDEC Tracking

Grant number	Project Name	O&M Responsible Party	Latitude	Longitude	Drainage area	Watershed Projects Database number	BMP Type (See BMP definitions Tab)	Impervious area treated (acres)	Impervious land use	Pervious area treated (acres)	Pervious land use	Storage volume (cuft)	Infiltration rate (in/hr)	Is this an upgrade to an existing BMP?	BMP status	Date of Planned Construction
	Richmond SWMP, WR-01		44.39693	-73.00161	5-WINOOSKI RIVER		Gravel Wetland	0.47	Developed Impervious	*0.23*	Developed Pervious	*3,300*		No	Planned	
	Richmond SWMP, WR-02		44.39821	-72.99781	5-WINOOSKI RIVER		Surface infiltration	1.76	Developed Impervious	0.44	Developed Pervious	7,200	2.41	No	Planned	
	Richmond SWMP, WR-03		44.40077	-72.99863	5-WINOOSKI RIVER		Wet pond/ Created Wetland	0.92	Developed Impervious	1.44	Developed Pervious	20,000		No	Planned	
	Richmond SWMP, WR-04		44.40203	-72.99649	5-WINOOSKI RIVER		Infiltration Trench	1.19	Developed Impervious	0.65	Developed Pervious	9,000	2.41	No	Planned	
	Richmond SWMP, WR-05		44.40213	-72.99481	5-WINOOSKI RIVER		Bioretention	1.10	Developed Impervious	0.79	Developed Pervious	8,000	2.41	No	Planned	
	Richmond SWMP, WR-06		44.40558	-72.998	5-WINOOSKI RIVER		Wet pond/ Created Wetland	16.94	Developed Impervious	33.69	Developed Pervious	49,032		No	Planned	
	Richmond SWMP, WR-07		44.40321	-72.9932	5-WINOOSKI RIVER		Gravel Wetland	13.25	Developed Impervious	109.42	Developed Pervious	31,400		No	Planned	
	Richmond SWMP, WR-08		44.40653	-72.9931	5-WINOOSKI RIVER		Bioretention	0.41	Developed Impervious	0.08	Developed Pervious	2,390	2.41	No	Planned	
	Richmond SWMP, WR-09		44.40259	72.99585	5-WINOOSKI RIVER		Infiltration Trench	0.46	Developed Impervious	0.55	Developed Pervious	4,400	2.41	No	Planned	
	Richmond SWMP, WR-10		44.40469	-72.99211	5-WINOOSKI RIVER		Bioretention	0.78	Developed Impervious	0.00	Developed Pervious	2,700	2.41	No	Planned	
	Richmond SWMP, WR-11		44.40736	-72.99245	5-WINOOSKI RIVER		Bioretention	3.07	Developed Impervious	36.01	Developed Pervious	20,300	2.41	No	Planned	
	Richmond SWMP, WR-12		44.41257	-72.9924	5-WINOOSKI RIVER		Porus Pavement	0.46	Developed Impervious	0.69	Developed Pervious	840	2.41	No	Planned	
	Richmond SWMP, WR-13		44.41288	-72.9924	5-WINOOSKI RIVER		Bioretention	0.08	Developed Impervious	0.33	Developed Pervious	2,363	2.41	No	Planned	
	Richmond SWMP, WR-14		44.41422	-72.9944	5-WINOOSKI RIVER		Regenerative Conveyance	2.47	Developed Impervious	3.03	Developed Pervious	8,990	2.41	No	Planned	
	Richmond SWMP, WR-15		44.41267	-72.99511	5-WINOOSKI RIVER		Wet pond/ Created Wetland	2.19	Developed Impervious	2.23	Developed Pervious	9,265		No	Planned	
	Richmond SWMP, WR-16		44.41241	-72.99339	5-WINOOSKI RIVER		Infiltration Trench	0.28	Developed Impervious	0.01	Developed Pervious	651	2.41	No	Planned	
	Richmond SWMP, WR-17		44.41241	-72.99289	5-WINOOSKI RIVER		Gravel Wetland	0.49	Developed Impervious	0.79	Developed Pervious	1,350		No	Planned	
	Richmond SWMP, WR-18		44.415352	-72.99387	5-WINOOSKI RIVER		Gravel Wetland	1.31	Developed Impervious	3.79	Developed Pervious	20,000		No	Planned	
	Richmond SWMP, WR-19		44.413514	-72.992355	5-WINOOSKI RIVER		Gravel Wetland	0.40	Developed Impervious	0.40	Developed Pervious	3,938		No	Planned	
	Richmond SWMP, WR-20		44.413059	-72.991606	5-WINOOSKI RIVER		Gravel Wetland	0.90	Developed Impervious	36.30	Developed Pervious	25,000		No	Planned	
	Richmond SWMP, WR-21		44.411746	-72.991034	5-WINOOSKI RIVER		Gravel Wetland	0.30	Developed Impervious	10.60	Developed Pervious	7,500		No	Planned	
	Richmond SWMP, WR-22		44.413991	-72.99368	5-WINOOSKI RIVER		Gravel Wetland	0.54	Developed Impervious	1.87	Developed Pervious	10,886		No	Planned	