Stormwater Master Plan for the Town of Shaftsbury, Vermont

FINAL REPORT

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1.0 Introduction

The Bennington County Regional Commission (BCRC) has been assisting the Town of Shaftsbury with stormwater planning and mitigation in relation to Hazard Mitigation Planning and VTANR municipal permits aimed at improving water quality, such as the Municipal Roads General Permit (MRGP). In 2017 BCRC applied for and received grant funding from the Vermont Agency of Natural Resources (VTANR) Ecosystem Restoration Program to develop a Stormwater Master Plan (SWMP) for the Town of Shaftsbury. Fitzgerald Environmental Associates, LLC (FEA) was hired by BCRC in the spring of 2018 to develop the plan.

1.1 Stormwater Master Planning

Stormwater runoff is generated any time rain or melting snow/ice runs off the land; stormwater runoff typically increases when the land use has been altered from its natural state. Typically, hardened surfaces such as rooftops and roads are the primary sources of stormwater runoff, however in a rural setting it is important to consider hayfields, pasture, and other developed or agricultural areas that may increase and concentrate runoff. Increased stormwater runoff leads to higher magnitude flood flows and greater erosive power in stream channels, increased delivery of sediment, nutrients, and other pollutants to waterways, and increased flooding conflicts with improved properties downstream. The network of roads, ditches, and culverts that are found in steep rural settings are important for conveying stormwater and protecting infrastructure. However, these systems concentrate runoff, reduce infiltration, and may lead to areas of erosion and sediment generation. Increased stormwater runoff is directly linked to the quality of water in our streams, rivers, ponds, and lakes that we depend on for drinking water, healthy fisheries, and recreation.

Stormwater master plans can prevent problems from happening either by mitigating impacts before they create problems or by avoiding the creation of problems; in other words, prevention is cheaper than restoration. If we are to avoid the high cost of restoring degraded surface waters, we must better manage stormwater runoff before waters become impaired. Plans are developed with public involvement and comment and should be as comprehensive as possible in listing all known problems. Plans are based on a prioritized list of projects or a strategic approach and are therefore more likely to succeed than a reactionary approach that addresses problems as they arise. Historically almost all Vermont municipalities have responded to stormwater runoff or drainage problems the latter way, and frequently during an emergency or after a structural failure has occurred. Stormwater management plans contain important information about preserving natural features and functions of a watershed and provide a list of evaluated alternatives such as using traditional pipe (gray) infrastructure versus green stormwater infrastructure.

1.2 Town and Project Background

The northern portion of Shaftsbury is predominantly forested, while the southern portion of the Town and the Routes 7 and 7A corridors have more significant agricultural and developed lands. Coupled with a relatively extensive network of gravel roads in the Town, Shaftsbury faces stormwater challenges both from developed lands and its rural road drainage.

Stormwater planning efforts in rural areas are most successful when carried out within a context of overarching watershed and stream corridor concerns including transportation infrastructure and

maintenance, agricultural land uses, and areas of problematic stream channel erosion. Phase 1 assessments on the Furnace Creek, Cold Spring Brook and Paran Creek (BCCD & HooRWA, 2005), Fayville Branch and Warm Brook (FGS, 2004) and the Walloomsac and Hoosic Tactical Basin Plan (VTANR, 2016) summarized stream corridor conflicts and watershed scale stressors and prioritized areas where specific projects and management strategies could reduce erosion conflicts and improve the ecological health of the watersheds. Additional information from high-resolution Light Detection and Ranging (LiDAR) elevation data, stormwater infrastructure mapping completed by the Vermont Department of Environmental Conservation (VTDEC), meetings with stakeholders in Shaftsbury, and field visits to the Town were incorporated into this planning effort to build on past work and identify problem areas associated with stormwater in Shaftsbury. Best Management Practices (BMPs) are recommended to mitigate stormwater problem areas contributing to infrastructure vulnerability and degradation of water quality in the watershed.

The recently issued VTANR Municipal Roads General Permit (MRGP) requires a Road Erosion Inventory (REI) to be conducted on all hydrologically connected (HC) town-maintained roads. FEA conducted road erosion inventories on all HC town-maintained roads and outfalls in the Town of Shaftsbury as part of the stormwater master planning process. The Shaftsbury SWMP follows the VTANR SWMP guidelines and was developed over the course of 2018 and 2019 through extensive field survey work, interaction with multiple stakeholders in the Town of Shaftsbury to prioritize projects, and follow-up analysis and design work.

1.3 Project Goals and Objectives

The goal of this project was to evaluate developed lands and road corridors in the Town to identify sources of increased stormwater runoff and associated sediments and nutrients discharging to the waterways draining Shaftsbury, particularly in areas affecting Town infrastructure. The work involved identifying sources of stormwater, prioritizing sources based on various environmental, economic, and social criteria, and designing projects to mitigate those sources. Stormwater mitigation projects are aimed at reducing or eliminating stormwater at the source through green stormwater infrastructure (GSI) approaches, retrofits of older and underperforming stormwater features, and back road erosion projects.

Specific project tasks and deliverables included: 1) identify, evaluate, and prioritize stormwater problem areas throughout the Town; 2) complete the REI for all on all hydrologically connected (HC) town-maintained roads; 3) develop one-page project summary sheets (including BMP concepts) for at least 30 project areas; 4) develop conceptual designs (30% level of completion) for at least five (5) project areas; and 5) produce a final report summarizing the assessment and design work.

2.0 Study Area Description

Shaftsbury is a 43.1 square mile town located in Bennington County in the southwestern corner of Vermont (Fig. 2.1). Shaftsbury is bordered by 5 towns in Vermont (Arlington, Sunderland, Glastenbury, Woodford, and Bennington) and 2 towns in New York (White Creek and Hoosick). The Town is entirely drained by Hudson River tributaries. Approximately 80% of the town drains to the Walloomsac River, via tributaries Little White Creek, Paran Creek, and Furnace Brook. The remainder of the town drains to the Batten Kill tributaries Fayville Branch and Warm Brook. The Town has a total population of 3,590 as of the 2010 Census, with 693 residing in South Shaftsbury (U.S. Census Bureau, 2011).

Land cover data based on imagery from 2011 National Land Cover Dataset (Homer et al., 2015) are summarized in Table 2.1. While Shaftsbury is predominantly forested, there is more extensive development and agricultural activity than most towns in Bennington County. Residential development and industry are particularly concentrated in South Shaftsbury and the areas of North Bennington extending across the town boundary. Agriculture lands are primarily pasture and hay, with a majority of the farmland in the area between White Creek Road and the Route 7A corridor. There are 101.1 miles of roads in Shaftsbury (Table 2.1), made up mainly of state highways (10.3%), town highways (70.8%) and private roads (10.9%). Road distances are based on road centerline data from VTrans (2017).

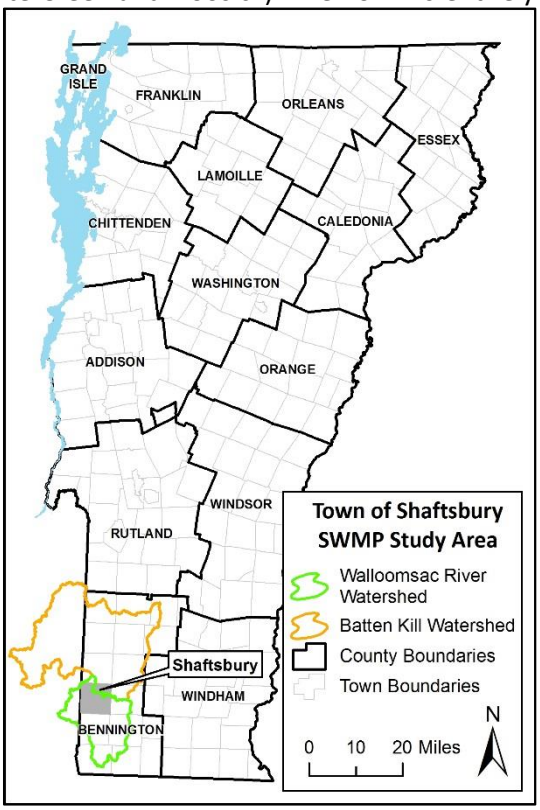

Figure 2.1: Town of Shaftsbury location map.

Table 2.1: Road length by AOT class in Shaftsbury (VTrans, 2017)

AOT Class	Description	Length (miles)	% of Town Road Length (excluding discontinued)
2	Class 2 Town Highway	19.8	19.6
3	Class 3 Town Highway	50.1	49.5
4	Class 4 Town Highway	1.8	1.7
5	State Forest Highway	0.2	0.2
7	Legal Trail	2.6	2.6
8 & 9	Private Road	11.0	10.9
30	Vermont State Highway	10.5	10.3
40	US Highway	5.3	5.2
96	Discontinued Road	1.9	-

Table 2.2: Land cover in Shaftsbury (Homer et al., 2015)

Land Cover/Land Use Type	% of Town
Agriculture	20.6
Barren	0.4
Developed	6.1
Forest	65.0
Open Water	0.2
Shrub/Scrub	1.0
Grassland/Herbaceous	0.3
Wetland	6.4

3.0 Stormwater Management Planning Library

We began our SWMP efforts by gathering and reviewing information and documentation related to stormwater runoff and watershed management in the Town of Shaftsbury as it pertains to the Shaftsbury SWMP. Below is a summary of available data, mapping, and documentation at the local, state, and federal level. Much of this information is from previously completed studies in Shaftsbury, but also includes sites discussed during a SWMP steering committee meeting on June 21st, 2018. Other potential sources of data and data gaps are also addressed.

Watershed Planning Data and Mapping

Basin Plan

The Tactical Basin Plan for the Batten Kill, Walloomsac and Hoosic Rivers was prepared by the Vermont Agency of Natural Resources in 2015 (VTANR, 2016). The basin plan catalogs current surface water quality conditions, stressors, and recommended actions for water quality restoration. Shaftsbury surface waters include Paran Creek, Furnace Brook, and Little White Creek, Walloomsac tributaries originating in Shaftsbury and neighboring towns, as well as Warm Brook, a tributary to the Batten Kill originating in the northern parts of Shaftsbury and Glastenbury. Overall water quality in Shaftsbury is good to excellent based on macroinvertebrate and fish data collected by VTDEC over the last 10 years, with one Good-Fair macroinvertebrate sample collected in Paran Creek in 2015 due to a moderate score for the Pinkham-Pearson Coefficient of Similarity - Function Feeding Groups (PPCS-F).

Ecological Condition

The Basin Plan summarizes significant natural communities in the watersheds. The Paran Creek Fen and Serendipity Fen are both located in Shaftsbury. Lake Shaftsbury is classified as altered due to the presence of invasive water chestnut.

Water Quality Stressors

Runoff from developed land, land erosion, and nutrient loading are identified as potential stressors for Shaftsbury surface waters, particularly Paran Creek. Monitoring efforts, stormwater infrastructure mapping, and efforts to develop green stormwater infrastructure are recommended for the creek.

Phase 1 Stream Geomorphic Assessment of the Walloomsac River Watershed in Southwestern Vermont & the Batten Kill Main-Stem and Major Tributaries

The Bennington County Conservation District (BCCD) and Hoosic River Watershed Association (HooRWA) conducted Phase 1 assessments in the Walloomsac River watershed in 2005. This included Furnace Creek, Cold Spring Brook and Paran Creek in Shaftsbury. Warm Brook and Fayville Branch Phase 1 assessments were summarized in a 2004 report on the Batten Kill and its major tributaries by VT DEC, Field Geology Services (FGS), and Bennington County Regional Commission (BCRC).

Table 3.1. Phase 1 SGA reaches and selected attributes in Shaftsbury, VT

Stream	Reach	Reference Stream Type	Confinement Type
Walloomsac River	M02	C	Broad
Cold Spring Brook	M01S1.01	C	Very Broad
	M01S1.02	C_b	Very Broad
Cold Spring Brook Tributary	M01S1.01S1.01	C_b	Very Broad
Paran Creek	M02T1.03	C	Very Broad
	M02T1.04	C	Very Broad
	M02T1.05	C	Very Broad
Furnace Creek	M05T2.04	C_b	Very Broad
	M05T2.05	C	Very Broad
Warm Brook	T2S1.03	E	Very Broad
	T2S1.04	C_b	Very Broad
Fayville Brook	T2S1S1.04	C	Very Broad
	T2S1S1.05	B	Very Broad
Fayville Brook Tributaries	T2S1S1S2.01	C	Very Broad
	T2S1S1S2.02	C_a	Very Broad
Warm Brook Tributaries	T2S1S2.01	C_b	Very Broad
	T2S1S3.01	E	Very Broad
	T2S1S3.02	C_a	Very Broad
	T2S1S3.03	C	Very Broad

Structex Culvert Records

Trout Unlimited and Vermont Fish & Wildlife completed culvert assessments in 2017 following the Vermont Bridge and Culvert Assessment Protocol (2009) for 87 structures in Shaftsbury in both the Walloomsac and Batten Kill watersheds. The data are available on the VTANR Stream Geomorphic Assessment Tool website (https://anrweb.vt.gov/DEC/SGA/datasets/structures.aspx). Useful parameters included in this dataset include stream bankfull width, structure dimensions, and presence or absence of scour at the structure. We will review structure sizing and geomorphic compatibility to guide where our field survey work should focus on stream culverts.

VTDEC Hydrologically Connected Road Segment Data

VTDEC created a statewide inventory of roads that are likely to be hydrologically connected to surface waters. The road network was split into 100-meter segments and then checked for proximity to surface waters and river corridors. Variables including road slope, adjacent hill slope, and soil erodibility were used to create a preliminary "road erosion risk rank". These ranking provide a good starting point for identifying areas of potential sediment generation from erosion of road surfaces and ditches. Road erosion risks are predicted to be low along low-gradient paved roads near the Bennington town line; moderate and high-risk segments become more prevalent along gravel roads in close proximity to streams and in steeper portions of town (see map in Appendix A). There are 716 hydrologically connected road segments in Shaftsbury in the 2018 dataset.

Light Detection and Ranging (LiDAR)

LiDAR returns for Bennington County were collected in a series of flights conducted in the Fall of 2017 as part of the VT LiDAR Initiative. Derivations of LiDAR data, such as Digital Elevation Models (DEMs), terrain models, and contours are useful tools for stormwater feature identification and site design. The 0.7-meter DEM will assist in culvert watershed delineation and the design of stormwater management projects. Terrain models will assist in remote identification of erosion features, such as stormwater gullies.

Town of Shaftsbury Stormwater Infrastructure Mapping Project

The VT Agency of Natural Resources completed infrastructure mapping for the Town of Shaftsbury (VTDEC 2018). The mapping products include drainage maps for 31 subwatersheds, stormwater infrastructure, and potential locations for stormwater BMP retrofits. The retrofit projects are described in detail in the mapping project report. Two priority areas in the report include: 1) a potential infiltration basin near the intersection of Route 67 with Church Street, and 2) a potential infiltration basin along Trailer Park Road just west of Route 7A. FEA will explore these potential projects in detail during our field assessments.

Local Data

Town of Shaftsbury Town Plan

The Town of Shaftsbury completed a Town Plan in 2015. The plan describes efforts to protect surface and ground water. Protection of natural resources with zoning regulations, such as limiting development in areas of important groundwater recharge, is emphasized.

Tropical storm Irene (TSI) hit Vermont on August 28th, 2011 and dumped 3-5 inches of rain throughout the state with localized areas receiving totals from 7-11 inches. This rainfall coupled with high antecedent soil moisture conditions produced flooding that approached or exceeded the historic flood of 1927 in many large basins. While damage in Shaftsbury was limited during TSI, nearby towns experienced severe damage (Figure 3.1).

Figure 3.1: Repairs to washed out wingwall abutment and retaining wall at the outlet of a Route 7 culvert near the Glastenbury-Shaftsbury town line.

Town of Shaftsbury Draft Hazard Mitigation Plan

The Town of Shaftsbury approved its Hazard Mitigation Plan in 2015. In support of flood and flash flood hazard analyses, the plan catalogues significant flood and rainfall events in Bennington County between 1996 and 2013. The plan includes a map of flood hazard areas zones, as well as the locations of impoundments on Shaftsbury surface waters. Recommended flood mitigation actions include developing stormwater management regulations, conducting an inventory of culverts and road ditches, and replacing undersized structures. The area around Old Depot Road is mentioned as an area that may affect flooding and groundwater.

Shaftsbury Culvert Records

BCRC completed bridge and culvert inventories in 2005 and the data were uploaded to the statewide database in 2013 (https://vtculverts.org/). Data from the 2005 inventory included 304 culverts and 32 bridges. The inventory included the structure dimensions and overall conditions but is missing some attributes such as the presence/absence of erosion. We will review the culvert data for overall condition characteristics to refine the selection of non-stream culverts we focus on during field surveys.

Data Gaps

The watershed library describes the available documents, reports, and datasets that characterize stormwater and flooding concerns within the Town of Shaftsbury. The geomorphic field data available for the Walloomsac and Batten Kill tributaries in Shaftsbury predate Tropical Storm Irene and no Phase 2 SGA data assessments were conducted on these reaches. A full Phase 2 SGA may not be appropriate for these sections; however, additional data collection for stormwater concerns would be beneficial. Jim Henderson

of BCRC has indicated that he will advocate for the Town updating the culvert inventory to account for changes in the protocol and to have a more up-to-date record.

4.0 Road Erosion Inventories

The new Municipal Roads General Permit (MRGP) requires a Road Erosion Inventory (REI) be conducted on all hydrologically connected (HC) town-maintained roads. FEA conducted road erosion inventories on all HC town-maintained roads and outfalls in the Town of Shaftsbury. In addition to providing a baseline assessment of work required to bring road segments up to the MRGP standard, this assessment allowed for a simultaneous initial assessment of stormwater problem areas throughout the town.

4.1 REI Methods

FEA followed the methods described in the January 2018 MRGP (VTANR). A municipal road segment was determined to be HC if it:

a) was within 100' to a water of the state or wetland;

b) bisected a water of the state or a wetland or a defined channel; or

c) was uphill from, and drained to, a municipal road that bisected a water of the state or wetland, or a define channel.

Stormwater infrastructure mapping was available from VTDEC (Feb. 2018) and was used to locate outfalls draining Town roads. An outfall was determined to be HC if it was located 500 feet or less from a water of the state. In the field, FEA added HC and deleted not HC (NHC) road segments based on observations of hydrologic connectivity. Shaftsbury had a few segments curbed on both sides and several networks of catch basins draining to outfalls, all of which were assessed. FEA visited 3 outfall locations draining town-maintained roads that were identified as HC in the Shaftsbury stormwater infrastructure mapping prepared by VTDEC. There were no HC Class 4 municipal road segments to assess.

4.2 REI Results

Added and Dropped Road Segments and Outfalls

Of the 708 segments in Shaftsbury identified as HC in the June 2018 update to the HC roads layer from VT DEC, 229 (32%) were determined to be NHC based on field observations. Reasons for dropping segments included:

- Mapped roads where the existing road was private.
- Mapped roads where the existing road ended or did not exist.
- Segments that were determined to be NHC based on the MRGP REI criteria.

Overall, the road segments identified as HC in the June 2018 update appeared to be selected conservatively. The features used to select HC segments included potential intermittent streams as well as, mapped river corridors and wetlands; however, these features were not always observed in the field. As observed on Mountain View Drive, 9 segments were identified as HC that were well over 100 feet from a wetland or stream when observed in the field. Outfalls that ran off into a forest or field over 500 feet from surface waters of the state were also identified as NHC. After field observation, FEA determined that all 3 outfall locations were HC.

Fifty-four (54) segments were added based on field observations of hydrologic connectivity. Generally, these were segments that drained to connected segments via sheet flow over the road or through connected ditch networks.

Number and Condition of Outfalls

Of the three (3) outfalls draining town roads identified from the stormwater infrastructure mapping, only one was assessed for erosion because the other two (Sycamore Lane and Church Street outfalls) could not be located. Figure 4.1 is an image of the located outfall. This outfall was not eroded and fully meets the MRGP standards. While the two other mapped outfall locations had no erosion, they warrant further exploration by the Town as there was evidence they may be buried under sediment and debris. One site had evidence of recent construction and site grading and the other location was at a very silted in depression.

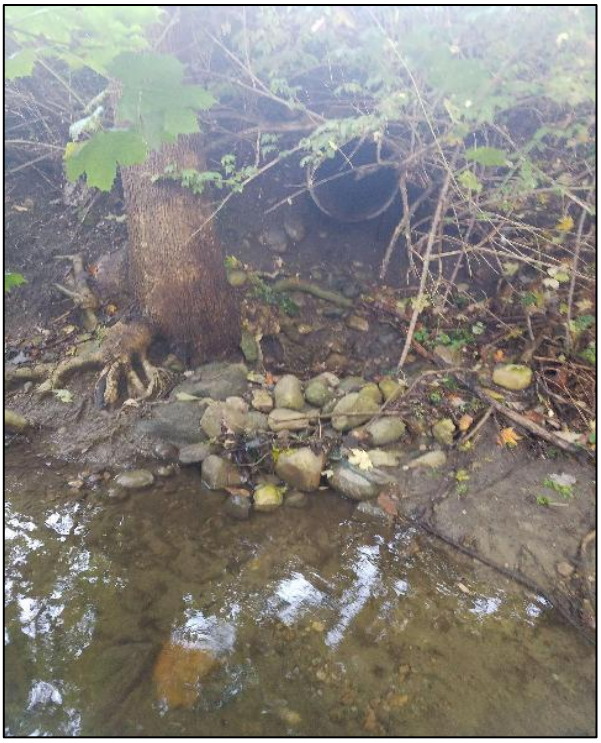

Figure 4.1: An outfall near Bank Street that "Fully" the meets REI standards.

MRGP Standards

An overview of the MRGP standards compliance of the HC segments covered in the inventory is presented below. Any municipal road segment that scored a "Does Not Meet" or a "Partially Meets" will have to be upgraded to meet MRGP standards. Any road segment that scored a "Fully Meets" needs to be consistently maintained to continue to meet MRGP standards. Figure 4.2 summarizes the MRGP compliance of the HC road segments in Shaftsbury. Examples of segments that fully meet, partially meet, and do not meet are presented in Figure 4.3.

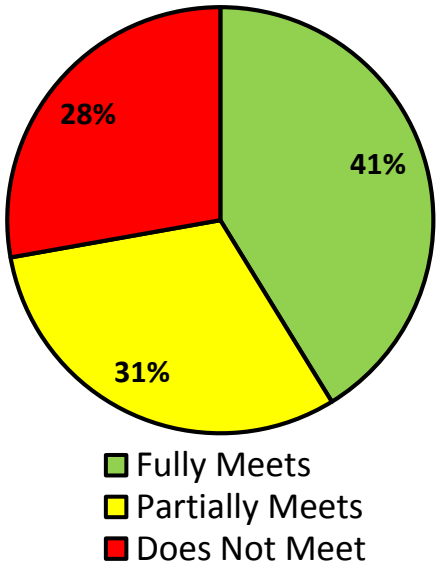

Figure 4.2: Standards compliance of HC road segments in Shaftsbury based on the MRGP (VT ANR 2018).

Prioritization of Road Segments

While the Town has some flexibility in deciding how and when to address road segments that "Do Not Meet" or "Partially Meet" the MRGP standards, these segments will need to be brought up to the standards unless an exemption to minimize disturbance of resources is granted. These exemptions include road

work that would disturb wetlands, historic large trees, historic stone walls, and lakeshore vegetation. To aid in the Town's prioritization process, FEA prepared a map showing the highest priority HC road segments to be upgraded to the MRGP standards ("Does Not Meet" with >10% slope) as well as the results of a prioritization method developed by FEA.

The FEA prioritization is based on a concept for categorizing REI data based on each variable's potential impact on stormwater runoff, sedimentation, and overall water quality in adjacent waterways. We organized the data based on water quality processes that indicate sources of sedimentation and transport mechanisms. This approach is similar to other projects in the region to prioritize stormwater and water quality remediation projects (i.e., Critical Source Area analysis). This framework identifies areas with the greatest water quality impacts where there is 1) a source of pollution, and 2) a transport mechanism to move the pollution to nearby waterways, whereby road segments with both source and transport mechanisms have a higher impact rating than those lacking one. A composite score for each hydrologically connected road segment was calculated by weighting scaled Slope, Source, and Transport scores and summing the three components. In the database and mapping, road segments with higher prioritization scores indicate a greater threat to water The FEA prioritization may be viewed as a way to prioritize projects with the greatest potential to benefit water quality within the VT ANR categories. Other variables, such as anticipated costs, should be taken into consideration as the Town selects segments to address.

4.3 REI Discussion

According to the new MRGP REI standards, a "Very High Priority Road Segments" must be upgraded to meet MRGP standards. These highest priority road segments and outfalls to bring up to standards are defined as:

- HC paved and gravel road segments with drainage ditches that score a "Does Not Meet" and have a slope greater than 10% (Upgrade by December 31, 2025)
- HC Class 4 road segments that score a "Does Not Meet" and have a slope greater than 10% (Upgrade by December 31, 2028)
- Outfalls with more than 3 cubic yards of erosion (Upgrade by December 31, 2025)

There are 15 very high priority road segments in Shaftsbury and they are located on gravel roads with drainage ditches. There are no Class 4 roads or outfalls that fall into the highest priority category. The 15 very high priority road segments could benefit from installing stone-lined ditches, flattening grader berms to improve water drainage on the road, and stabilizing conveyances with vegetation.

Overall, 41% of the HC municipal road segments "Fully Meet", 31% "Partially Meet", and 28% "Do Not Meet" the MRGP REI standards. Road segments that did not meet the standards most often lacked drainage ditches, had eroded drainage ditches, or had unstable and eroded conveyances. In some cases, as noted in the database, roadsides lacked the space for a drainage ditch (due to the presence of trees, homes, stone walls, or ledges). These cases may require exemption from the MRGP standards by VTDEC. Common conditions for road segments partially meeting the standards include only one side of the road having adequate drainage (e.g. downslope side sheets off, but upslope side lacks ditch), eroded culvert headers, grader berms that resulted in drainage issues, and a lack of vegetation or stone at conveyances.

Fully Meets

Partially Meets

Does Not Meet

Figure 4.3: Examples of road segments with different levels of MRGP compliance.

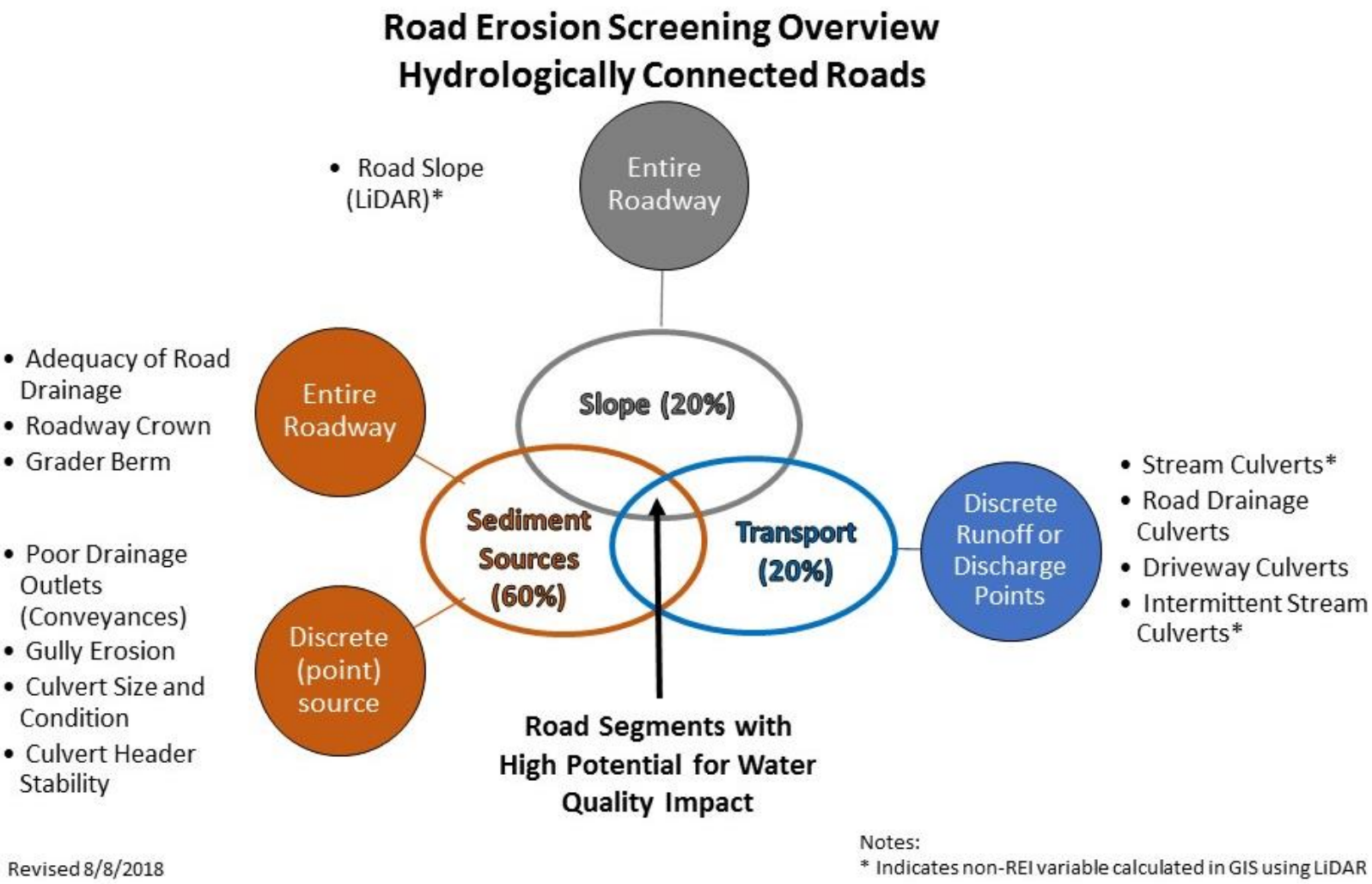

Figure 4.4: Conceptual framework for prioritization of hydrologically connected road segments.

4.4 REI Next Steps

All REI data collected in the Town of Shaftsbury is housed in the VT ANR online database. VT ANR is integrating the REI results in each town into the basic prioritization from the MRGP permit (links to the implementation portal with MRGP status and the first-cut VTANR prioritization are located here: https://anrweb.vt.gov/DEC/IWIS/MRGPReportViewer.aspx?ViewParms=True&Report=Portal). The state has also added the results to the VT ANR Natural Resources Atlas - Municipal Roads Theme for a map view of the results (https://anrmaps.vermont.gov/websites/anra5/). This information can be accessed by the Town to develop a plan for addressing segments that "Do Not Meet" or "Partially Meet" the MRGP standards.

The next step will involve thought from the Town on how to sort the list of road segments that need work, based on MRGP requirements for high priority sites, expected costs, and other factors. In addition to upgrading the "Very High Priority Road Segments", the Town is required to upgrade 15% of non-compliant road segments by January 2023. The segments chosen will be included in an implementation table developed by the Town, outlining a plan for complying with the permit by the December 31, 2036 deadline. To aid in this process, FEA developed a table of the high and very high priority segments identified by VT ANR and the work needed to bring the segments into compliance, which is provided in Appendix C. The prioritization map, data files, and water quality screening provided to BCRC and the Town by FEA in February 2019 may be viewed as further guidance in developing the 20-year plan for the MRGP.

5.0 Stormwater Problem Areas

One of the primary objectives of the SWMP is to "develop a comprehensive list of stormwater problems" within the Town of Shaftsbury. FEA conducted multiple field tours of the project area after the REI was completed to identify existing problem areas, evaluate and prioritize sites, and recommend potential solutions.

5.1 Identification of Problem Areas

The initial round of problem area scoping began with the identification of stormwater related projects using a desktop exercise scanning the watershed with aerial imagery, NRCS soils data, VTDEC stormwater infrastructure mapping, contour data, and road erosion risk in a GIS. Potential project areas were identified and mapped for review during site visits. Sites identified during road erosion inventories as potential stormwater problem areas were revisited during field tours. A total of 49 stormwater problem areas were identified and assessed in the field (see map in Appendix A and table in Appendix B). We grouped the problem areas into three (3) project categories described below.

- **BMP Installation, Repair, or Retrofit –** Sites were identified where runoff and associated sediment and nutrient loads could be reduced through the implementation or retrofit of stormwater best management practices in areas of concentrated surface runoff or stormwater drainage infrastructure.
- **Road, Ditch, Culvert, or Conveyance Stabilization/Improvement –** Potential areas of sediment and nutrient loading from the erosion of roads and their associated Town infrastructure were identified during field visits. Runoff and erosion projects were identified in many areas where

runoff from steep roads (typically gravel) was causing increased sediment and nutrient loading due to ditch erosion.

- **Culvert Replacement –** Ten (10) Town culverts, mainly draining first order and intermittent streams, were analyzed for hydraulic capacity. Runoff volumes for different design storms (e.g., 2-year 24-hour rainfall) were modeled for each crossing using standard rainfall-runoff methods to recommend appropriate replacement culvert sizing.

5.2 Evaluation and Prioritization of Problem Areas

The 49 projects described in Appendix B were prioritized based on the potential for each project to reduce impacts on water quality and Town infrastructure. The prioritization considered the potential reduction of nutrient and sediment inputs to surface waters, landowner support for the project, operation and maintenance requirements for the recommended project, cost and constructability of the project, and additional benefits associated with implementation of the project.

GIS-based Site Screening

Using the field data points collected with sub-meter GPS during our watershed tours, we evaluated key characteristics for each site indicating the potential for increased stormwater runoff and pollutant loading, among several other factors described below. These GIS-based observations, along with field-based observations of site characteristics, are summarized in the Appendix B table under the "Problem Area Description" column.

The following geospatial data were reviewed and evaluated as part of the GIS-based screening:

- **Aerial Photography** – We used the 0.5 m 2015 imagery collected for Bennington County and 0.6 m 2016 NAIP imagery to review the site land cover characteristics (i.e., forest, grass, impervious) and measure the total impervious area in acres draining to the project area as identified in the field.
- **NRCS Soils** – We used the Bennington County Soils data to evaluate the inherent runoff and erosion potential of native soil types (i.e., hydrologic soil group, erodible land class). For project sites with potential for green stormwater infrastructure (GSI), we assessed the general characteristics of the proposed BMP area using hydrologic soil group (HSG) to recommend a stormwater treatment practice most likely to be compatible with the soil's infiltration capacity.
- **Parcel Data** – We used the parcel data available through VCGI to scope the limits of potential projects based on approximate parcel boundaries and road right-of-way.
- **VTDEC Stormwater Infrastructure Mapping** – We used maps completed by VTDEC in 2018 to locate outfalls and other drainage features as well as determine drainage areas and flow paths of stormwater features.
- **VTDEC Hydrologically Collected Road Segment Data –** We used a statewide inventory of road erosion risk and hydrologic connectivity of road segments, updated with information collected during the Road Erosion Inventory, to prioritize areas of potential sediment loading to visit for field surveys.

The stormwater problem areas identified during field tours of the study area were assigned several numerical scoring metrics that are weighted to assist in prioritizing each project based on water quality benefits, project feasibility, maintenance requirements, costs, and any additional benefits. The maximum possible score is 30 and the individual site scores ranged from 9 to 19 (Figure 5.1). Each category is described below and includes a description of the scoring for each criterion. Final evaluation criteria summarized in the table in Appendix B included the overall prioritization and the following components of the score:

- **Water Quality Benefits (15 points total)**
  - **Nutrient Reduction Effectiveness (4 points)** – Degree of nutrient removal potential with project implementation, this accounts for both the existing nutrient loads and the removal efficiency and capacity of the proposed treatment. Nutrient loading was quantified based on the watershed size, the land cover types, and percent impervious surfaces, and the effectiveness was based on the treatment efficacy of the potential mitigation options appropriate for the space and location of the treatment area.
    - 0 points – No nutrient source and/or no increased treatment
    - 1 point – Minor nutrient source and/or minor increase in treatment
    - 2 points – Moderate nutrient source with some increase in treatment
    - 3 points – Moderate nutrient source with significant increase in treatment
    - 4 points – Major nutrient source with significant increase in treatment
  - **Sediment Reduction Effectiveness (4 points)** – Degree of sediment removal potential with project implementation, this accounts for both the existing sediment loads and the removal efficiency and capacity of the proposed treatment. Sediment loading was quantified based on the watershed size, the land cover types, and percent impervious surfaces, and the effectiveness was based on the treatment efficacy of the potential mitigation options appropriate for the space and location of the treatment area.
    - 0 points – No sediment source and/or no increased treatment
    - 1 point – Minor sediment source and/or minor increase in treatment
    - 2 points – Moderate sediment source with some increase in treatment
    - 3 points – Moderate sediment source with significant increase in treatment
    - 4 points – Major sediment source with significant increase in treatment
  - **Drainage Area (1 point)** – Approximate drainage area to site is greater than 2 acres
  - **Impervious Drainage (3 points)**– Approximate area of impervious surfaces draining to the site.
    - 0 points – Area of impervious surfaces is less than 0.25 acres
    - 1 point – Area of impervious surfaces is 0.25-0.5 acres
    - 2 points – Area of impervious surfaces is 0.5-1.0 acres
    - 3 points – Area of impervious surfaces is >1.0 acres
  - **Connectivity to Surface Waters (3 points)**
    - 0 points – All stormwater infiltrates on site
    - 1 point – Stormwater receives some treatment before reaching receiving waters
    - 2 points – Stormwater drains into drainage infrastructure that directly outlets to receiving waters (assumes no erosion or additional pollutant loading to discharge point)

        - 3 points – Stormwater drains directly into receiving waters (typically stormwater draining directly into a large wetland is assigned 2 points)
- **Landowner Support (2 points)**
    - 0 points – Project is located on private property, no contact with landowner
    - 1 point – Project is on Town or State property with no contact
    - 2 points – Project has been discussed and is supported by landowner
- **Operation and Maintenance Requirements (2 points)**
    - 0 points – Project will require significant increased maintenance effort
    - 1 point – Project will require some increased maintenance effort
    - 2 points – Project will require no additional maintenance effort
- **Cost and Constructability (6 points) –** This score is based on the overall project cost (low score for high cost) and accounts for additional design, permitting requirements, and implementation considerations, such as site constraints and utilities, prior to project implementation.
- **Additional Benefits (5 points total) –** Description of other project benefits, total score is roughly a count of the number of additional benefits. Additional benefits considered in the prioritization are as follows:
    - **(1) Chronic Problem Area** – The site requires frequent maintenance and/or is an ongoing problem affecting water quality
    - **(2) Seasonal Flooding** – The site is affected by or contributes to seasonal flooding
    - **(3) Educational** – The site provides an opportunity to educate the public about stormwater treatment practices
    - **(4) High Visibility** – The site is highly visible and will benefit from aesthetically designed treatment practices
    - **(5) Infrastructure Conflicts** – The stormwater problem area is increasing erosion or inundation vulnerability of adjacent infrastructure (i.e. roads, buildings, etc.)
    - **(6) Drains to Connected Stormwater Infrastructure** – The site drains into a larger stormwater conveyance system that is less likely to receive downstream treatment
    - **(7) Reduces Thermal Pollution** – Project implementation will reduce the risk of thermal loading from runoff to receiving surface waters
    - **(8) Improves BMP Performance** – Project implementation will improve the performance of existing stormwater treatment practices that receive runoff from the site
    - **(9) Peak Flow Reduction** – Project implementation will significantly reduce stormwater peak flows leaving the site

Figure 5.1: A damaged drainage culvert on Potter Montgomery Road had the lowest individual score (DC-3). A chronic problem area for erosion along Cross Hill Road (RD-10) was tied for the highest problem area score.

Problem area summary sheets were developed for 33 of the highest-priority project sites, and are provided in Appendix D. The summaries include a site map and description, site photographs, description of the proposed practice, prioritization criteria, and an initial cost range. Problem areas and prioritization strategies were discussed and refined with input from representatives of BCRC and the Town of Shaftsbury.

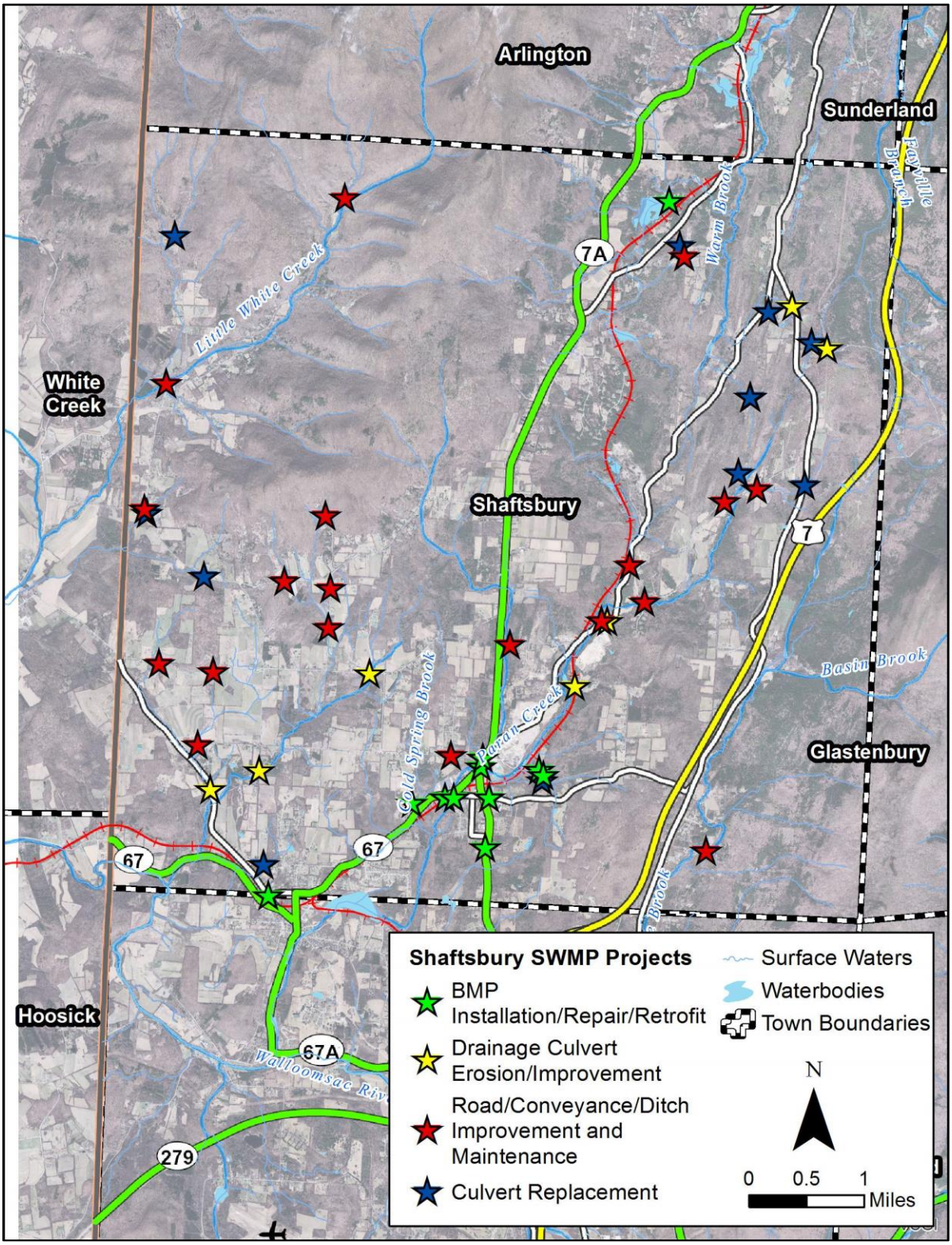

Figure 5.2: Stormwater Problem Area Overview Map. See large map in Appendix A for greater detail.

5.3 Project Prioritization and Conceptual Designs

The Shaftsbury SWMP partners reviewed and commented on the list of preliminary projects during various meetings and email correspondences. A total of 49 projects are described in the SWMP, and a subset of projects were discussed for further development. Based on stakeholder input five (5) projects were chosen for 30 percent conceptual design development.

Figure 5.3: Collection of high resolution GPS data along Route 7A.

30% Concept Designs

Five (5) projects were selected for 30% concept designs (Appendix E). Additional survey data was collected at each site and hydrologic models were utilized to estimate runoff volumes and inform BMP design and sizing (Figure 5.3). Conceptual designs include:

- A site plan with contours, existing stormwater infrastructure, and proposed design elements
- Where relevant, hydrologic and hydraulic modeling data of the contributing drainage area and proposed BMP sizing and design specifications
- Typical details for proposed practices
- A preliminary cost opinion

The projects chosen for 30% conceptual design were:

1. **Projects SW-9 & SW-10: Howard Park Infiltration and Constructed Wetland –** Runoff from Howard Park Road and the gravel parking lot drains to a stream to the south and a grassy area to the north adjacent to the tennis court where there is space for a stormwater treatment practice. In the grassed swale south of the soccer field, water from the artesian well overflow pools and causes maintenance issues.
2. **Project RD-8: Trumbull Hill Road Drainage Improvement –** An approximately 1,200-foot stretch of road lacks adequate drainage, causing the formation of a secondary ditch on the north side of the road that extends west to Paran Creek.

3. **Project C-6: Murphy Hill Road Culvert Replacement –** The culvert headers are eroding, with severe erosion of the road embankment and downstream channel at the culvert outlet. Hydraulic modeling shows the culvert is undersized.
4. **Project DC-7: Rollin Road Culvert/Gully Stabilization –** This culvert has severe header and outlet gully erosion. This erosion continues for 85 feet to a nearby stream.
5. **Project SW-1: Stormwater Improvements near the Route 7A - Daniels Road Intersection –** The area near the intersection of Route 7A and Daniels road has substantial impervious cover and a high groundwater table. A nearby tributary to Paran Creek shows signs of sedimentation from nearby gravel shoulders and parking areas. We evaluated opportunities to reduce the stormwater sediment and nutrient loads in this area.

6.0 Next Steps

This Stormwater Master Plan represents an extensive effort to identify, describe, and evaluate stormwater problem areas affecting Shaftsbury, Vermont. For each project recommendation, we provided a preliminary cost estimate and a site rating to aid the BCRC and the Town of Shaftsbury in planning and prioritizing restoration efforts. Many of the problem area descriptions (e.g., roadside ditches) will aid the Town Highway Department in proactively stabilizing and maintaining these features to avoid future stormwater problems, and to come into compliance with the VTANR Municipal Roads General Permit.

We recommend that BCRC works with the Town, VTDEC, and BCCD to secure funding for the high priority projects described in Appendices B, D, and E. Based on the level of scoping and design work already completed to date, overall project prioritization, and past stakeholder input, we recommend that the following projects are prioritized for further work in the near term.

- Howard Park Projects, SW-9 & SW-10 (30% design already complete)
- Trumbull Hill Road Project, RD-8 (30% design already complete)
- Murphy Hill Road Culvert Project, C-6 (30% design already complete)
- Rollin Road Drainage Culvert/Gully Stabilization (30% design already complete)

In addition to addressing the problem areas identified in this document, the Town can take steps to reduce future stormwater problems through planning and zoning regulations. Stormwater best management strategies and other planning and zoning regulations may be applied to existing and future growth to reduce the risk of stormwater runoff conflicts and nutrient and sediment loading to receiving waters.

Finally, though 9 projects were selected as high-priority based on selected criteria (Total score of 16 or higher), the other identified projects (and any additional new problem areas that develop over time) are also important and should be remediated as time and resources permit.

7.0 References

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