Stormwater Master Plan
Town of Sunderland, Vermont

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1.0 Introduction

The Town of Sunderland is situated on the Western slopes of the Green Mountains. The mountains and valleys in most of the Town east of the Route 7 corridor are well forested with very limited roadways and development. Much of the Town drains to the Batten Kill and its tributaries, including the Roaring Branch, Warm Brook, and Lye Brook. These streams mainly begin to the east in high-elevation wetlands in the Green Mountain National Forest, which occupies 75% of the Town. The Town of Sunderland is predominantly forested with areas of low-density residential and agricultural land use. As with most mountain-valley villages of rural Vermont, stormwater concerns are typically related to road washouts and localized erosional areas. Since 1990, the Town of Sunderland has experienced nine moderate floods and one extreme flood, some of which have caused severe damage to private and public land and infrastructure from fluvial erosion and stormwater runoff. The most recent event, Tropical Storm Irene in August 2011, caused widespread damage in southern Vermont, including the Town of Sunderland.

In summer 2016, the Bennington County Regional Commission (BCRC) received a grant from the Vermont Agency of Natural Resources (Ecosystem Restoration Program) to develop a Stormwater Master Plan (SWMP) for the Town of Sunderland. Fitzgerald Environmental Associates, LLC (FEA) was hired by BCRC in the fall of 2016 to develop the plan. The Sunderland SWMP follows the VTANR SWMP guidelines and was developed over the course of 2016 and 2017 through extensive field survey work, interaction with multiple stakeholders in the Town of Sunderland to prioritize projects, and follow-up analysis and design work.

1.1 Project Background

Stormwater runoff is generated any time rain or melting snow 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 runoff from these areas can exceed the capacity of natural hydrologic systems leading to erosion, flooding, and degradation of downstream receiving water bodies. 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.

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. The Roaring Branch/Batten Kill Corridor Plan (FGS, 2007) and Batten Kill, 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, a detailed culvert assessment completed with a follow-up in progress by the Bennington County Regional Commission (BCRC), meetings with stakeholders in Sunderland, 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 Sunderland. Best

Management Practices (BMPs) are suggested to mitigate stormwater problem areas contributing to infrastructure vulnerability and degradation of water quality in the watershed.

1.2 Project Goals

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 Batten Kill or its tributaries. The SWMP for Sunderland follows template 3b of the Vermont Stormwater Master Planning Guidelines with a focus on rural roads (VTDEC, 2013). The project tasks were to identify stormwater problem areas throughout the Town, develop one-page summary sheets for approximately 30 projects, complete detailed subwatershed mapping as needed for problem sites, and develop conceptual designs for five (5) high-priority projects.

The Sunderland Town Plan includes encroachment on the river corridor and flood vulnerability as primary concerns for protecting water quality and infrastructure. The Plan lists management and protection of important floodplains and channel meanders, regulations on development in river corridors, low impact development incorporating green stormwater infrastructure, and stream crossing upgrades to reduce water quality impacts and improve infrastructure resiliency (Town of Sunderland, 2015). The Town Highway Department has taken a number of steps to address stormwater runoff and water quality concerns by stabilizing ditches and culvert headers throughout the road network.

This SWMP provides Town officials and stakeholders with a list of high priority stormwater problem areas and conceptual solutions, which will support the development and implementation of future mitigation and restoration projects to improve water quality and reduce stormwater runoff impacts in Sunderland.

2.0 Study Area Description

Sunderland is a 45.6 square mile town located in Bennington County in the southwestern corner of Vermont (Figure 1). Sunderland is bordered by 8 towns (Sandgate, Manchester, Winhall, Stratton, Somerset, Glastenbury, Shaftsbury, and Arlington). The Batten Kill flows through the northwest corner of Sunderland, and most of the Town is drained by tributaries to the Batten Kill, including the Roaring Branch, Warm Brook, and Lye Brook. The Town has a total population of 956 as of the 2010 Census (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 1. The Town of Sunderland is primarily drained by rural watersheds, with forests representing the dominant land cover type. Agricultural lands, primarily as pasture land and hay fields, cover 2.1% of the Town with a majority of the farmlands found along the Sunderland Hill

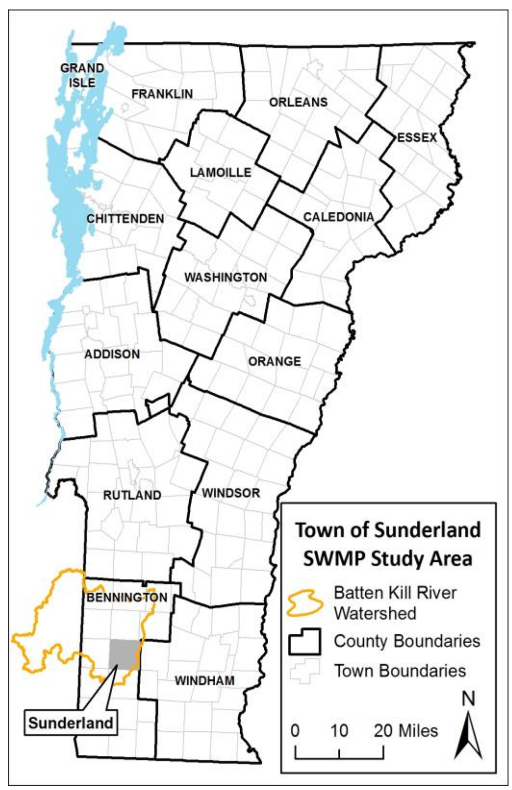

Figure 1: Town of Sunderland and Batten Kill watershed location map.

Table 1: Land cover in Sunderland.

Land Cover/Land Use Type	% of Town
Agriculture	2.1
Developed	2.7
Forest	83.5
Open Water	0.4
Shrub/Scrub	1.1
Grassland/Herbaceous	0.1
Wetland	9.9

Road corridor. Development is low throughout the Town (1.8%) and is mainly concentrated on the western side of the Route 7 corridor, near the Arlington-Sunderland border. There are 55 miles of roads within the Town, over half of which are Town maintained (Table 2). Kelley Stand Road running from Sunderland into Stratton is a very unique road; it is a Town maintained Class 2 gravel road through the National Forest and most of the road is closed in the winter.

Table 2: Road length by AOT class in Sunderland.

AOT Class	Description	Length (miles)	% of Town Road Length
2	Class 2 Town Highway	15.1	27.6
3	Class 3 Town Highway	13.8	25.2
4	Class 4 Town Highway	1.6	2.9
6	National Forest Highway	3.9	7.1
8	Private Road	9.2	16.8
30	State Highway	2.8	5.1
40, 45	US Highway	8.4	15.3

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 Sunderland. This section summarizes available documentation and other potential sources of information we explored. Much of this information is from previously completed studies in Sunderland or its associated watersheds, but also includes data sources discussed during a SWMP steering committee meeting on October 20rd, 2016. Other potential sources of data and data gaps are also addressed.

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. Sunderland surface waters include Bourn Brook, Lye Brook, and Mill Brook, Batten Kill tributaries which originate in the higher elevations of Sunderland, as well as the Roaring Branch and the Batten Kill mainstem. Overall the water quality in Sunderland is good to excellent based on data collected by VTDEC over the last 10 years.

Ecological Condition

The Basin Plan summarizes streams and waterbodies with notable in ecological significance in the watersheds. The Roaring Branch and Batten Kill are designated by Vermont Department of Fish and Wildlife as Very High Quality spawning and nursery tributaries for trout, and the Batten Kill is designated as a Very High Quality stream for supporting significant wild trout populations. Bourn Pond and Branch Pond are identified as Very High Quality based on Vermont DEC criteria, including wilderness status and the presence of rare species.

Water Quality Stressors

Non-point source pollution from gravel roads is identified as a potential stressor for Sunderland surface waters. Basin-wide restoration recommendations include riparian buffer plantings, agricultural BMP implementation in fields with high erosion risk, and identifying opportunities for dam removals and retrofits.

<u>Roaring Branch/Batten Kill Corridor Plan</u>

Field Geology Services prepared the Roaring Brach/Batten Kill Corridor Plan for the Vermont Department of Environmental Conservation in in 2007 (FGS, 2007). Highlights from the Corridor Plan relevant to recent flooding and stormwater runoff in the watershed are summarized below.

Flood Damage

The Roaring Branch/Batten Kill Phase 2 assessments were conducted prior to Tropical Storm Irene. However, berms constructed in response to flooding in 1973 and older berms that may have been constructed in response to early 20th century flooding were identified in the Corridor Plan. These berms were found along lower reaches of Batten Kill tributaries, such as the Roaring Branch.

Hydrologic and Sediment Regime Stressors

The Corridor Plan includes maps of stressors on the hydrologic and sediment regimes of the Batten Kill and Roaring Branch based on data collected during the Phase 2 Stream Geomorphic Assessments between 2000 and 2005. These maps provide a means for linking the effects of increased stormwater runoff (i.e., gullying, severe channel sedimentation) to known stormwater problem areas in upslope watersheds. The hydrologic regime stressors identified in the Corridor Plan include areas of locally high road densities at the subwatershed level and wetland loss. The sediment regime stressors identified in the Corridor Plan include areas of higher densities of depositional and migration features in the channel such as bar features and flood chutes, identified at the reach-scale.

Overall Stream Stability and Habitat Conditions

A summary of the geomorphic and habitat conditions is provided below in Table 3. Overall the stream conditions are fair to good for those river reaches assessed in more detail in the field. Where the Batten Kill flows through Sunderland, the conditions are fair due to channel alterations and widening with stretches of good conditions where the river has maintained or regained natural meanders. In the lower reaches of Fayville Brook and the Roaring Branch, the conditions are fair mainly due to channel degradation which has resulted in several stream type departures.

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 100m 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 Arlington; moderate and high-risk segments become more prevalent along gravel roads in close proximity to streams and in steeper portions of town.

Light Detection and Ranging (LiDAR)

LiDAR data for Bennington County were collected in a series of flights conducted in the Spring of 2012 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 2-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.

Table 3. SGA reaches and selected attributes in Sunderland, VT

Stream	Reach	Reference Stream Type	Existing Stream Type	Confinement Type	Habitat Condition	Geomorphic Condition	Notes
Fayville Brook	T2S1S1.02A	B	B	-	-	Good	Bedrock Gorge
	T2S1S1.02B	C	F	Narrow	Fair	Fair	
	T2S1S1.03	C	C	Broad	Good	Fair	
	T2S1S1.04*	C	-	Very Broad	-	-	
Fayville Brook Trib.	T2S1S1S1.01*	C_a	-	Very Broad	-	-	
Roaring Branch	T2.03A	C_b	C	Very Broad	Good	Fair	
	T2.03B	C_b	F	Broad	Good	Fair	
	T2.03C	A_b	A_b	-	-	Good	Bedrock Gorge
	T2.03D	C_b	F_b	Broad	Good	Fair	
	T2.04A	C	F	Very Broad	Good	Fair	
	T2.04B	D_b	D_b	-	-	Fair	Alluvial Fan; Braiding
	T2.04C	D_b	F_b	Very Broad	Fair	Fair	
	T2.05	C_b	C_b	Semi-Confined	Good	Fair	
	T2.06*	B_a	-	Narrow	-	-	
	T2.07*	B	-	Narrow	-	-	
	T2.08*	C_b	-	Very Broad	-	-	
S. Fork Roaring Branch	T2S2.01*	B_a	-	Broad	-	-	
Batten Kill	M05A	E	E	Very Broad	Fair	Fair	
	M05B	E	E	Very Broad	Good	Good	
	M05C	E	E	Very Broad	Fair	Fair	
	M05D	E	E	Very Broad	Good	Good	
	M05E	E	E	Very Broad	Fair	Fair	
	M06	E	E	Broad	Good	Good	
	M07	E	E	Very Broad	Good	Good	
Lye Brook	T3.04*	B_a	-	Broad	-	-	
	T3.05*	C	-	Very Broad	-	-	
	T3.06*	D	-	Very Broad	-	-	
Winhall River	T11.11*	C	-	Broad	-	-	

** Phase 1 assessment only*

Local Data

Town of Sunderland Hazard Mitigation Plan

The Town of Sunderland completed a Hazard Mitigation Plan in 2014. In support of flood and flash flood hazard analyses, the plan catalogues significant flood events in Bennington County between 1996 and 2011. The plan includes a map of flood hazard areas and fluvial erosion hazard zones in Sunderland. Tropical Storm Irene landslide locations as well as road and culvert damages in Sunderland are mapped as well.

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. In Sunderland, damage resulting from Tropical Storm Irene was significant, including three houses lost along Kelley Stand Road, which runs parallel to the Roaring Branch (Figure 2).

Figure 2: Washout along Kelley Stand Road after Tropical Storm Irene. Photo courtesy of BCRC.

Sunderland Culvert Records

The Town of Sunderland completed bridge and culvert inventories in 2009, and a follow-up inventory is currently being conducted by Jim Henderson of Bennington County Regional Commission (BCRC). Data from the 2013 inventory included 277 culverts and 4 bridges. The 2013 inventory included the structure dimensions but is missing several key attributes including overall culvert condition and presence/absence of erosion. The inventory included 57 culverts that have a diameter less than 18 inches, indicating they may be hydraulically undersized depending on the upslope drainage area.

Data Gaps

The watershed library describes the available documents, reports, and datasets that characterize stormwater and flooding concerns within the Town of Sunderland. The geomorphic field data available for the Batten Kill and its tributaries through Sunderland were collected prior to Tropical Storm Irene. A full Phase 2 SGA may not be appropriate for these sections; however, additional data collection for stormwater concerns would be beneficial. Biomonitoring data is relatively sparse for the town and primarily was collected before Tropical Storm Irene. Additional sampling effort in the Batten Kill and smaller streams that may be affected by sedimentation from gravel roads would be helpful for tracking water quality changes over time.

4.0 Stormwater Problem Areas

One of the primary goals of the stormwater master plan is to "develop a comprehensive list of stormwater problems" within the Town. FEA conducted four (4) field tours of the project area and met with Marc Johnston (Town Road Foreman) and with Jim Henderson (BCRC) to identify existing problem areas, evaluate and prioritize sites, and recommend potential solutions.

4.1 Identification of Problem Areas

The initial round of problem area identification began with a desktop exercise scanning the watershed with imagery, NRCS soils data, and high-resolution LiDAR contours and hillshade in a GIS. Meetings with Town officials including tours with the Town Highway Foreman were conducted in the spring of 2017. A detailed watershed tour was conducted on two subsequent field visits by FEA staff to identify the remaining stormwater problem areas. A total of 28 stormwater problem areas were identified and assessed in the field (Figure 3, see detail map in Appendix A and table in Appendix B). We grouped the problem areas into five (5) categories described below.

- **C -** Seven (7) 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 check for appropriate culvert sizing.

- **DC** - Drainage culvert projects were identified in 2 locations where maintenance practices or stormwater runoff and associated sediment loads at cross-culverts located under Town maintained roads were deemed problematic.

- **RD** – Twelve (12) Roadside ditch projects were identified, typically along steep sections of Town maintained gravel roads. Ditches may convey large volumes of sediment to receiving surface waters, especially if the ditch is eroding, or filling in causing water to run across the road surface.

- **SC** – Three (3) stream crossing projects were identified where a perennial stream crosses under a Town maintained road. These sites were assessed for culvert capacity and for the ease of Aquatic Organism Passage. Runoff volumes for different design storms (e.g., 2-year 24-hour rainfall) were modeled for each project using standard rainfall-runoff methods to check for appropriate culvert sizing.

- **SW –** Four (4) stormwater BMP projects were identified in areas where improved maintenance practices and or the construction of stormwater treatment infrastructure could significantly reduce sediment and nutrient loading to receiving waters.

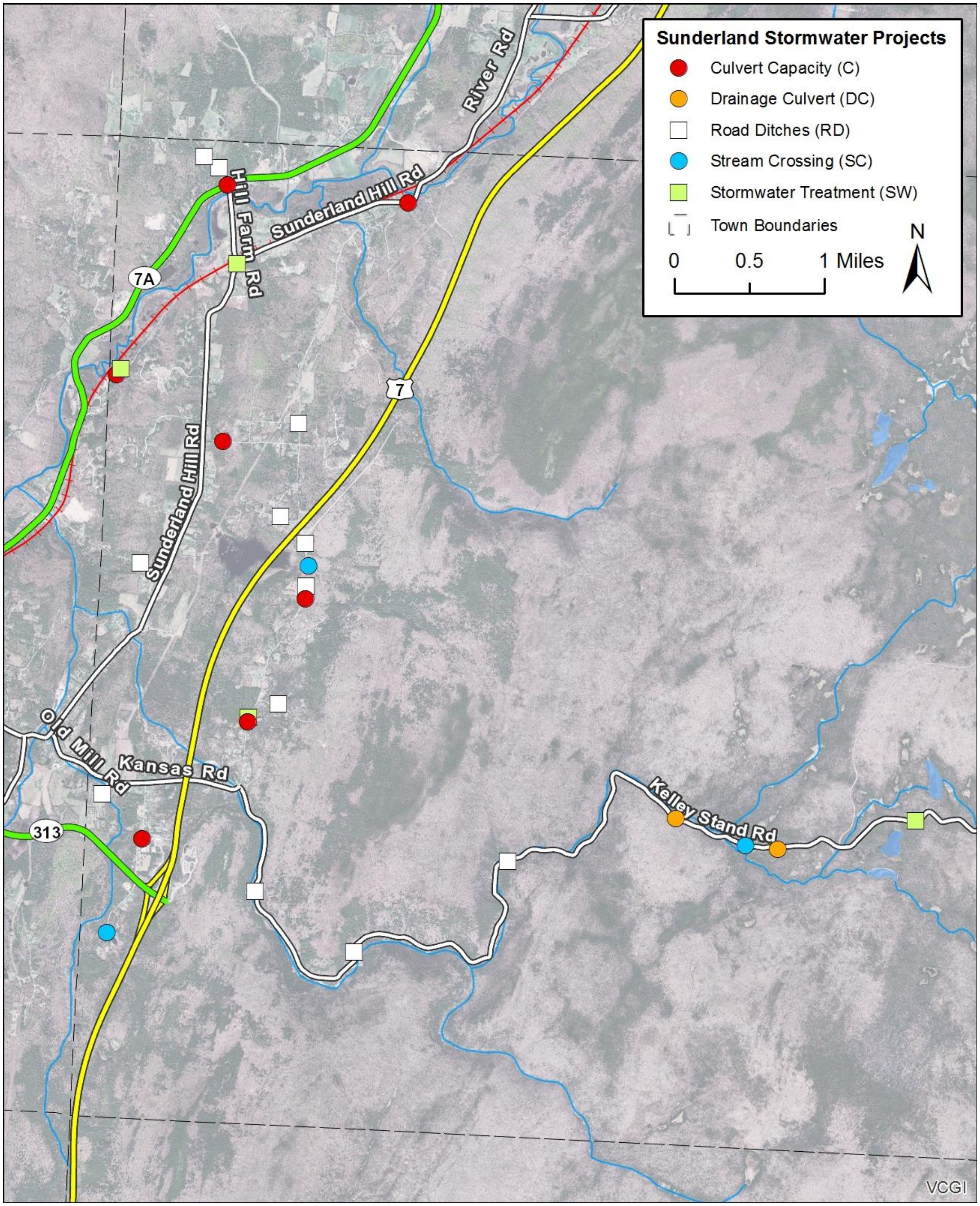

Figure 3: Stormwater problem area overview map, see large map in Appendix A for detail.

4.2 Evaluation and Prioritization of Problem Areas

The 28 projects described in Appendix B were prioritized based on the potential for each project to reduce nutrient and sediment inputs to surface waters, landowner support for the project, operation and maintenance requirements for the project, project cost and constructability, 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 Appendix B in 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 imagery collected for Bennington and Windham counties in 2015 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 runoff characteristics of the drainage area based on hydrologic soil group (HSG).
- **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 Hydrologically Collected Road Segment Data –** We used a statewide inventory of road erosion risk and hydrologic connectivity of road segments to prioritize areas of potential sediment loading to visit for field surveys.

Prioritization Metrics

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, infrastructure resiliency, project feasibility, maintenance requirements, costs, and any additional benefits. The maximum possible score is 30 and the individual site scores ranged from 10 to 24 (Figure 4). 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 (14 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 (2 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 acres
    - 2 points – Area of impervious surfaces is >0.5 acres
- **Connectivity to Surface Waters (2 points)**
    - 0 points – All stormwater infiltrates on site
    - 1 point – Stormwater receives some treatment before reaching receiving waters
    - 2 points – Stormwater receives minimal treatment before reaching receiving waters
    - 3 points – Stormwater drains directly into receiving waters (typically stormwater draining directly into a large wetland is assigned 2 points)

- **Infrastructure Resiliency/Flood Vulnerability (3 points)** – Reduction in flood vulnerability and/or improvement in infrastructure vulnerability associated with project implementation.
    - 0 points – No change in resiliency or vulnerability
    - 1 point – Some improvement in resiliency or reduced vulnerability, especially in smaller floods
    - 2 points – Project will increase resiliency and/or decrease vulnerability across a range of flood magnitudes
    - 3 points – Project will significantly increase resiliency and decrease vulnerability during large flood events

- **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 (3 points total)** – Description of other project benefits, total score is roughly a count of the number of additional benefits.
  - (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) High Visibility – The site is highly visible and will benefit from aesthetically designed treatment practices
  - (4) Improves BMP Performance – Project implementation will improve the performance of existing stormwater treatment practices that receive runoff from the site
  - (5) Improves Aquatic Organism Passage – Project implementation will improve fish passage through stream crossing structure


Figure 4: The AOP barrier created by a perched 48" culvert along South Road (left) was the lowest scoring projects (SC-2). The extreme erosion along the edges of Barney Orchard Road (right) was the highest scoring project (RD-8).

Hydraulic Analysis

Hydrologic and hydraulic analyses were completed to determine predicted flow volumes and culvert capacity for selected culverts described in the C and SC projects. This process aids in prioritizing potential culvert replacement projects. Culvert drainage areas were delineated using the USGS StreamStats software and contours generated from the LiDAR DEM. Field observations of ditch drainage areas were incorporated into the watershed delineations (drainage areas shown in Appendix A). The dimensions, inlet/outlet configuration, and slope for each culvert were determined in the field using laser surveying equipment. Recurrence interval flow rates were estimated for each culvert using the USGS StreamStats software, which calculates flows based on a statewide regression equation; including drainage area, percentage of wetland cover within the watershed, and total annual precipitation. Culvert capacity was calculated using the Federal Highway Administration HY-8 software. The software calculates headwater depth for each recurrence interval flow and estimates the culvert capacity before the road is overtopped (Table 4). VTrans hydraulic studies were available for the North Road (Cole Brook) and the Dunham Road culverts.

Table 4: Estimated recurrence interval flows and culvert capacity analysis for selected culverts in Sunderland.

		Drainage Area							Discharge (cfs)			
Structure	**Site ID**	**Acres**	**Square Miles**	**Bankfull Width (ft)[1]**	**Culvert Type**	**Culvert Length (ft)**	**Slope (%)**	**Dimensions**	**Q10**	**Q25 (design)**	**Q100 (extreme)**	**Culvert Capacity[2]**
Dunham Road[3]	C-3	355	0.55	10.1	CMP	28	1.0	3' Diameter	65.0	80.0	110.0	41.6
North Road at Cole Brook	SC-1	779	1.22	14.3	CMP	32	6.0	3.5'x5' Squash	202.0	277.0	418.0	115.0
North Road Twin Culverts	C-5	31	0.05	3.5	CPP	36	2.0	1.5' Diameter (2 culverts)	10.6	14.8	23.1	19.0
Sunderland Hill Road	C-2	677	1.06	13.4	CMP	42	4.5	4' Diameter	152.0	209.0	313.0	115.3

[1]Calculated using VTANR hydraulic geometry regressions

[2]Culvert capacity before overtopping road based on HY-8 model

[3]Dunham Road recurrence interval flows are from the VTANR hydraulic study, not StreamStats

4.3 Problem Area Summary Sheets

Problem area summary sheets were developed for each of the 28 projects (Appendix C). The summary sheets include a site map, problem area description, site photographs, a summary of the prioritization categories, and ballpark cost estimates. These sheets were shared with BCRC and Town representatives.

4.4 Project Prioritization and Conceptual Designs

Evan Fitzgerald and Joe Bartlett met with Jim Henderson (BCRC) and Marc Johnston (Sunderland) to review and prioritize the problem areas identified in this document. The following five (5) problem areas were selected for further investigation with conceptual designs provided in Appendix D.

- **C-3:** A small stream crosses under Dunham Road through an undersized culvert. The road washed out in T.S. Irene and severed an important transportation link within the town.
- **RD-1:** A roadside ditch along Bentley Hill Road empties on to the road where a driveway connects to the road without a culvert, significant gully erosion along the road embankment draining directly into a small stream.
- **RD-8:** Extreme ditch erosion along a steep section of Barney Orchard Road is causing significant sediment loading to a small stream.
- **RD-9:** The roadway drainage network along lower Prouty Hill Road is complicated due to a missing driveway culvert, and severe ditch erosion and runoff across the road is causing significant sediment loading to the Fayville Branch.
- **SC-1:** The Cole Brook culvert under North Road is undersized and was the location of significant flooding and roadway damage during T.S. Irene.

5.0 Next Steps

This Stormwater Master Plan represents an extensive effort to identify, describe, and evaluate stormwater problem areas throughout the Town of Sunderland. Many of the problem area descriptions (e.g., drainage culverts and roadside ditches) will aid the Town Highway Department in proactively sizing and constructing these features to avoid future stormwater problems. We provided a preliminary cost estimate and a site rating to aid the Town and other stakeholders in planning and prioritizing restoration efforts.

We recommend that the Town of Sunderland, BCRC and BCCD work together and with VTDEC and VTrans to secure funding for the highest priority projects listed above in Section 4.4 and described in detail in Appendix D. The remaining stormwater problem areas summarized in Section 4.3 and Appendices B and C could be prioritized based on their overall impact and programmed for funding in the future. 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 as described in the Town Plan (Town of Sunderland, 2015). Many of the problem areas covered in this document are representative of typical issues encountered on gravel roads (i.e., stone lining ditches, culvert sizing, ditch maintenance) in steep watersheds. The recommended practices to address these issues should be applied to future projects to reduce the risk of stormwater runoff conflicts and sediment loading to receiving waters.

6.0 References

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