Stormwater Master Plan
Town of Sandgate, Vermont

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1.0 Introduction

The Town of Sandgate is situated within the steep mountains of the Taconic Range. The mountains, especially in the eastern and northern portions of the Town are densely forested with very limited roadways and development. The Town of Sandgate is entirely drained by Batten Kill tributaries, including the Green River and its tributaries, Chunks Brook, Sandgate Brook, and Terry Brook. These streams mainly begin to the east and north of the village and find their way into idyllic, wide valleys where the land has been in agricultural use for over two centuries. The Town of Sandgate 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 1996, the Town of Sandgate has experienced eight 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 Sandgate.

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 Sandgate. Fitzgerald Environmental Associates, LLC (FEA) was hired by BCRC in the fall of 2016 to develop the plan. The Sandgate 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 Sandgate 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 Batten Kill Corridor Plan (FGS, 2007), the White Creek and Mill Brook Corridor Plan (FEA, 2013), 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 by the Bennington County Regional Commission (BCRC), meetings with stakeholders in Sandgate, 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 Sandgate. 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 Sandgate 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 Sandgate Town Plan includes stormwater runoff and flood vulnerability as primary concerns for protecting water quality and infrastructure. It lists low impact development incorporating green stormwater infrastructure, stream crossing upgrades, and gravel road maintenance as specific opportunities to reduce water quality impacts and improve infrastructure resiliency (Town of Sandgate, 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 Sandgate.

2.0 Study Area Description

Sandgate is a 42.3 square mile town located in Bennington County in the southwestern corner of Vermont (Fig. 1). Sandgate is bordered by 5 towns in Vermont (Rupert, Dorset, Manchester, Sunderland, and Arlington) and 1 in New York (Salem). The Town is entirely drained by Batten Kill tributaries, with the 30.4 square mile Green River watershed draining approximately half of Sandgate. The Town has a total population of 405 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 Green River and the Town of Sandgate as a whole are drained by a rural watershed, with forests representing the dominant land cover type. Agricultural lands, primarily as pasture land and hay fields, cover 3.2% of the Town, with a majority

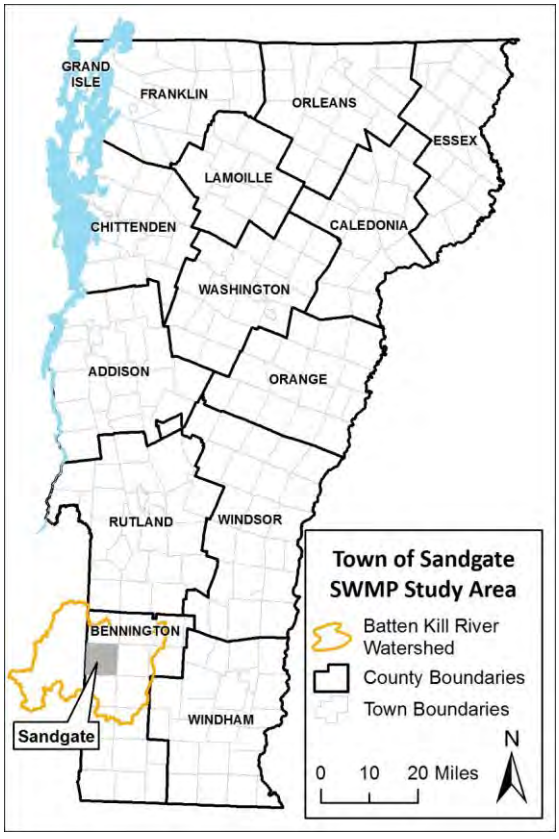


Figure 1: Town of Sandgate and Batten Kill watershed location map.

Table 1: Land cover in Sandgate.

Land Cover/Land Use Type	% of Town
Agriculture	3.2
Developed	1.6
Forest	93.9
Open Water	0.1
Shrub/Scrub	0.6
Grassland/Herbaceous	0.1
Wetland	0.5

of the farmlands found along the Sandgate and West Road corridors. Development is low throughout the study area (1.6%). There are 46.9 miles of roads in Sandgate (Table 2), made up of town highways (71.6%) and private roads (28.4%).

Table 2: Road length by AOT class in Sandgate.

AOT Class	Description	Length (miles)	% of Town Road Length
2	Class 2 Town Highway	7.5	16.0
3	Class 3 Town Highway	22.3	47.5
4	Class 4 Town Highway	3.8	8.1
8 & 9	Private Road	13.3	28.4

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 Sandgate. This section summarizes available documentation and other potential sources of information we explored. Much of this information is from previously completed studies in Sandgate or its associated watersheds, but also includes data sources discussed during a SWMP steering committee meeting on October 3rd, 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. Sandgate surface waters include the Batten Kill tributaries Green River and Chunks Brook and the White Creek tributary Sandgate Brook. Overall the water quality of the streams in Sandgate 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 Green River is designated as very high quality by the Vermont Department of Fish and Wildlife for trout population densities. The ecological integrity of two Sandgate streams,

Chunks Brook and the Green River, was rated as exceptional based on macroinvertebrate surveys collected in 2007 (Green River), 2008 (Chunks Brook), and 2013 (Green River).

Water Quality Stressors

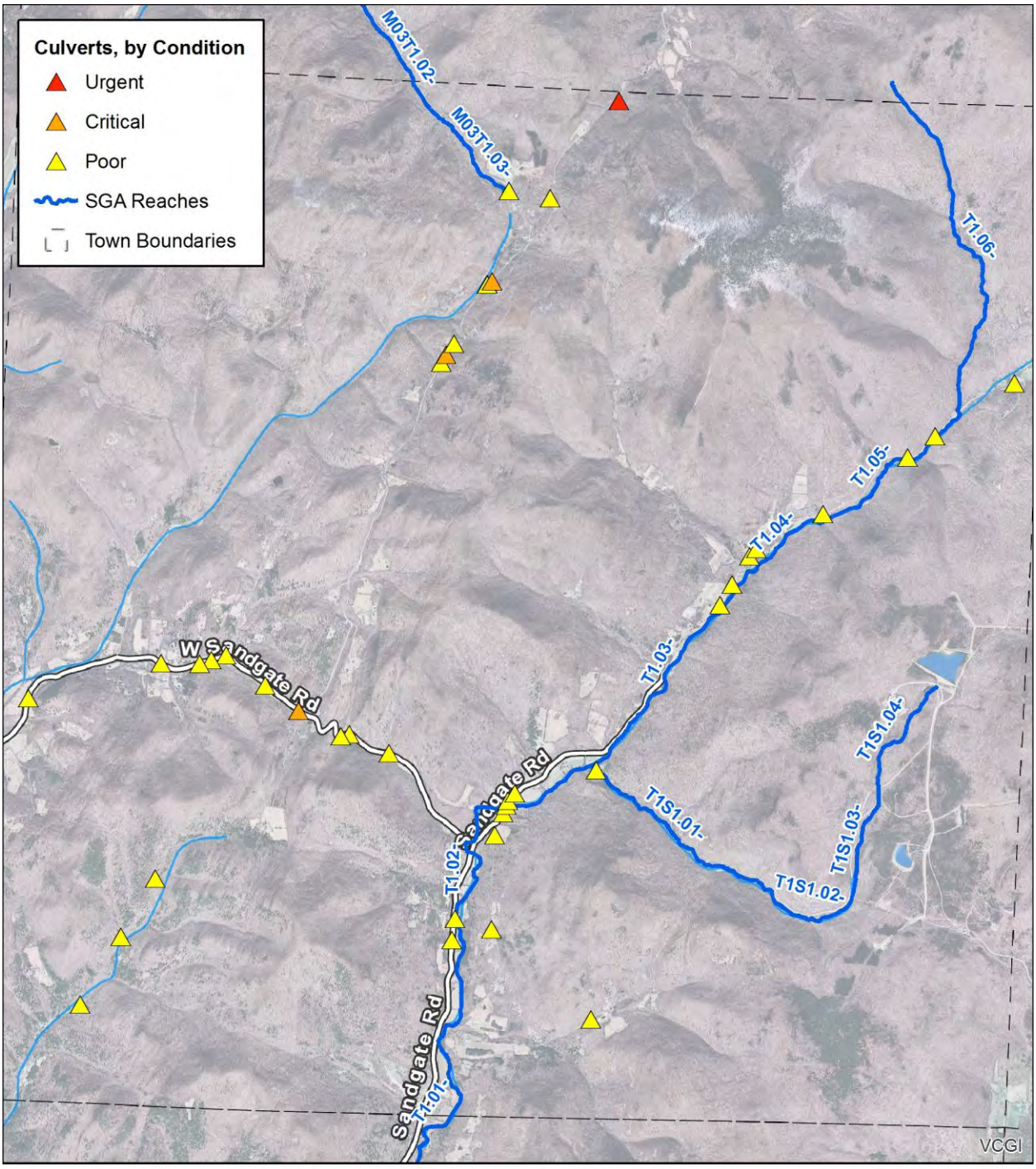
Potential water quality stressors specific to the Town of Sandgate include non-point source pollution from gravel roads and flow regulation from the hydroelectric operation at Lake Madeline in the headwaters of Hopper Brook (a tributary to Green River). Basin-wide restoration recommendations include riparian buffer plantings, agricultural BMP implementation in fields with high erosion risk, and identifying opportunities for dam removals and retrofits.

Green River/Batten Kill and White Creek/Mill Brook Corridor Plans

Field Geology Services prepared the Green River/Batten Kill Corridor Plan for the Vermont Department of Environmental Conservation in 2007 (FGS, 2007). Fitzgerald Environmental prepared the White Creek/Mill Brook Corridor Plan for the Bennington County Conservation District in 2013 (FEA, 2013). Several background themes relevant to stormwater master planning are touched on in the plans. Highlights from the Corridor Plans relevant to recent flooding and stormwater runoff in the watersheds are summarized below.

Overall Stream Stability and Habitat Conditions

A summary of the geomorphic and habitat conditions is provided below in Table 3, and a map of corresponding stream reaches is shown in Figure 2. Overall the stream conditions are fair to good for those river reaches assessed in more detail in the field. In the lower reaches of the Green River, the conditions are fair due to historic channel alterations resulting in reduced sinuosity, incision, and widening. In the upper reaches of Sandgate Brook where a steeper stream is found in a narrow valley, the conditions were assessed as good with limited impacts from road encroachment or adjacent development.



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	SGA and Culvert Inventory Data	**Figure 2**	**Date:** December 29, 2017 **Drawn:** EHB

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

Stream	Reach	Reference Stream Type	Existing Stream Type	Confinement Type	Habitat Condition	Geomorphic Condition	Notes
Green River	T1.01	C	C	Very Broad	Fair	Fair	Departure to plane bed from riffle pool
	T1.02	C	C	Broad	Fair	Good	
	T1.03	B	B_c	Broad	Good	Good	
	T1.04*	B	-	Broad	-	-	
	T1.05*	B	-	Semi-confined	-	-	
	T1.06*	A	-	Semi-confined	-	-	
Hopper Brook	T1S1.01*	B	-	Narrow	-	-	
	T1S1.02*	B	-	Narrow	-	-	
	T1S1.03*	A	-	Narrow	-	-	
	T1S1.04*	C	-	Broad	-	-	
Sandgate Brook	M03T1.02	B_a	B	Narrow	Good	Good	
	M03T1.03*	A	-	Broad	-	-	

** Phase 1 assessment only*

Flood Damage

The Green River Phase 2 assessments were conducted prior to Tropical Storm Irene. However, berms constructed in response to flooding in 1973 and other historic floods were identified. These berms were generally found along the lower reaches of Batten Kill tributaries, such as the Green River in Sandgate.

Hydrologic and Sediment Regime Stressors

The Corridor Plans include maps of stressors on the hydrologic and sediment regimes of White Creek and the Green River based on data collected during the Phase 2 Stream Geomorphic Assessments in 2008 and from 2000-2005 respectively. 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 Plans include areas of locally high road densities at the subwatershed level, wetland loss, and dam locations. The sediment regime stressors identified in the Corridor Plans 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.

<u>VTDEC Hydrologically Connected Road Segment Data</u>

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 the Green River valley bottom; moderate and high-risk segments become more prevalent along gravel roads in the steeper portions of the 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.

Local Data

Sandgate Culvert Records

The Town of Sandgate completed bridge and culvert inventories in spring of 2013, and a follow-up inventory was conducted by Jim Henderson of Bennington County Regional Commission (BCRC) in the fall of 2016. A total of 379 culverts were included in the inventory. This assessment found 40 culverts that were rated as having an overall condition of poor, urgent, or critical (Figure 2). The assessments documented 18 culverts with a medium or high level of erosion. These culverts were further reviewed as part of our field surveys to determine whether upgrades or erosion control measures are warranted.

Town of Sandgate Hazard Mitigation Plan

The Town of Sandgate completed a 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 and fluvial erosion hazard zones, as well as the locations of impoundments and beaver dams on Sandgate surface waters. Tropical Storm Irene landslide locations as well as road and culvert damages in Sandgate are mapped as well.

Tropical storm Irene (TSI) hit Vermont on August 28^{th,} 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 Sandgate, damage resulting from Tropical Storm Irene was significant, including road and culvert damages along Sandgate and Snow Roads.

Data Gaps

This watershed library describes the available documents, reports, and datasets that characterize stormwater and flooding concerns within the Town of Sandgate. The geomorphic field data available for the Green River and Hopper Brook through Sandgate 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, as most monitoring has occurred at downstream sites outside of Sandgate. Additional sampling effort in

the Green River and smaller streams such as Chunks Brook would be helpful for tracking water quality within the Town.

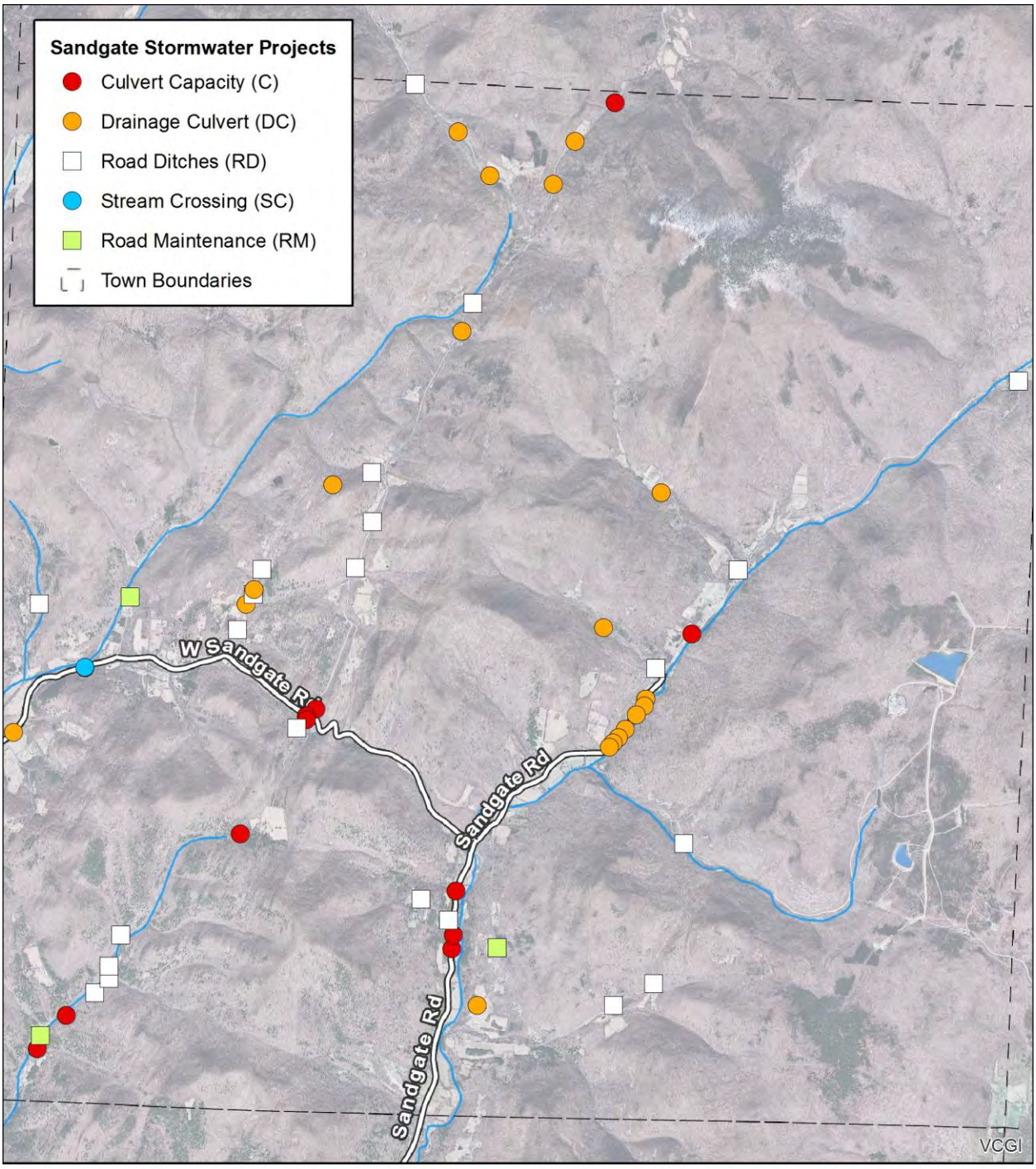
4.0 Stormwater Problem Areas

One of the primary goals of the stormwater master plan is to "develop a comprehensive list of stormwater problems" within the Town. FEA conducted several field tours of the project area and had meetings with the Sandgate Highway Department 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, Town of Sandgate culvert data, and high-resolution LiDAR contours and hillshade in a GIS. As part of this screening, FEA identified 12 culverts to visit mainly on first order and intermittent streams that were either in poor condition, had upstream or downstream bank erosion, or were suspected to be undersized. Meetings with Town officials including tours with the Town Road 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 51 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 -** Eleven (11) 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.
- **DC** - Drainage culvert projects were identified in 14 locations where maintenance practices or stormwater runoff and associated sediment loads at cross-culverts located under Town maintained roads were deemed problematic.
- **RM** - Three (3) road maintenance projects were identified where longer stretches of road were deemed problematic and likely require work over a larger area than other projects in Sandgate.
- **RD** - Roadside ditch projects (22) were typically observed 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** – One (1) stream crossing project was identified where a perennial stream crosses under a Town maintained road with an outlet drop that reduces Aquatic Organism Passage. Runoff volume and peak discharge for the contributing watershed was modeled to recommend appropriate replacement culvert size.



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	Stormwater Problem Area Locator Map	**Figure 3**	**Date:** December 29, 2017 **Drawn:** EHB

4.2 Evaluation of Problem Areas

The 51 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, project cost and constructability, and additional benefits associated with project implementation.

GIS-based Site Screening

Using the field data points collected with a 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 11 to 21 (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 (3 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: Ditch erosion at a culvert inlet along Woodcock Road (left) was one of the lowest scoring projects (DC-9). Large piles of loose sediment along Sandgate Road (right) following recent culvert and road work were the highest scoring project due partly to its proximity to the stream (DC-14).

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. The dimensions, inlet/outlet configuration, and slope for each culvert were determined in the field using laser surveying equipment. 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). Recurrence interval flow rates were estimated for each culvert using a TR-20 hydrologic model constructed with HydroCAD 10.0 software. The watershed was characterized by land cover, soils, and topography to estimate runoff volumes and peak flow rates. 24-hour rainfall depths for the recurrence interval storms were estimated using the Extreme Precipitation in New York and New England web tool created by the Northeast Regional Climate Center and the Natural Resources Conservation Service. 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). We compared HydroCAD and HY-8 estimates of culvert capacity and, in all cases, the culvert capacity predicted by the HY-8 model was lower. The HY-8 modeling results are reported in Table 4.

Table 4: Basin runoff and culvert capacity from HY-8 modeling

Site ID	Road	Drainage Area (ac)	Culvert Type	Slope (ft/ft)	Dimensions (ft)	Manning's Roughness	Discharge (cfs)				Q10 Free-board (ft)	Q25 Free-board (ft)
							Q10	Q25 (design)	Q100 (extreme)	Culvert Capacity[1]		
C-1	Chunks Brook Road	112.9	Pipe Arch	0.04	2.2' x 3.5'	0.025	57.5	92.0	169.3	40.2	-0.25	-0.5
C-2	Tate Hill Road	56.4	CPP	0.11	2' Diameter	0.024	26.0	40.9	74.1	18.4	-0.19	-0.4
C-3	Tate Hill Road	73.7	CMP	0.02	2' Diameter	0.024	60.7	95.5	172.4	27.3	-0.30	-0.5
C-4	Tate Hill Road	134.3	Tank & CMP	0.05	3' Diameter	0.018	69.7	107.2	189.3	54.5	-0.19	-0.4
C-5	Sandgate Road	44.9	CPP	0.04	18" Diameter	0.024	10.3	19.2	41.3	14.5	2.25	-0.1
C-6	Sandgate Road	46.6	CMP	0.06	2' Dia. (0.7' sediment)	0.024/ 0.035	20.5	36.0	72.4	14.8	-0.12	-0.3
C-7	Sandgate Road	437.0	CMP	0.09	4' Diameter	0.024	153.0	257.8	499.6	115.7	-0.31	-0.8
C-8	Sandgate Road	103.4	CMP	0.01	1.5' Dia. (0.05' sediment)	0.024/ 0.035	19.8	38.0	84.1	10.1	-0.24	-0.5
C-9	Snow Road	108.6	Pipe Arch	0.08	2.5' x 3.5'	0.025	56.8	94.0	179.0	43.2	-0.48	-0.7
C-10	Rupert Road	53.2	CMP	0.02	2' Dia. (0.7' sediment)	0.024/ 0.035	34.2	53.8	97.5	16.3	-0.25	-0.4
SC-1	West Sandgate Road	1,715.4	Tank	0.02	5.3' Diameter	0.012	439.2	736.6	1,428.1	214.5	-0.53	-0.9
C-11	West Sandgate Road	56.5	CMP	0.04	2' Diameter	0.024	33.7	53.9	99.3	24.2	-0.26	-0.6

1 - Culvert capacity before road overtops using HY-8 model

4.3 Problem Area Summary Sheets

Problem area summary sheets were developed for 27 selected 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 Mike Hill (Sandgate) 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.

- **RD-2:** Runoff from Rupert Road is exacerbating severe slope erosion along a very steep embankment to Terry Brook.
- **RD-8:** A long section of West Road lacks appropriate drainage increasing erosion and exacerbating poor road conditions during wet periods.
- **RD-14:** Concentrated runoff from the road surface is causing severe erosion at the outlet of a cross-culvert directly into a stream along lower Wilcox Hollow Road. The culvert outlet is also scoured.
- **RD-15:** Concentrated runoff from Wuerslin Road is causing erosion at the intersection with Sandgate Road.
- **RD-21:** Poor road drainage along Sandgate Road in “Beartown” is causing significant erosion along the road edges.

5.0 Next Steps

This Stormwater Master Plan represents an extensive effort to identify, describe, and evaluate stormwater problem areas throughout the Town of Sandgate. 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 Sandgate, 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 Sandgate, 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

FEA (Fitzgerald Environmental Associates), 2013, White Creek and Mill Brook Corridor Plan. Prepared for Bennington County Conservation District. Dated April 11, 2013

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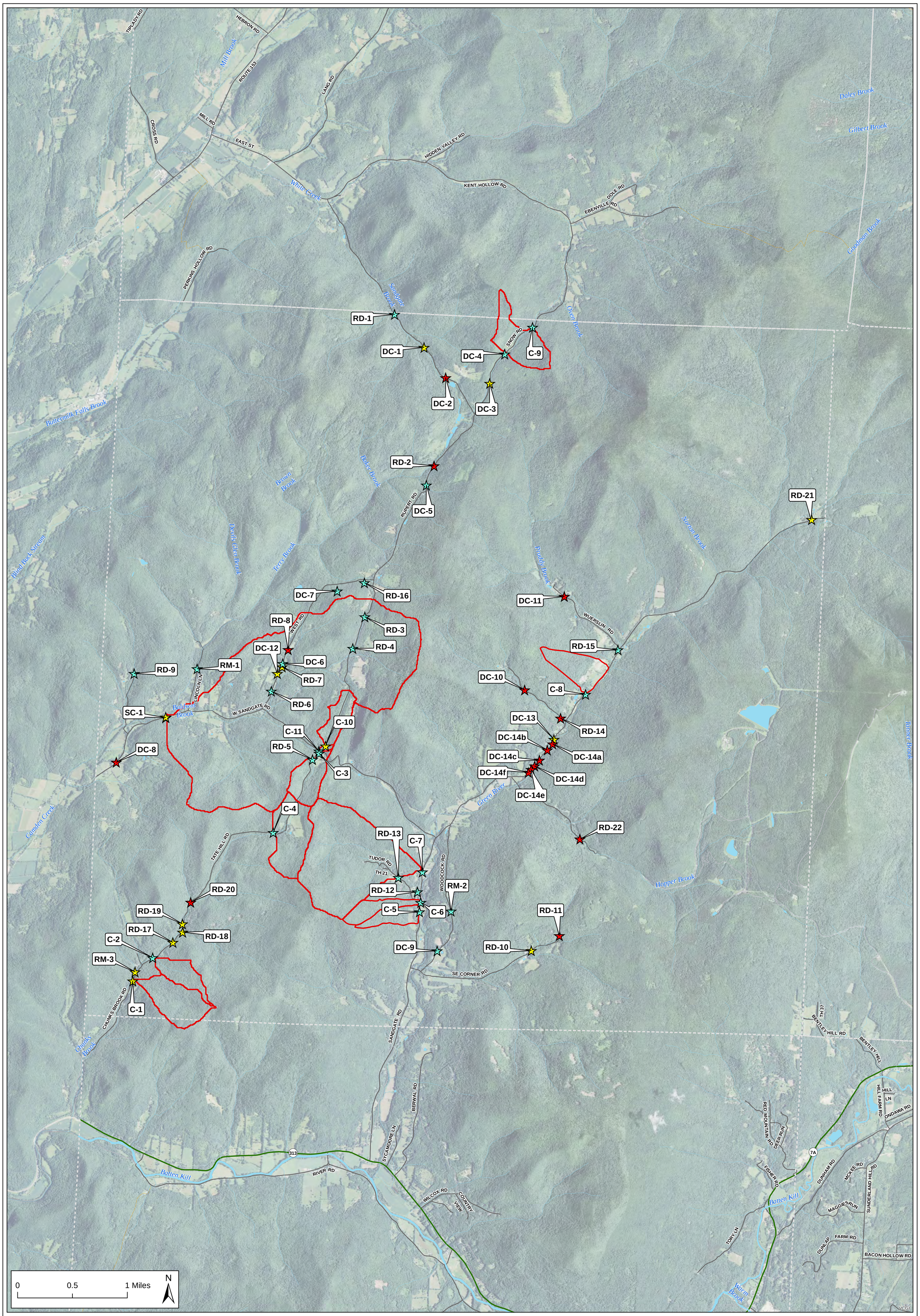
APPENDIX A:

Stormwater Problem Areas
Location Map



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Stormwater Problem Areas

Town of Sandgate

Project Priority (Score)
- Low (11 - 14)
- Moderate (15 - 16)
- High (17 - 21)
- Culvert Drainage Area
- Town Boundary

- Waterbodies
- Surface Waters
- Vermont State Highway
- Town Highway: Class 1-3
- Town Highway: Class 4
- Legal Trail
- Other Road Type

Notes
- Problem areas were identified by FEA in April and June 2017.
- Culvert surveys were completed in June 2017.
- NAIP imagery is from 2014.

Map By: EHB
Date: December 27, 2017
Scale: 1:24,000

APPENDIX B:

Problem Area Summary Table and Prioritization Matrix

Project	Project Type	Location	Problem Area Description	BMP Type/Description	Water Quality Mitigation					Infrastructure Resiliency/ Flood Vulnerability	Landowner Support	Operation & Maintenance Requirements	Cost and Constructability	Additional Benefits	Additional Benefits Score	Total Score
					Sediment Reduction	Nutrient Reduction	Drainage Area	Impervious Drainage	Connectivity to Surface Waters							
				Maximum Score	**4**	**4**	**1**	**2**	**3**	**3**	**2**	**2**	**6**		**3**	**30**
C-1	Culvert Replacement	Chunks Brook Road	Moderately undersized squashed corrugated metal pipe is a barrier to AOP.	Install larger structure with AOP compatibility.	2	0	1	0	3	3	1	2	3	AOP	1	16
C-2	Culvert Replacement	Tate Hill Road	Moderately undersized corrugated plastic pipe.	Install larger structure.	1	0	1	0	3	3	1	2	3		0	14
C-3	Culvert Replacement	Tate Hill Road	Severely undersized corrugated metal pipe.	Install larger structure.	0	0	1	0	3	3	1	2	3		0	13
C-4	Culvert Replacement	Tate Hill Road	Slightly undersized half tank, half corrugated metal pipe.	Install larger structure.	1	0	1	0	3	3	1	2	3		0	14
C-5	Culvert Replacement	Sandgate Road	Slightly undersized corrugated plastic pipe.	Install larger structure.	0	0	1	0	3	3	1	2	3		0	13
C-6	Culvert Replacement	Sandgate Road	Moderately undersized corrugated metal pipe.	Install larger structure.	0	0	1	0	3	3	1	2	3		0	13
C-7	Culvert Replacement	Sandgate Road	Moderately undersized corrugated metal pipe.	Install larger structure.	1	0	1	0	3	3	1	2	3		0	14
C-8	Culvert Replacement	Sandgate Road	Severely undersized corrugated metal pipe.	Install larger structure.	0	0	1	0	3	3	1	2	3		0	13
C-9	Culvert Replacement	Snow Road	Moderately undersized squashed corrugated metal pipe.	Install larger structure.	0	0	1	0	3	3	1	2	3		0	13
C-10	Culvert Replacement	Rupert Road	Severely undersized corrugated metal pipe.	Install larger structure.	2	0	1	0	3	3	1	2	3		0	15
C-11	Culvert Replacement	West Sandgate Road	Moderately undersized corrugated metal pipe.	Install larger structure.	0	0	1	0	3	3	1	2	3		0	13
DC-1	Ditch Improvement at Cross-Culvert	Rupert Road north of Snow Road	Inlet of cross-culvert is eroded with an active headcut near Sandgate Brook.	Monitor inlet and add armor as needed to reduce erosion. Grade road ditch at inlet to remove headcut and line with 8" minus stone.	2	2	0	0	2	1	1	2	5		0	15
DC-2	Ditch Improvement at Cross-Culvert	Rupert Road north of Snow Road	Inlet of cross-culvert and ditch upstream of crossing are severely eroded. Additionally, loose gravel is piled alongside outlet channel near Sandgate Brook.	Stabilize road ditch with a minimum of 6-8" minus stone. Discontinue dumping loose gravel near outlet.	3	2	0	0	3	2	1	2	4	Chronic Problem Area	1	18
DC-3	Ditch Improvement at Cross-Culvert	Snow Road	Inlet of cross-culvert has no headwall and is eroded. Cross-culvert outlet is broken but fairly stable. Cross-culvert is heaving through road. Culvert is near a first order tributary to Terry Brook.	Assess if the culvert needs to be reset at a greater depth. Stabilize culvert inlet with coarse material. Stabilize ditch with a minimum of 6-8" minus stone.	2	2	0	0	3	2	1	2	4		0	16
DC-4	Ditch Improvement at Cross-Culvert	Snow Road	Inlet of cross-culvert is eroded with an active headcut.	Monitor inlet and add armor as needed to reduce erosion. Grade road ditch at inlet to remove headcut.	2	2	0	0	1	1	1	2	5		0	14
DC-5	Ditch Improvement at Cross-Culvert	Rupert Road south of Snow Road	Culvert inlet is moderately clogged by loose sediment moving through the ditch.	Clean out ditch and culvert.	2	2	0	0	0	1	1	2	5		0	13

Project	Project Type	Location	Problem Area Description	BMP Type/Description	Water Quality Mitigation					Infrastructure Resiliency/ Flood Vulnerability	Landowner Support	Operation & Maintenance Requirements	Cost and Constructability	Additional Benefits	Additional Benefits Score	Total Score
					Sediment Reduction	Nutrient Reduction	Drainage Area	Impervious Drainage	Connectivity to Surface Waters							
				Maximum Score	4	4	1	2	3	3	2	2	6		3	30
DC-6	Ditch Improvement at Cross-Culvert	West Road	Culvert inlet is moderately clogged by loose sediment moving through the ditch and running off the road. Near a second order tributary to Baldwin Brook.	Clean out ditch and culvert.	1	1	0	0	1	1	1	2	5		0	12
DC-7	Road Erosion and Ditch Improvement at Cross-Culvert	West Road	Culvert inlet is plugged. Water flowing across the road is causing erosion.	Clean out ditch and culvert.	1	1	0	0	0	1	1	2	5		0	11
DC-8	Road Erosion and Ditch Improvement at Cross-Culvert	W Sandgate Road near Sandgate-Salem Town Boundary	Severe gully erosion present at cross-culvert inlet and along the edge of the road.	Clean out ditch upstream of cross-culvert and crown road to direct water into the ditch. Stabilize erosion areas.	4	2	0	1	0	2	1	2	5	Chronic Problem Area	1	18
DC-9	Ditch Improvement at Cross-Culvert	Woodcock Road	Rock at culvert inlet is too small for stabilization and may clog culvert.	Remove small rocks and add coarser material to inlet. Stabilize ditch with a minimum of 6-8" minus stone.	0	0	0	0	1	2	1	2	5		0	11
DC-10	Road Erosion at Cross-Culvert	Wilcox Hollow Road	Severe road erosion at cross-culvert outlet behind headwall adjacent to a second order tributary to the Green River.	Crown road to direct water into ditch upstream of the cross-culvert inlet. Stabilize cross-culvert outlet as needed.	3	2	0	0	2	2	1	2	5		0	17
DC-11	Road Erosion and Ditch Improvement at Cross-Culvert	Wuerslin Road	Severe erosion of the roadway present at the cross-culvert outlet. Road crown does not effectively direct water into ditch on the south side of the road, causing water to flow over the road toward Pruddy Brook.	Crown road to direct water into ditch on the south side of the road. Stabilize cross-culvert outlet as needed.	3	2	0	1	3	2	1	2	4		0	18
DC-12	Ditch Improvement at Cross-Culvert	West Road	Inlet of cross-culvert and ditch upstream are eroded with an active headcut. Outlet is eroded with a 3' perch. Near a second order tributary to Baldwin Brook.	Stabilize culvert inlet and outlet with coarse material. Stabilize road ditch with of 12" minus stone. Grade road ditch at inlet to remove headcut. Improve armor at the culvert outlet to reduce scour.	2	2	0	1	1	2	1	2	4		0	15
DC-13	Road Erosion and Ditch Improvement at Cross-Culvert	Sandgate Road	Water exits roadway at a drainage culvert near the gravel-pavement transition on Sandgate Road, eroding the road embankment and pushing sediment into the Green River and a wetland upstream of the culvert.	Crown the road to direct water into ditches. Vegetate area upstream and downstream of culvert. Install a stone lined turnout near the culvert if necessary	2	2	0	0	3	1	1	2	4		0	15

Project	Project Type	Location	Problem Area Description	BMP Type/Description	Water Quality Mitigation					Infrastructure Resiliency/ Flood Vulnerability	Landowner Support	Operation & Maintenance Requirements	Cost and Constructability	Additional Benefits	Additional Benefits Score	Total Score
					Sediment Reduction	Nutrient Reduction	Drainage Area	Impervious Drainage	Connectivity to Surface Waters							
				Maximum Score	**4**	**4**	**1**	**2**	**3**	**3**	**2**	**2**	**6**		**3**	**30**
DC-14	Road Erosion and Ditch Improvement at Cross-Culvert	Sandgate Road	Unstable sediment associated with a series of culvert installations along Sandgate Road is piled alongside the Green River, a potential contributor to sediment loading, and along the upstream side of the drainage culverts, which may plug the culverts.	Clean up the sediment where applicable and stabilize the culvert outlets with rock to prevent scour.	3	2	1	1	3	1	2	2	5	High Visibility	1	21
RD-1	Road Erosion and Ditch Improvement	Rupert Road near the Sandgate-Rupert Town Boundary	Road is poorly crowned and rutted ditch is poor and eroding. Steep road.	Crown road and stabilize ditch with a minimum of 6-8" minus stone.	2	1	0	1	1	1	1	2	4		0	13
RD-2	Road Erosion and Ditch Improvement	Rupert Road south of Snow Road	Road is not crowned and sheet flow over very steep bank is causing severe bank erosion and threatening the road. Cross-culvert down slope is in decent shape. Steep drop down to Terry Brook. Ditch on east side may be spilling onto road and increasing erosion.	Crown road to direct water into the existing ditch and cross-culvert. Stabilize road embankment slope as needed.	4	3	0	1	3	3	2	2	2	Chronic Problem Area	1	21
RD-3	Road Erosion and Ditch Improvement	Rupert Road south of West Road	Road crown does not effectively direct water into ditch. Ditches are poorly formed and eroding. Near first order tributary to Baldwin Brook.	Crown road to direct water into ditch. Enlarge ditch and line with 8-12" minus stone.	2	2	0	1	1	1	1	2	4		0	14
RD-4	Ditch Improvement	Rupert Road south of West Road	Ditches are eroding.	Stabilize ditch with a minimum of 12" minus stone.	2	2	0	0	1	1	1	2	4		0	13
RD-5	Road Erosion and Ditch Improvement	Tate Hill Road near W Sandgate Road	Water flows along the road edges, with additional runoff from a driveway. No roadside ditch present to convey water from the road.	Build roadside ditch, stabilized with a minimum of 12" minus stone. Grade road to direct water into ditch.	2	2	0	2	0	1	1	2	3		0	13
RD-6	Road Erosion and Ditch Improvement	West Road	West ditch ends, spilling water across road with moderate rilling.	Add a cross-culvert to convey water underneath the road. Alternatively, build a roadside ditch on the west side of the road and stabilized with a minimum of 12" minus stone and crown road to direct water into ditch.	2	2	0	1	1	2	1	1	3		0	13
RD-7	Road Erosion and Ditch Improvement	West Road	Road crown does not effectively direct water into ditch. Rutting present from water running down the road. Ditches spill across the road.	Improve road crown and enlarge the ditch.	2	2	0	1	1	1	1	2	5		0	15

Project	Project Type	Location	Problem Area Description	BMP Type/Description	Water Quality Mitigation					Infrastructure Resiliency/ Flood Vulnerability	Landowner Support	Operation & Maintenance Requirements	Cost and Constructability	Additional Benefits	Additional Benefits Score	Total Score
					Sediment Reduction	Nutrient Reduction	Drainage Area	Impervious Drainage	Connectivity to Surface Waters							
				Maximum Score	**4**	**4**	**1**	**2**	**3**	**3**	**2**	**2**	**6**		**3**	**30**
RD-8	Road Erosion	West Road	Road crown does not effectively direct water into ditch. Rutting present from water running down the road. Ditches spill across the road.	Crown road to direct water into ditch.	2	1	1	2	1	1	2	2	3	1	2	17
RD-9	Ditch Improvement	Campbell Road	Ditch is unstable and eroding.	Stabilize ditch with a minimum of 12" minus stone.	2	2	0	0	1	2	1	2	3		0	13
RD-10	Road Erosion and Ditch Improvement	SE Corner Road	Road crown does not effectively direct water into the ditch. Water running over the roadway is causing rill erosion through the steep section of road.	Crown road to direct water into the existing ditch. Clean out ditch, stabilize the side slope, and line the ditch with 12” minus stone.	2	2	0	1	2	2	1	2	3		0	15
RD-11	Road Erosion and Ditch Improvement	SE Corner Road	Erosion along the edge of a steep section of road due to an unstable ditch that is relatively full of material. A first order tributary to a third order Green River tributary runs alongside the road.	Clean out ditch and stabilize with a minimum of 6-8" minus stone. Steeper ditch sections require 12" minus stone.	3	2	0	0	3	2	1	2	4	High Visibility; Chronic Problem Area	2	19
RD-12	Road Erosion and Ditch Improvement	Tudor Road	Water leaves the ditch at the top of a sharp bend in the road, causing erosion of the roadway.	Clean out ditch along the outside of the bend so water stays in the ditch.	2	1	0	0	0	1	1	2	5		0	12
RD-13	Road Erosion and Ditch Improvement	Walsh Road at Tudor Road	Water runs down a very steep section of Walsh Road at the intersection with Tudor Road and lacks crowning on the road to direct water.	Install roadside ditches stabilized with a minimum of 12" minus stone along steep section of Walsh Road on both sides. Crown Walsh Road to direct runoff into ditches and install cross-culverts to convey water across Tudor Road.	2	2	0	2	0	2	1	0	3		0	12
RD-14	Road Erosion and Ditch Improvement	Wilcox Hollow Road	Ditch upstream of culvert inlet is filled in, causing water to follow the road and erode the road edge at the culvert outlet adjacent to a second order tributary to the Green River.	Clean out ditch upstream of cross-culvert to allow flow to enter the ditch. Monitor and stabilize culvert outlet as needed.	2	2	0	1	3	2	1	2	5		0	18
RD-15	Road Erosion and Ditch Improvement	Wuerslin Road at Sandgate Road	Water runs down a steep section of Wuerslin Road near the intersection with Sandgate Road, eroding the roadway.	Install a roadside ditch stabilized with a minimum of 12" minus stone along the northeast side of Wuerslin Road. Grade road to direct water into ditch.	2	1	0	2	1	2	2	2	3	Chronic Problem Area	2	17
RD-16	Road Erosion and Ditch Improvement	West Road near Rupert Road	Water from Sandgate and West Roads flows across the road toward the Terry Brook tributary on the south side of the road. No ditch or culvert on north side of road.	Form ditch on the north side of the road, extending west toward the floodplain.	2	2	0	2	1	1	1	1	3		0	13

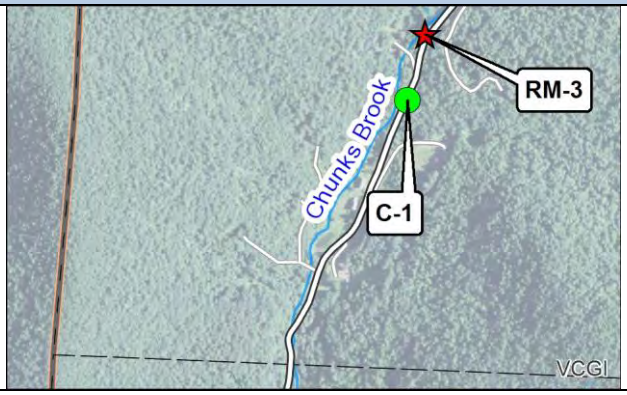
Project	Project Type	Location	Problem Area Description	BMP Type/Description	Water Quality Mitigation					Infrastructure Resiliency/ Flood Vulnerability	Landowner Support	Operation & Maintenance Requirements	Cost and Constructability	Additional Benefits	Additional Benefits Score	Total Score
					Sediment Reduction	Nutrient Reduction	Drainage Area	Impervious Drainage	Connectivity to Surface Waters							
				Maximum Score	**4**	**4**	**1**	**2**	**3**	**3**	**2**	**2**	**6**		**3**	**30**
RD-17	Road Erosion and Ditch Improvement	Tate Hill Road	Water flows along Tate Hill road, causing erosion along steep road embankments adjacent to Chunks Brook.	Install a ditch on the opposite side of the road and crown the road to direct water into the ditch. At least one cross-culvert is recommended.	2	3	0	1	3	1	1	2	3		0	16
RD-18	Road Erosion and Ditch Improvement	Tate Hill Road	Water flows across a steep section of Tate Hill Road, eroding the roadway.	Clean out ditches and crown road to direct water into ditches.	2	2	0	1	2	1	1	2	5		0	16
RD-19	Road Erosion and Ditch Improvement	Tate Hill Road	Chunks Brook flows alongside Tate Hill Road with no buffer, eroding the stream bank and road embankment.	Armor the road embankment. Crown and ditch road to keep stormwater from flowing across road to streambank.	2	2	1	0	3	2	1	2	3		0	16
RD-20	Road Erosion and Ditch Improvement	Tate Hill Road	Water flows along a steep section of Tate Hill Road eroding the surface and directing sediment toward a culvert where Chunks Brook crosses the road.	Crown road to direct water into ditches. Excavate and stabilize ditches as needed.	3	2	0	0	3	1	1	2	4	Chronic Problem Area	1	17
RD-21	Road Erosion and Ditch Improvement	Sandgate Road near Sandgate-Manchester Town Line	Limited space along north side of road for drainage. Driveway culverts needed. Road erosion and rilling along the road leading chronic maintenance area.	Install roadside ditches and driveway culverts. Review need for additional cross culverts under Town road and outlets to south.	3	1	0	1	2	2	2	2	3	Chronic Problem Area	2	18
RD-22	Road Erosion and Ditch Improvement	Upper Hamilton Hollow Road	Limited space along north side of road for drainage from Merritt residence down along Hopper Brook. Road erosion and rilling along the road leading to sedimentation in brook.	Consider installing larger cross culvert below Merritt property. Install ditch along north side of road across from Hopper Brook.	3	2	0	1	3	2	2	1	3	Chronic Problem Area	2	19
RM-1	Chronic Problem Area	Lincoln Lane	Road bed is too low, many potholes. Road runs along Terry Brook and a second order tributary to Baldwin Brook.	Raise and crown road bed to shed runoff to areas where it can infiltrate.	0	0	0	2	2	1	2	2	2	Seasonal Flooding, Chronic Problem Area	2	13
RM-2	Road Erosion	Woodcock Road	Poorly crowned	Crown road to direct water off road and into ditches or other areas where it can infiltrate.	1	1	0	2	1	1	1	2	5		0	14
RM-3	Road Erosion	Chunks Brook Road	A tree is down across Chunks Brook alongside Chunks Brook road. This creates an erosion hazard for the road by destabilizing the embankment and potentially directing flow toward the road.	Remove tree from channel and armor road embankment.	2	2	0	0	3	2	1	2	4		0	16
SC-1	Culvert Retrofit or Replacement	Baldwin Brook at W Sandgate Road	Rusted steel tank or smoke stack culvert upstream of hydrant is perched, reducing Aquatic Organism Passage (AOP).	Install boulder veins downstream of outlet pool to raise tailwater control and reduce outlet drop.	0	0	1	0	3	3	1	2	4	Aquatic Organism Passage	1	15

APPENDIX C:

Problem Area Summary Sheets

Project: C-1	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Chunks Brook Road
Latitude: **Longitude:**	43.12699 N 73.25572 W
Land Ownership:	Town



Site Description: An undersized squashed corrugated metal pipe is located on Chunks Brook Road to convey the flow from an unmapped perennial stream draining to Chunks Brook (Photo 1). The culvert capacity is estimated at 40.2 cfs, a flow that may conservatively be exceeded in the 10-year flood event. Additionally, the culvert is perched and there is erosion upstream of the culvert inlet increasing sediment load to Chunks Brook (Photo 2).

Photo 1: An undersized culvert on Chunks Brook Road.

Photo 2: Some bank erosion is present upstream of an undersized culvert on Chunks Brook Road.

BMP Description: Replace the undersized structure with a larger structure sized to convey the 25-year flow (e.g. a 6' wide, 4' tall squashed corrugated metal culvert with 1' of embeddedness).

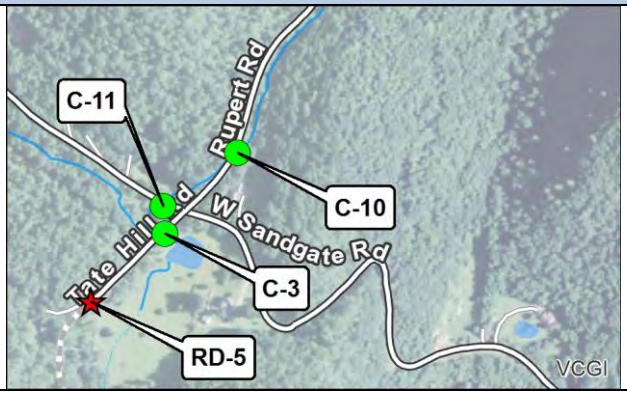
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
6	3	3	3	1	16 **(Moderate)**

Additional Project Benefits Description: Replacing the structure with an appropriately aligned culvert would remove an AOP barrier.

Project Comments: Moderate priority project due to the potential to improve infrastructure resiliency as well as mitigate a sediment source to a first order stream and Chunks Brook. **We estimate that this project will cost $10,000 to $20,000, primarily based on the replacement culvert cost. Permitting requirements from ANR and/or USACE, such as AOP passage, may make this project more costly.**

Project: C-10	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Rupert Road
Latitude: **Longitude:**	43.15823 N 73.22132 W
Land Ownership:	Town



Site Description: An undersized round corrugated metal pipe is located on Rupert Road to convey the flow from a first order stream (Photo 1). The culvert capacity is estimated at 16.2 cfs, a flow that may conservatively be exceeded in the 10-year flood event. Additionally, there is some erosion upstream and downstream of the culvert inlet acting as a sediment source to the first order stream (Photo 2).

Photo 1: Some bank erosion is present upstream of an undersized culvert on Rupert Road.

Photo 2: Some bank erosion is present downstream of an undersized culvert on Rupert Road.

BMP Description: Replace the undersized structure with a larger structure sized to convey the 25-year flow (e.g. a 6' wide, 4' tall squashed corrugated metal culvert with 1' of embeddedness).

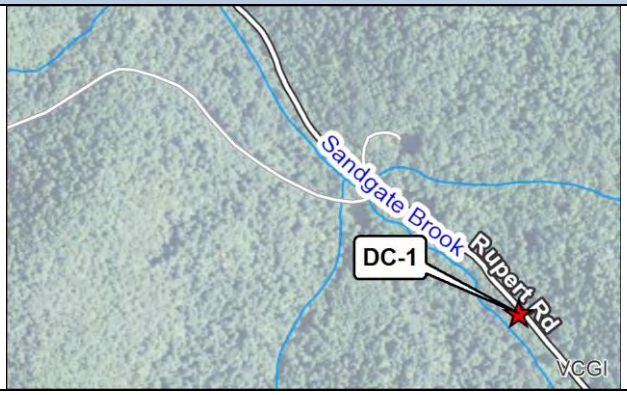
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
6	3	3	3	0	15 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to improve infrastructure resiliency as well as mitigate a sediment source to a first order stream. **We estimate that this project will cost $10,000 to $20,000, primarily based on the replacement culvert cost. Permitting requirements from ANR and/or USACE, such as AOP passage, may make this project more costly.**

Project: DC-1	**Problem Area Summary**

Date Observed:	4/27/2017
Location:	Rupert Road
Latitude: **Longitude:**	43.13213 N 73.24857 W
Land Ownership:	Town



Site Description: Inlet of cross-culvert is eroded with an active headcut in the upstream ditch. The runoff collected in the ditch is directed toward nearby Sandgate Brook (Photo 1).

Photo 1: Erosion and a headcut in the Rupert Road ditch upstream of a cross culvert inlet.

BMP Description: Monitor inlet and add armor as needed to reduce erosion. Grade road ditch at inlet to remove the headcut and line ditch with 8" minus stone.

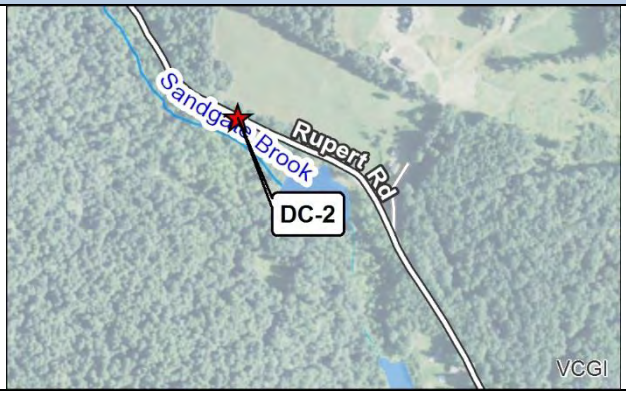
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
6	3	1	5	0	15 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to Sandgate Brook and the low cost of the project. **We estimate that this project will cost $5,000 to $10,000.**

Project: DC-2	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	Rupert Road north of Snow Road
Latitude: **Longitude:**	43.20701 N -73.20022 W
Land Ownership:	Town



Site Description: 18" diameter corrugated steel culvert under Rupert Road delivers sediment and stormwater to Sandgate Brook. The inlet to the cross-culvert and ditch immediately upstream of the crossing are severely eroded (Photo 1). Additionally, loose gravel is piled alongside the channel downstream of the outlet (Photo 2).

Photo 1: Eroded and unstable ditch upstream of cross-culvert inlet.

Photo 2: Cross-culvert outlet with gravel dumped alongside channel flowing toward Sandgate Brook.

BMP Description: Stabilize the road ditch with 12" minus stone. Discontinue dumping loose gravel near outlet.

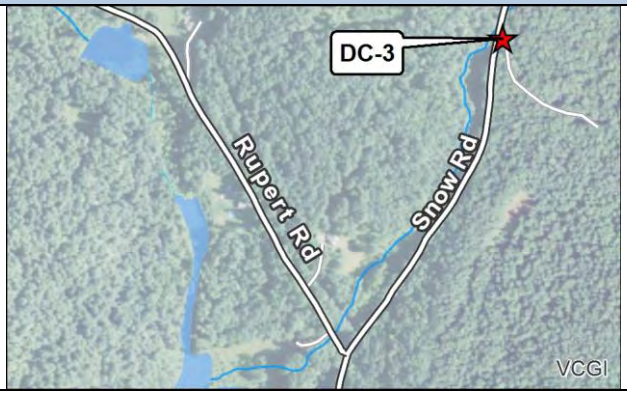
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
8	3	2	4	1	18 **(High)**

Additional Project Benefits Description:

Project Comments: Moderate to high priority project due to low cost and potential to mitigate a sediment source to Sandgate Brook. **We estimate that this project will cost $2,000 to $5,000.**

Project: DC-3	**Problem Area Summary**

Date Observed:	4/27/2017
Location:	Snow Road
Latitude: **Longitude:**	43.20632 N 73.19227 W
Land Ownership:	Town



Site Description: Inlet of Snow Road cross-culvert near a first order tributary to Terry Brook has no headwall and is eroded (Photo 1). Additionally, the cross culvert is heaving through the road and the outlet is broken but otherwise stable (Photo 2).

Photo 1: Erosion at the inlet of a Snow Road cross culvert.

Photo 2: Broken Snow Road cross culvert outlet.

BMP Description: Assess if the culvert needs to be reset at greater depth. Stabilize culvert inlet with stone armor. Stabilize ditch with a minimum of 6-8" minus stone.

WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	3	2	4	0	16 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to a first order tributary to Terry Brook and the low cost of the project. **We estimate that this project will cost $2,000 to $4,000.**

Project: DC-8	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	West Sandgate Road near Sandgate-Salem Town Boundary
Latitude: **Longitude:**	43.15584 N 73.25902 W
Land Ownership:	Town

Site Description: Roadside ditch along West Sandgate Road is filled with sediment, causing runoff to scour around the edge of the roadway at the inlet of an 18" corrugated plastic cross-culvert. Severe gully erosion is present at the culvert inlet and along the road edge (Photos 1 & 2).

Photo 1: Severe gully erosion along the road edge and at the cross-culvert inlet.

Photo 2: Filled in, poorly defined ditch with erosion where runoff flows along the road over the culvert inlet.

BMP Description: Clean out ditch upstream of cross-culvert and crown road to direct water into the ditch. Stabilize erosion areas.

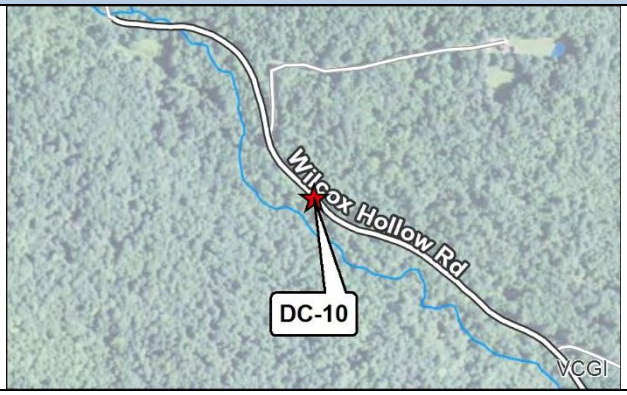
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	3	2	5	1	18 **(High)**

Additional Project Benefits Description: Project would address a chronic erosion issue.

Project Comments: High priority project due to low cost, potential to mitigate sediment losses, and potential to increase infrastructure resiliency. **We estimate that this project will cost $2,000 to $5,000.**

Project: DC-10	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	Wilcox Hollow Road
Latitude: **Longitude:**	43.16587 N 73.18553 W
Land Ownership:	Town



Site Description: Severe road erosion is present behind the headwall of a cross-culvert outlet adjacent to a second order tributary to the Green River (Photo 1).

Photo 1: Severe road erosion around the headwall of a cross-culvert outlet on Wilcox Hollow Road.

BMP Description: Crown the road to direct water into the ditch upstream of the cross-culvert inlet. Stabilize cross-culvert outlet as needed.

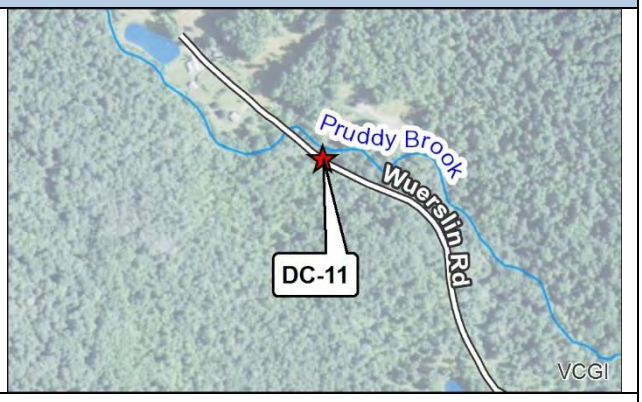
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	3	2	5	0	17 **(High)**

Additional Project Benefits Description:

Project Comments: High priority project due to low cost and potential to mitigate a sediment source to a stream that drains directly to the Green River. **We estimate that this project will cost $2,000 to $5,000.**

Project: DC-11	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	Wuerslin Road
Latitude: **Longitude:**	43.17824 N 73.17850 W
Land Ownership:	Town



Site Description: Severe erosion of the roadway is present at a cross-culvert outlet on Wuerslin Road (Photo 1). The road crown does not effectively direct water into ditch on the south side of the road, causing water to flow over the road toward Pruddy Brook.

Photo 1: Severe road erosion near a cross-culvert outlet on Wuerslin Road.

BMP Description: Crown road to direct water into ditch on the south side of the road. Stabilize the cross-culvert outlet as needed.

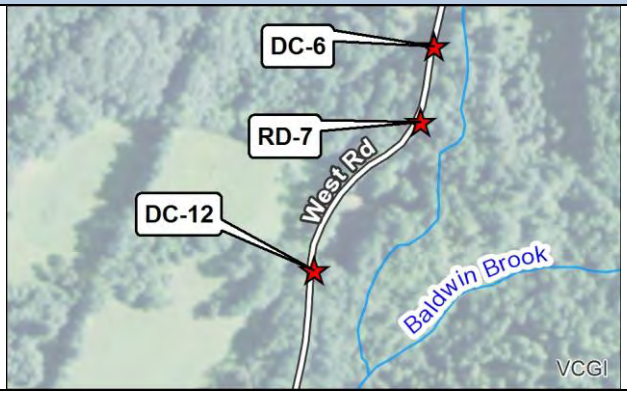
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
9	3	2	4	0	18 **(High)**

Additional Project Benefits Description:

Project Comments: High priority project due to low cost, potential to mitigate a sediment source to Pruddy Brook, and potential to increase infrastructure resiliency. **We estimate this project will cost less than $2,000.**

Project: DC-12	**Problem Area Summary**

Date Observed:	4/27/2017
Location:	West Road
Latitude: **Longitude:**	43.16774 N 73.23013 W
Land Ownership:	Town



Site Description: Inlet of a West Road cross-culvert and ditch upstream are eroded with an active headcut (Photo 1). Outlet is eroded with a 3' perch and drains to a second order tributary to Baldwin Brook (Photo 2).

Photo 1: A headcut and erosion in the ditch upstream of a West Road cross culvert.

Photo 2: Erosion at the perched outlet of a West Road cross culvert.

BMP Description: Stabilize culvert inlet and outlet with coarse material. Stabilize road ditch with of 12" minus stone. Grade road ditch at inlet to remove headcut. Improve armor at the culvert outlet to reduce scour.

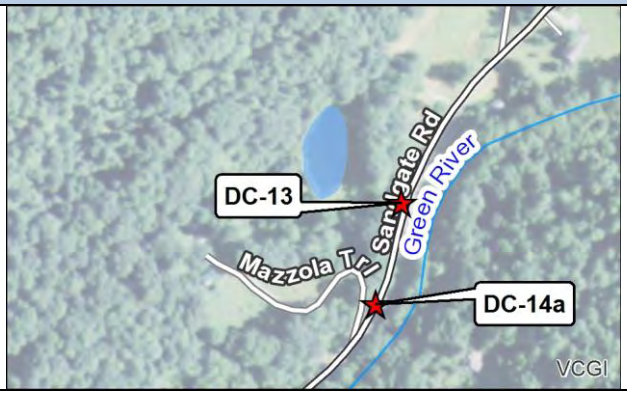
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
6	3	2	4	0	15 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to a second order tributary to Baldwin Brook and the relatively low cost of the project. **We estimate that this project will cost $7,500 to $15,000.**

Project: DC-13	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Sandgate Road
Latitude: **Longitude:**	43.15936 N 73.18017 W
Land Ownership:	Town



Site Description: Water exits roadway at a drainage culvert near the gravel-pavement transition on Sandgate Road, eroding the road embankment and pushing sediment into a wetland upstream of the culvert (Photo 1) and the Green River (Photo 2).

Photo 1: Water flowing over Sandgate Road is causing erosion at a cross culvert inlet, acting as a source of sediment to a roadside wetland.

Photo 2: Erosion at a Sandgate Road cross culvert outlet is acting as a source of sediment to the Green River directly downstream.

BMP Description: Crown the road to direct water into ditches upstream of the cross-culvert inlet. Vegetate area upstream and downstream of cross culvert. Install a stone lined turnout near the culvert if necessary.

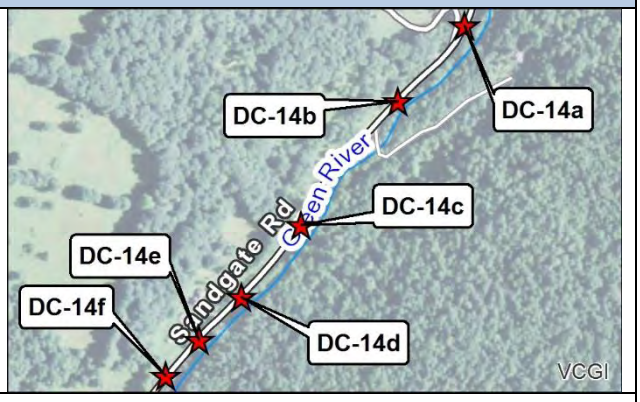
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	3	1	4	0	15 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to a wetland and the Green River. **We estimate that this project will cost $2,000 to $5,000.**

Project: DC-14	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Sandgate Road
Latitude: **Longitude:**	43.15662 N 73.18278 W
Land Ownership:	Town



Site Description: Unstable sediment associated with a series of culvert installations along Sandgate Road is piled alongside the Green River, a potential contributor to sediment loading (Photo 1). Sediment is also piled along the upstream side of the drainage culverts, which may plug the culverts (Photo 2).

Photo 1: Sediment piled on a road embankment adjacent to the Green River.

Photo 2: Unstable sediment at a Sandgate Road cross-culvert-inlet.

BMP Description: Clean up the loose sediment piles and stabilize the culvert outlets with rock to prevent scour.

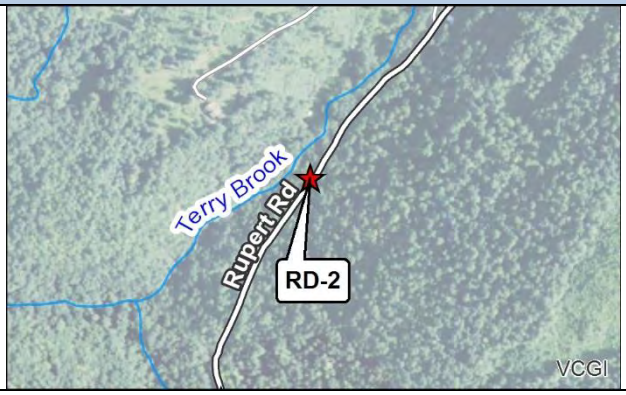
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
10	4	1	5	1	21 **(High)**

Additional Project Benefits Description: This problem area is a high-visibility water quality impact, where Sandgate Road runs alongside the Green River.

Project Comments: High priority project due to low cost and potential to mitigate a major sediment source to the Green River. **We estimate that this project (multiple sites) will cost $5,000 to $10,000.**

Project: RD-2	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	Rupert Road south of West Road
Latitude: **Longitude:**	43.19535 N 73.20220 W
Land Ownership:	Town



Site Description: The road crown along a portion of Rupert Road, directs water away from the ditch to a steep slope on the northwest side of the road above Terry Brook. Road runoff has eroded an approximately 50'-tall gully that conveys sediment from the road toward the brook and threatens the road (Photo 1).

Photo 1: Massive gully conveying sediment toward Terry Brook.

Photo 2: Road grade conveying runoff toward the steep slope and brook, rather than the existing ditch and cross-culvert.

BMP Description: Crown the road into the existing ditch and 18" corrugated steel cross-culvert on the southeast side of the road (Photo 2). Enlarge the ditch. Install log terraces and stone to stabilize road embankment slope as needed.

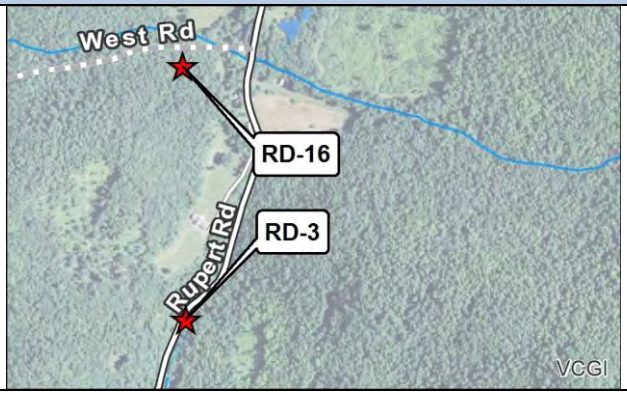
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
11	3	3	2	1	21 **(High)**

Additional Project Benefits Description:

Project Comments: High priority project due to potential to mitigate a major sediment source to Terry Brook and potential to increase infrastructure resiliency. **We estimate that this project will cost $8,000 to $10,000.**

Project: RD-3	**Problem Area Summary**

Date Observed:	4/27/2017
Location:	Rupert Road
Latitude: **Longitude:**	43.17534 N 73.21447 W
Land Ownership:	Town



Site Description: The road crown along a section of Rupert Road does not effectively direct water into the roadside ditch (Photo 1) and the ditches are poorly formed and eroding (Photo 2). The erosion is located near a first order tributary to Baldwin Brook.

Photo 1: The road crown on a section of Rupert Road is not effectively directing water into the roadside ditches.

Photo 2: Ditches along a section of Rupert Road are poorly formed and eroding.

BMP Description: Crown road to direct water into ditch. Enlarge ditch and line with 8" to 12” minus stone.

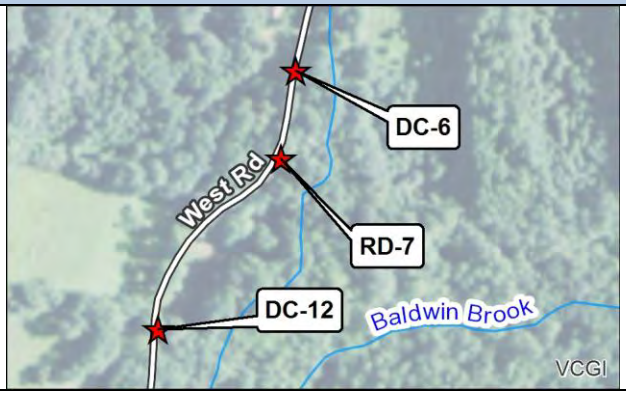
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
6	3	1	4	0	14 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to a first order tributary to Baldwin Brook and the low cost of the project. **We estimate that this project will cost $15,000 to $30,000 depending on length of ditch work required.**

Project: RD-7	**Problem Area Summary**

Date Observed:	4/27/2017
Location:	West Road
Latitude: **Longitude:**	43.16863 N 73.22927 W
Land Ownership:	Town



Site Description: Road crown does not effectively direct water into ditch, causing rutting where water runs down the road. Ditches spill across the road, eroding the roadway and embankment (Photo 1).

Photo 1: Erosion and sediment loss along a steep section of road embankment upslope of a tributary to Baldwin Brook.

BMP Description: Improve road crown and enlarge the ditch.

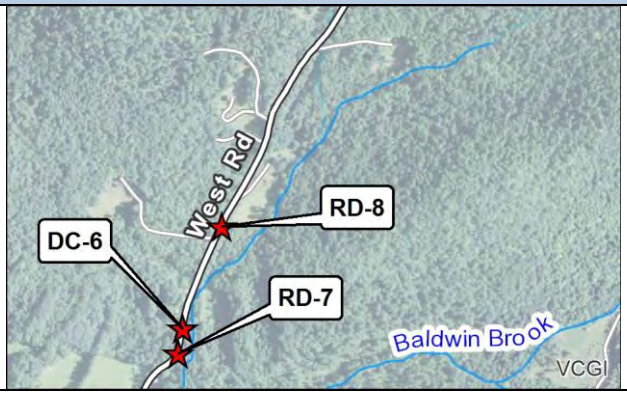
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
6	3	1	5	0	15 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to a Baldwin Brook tributary and the low cost of the project. **We estimate that this project will cost $5,000 to $15,000.**

Project: RD-8	**Problem Area Summary**

Date Observed:	4/27/2017
Location:	West Road
Latitude: **Longitude:**	43.17089 N 73.22823 W
Land Ownership:	Town



Site Description: A long (1,000ft) section of West Road is set between a steep forested bank and a tall grader berm with mature trees. The ditch along the west side is undersized and there are few opportunities for runoff to leave the road, leading to large areas of rill erosion. (Photo 1).

Photo 1: Rill erosion along the side of West Road.

BMP Description: Raise the road bed approximately 2ft and install a stone-lined ditch (12" minus stone) along the west side. Turnouts should be installed or improved along the east side. A new cross-culvert is also recommended.

WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	4	1	3	2	17 **(High)**

Additional Project Benefits Description: Project implementation will address a chronic road erosion area that requires frequent maintenance.

Project Comments: High priority project due to length of road lacking appropriate drainage and ongoing erosion issues. **We estimate that this project will cost $40,000 to $50,000, depending on the length or road to be raised.**

Project: RD-10	**Problem Area Summary**

Date Observed:	4/27/2017
Location:	Southeast Corner Road
Latitude: **Longitude:**	43.13142 N 73.18392 W
Land Ownership:	Town

Site Description: Road crown does not effectively direct water into ditch, causing rutting where water runs down this steep section of road (Photo 1).

Photo 1: Erosion along a steep section of Southeast Corner Road.

BMP Description: Crown road to direct water into the existing ditch. Clean out ditch, stabilize the side slope, and line the ditch with 12" minus stone.

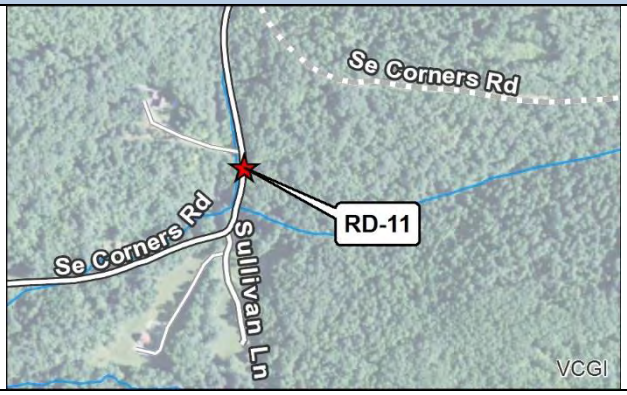
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	3	2	3	0	15 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to a first order stream. **We estimate that this project will cost $10,000 to $20,000.**

Project: RD-11	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	Southeast Corner Road
Latitude: **Longitude:**	43.13343 N 73.17889 W
Land Ownership:	Town



Site Description: Erosion along the edge of a steep section of Southeast Corner Road due to an unstable ditch that is relatively full of material. A first order tributary to a third order Green River tributary runs alongside the road (Photo 1).

Photo 1: Erosion of steep section of Southeast Corner Road.

BMP Description: Clean out ditch and stabilize with a minimum of 6-8" minus stone. Steeper ditch sections require 12" minus stone.

WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
8	3	2	4	2	19 **(High)**

Additional Project Benefits Description: This problem area is a high-visibility water quality impact, where a third order Green river tributary runs alongside Sandgate Road and creates a chronic problem area for road erosion.

Project Comments: High priority project due to low cost and potential to mitigate a sediment source to a tributary that drains directly into the Green River. **We estimate that this project will cost $10,000 to $20,000.**

Project: RD-14	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	Wilcox Hollow Road
Latitude: **Longitude:**	43.16217 N 73.17900 W
Land Ownership:	Town

Site Description: A cross-culvert along Wilcox Hollow Road is undersized and eroding at the outfall. The 15" corrugated metal pipe conveys water toward a second-order tributary to the Green River. The culvert outlet drops 8-9 feet down the steep road embankment to a second-order tributary to the Green River, causing erosion and sedimentation in the channel (Photo 2).

Photo 1: Ditch upstream of cross-culvert inlet on Wilcox Hollow Road is filled in, causing water to follow the road.

Photo 2: Erosion along the road edge at the cross-culvert outlet adjacent to a second order tributary to the Green River.

BMP Description: Replace cross-culvert with an 18" at a higher slope to reduce outlet drop. Stabilize the road edge and add an appropriate header and footer at the culvert outlet, stabilize the outflow channel to stream.

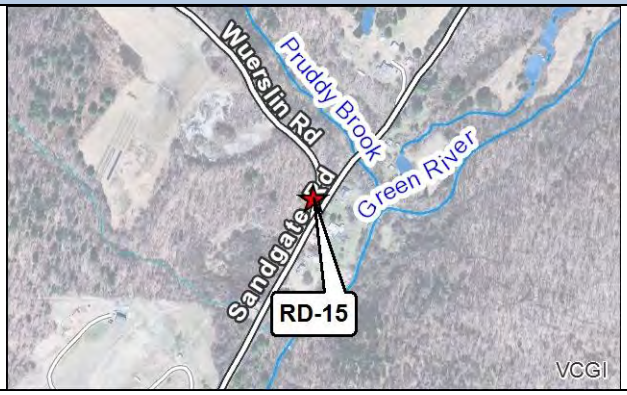
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
8	3	2	5	0	18 **(High)**

Additional Project Benefits Description:

Project Comments: High priority project due to low cost and potential to mitigate a sediment source to a stream that drains directly to the Green River. **We estimate that this project will cost $5,000 to $10,000.**

Project: RD-15	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Wuerslin Road at Sandgate Rd
Latitude: **Longitude:**	43.17123 N 73.16871 W
Land Ownership:	Town



Site Description: The ditches along the steep section of Wuerslin Road show signs of erosion and sedimentation and require stone to meet the MRGP standards. There is no room for a ditch along the west side of the lower road, requiring a new cross culvert. The spur of Wuerslin Road is used infrequently by vehicles and is an ideal location for a stormwater treatment feature. This area is a nuisance maintenance problem for the road foreman. Runoff from the lower part of Wuerslin Road spills onto Sandgate Road causing erosion problems where conveyance features are lacking.

Photo 1: Runoff down a steep portion of Wuerslin Road is causing erosion at the secondary turn to Sandgate Road.

Photo 2: Runoff from Wuerslin Road causing significant erosion as it crosses Sandgate Road.

BMP Description: Improve ditches along Wuerslin Road and install a stormwater treatment feature along the side of the road at the spur.

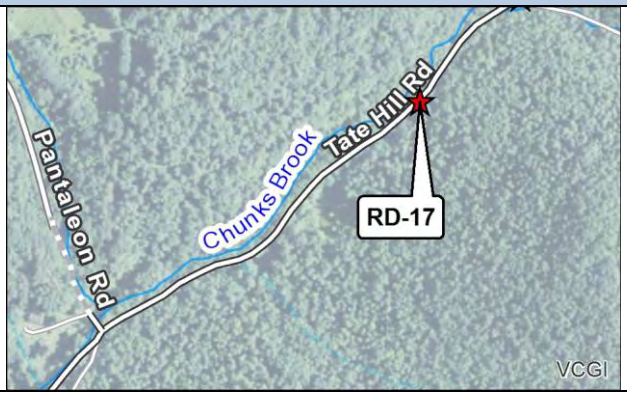
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
6	4	2	3	2	17 **(High)**

Additional Project Benefits Description: Project implementation will address a chronic erosion area.

Project Comments: High priority project due to the ongoing erosion issues and sediment loading at the site. **We estimate that this project will cost $15,000 to $25,000.**

Project: RD-17	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Tate Hill Road
Latitude: **Longitude:**	43.13213 N 73.24857 W
Land Ownership:	Town



Site Description: Water flows along Tate Hill road, causing erosion along steep road embankments adjacent to Chunks Brook (Photo 1).

Photo 1: Erosion of a steep road embankment along Tate Hill Road.

Photo 2: Water currently flowing over the road and eroding the road embankment may be directed into a ditch constructed on the opposite side of the roadway.

BMP Description: Install a ditch on the opposite side of the road (Photo 2) and crown the road to direct water into the ditch. At least one cross-culvert is recommended.

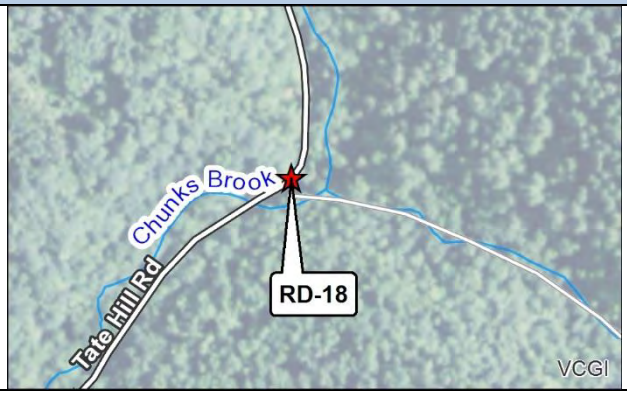
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
9	3	1	3	0	16 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to Chunks Brook. **We estimate that this project will cost $10,000 to $20,000.**

Project: RD-18	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Tate Hill Road
Latitude: **Longitude:**	43.13347 N 73.24682 W
Land Ownership:	Town



Site Description: Water flows across a steep section of Tate Hill Road, eroding the roadway (Photo 1).

Photo 1: Erosion of steep section of Tate Hill Road.

BMP Description: Clean out ditches and line with stone, crown road to direct water into ditches.

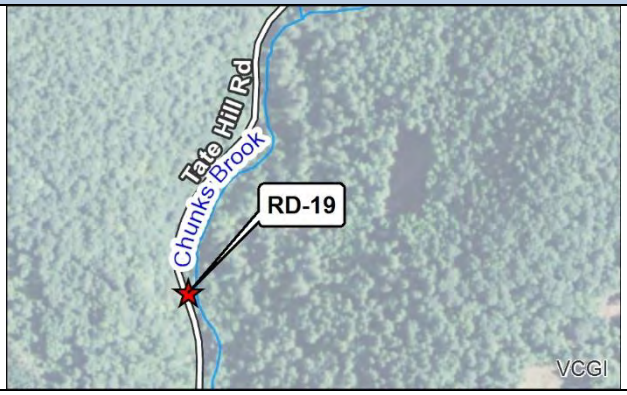
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	3	1	5	0	16 **(Medium)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to low cost and potential to mitigate a sediment source to Chunks Brook. **We estimate that this project will cost $5,000 to $10,000.**

Project: RD-19	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Tate Hill Road
Latitude: **Longitude:**	43.13460 N 73.24687 W
Land Ownership:	Town



Site Description: Chunks Brook flows alongside Tate Hill Road with no buffer, eroding the stream bank and road embankment (Photo 1).

Photo 1: Erosion where Chunks Brook flows alongside the Tate Hill Road embankment.

BMP Description: Armor the road embankment. Crown and ditch road to keep stormwater from flowing across the road to the streambank.

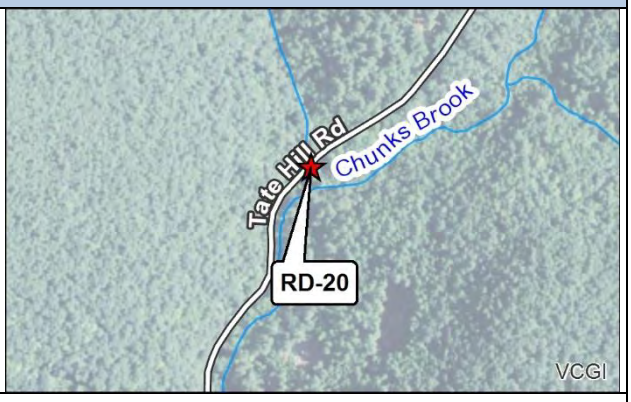
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
8	3	2	3	0	16 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to potential protect Tate Hill Road from erosion from runoff and from the stream, reduces sediment inputs to Chunks Brook. **We estimate that this project will cost $5,000 to $10,000.**

Project: RD-20	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Tate Hill Road
Latitude: **Longitude:**	43.13757 N 73.24531 W
Land Ownership:	Town



Site Description: Water flows along a steep section of Tate Hill Road eroding the surface and directing sediment toward a culvert where Chunks Brook crosses the road (Photos 1 & 2).

Photo 1: Road erosion to a conveyance at a Chunks Brook stream crossing.

Photo 2: Road erosion along a steep section of Chunks Brook Road.

BMP Description: Crown road to direct water into ditches. Excavate and stabilize ditches with stone as needed.

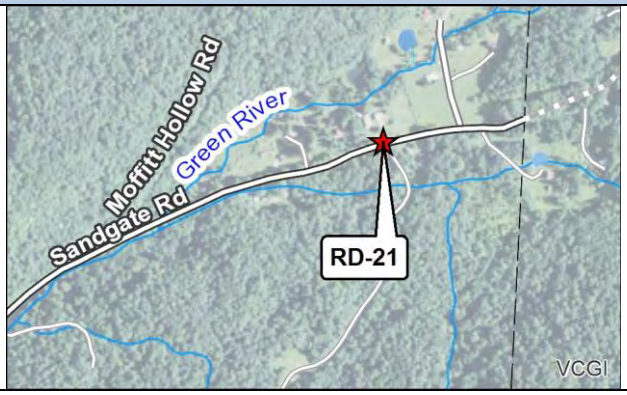
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
8	3	1	4	1	17 **(High)**

Additional Project Benefits Description: Erosion appears to be a chronic issue at this site.

Project Comments: High priority project due to low cost and potential to mitigate a sediment source to Chunks Brook. **We estimate that this project will cost approximately $5,000 to 10,000.**

Project: RD-21	**Problem Area Summary**

Date Observed:	4/13/2017
Location:	Sandgate Road
Latitude: **Longitude:**	43.18866 N 73.13398 W
Land Ownership:	Town



Site Description: Sandgate Road lacks a good crown and drainage ditches (Photo 1). The road elevation sits below adjacent properties in many locations, leading to rilling along the road edge and washouts during spring runoff and heavy rain storms. One existing turnout to the stream is unstable and contributing sediment to the channel. A 15" metal cross culvert is undersized and in fair condition, and has been plugged in the past per RPC culvert inventory data.

Photo 1: Upper section of Sandgate Road at Woods Gift Lane.
Runoff is running along the road edge causing rilling and sedimentation downhill.

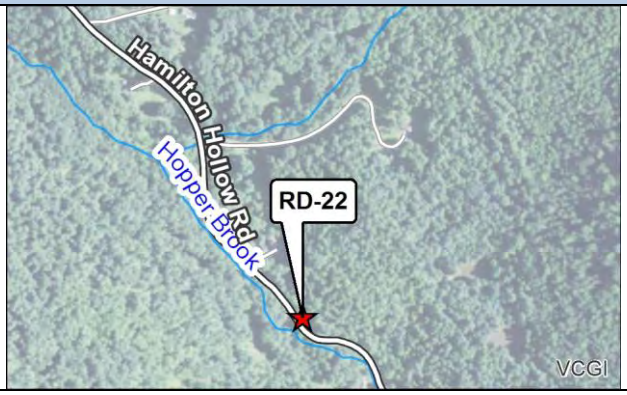
BMP Description: Improve road crown, Install roadside ditches, upgrade the existing cross-culvert and install a driveway culvert.

WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	4	2	3	2	18 **(High)**

Additional Project Benefits Description: The lack of appropriate drainage likely requires frequent maintenance to address chronic erosion issues.

Project Comments: Moderate priority project due to the potential to mitigate a sediment source to a tributary of the Green River and alleviate the infrastructure conflicts and erosion issues in this chronic problem area. **We estimate that this project will cost $15,000 to $25,000.**

Project: RD-22	**Problem Area Summary**
Date Observed:	4/13/2017
Location:	Upper Hamilton Hollow Road
Latitude: **Longitude:**	43.14623 N 73.17533 W
Land Ownership:	Town



Site Description: Limited space along north side of road for drainage from Merritt residence down along Hopper Brook. Road erosion and rilling along the road leading to sedimentation in brook (Photo 1).

Photo 1: Narrow road with Hopper Brook on left and limited space for a ditch on the east side of road.

BMP Description: Consider installing larger cross culvert below Merritt property. Install ditch along north side of road across from Hopper Brook. This may involve significant cutting of the slope to install an adequate ditch.

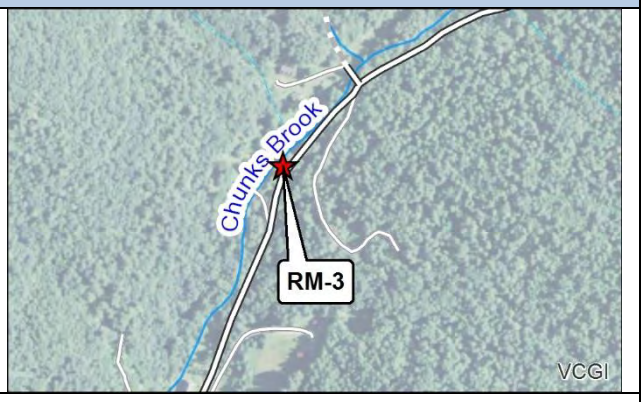
WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
9	3	2	3	2	19 **(High)**

Additional Project Benefits Description: Project implementation will address chronic erosion issues at this site and reduce sediment loading directly into Hopper Brook.

Project Comments: High priority project due to the potential to mitigate a sediment source to Hopper Brook and the relatively low cost of the project. **We estimate that this project will cost $15,000 to $25,000, potentially higher if additional roadway improvements are necessary.**

Project: RM-3	**Problem Area Summary**

Date Observed:	6/28/2017
Location:	Chunks Brook Road
Latitude: **Longitude:**	43.12819 N 73.25531 W
Land Ownership:	Town



Site Description: A tree is down across Chunks Brook alongside Chunks Brook road (Photo 1). This creates an erosion hazard for the road by destabilizing the embankment and potentially directing flow toward the road (Photo 2).

Photo 1: Tree down across Chunks Brook.

Photo 2: Exposed embankment along Chunks Brook road.

BMP Description: Remove tree from channel and armor road embankment. This project requires further review by the ANR River Management Engineer.

WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
7	3	3	4	0	16 **(Moderate)**

Additional Project Benefits Description:

Project Comments: Moderate priority project due to low cost, potential to increase infrastructure resiliency, and potential to mitigate a nutrient/sediment source to Chunks Brook. **We estimate that this project will cost $5,000 - $10,000.**

Project: SC-1	**Problem Area Summary**

Date Observed:	4/26/2017
Location:	Baldwin Brook at West Sandgate Road
Latitude: **Longitude:**	43.16186 N 73.25019 W
Land Ownership:	Town

Site Description: 5.3' diameter rusted repurposed steel tank culvert perched 0.35' above downstream pool, resulting in reduced Aquatic Organism Passage (AOP) (Photo 1). Additionally, the culvert is hydraulically undersized for the 2.68 mi^2 watershed.

Photo 1: Outlet drop from Baldwin Brook culvert at West Sandgate Road.

Photo 2: View of downstream channel from roadway. Location of proposed boulder veins to raise tailwater control.

BMP Description: Install boulder veins downstream of the outlet pool, which doubles as a fire department hydrant, to raise the tailwater control to provide AOP (Photo 2). Seek detailed hydraulic study to replace culvert with a larger structure to obtain sufficient capacity for larger storm events. Preliminary HY-8 modeling suggests a 6ft x 14ft box culvert to improve geomorphic compatibility and pass the 25-yr storm.

WQ Benefits	Landowner Support and O&M	Infrastructure Resiliency	Cost and Constructability	Additional Benefits	Total Score (Priority)
4	3	3	4	1	15 **(Moderate)**

Additional Project Benefits Description: This project will restore habitat connectivity for aquatic organisms in Baldwin Brook.

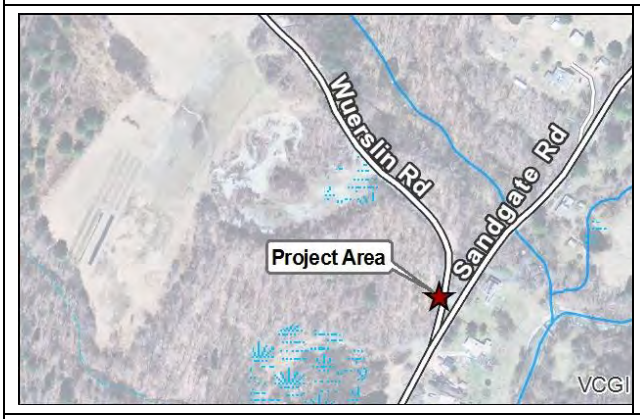
Project Comments: Moderate priority project due to the potential to restore aquatic organism passage to a section of Baldwin Brook. **We estimate that raising the tailwater elevation will cost $2,000 to $5,000, while replacing the culvert with a new box culvert will likely cost upwards of $100,000.**

APPENDIX D:

Conceptual Designs

Town: Sandgate	**Road Name:** Wuerslin and Sandgate Roads	**Date Visited:** 9/29/2017

Road Segment IDs: Wuerslin Road: 200996, 200997; Sandgate Road: 163647, 163648



Existing Conditions

Field Determined Slope: 10-14%

Road Type: Gravel

Conveyance Area/Turnout: 1 Poor, 2 Filtered

Erosion Types Present: Rill

Drainage Culverts: 3 Cross

Driveway Culverts: None

Municipal Road General Permit Standards:

+ Meets Standard, **--** Partially Meets Standard (needs work), **X** Does Not Meet Standard

Roadway Crown/Travel Lane	X	Grader Berm/Windrow	+
Road Drainage	X	Conveyance Area/Turnout	X
Municipal Drainage Culverts	+	Driveway Culverts (within ROW)	+

Existing Conditions Notes: The ditches along the steep section of Wuerslin Road show signs of erosion and sedimentation and require stone to meet the MRGP standards. There is no room for a ditch along the west side of the lower road, requiring a new cross culvert. The spur of Wuerslin Road is used infrequently by vehicles and is an ideal location for a stormwater treatment feature. This area is a nuisance maintenance problem for the road foreman. Runoff from the lower part of Wuerslin Road spills onto Sandgate Road causing erosion problems where conveyance features are lacking.

Photo 1: Steep section of upper Wuerslin Road needing stone in ditches and additional cross culverts.

Photo 2: Area of Wuerslin Road to be abandoned for vehicle traffic and turned into a stormwater treatment feature.

Proposed Scope of Work

Roadway/Travel Lane Practices

X	Improve Road Crown	X	Adjust Road Grade
	Remove Grader Berm		Edge of Road Stabilization/Maintenance

Roadway Drainage Practices

X	Install New Ditch	X	Improve Existing Ditch
	Side Slope Excavation for New Ditch		

Conveyance/Turnout Practices

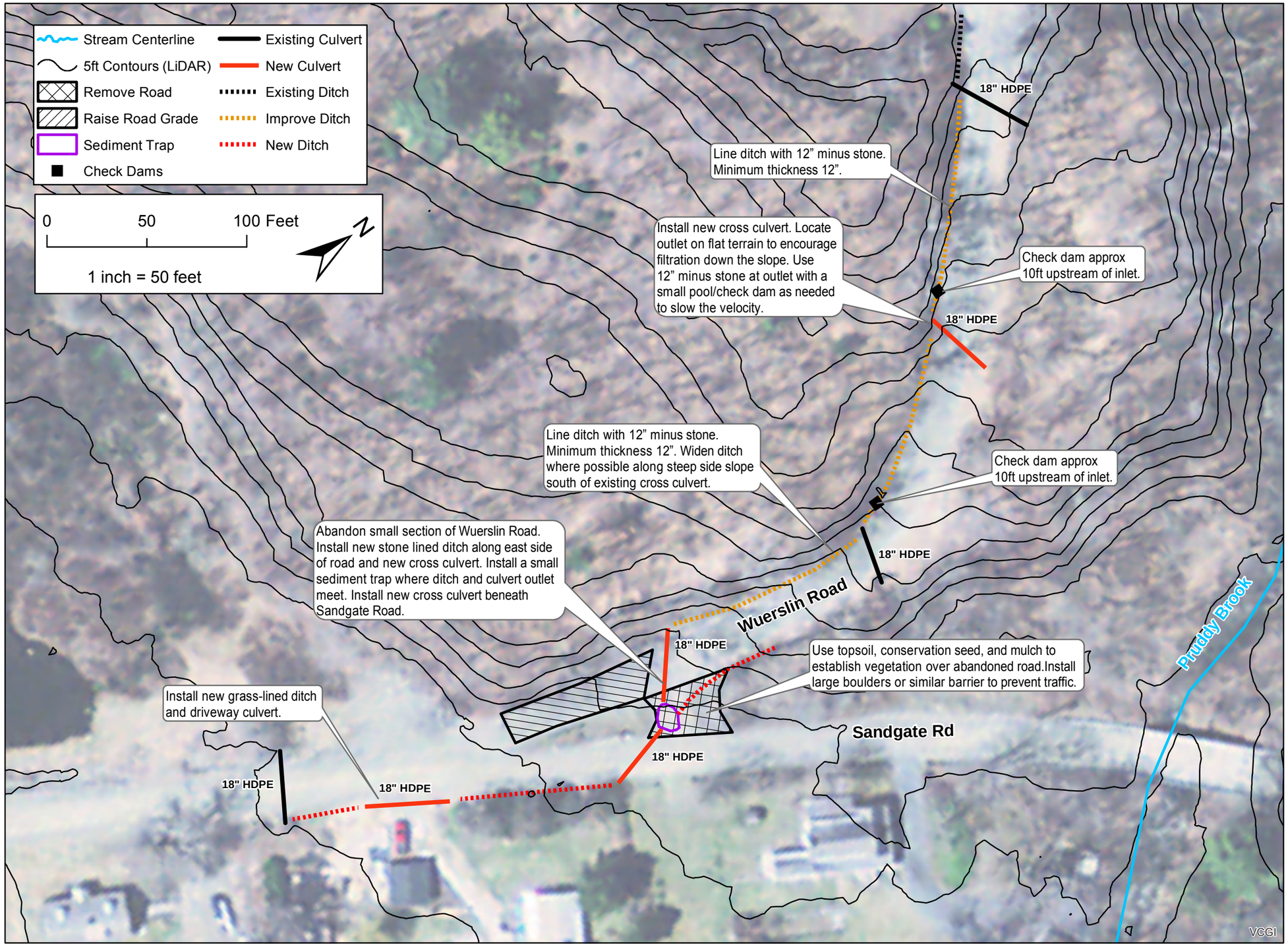
	Install Turnout		Stabilize/Improve Existing Turnout
X	Install Sediment Trap		Stone Armor on Bank/Slope
X	Install Check Dams in Existing Feature		

Culvert Practices

X	New Municipal Culvert		Upgrade Municipal Culvert
X	New Driveway Culvert		Upgrade Driveway Culvert
	Headwall or Armor at Culvert Inlet/Outlet	X	Clean Sediment/Debris from Culvert

Estimated Project Costs

Practice	Units	Unit Cost	Quantity	Total
Improve Road Crown	Linear Foot	$ 5	0	$ -
Raise Road Grade	Cubic Yard	$ 15	27	$ 405
Remove Grader Berm/Lower Shoulder	Linear Foot	$ 5	0	$ -
Edge of Road Stabilization/Maintenance	Linear Foot	$ 8	0	$ -
New Stone-Lined Ditch	Linear Foot	$ 25	60	$ 1,500
New Grass-Lined Ditch	Linear Foot	$ 8	125	$ 1,000
Side Slope Excavation for New Ditch	Linear Foot	$ 10	0	$ -
Improve Existing Ditch (Stone)	Linear Foot	$ 20	340	$ 6,800
Improve Existing Ditch (Grass)	Linear Foot	$ 5	0	$ -
Install/Improve Turnout	Each	$ 200	1	$ 200
Install Sediment Trap	Each	$ 750	1	$ 750
Install Stone Armor (Bank/Slope)	Cubic Yard	$ 40	0	$ -
Install Check Dam	Each	$ 40	2	$ 80
New/Upgrade Cross-Culvert (18" to 24")	Each	$ 1,500	3	$ 4,500
New/Upgrade Conveyance Culvert	Each	$ 2,500	0	$ -
New/Upgrade Driveway Culvert	Each	$ 750	1	$ 750
Install Culvert Headwall/Armor	Each	$ 300	0	$ -
Remove Sediment/Debris from Culvert	Each	$ 100	1	$ 100
			Total Cost:	**$ 16,085**



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Notes:
Site visit completed on 9/29/2017

Drawn: EPF
Date: 10/29/2017

Concept Design Overview

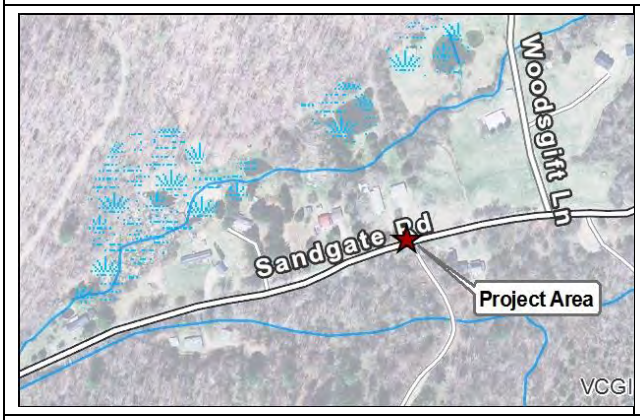
Sandgate Stormwater Master Plan

Wuerslin-Sandgate Rd Intersection
Sandgate, VT

Wuerslin Road & Sandgate Road

Town: Sandgate	**Road Name:** Sandgate Road ("Beartown")	**Date Visited:** 9/29/2017

Road Segment IDs: Sandgate Road: 163662, 163663



Existing Conditions

Field Determined Slope: 4-5%

Road Type: Gravel

Conveyance Area/Turnout: 1 Poor

Erosion Types Present: Rill, Gully

Drainage Culverts: 1 Cross

Driveway Culverts: None

Municipal Road General Permit Standards:

+ Meets Standard, **--** Partially Meets Standard (needs work), **X** Does Not Meet Standard

Roadway Crown/Travel Lane	X	Grader Berm/Windrow	X
Road Drainage	X	Conveyance Area/Turnout	X
Municipal Drainage Culverts	+	Driveway Culverts (within ROW)	+

Existing Conditions Notes: Sandgate Road lacks a good crown and drainage ditches. The road elevation sits below adjacent properties in many locations, leading to rilling along the road edge and washouts during spring runoff and heavy rain storms. One existing turnout to the stream is unstable and contributing sediment to the channel. A 15" metal cross culvert is undersized and in fair condition, and has been plugged in the past per RPC culvert inventory data.

Photo 1: Upper section of Sandgate Road at Woods Gift Lane. Runoff is running along the road edge causing rilling and sedimentation downhill.

Photo 2: Lower section of Sandgate Road. Runoff is running along the road edge causing rilling and sedimentation downhill.

Proposed Scope of Work

Roadway/Travel Lane Practices

X	Improve Road Crown	X	Adjust Road Grade
	Remove Grader Berm		Edge of Road Stabilization/Maintenance

Roadway Drainage Practices

X	Install New Ditch		Improve Existing Ditch
	Side Slope Excavation for New Ditch		

Conveyance/Turnout Practices

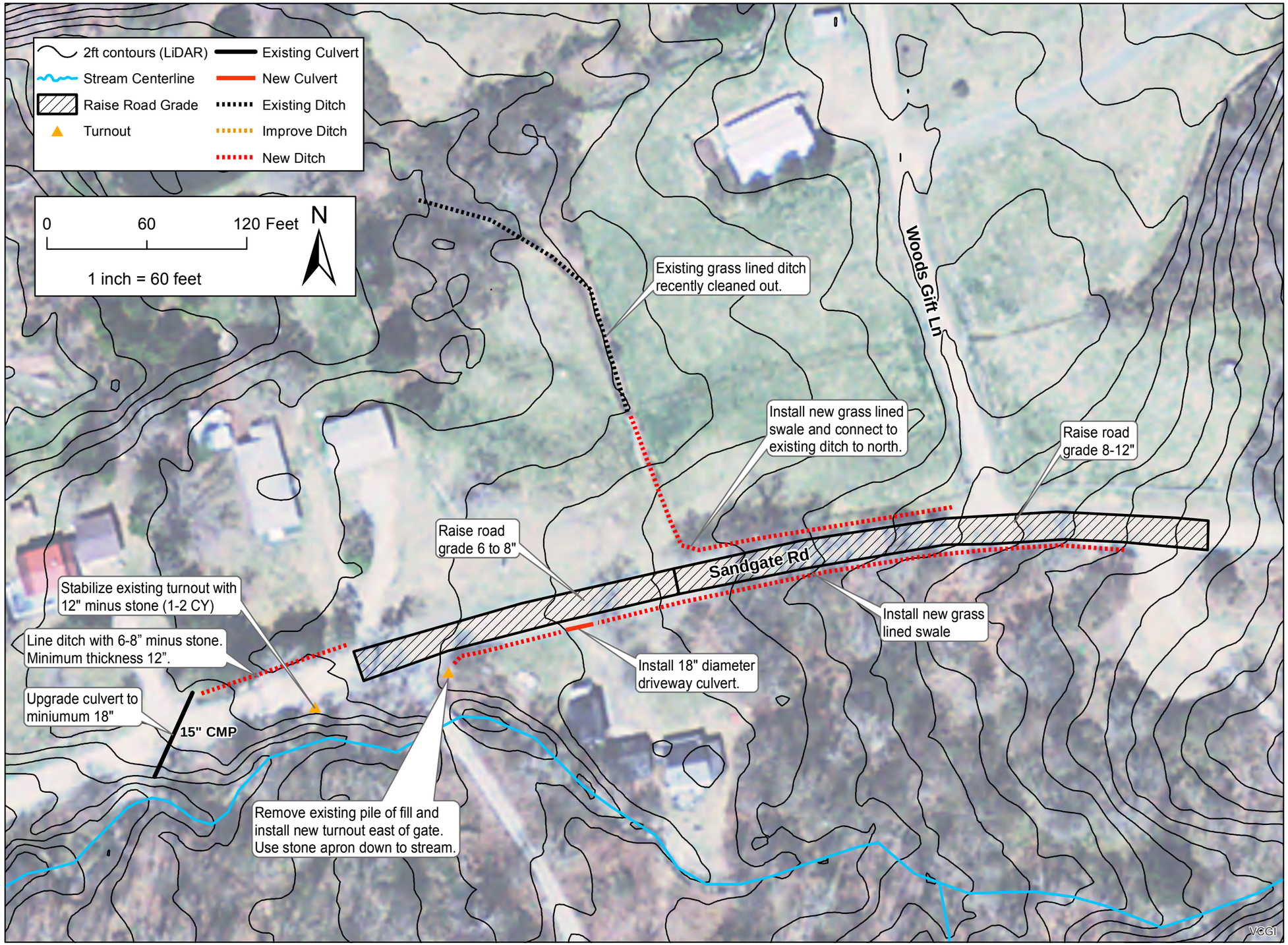
X	Install Turnout	X	Stabilize/Improve Existing Turnout
	Install/Improve Sediment Trap		Stone Armor on Bank/Slope
	Install Check Dams in Existing Feature		

Culvert Practices

	New Municipal Culvert	X	Upgrade Municipal Culvert
X	New Driveway Culvert		Upgrade Driveway Culvert
	Headwall or Armor at Culvert Inlet/Outlet		Clean Sediment/Debris from Culvert

Estimated Project Costs

Practice	Units	Unit Cost	Quantity	Total
Improve Road Crown	Linear Foot	$ 5	130	$ 650
Raise Road Grade	Cubic Yard	$ 15	250	$ 3,750
Remove Grader Berm/Lower Shoulder	Linear Foot	$ 5	0	$ -
Edge of Road Stabilization/Maintenance	Linear Foot	$ 8	0	$ -
New Stone-Lined Ditch	Linear Foot	$ 80	60	$ 4,800
New Grass-Lined Ditch	Linear Foot	$ 8	640	$ 5,120
Side Slope Excavation for New Ditch	Linear Foot	$ 10	0	$ -
Improve Existing Ditch (Stone)	Linear Foot	$ 20	0	$ -
Improve Existing Ditch (Grass)	Linear Foot	$ 5	0	$ -
Install/Improve Turnout	Each	$ 200	2	$ 400
Install Sediment Trap	Each	$ 750	0	$ -
Install Stone Armor (Bank/Slope)	Cubic Yard	$ 40	0	$ -
Install Check Dam	Each	$ 40	0	$ -
New/Upgrade Cross-Culvert (18" to 24")	Each	$ 1,500	1	$ 1,500
New/Upgrade Conveyance Culvert	Each	$ 2,500	0	$ -
New/Upgrade Driveway Culvert	Each	$ 750	1	$ 750
Install Culvert Headwall/Armor	Each	$ 300	0	$ -
Remove Sediment/Debris from Culvert	Each	$ 100	0	$ -
			Total Cost:	**$ 16,970**



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Notes: Site visit completed on 9/29/2017

Drawn: EPF

Date: 11/3/2017

Concept Design Overview

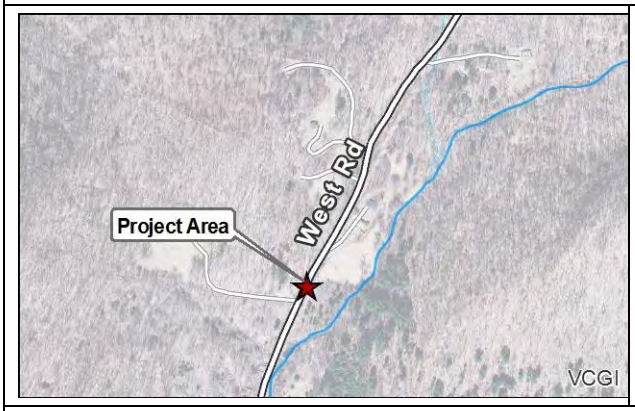
Sandgate Stormwater Master Plan

"Beartown" on Sandgate Road
Sandgate, VT

"Beartown" on Sandgate Road

Town: Sandgate	**Road Name:** West Road	**Date Visited:** 10/23/2017

Road Segment IDs: West Road 196119, 196118, 196117



Existing Conditions

Field Determined Slope: 10%

Road Type: Gravel

Conveyance Area/Turnout: 2 Filtered

Erosion Types Present: Gully, Rill

Drainage Culverts: 1 Cross

Driveway Culverts: 1

Municipal Road General Permit Standards:

+ Meets Standard, **--** Partially Meets Standard (needs work), **X** Does Not Meet Standard

Roadway Crown/Travel Lane	X	Grader Berm/Windrow	X
Road Drainage	X	Conveyance Area/Turnout	--
Municipal Drainage Culverts	X	Driveway Culverts (within ROW)	+

Existing Conditions Notes: The section of West Road from the crest of the hill down to the dry hydrant pond is set between a tall berm with large trees and a relatively steep forested hillslope. The ditch along the west side is shallow and undersized. The road is poorly crowned, and runoff has limited opportunities to leave the road, increasing erosion and sediment loading downstream. The underlying clay soils are prone to extended periods of saturation, increasing road maintenance requirements.

Photo 1: The road has a near continuos tall grader berm (with large trees) along the east side and an undersized and shallow ditch along the west side.

Photo 2: Existing armored turnouts are only partially accessible due to accumulation of road bed material.

Proposed Scope of Work

Roadway/Travel Lane Practices

	Improve Road Crown	X	Adjust Road Grade
	Remove Grader Berm		Edge of Road Stabilization/Maintenance

Roadway Drainage Practices

	Install New Ditch	X	Improve Existing Ditch
X	Side Slope Excavation for New Ditch		

Conveyance/Turnout Practices

	Install Turnout	X	Stabilize/Improve Existing Turnout
	Install/Improve Sediment Trap		Stone Armor on Bank/Slope
	Install Check Dams in Existing Feature		

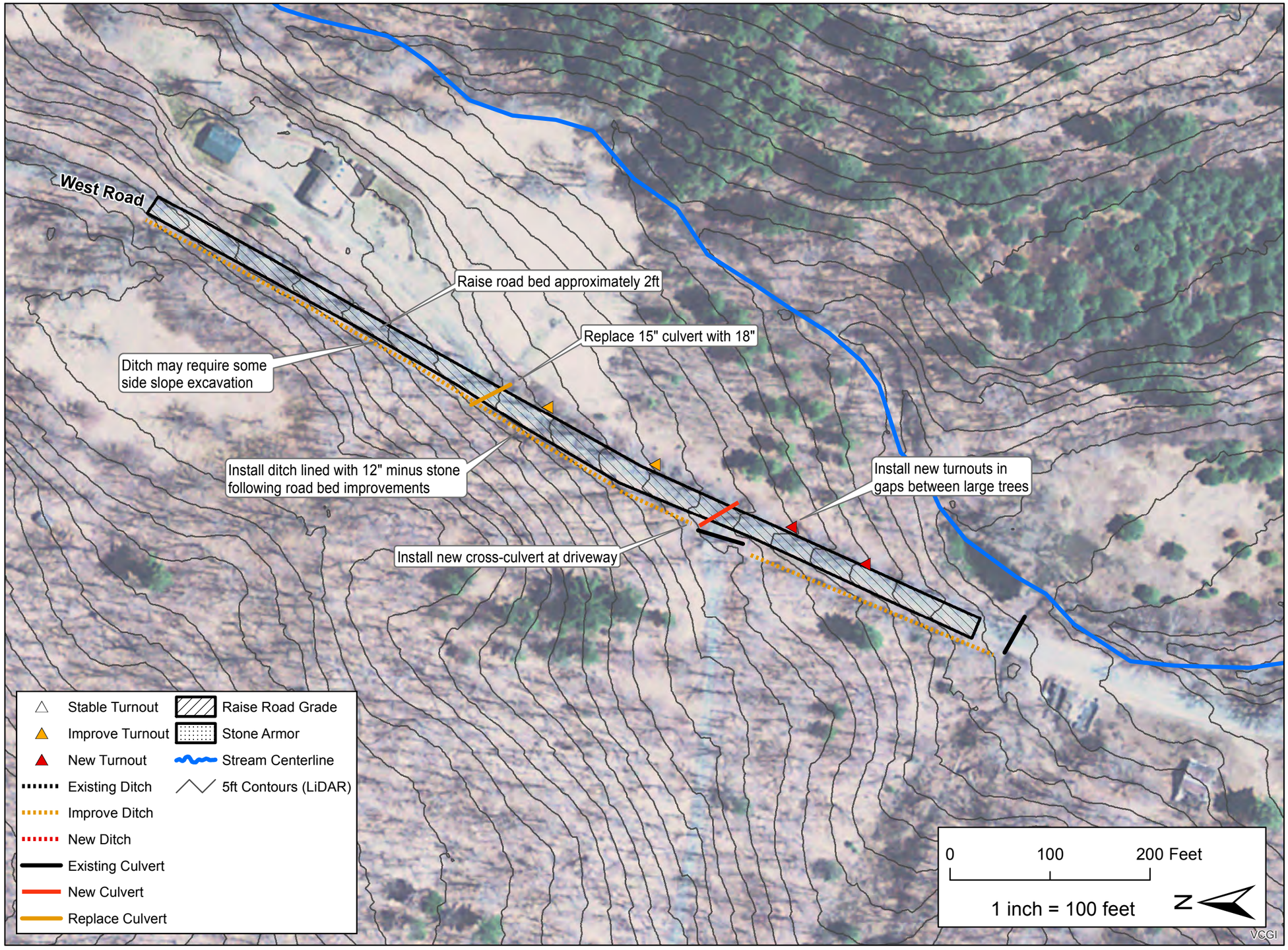
Culvert Practices

X	New Municipal Culvert		Upgrade Municipal Culvert
	New Driveway Culvert		Upgrade Driveway Culvert
X	Headwall or Armor at Culvert Inlet/Outlet		Clean Sediment/Debris from Culvert

Estimated Project Costs

Practice	Units	Unit Cost	Quantity	Total
Improve Road Crown	Linear Foot	$ 5	0	$ -
Raise Road Grade	Cubic Yard	$ 15	1100	$16,500
Remove Grader Berm	Linear Foot	$ 5	0	$ -
Edge of Road Stabilization/Maintenance	Linear Foot	$ 8	0	$ -
New Stone-Lined Ditch	Linear Foot	$ 25	0	$ -
New Grass-Lined Ditch	Linear Foot	$ 8	0	$ -
Side Slope Excavation for New Ditch	Linear Foot	$ 10	150	$ 1,500
Improve Existing Ditch (Stone)	Linear Foot	$ 20	1000	$20,000
Improve Existing Ditch (Grass)	Linear Foot	$ 5	0	$ -
Install/Improve Turnout	Each	$ 200	4	$ 800
Install Sediment Trap	Each	$ 750	0	$ -
Install Stone Armor (Bank/Slope)	Cubic Yard	$ 40	0	$ -
Install Check Dam	Each	$ 40	0	$ -
New/Upgrade Cross-Culvert (18" to 24")	Each	$ 1,500	2	$ 3,000
New/Upgrade Conveyance Culvert	Each	$ 2,500	0	$ -
New/Upgrade Driveway Culvert	Each	$ 750	0	$ -
Install Culvert Headwall/Armor	Each	$ 300	1	$ 300
Remove Sediment/Debris from Culvert	Each	$ 100	0	$ -
			Total Cost:	**$42,100**

Note: Estimated costs are maximum probable costs based on typical contractor rates. Actual costs will vary by municipality based on labor rates, availability of town-owned equipment, and cost of materials.



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Notes:
Site visit completed on 11/3/2017

Drawn: JHB, EHB
Date: 12/21/2017

Concept Design Overview

Sandgate Stormwater Master Plan

West Road
Sandgate, VT

West Road

Project RD-2, Rupert Road Embankment Stabilization

Existing Conditions

The road crown along a portion of Rupert Road directs water away from the ditch to a steep slope on the northwest side of the road above Terry Brook (Figures 1 & 2). Road runoff has eroded an approximately 50'-tall gully that conveys sediment from the road toward the brook and threatens the road (Figure 3). The slope of the embankment down to the stream is approximately 75%. A small grader berm on the west side of Rupert Road prevents water from sheeting off the road before it reaches the gully.

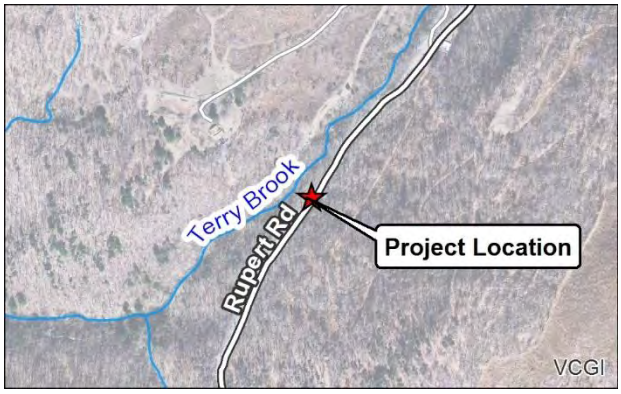


Figure 1: Project location map for the Rupert Road embankment stabilization.

Figure 2: The road crown does not direct water into the existing ditch and cross culvert along a section of Rupert Road.

Figure 3: Gully erosion along the steep Rupert Road embankment.

Problem Overview

This gully is likely a major sediment source to Terry Brook. The gully erosion threatens Rupert Road, which could require costly maintenance. For instance, FEA observed a failed guardrail that appeared to have slid down the embankment as it eroded. Additionally, the cross-culvert outlet was partially blocked by sediment from the erosion.

Concept Design

Removing the grader berm would help water sheet flow off the road before the gully. Ensuring the road is crowned toward the ditch and that the cross-culvert outlet in unobstructed would help keep water from flowing over the top of the road embankment.

A 30" diameter standing dead ash tree is located along the road embankment. The tree could be harvested to obtain two (2), 20-foot long logs. The logs could be used to construct two (2) log terraces located approximately 15-feet and 30-feet down the embankment from the culvert outlet (Sheets 1 & 2). The logs should be anchored with 10-foot lengths of #9 rebar driven 7 feet into the slope, with 4 pieces of rebar used per log. Twelve (12) inch minus stone should tapered into the slope above the log terraces and used to stabilize the culvert outlet. This effort would require additional technical design guidance and oversight in coordination with the Town.

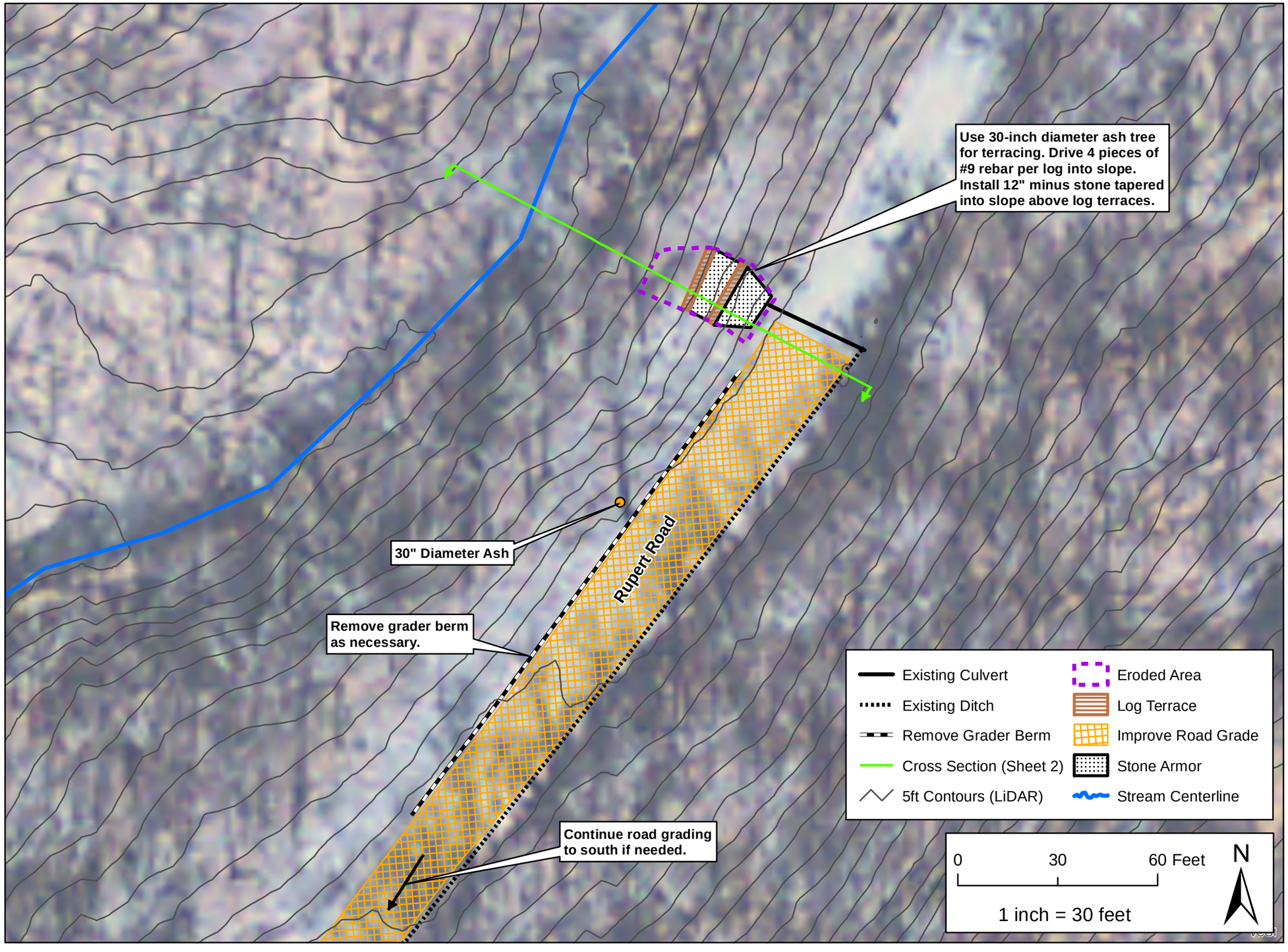
Regulatory Requirements

All the work can be done from the road with no impacts to streams or wetlands, and no tree cutting. Therefore, no permit requirements are anticipated for the work proposed.

Project Cost Estimate

Estimated Project Costs

Description	Units	Unit Cost	Quantity	Cost
Improve Road Crown	Linear Foot	$ 5	400	$ 2,000
Excavator Log and Rebar Placement	Hours	$ 120	16	$ 1,920
Remove Grader Berm	Linear Foot	$ 5	175	$ 875
#9 Rebar	Linear Foot	$ 10	80	$ 800
12" Stone Placed	Cubic Yard	$ 50	16	$ 800
Laborer	Hours	$ 40	16	$ 640
			Subtotal Cost:	$ 7,035
			Contingency (20%):	$ 1,407
			Total:	**$ 8,442**



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Notes:
Site visits completed on 4/27/2017 and 9/29/2017

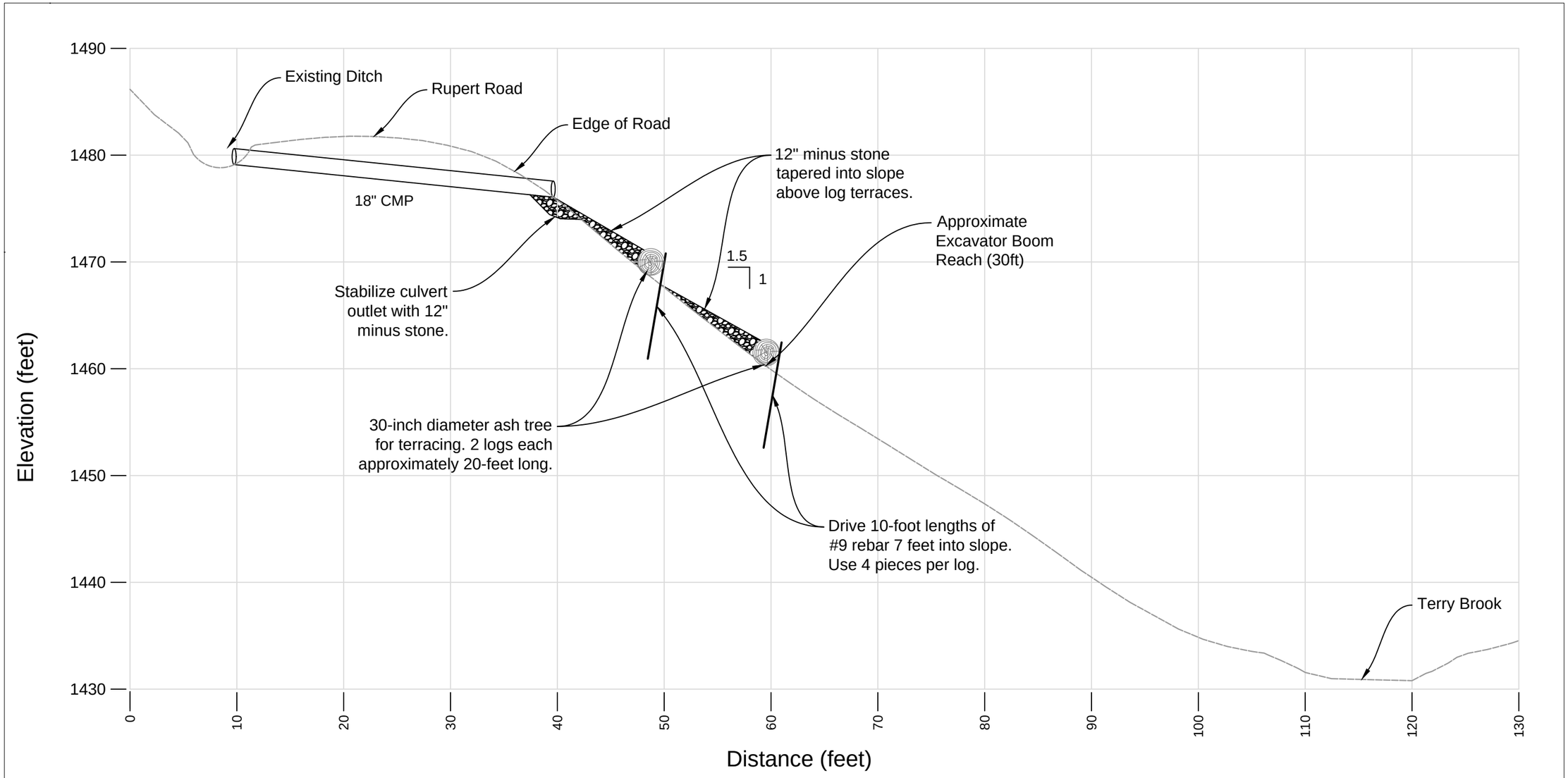
Drawn: EPF, EHB
Date: 12/21/2017

Concept Design Overview

Sandgate Stormwater Master Plan

Rupert Road
Sandgate, VT

Rupert Road
Sheet 1: Plan



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Sandgate Stormwater Master Plan
Concept Design
Rupert Road - Eroded Slope
Sandgate, VT

Scale: 1"=10'
December 21, 2017
Drawn: EHB
Checked: EPF

Notes: Existing profile and features based on LiDAR data and field measurements.

SHEET 2
Cross-Section

Project RD-14, Wilcox Hollow Culvert Replacement

Existing Conditions

A cross-culvert along Wilcox Hollow Road is undersized and eroding at the outfall (Figures 1 & 2). The 15" corrugated metal pipe conveys water toward a second-order tributary to the Green River. The culvert outlet drops 8-9 feet down the steep road embankment to a second-order tributary to the Green River, causing erosion and sedimentation in the channel. The outlet of the pipe is bent and deformed, indicating a need for replacement. Additionally, water from the road is causing rilling along the road edge.

Figure 1: Project location map for the Wilcox Hollow culvert replacement.

Figure 2: Rilling along the road edge and erosion of the Wilcox Hollow Road cross culvert outfall.

Figure 3: Filling in of the ditch upstream of the culvert may be causing water to spill out of the ditch onto the roadway.

Problem Overview

The erosion along the road edge and embankment is likely a significant sediment source to stream. Additionally, the erosion at the outfall and road edge is a chronic problem area requiring maintenance by the Town. The metal culvert requires replacement due to its condition and size to meet the forthcoming MRGP requirements.

Concept Design

Replacing the 15" CMP cross culvert with an 18" CPP culvert would increase the culvert capacity. The new culvert should be installed with a higher slope, reducing the outlet drop to the stream. This would reduce erosion of the road embankment. Additionally, the header and footer of the culvert outlet should be stabilized with stacked stone to armor the embankment and outfall. Stone (12'-minus) should be placed

on the area from the header to the edge of the road to prevent rilling of the road edge and erosion of the header. Ensuring the road is crowned and upstream ditch is cleaned out will help direct water into the cross-culvert and may reduce rilling of the road edge (Figure 3).

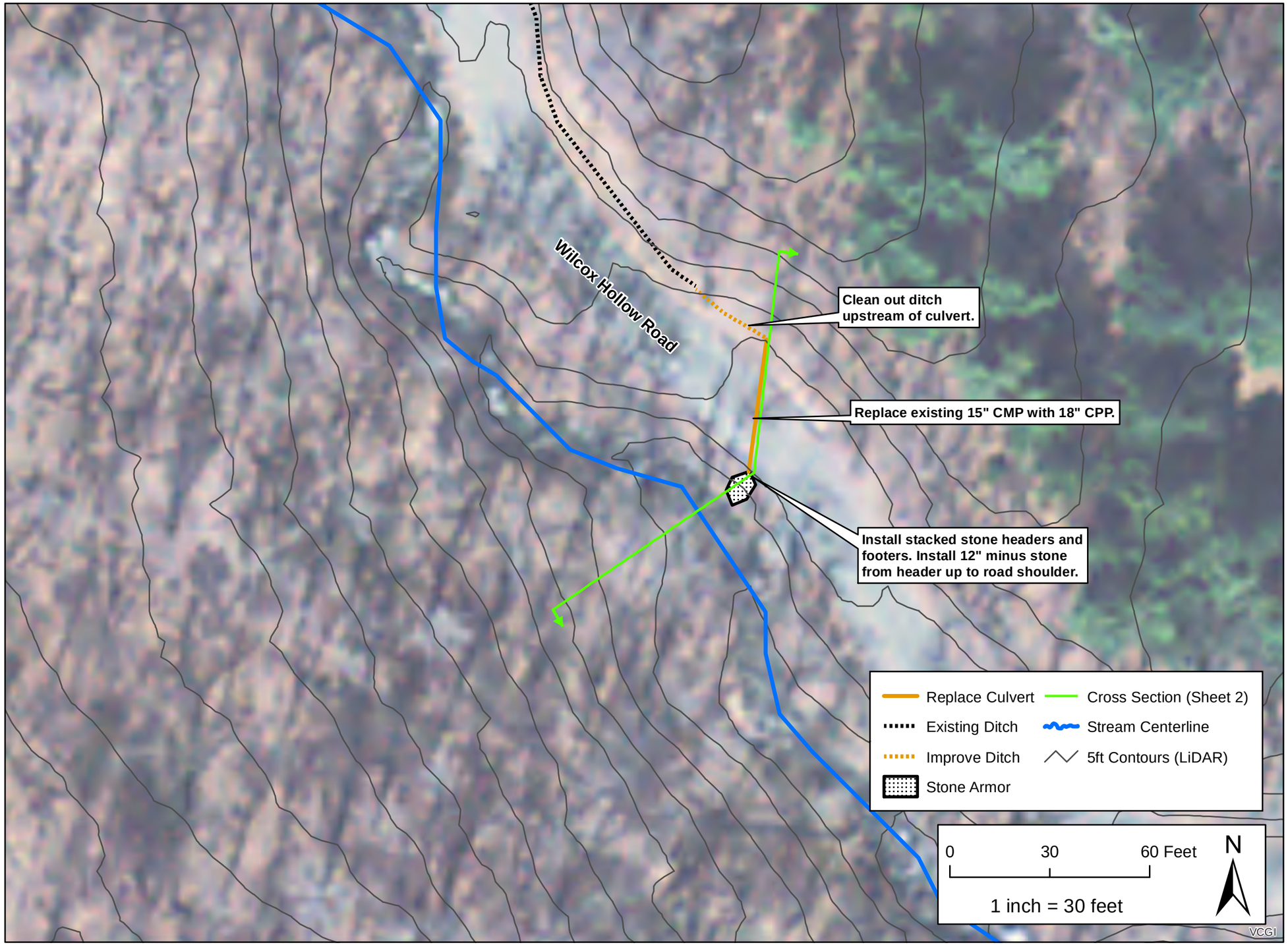
Regulatory Requirements

All the work can be done from the road with no impacts to streams or wetlands, and no tree cutting. Therefore, no permit requirements are anticipated for the work proposed.

Project Cost Estimate

Estimated Project Costs

Description	Units	Unit Cost	Quantity	Cost
Stone Transport and Placement	Cubic Yard	$ 50	16	$ 800
Improve Existing Ditch (Stone)	Linear Foot	$ 20	25	$ 500
New/Upgrade Cross-Culvert (18" to 24")	Each	$ 3,000	1	$ 3,000
Install Culvert Header/Footer	Each	$ 1,000	1	$ 1,000
			Subtotal Cost:	$ 5,300
			Contingency (20%):	$ 1,060
			Total:	**$ 6,360**



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Notes:
Site visit completed on 4/27/2017

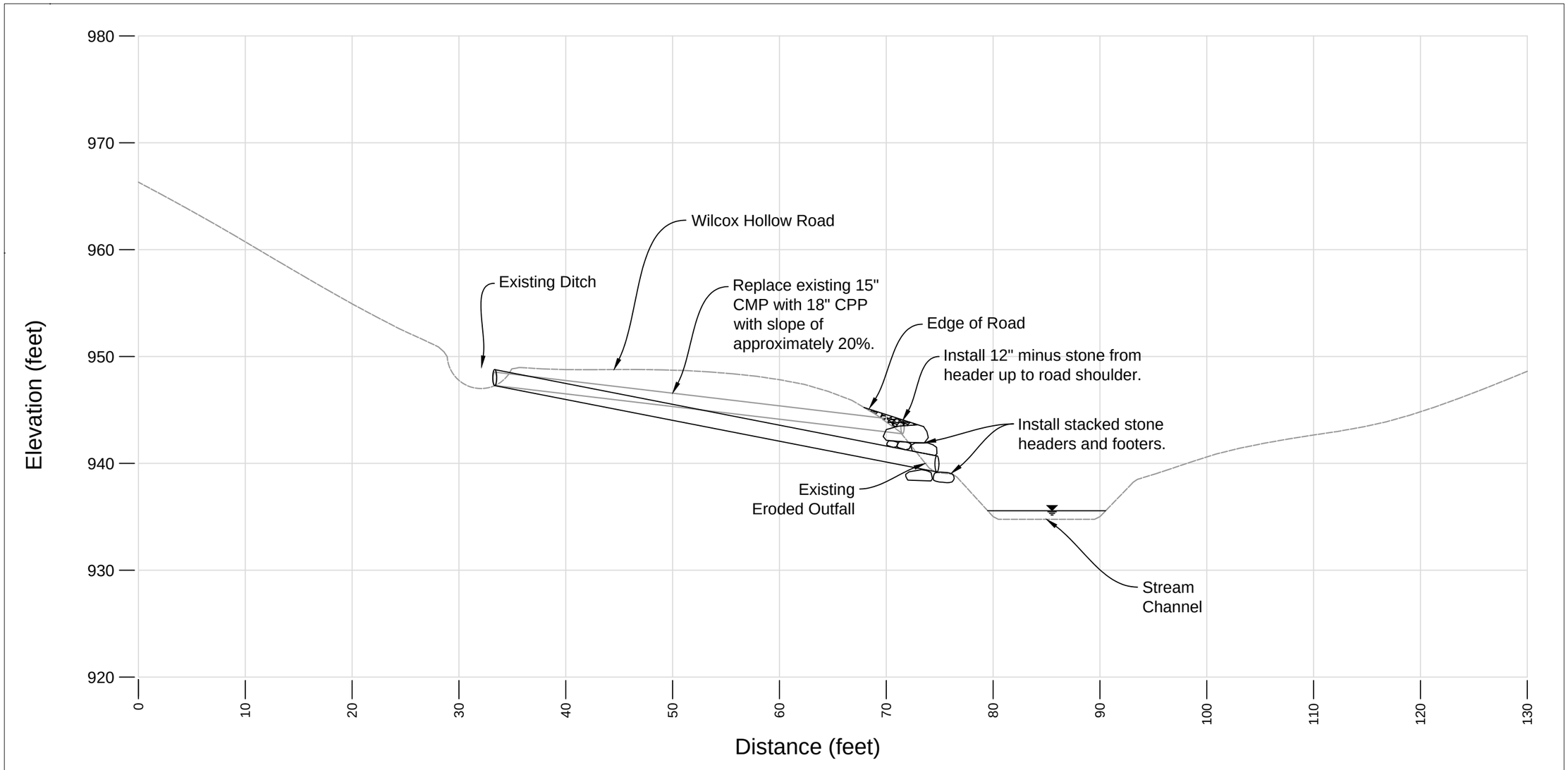
Drawn: EPF, EHB
Date: 12/21/2017

Concept Design Overview

Sandgate Stormwater Master Plan

Wilcox Hollow Road
Sandgate, VT

Wilcox Hollow Road
Sheet 1: Plan



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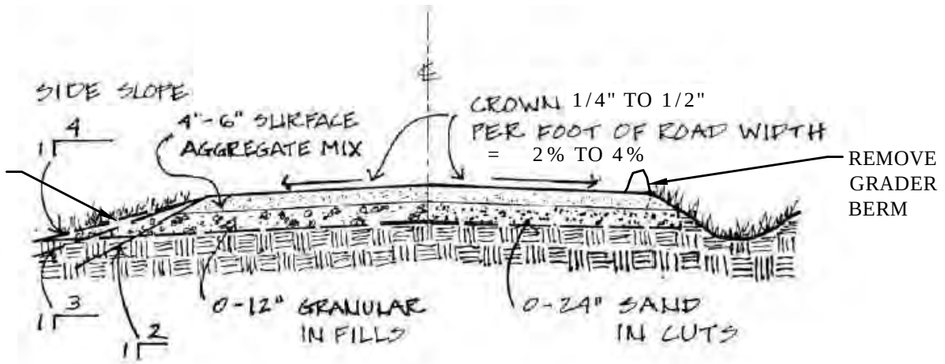
Sandgate Stormwater Master Plan
Concept Design
Wilcox Hollow Road
Sandgate, VT

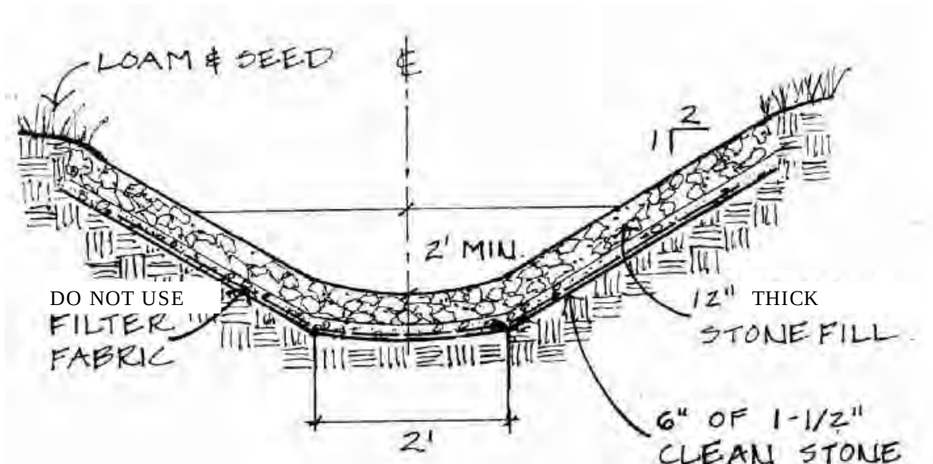
Scale: 1"=10'
December 21, 2017
Drawn: EHB
Checked: EPF

Notes: Existing profile and features based on LiDAR data and field observations.

SHEET 2
Cross Section

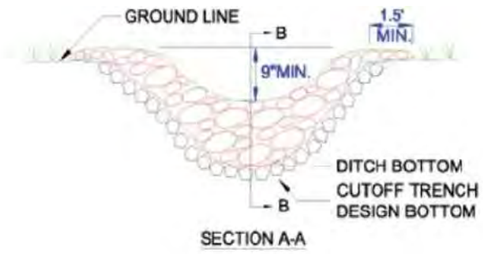


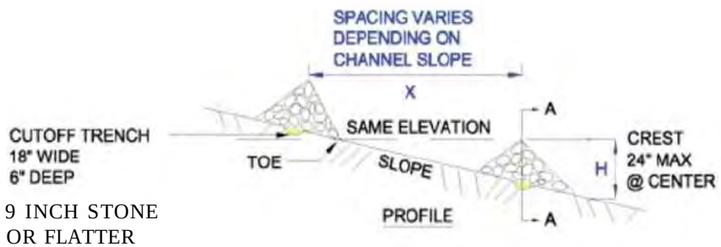
GRAVEL
ROAD CROWN & PROFILE

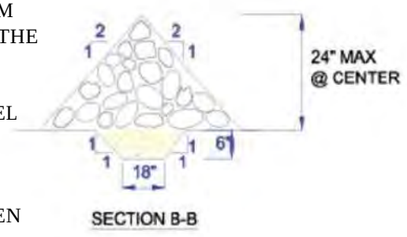


STONE FILL SIZE:
- SLOPES 5% TO 10% USE 6-8 INCH MINUS
- SLOPES MORE THAN 10% USE 12 INCH MINUS

STONE LINED DITCH

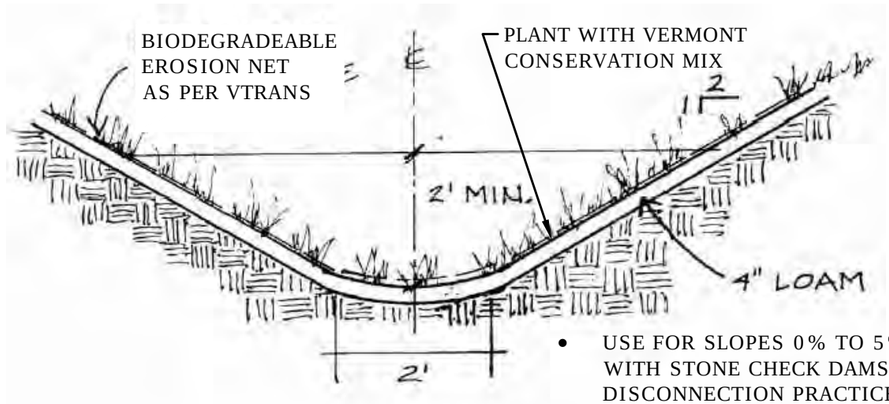






- USE MIX OF 2 TO 9 INCH STONE
- SIDE SLOPES 2:1 OR FLATTER
- SPAN WIDTH OF CHANNEL AND UP SIDES OF BANKS
- SPACE SO THAT THE TOE OF THE UPSTREAM DAM IS THE ELEVATION OF THE CREST OF THE DOWNSTREAM DAM
- PERIODICALLY REMOVE ACCUMULATED SEDIMENT AND DEBRIS TO ALLOW CHANNEL TO DRAIN THROUGH THE STONE AND PREVENT LARGE FLOWS FROM CARRYING SEDIMENT OVER THE DAM
- IF SIGNIFICANT EROSION OCCURS BETWEEN DAMS, A LINER OF STONE SHOULD BE INSTALLED

STONE CHECK DAM



GRASS LINED DITCH

- USE FOR SLOPES 0% TO 5% OR 5% TO 8% WITH STONE CHECK DAMS OR DISCONNECTION PRACTICES EVERY 164 FEET
- NO BARE SOILS ALLOWED
- USE TRAPEZOIDAL OR PARABOLIC CROSS SECTION

REFERENCE NOTE: ADAPTED FROM "VERMONT BETTER BACKROADS MANUAL, CLEAN WATER YOU CAN AFFORD" A PULICATION OF THE NORTHERN VERMONT & GEORGE D. AIKEN RESOURCE CONSERVATION DEVELOPMENT (R C& D) COUNCILS, NOVEMBER 1995, UPDATED 2002, 2009.

STONE CHECK DAM DETAIL FROM STATE OF VERMONT AGENCY OF NATURAL RESOURCES DEPARTMENT OF ENVIRONMENTAL CONSERVATION VERMONT POLLUTION DISCHARGE ELIMINATION SYSTEM (VPDES) GENERAL PERMIT 3-9040 FOR STORMWATER DISCHARGES FROM MUNICIPAL ROADS, FINAL DRAFT.

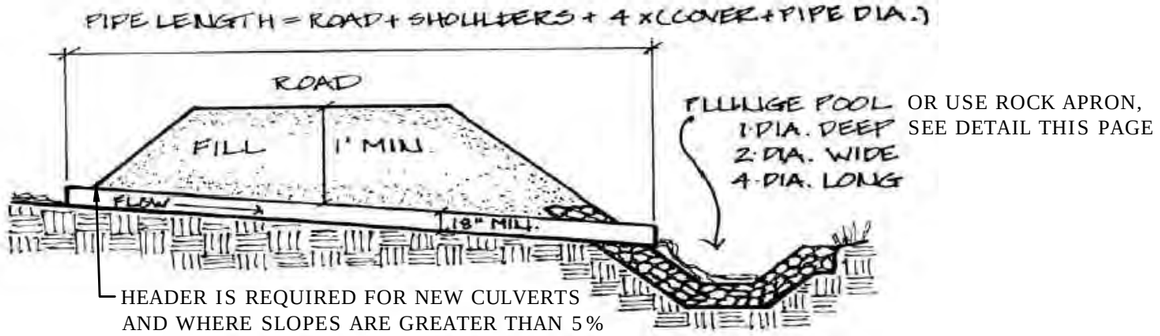
MILONE & MACBROOM®
Fitzgerald Environmental Associates, LLC

REVISIONS

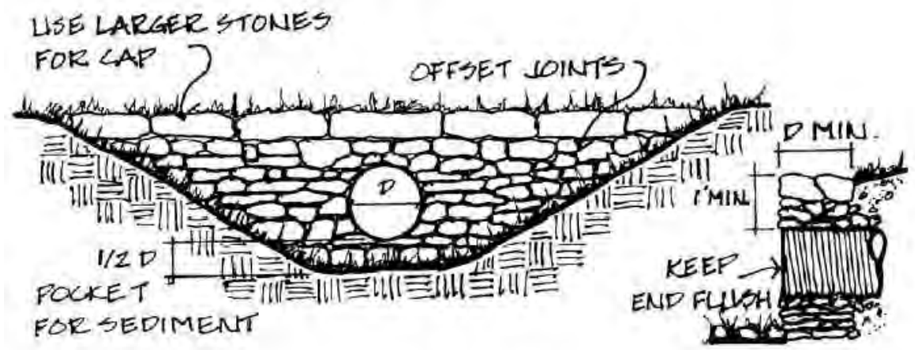
DETAILS - ROAD SECTION
CCRPC ROAD EROSION INVENTORY
CHITTENDEN COUNTY, VERMONT

JCL	JCL	RKS
DESIGNED	DRAWN	CHECKED

SCALE: NOT TO SCALE
DATE: SEPTEMBER 28, 2017
PROJECT NO.: 4294-03
SHEET NO.: D-1



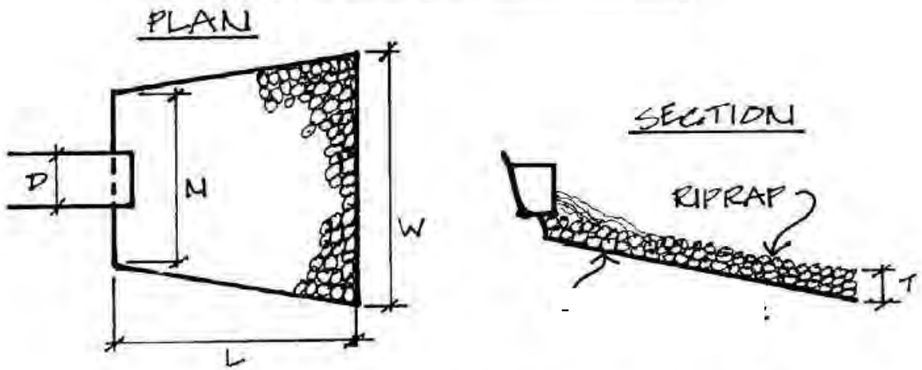
CULVERT PROFILE & CROSS SECTION



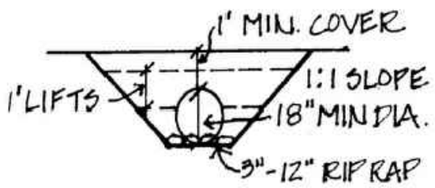
HEADER

Rock Apron Specifications					
Culvert Diameter (D)	Riprap Size	T (in.)	N (ft.)	W (ft.)	L (ft.)
18 inches	(3-12 inch)	18	4.5	14.5	10.0
24 inches	(3-12 inch)	18	6.0	20.0	14.0

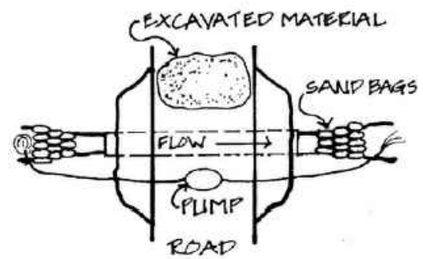
D= diameter of culvert
T= depth of stone in apron
N= width of apron near culvert
W= width at downhill end of apron
L= length of apron



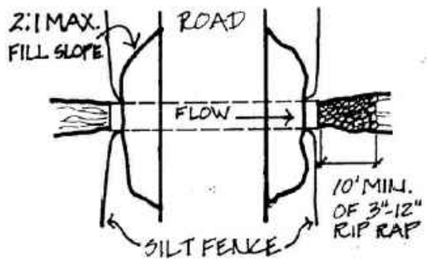
ROCK APRON



CULVERT CROSS SECTION



CULVERT INSTALLATION
FLOW BYPASS



CULVERT PLAN VIEW

REFERENCE NOTE: ADAPTED FROM "VERMONT BETTER BACKROADS MANUAL, CLEAN WATER YOU CAN AFFORD" A PULICATION OF THE NORTHERN VERMONT & GEORGE D. AIKEN RESOURCE CONSERVATION DEVELOPMENT (R C& D) COUNCILS, NOVEMBER 1995, UPDATED 2002, 2009.

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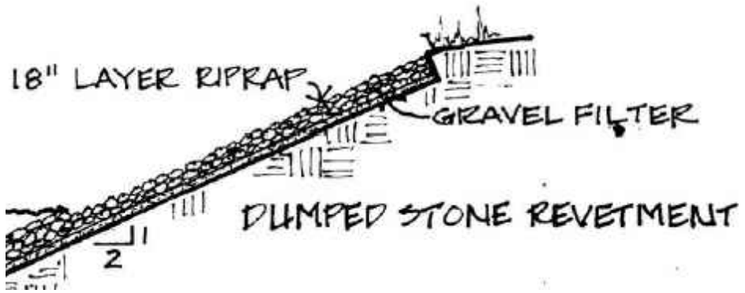
Applied Watershed Science & Ecology

REVISIONS

DETAILS - CULVERT
CCRPC ROAD EROSION INVENTORY
CHITTENDEN COUNTY, VERMONT

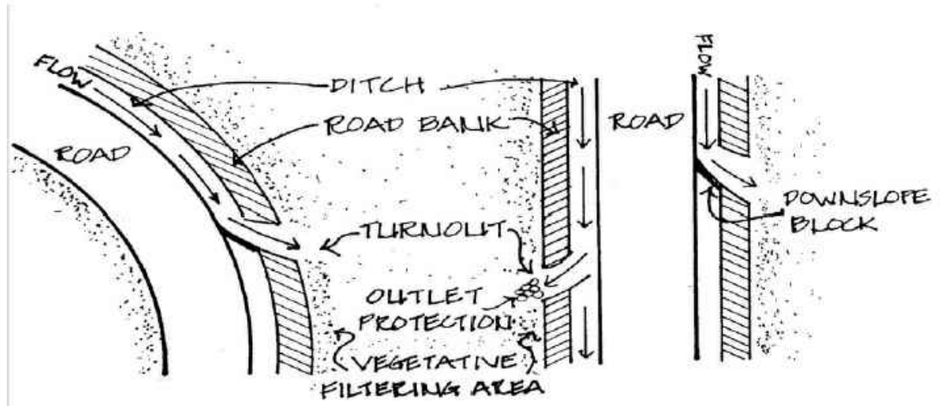
JCL DESIGNED	JCL DRAWN	RKS CHECKED

SCALE: NOT TO SCALE
DATE: SEPTEMBER 28, 2017
PROJECT NO.: 4294-03
SHEET NO.: D-2



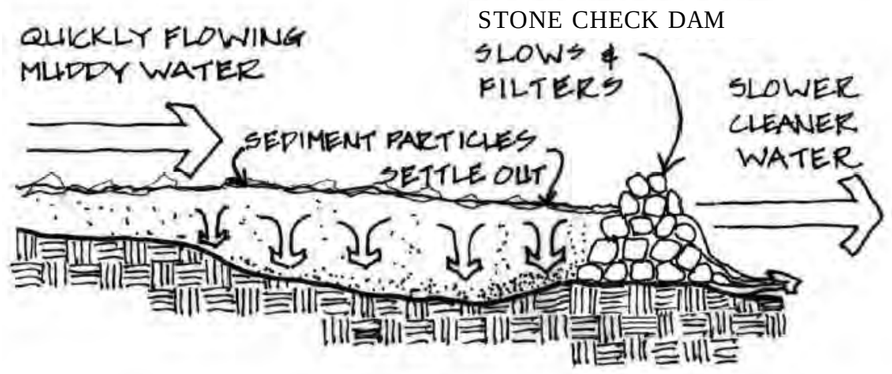
STONE ARMOR (BANK/SLOPE)

- RIRPAP SIZE IS BASED ON QUANTITY AND VELOCITY OF WATER
- ALWAYS CONTACT A STREAM ALTERNATION ENGINEER BEFORE INSTALLING RIPRAP AT A STREAM BANK
- USE ANGULAR STONE
- COVER WITH GRUBBINGS OR TOPSOIL AND SEED. IF ON A STREAM BANK, ONLY APPLY ABOVE ORDINARY HIGH WATER.
- CONSIDER PLANTING WITH ADDITIONAL VEGETATION



TURN-OUT

- AVOID DIRECT OUTLET TO SURFACE WATERS
- STABILIZE OUTLET BASED ON SLOPE:
  - 0% TO 5% STABILIZE WITH GRASS
  - 5% TO 10% STABILIZE WITH 6-8 INCH MINUS STONE
  - GREATER THAN 10% STABILIZE WITH 12 INCH MINUS STONE



SEDIMENT TRAP

- INSPECT ANNUALLY AND AFTER LARGE STORMS
- REMOVE ACCUMULATED SEDIMENT WHEN HALF FULL.

REFERENCE NOTE: ADAPTED FROM "VERMONT BETTER BACKROADS MANUAL, CLEAN WATER YOU CAN AFFORD" A PULICATION OF THE NORTHERN VERMONT & GEORGE D. AIKEN RESOURCE CONSERVATION DEVELOPMENT (R C& D) COUNCILS, NOVEMBER 1995, UPDATED 2002, 2009.

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REVISIONS

DETAILS - CULVERT

CCRPC ROAD EROSION INVENTORY

CHITTENDEN COUNTY, VERMONT

JCL	JCL	RKS
DESIGNED	DRAWN	CHECKED

SCALE: NOT TO SCALE

DATE: SEPTEMBER 28, 2017

PROJECT NO.: 4294-03

SHEET NO.: D-3