Stormwater Master Plan
Town of Rupert, Vermont

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1.0 Introduction

The Town of Rupert is situated at the toe of steep mountains of the Taconic Range rising to the east. The steep mountains east and north of Rupert village are well forested with very limited roadways and development. White Creek and Mill Brook, and their tributaries, 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. As with most mountain-valley villages of rural Vermont, stormwater concerns are typically related to road washouts and localized erosional areas. Over the last 20 years, the Town of Rupert has experienced four major floods that 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 Rupert.

In late 2013, 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 Rupert focusing on the White Creek/Mill Brook watershed in the southern half of the Town. Fitzgerald Environmental Associates, LLC (FEA) was hired by BCRC in spring of 2014 to develop the plan. The goals of the planning study are described below.

A Stormwater Master Plan for the Town of Rupert is intended to describe stormwater issues and problem areas within the Town and provide municipal managers with options to reduce stormwater runoff impacts and protect Town infrastructure. Watershed-based stormwater planning typically involves multiple towns and a wide range of land use considerations; however, the Town of Rupert is closely linked to the White Creek/Mill Brook watershed and is predominantly forested rural setting with low density residential and agricultural land use. As a result of the close geographic linkage between the Town and the White Creek/Mill Brook watershed, this SWMP focuses on the portion of Rupert located within this watershed. Specific stormwater problem areas identified in this plan will highlight areas where the Town can address water quality impacts and/or protect infrastructure through stormwater management planning and project implementation.

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 White

Creek and Mill Brook Corridor Plan (FEA, 2013) summarized stream corridor conflicts and prioritized areas where specific projects and management strategies could reduce erosion conflicts and improve the ecological health of White Creek and Mill Brook. Several of the high priority restoration sites identified in the Corridor Plan have been addressed by the Town of Rupert and stakeholders involved in the work (i.e., BCRC, Bennington County Conservation District, and Batten Kill Watershed Alliance). This SWMP builds on this past work by focusing on the identification of stormwater problem areas that contribute to infrastructure vulnerability and degradation of water quality in the watershed.

1.2 Project Goals

The Rupert Town Plan includes stormwater runoff as a primary concern for protecting water quality and lists gravel road maintenance, stream crossings, and construction sites as specific opportunities to reduce water quality impacts (Rupert Planning Commission, 2015). The Town has taken a number of steps to address stormwater runoff concerns and improve water quality as described in Section 3. As described in the Vermont Stormwater Master Planning Guidelines, the SWMP for Rupert follows template 3b with a focus on rural roads (VTDEC, 2013). The primary goal of this Stormwater Master Planning document is build on past water quality planning efforts by providing Town officials and other 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 Rupert.

Included with this Stormwater Master Plan are the following:

- Identification and description of 21 stormwater problem areas where concentrated runoff or increased stream flows are increasing sediment loading to surface waters;
- A ranking of each site based on degree of impact, ease of implementation, relative cost, and priority;
- Recommended mitigation and restoration options to address these problem areas;
- Cost estimates and potential project partners to assist in funding and implementing solutions.

2.0 Study Area Description

Rupert is located in Bennington County in the southwestern corner of Vermont. Rupert is bordered by 5 towns in Vermont (Pawlet, Danby, Dorset, Manchester, and Sandgate) and 2 in New York (Salem and Hebron). The 22.5 square mile watershed for White Creek and Mill Brook drains approximately half of Rupert and is almost completely located within the Town boundary (Figure 1). White Creek/Mill Brook is the largest subwatershed of the Batten Kill River draining into New York State (BCCD, 2006). The Town has a total population of 714 as of the 2010 Census (U.S. Census Bureau, 2011).

Land cover data based on imagery from 2006 (NOAA, 2008) are summarized in Table 1. White Creek and Mill Brook and the Town of Rupert as a whole are drained by a rural watershed, with forests representing the dominant land cover type. Agricultural lands cover 17.5% of the Town with a

majority of the farmlands found along the corridors for Routes 30, 153, and 315. Development is low throughout the study area (0.5%).

Table 1: Land cover in Rupert and the White Creek/Mill Brook watershed.

Land Cover/Land Use Type	% of Town	% of Watershed
Agriculture	17.5%	14.0%
Development	0.6%	0.5%
Forest	79.6%	84.2%
Open Water	0.0%	0.0%
Scrub/Shrub	1.4%	0.9%
Wetland	0.8%	0.4%

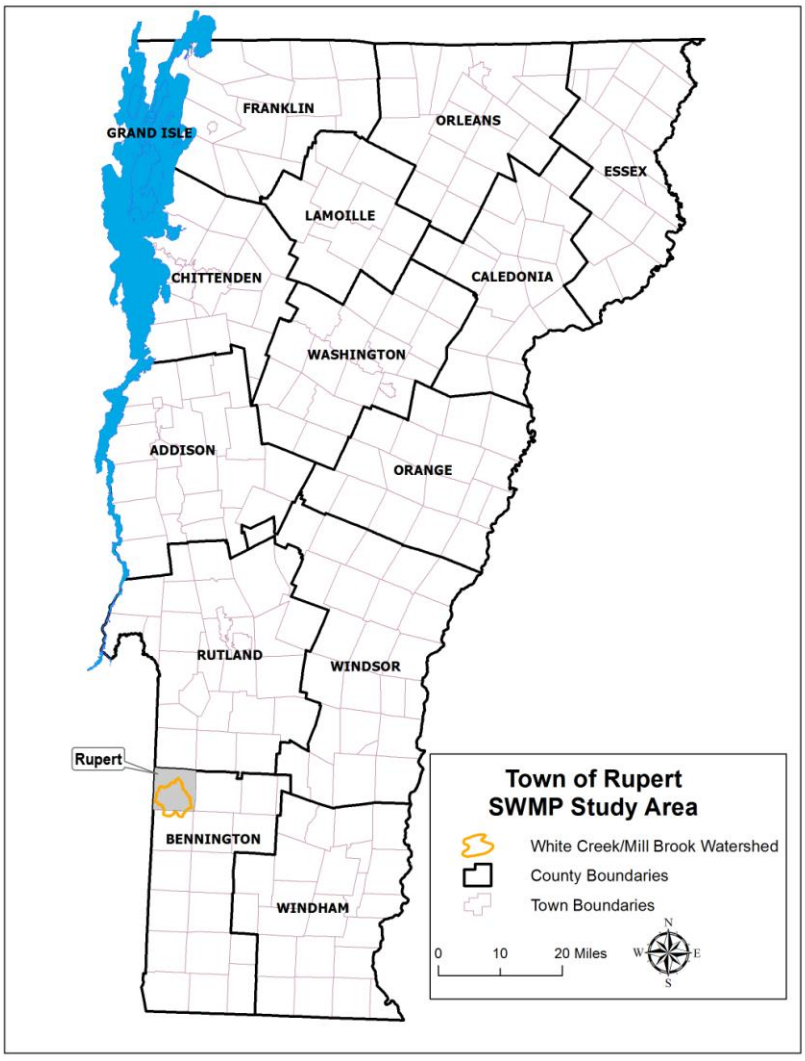


Figure 1: Town of Rupert and White Creek/Mill Brook watershed location map

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 Rupert. This section summarizes available documentation and other potential sources of information we explored.

Basin Plan

The Poultney Mettowee Basin Plan describes the long term planning goals for the portion of Rupert covered in this document. Gravel road maintenance and runoff are listed as prevalent sources of sediment and thermal pollution within the basin and are included as the third highest priority non-point source reduction goal: *"Reduce gravel erosion from unpaved roads. Reduce back road runoff and nutrient enrichment of surface waters through better back road practices".* The plan recommends workshops with Better Backroads and VTrans to help town highway managers and crews increase awareness of maintenance strategies to reduce erosion (VTDEC, 2005).

Town Planning

The Rupert Hazard Mitigation Plan lists several areas with vulnerable culverts and bridges where flooding has repeatedly damaged or closed roads. These washouts have occurred during major regional storm events but more frequently as a result of localized flash flooding events. The Hazard Mitigation Plan includes culvert inventory and culvert replacement to improve flood capacity on the list of recommended mitigation projects (Town of Rupert, 2014). The Rupert Town Plan lists stormwater runoff and pollution from gravel roads as primary concerns for surface water quality (Rupert Planning Commission, 2015).

White Creek/Mill Brook Corridor Plan

Fitzgerald Environmental prepared this plan for the Bennington County Conservation District (BCCD) in 2013 (FEA, 2013). Several background themes relevant to stormwater master planning are touched on in the plan. Highlights from the Corridor Plan relevant to recent flooding, stormwater runoff, and health of the aquatic biota community in the watershed are summarized below.

Tropical Storm Irene Flood Damage

Tropical storm Irene (TSI) hit Vermont on August 28th 2011 and dumped 3-5 inches of rain throughout the state with localized areas receiving totals from 7-11 inches. This rainfall coupled with high antecedent soil moisture conditions produced flooding that approached or exceeded the historic flood of 1927 in many large basins. In Rupert, damage resulting from Tropical Storm Irene was severe, but less so than other recent flood events. For example, a localized downburst that occurred in August, 2010 caused severe flooding and damage along the Mill Brook corridor along VT Route 315. Table 2.3 in the Corridor Plan provides a summary of areas that saw the most severe damage or channel adjustments during Tropical Storm Irene.

Ecological Setting

The Corridor Plan summarizes VTDEC monitoring data for macroinvertebrates and fishes over the past 25 years. The most recent sampling data from 2008 indicate an “excellent” macroinvertebrate community and a “good/fair” fish community in White Creek. Biotic sampling

has not been conducted since TSI, which likely had a measurable impact on fish and macroinvertebrate communities.

Hydrologic and Sediment Regime Stressors

The Corridor Plan includes maps of stressors on the hydrologic and sediment regimes of White Creek and Mill Brook based on data collected during the Phase 2 Stream Geomorphic Assessments in 2008. These maps provide a means for linking the effects of increased stormwater runoff (i.e., gullying, severe channel sedimentation) to known stormwater problem areas in upslope watersheds. The hydrologic regime stressors identified in the Corridor Plan include areas of locally high road densities at the subwatershed level, wetland loss, and stormwater inputs. The sediment regime stressors identified in the Corridor Plan include areas of higher densities of depositional and migration features in the channel such as bar features and flood chutes, identified at the reach-scale.

Rupert Town Records

The Town of Rupert does not maintain formal records of stormwater infrastructure. In the future, a full inventory of the Town's culverts would be extremely valuable for future stormwater planning work. Tom and Skip Wilson of the Rupert Highway Department have a wealth of first-hand knowledge of stormwater and culvert problem areas, structures that have been replaced over the years, and flood recovery work following large floods such as TSI. Evan Fitzgerald and Joe Bartlett have met with Tom and Skip on several occasions over the past 2 years (both for this project and the previous corridor planning project), and toured the watershed three times to review problems related to stream channel instability and stormwater runoff. We have documented these sites with photographs, field notes, and GPS locations. This information is described in Section 4 of this document.

Sandgate Town Records

The Town of Sandgate completed bridge and culvert inventories in spring of 2013, and a follow-up inventory was conducted in the fall of 2014 by BCRC. Several culverts in the upper White Creek watershed along Beebe Hill Road and Snow Road were evaluated with this project.

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 Rupert 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 by identifying stormwater related projects from the White Creek/Mill Brook RCP and a desktop exercise scanning the watershed with imagery, NRCS soils data, and high-resolution LiDAR contours in a GIS. Meetings with Town officials including the Town Highway Crew were conducted in the fall of 2014 and summer of 2015. A detailed watershed tour was conducted on two subsequent field visits by FEA staff to identify the remaining

stormwater problem areas. A total of 21 stormwater problem areas were identified and assessed in the field (Figure 2). We grouped the problem areas into five (5) categories described below.

- **BE** - Bank erosion projects were observed in two locations where areas of increased stream power are causing major bank erosion and introducing large volumes of sediment to the channel. Stormwater runoff to these areas increases peak flows and exacerbates bank erosion processes.
- **CR** - Concentrated runoff projects were identified in three areas where land use changes (impervious surfaces or conversion from forest to pasture) have increased and concentrated surface runoff. Concentrated stormwater runoff can increase erosion and/or carry pollutants to receiving surface waters.
- **DC** - Drainage culvert projects were identified in 8 locations where stormwater runoff and associated sediment loads were exceeding the capacity of drainage culverts located under Town maintained roads. Runoff volumes for different design storms (e.g., 2-year 24 hour rainfall) was modeled for each project using standard rainfall-runoff methods to check for appropriate culvert sizing.
- **RD** - Roadside ditch projects 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 stream crossing project was identified where a perennial stream crosses under a Town maintained road. Runoff volume and peak discharge for the contributing watershed was modeled to check for appropriate culvert sizing.

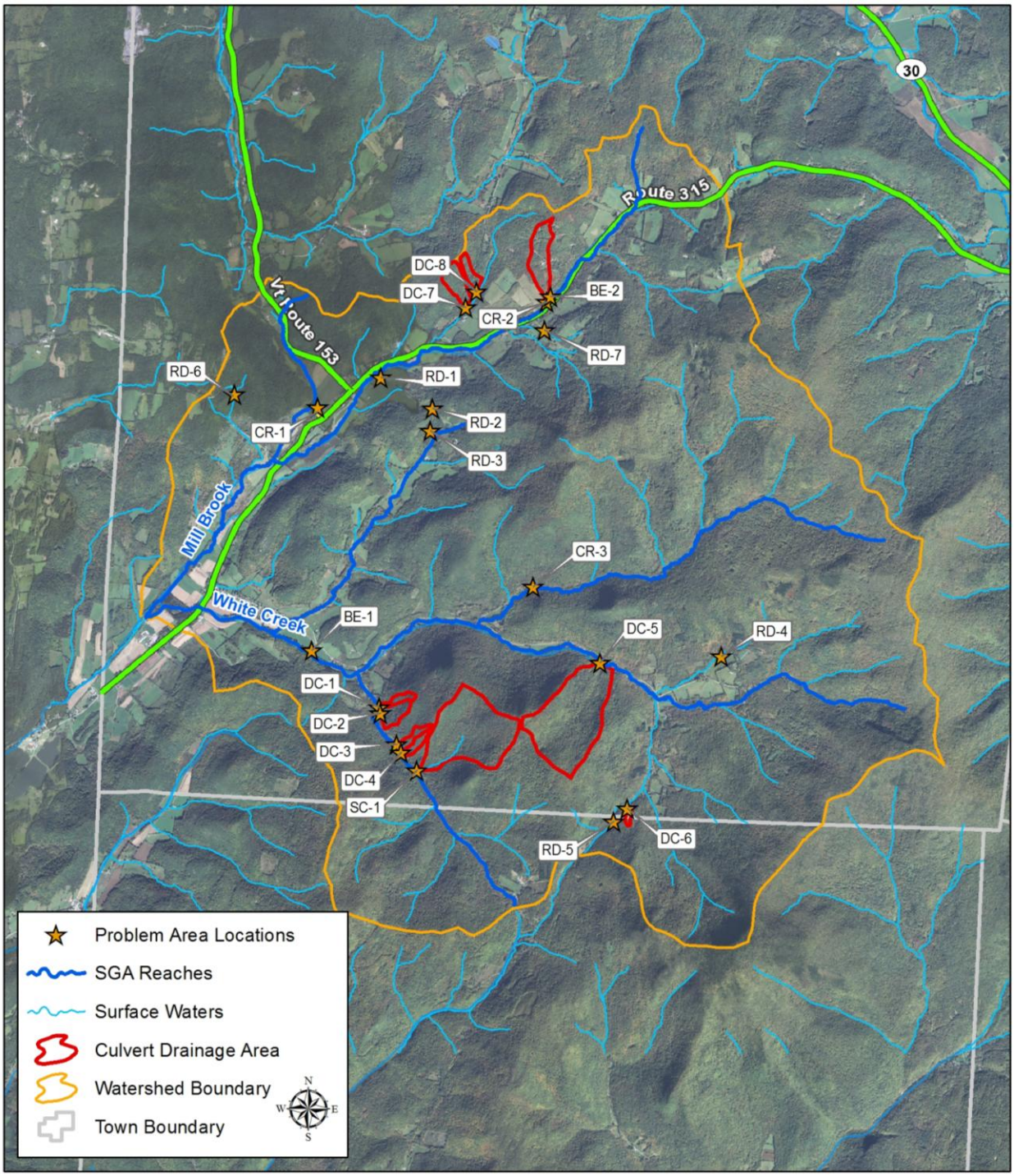


Figure 2: Stormwater problem area location map with culvert drainage area delineations.

4.2 Evaluation of Problem Areas

Problem area summary sheets were developed to guide data collection efforts by FEA personnel and to assist in rating and prioritizing each of the 21 identified problem areas (see Table 3 on following pages). A preliminary site ranking was assessed at each site to describe the overall impact, priority, and feasibility on a scale of 1 (Low/Unfeasible) to 4 (High). The overall impact to water quality, risk to infrastructure, impact frequency, current condition, and the urgency for addressing the problem were also described or ranked on a scale of 1 (Low) to 4 (High).

Most of the projects are located on public roadways and involve public infrastructure, simplifying planning and implementation. We assigned a “yes” or "no” description for additional impacts beyond water quality (i.e., risk to infrastructure) and an assessment of the problem area as a part of systemic issue in the watershed (i.e. aquatic organism passage through a network of culverts). Watershed runoff models were constructed for all of the DC and SC projects to estimate watershed runoff volumes for a range of design storms and culvert capacity. Watershed size, slope, land cover, and soil type were used to estimate runoff using HydroCAD following NRCS methods (SCS, 1983). Culvert capacity was calculated based on size, type, and field or GIS estimated sloped (see Table 2 below); peak runoff values in **bold** represent the largest design storm expected to pass through the culvert. It should be noted that the soil types within the White Creek/Mill Brook watershed are predominantly (90%) classified as "highly erodible" and therefore we did not include mapping of erodible soils. Additional description and location information for each problem area follows the table below. Detailed projects maps are presented in Appendix A.

Table 2: Basin runoff and culvert capacity from HydroCAD modeling

							Basin Peak Runoff (cfs)			
Location	**Site ID**	**Drainage Area (ac)**	**Culvert Type**	**Culvert Dimensions**	**Culvert Slope**	**Peak Capacity (cfs)**	**2-yr**	**10-yr**	**25-yr**	**100-yr**
Sandgate Rd	DC-1	7.4	CPP	36"	5%	97	3.7	9.2	13.4	**25.1**
Sandgate Rd	DC-2	17.6	CPP	36"	5%	97	5.6	17	26.1	**52.3**
Sandgate Rd	DC-3	9.5	CPP	12"	5%	16.4	5.9	**13.7**	19.6	35.7
Sandgate Rd	DC-4	8.8	CPP	18"	5%	5.6	**4.6**	12.7	19.1	37
Kent Hollow Rd	DC-5	197	CMP	2'X3'	5%	52	**25**	87	143	307
Kent Hollow Rd	DC-6	2.9	CPP	18"	5%	15.3	0.1	1	2	**5.33**
Pawlet Mtn Rd	DC-7	23.4	CPP	36"	5%	97	12.4	28.2	40.1	**72.3**
Pawlet Mtn Rd	DC-8	11.1	CPP	18"	4%	13.7	4.7	**12**	17.6	33
Sandgate Rd	SC-1	174	CMP	4'X6'	7%	360	38	114.8	178.9	**361.7**

Table 3: Problem area summary table

Project ID	Location	Description	Water Quality Risk	Flood and Erosion Risk to Infrastructure	Site Ranking	Recommendations	Ballpark Cost
BE-1	Kent Hollow Road near Lang Road	Approximately 150' of bank erosion along the edge of a mowed field	Moderate	Low	2	Establish an unmanaged buffer zone and plant bank and buffer with woody vegetation and leave existing LWD in place to protect bank	<2K
BE-2	Route 315 between Watrous and Clark Road	Two areas of bank erosion/mass failure along the north bank where the stream channel is pushing into the steep valley wall.	Moderate to High	Low	2	Protect mature forest vegetation along the top of each bank. Consider mass failure stabilization with bioengineering approach with plantings.	5-10K
CR-1	Rupert Town Garage	The newly constructed town garage building and the scheduled construction of the sand/salt storage shed will result in a large area of impervious surfaces generating stormwater runoff. The garage roof drains are connected to a 6" pipe that directly outlets to a ditch to the west.	Moderate	Low	3	Direct runoff from the parking area, road, and sand/salt storage shed to a green stormwater infrastructure collection system where possible, otherwise disperse runoff to grassed area.	5-10K
CR-2	Route 315 between Watrous and Clark Road	A large gully from an area of concentrated runoff draining from 41 acres of forest, pasture, and residential lands.	High	Low	4	Stabilize bed to arrest incision using stone and log check dams and weirs. Review upslope drainage patters for stormwater diversion opportunities.	15-25K
CR-3	Hidden Valley Rd at first Merck Forest parking area	Erosion along a small area of parking lot and access road is generating a moderate volume of sediment.	Moderate	Low	2	Armoring edge of road and add log check dams and natural roughness (brush matting) to the floodplain to trap sediment.	<2K
DC-1	Sandgate Road	36" HDPE culvert with moderate scour at inlet and outlet	Low	Low	1	Monitor outlet and add armor as needed to reduce scour and improve stability of downstream swale	<2K

Table 3: Problem area summary table

Project ID	Location	Description	Water Quality Risk	Flood and Erosion Risk to Infrastructure	Site Ranking	Recommendations	Ballpark Cost
DC-2	Sandgate Road	36" HDPE culvert with moderate scour at inlet and outlet	Moderate	Moderate	3	Improve armor at the culvert outlet to reduce scour and install stone check dams to stabilize the downstream swale.	<2K
DC-3	Sandgate Road	12" HDPE culvert with sediment clogging	Low	Moderate	2	Install stone check dams to stabilize road ditch and consider the culvert for replacement with a larger structure (18 to 24" diameter).	2-5K
DC-4	Sandgate Road	18" HDPE culvert with minor sediment clogging; ditch erosion upstream	Low	Low	2	Install stone check dams to stabilize road ditch.	<2K
DC-5	Kent Hollow Road	2'x3' squash CMP culvert with significant sediment clogging	Low	Moderate to High	3	Replace existing culvert with larger culvert.	25-30K
DC-6	Kent Hollow Road	18" HDPE culvert with minor sediment clogging; ditch erosion upstream	Low	Moderate	2	Install stone check dams to stabilize upstream ditch and capture sediment.	<2K
DC-7	Pawlet Mountain Road	3' diameter HDPE culvert is half filled with gravel and the upstream channel is severely eroded with an active headcut.	Moderate to High	Moderate	3	Recommend stabilizing upstream channel with rock check dams and grade control structures as needed.	2-5K
DC-8	Pawlet Mountain Road	18" diameter HDPE culvert is filled with fine sediment upstream, causing water to pond and flow over the road.	Moderate to High	High	4	Recommend replacing with a larger structure or adjusting culvert slope, and stabilizing ditch with rock check dams. Work with landowner to stabilize driveway erosion.	10-15K

Table 3: Problem area summary table

Project ID	Location	Description	Water Quality Risk	Flood and Erosion Risk to Infrastructure	Site Ranking	Recommendations	Ballpark Cost
RD-1	Youlin Road	Ditches on both sides of Youlin Road are filled in and have reduced capacity. The east edge of the road does not fully drain to the ditch causing erosion and sediment deposition on the road. A cross culvert is set near the road surface and is damaged.	Moderate	Moderate	3	Recommend raising the road bed to shed runoff to the north and cleaning out ditches to better direct runoff and reduce erosion. Replace damaged culvert as necessary.	5-10K
RD-2	Youlin Road	Ditch along steep section of Youlin Road is eroding and generating large volumes of sand/gravel, clogging a drainage culvert.	Low to Moderate	Moderate	2	Recommend stabilizing ditch using stone check dams.	<2K
RD-3	Youlin Road	Ditch along moderately steep section of Lang Road is eroding and generating large volumes of sand/gravel, clogging a drainage culvert.	Low to Moderate	Moderate	2	Recommend stabilizing ditch using stone check dams.	<2K
RD-4	Dole Road	Ditch along steep section of Dole Road is eroding and generating large volumes of sediment.	Moderate	Low to Moderate	2	Recommend stabilizing ditch using stone check dams.	2-5K
RD-5	Snow Road	Roadside ditches recently cleaned by Sandgate were left with large areas of exposed raw soil and cross culverts were fully blocked. Large volumes of fine sediment were observed entering tributary.	High	Moderate to High	4	Recommend stabilizing ditch with coarse material and stone check dams, and working with highway department to improve ditch maintenance practices.	2-5K
RD-6	Hebron Road	Roadside ditch along a very steep portion of Hebron Road is deeply incised. Exposed bedrock underlies some of the ditch and the road edge is eroding in areas.	Moderate	Moderate	3	Recommend stabilizing ditch using stone check dams.	<2K

Table 3: Problem area summary table

Project ID	Location	Description	Water Quality Risk	Flood and Erosion Risk to Infrastructure	Site Ranking	Recommendations	Ballpark Cost
RD-7	Clark Road	Roadside ditch along a steep portion of Clark Road is filled in with sediment and partially blocking a CPP crossing under the road to the stream. Stormwater flows across the road leading to erosion and rilling.	Moderate	Low	2	Recommend stabilizing ditch using stone check dams.	<2K
SC-1	Sandgate Road	4' X 6' squash CMP culvert with major deposition and a headcut near inlet	Moderate	Moderate	3	Reset culvert to increase slope and improve sediment transport	10-15K

4.3 Stormwater Problem Area Summaries

Site ID	BE-1
Date Observed	5/20/2015
Location	South of Kent Hollow Road near Lang Road intersection
Stream	White Creek
SGA Reach	M02
Latitude:	43.23211 N
Longitude:	73.22812 W
Land Ownership	Private
Site Ranking	2 - Moderate

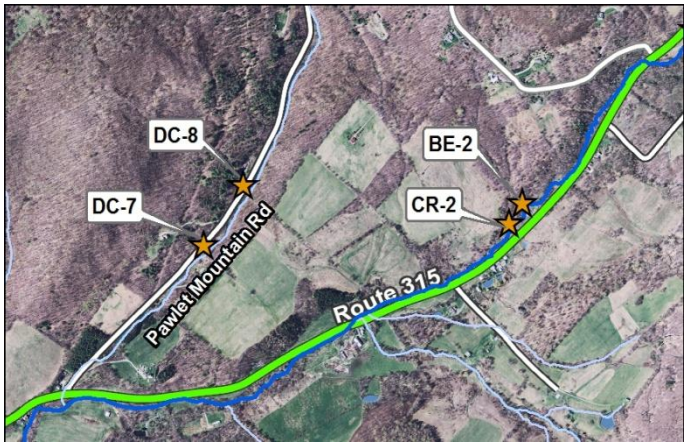
Site Description: Project #4 in White Creek/Mill Brook RCP. Bank erosion into the farm field initiated during Tropical Storm Irene and is continuing as the channel adjusts planform. Recommend planting the bank and buffer with native woody vegetation and establishing an unmanaged buffer area in hay field. Woody debris in channel should remain undisturbed.

Photo 1: Bank erosion into hay field. Woody debris accumulation along toe of bank is temporarily slowing erosion, however no woody vegetation was present along the bank. Recommend establishing a vegetated buffer extending at least 25 feet from the top of the bank.

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	2	2	2	No	Easy	Low	Yes	No

Site ID	BE-2
Date Observed	8/18/2015
Location	Route 315 between Watrous and Clark Road
Stream	Mill Brook
SGA Reach	M01T1.04
Latitude:	43.27017 N
Longitude:	73.19386 W
Land Ownership	Private
Site Ranking	2 – Low to Moderate



Site Description: Two areas of bank erosion/mass failure along the right bank (north) where the stream channel is pushing into the steep valley wall. The downstream section of active bank erosion is approximately 6-8' tall and 75' long. The large mass failure is slowly revegetating and the toe of the failure is somewhat protected by sediment accumulation. Recommend low cost approach of protecting trees along top of mass failure slope. Another low cost option is to revegetate the lower-middle mass failure slope. Bank stabilization would be costly given the length and height (photo 1).

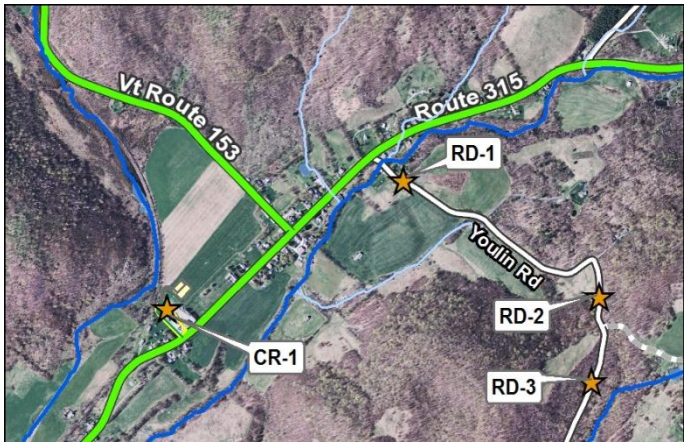
Photo 1: Severe bank erosion approximately 100' downstream CR2 and 400' downstream of the mass failure

Photo 2: Somewhat stable mass failure area on sharp bend in the stream channel (located just upstream of barn which is being undermined by bank erosion on the south bank).

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
1	2	3	1	No	Easy	Mod	Yes	Yes

Site ID	CR-1
Date Observed	8/18/2015
Location	Rupert Town Garage
Stream	Trib to Mill Brook
SGA Reach	M01T1S1.01
Latitude:	43.25819 N
Longitude:	73.22727 W
Land Ownership	Public
Site Ranking	3 – Moderate to High



Site Description: The newly constructed town garage building and the scheduled construction of the sand/salt storage shed will result in a large area of impervious surfaces generating stormwater runoff. The roof drains are connected to a pipe that directly outlets to a ditch along the rail bed. Recommend directing runoff from the parking area, road, and sand/salt storage shed to a green stormwater infrastructure collection system where possible, otherwise disperse runoff to grassed areas to encourage infiltration.

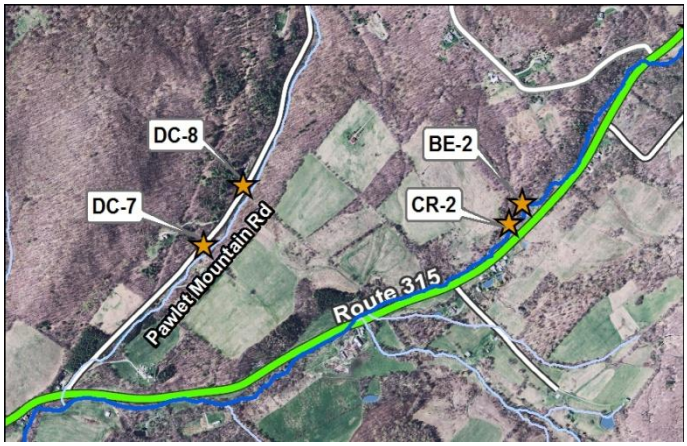
Photo 1: Town garage building and future sand/salt storage building area (foreground)

Photo 2: Existing drainage pathway for current sand pile and access road.

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
3	3	3	3	Yes	Difficult	Mod	Yes	No

Site ID	CR-2
Date Observed	8/18/2015
Location	Route 315 between Watrous and Clark Road
Stream	Mill Brook
SGA Reach	M01T1.04
Latitude:	43.26955 N
Longitude:	73.19440 W
Land Ownership	Private
Site Ranking	4 - High



Site Description: A large and active gully has formed in an area of concentrated runoff draining from 41 acres of forest, pasture, and residential lands. The lower portion of the gully has numerous head cuts and active bank erosion. The upper portion of the gully is moderately stable, however the headcuts will advance upslope. Recommend stabilizing the gully with log and stone check dams to mitigate sediment load to Mill Brook. The upslope contributing drainage should be reviewed in the field to identify potential stormwater diversion opportunities.

Photo 1: Raw eroding banks and numerous headcuts in the lower portion of the gully

Photo 2: Headcut at the transition to the somewhat more stable upper portion of the gully

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
4	3	4	3	No	Difficult	High	Yes	Yes

Site ID	CR-3
Date Observed	8/18/2015
Location	Hidden Valley Rd at first Merck Forest parking area
Stream	Trib to White Creek
SGA Reach	M03T2.01
Latitude:	43.23907 N
Longitude:	73.19603 W
Land Ownership	Private
Site Ranking	2 – Low to Moderate

Site Description: A small area of parking lot and access road drain from the road to a narrow strip of forested floodplain. A moderate volume of sediment is being generated from these surfaces and the edge of the road is eroding. Recommend armoring the edge of the road and adding log check dams and natural roughness (brush matting) to the floodplain to trap sediment in the area shown in photo 2.

Photo 1: Concentrated runoff from parking area and road causing erosion of road edge

Photo 2: Sediment deposition on forested floodplain

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	2	2	1	No	Easy	Low	Yes	No

Site ID	DC-1
Date Observed	9/10/2014
Location	Cross drainage culvert under Sandgate Road
Stream	Sandgate Brook
SGA Reach	M03T1.01
Latitude:	43.22632 N
Longitude:	73.21853 W
Land Ownership	Public
Site Ranking	1-Low

Site Description: 36" diameter corrugated HDPE culvert under Sandgate Road delivers sediment and stormwater to Sandgate Brook. The culvert has appropriate hydraulic capacity for the 7.7 acre forested watershed and the downstream swale is stable. No immediate action is recommended, however the Town should monitor the outlet and the swale for erosion and add armor if needed.

Photo 1: Culvert outlet

Photo 2: Stable and vegetated swale downstream to Sandgate Brook

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
1	2	1	1	Yes	Easy	Low	No	No

Site ID	DC-2
Date Observed	9/10/2014
Location	Cross drainage culvert under Sandgate Road
Stream	Sandgate Brook
SGA Reach	M03T1.01
Latitude:	43.22550 N
Longitude:	73.21816 W
Land Ownership	Public
Site Ranking	3 - Moderate to High

Site Description: 36" diameter corrugated HDPE culvert under Sandgate Road delivers sediment and stormwater to Sandgate Brook. The culvert has appropriate hydraulic capacity for the 17.6 acre forested watershed, however the outlet is perched leading to scour below, and scour continues down the outlet swale to the stream. Recommend improving armor at the culvert outlet to reduce scour and installing stone check dams to stabilize the downstream swale.

Photo 1: Culvert outlet with scour below

Photo 2: Incised outlet swale to Sandgate Brook

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
3	2	2	2	Yes	Easy	Low	No	No

Site ID	DC-3
Date Observed	8/18/2015
Location	Cross drainage culvert under Sandgate Road
Stream	Sandgate Brook
SGA Reach	M03T1.02
Latitude:	43.22223 N
Longitude:	73.21578 W
Land Ownership	Public
Site Ranking	2 - Low to Moderate

Site Description: 12" diameter corrugated HDPE culvert under Sandgate Road delivers sediment and stormwater to Sandgate Brook. The culvert is hydraulically undersized for the 9.5 acre forested watershed and the upstream ditch along the road is somewhat incised. Recommend installing stone check dams to stabilize road ditch and consider the culvert for replacement with a larger structure (18 to 24" diameter).

Photo 1: Somewhat incised ditch along Sandgate Road

Photo 2: Culvert inlet is partially filled with gravel and leaves

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	2	3	2	Yes	Moderate	Low	No	No

Site ID	DC-4
Date Observed	8/18/2015
Location	Cross drainage culvert under Sandgate Road
Stream	Sandgate Brook
SGA Reach	M03T1.02
Latitude:	43.22143 N
Longitude:	73.21509 W
Land Ownership	Public
Site Ranking	2 – Low to Moderate

Site Description: 18" Corrugated HDPE culvert under Sandgate Road delivers sediment and stormwater to Sandgate Brook. The culvert is appropriately hydraulically sized for the 8.8 acre forested watershed and the upstream ditch along the road is somewhat incised. Recommend installing stone check dams to stabilize road ditch.

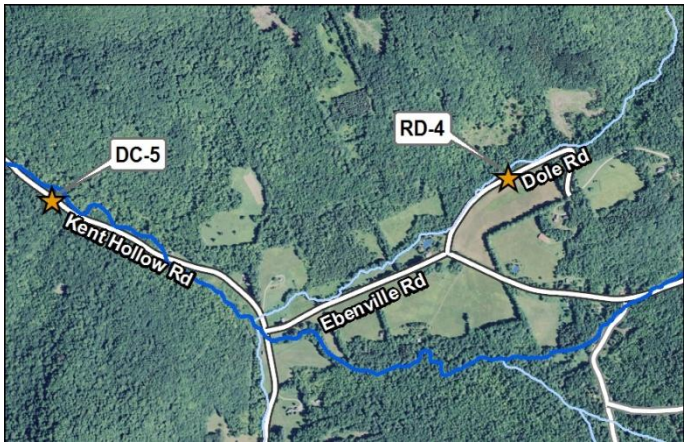
Photo 1: Somewhat incised ditch along Sandgate Road

Photo 2: Culvert inlet is partially filled with gravel and leaves

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	2	2	2	Yes	Easy	Low	No	No

Site ID	DC-5
Date Observed	8/18/2015
Location	Cross drainage culvert under Kent Hollow Road
Stream	White Creek
SGA Reach	M05
Latitude:	43.23117 N
Longitude:	73.18620 W
Land Ownership	Public
Site Ranking	3 –Moderate to High



Site Description: 2' X 3' Squash CMP under Kent Hollow Road delivers sediment and stormwater to White Creek. The culvert is hydraulically undersized for the 197 acre forested watershed (i.e., cannot handle 10-year flow) leading to significant gravel and cobble deposition near the culvert inlet. Recommend replacing with a larger structure to obtain sufficient capacity for larger storm events and improve sediment transport through the culvert.

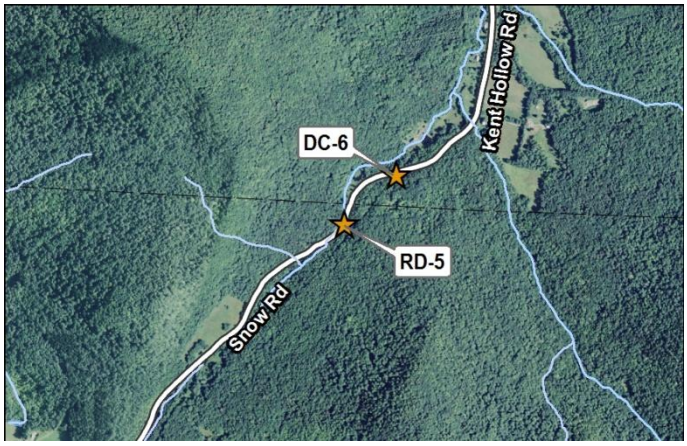
Photo 1: Upstream channel is steep and stable

Photo 2: Culvert inlet is partially filled with gravel and cobble deposits

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
3	2	3	2	Yes	Moderate	High	Yes	No

Site ID	DC-6
Date Observed	9/10/2014
Location	Cross drainage culvert under Kent Hollow Road at town line
Stream	Trib to Oven Brook
SGA Reach	N/A
Latitude:	43.21563 N
Longitude:	73.18207 W
Land Ownership	Public
Site Ranking	2 – Low to Moderate



Site Description: 18" diameter HDPE culvert under Kent Hollow Road delivers sediment and stormwater to a tributary of Oven Brook. The culvert is appropriately hydraulically sized, however the upstream swale is deeply incised and is generating large volumes of sediment, causing the culvert to be partially plugged. Recommend installing stone check dams immediately upstream of the culvert inlet to stabilize the channel and reduce sedimentation.

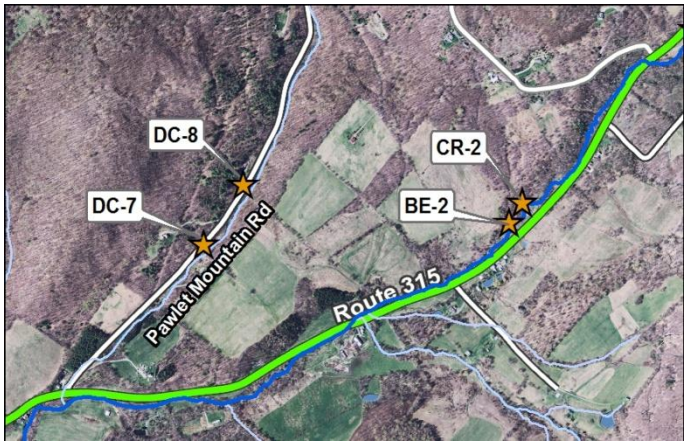
Photo 1: Upstream channel steep and incising to underlying shale

Photo 2: Significant gravel deposits partially filling culvert inlet

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	2	3	2	Yes	Easy	Low	No	No

Site ID	DC-7
Date Observed	8/18/2015
Location	Cross drainage culvert under Pawlet Mountain Road
Stream	Trib to Mill Brook
SGA Reach	N/A
Latitude:	43.26892 N
Longitude:	73.20622 W
Land Ownership	Public
Site Ranking	3 – Moderate to High



Site Description: 3' diameter HDPE culvert under Pawlet Mountain Rd is half filled with gravel and the upstream channel is severely eroded with an active headcut. Recommend stabilizing upstream channel with rock check dams and grade control structures as needed.

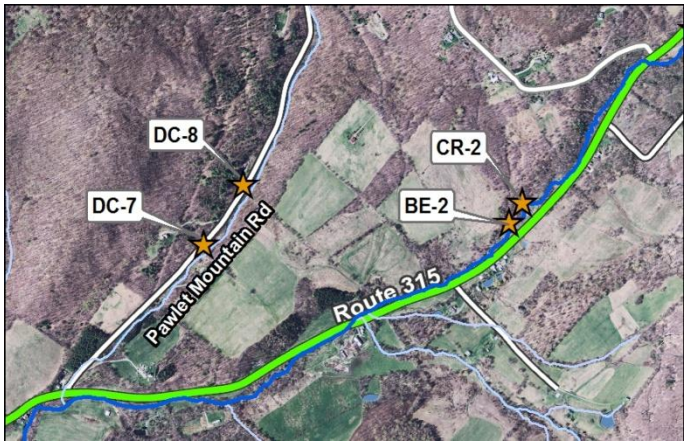
Photo 1: Culvert inlet half filled with sand/gravel

Photo 2: 2' tall headcut upstream of culvert, bad bank erosion to inlet

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
3	2	3	3	Yes	Moderate	Mod	Yes	No

Site ID	DC-8
Date Observed	8/18/2015
Location	Cross drainage culvert under Pawlet Mountain Road
Stream	Trib to Mill Brook
SGA Reach	N/A
Latitude:	43.26892 N
Longitude:	73.20622 W
Land Ownership	Public
Site Ranking	4 - High



Site Description: 18" diameter HDPE culvert under Pawlet Mountain Rd is fully filled with fine sediment upstream, causing water to pond and flow over the road. Road ditch and adjacent driveway are both carrying large volumes of sediment to culvert inlet. Recommend replacing with a larger structure or adjusting culvert slope, and stabilizing ditch with rock check dams. Work with landowner to stabilize driveway erosion.

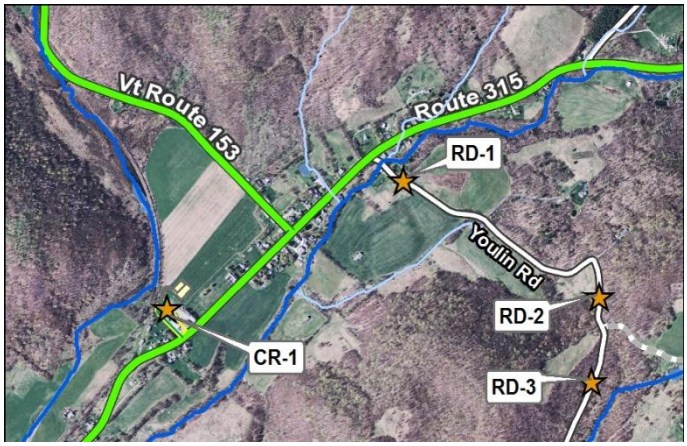
Photo 1: Sediment deposits filling road ditch and base of driveway

Photo 2: Culvert inlet is buried in fine sediment

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
4	3	4	4	Yes	Moderate	High	Yes	No

Site ID	RD-1
Date Observed	8/18/2015
Location	Youlin Rd near Route 315
Stream	Mill Brook
SGA Reach	M01T1.02
Latitude:	43.26165N
Longitude:	73.21913 W
Land Ownership	Public
Site Ranking	3 – Moderate to High



Site Description: Ditches on both sides of Youlin Road are filled in and have reduced capacity. The east edge of the road does not fully drain to the ditch causing erosion and sediment deposition on the road. A cross culvert is set near the road surface and is damaged (photo 2). Recommend raising the road bed to shed runoff to the north and cleaning out ditches to better direct runoff and reduce erosion. Replace damaged culvert as necessary.

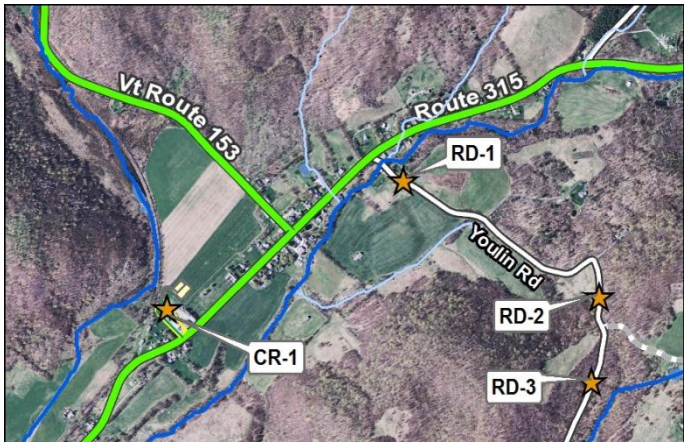
Photo 1: Erosion and deposition along edge of road, runoff is not directed towards ditch

Photo 2: Exposed and damaged culvert crossing road

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
3	3	4	3	Yes	Moderate	Mod	Yes	No

Site ID	RD-2
Date Observed	9/10/2014
Location	Youlin/Lang Rd
Stream	Mill Brook
SGA Reach	M01T1.02
Latitude:	43.25812N
Longitude:	73.21094 W
Land Ownership	Public
Site Ranking	2 – Low to Moderate



Site Description: Ditch along steep section of Youlin Road is eroding and generating large volumes of sand/gravel, clogging a drainage culvert. Recommend stabilizing ditch using stone check dams.

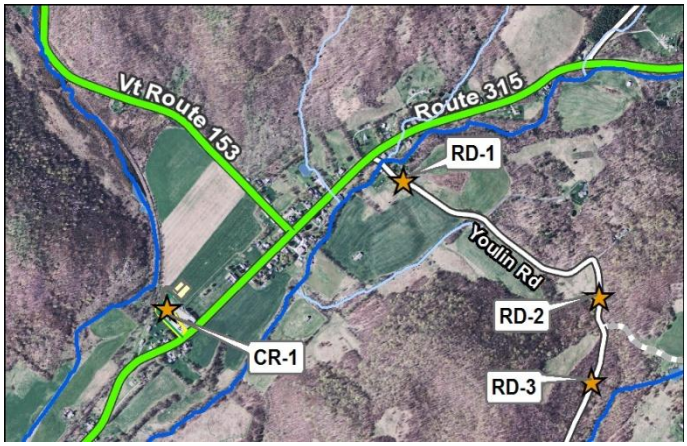
Photo 1: Sediment deposition and a clogged 16" CPP culvert under Youlin Road

Photo 2: Ditch is eroded and generating large volumes of sediment

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	3	3	2	Yes	Easy	Low	Yes	No

Site ID	RD-3
Date Observed	9/10/2014
Location	Youlin/Lang Rd
Stream	Trib to White Creek
SGA Reach	M01T2.02
Latitude:	43.25572 N
Longitude:	73.21119 W
Land Ownership	Public
Site Ranking	2 – Low to Moderate



Site Description: Ditch along moderately steep section of Lang Road is eroding and generating large volumes of sand/gravel, clogging a drainage culvert. Recommend stabilizing ditch using stone check dams.

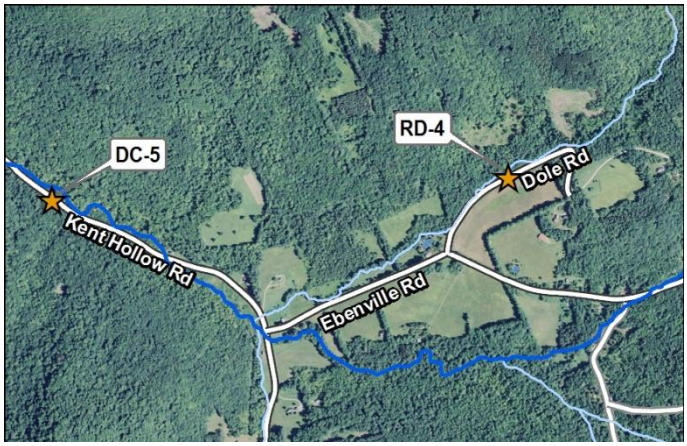
Photo 1: Sediment deposition and a clogged 12" CPP culvert under Lang Road

Photo 2: Shallow ditch is eroding and generating large volumes of sediment

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	3	3	2	Yes	Easy	Low	Yes	No

Site ID	RD-4
Date Observed	8/18/2015
Location	Dole Rd
Stream	Trib to White Creek
SGA Reach	N/A
Latitude:	43.23194 N
Longitude:	73.16857 W
Land Ownership	Public
Site Ranking	2 – Low to Moderate



Site Description: Ditch along an approximately 1000' long and steep section of Dole Road is eroding and exposing raw sediment along the opposite bank. Recommend stabilizing the ditch with stone check dams.

Photo 1: Steep roadside ditch with moderate erosion

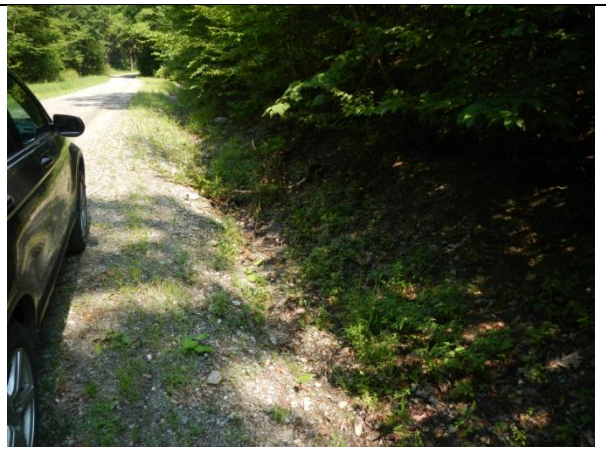
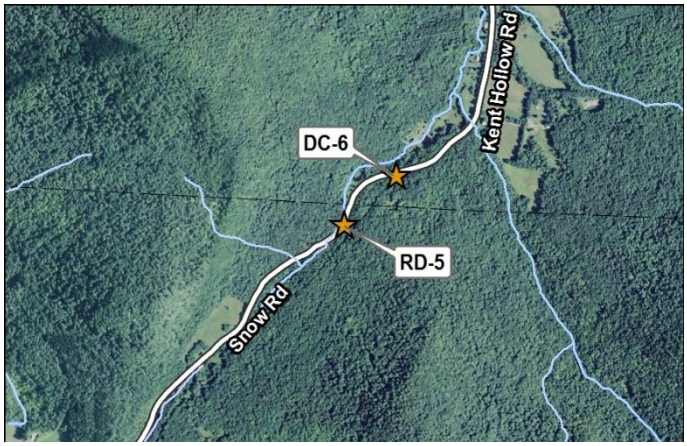


Photo 2: Steep roadside ditch with moderate erosion

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	2	2	1	Yes	Easy	Mod	Yes	No

Site ID	RD-5
Date Observed	8/18/2015
Location	Snow Road near town line
Stream	Trib to Oven Brook
SGA Reach	N/A
Latitude:	43.21413 N
Longitude:	73.18412 W
Land Ownership	Public
Site Ranking	4 - High



Site Description: Roadside ditches recently cleaned by Sandgate highway department were left with large areas of exposed raw soil and cross culverts were fully blocked. Large volumes of fine sediment were observed entering tributary. Recommend stabilizing ditch with coarse material and stone check dams, and working with highway department to improve ditch maintenance practices.

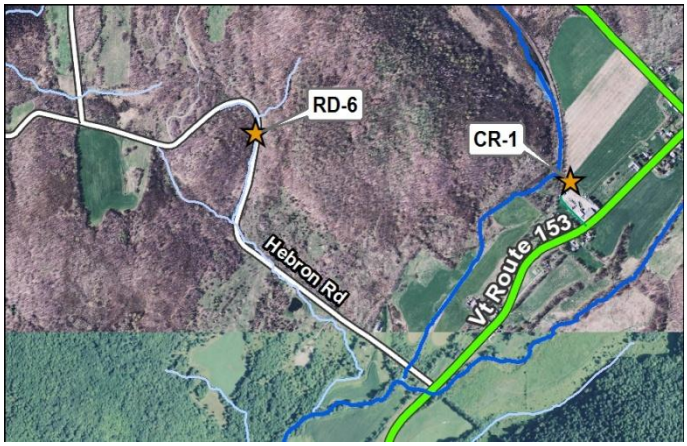
Photo 1: Recent ditch cleanout left behind exposed raw sediment and blocked culverts

Photo 2: Buried culvert outlet with raw sediment

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
4	3	4	4	Yes	Easy	Mod	Yes	No

Site ID	RD-6
Date Observed	9/9/2014
Location	Hebron Road
Stream	Trib to Mill Brook
SGA Reach	N/A
Latitude:	43.25940N
Longitude:	73.23985 W
Land Ownership	Public
Site Ranking	3-Moderate to High



Site Description: Roadside ditches along a very steep portion of Hebron Road are incised. Exposed bedrock underlies some of the ditch and the road edge is eroding in areas. Recommend installing stone check dams to trap sediment and reduce ditch incision and rilling of the road edge.

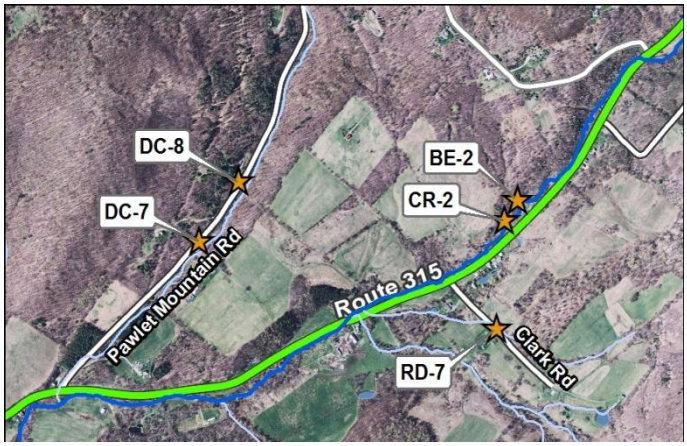
Photo 1: Deeply incised ditch with exposed bedrock

Photo 2: Erosion along the road edge delivering sediment to ditch

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
3	3	3	3	Yes	Easy	Low	Yes	No

Site ID	RD-7
Date Observed	8/18/2015
Location	Clark Road
Stream	Trib to Mill Brook
SGA Reach	N/A
Latitude:	43.26654N
Longitude:	73.19469 W
Land Ownership	Private
Site Ranking	1 – Low to Moderate



Site Description: Roadside ditch along a steep portion of Clarke Road is filled in with sediment and partially blocking a culvert crossing under the road to the stream. Stormwater flows across the road leading to erosion and rilling. Recommend cleaning out the ditch and installing stone check dams for easier future maintenance.

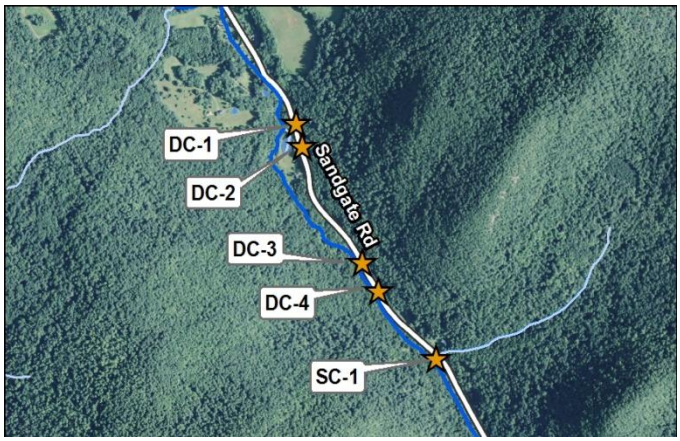
Photo 1: Road side ditch is filled with sediment and gravel

Photo 2: Stormwater flowing across Clark Road is causing erosion and rilling of the road surface

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
2	2	2	2	Yes	Easy	Low	Yes	No

Site ID	SC-1
Date Observed	8/18/2015
Location	Tributary culvert under Sandgate Road
Stream	Tributary to Sandgate Brook
SGA Reach	M03T1.01
Latitude:	43.21953 N
Longitude:	73.21277 W
Land Ownership	Town
Site Ranking	3 – Moderate to High



Site Description: 4' x 6' squash CMP culvert under the road has significant sediment deposition upstream and material throughout the culvert. The culvert is appropriately sized hydraulically for the 174 acre forested watershed. A large 4' tall headcut was observed immediately upstream of the inlet. The culvert slope is lower than the tributary channel slope, leading to increased deposition upstream. Recommend resetting the culvert to better match channel slope and improve sediment transport and aquatic organism passage.

Photo 1: Headcut and deposition upstream of culvert inlet

Photo 2: Large cobbles deposited in culvert, outlet is stable

Prioritization Criteria: 1(Low/Easy) to 4 (High/Difficult)

Overall Impact	Impact Frequency	Current Condition	Urgency	Public Infrastructure	Ease of Implementation	Estimated Cost	Additional Impacts?	Part of larger or systemic problem?
3	3	3	3	Yes	Difficult	High	Yes	Yes

4.4 Project Prioritization and Conceptual Designs

Evan Fitzgerald held a meeting with Tom Wilson (Town of Rupert), Jim Henderson (BCRC), Shelly Stiles (BCCD), and Ethan Swift (VTDEC) on October 5, 2015 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 B:

- **CR-2:** Large gully where concentrated runoff enters Mill Brook.
- **DC-2:** 36" HDPE culvert under Sandgate Road with an incised and eroding ditch downstream.
- **DC-5:** Large forested watershed draining to an undersized culvert at Sandgate Road; significant deposition upstream.
- **RD-1:** Filled in roadside ditches and grading on Youlin Road causing significant sediment loading to Mill Brook.
- **RD-6:** Deeply incised ditch and eroding road bed along a steep portion of Hebron Road.

5.0 Next Steps

This Stormwater Master Plan represents an extensive effort to identify, describe, and evaluate stormwater problem areas throughout the White Creek/Mill Brook watershed within the Town of Rupert. We provided a preliminary cost estimate and a site rating to aid the Town and other stakeholders in planning and prioritizing restoration efforts. 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 recommend that the Town of Rupert, BCRC and BCCD work together and with VTDEC and VTrans to secure funding for the high priority projects listed above in Section 4.4. The remaining stormwater problem areas summarized in Section 4.3 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 (Rupert Planning Commission, 2015). Many of the problem areas covered in this document are representative of typical issues encountered on gravel roads (i.e., stone check dams in ditches, culvert sizing, culvert slope, ditch maintenance) in steep watersheds. The recommended practices to address these issues should be applied to future projects to reduce the risk of stormwater runoff conflicts and sediment loading to receiving waters.

6.0 References

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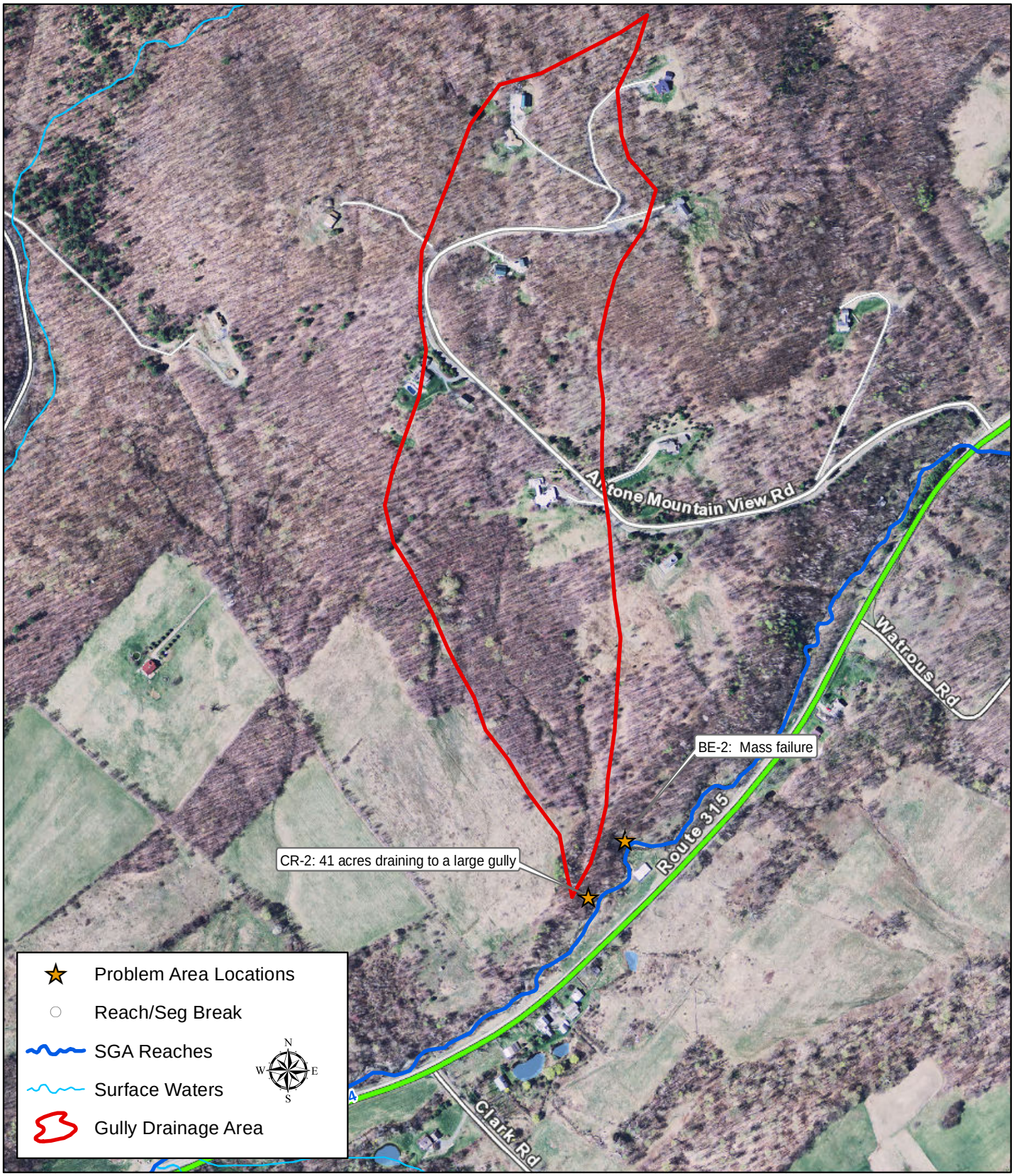
Appendix A: Stormwater Problem Area Maps



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Town of Rupert
Stormwater Master Plan

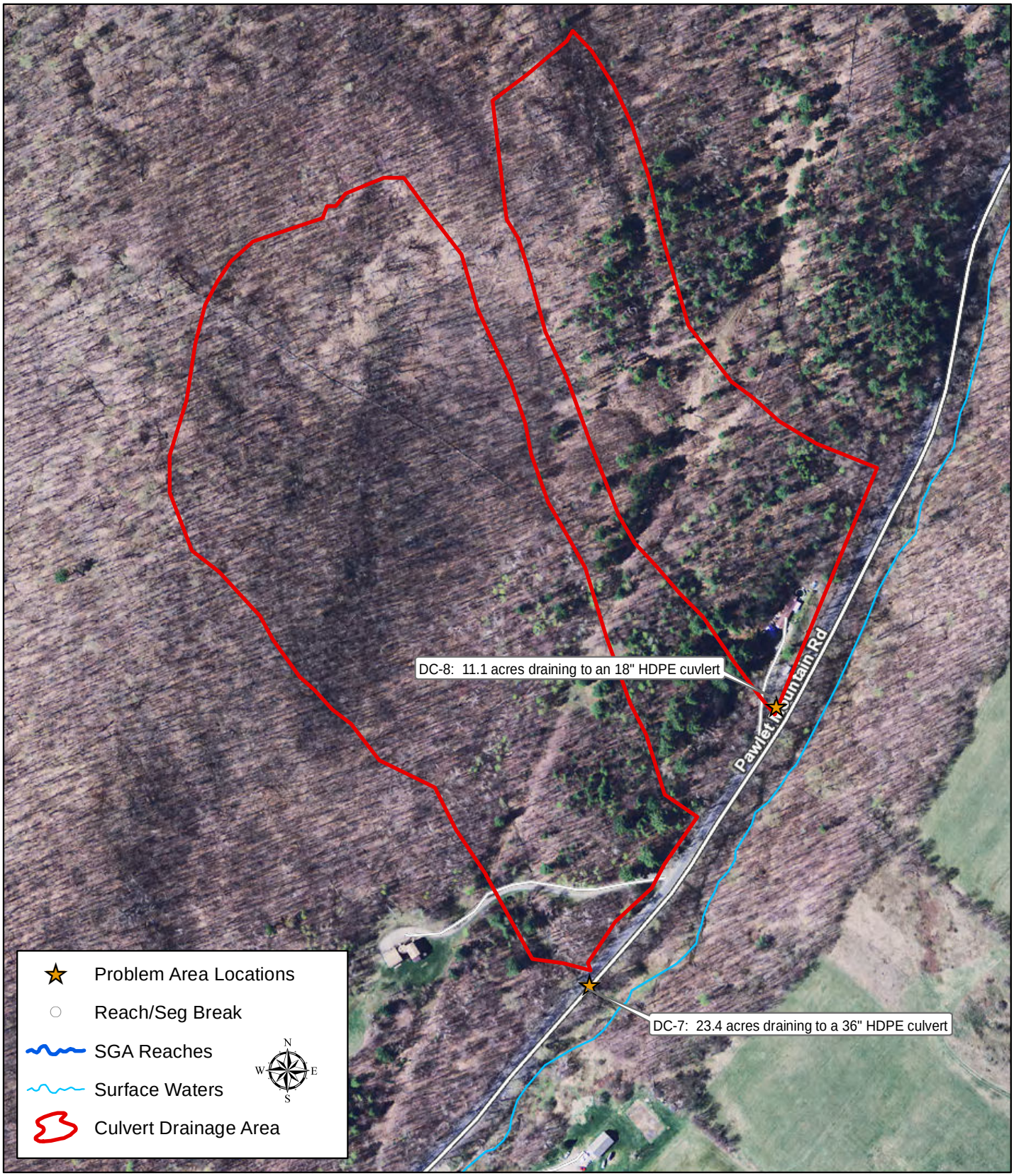
0 250 500 Feet

Problem Areas BE-2 and CR-2

Map 1

1 inch = 500 ft

Date: Sept 18, 2015
Drawn: JHB



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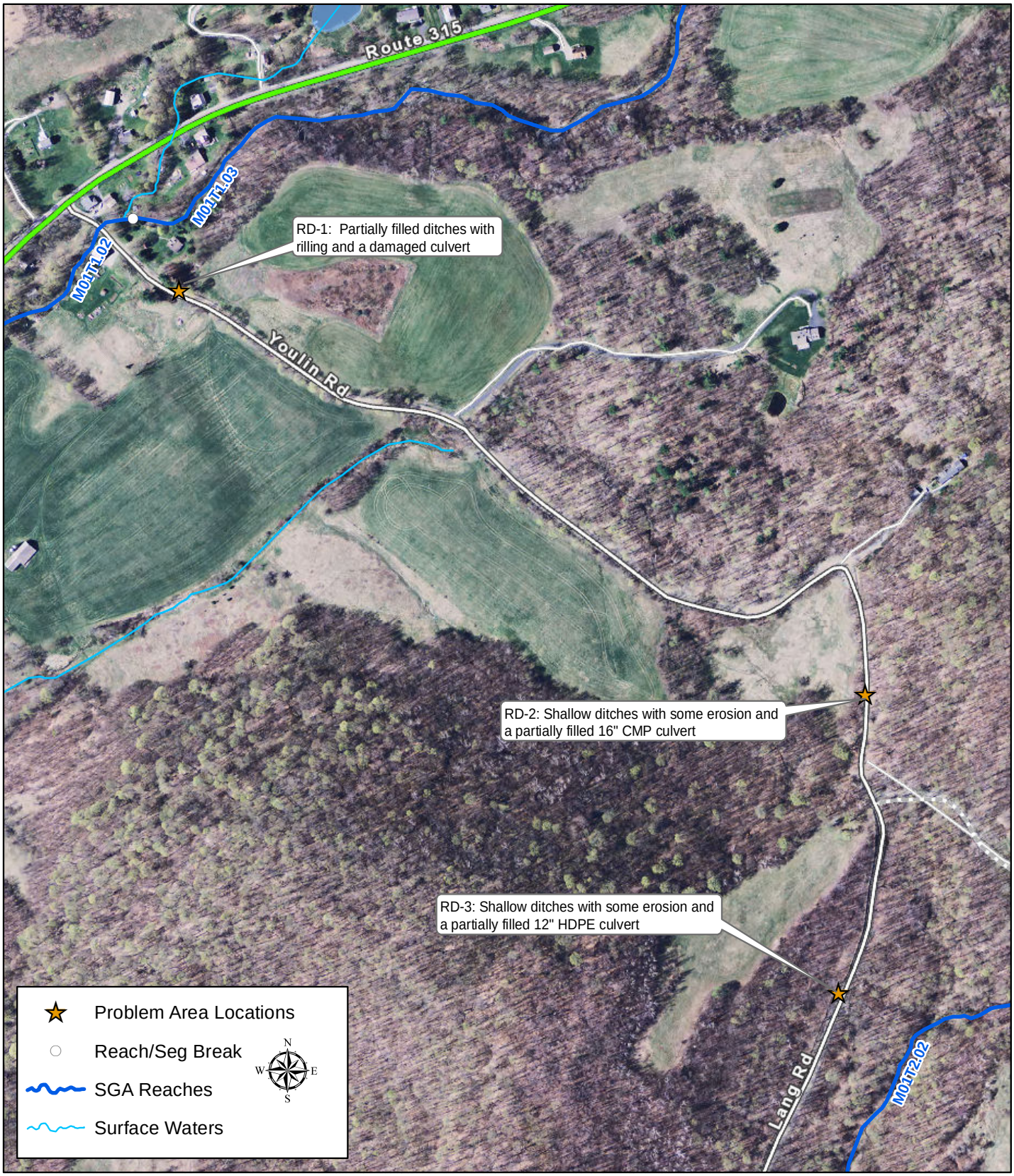
0 150 300 Feet

Problem Areas DC-7 and DC-8

Map 2

1 inch = 300 ft

Date: Sept 18, 2015
Drawn: JHB



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0 200 400 Feet

Problem Area RD-1, RD-2, and RD-3

Map 3

1 inch = 400 ft

Date: Sept 18, 2015
Drawn: JHB

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	Problem Area CR-1	Map 4 1 inch = 100 ft Date: Sept 18, 2015 Drawn: JHB

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Stormwater Master Plan

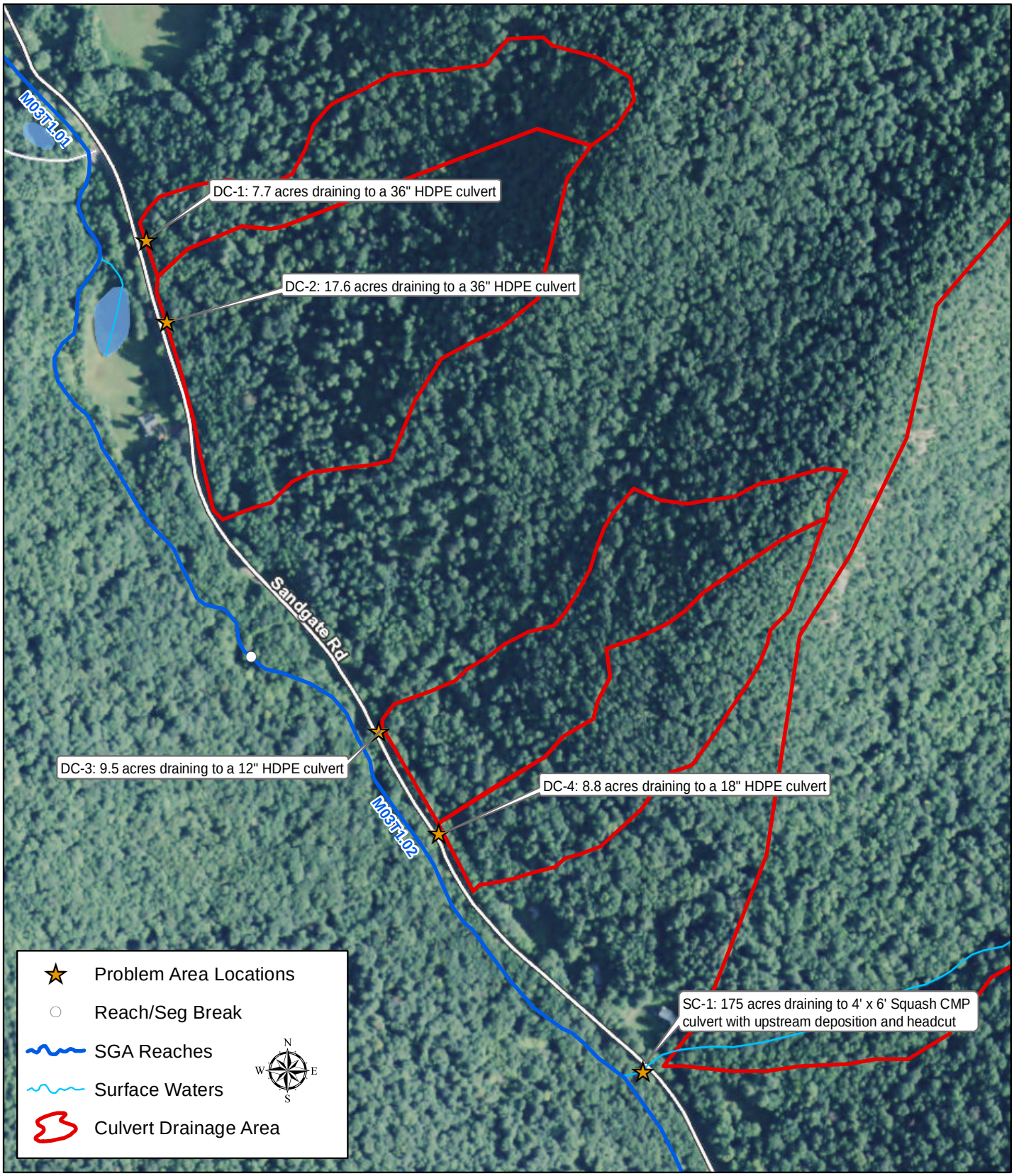
0 200 400 Feet

Problem Area BE-1

Map 5

1 inch = 400 ft

Date: Sept 18, 2015
Drawn: JHB



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Town of Rupert
Stormwater Master Plan

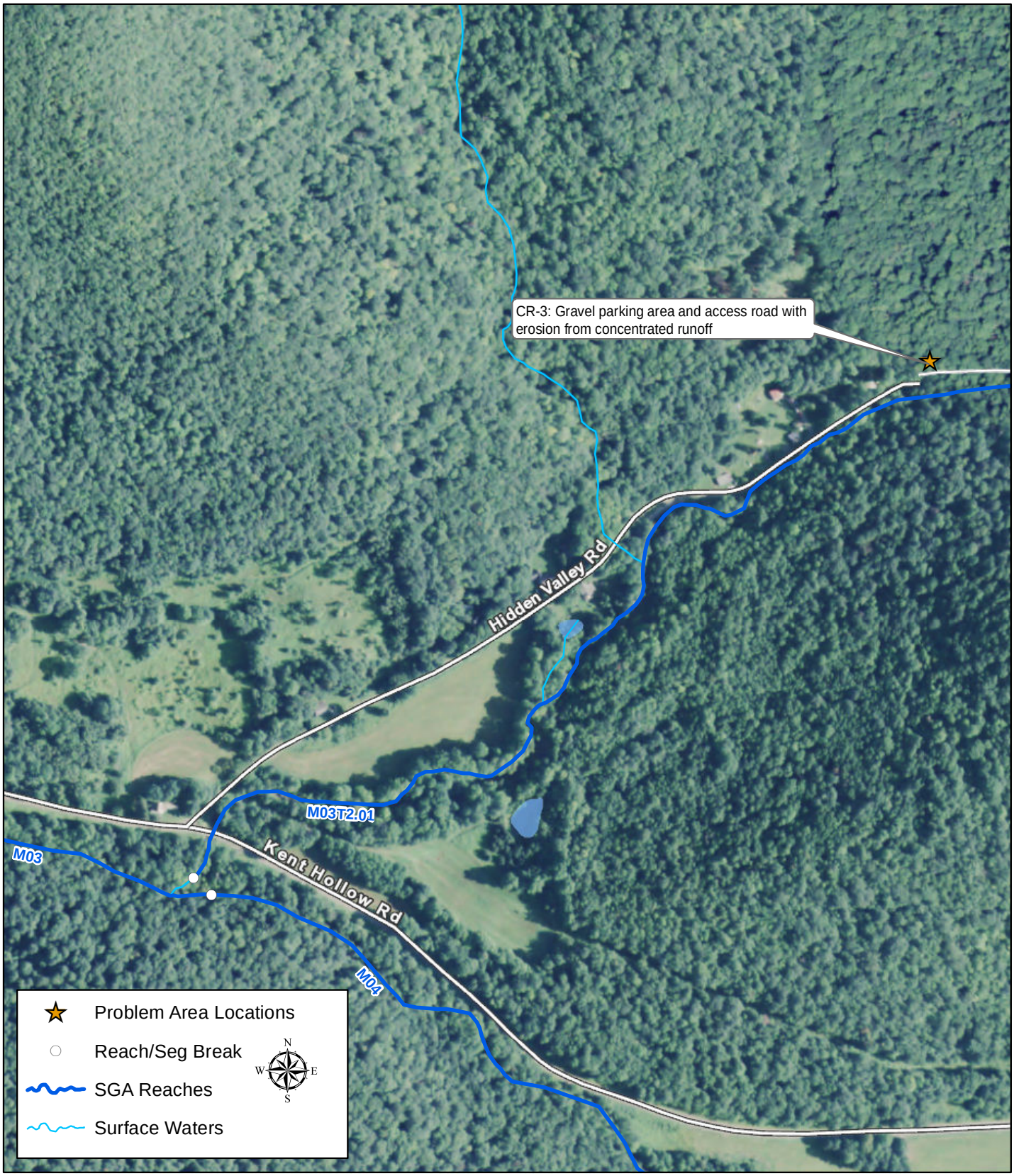
0 200 400 Feet

Problem Areas DC-1, DC-2, DC-3, DC-4 and SC-1

Map 6

1 inch = 400 ft

Date: Sept 18, 2015
Drawn: JHB



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Town of Rupert Stormwater Master Plan

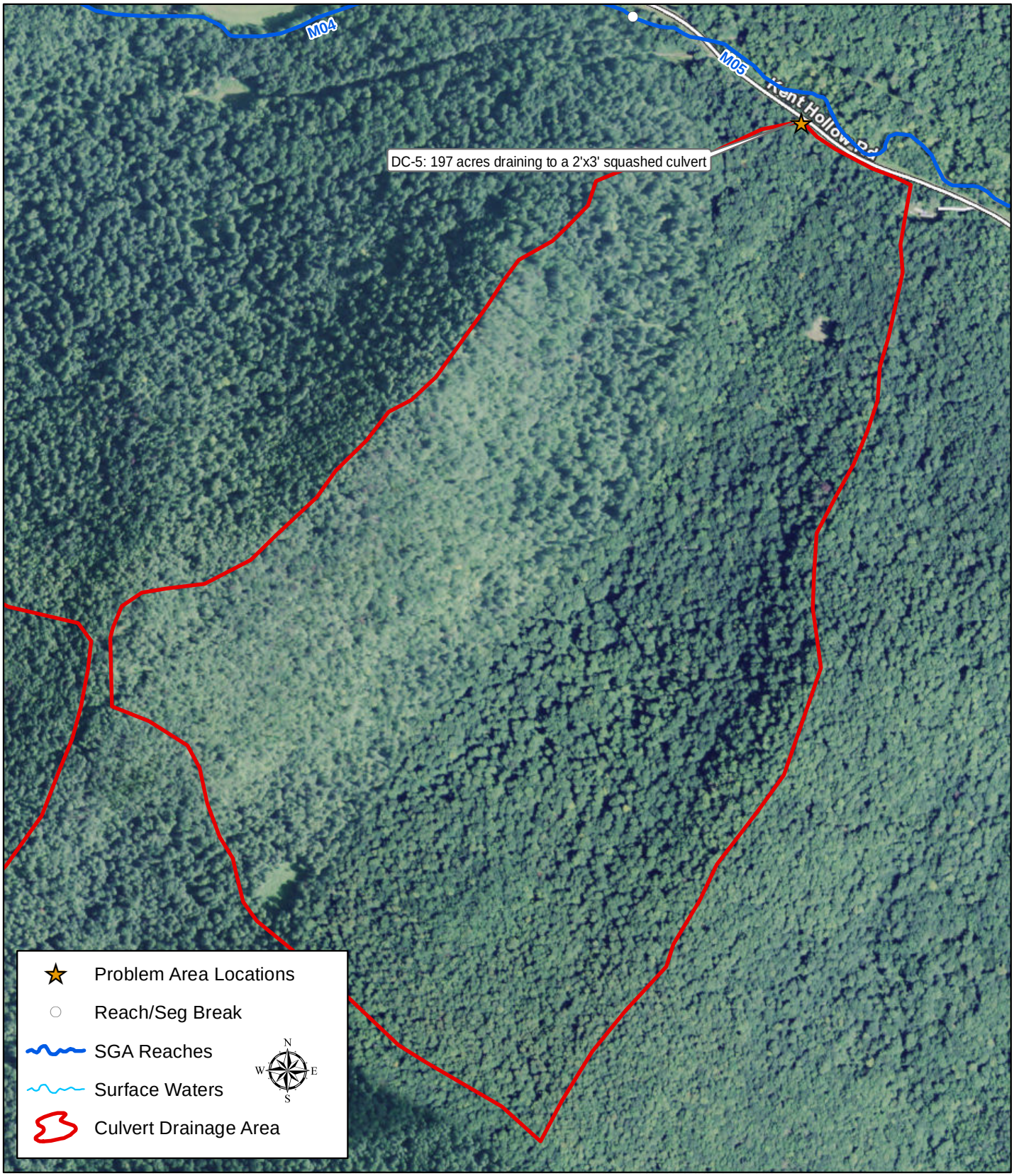
0 200 400 Feet

Problem Area CR-3

Map 7

1 inch = 400 ft

Date: Sept 18, 2015
Drawn: JHB



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Town of Rupert
Stormwater Master Plan

0 300 600 Feet

Problem Area DC-5

Map 8

1 inch = 600 ft

Date: Sept 18, 2015
Drawn: JHB

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Town of Rupert Stormwater Master Plan

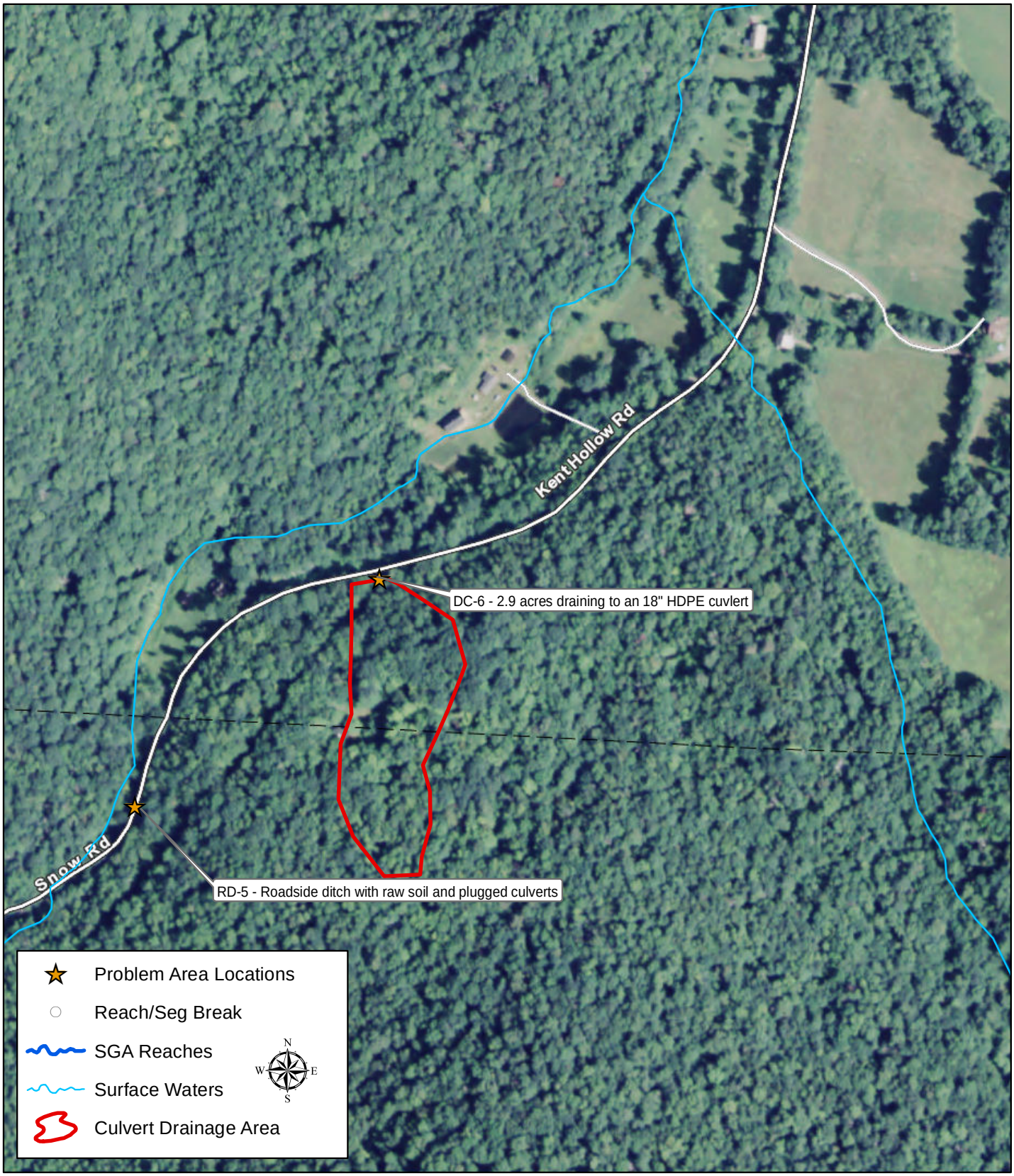
0 200 400 Feet

Problem Area RD-4

Map 9

1 inch = 400 ft

Date: Sept 18, 2015
Drawn: JHB



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Town of Rupert
Stormwater Master Plan

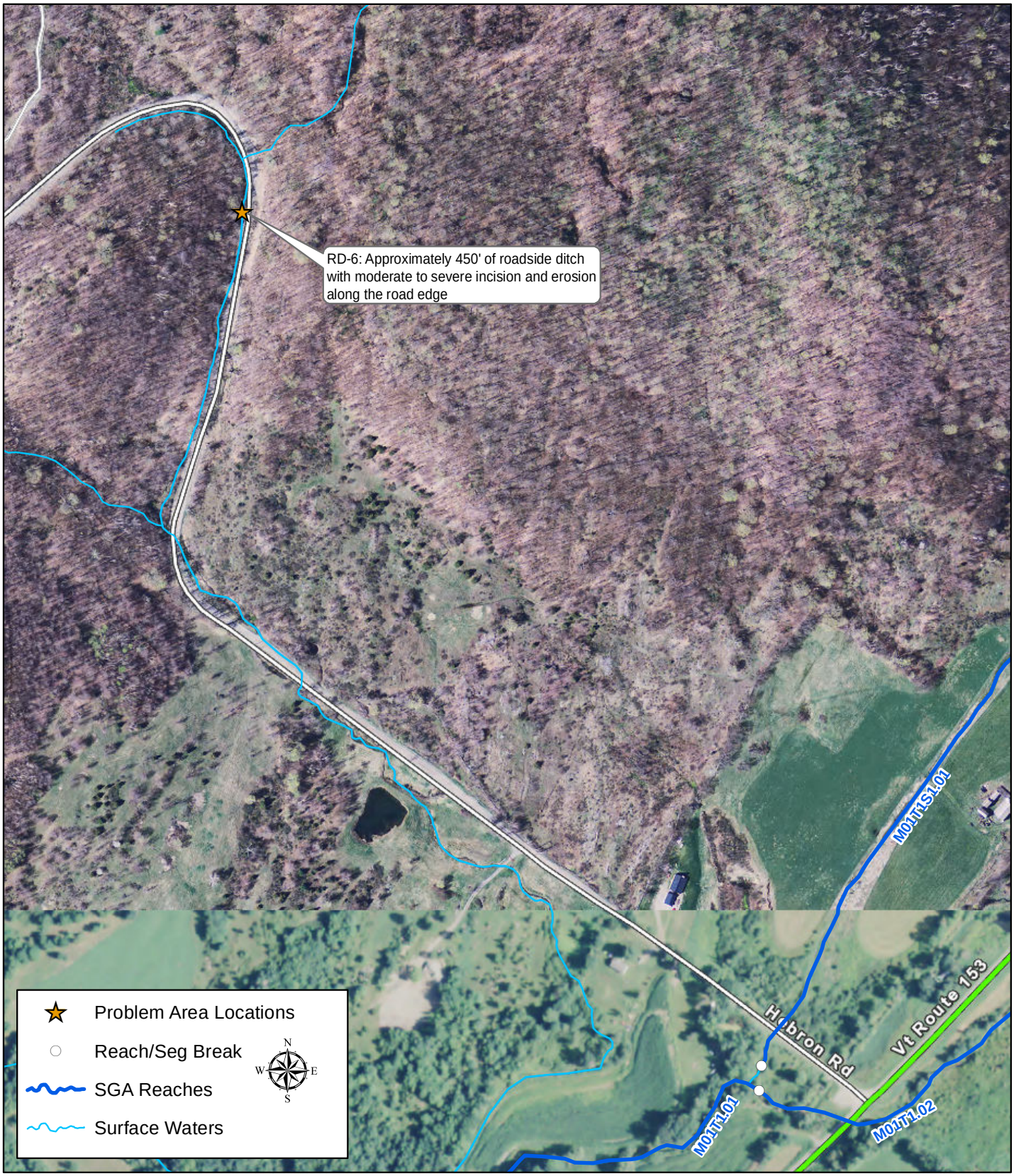
0 150 300 Feet

Problem Area DC-6 and RD-5

Map 10

1 inch = 300 ft

Date: Sept 18, 2015
Drawn: JHB



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Town of Rupert
Stormwater Master Plan

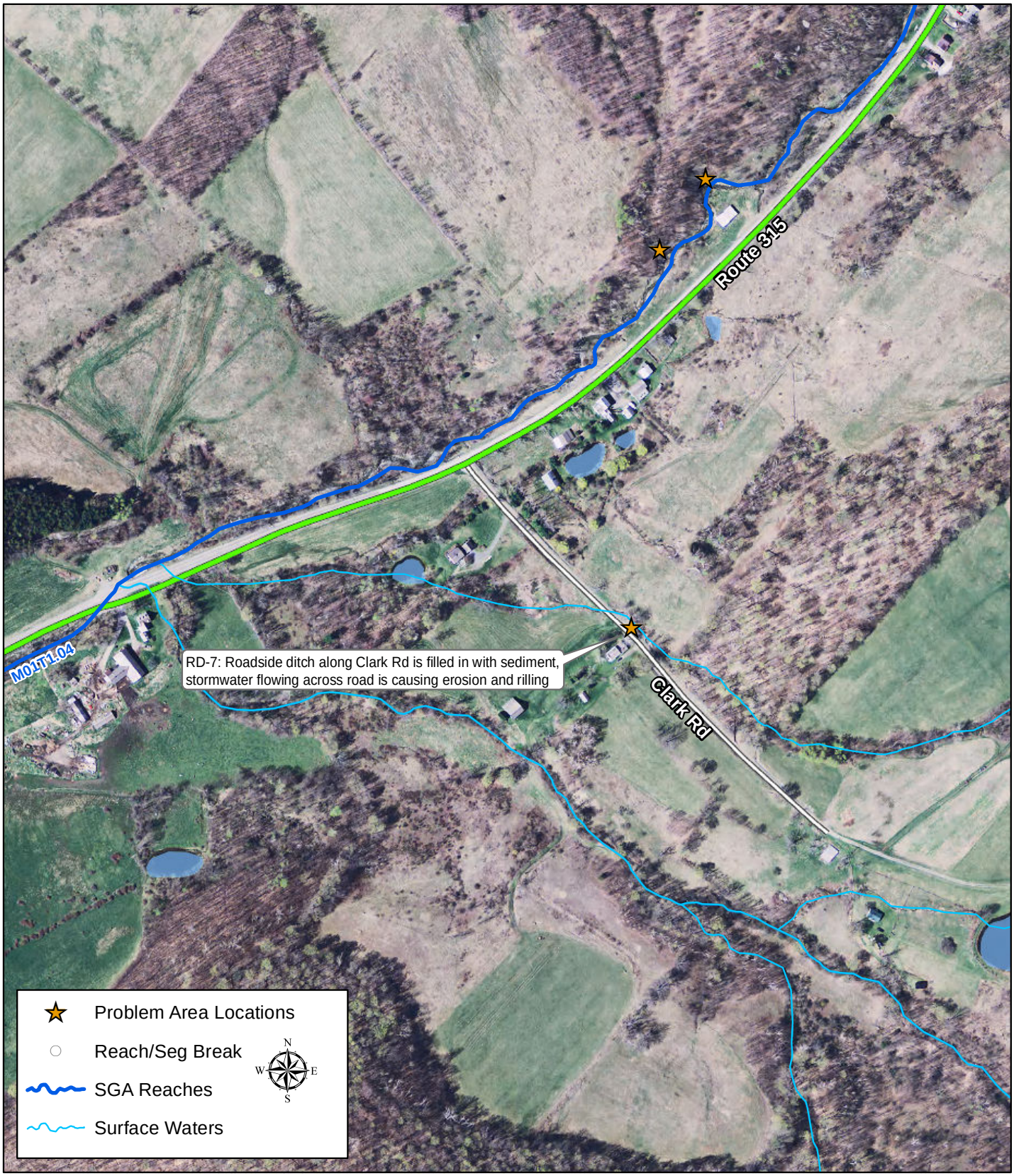
0 200 400 Feet

Problem Area RD-6

Map 11

1 inch = 400 ft

Date: Oct 6, 2015
Drawn: JHB



Fitzgerald Environmental Associates, LLC 18 Severance Green, Suite 203 Colchester, VT 05446 Telephone: 802.876.7778 www.fitzgeraldenvironmental.com	**Town of Rupert** **Stormwater Master Plan**	0 200 400 Feet
	Problem Area RD-7	Map 12 1 inch = 400 ft Date: Oct 6, 2015 Drawn: JHB

Appendix B: Conceptual Designs

Project CR-2: Gully Stabilization

Site Description

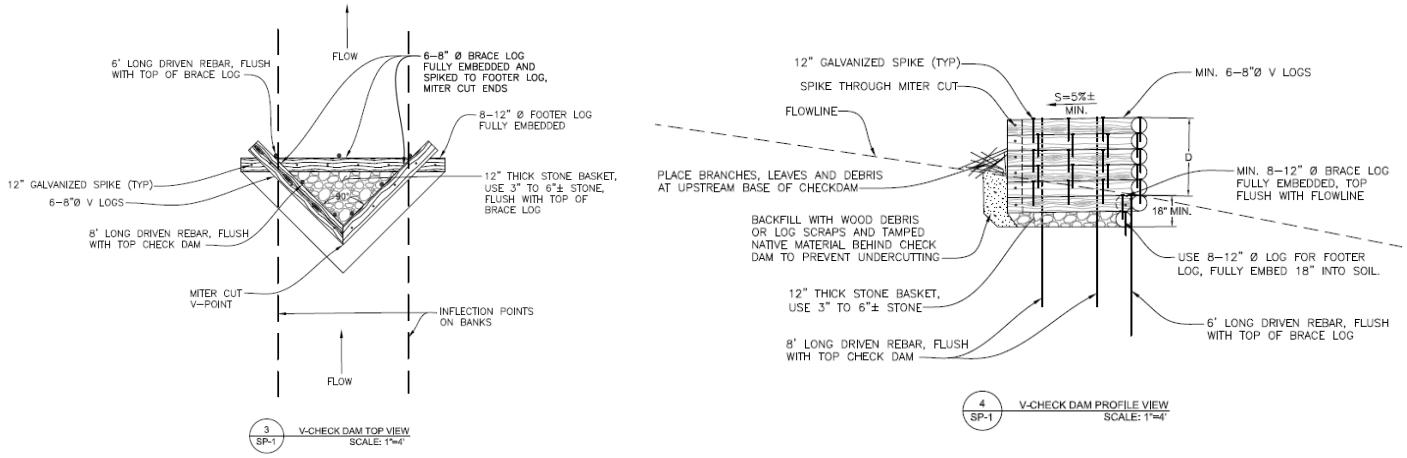
A large and active gully has formed in an area of concentrated runoff draining from 41 acres of forest, pasture, and residential lands (Map 1 in Appendix A). The lower portion of the gully is approximately 150 feet long and is very steep (slope = 25-30%) with numerous head cuts and active bank erosion and mass failure. The upper portion of the gully is approximately 250 feet long and is moderately stable, however the headcuts will continue to advance upslope.

Steep failing banks and several headcuts in the lower portion of the gully

Stable banks and less incised gully in the upper portion

Site Recommendations

We recommend stabilizing the gully with log structures and stone check dams. The lower portion of the gully is of greatest concern with mass failure along the steep banks (1V:1.5H) and active incision further eroding the bottom of the gully. Installation of log check dams in the lower portion of the gully with an appropriate height and spacing will serve to reduce the slope, trap sediment, and stabilize the gully. Stone check dams and brush matting can be installed in the upper portion of the gully to reduce erosion and trap sediment. Based on our detailed designs for a project in northern Vermont with similar gully slopes and dimensions, we expect that at least 8 V-shaped log check dams will be required to reduce slope and stabilize the lower gully (design details shown below). An additional 8-10 straight log check dams and/or stone check dams are recommended to stabilize the upper portion of the gully.



V-shape log check dam top view (left) and profile view (right). Logs will be keyed into the banks and into the gully bottom to reduce the risk of erosion around or under the structure. A stone filled splash area will limit erosion on the downstream end of the structure.

Cost Estimate

We estimate that this project will cost approximately $20,000 based on comparable costs for our project in northern Vermont, the number of structures required, equipment access, on-site availability of suitable logs, and availability of low-cost labor crews (i.e., VYCC).

Project Implementation and Funding Partners

VTANR Ecosystem Restoration Program (ERP) could provide funding and technical assistance for all aspects of the project. Vermont Youth Conservation Corps (VYCC) could provide the labor needed for most of the project, potentially resulting in substantial cost savings over another approach involving more machinery. Bennington County Regional Commission and Bennington County Conservation District would likely be available to assist with grant applications and coordination of funding.

Permitting Requirements

If this project is sponsored by VTDEC and is proactive restoration in nature, it is assumed that the Wetlands Office will be informed of the work and appropriate clearances will be made by VTDEC. U.S. Army Corps of Engineers (USACE) reporting is typically required for projects that impact greater than 3,000 square feet of wetlands. Our estimates at this time indicate this project would impact less than the 3,000 square foot threshold; therefore USACE permitting is not required at this time.

Project DC-2: Culvert and Swale Stabilization

Site Description

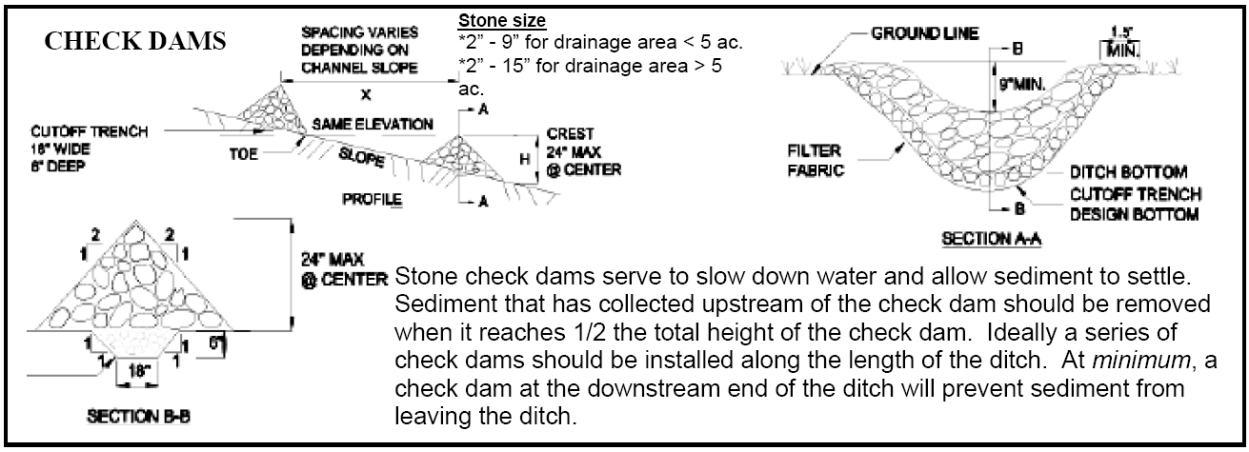
A 36" Corrugated HDPE culvert under Sandgate Road delivers sediment and stormwater to Sandgate Brook (Map 6 in Appendix A). The culvert has appropriate capacity for the 17.6 acre forested watershed however the outlet is perched above the receiving swale leading to scour below the outlet. The downstream swale is deeply incised and is further eroding where flow spills over the steep bank to Sandgate Brook. The swale is 4-6 feet wide has a relatively low slope (3%) before reaching the top of the bank where it sharply drops to the brook (approximately 30% slope).

Perched culvert outlet and scour in swale

Incised swale leading to stream bank

Site Recommendations

We recommend armoring the area around and below the culvert outlet with heavy stone (12" minimum) to stop erosion and dissipate energy from the perched culvert. Stone check dams (refer to concept design below) should be installed approximately every 20 feet in the downstream swale to reduce incision and trap sediment. Rock armor should be installed at the end of the swale where the slope increases; this will reduce the risk of erosion cutting back into the swale from the steep bank.



Cost Estimate

We estimate that 2 CY of stone will be required to construct 3 stone check dams and an additional 4-8 CY of stone will be needed to armor the swale at the culvert outlet and at the downstream slope transition. We estimate that this project should cost less than $1,000 including material and labor if carried out by the Rupert Highway Department.

Project Implementation and Funding Partners

The VTANR and VTrans Better Backroads Program (BBP) promotes the use of erosion control and maintenance techniques that save money while protecting and enhancing Vermont's lakes and streams. This project – perhaps combined with other high priority projects identified in the SWMP - would be eligible for a BBP grant but would require 25% match from the Town, Bennington County Regional Commission and Bennington County Conservation District would likely be available to assist with grant applications and coordination of funding.

Permitting Requirements

No permits are required for this project.

Project DC-5: Replace Undersized Culvert

Site Description

A 197 acre forested watershed drains to a perennial stream that crosses under Kent Hollow Road through a severely undersized 2'X3' squashed CMP (Map 8 in Appendix A). Large deposits of gravel and cobble have formed near the culvert inlet and partially fill the culvert. Town officials have not observed flooding or erosion issues at this crossing, however it is our opinion that the culvert is vulnerable to plugging with debris or sediment with the potential of washing out Sandgate Road. Based on hydraulic geometry curve calculations, the predicted bankfull channel width for this watershed is approximately 7 feet. Analysis of high-resolution LiDAR elevation data indicates a channel width of 9-12 feet upstream of the culvert. Hydraulic modeling of the drainage area shown in Table 2 of the Rupert SWMP indicates that the current culvert does not have sufficient capacity for the 10-year storm or larger events.

Site Recommendations

The Town should request a more detailed hydraulic study of the culvert from VTrans. If VTrans confirms that the culvert is undersized and in need of replacement, we recommend replacing the culvert with a larger structure to obtain sufficient capacity for large storm events, improve sediment transport through the culvert, and reduce the risk of plugging with sediment or debris. A 4'X6' squashed culvert would have capacity for the 100-year storm and is more similar to the predicted and observed channel width. The culvert should be set at a slope close to 10% to best match the upstream and downstream channel. The VTrans hydraulic study would likely detail similar recommendations regarding the sizing and installation of the replacement.

Cost Estimate

Based on recent culvert replacements carried out by the Town of Rupert Highway Department, this culvert replacement would likely cost between $25,000-30,000 after accounting for in-kind labor and equipment from the Town.

Project Implementation and Funding Partners

The Town could apply for a VTrans structures grant to cover the costs of the culvert replacement. As noted above VTrans could assist with the sizing of the culvert.

Permitting Requirements

The site is not currently mapped as a perennial stream, however it is likely perennial. Culvert replacement will involve work within the bankfull channel, therefore environmental clearances will likely be required from VTDEC, and possibly Army Corps of Engineers.

Project RD-1: Youlin Road Erosion and Ditches

Site Description

Ditches on both sides of Youlin Road are filled in and have reduced capacity (Map 3 in Appendix A). The northeast edge of the road for approximately 240 feet does not fully drain to the ditch causing runoff to flow along the edge of the road bypassing the inlet of the 18” diameter cross-culvert. This runoff is causing erosion and sediment deposition along the road (see photograph below). An 18" CPP located 180 feet up the hill from the erosion site is set too shallow and is damaged. A site detail map is provided on the following page.

Rilling of road edge from stormwater runoff along lower Youlin Road.

Site Recommendations

We have discussed this site in detail in the field with the Town Highway Department, including the potential to raise the road grade along and above the steep hill on Youlin Road. Raising the road bed and altering the grading would help to direct runoff to the northern ditch. Ditches on both sides of the road should be cleaned out to increase capacity. The 18" cross-culvert that is partially exposed and damaged should be replaced and set with sufficient cover. The road bed should be raised and graded to better direct runoff to the ditches.

Cost Estimate

Depending on the extent of the raising of the road grade uphill on Youlin Road, we estimate this project would cost between $5,000 and 10,000 after accounting for in-kind labor and equipment from the Town.

Project Implementation and Funding Partners

The VTANR and VTrans Better Backroads Program (BBP) promotes the use of erosion control and maintenance techniques that save money while protecting and enhancing Vermont's lakes and streams. This project – perhaps combined with other high priority projects identified in the SWMP - would be eligible for a BBP grant but would require 25% match from the Town. Bennington County Regional Commission and Bennington County Conservation District would likely be available to assist with grant applications and coordination of funding.

Permitting Requirements

No permits are anticipated for this project.

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Town of Rupert
Stormwater Master Plan

0 50 100 Feet

Problem Area RD-1 Detail Map

Map 1

Date: Oct 19, 2015
Drawn: JHB

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Project RD-6: Hebron Road Erosion and Incised Ditches

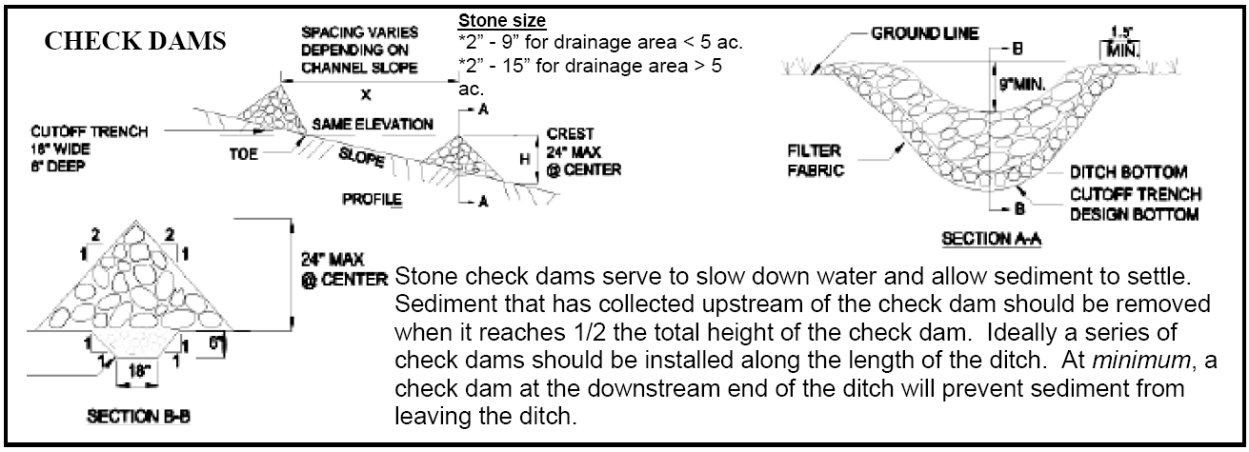
Site Description

The roadside ditch along a very steep portion of Hebron Road is deeply incised and has scoured down to bedrock in several areas (Map 11 in Appendix A). The edge of the road is eroding and generating large volumes of sediment (see photograph below). The section of eroding ditch has a slope of 10-14% and an overall length of approximately 450 feet.

Rilling of road edge from stormwater runoff along upper Hebron Road.

Site Recommendations

We recommend stabilizing the ditch with stone check dams to reduce scour and store sediment. A traditional approach to check dam installation (see design concept on following page) would result in many check dams due to the slope and length of the ditches. Therefore, we recommend a modified approach whereby check dams are installed at every 3 feet of elevation change; this would result 15 to 20 check dams along the unstable ditch. Check dams should be constructed out of Type II stone and with an approximate height of 18 to 24 inches.



Cost Estimate

We estimate that 15 CY of stone will be required to construct 20 stone check dams. We estimate that this project should cost less than $1,500 including material and labor if carried out by the Rupert Highway Department.

Project Implementation and Funding Partners

The VTANR and VTrans Better Backroads Program (BBP) promotes the use of erosion control and maintenance techniques that save money while protecting and enhancing Vermont's lakes and streams. This project – perhaps combined with other high priority projects identified in the SWMP - would be eligible for a BBP grant but would require 25% match from the Town, Bennington County Regional Commission and Bennington County Conservation District would likely be available to assist with grant applications and coordination of funding.

Permitting Requirements

No permits are required for this project.