Cambridge, Vermont
Seymour River Corridor Plan

May 31, 2018

Prepared by:
Bear Creek Environmental, LLC
149 State Street, Suite 3
Montpelier, Vermont 05602

Bear Creek Environmental

Prepared under contract to:
Lamoille County Planning Commission
52 Portland Street
Morrisville, VT 05661

LAMOILLE COUNTY PLANNING COMMISSION

Funding for this project was provided by:
State of Vermont Ecosystem Restoration Program

Cambridge, Vermont
Seymour River Corridor Plan

TABLE OF CONTENTS

<u>Appendices</u>

Bear Creek Environmental, LLC
149 State Street, Suite 3 / Montpelier, VT 05602
Phone: (802) 223-5140 / Web: www.BearCreekEnvironmental.com

Cambridge, Vermont
Seymour River Corridor Plan

1.0 EXECUTIVE SUMMARY

A stream geomorphic assessment within the Seymour River watershed was conducted by Bear Creek Environmental, LLC (BCE) under the direction of Lamoille County Planning Commission (LCPC) and the Vermont Agency of Natural Resources (VANR) during the summer of 2017. Funding for the project was provided through the State of Vermont Ecosystem Restoration Program. A planning strategy based on fluvial geomorphic science (see glossary at end of report for associated definitions) was chosen because it provides a holistic, watershed-scale approach to identifying the stressors on river ecosystem health. The stream geomorphic assessment data can be used by resource managers, community watershed groups, municipalities and others to identify how changes to land-use alter the physical processes and habitat of rivers.

The Town and Village of Cambridge, Vermont experience periodic flooding and damage to infrastructure as a result of river and development conflicts. As part of the long term plan to mitigate the impact of flooding, improve aquatic habitat, and increase river stability, Lamoille County Planning Commission secured state funding to complete a Phase 2 stream geomorphic assessment within the Seymour River watershed. An additional focus for this study is water quality improvement; the surface waters within the study area drain to the Lamoille River and Lake Champlain. Small tributaries that flow into the Seymour River were included in the study to evaluate potential sources of sediment and nutrients to the Lamoille watershed and Lake Champlain. The stream geomorphic assessment data will be used to help focus stream restoration and protection and water quality improvement activities within the watershed and assist the Town and Village with flood resiliency planning.

The study encompassed approximately 13 miles of stream channel within 40 reaches on the Seymour River, Settlement Brook, and numerous unnamed tributaries to the Seymour River. This stream geomorphic assessment facilitated the identification of major stressors to geomorphic stability and habitat conditions within the study area. One predominant stressor observed within the Seymour River watershed is stream channel straightening and corridor encroachment associated with the existence of roads and development. In many cases, this encroachment has limited floodplain access and has caused moderate to extreme channel degradation (lowering of the bed) resulting in sediment build up, channel widening, and planform adjustment (lateral movement). Numerous state and town highways were historically built into river valleys throughout the study area, including Vermont Route 15 and Pleasant Valley Road. The Village of Cambridge, a hub of residential and municipal activity, lies within the Lamoille River Valley at the mouth of the Seymour River.

The river corridor planning effort in the Seymour River watershed is a continuous and collaborative process. The stream geomorphic assessment data collected in this study build on other data that have been collected throughout the Lamoille River watershed in the past decade. Analysis of these data has aided the identification of major impacts and stressors and the development of projects to mitigate impacts, increase geomorphic stability, and improve aquatic habitat. The study also identified major assets within the Seymour River watershed including channel spanning bedrock on the mainstem that provides vertical stability for the river and depositional areas with floodplain access that provide attenuation of sediment and floodwaters.

A list of 59 potential restoration, conservation, and flood resiliency projects was developed using the stream geomorphic assessment data collected within the study area. The projects fall within five categories, as outlined by the Vermont Watershed Management Division in its Watershed Projects Database table:

Project Category	**Number of Proposed Projects**
Agricultural Pollution Prevention - Preliminary Design	9
Floodplain/Stream Restoration - Preliminary Design	22
Pollution Prevention, Abatement, and Mitigation	1
River - Planting	23
River Corridor Easement - Design	3
Stormwater - Preliminary Design	1
Total Number of Projects	**59**

Types of projects include river corridor easements, riparian buffer improvements, berm removals, bridge and culvert replacements, livestock exclusion, and more. Potential projects will be prioritized based on several factors, including ease of implementation, cost, landowner interest, effectiveness, and site-specific factors. Further project development, including additional data collection, may be required for project design, permitting, and implementation.

2.0 LOCAL PLANNING PROGRAM OVERVIEW

There are many scientific terms used in this river corridor plan, and the reader is encouraged to refer to the glossary at the end of the document. Important terms that are in the glossary are shown in italics the first time they are used in the text.

2.1 Overview

This project focuses on the Seymour River watershed in the town of Cambridge, Vermont. The main stem of the Seymour River and several of its *tributaries* were assessed during the summer and fall of 2017 using the Vermont Agency of Natural Resources Phase 2 Stream Geomorphic Assessment protocol. In addition to the main stem of the Seymour River, Settlement Brook and numerous small unnamed tributaries to the Seymour were included in this study.

The Seymour River watershed is part of the larger Lamoille River watershed, one of the biggest by drainage area in the state. Phase 2 geomorphic assessments have occurred in numerous areas in the Lamoille River watershed within the past decade. Corridor plans for other phase 2 assessment areas in the Lamoille River watershed can be found at https://anrweb.vt.gov/DEC/SGA/finalReports.aspx.

The Vermont Rivers Program has developed state-of-the-art Stream Geomorphic Assessment (SGA) protocols that utilize the science of *fluvial geomorphology* (fluvial = water, geo = earth, and morphology = the study of structure or form). Fluvial geomorphology focuses on the processes and pressures operating on river systems. The Vermont protocol includes three phases:

1. Phase 1 – Remote sensing and cursory field assessment;
2. Phase 2 – Rapid habitat and rapid geomorphic assessments to provide field data to characterize the current physical condition of a river; and
3. Phase 3 – Detailed survey information for designing "active" channel management projects.

2.2 River Corridor Planning Team

The river corridor planning team for the Seymour River watershed is comprised of Lamoille County Planning Commission (LCPC), Bear Creek Environmental (BCE), the Vermont Agency of Natural Resources (VANR), and the Town of Cambridge. The 2017 study was funded through The State of Vermont Ecosystem Restoration Program under contract to Lamoille County Planning Commission. Staci Pomeroy from the Vermont River Management Program of VANR provided a quality control/assurance review of the stream geomorphic assessment data, and Meghan Rodier of the Lamoille County Planning Commission assisted with the field work and provided the overall project coordination.

2.3 Local Project Objectives

The stream geomorphic assessment data are useful to resource managers, community watershed groups, municipalities and others for identifying how changes to land-use alter the physical processes and *habitat* of rivers. Characterizing stream type, identifying stressors in the watershed, and assessing the health of aquatic habitat and the riparian corridor are essential for the preparation of an effective and long-term river corridor plan. Lamoille County Planning Commission and project partners, in collaboration with towns and other organizations, have the opportunity to address and mitigate major watershed stressors through the design and implementation of *restoration* and protection projects outlined in this corridor plan.

The tactical basin plan for Basin 7 (Lamoille River) outlines several strategies to restore and protect all surface waters within the watershed. From the mouth of the Seymour River upstream for 3.5 miles, the river is listed on the State's 2016 Stressed Waters List due to sediment and nutrient pollutants associated with bank erosion, agricultural encroachments, and channel instability (VDEC, 2016). The basin plan outlines strategies that can be implemented within the Seymour River watershed to mitigate impacts from agriculture and development, such as implementing agricultural and road best management practices (BMPs) and riparian plantings. The plan also states that the Seymour River from the headwaters to Settlement Brook, as well as the entire length of Settlement Brook, host high quality populations of trout including spawning and nursery stream populations (VANR, 2016).

2.4 Goals of the Vermont River Management Program

The State of Vermont's Rivers Program has set out several goals and objectives that are supportive of the local initiative in the Seymour River Watershed. The state management goal is to, "manage toward, protect, and restore the fluvial geomorphic equilibrium condition of Vermont rivers by resolving conflicts between human investments and river dynamics in the most economically and ecologically sustainable manner" (VANR, 2009b). The objectives of the Program include *fluvial erosion* hazard mitigation and sediment and nutrient load reduction, as well as aquatic and riparian habitat protection and restoration. The Program seeks to conduct river corridor planning in an effort to remediate the geomorphic instability that is largely responsible for problems in a majority of Vermont's rivers. Additionally, the Vermont River Management Program has set out to provide funding and technical assistance to facilitate an understanding of river instability and the establishment of well-developed and appropriately scaled strategies to protect and restore river equilibrium.

3.0 BACKGROUND WATERSHED INFORMATION

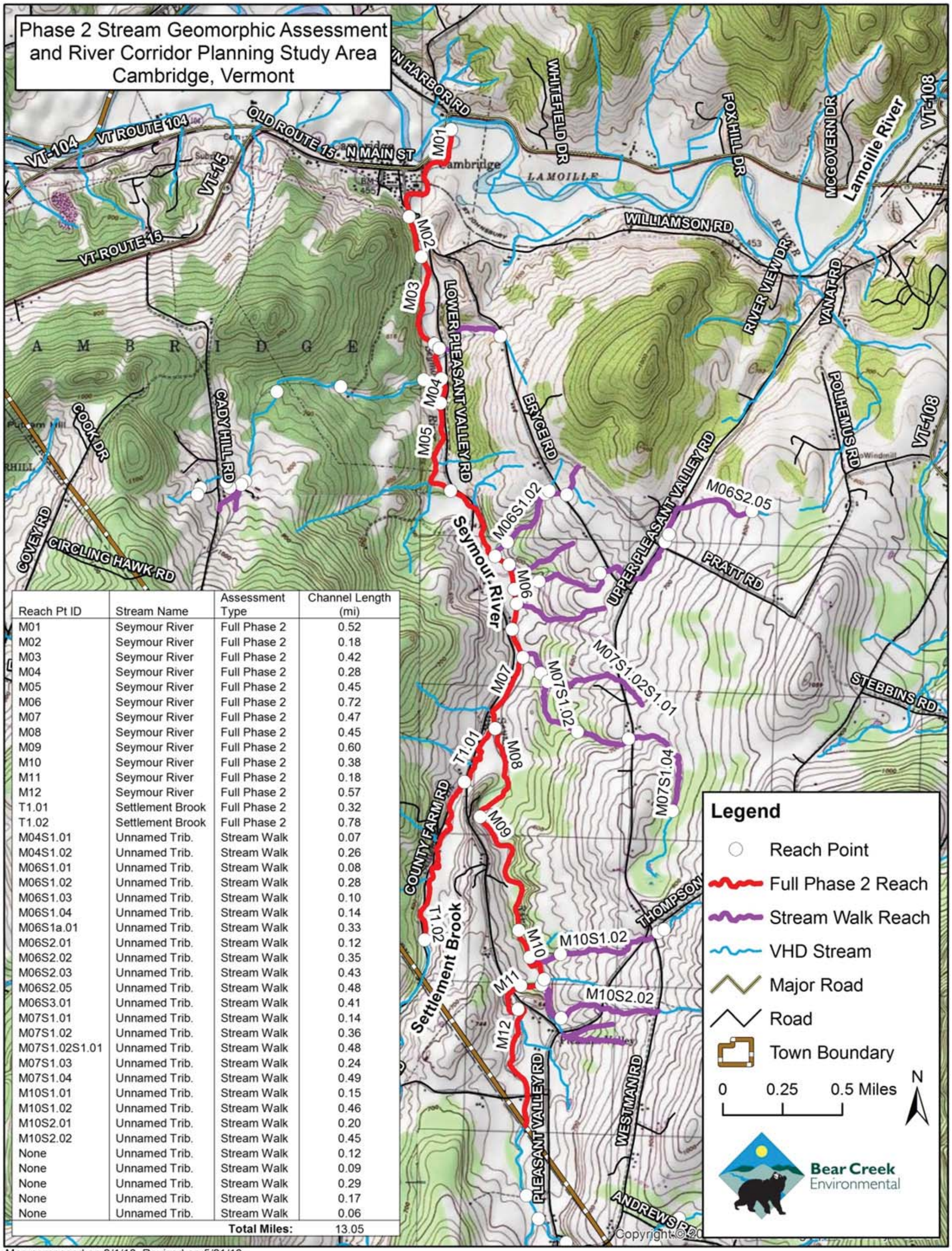
3.1 Watershed Description

The Lamoille River originates in Wheelock, Vermont and flows 85 miles west to where it meets Lake Champlain in Milton. Its watershed encompasses 706 square miles in multiple Vermont counties. The Seymour River begins in Underhill and flows for nine miles in a northerly direction to the Lamoille River in the Village of Cambridge. The Seymour River drains nearly 23 square miles of land. The largest tributary to the Seymour River is Settlement Brook. Settlement Brook has a drainage area of 5.8 square miles.

The Seymour River watershed is located in the Northern Green Mountain biophysical region. This region is characterized by Thompson and Sorenson (2000) as an area of high elevations, which includes Vermont's tallest peaks. These mountains greatly influence the climate of the region. Precipitation is abundant in this region, and temperatures are colder than in other areas of the state due to higher elevations. The typical zonation of forest types can be found in this biophysical region. From the lower slopes to the summits, Northern Hardwood Forest change to Montane Yellow Birch-Red Spruce Forest, to Montane Spruce-Fir Forest, and finally to Subalpine Krummholz at the tree lines (Thompson and Sorenson, 2000). The Northern Green Mountains contain extensive habitat for mammals such as bear, white-tailed deer, bobcat, fisher, beaver, and red squirrel. Bird species that nest in high elevations include blackpoll warblers, Swainson's thrush, and the rare Bicknells' thrush (Thompson and Sorenson, 2000).

3.2 Geomorphic Setting

A Phase 1 Stream Geomorphic Assessment of the Seymour River watershed was completed in 2017 by the Lamoille County Planning Commission. During Phase 1, the Seymour River watershed was broken into 107 *reaches*; each reach represents a similar section of the stream based on physical attributes such as valley confinement, slope, sinuosity, bed material, dominant *bedform*, land-use, and other hydrologic characteristics. Sixty two of the 107 reaches that were delineated were included in the Phase 1 assessment. A total of 40 reaches were included in this Phase 2 assessment, which equates to 13 river miles (see Figure 3.1). Each point in Figure 3.1 represents the downstream end of the reach. A modified assessment approach, or stream walkover, was utilized for 26 of the total 40 reaches to maximize data collection efficiency on numerous very small tributaries to the Seymour River. This modified approach is detailed further in section 4.2.



Reach Pt ID	Stream Name	Assessment Type	Channel Length (mi)
M01	Seymour River	Full Phase 2	0.52
M02	Seymour River	Full Phase 2	0.18
M03	Seymour River	Full Phase 2	0.42
M04	Seymour River	Full Phase 2	0.28
M05	Seymour River	Full Phase 2	0.45
M06	Seymour River	Full Phase 2	0.72
M07	Seymour River	Full Phase 2	0.47
M08	Seymour River	Full Phase 2	0.45
M09	Seymour River	Full Phase 2	0.60
M10	Seymour River	Full Phase 2	0.38
M11	Seymour River	Full Phase 2	0.18
M12	Seymour River	Full Phase 2	0.57
T1.01	Settlement Brook	Full Phase 2	0.32
T1.02	Settlement Brook	Full Phase 2	0.78
M04S1.01	Unnamed Trib.	Stream Walk	0.07
M04S1.02	Unnamed Trib.	Stream Walk	0.26
M06S1.01	Unnamed Trib.	Stream Walk	0.08
M06S1.02	Unnamed Trib.	Stream Walk	0.28
M06S1.03	Unnamed Trib.	Stream Walk	0.10
M06S1.04	Unnamed Trib.	Stream Walk	0.14
M06S1a.01	Unnamed Trib.	Stream Walk	0.33
M06S2.01	Unnamed Trib.	Stream Walk	0.12
M06S2.02	Unnamed Trib.	Stream Walk	0.35
M06S2.03	Unnamed Trib.	Stream Walk	0.43
M06S2.05	Unnamed Trib.	Stream Walk	0.48
M06S3.01	Unnamed Trib.	Stream Walk	0.41
M07S1.01	Unnamed Trib.	Stream Walk	0.14
M07S1.02	Unnamed Trib.	Stream Walk	0.36
M07S1.02S1.01	Unnamed Trib.	Stream Walk	0.48
M07S1.03	Unnamed Trib.	Stream Walk	0.24
M07S1.04	Unnamed Trib.	Stream Walk	0.49
M10S1.01	Unnamed Trib.	Stream Walk	0.15
M10S1.02	Unnamed Trib.	Stream Walk	0.46
M10S2.01	Unnamed Trib.	Stream Walk	0.20
M10S2.02	Unnamed Trib.	Stream Walk	0.45
None	Unnamed Trib.	Stream Walk	0.12
None	Unnamed Trib.	Stream Walk	0.09
None	Unnamed Trib.	Stream Walk	0.29
None	Unnamed Trib.	Stream Walk	0.17
None	Unnamed Trib.	Stream Walk	0.06
		Total Miles:	13.05

Map composed on 2/1/18. Revised on 5/21/18.

Figure 3.1. Seymour River watershed 2017 Phase 2 study reaches.

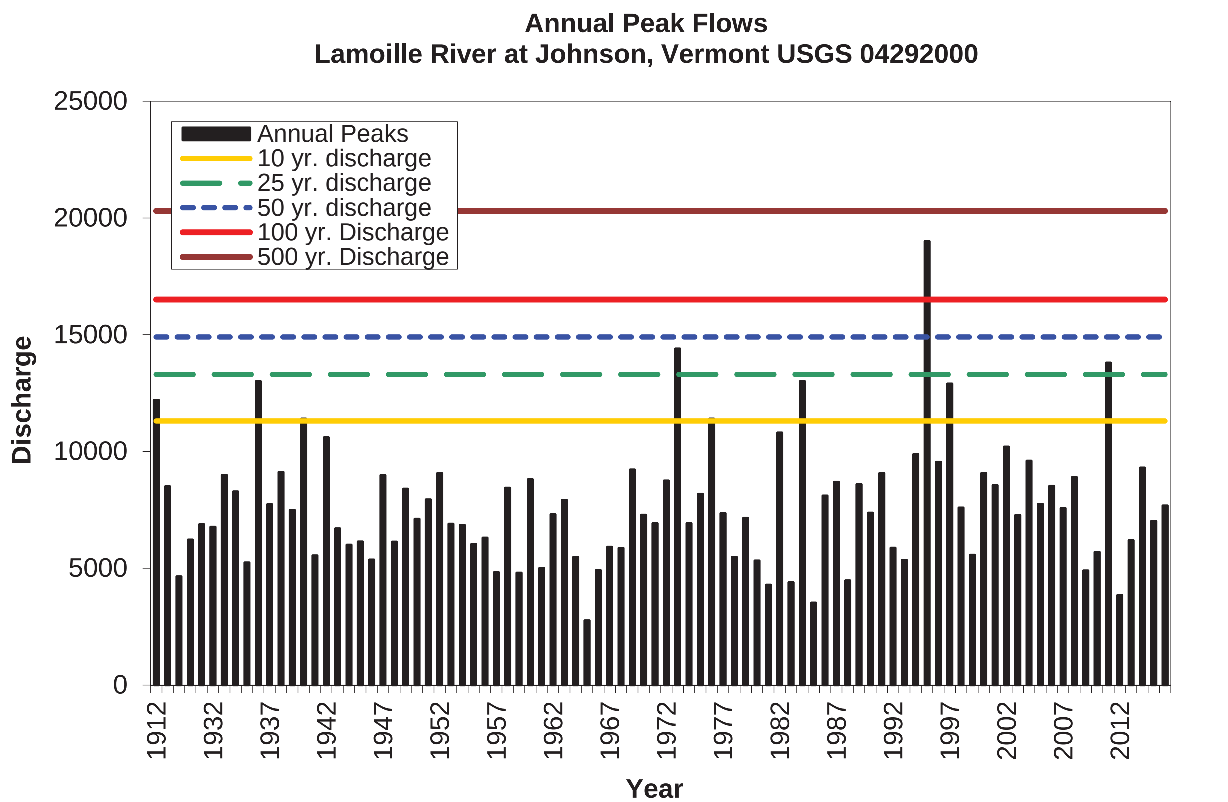
3.3 Hydrology

Of all the natural hazards experienced in Vermont, flooding is the most frequent, damaging, and costly. During the period of 1995-1998 alone, flood losses in Vermont totaled nearly $57 Million (VANR, 2010b). While some flood losses are caused by inundation (i.e. waters rise, fill, and damage low-lying structures), most flood losses in Vermont are caused by fluvial erosion. Fluvial erosion is caused by rivers and streams, and can range from gradual bank erosion to catastrophic changes in river channel location and dimension during flood events (Vermont VANR, 2010b). The VANR (2010b) attributes the high cost and frequency of fluvial erosion in Vermont to its geography (mountainous setting with narrow valleys and extreme climate) and past land-use practices (forest clearing).

In order to better understand the flood history of the Seymour River and its tributaries, long-term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS), were obtained (USGS, 2018). There is one USGS *gaging* station within the Lamoille River watershed near the Seymour River study area. The station is located on the Lamoille River main stem in the town of Johnson, Vermont and has a drainage area of 310 square miles. Peak flow data from this station were reviewed for all years on record, allowing for an analysis of the recurrence of flooding within the Lamoille River watershed. There are two hydroelectric dams located on the Lamoille River within ten miles upstream of the gaging station in Morrisville. One additional dam exists upstream on the main stem of the Lamoille River in Wolcott, Vermont. Numerous additional dams exist on various tributaries to the Lamoille River that are above the gaging station. Due to the presence of these dams upstream, the gage on the Lamoille River in Johnson is impacted by a degree of flow regulation. This can result in changes in peak flows by reduction (storage of water in reservoirs behind dams) and possible increase due to dam release activities.

Peak discharge records are available for the Lamoille River at Johnson, Vermont from 1912 through 2017. The highest annual peak flow on record is from a flood in 1995 that exceeded the 100 year return interval, followed by floods in 1973 and 2011 (USGS, 2018). The Cambridge Local Hazard Mitigation Plan, which was written in 2015, identifies flood inundation and flash floods as one of the "worst threat" hazards to the Town and Village of Cambridge. The plan states that flooding occurs frequently within Cambridge, and the worst events in recent years occurred in April 2011 and in 1995 (Cambridge, 2015). Additionally, while conducting the Phase 2 field study, BCE spoke with a landowner along Settlement Brook who mentioned that the brook was hit by a microburst storm in June 2013 that caused localized flooding.

The Town of Cambridge and its villages of Cambridge and Jeffersonville have endured flooding along the Lamoille River for years. Following heavy rains or rapid snowmelt, the Lamoille frequently floods farm fields, important transportation routes such as Vermont Route 15, and in severe cases, buildings including homes and businesses. Within the Seymour River watershed, of particular concern is flooding along Pleasant Valley Road, which runs along the Seymour River for nearly its entire length (Cambridge, 2015).



*Discharges for annual exceedance probabilities from USGS report "Annual Exceedance Probabilities of Peak Discharges of 2011 at Streamgages in Vermont and Selected Streamgages in New Hampshire, Western Massachusetts, and Northeastern New York" (2013).

Figure 3.2. Annual Peak Flows for the Lamoille River at Johnson, Vermont.

4.0 METHODS

A summary of the Phase 1, Phase 2, and Bridge and *Culvert* methodologies is provided in the following sections.

4.1 Phase 1 Methodology

The Phase 1 assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Phase 1 Handbook (Vermont Agency of Natural Resources), and used the Stream Geomorphic Assessment Tool (SGAT). SGAT is an ArcGIS extension. Phase 1, the remote sensing phase, involves the collection of data from topographic maps and aerial photographs, from existing studies, and from very limited field studies, called "windshield surveys". The Phase 1 assessment provides an overview of the general physical nature of the watershed. As part of the Phase 1 study, stream reaches are determined based on geomorphic characteristics such as: valley confinement, valley slope, geologic materials, and tributary influence.

4.2 Phase 2 Methodology

The Phase 2 assessment within the Seymour River watershed followed procedures specified in the Vermont Stream Geomorphic Assessment (SGA) Phase 2 Handbook (VANR, 2009b), and used version 10.3.3 of the SGAT Geographic Information System (GIS) extension to index impacts within each reach.

The geomorphic condition for each Phase 2 reach is determined using the Rapid Geomorphic Assessment (RGA) protocol, and is based on the degree of departure of the channel from its reference stream type (VANR, 2009b). The study used the 2008 Rapid Habitat Assessment (RHA) protocol (VANR, 2008; Milone and MacBroom, Inc., 2008). The RHA is used to evaluate the physical components of a stream (channel bed, banks, and riparian vegetation) and how the physical condition of the stream affects aquatic life. The RHA results can be used to compare physical habitat condition between sites, streams, or watersheds, and they can also serve as a management tool in watershed planning.

RHA and RGA field forms were completed for the Phase 2 reaches. The appropriate RHA and RGA forms were selected based on segment characteristics and scored according to the data collected from the field assessment. A segment score and corresponding condition were determined for both the RHA and the RGA. Additionally for the RGA, major geomorphic processes were identified, the stage of channel evolution was determined, and a stream sensitivity rating was assigned.

A modified Phase 2 methodology (stream walkover) was utilized on numerous reaches within the study area that have very small drainage areas. This methodology involved targeted Phase 2 data collection to maximize assessment efficiency on these very small streams. Similarly to the full Phase 2 reaches, these reaches were walked to the extent feasible in the field and impacts were recorded with a submeter GPS unit. Data for assessment steps 0, 1, 3, 4, and 5 were collected and entered into the State Data Management System. Additionally, bridge and culvert data were collected for these reaches for all structures not previously assessed.

To assure a high level of confidence in the Phase 2 SGA data, strict quality assurance/quality control (QA/QC) procedures were followed by Bear Creek Environmental. These procedures involved a thorough in-house review of all data, which took place during the fall and winter of 2017. The Project Team conducted the assessment according to the approved Quality Assurance procedures specified in the Phase 2 handbook. Staci Pomeroy of the State of Vermont Watershed Management Division conducted a QA/QC review of the data collected by BCE for the Seymour River watershed during January and February of 2018.

4.3 Bridge and Culvert Methodology

Bridge and culvert assessments were conducted by BCE on all public and private crossings within the Phase 2 reaches that had not been previously assessed. The Agency of Natural

Resources Bridge and Culvert protocols (VANR, 2009a) were followed. Latitude and Longitude at each of the structures was determined using an AshTech MobileMapper 100 GPS unit. The assessment included photo documentation of the inlet, outlet, upstream, and downstream of each of the structures.

A modification of the Vermont Culvert Geomorphic Compatibility Screening Tool (Milone and MacBroom, Inc. 2008) was used to determine geomorphic compatibility for each bridge. Bridges are not typically screened for geomorphic compatibility in the VANR protocol because they are usually more robust and have less impact on stream channel function than culverts. Bridges also do not have potential to become perched above the water surface, because the bottom of the structure is natural substrate. Bridges in this study were screened using the geomorphic compatibility tool that was modified to exclude the slope parameter. Tables 1 and 2 in Appendix A explain how each bridge was scored using the Screening Tool. The compatibility rating is based on four criteria: structure width in relation to bankfull channel width, sediment continuity, river approach angle, and erosion & armoring and the ratings span the following range:

- Fully Compatible
- Mostly Compatible
- Partially Compatible
- Mostly incompatible
- Fully Incompatible

All culverts were evaluated for geomorphic compatibility using the Vermont Culvert Geomorphic Compatibility Screening Tool (Tables 3 and 4). In addition, the culverts within the study area were assessed for Aquatic Organism Passage (AOP) using the Vermont Culvert Aquatic Organism Passage Screening Tool (Milone and MacBroom, Inc., 2009). Table 5 in Appendix A explains how each culvert was scored for AOP. The screening guide has the four following categories:

- Full AOP for all organisms
- Reduced AOP for all aquatic organisms
- No AOP for all aquatic organisms except adult salmonids
- No AOP for all aquatic organisms

The location of each structure evaluated is shown on the map on page 8 of Appendix A.

4.4 Condition and Departure Analysis

4.4.1 Stream Types

Reference stream types are based on the valley type, geology and climate of a region and describe what the channel would look like in the absence of human-related changes to the channel, floodplain, valley width, and/or watershed. Table 1 shows the typical characteristics used to determine reference stream types (VANR, 2009b). Reference reach typing was based on both the Rosgen (1996) and the Montgomery and Buffington (1997) classification systems.

Table 1. Reference Stream Type			
Stream Type	**Confinement**	**Valley Slope**	**Bed Form**
A	Narrowly Confined	Very steep > 6.5 %	Cascade
A	Confined	Very steep 4.0 - 6.5 %	Step-Pool
B	Confined or Semi- confined	Steep 3.0 – 4.0 %	Step-Pool
B	Confined, Semi- confined or Narrow	Moderate to Steep 2.0 – 3.0 %	Plane Bed
C or E	Unconfined (Narrow, Broad or Very Broad)	Moderate to Gentle <2.0 %	Riffle-Pool or Dune-Ripple
D	Unconfined (Narrow, Broad or Very Broad)	Moderate to Gentle <4.0 %	Braided Channel
F	Confined or Semi-confined	Moderate to Gentle <4.0 %	Variable

During the Phase 2 assessment, the 40 study reaches were broken into 60 segments based on detailed field observations. A segment is distinct in one or more of the following parameters: degree of floodplain encroachment or channel alteration, *grade control* occurrence (e.g. ledge), channel dimensions, channel sinuosity and slope, *riparian buffer* and corridor conditions, and degree of flow regulation. The most downstream segment within a reach is labeled “A”, the second from the reach point is “B, etc. (i.e. M08-A is the most downstream segment on Reach M08).

The existing stream type is based on channel dimensions measured during the Phase 2 assessment. A stream type departure occurs when the channel dimensions deviate so far from the reference condition that the existing stream type is no longer the reference stream type. These stream type departures represent a significant change in floodplain access and stability. Watersheds that have lost attenuation or sediment storage areas due to human related constraints are generally more sensitive to erosion hazards, transport greater quantities of sediment and nutrients to receiving waters, and lack the sediment storage and distribution processes that create and maintain habitat (VANR, 2009b).

4.4.2 Geomorphic Condition

The stream condition is determined using the scores on the rapid assessment field forms, and is defined in terms of departure from the reference condition. There are four categories to describe the condition (reference, good, fair and poor). These ratings are defined below.

- Reference – no departure
- Good – minor departure
- Fair – major departure
- Poor – severe departure

Geomorphic condition is determined based on the degree (if any) of channel degradation, aggradation, widening and *planform* adjustment. Degradation is the term used to describe the process whereby the stream bed lowers in elevation through erosion, or scour, of bed material. Aggradation is a term used to describe the raising of the bed elevation through an accumulation of sediment. The planform of a channel is its shape as seen from the air. Planform change can be the result of a straightened course imposed on the river through different channel management activities, or a channel response to other *adjustment processes* such as aggradation and widening. Channel widening is a result of channel degradation or sediment build-up in the channel. In both situations the stream's energy is concentrated into both banks.

4.4.3 Habitat Condition

A second condition rating is used to evaluate reaches in a phase 2 assessment – habitat condition. Habitat condition is determined using the scores on the rapid habitat assessment (RHA) field forms. The categories for condition rating are the same as those detailed above for geomorphic condition. Scores assigned for the RHA are based on parameters that evaluate the physical characteristics of a stream. This method relates these characteristics to the habitat they provide for aquatic organisms. The RHA evaluates such characteristics as woody debris content, deposition and scour features, channel morphology, and bank and buffer vegetation.

4.4.4 Sediment Regime

Functioning floodplains play a crucial role in providing long-term stability to a river system. Natural and anthropogenic impacts may alter the equilibrium of sediment and discharge in natural stream systems and set in motion a series of morphological responses (aggradation, degradation, widening, and/or planform adjustment) as the channel tries to reestablish a dynamic equilibrium. Small to moderate changes in slope, discharge, and/or sediment supply can alter the size of transported sediment as well as the geometry of the channel; while large changes can transform reach level channel types (Ryan, 2001). Human-induced practices that have contributed to stream instability in the Seymour River watershed include:

- Channelization and bank armoring
- Removal of woody riparian vegetation
- Floodplain encroachments
- Agricultural practices

These anthropogenic practices have altered the balance between water and sediment discharges. The sediment regime is the quantity, size, transport, sorting, and distribution of sediments. The sediment regime may be influenced by the proximity of sediment sources, the hydrologic characteristics of the region, and the valley, floodplain, and stream morphology (VANR, 2010a). Sediment can be supplied to the river through bank erosion, large flooding events, and stormwater inputs. Reference and existing sediment regimes were derived from the Agency of Natural Resources Data Management System according to the sediment regime criteria established by the Vermont Agency of Natural Resources (2010a).

Changes in hydrology (such as flow alteration and development of land within the riparian corridor) as well as sediment storage within the watershed have altered the reference sediment regime types for many segments within the study area. The analysis of sediment regimes at the watershed level is useful for summarizing the stressors affecting geomorphic condition of river channels. Sediment regime mapping provides a context for understanding the sediment transport and channel evolution processes.

4.4.5 Channel Evolution Model

Channel morphologic responses to anthropogenic practices contribute to channel adjustment that may further create unstable channels. All three adjustment processes, aggradation, widening and planform migration as a result of active and historic channel management are present within the Seymour River watershed. The placement of town roads has changed river valley widths, reduced floodplain access, and altered ability of streams to meander within the study area.

The segment condition ratings indicate that most of the segments are actively undergoing or have historically undergone a process of major geomorphic adjustment. Many of the reaches studied in the Cambridge area are undergoing a channel evolution process in response to human influences on the watershed.

The “F” stage channel evolution model (VANR, 2009b; VANR, 2004) is helpful for explaining the channel adjustment processes underway in the Seymour River watershed, and is used to understand the process that occurs when a stream degrades (incises).

The common stages of the “F” channel evolution stage, as depicted in Figure 4.1 include:

- Stable (F-1) - a pre-disturbance period
- Incision (F-II) – channel degradation (*headcutting*)
- Widening (F-III) – bank failure
- Stabilizing (F-IV) – channel narrows through sediment build up and moves laterally building juvenile floodplain
- Stable (F-V) - gradual formation of a stable channel with access to its floodplain at a lower elevation

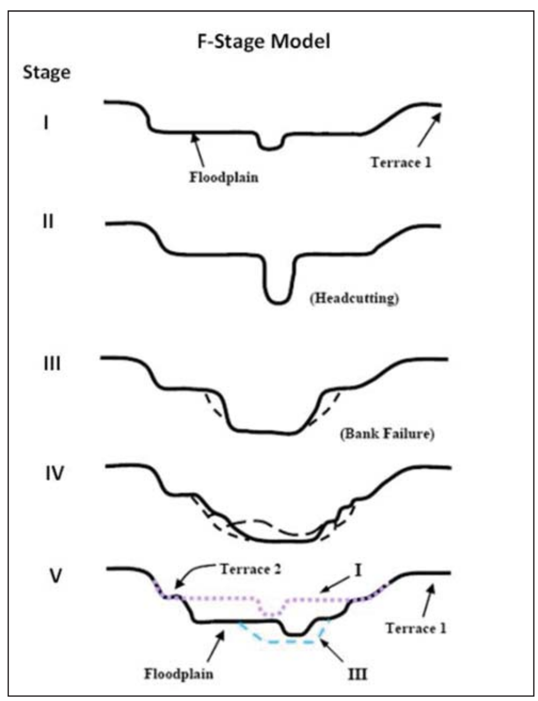


Figure 4.1 Typical channel evolution models for F-Stage (VANR, 2009b)

When stream channels are altered through straightening, it can set this evolution process into motion and cause adjustment processes to occur. The bed erosion that occurs when a meandering river is straightened in its valley is a problem that translates to other sections of the stream. Localized incision will travel upstream and into tributaries, thereby eroding sediments from otherwise stable streambeds. These bed sediments will move into and clog reaches downstream, leading to lateral scour and erosion of the stream banks. Channel evolution processes may take decades to play out. Even landowners that have maintained wooded areas along their stream and riverbanks may have experienced eroding banks as stream channel slopes adjust to match the valley slopes. It is difficult for streams to attain a new equilibrium where the placement of roads and other infrastructure has resulted in little or no valley space for the stream to access or to create a floodplain.

A second channel evolution model, known as the "D" channel evolution model is helpful for explaining channel adjustments that are driven by major aggradation. In the "D" model, channel degradation has not occurred, but rather the accumulation of sediment on the streambed causes channel widening and planform adjustment.

5.0 RESULTS

The results of the Phase 2 study in Cambridge are described by reach and segment in section 5.1 below. Maps in Appendix B show the results for geomorphic condition, habitat condition, and sediment regime for each segment that was assessed. Six segments were not able to be fully assessed by the protocol due to being denied access by the landowner. An additional three segments were only partially assessed due to being bedrock gorges. Of the 13 segments assessed for geomorphic condition, 1 was found to be in "reference" geomorphic condition, 3 were in "good" geomorphic condition, and 9 were in "fair" geomorphic condition. Twelve segments were evaluated for habitat condition with the following results: 4 segments in "good" habitat condition and 8 in "fair" habitat condition. The current geomorphic and habitat condition ratings in the assessed segments are a result of several factors. Corridor encroachments are common throughout the study area, as roads run directly along these streams and houses exist on their banks. Development within a river corridor can cause a loss of floodplain access, changes in valley confinement, and overall geomorphic instability. Historic channel straightening is prevalent on the streams included in this assessment and has led to adjustments that are reflected in geomorphic condition scores. The segments that are in "good" habitat condition generally have a more natural channel planform and features such as well vegetated banks and buffers, abundant in-channel large woody debris, and a diversity of bed features including many pools, all of which provide habitat for aquatic life. Segments in "fair" habitat condition have fewer of these features and characteristics and thus provide less habitat for aquatic organisms.

As shown on the map on page 2 of Appendix B, many segments have experienced a departure from their reference sediment regime. Additionally, channel evolution stage for each Phase 2 segment was determined based on field data and observations. This information is provided by segment in section 5.1 below.

5.1 Reach/Segment Descriptions

A description of each segment is provided in this section, including major stressors and evolution processes. The segments are listed by stream location from downstream to upstream in the watershed and on each stream. Phase 2 Segment Summary Reports from the Agency of Natural Resources' Data Management System, which contain all the data for the Phase 2 steps, can be found at the following link:
https://anrweb.vt.gov/DEC/SGA/projects/phase2/reports.aspx?pid=192.

Site-specific projects have been developed to facilitate restoration, conservation, and increased *flood resiliency* within the study watersheds. Proposed project locations are provided on maps in Appendix C. Tables and photos provide greater detail about proposed projects in Appendix C. The Phase 2 stream geomorphic assessment provides a picture of the condition of the channel and the adjustment process occurring; however, it is not a comprehensive study for determining site specific actions. The Phase 2 study provides a foundation for project development, and additional work is recommended to further develop these projects.

Seymour River

M01

Reach one on the Seymour River spans roughly 2,800 feet from the mouth at the Lamoille River upstream to just above the Mansfield Avenue bridge. The river flows through agricultural and residential lands at the edge of Cambridge Village. M01 was divided into two segments during field work due to restricted landowner access in the upper portion of the reach.

M01-A

The downstream segment on reach M01 begins at the confluence with the Lamoille River and continues upstream for just over 500 feet to the Gates Covered Bridge. This segment is characterized by a very low slope and plane bed bedform, having very few channel features such as riffles and pools. The entirety of the segment appears to have been historically straightened due to the presence of adjacent agricultural lands and Vermont Route 15 just to the west of the river. This historic straightening has led to severe historic incision, causing a stream type departure and loss of floodplain access in M01-A. Areas of bank armoring and very large trees growing on the river banks are preventing channel widening from occurring here. For these reasons, M01-A is in **fair** geomorphic condition. The Seymour River is also in **fair** habitat condition in this segment due to lacking riffle and pool features and impacted riparian buffers.

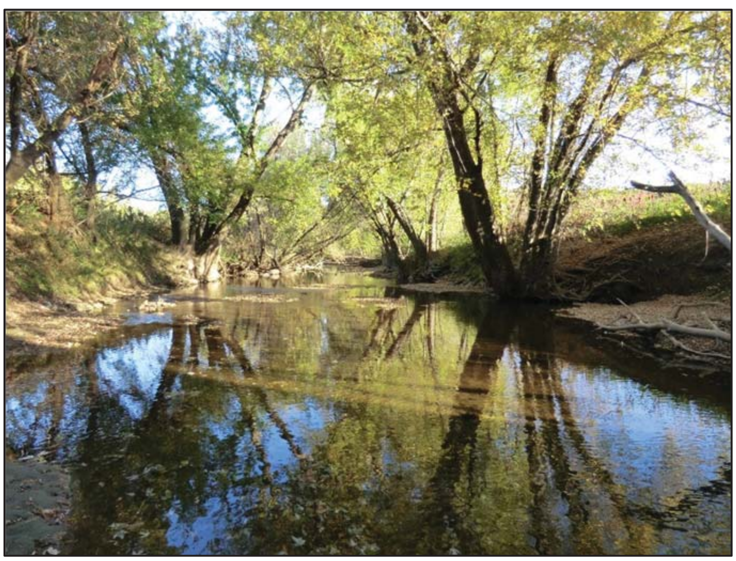


Figure 5.1. Straightened, featureless channel in M01-A.

M01-A Data Summary		Reference	Existing
Length: 563 ft Drainage Area: 22.5 sq.mi. Evolution Stage: F-II Sensitivity: Very High	Confinement	Very Broad	Very Broad
	Stream Type	C	F
	Entrenchment Ratio	> 2.2	1.1
	Incision Ratio	< 1.2	2.2
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Plane bed
Major Stressors:	**Channel straightening, bank armoring, erosion, lacking buffers**		

M01-B

The upstream segment on reach M01 of the Seymour River is nearly 2,200 feet in length, spanning the distance from the Gates Covered Bridge at the downstream end to just above the Mansfield Avenue bridge at the upstream end. Access to this segment was denied by the landowner, so M01-B could not be fully assessed. Limited observations were recorded about the segment from the downstream segment and the Mansfield Avenue bridge. Lands to the east of the river in this section are primarily agricultural, while to the west is both agricultural and residential development in Cambridge Village. Based on limited observations of this segment, it appears that major historic incision has likely occurred here, resulting in a likely stream type departure and loss of floodplain access. Riparian buffer vegetation appears to be lacking for about half of the segment. This segment was given an administrative judgment of "fair" condition.

Figure 5.2. M01-B from the Mansfield Avenue bridge looking downstream.

M01-B Data Summary	*NOT ASSESSED	Reference	Existing
Length: 2,196 ft Drainage Area: 22.5 sq.mi. Evolution Stage: N/A[1] Sensitivity: N/A	Confinement	Very Broad	Very Broad
	Stream Type	C	F
	Entrenchment Ratio	1.4 – 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Lacking buffers, bank armoring**		

[1] N/A – Not Applicable

M02

The second reach on the Seymour River is nearly 950 feet in length, extending from just above the Mansfield Avenue bridge downstream to upstream where the river valley opens up near the intersection of Lower Pleasant Valley Road and Bryce Road. Similarly to downstream, access to this reach was denied by the landowner, so a full Phase 2 assessment could not be completed. Observations were recorded from Lower Pleasant Valley Road to characterize the reach to the extent feasible. The river valley is naturally much narrower in this reach than it is above and below, and the river channel appears to be naturally straight as a result. Based on limited observations from the road, M02 appeared to be in a fairly stable state with minimal impacts (lacking riparian buffer vegetation and possible bank armoring) and did not appear to be undergoing major adjustments. The reach was given an administrative judgment of "good" condition.

Figure 5.3. View of reach M02 from Lower Pleasant Valley Road.

M02 Data Summary	*NOT ASSESSED	Reference	Existing
Length: 942 ft Drainage Area: 22.5 sq.mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Semi-Confined	Semi-Confined
	Stream Type	B_C	B_C
	Entrenchment Ratio	> 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Lacking buffers, bank armoring**		

M03

Reach M03 on the Seymour River flows through a very broad valley that is bisected by Lower Pleasant Valley Road on the east, reducing the functional width of the river valley to broad. Access to this reach was denied by the landowner, and, similarly to the downstream reaches, a full Phase 2 assessment could not be completed on M03. Limited data were collected from one observation point on Lower Pleasant Valley Road and through remote sensing analysis. Lands to the west of the river in this reach are primarily forested with possible pastureland at the downstream end. On the east, adjacent lands are primarily pasture, with a small section of forest at the upstream end of the reach. It appears that most of the reach may have been historically straightened as a result of adjacent land uses. Large bar features and lateral bank erosion were observed from the road, which suggests that the river may be in the process of widening with planform change. Riparian buffer vegetation is lacking in this reach, especially along the pasture on the eastern side of the river. These factors resulted in an administrative judgement of "fair" condition.

Figure 5.4. Looking west across the river from Lower Pleasant Valley Road.

M03 Data Summary	*NOT ASSESSED	Reference	Existing
Length: 2,196 ft Drainage Area: 22.4 sq.mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Very Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel straightening, lacking buffers**		

M04

Reach M04 is nearly 1,500 feet in length, beginning in the vicinity of 611 Lower Pleasant Valley Road downstream and extending upstream to near 811 Lower Pleasant Valley Road. Access to conduct a Phase 2 assessment on this reach was denied by the landowner, so limited data were collected from an observation point on Lower Pleasant Valley Road and through remote sensing. The Seymour River flows through a broad valley in this reach and a mix of forested and pastured land. This reach appears to have been historically straightened for much of its length due to the presence of Lower Pleasant Valley Road on the eastern bank and pastureland on the west. Extensive bank erosion was observed from the road, which suggests that the river is undergoing widening in this reach, likely in response to historic incision. It is possible that a stream type departure has occurred within this reach due to historic incision, leading to loss of some floodplain access. Riparian buffer vegetation is lacking due to the adjacent pastureland. Taking into account the extensive bank erosion and the lack of vegetation along the channel, this reach was given an administrative judgment of "fair" condition.

Figure 5.5. View across Seymour River valley in reach M04 (looking east to west).

M04 Data Summary	*NOT ASSESSED	Reference	Existing
Length: 1,461 ft Drainage Area: 22.2 sq.mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Broad	Broad
	Stream Type	C	B_C
	Entrenchment Ratio	> 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel straightening, lacking buffers, bank erosion**		

M05

Reach five on the Seymour River is nearly 2,400 feet in length and extends from near 811 Lower Pleasant Valley Road downstream to roughly 600 feet below the first bridge on Lower Pleasant Valley Road upstream. This reach could not be fully assessed because the landowner denied access to the river on his property. Limited observations were collected from a vantage point on Lower Pleasant Valley Road, as well as through remote sensing. The river flows along agricultural land toward the upstream end of the reach and along Lower Pleasant Valley Road on the east and forested land along the west for the remainder for the reach. The upstream half of the reach has a more sinuous planform than the downstream half, which is fairly straight. Where the river meanders, there are large depositional features and the river banks are low. Both the channel and valley are narrower in the downstream half of the reach than upstream. Riparian buffer vegetation is lacking for some sections of this reach. This reach was given an administrative judgment of “fair” condition.

Figure 5.6. Reach M05 looking southwest from Lower Pleasant Valley Road.

M05 Data Summary	*NOT ASSESSED	Reference	Existing
Length: 2,357 ft Drainage Area: 21 sq.mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Very Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel straightening, lacking buffers**		

M06

Reach six on the Seymour River is roughly 3,800 feet in length and was divided into two segments during the Phase 2 assessment to account for changes in depositional features, channel dimensions, and bank and buffer vegetation.

M06-A

The downstream segment on reach M06 begins just downstream of the first bridge on Lower Pleasant Valley Road and extends upstream for approximately 2,600 feet to near 1680 Lower Pleasant Valley Road. The Seymour River flows through a very broad valley in this segment and is characterized by abundant large depositional features, as well as planform change. The stream channel has aggraded and widened within this segment, which has resulted in a stream type departure. As aggradation continues over time, the channel will likely narrow again as the depositional features form a juvenile floodplain. Moderate historic incision has occurred within M06-A, and historic channel straightening was noted at and downstream of the Lower Pleasant Valley Road bridge. M06-A was placed in **fair** geomorphic condition due to abundant adjustments currently occurring within the segment. Similarly, it is in **fair** habitat condition as a result of the wide, shallow channel found throughout most of the segment and the lack of bank and buffer vegetation.

Figure 5.7. Cross section of M06-A showing major aggradation and widening.

M06-A Data Summary		Reference	Existing
Length: 2,606 ft	Confinement	Very Broad	Very Broad
Drainage Area: 20.3 sq.mi.	Stream Type	C	D
Evolution Stage: F-IV	Entrenchment Ratio	>2.2	2.5
Sensitivity: Very High	Incision Ratio	< 1.2	1.6
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Encroachment, channel straightening, erosion, lacking buffers**		

M06-B

The upstream segment on reach six of the Seymour River is shorter, nearly 1,200 feet in length. It extends from near 1680 Lower Pleasant Valley Road upstream to near 1867 Lower Pleasant Valley Road. This segment is characterized by extensive historic straightening due to the presence of agricultural and residential lands on both sides of the river. This straightening has led to major historic incision, a stream type departure, and loss of floodplain access in M06-B. The channel is in the process of widening, with scattered bank erosion observed throughout the segment. M06-B is in **fair** geomorphic condition as a result of extensive historic straightening and associated channel adjustments. The river lacks large woody debris, floodplain connectivity, and bank and buffer vegetation in this segment, which resulted in its placement in **fair** habitat condition.

Figure 5.8. Straightened channel in M06-B.

M06-B Data Summary		Reference	Existing
Length: 1,185 ft Drainage Area: 20.3 sq.mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Very Broad	Very Broad
	Stream Type	C	F
	Entrenchment Ratio	> 2.2	1.2
	Incision Ratio	< 1.2	2.1
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel straightening, lacking buffers, bank erosion**		

M07

Reach M07 on the Seymour River is roughly 2,500 feet in length. It was divided into two segments during the Phase 2 assessment to account for changes in valley width.

M07-A

The downstream segment in reach M07 is just over 1,700 feet in length, extending from 1867 Lower Pleasant Valley Road downstream to where the valley narrows significantly upstream. The river valley is broad in this segment and surrounding lands are agricultural and residential. Roughly one third of this segment appears to have been historically straightened due to adjacent land uses. Three ledge grade controls were documented in this segment, which afford the river vertical stability. Moderate historic incision was measured within this segment. It is likely that the channel incised down to bedrock, however, future incision is limited due to the presence of this bedrock. No major adjustment processes were notes for M07-A, and as such, it was placed in **good** geomorphic condition. The segment was placed in **fair** habitat condition as a result of lacking large woody debris in the channel, as well as reduced bank and buffer vegetation.

Figure 5.9. Looking downstream at cross section in M07-A.

M07-A Data Summary		Reference	Existing
Length: 1,718 ft Drainage Area: 19.0 sq.mi. Evolution Stage: F-III Sensitivity: Moderate	Confinement	Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	2.8
	Incision Ratio	< 1.2	1.7
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel straightening, lacking buffers**		

M07-B

The upstream segment on reach M07 of the Seymour River is nearly 800 feet in length. The river flows through a bedrock gorge in this segment and, for this reason, could not be fully assessed. The river valley is semi-confined in this segment and bedrock grade controls are common. Impacts within this segment are minimal, but include areas where riparian buffer vegetation is lacking. Overall, this segment is very stable as a result of its narrow valley and bedrock-dominant substrate.

Figure 5.10. Bedrock grade control in M07-B.

M07-B Data Summary	***NOT ASSESSED**	**Reference**	**Existing**
	Confinement	Semi-Confined	Semi-Confined
Length: 760 ft	Stream Type	F	F
Drainage Area: 19.0 sq.mi.	Entrenchment Ratio	< 1.4	N/A
Evolution Stage: N/A	Incision Ratio	< 1.2	N/A
Sensitivity: N/A	Dominant Bed Material	Bedrock	Bedrock
	Dominant Bedform	Bedrock	Bedrock
Major Stressors:	**Lacking buffers**		

M08

Reach M08 on the Seymour River flows through forested and agricultural lands. The reach begins downstream at the confluence with Settlement Brook and continues upstream into the woods near West Hill View Drive. M08 was divided into two segments during the assessment to account for changes in channel dimensions and bank and buffer vegetation.

M08-A

The downstream segment on reach M08 flows for roughly 1,200 feet through a very broad valley along agricultural lands. This segment appears to have been historically straightened in its entirety due to surrounding land uses. Riprap is common along both banks throughout the segment. Major historic incision has occurred within M08-A as a result of historic channel management, however, a stream type departure was not noted based on channel dimensions. Channel widening is prevented by abundant bank armoring. For these reasons, M08-A is in **fair** geomorphic condition. Additionally, historic straightening and degradation have resulted in the loss of riffle-pool bedform within this segment and conversion to a featureless, plane bed system. This, in addition to lacking woody debris cover and reduced bank and buffer vegetation, led to the placement of M08-A in **fair** habitat condition.

Figure 5.11. Straightened, featureless channel in M08-A.

M08-A Data Summary		**Reference**	**Existing**
Length: 1,162 ft Drainage Area: 12.2 sq.mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	3.1
	Incision Ratio	< 1.2	1.9
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Channel straightening, bank armoring, lacking buffers**		

M08-B
The upstream segment on reach M08 is characterized by having a relatively natural planform. The river flows through the woods in the vicinity of West Hill View Drive for just over 1,200 feet in this segment. Very few impacts were recorded in this segment. Moderate historic incision was measured at the cross section. The river is fairly depositional and has a wide channel for most of this segment. The river valley is wide for the upper portion of the segment, but pinches in dramatically at the downstream end for a very short lived narrow bedrock section. Immediately below this bedrock area, the valley opens back up again in the next segment downstream. Some planform change was noted within this segment, primarily as flood chutes on bars. M08-B was placed in **fair** geomorphic condition as a result of active adjustments occurring. The river has an abundance of woody debris, instream cover for fish, good floodplain connectivity, and well forested banks and buffers in this segment. For these reasons, M08-B is in **good** habitat condition.

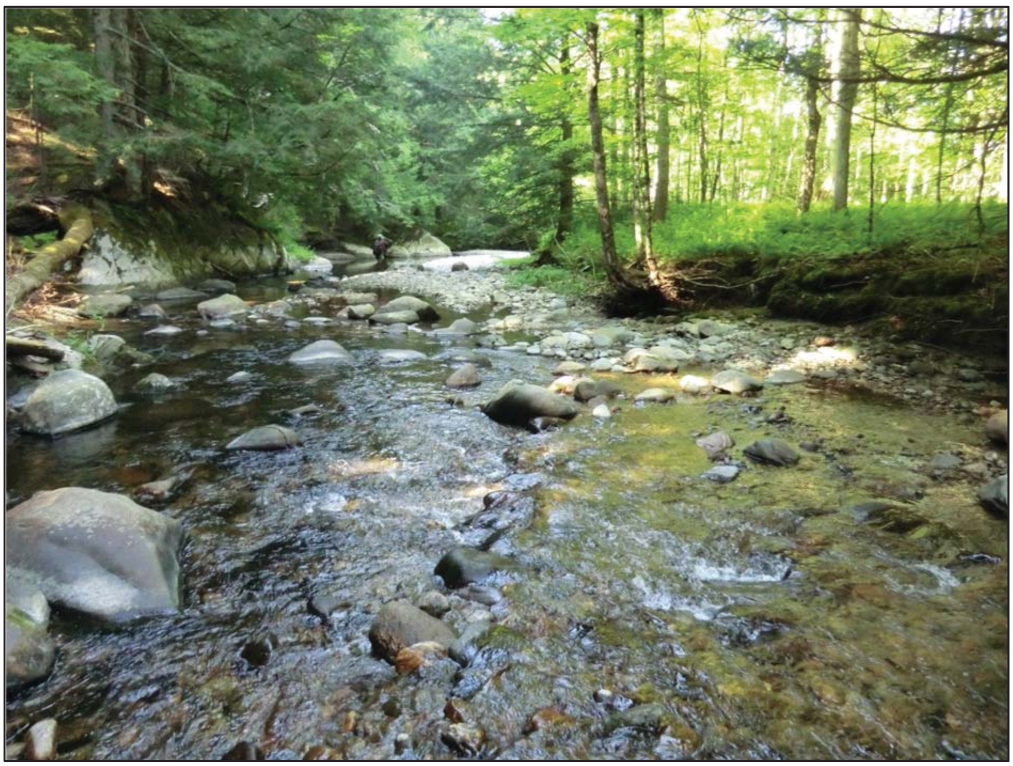


Figure 5.12. The Seymour River flows through a well forested area with minimal impacts in M08-B.

M08-B Data Summary		Reference	Existing
Length: 1,210 ft Drainage Area: 12.2 sq.mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	3.3
	Incision Ratio	< 1.2	1.7
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank erosion**		

M09

Reach nine on the Seymour River is nearly 3,200 feet in length and flows through a broad valley in the vicinity of Hidden Valley Drive and West Hill View Drive in Cambridge. Adjacent lands to the river in this reach are primarily forested and minimal human impacts to the river and river corridor were recorded. There is one house on the western bank of the river toward the upstream end of this reach where bank armoring and an impacted riparian buffer were observed. Overall, this reach is very stable. It is located immediately downstream of a bedrock gorge and upstream of a bedrock grade control in M08-A, both of which afford the river vertical stability in this reach. Natural entrenchment was measured at the cross section for M09 and a higher terrace exists along one side of the river for much of this reach. Active adjustments were not documented during the Phase 2 assessment of M09. For this reason and its apparent stability, the reach was placed in **good** geomorphic condition. Additionally, this reach provides high quality habitat for aquatic organisms, including ample large woody debris, a diversity of bed features, and well forested banks and buffers. For these reasons, M09 is also in **good** habitat condition.

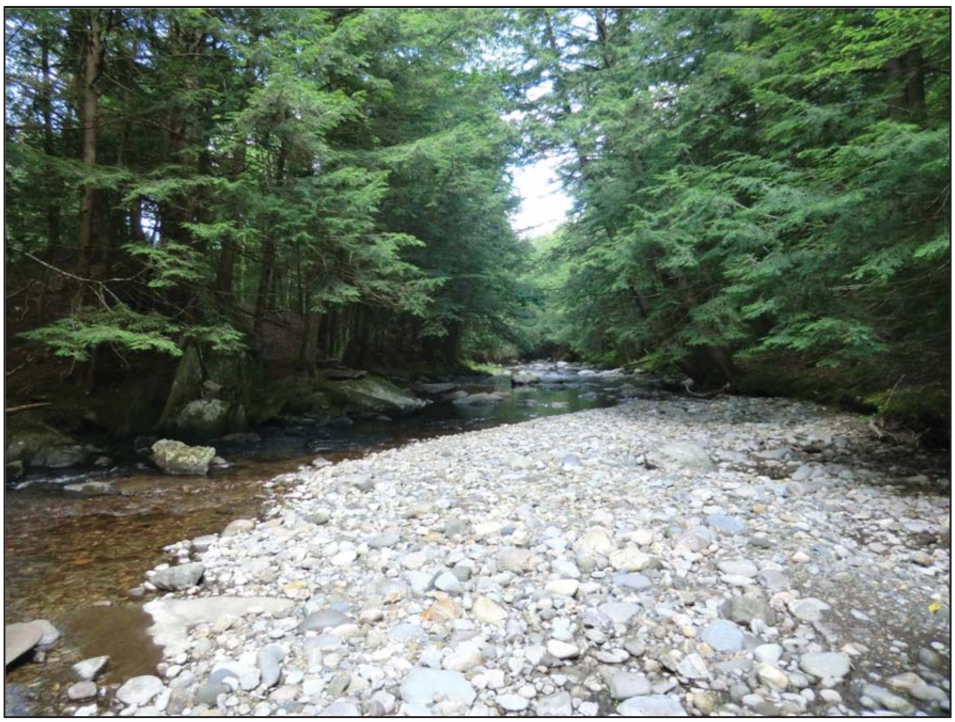


Figure 5.13. M09-A flows through the woods largely away from human impacts.

M09 Data Summary			Reference	Existing
Length:	3,175 ft	Confinement	Broad	Broad
Drainage Area:	12.0 sq. mi.	Stream Type	F	F
Evolution Stage:	F-V	Entrenchment Ratio	< 1.4	1.3
Sensitivity:	High	Incision Ratio	< 1.2	1.3
		Dominant Bed Material	Cobble	Cobble
		Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:		**Bank armoring, lacking buffer**		

M10

Reach M10 on the Seymour River is just over 2,000 feet long and was split into two very distinct segments during the Phase 2 assessment.

M10-A

The downstream segment on reach M10 is very short, only 360 feet in length. This segment is a bedrock gorge. The river flows through a semi-confined valley in this segment, and bedrock cascades are the dominant bedform. The abundant bedrock on the streambed and banks makes this segment extremely stable. An administrative judgement for geomorphic condition of **reference** was assigned to this segment.

Figure 5.14. M10-A is a bedrock gorge and is very stable.

M10-A Data Summary	*NOT ASSESSED	Reference	Existing
Length: 360 ft Drainage Area: 11.8 sq. mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Semi-Confined	Semi-Confined
	Stream Type	G	G
	Entrenchment Ratio	< 1.4	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Bedrock	Bedrock
	Dominant Bedform	Cascade	Cascade
Major Stressors:	**None**		

M10-B

The upstream segment on reach M10 of the Seymour River is nearly 1,700 feet in length, extending from just above the bedrock gorge downstream to just below the Lower Pleasant Valley Road bridge near the intersection with Upper Pleasant Valley Road upstream. This segment is characterized by a very broad valley and extensive historic channel management. The river flows along mostly forested land to the east and a large cow pasture to the west. It appears that much of the segment was historically straightened to accommodate these surrounding land uses. Major historic incision was measured at the cross section, as well as major channel widening. Bank erosion was prevalent along both banks, further indicating widening. Abundant planform change was also noted via several very large flood chutes. The river has undergone major aggradation in this segment, which is related to it being located just upstream of a major channel constriction (bedrock gorge). Despite its historic incision, further incision is unlikely in this segment due to its location between two bedrock gorges. The major channel widening and aggradation observed have led to a stream type departure in this segment. As a result of the major adjustments occurring gin M10-B, it is in **fair** geomorphic condition. This segment is in **good** habitat condition with its abundant large woody debris, pools, and refuge areas.

Figure 5.15. Large bar feature and very wide channel characteristic of M10-B.

M10-B Data Summary		Reference	Existing
Length: 1,664 ft Drainage Area: 11.8 sq. mi. Evolution Stage: F-III Sensitivity: Extreme	Confinement	Very Broad	Very Broad
	Stream Type	C	D
	Entrenchment Ratio	> 2.2	2.3
	Incision Ratio	< 1.2	2.1
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel straightening, bank erosion, lacking buffer, stream ford**		

M11

Reach 11 on the Seymour River is a bedrock gorge, and thus was not fully assessed. The river flows for just under 1,000 feet through the woods from just below the Lower Pleasant Valley Road bridge downstream and the intersection of Lower and Upper Pleasant Valley Road upstream. The river flows through a semi-confined valley in this reach and has a dominant bedform of bedrock cascades. Although it was not assessed, an administrative judgement geomorphic condition of **reference** was assigned to M11 due to its extremely stable nature.

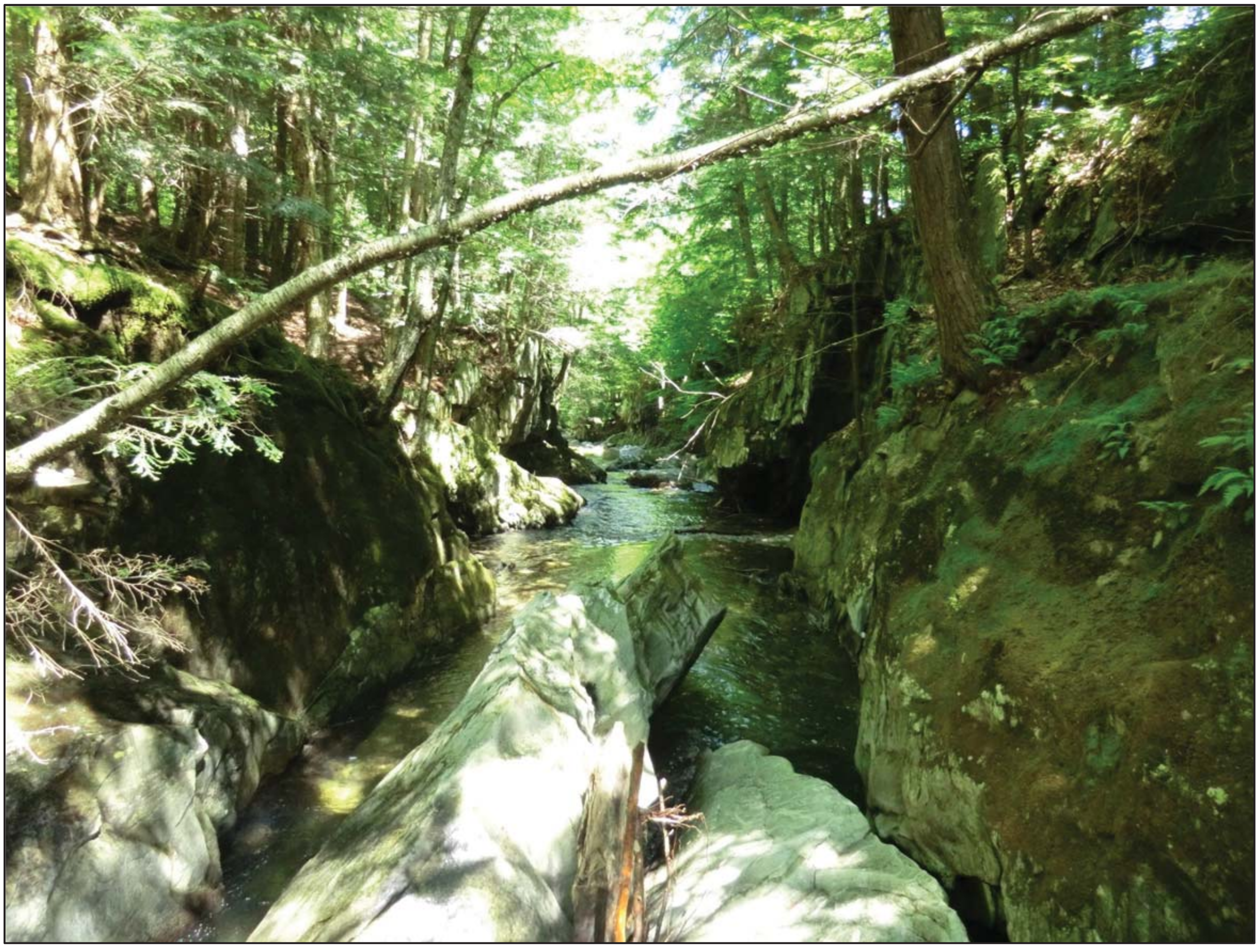


Figure 5.16. M11 is a bedrock gorge.

M11 Data Summary	*NOT ASSESSED	Reference	Existing
Length: 935 ft Drainage Area: 10.3 sq. mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Semi-Confined	Semi-Confined
	Stream Type	G	G
	Entrenchment Ratio	< 1.4	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Bedrock	Bedrock
	Dominant Bedform	Cascade	Cascade
Major Stressors:	**Lacking buffer**		

M12

Reach 12 on the Seymour River is the upstream-most reach included in the study. Roughly two-thirds of the nearly 4,800 foot reach was included in the assessment. The upper portion of the reach is located in the Town of Underhill, which is outside of the jurisdiction of the Lamoille County Planning Commission, and was excluded from the study for this reason.

M12-A

The downstream segment on reach M12 is characterized by extreme aggradation. The river flows through a very broad valley for roughly 3,000 feet from near the intersection of Lower and Upper Pleasant Valley Road downstream to the town line upstream. Adjacent lands in this segment are primarily agricultural. The upstream half of the segment appears to have been historically straightened due to adjacent land uses. The channel slope in this segment is low, and its location immediately above a bedrock gorge contributes to its extreme aggradation. Aggradation is the primary process driving adjustments within M12-A. It has led to major widening in this segment and low flow braiding. There are multiple side channels and large flood chutes throughout the segment, indicating active planform change. Floodplain connectivity is excellent in this segment, and this section of river is providing attenuation of sediment, nutrients and flood flows. M12-A scored **fair** for geomorphic condition due to its abundant active adjustments. The segment received a rating of **good** for habitat condition, with its abundant low and high flow refuge, diverse pool features, large woody debris, and floodplain connectivity.

Figure 5.17. Depositional features are large and abundant in M12-A.

M12-A Data Summary		Reference	Existing
Length: 3,005 ft Drainage Area: 10.2 sq. mi. Evolution Stage: D-IId Sensitivity: Extreme	Confinement	Very Broad	Very Broad
	Stream Type	D	D
	Entrenchment Ratio	> 2.2	4.3
	Incision Ratio	< 1.2	1.0
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Braided	Braided
Major Stressors:	**Channel straightening, bank armoring, bank erosion, lacking buffers**		

Settlement Brook

Settlement Brook is a tributary to the Seymour River that flows south to north along County Farm Road and enters the Seymour River at the downstream end of reach M08. Settlement Brook drains nearly six square miles of land area in southern Cambridge.

T1.01

Reach one on Settlement Brook is 1,700 feet long and spans the stretch between the confluence with the Seymour River to just upstream of the arch on Lower Pleasant Valley Road near the intersection of County Farm Road. Settlement Brook flows through a very broad valley in T1.01 and adjacent lands are mainly agricultural. Lower Pleasant Valley Road runs along the west side of the brook for much of the reach. The majority of T1.01 appears to have been historically straightened due to the placement of Lower Pleasant Valley Road and management for agricultural lands to the east of the brook. Riprap is common along both banks in this segment, and bank erosion is present in some areas where riprap has failed. Despite historic channel management practices, very little adjustments are occurring within T1.01. For this reason, the reach scored **good** for geomorphic condition. The brook lacks in-channel large woody debris, as well as diverse bank and buffer vegetation, which contributed to its rating of **fair** for habitat condition.

Figure 5.18. Narrow, straight channel characteristic of T1.01.

T1.01 Data Summary		Reference	Existing
Length: 1,699 ft Drainage Area: 5.8 sq. mi. Evolution Stage: F-III Sensitivity: High	Confinement	Very Broad	Very Broad
	Stream Type	E	E
	Entrenchment Ratio	> 2.2	18.5
	Incision Ratio	< 1.2	1.3
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel straightening, bank armoring, bank erosion, animal stream crossings**		

T1.02

Reach two on Settlement Brook is 4,100 feet in length, beginning just above the arch on Lower Pleasant Valley Road and ending upstream roughly 800 feet north of the Cambridge/Underhill town line. The reach was divided into three segments during the assessment to account for changes in channel planform, bank and buffer vegetation, corridor encroachment, and property access.

T1.02-A

The downstream-most segment on reach T1.02 is nearly 750 feet long and flows directly along County Farm Road for its entire length. This segment of the brook was extensively historically straightened due to the placement of the road. This straightening has led to moderate channel incision. Widening is being prevented in some portions of this segment due to bank armoring. Bank erosion was observed in many areas that are not armored. The extensive alteration of channel planform and historic moderate incision led to the placement of T1.02-A in **fair** geomorphic condition. The brook is lacking large woody debris, a well-defined riffle-pool bedform, and bank and buffer vegetation in this segment, which is why it was also placed in **fair** habitat condition.

Figure 5.19. Straightened channel and road encroachment in T1.02-A.

T1.02-A Data Summary			**Reference**	**Existing**
		Confinement	Very Broad	Very Broad
Length	745 ft	Stream Type	C	C
Drainage Area:	5.5 sq. mi.	Entrenchment Ratio	>2.2	7.6
Evolution Stage:	F-III	Incision Ratio	< 1.2	1.6
Sensitivity:	Very High	Dominant Bed Material	Gravel	Gravel
		Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:		**Channel straightening, bank armoring, bank erosion, stormwater inputs**		

T1.02-B

The middle segment on reach two of Settlement Brook is nearly 2,500 feet in length and flows through a very broad valley. Surrounding lands are a mix of forested and residential. Several houses are present along the west side of the brook on County Farm Road. Historic and recent channel management is evident in the areas where the brook abuts these houses. Observed management activities include historic channel straightening for the majority of the segment, gravel mining, stream ford presence, windrowing, and berming. Additionally, riparian buffer vegetation is lacking along the houses on the west side of the brook. Historic incision was observed in T1.02-B, likely resulting from historic channel management. Recent channel alteration observed included two berms on the western bank of the brook, new riprap in the vicinity of some houses, and gravel mining. T1.02-B scored **fair** for geomorphic condition as a result of extensive channel alteration and moderate incision. Similarly, the segment was placed in **fair** habitat condition due to lacking large woody debris, altered channel morphology, and areas of lacking bank and buffer vegetation.

Figure 5.20. Large, recently constructed berm in T1.02-B.

T2.01-B Data Summary			**Reference**	**Existing**
Length:	2,435 ft	Confinement	Very Broad	Very Broad
Drainage Area:	5.5 sq. mi.	Stream Type	C	C
Evolution Stage:	F-III	Entrenchment Ratio	>2.2	3.8
Sensitivity:	Very High	Incision Ratio	< 1.2	1.6
		Dominant Bed Material	Gravel	Gravel
		Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:		**Channel straightening, bank armoring, bank erosion, lacking buffers, berms, development**		

Unnamed Tributary to Reach M04 of the Seymour River

This unnamed tributary has a drainage area of 0.1 square miles and flows generally from east to west, entering the Seymour River in reach M04. Two reaches on this very small stream were included in the stream walkovers for this assessment.

M04S1.01

Reach one on this unnamed tributary is located about 0.45 miles south of the junction of Bryce Road and Lower Pleasant Valley Road at the base of the subwatershed. The reach is only 375 feet in length, flowing through mostly residential and agricultural lands in the vicinity of 611 Lower Pleasant Valley Road. The last 100 feet of this 375 foot long reach could not be assessed due to lack of landowner permission. In general, this very small channel had a buffer of less than 25 feet on the north side for most of its length and for a short stretch on the south as well. This segment could be enhanced by widening the buffer where it is lacking on one or both sides of the channel. An animal crossing was observed at the upstream end of this reach.

Figure 5.21. Animal crossing at upstream end of M04S1.01.

M04S1.02

Reach M04S1.02 has a drainage area of 0.09 sq. mi. and was split into three segments during the assessment based on planform and slope, banks and buffers and valley widths.

M04S1.02-A

The downstream-most segment within reach M04S1.04 has low banks and a very broad valley. There are extensive wetlands adjacent to the channel. The segment is in good overall condition with limited erosion. A trail runs along the east side of the channel for a short distance, resulting in buffer widths less than 25 feet. For most of the segment, the east side has a buffer width of greater than 100 feet, while the right side has a dominant buffer width of 26 to 50 feet. There is concrete in the channel covering a small culvert in this segment. This stream crossing does not appear to be very stable and could benefit from being replaced or removed, if not needed. Two animal crossings are present within this segment.

Figure 5.22. Photo of channel in M04S1.02-A.

M04S1.02-B

The middle segment on reach M04S1.02 is just over 500 feet in length and flows through a pastured and wooded area between Bryce Road and Lower Pleasant Valley Road. This segment has a considerable amount of erosion along the stream banks. Approximately 50 percent of the south bank is eroded, while 80 percent of the north bank is eroded. The dominant corridor land use is pasture along each side of the channel. There are a couple of measures that would improve channel and bank stability in this segment. First, livestock exclusion would allow the buffer to rejuvenate; thereby, improving channel and bank stability. Stream crossings could be eliminated or improved. In particular, the tractor crossing could be stabilized to reduce erosion and sedimentation. A gully on the north side of the channel that appears to originate at Bryce Road should be investigated.

Figure 5.23. Severe bank erosion was documented along both banks in M04S1.02-B.

M04S1.02-C

The upper segment on M04S1.02 is roughly 300 feet in length, beginning just downstream of the Bryce Road culvert and continuing downstream into the woods. The stream channel is steeper and more confined in this segment than the lower two segments. There is an extensive mass failure along the north bank in this segment, as well as abundant bank erosion. The banks are very steep and comprised of wet soils. No projects are recommended for this segment. Overtime, the mass failure and erosion should stabilize and revegetate on their own.

Figure 5.24. Photo of extensive mass failure along north bank in M04S1.02-C.

Unnamed Tributary 1 to Reach M06 of the Seymour River

This small tributary drains 0.22 square miles, flowing east to west between Bryce Road and Lower Pleasant Valley Road before entering the Seymour River in reach M06. Three reaches were included in the stream walkovers.

M06S1.01

Reach one on tributary 1 to M06 is just over 400 feet in length and flows through primarily pastured land. Impacts noted in this short reach were minimal, but included some channel straightening and lacking riparian buffers due to adjacent land uses. Opportunities for improvement in this reach include planting native trees and shrubs in the riparian buffer zone on the north side of the stream where vegetation is currently lacking.

Figure 5.25. Small stream channel in M06S1.01.

M06S1.02

Reach two on tributary 1 to M06 is nearly 1,500 feet long and was divided into three distinct segments during the walkover to account for changes in bank and buffer vegetation, valley width, and channel dimensions.

M06S1.02-A

The downstream most segment on M06S1.02 is nearly 600 feet long and flows through primarily agricultural land (pasture and hay). The upper end of this segment is located approximately 1,300 feet downstream of Bryce Road. Clay substrate was observed in areas of bank erosion during the walkover. There is a large bedrock grade control (estimated 100 feet long) at the upstream end of the segment offering some vertical stability to the channel in and above this segment. At the downstream end of the segment, an active headcut was observed just downstream of a stream ford. Opportunities for improvement in this segment include investigating methods for arresting the active headcut and planting vegetation in areas where the riparian buffers are lacking.

Figure 5.26. Bedrock grade control at upstream end of M06S1.02-A.

M06S1.02-B

The second segment on reach two of unnamed tributary 1 to M06 is just over 550 feet long and flows through a wooded section between Bryce Road and Lower Pleasant Valley Road. Few impacts were documented in this segment during the stream walkover. Three small mass failures as well as some minor bank erosion were observed in this segment. Two debris jams create nice habitat and well forested buffers shade the stream channel.

Figure 5.27. M06S1.02-B has well forested buffers and debris jams.

M06S1.02-C

The upstream most segment on reach two of tributary 1 to M06 is 350 feet long and begins at the downstream end roughly 700 feet below the Bryce Road crossing. This segment flows through agricultural lands and has lacking riparian buffers on both sides for almost its entire length. There are three animal crossings within this segment that are contributing to bank and channel instability. Nearly the whole segment has been subjected to channel straightening and bank armoring is common. Additional channel modifications have occurred at the upstream end of the segment. The uppermost portion of the segment has been subjected to windrowing, involving excavating the channel and piling streambed materials on the banks to create berms. There is also a culvert at the downstream end of the segment near the transition between agricultural and forested surrounding land uses. Opportunities to improve conditions in M06S1.02-C include buffer improvements, livestock exclusion, and berm removal/restoring the windrowed section.

Figure 5.28. Windrowed section at upstream end of M06S1.02-C.

M06S1.03

Reach three on tributary 1 to M06 is a very narrow channel that flows through an agricultural field for just over 500 feet immediately below the Bryce Road crossing. Buffer vegetation is lacking for the entirety of this reach on both sides of the ditch. At the downstream end of the reach, major channel alteration in the form of windrowing has been carried out. Berms exist on both sides of the channel. A headcut is located immediately upstream of this area of windrowing and is likely related to channel modification activities. Opportunities to improve this segment could include planting native trees and shrubs in the buffer zone, removing the berms/restoring the windrowed section, and replacing the undersized and perched culvert at Bryce Road.

Figure 5.29. Headcut in M06S1.03.

Unnamed Tributary 2 to Reach M06 of the Seymour River

Three reaches on the second unnamed tributary to M06 were included in the stream walkovers. This small tributary drains east to west between Bryce Road and Lower Pleasant Valley Road in the vicinity of the intersection of Bryce Road and Upper Pleasant Valley Road. At its mouth, this tributary drains 0.5 square miles.

M06S2.01

Reach one on tributary 2 to M06 flows for approximately 650 feet through agricultural land before meeting the Seymour River. This reach appears to have been historically straightened for its entire length due to adjacent land uses. A stream ford for vehicles and an animal stream crossing were observed at the upstream end of this reach. Riparian buffers are lacking on both banks for about half of the reach. The reach would benefit from establishing a “no mow” zone in the adjacent pastures to allow the riparian buffer to regenerate where it is currently lacking.

Figure 5.30. View looking upstream in M06S2.01.

M06S2.02

The second reach on tributary 2 to M06 was divided into three segments during the stream walkover to account for changes in bank and buffer vegetation, valley width, planform and slope, and channel dimensions.

M06S2.02-A

The downstream most segment on reach two is just over 700 feet long and flows through a wooded section. This segment has a steeper slope and narrower valley than the upstream segments. The stream banks are very steep and erosion is common along the north bank. There is one mass failure on the south bank in this segment. A gully exists coming off of the north bank that is likely a source of sediment to the stream.

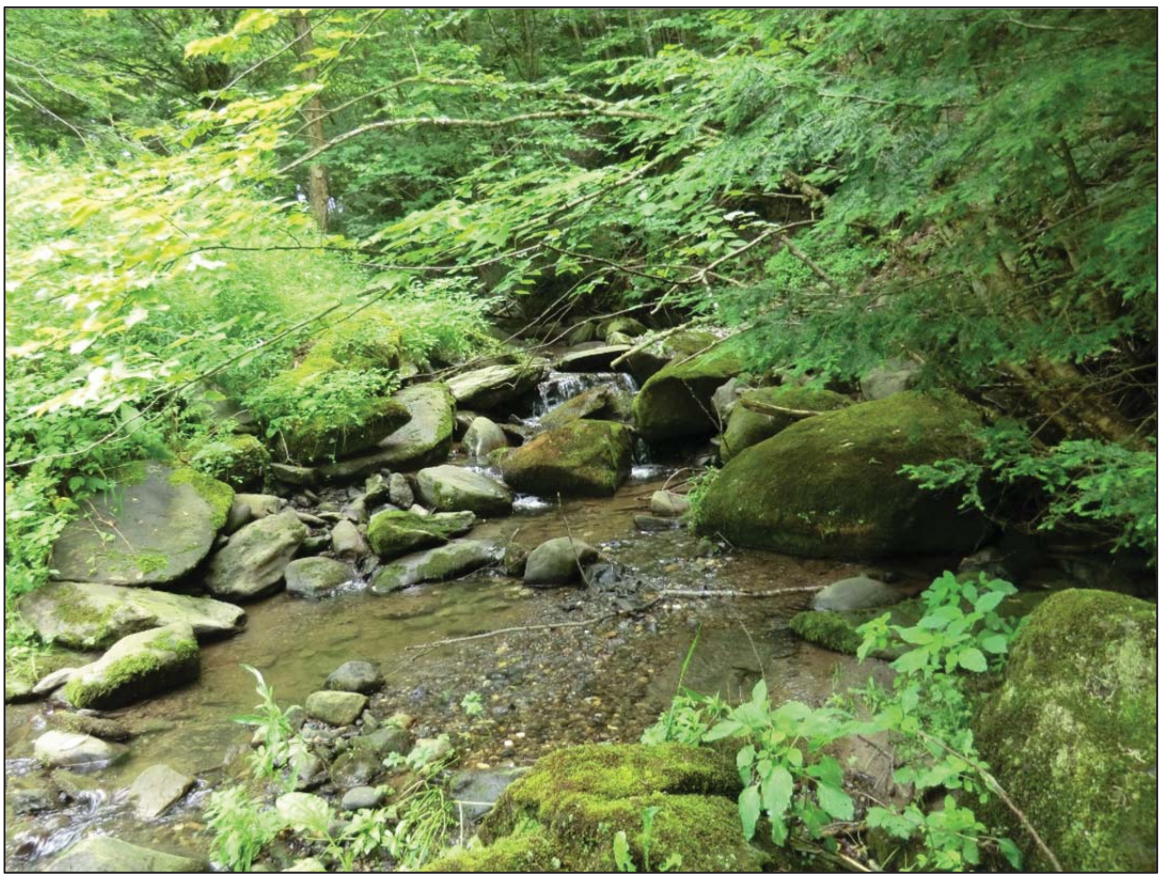


Figure 5.31. The channel is steeper and has larger substrate in M06S2.02-A than surrounding segments.

M06S2.02-B

The second segment on reach two of tributary 2 to M06 is roughly 550 feet in length and flows through agricultural lands in a very broad valley. The entirety of the segment appears to have been historically straightened due to the adjacent pastures. Riparian buffers are lacking on both banks throughout the segment. One animal crossing was observed during the stream walkover.

Figure 5.32. M06S2.02-B flows through pastured land and is lacking riparian buffers.

M06S2.02-C
The upper segment on reach two of tributary two to M06 is characterized by extensive historic straightening. Old riprap was observed in the stream channel. This segment is nearly 600 feet long and flows through agricultural lands. Some areas of bank erosion were noted during the stream walkover. Riparian buffers are lacking on both banks in this segment due to adjacent land uses.

Figure 5.33. Old riprap in the channel in M06S2.02-C.

M06S2.03

Reach three on tributary 2 to M06 is nearly 2,300 feet long and was not segmented during the stream walkover. It begins downstream just below the Bryce Road culvert and extends upstream to just above the Pratt Road culvert. For most of the length of this segment, the stream flows through a wetland channel. Other than lacking buffer vegetation, few impacts were noted to this segment. Most of the lacking buffer is due to Upper Pleasant Valley Road running along the stream in this reach.

Figure 5.34. There are extensive adjacent wetlands along M06S2.03.

Unnamed Tributary 3 to Reach M06 of the Seymour River

Unnamed tributary 3 to M06 is located between Upper Pleasant Valley Road and the Seymour River in the vicinity of the intersection with Bryce Road. This tributary drains 0.22 square miles at its mouth.

M06S3.01

M06S3.01 was divided into three segments during the stream walkover to account for changes in valley width, channel dimensions, planform and slope, and bank and buffer vegetation.

M06S3.01-A

The downstream segment on reach M06S3.01 is nearly 900 feet long and flows through agricultural land. The brook in this segment appears to have been extensively historically straightened and is lacking riparian buffers on both banks for its entire length. Four animal stream crossings are present at the upstream end of the segment and are contributing to instability of the streambanks in this location. Toward the lower end of the segment, the channel becomes a grassed ditch.

Figure 5.35. One of four animal stream crossings in M06S3.01-A.

M06S3.01-B

The second segment on tributary 3 to M06 is 375 feet long and flows through a small section of woods within pastured land. Bank erosion is common in this segment, especially on the south bank, and one mass failure was observed during the stream walkover. One animal stream crossing was documented at the downstream end of the segment and is contributing to localized instability there. Overall, buffers are forested in this segment though there are short sections of lacking buffer at the upstream and downstream ends of the segment.

Figure 5.36. Downstream channel photo in M06S3.01-B.

M06S3.01-C

The upstream most segment on this reach spans just over 700 feet just downstream of the woods below Upper Pleasant Valley Road. Similar to segment A, the stream channel in this section appears to have been extensively historically straightened to accommodate adjacent pastureland. Riparian buffers are lacking on both sides of the channel for this entire segment. Some areas of bank erosion were noted during the walkover and this bank instability appears to be related to grazing activities.

Figure 5.37. Animal access inM06S3.01-C is contributing to bank instability.

Tributary 1 to Reach M07 of the Seymour River

Trib 1 to M07 is a small stream that drains southeast to northwest between Upper Pleasant Valley Road and reach M07 of the Seymour River. At its mouth, the stream drains 0.66 square miles. Only one reach (reach three) on this stream was included in the stream walkover.

M07S1.03

Reach three on trib 1 to M07 begins just below the Upper Pleasant Valley Road crossing and continues downstream into the woods below the road for 2,500 feet. The reach was split into two segments during the stream walkover to account for changes in valley width, planform and slope, channel dimensions, and bank and buffer vegetation.

M07S1.03-A

The downstream segment on this reach is nearly 800 feet in length, flows through forested land, and is naturally entrenched. Two bedrock grade controls were observed within this segment during the field work.

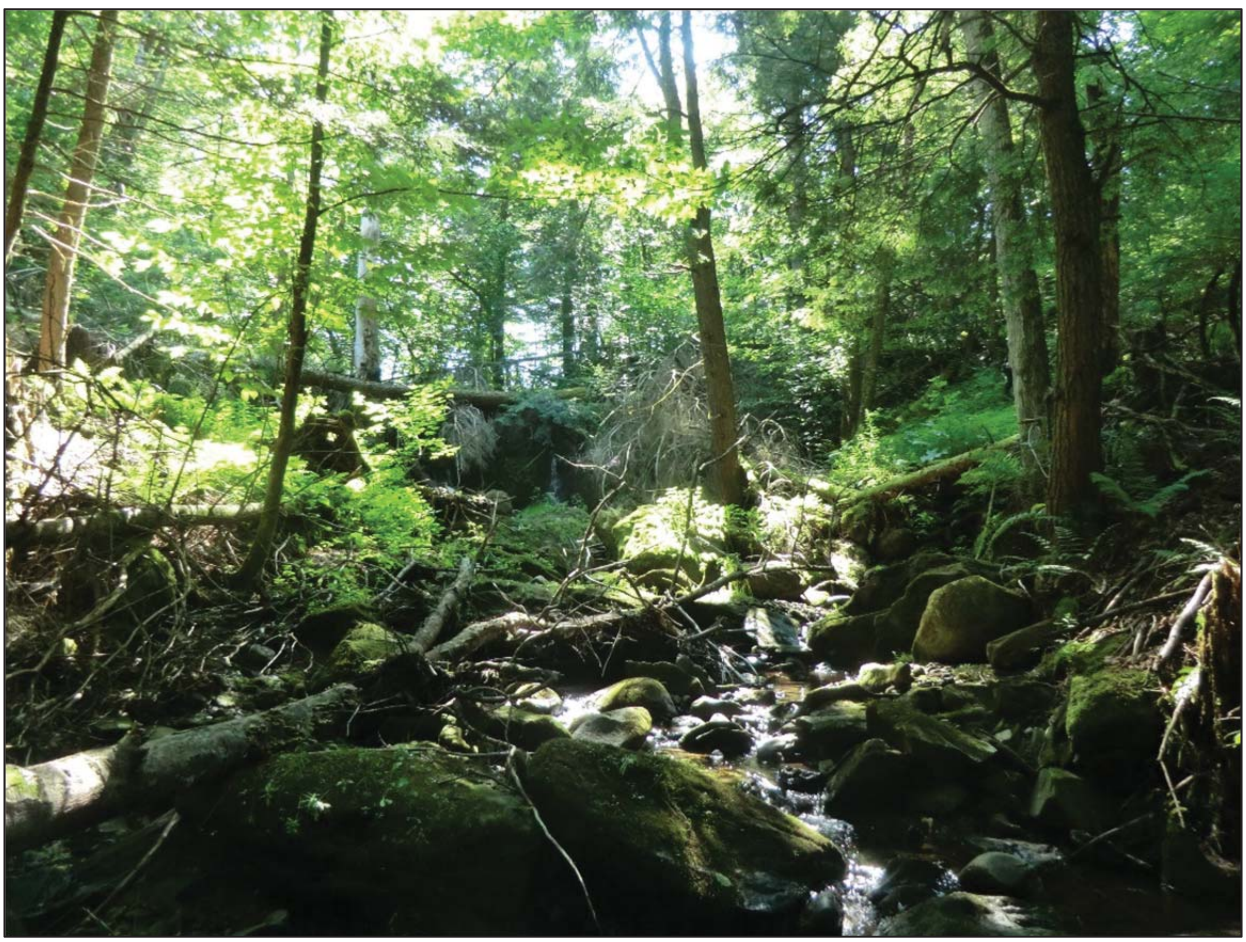


Figure 5.38. M07S1.03-A flows through the woods and is naturally entrenched.

M07S1.03-B

The upstream segment on this reach has a flatter slope and narrow channel. It flows for nearly 500 feet through agricultural land and appears to have been historically straightened for most of its length. Bank erosion was nearly continuous along both banks in this segment at the time of the stream walkover. This erosion appears to be related to lacking riparian vegetation and grazing activities along the banks of the stream. Two animal stream crossings are contributing to instability in this segment.

Figure 5.39. One of two animal stream crossings present in M07S1.03-B.

Unnamed Tributary 1 to Reach M10 of the Seymour River

This stream flows from the vicinity of the intersection of Upper Pleasant Valley Road and Westman Road into reach M10 of the Seymour River. In total, it drains 0.59 square miles at its confluence with the Seymour.

M10S1.01

Reach one on this tributary is nearly 800 feet in length and flows through the woods to the Seymour River. Overall, the stream channel is stable in this segment and riparian buffers are well forested. Very few impacts were observed during the stream walkover.

Figure 5.40. M10S1.01 is stable and has well forested banks and buffers.

M10S1.02

Reach two on tributary one to M10 is longer, nearly 2,500 feet in length. It was divided into two segments during the walkover to account for changes in planform and slope, valley width, channel dimensions, and bank and buffer vegetation.

M10S1.02-A

The downstream segment on reach two of trib 1 to M10 is roughly 1,500 feet long. It flows through the woods and has a narrower valley width than the surrounding segments. In general, this segment is very stable and minimal impacts were observed. Some minor bank erosion was noted that may be related to grazing activities on adjacent pasture land to the south of the stream. Riparian buffers in this segment are well forested, though a short section of lacking buffer is present on the south side where the pastureland exists.

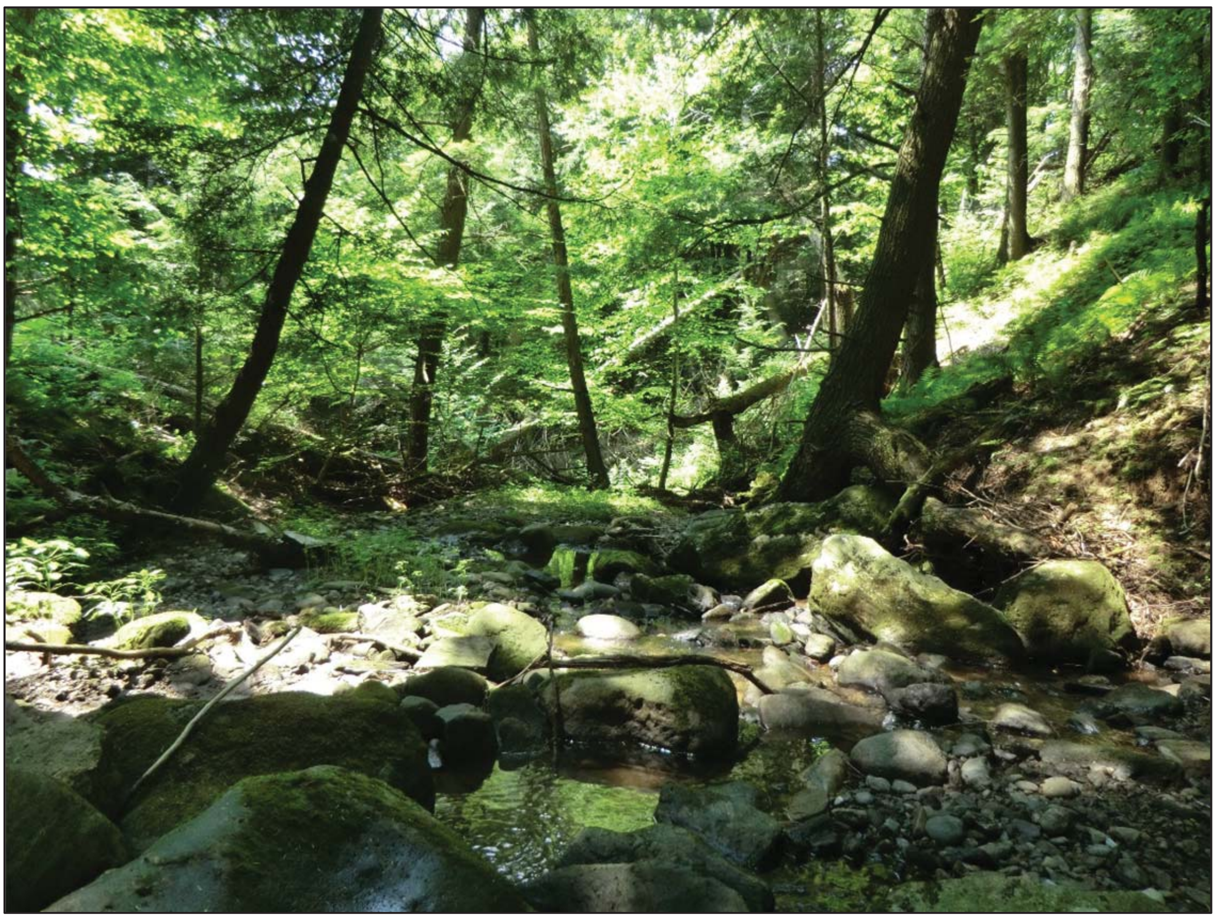


Figure 5.41. M10S1.02-A is stable and has well forested banks and buffers.

M10S1.01-B

The upstream segment on this reach is nearly 1,000 feet long and has a flatter slope and wider valley than the segment below. Adjacent lands are covered by shrub/sapling vegetation, with an intact riparian buffer on the south side of the channel and a regenerating buffer on the north. Overall, the stream was noted to be stable and no bank erosion was observed. Two culverts are present within this segment and both are significantly undersized and likely pose barriers to aquatic organism passage.

Figure 5.42. Dense shrub/sapling vegetation covers the banks for much of M10S1.02-B.

Unnamed Tributary 2 to Reach M10 of the Seymour River

The second unnamed tributary to reach M10 flows general east to west between Westman Road and the Seymour River near the intersection of Upper and Lower Pleasant Valley Roads. The stream drains 0.77 square miles of primarily agricultural and forested lands.

M10S2.01

Reach one on trib 2 to M10 is roughly 1,000 feet long and was divided into two segments during the stream walkover due to changes in valley width and planform and slope.

M10S2.01-A

The downstream segment on this reach is nearly 500 feet long and has a wider valley than the upstream segment. It flows through a section of woods and into the Seymour River. Generally, this segment appears to be stable and has well forested banks and buffers. There is some lateral bank erosion occurring as the sinuosity of this short segment changes over time.

Figure 5.43. Upstream channel photo in M10S2.01-A.

M10S2.01-B
The second segment on reach one of trib 2 to M10 is slightly longer – almost 600 feet and has a narrower valley than the downstream segment. No impacts to this segment were noted in the field and it is characterized as being very stable.

Figure 5.44. M10S2.01-B looking downstream.

M10S2.02
The second reach on tributary 2 to M10 is nearly a mile in length. Only roughly half of this reach was included in the stream walkover; the section above the Westman Road crossing is wooded and appears to be stable. Therefore, it was not included in the walkover. The area assessed was split into two segments due to changes in bank and buffer vegetation, planform and slope, and channel dimensions.

M10S2.02-A

The first segment on this reach is approximately 2,000 feet long and flows primarily through forested land with some agricultural land. Minimal impacts to this segment were recorded during the stream walkover. Riparian buffers are lacking in a couple areas but overall are intact. Some planform adjustment via flood chutes was noted. There is an undersized culvert at Lower Pleasant Valley Road in this segment that is in poor condition and is perched.

Figure 5.45. Downstream channel photo in M10S2.02-A.

M10S2.02-B

The upper segment on this reach that was included in the stream walkover is shorter – just over 400 feet long. The segment begins at the Westman Road culvert and continues downstream from there. This segment is characterized as having an entrenched channel and forested banks and buffers. Bedform is primarily step pool with a steeper slope than the downstream segment. Observed impacts were minimal but included abundant trash along the banks. The culvert at Westman Road at the upstream end of this segment is significantly undersized and may have reduced aquatic organism passage.

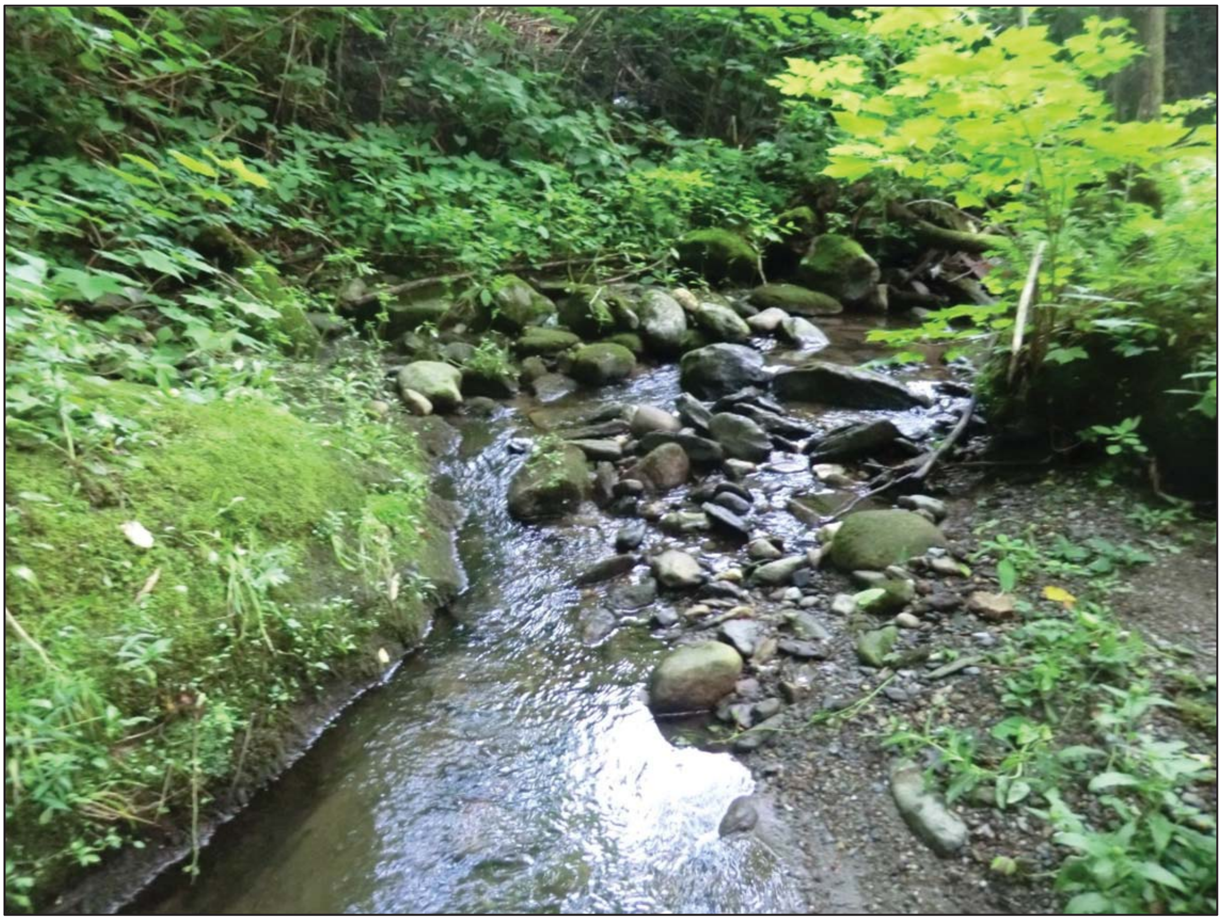


Figure 5.46. Stable stream channel in M10S2.02-B.

5.2 Stream Crossings

The Vermont Culvert Geomorphic Compatibility Screen Tool and the Vermont Aquatic Organism Passage Coarse Screen Tool (Appendix A pages 1 through 3) were used to evaluate bridges and culverts within the Phase 2 study area. Of the 18 bridges and culverts assessed, none were determined to be “fully incompatible,” three are “mostly incompatible,” twelve are “partially compatible,” three are “mostly compatible,” and none are “fully compatible.”

Tables 6 and 7 in Appendix A (pages 4 and 5) summarize the data collected for the assessed structures and recommendations for replacement of the structures. One bridge and seven culverts within the study area have been recommended for replacement at a high priority. One bridge and two culverts are recommended for replacement at a moderate priority, one bridge and one culvert at a low priority, and five bridges are not recommended for replacement at all. This information can be used by the Town of Cambridge and the Vermont Agency of Transportation to prioritize bridge and culvert replacements.

6.0 PRELIMINARY PROJECT IDENTIFICATION

Phase 2 Stream Geomorphic data were analyzed for the Seymour River watershed in order to determine major stressors and impacts to each stream segment. These data were used to identify potential projects to mitigate adverse impacts, increase geomorphic stability, and improve habitat throughout the study area. Many projects utilize restoration and conservation strategies to bring the study streams closer to equilibrium conditions.

6.1 Project Identification

A total of 59 projects were identified within the study area. These include a variety of types of projects, such as riparian buffer plantings, river corridor easements, berm removals, bridge and culvert replacements, and more. Detailed information about proposed projects can be found in Appendix C. Projects were categorized and reported according to standards set by the Vermont Watershed Management Division using its Watershed Projects Database table. Based on these standards, five types of projects were identified within the Phase 2 study area: Agricultural Pollution Prevention - Preliminary Design, Floodplain/Stream Restoration - Preliminary Design, River - Planting, River Corridor Easement – Design, and Stormwater – Preliminary Design. Examples of types of these projects are shown in the table below.

Project Type	Project Examples	Flood Resiliency and Habitat Enhancement Measures
Agricultural Pollution Prevention - Preliminary Design	➢ Livestock exclusion	➢ Improve physical stability and habitat condition of a river by excluding livestock from accessing it; also allow buffer regeneration at previous access points. ➢ Improve water quality.
Floodplain/Stream Restoration - Preliminary Design	➢ Berm removal ➢ Bridge/culvert replacement ➢ Floodplain creation ➢ Investigate gully remediation ➢ Stream crossing improvements ➢ Headcut stabilization	➢ Remove berms to improve stream access to floodplains. ➢ Windrowing can disconnect streams from their floodplains through excavation and berming. Return windrowed material to a channel or remove it to improve floodplain access. ➢ Incorporate ecologically-based stream crossings with natural channel bottom to improve aquatic organism passage. Structures that mimic the natural stream channel are more flood resilient. ➢ Upgrade undersized structures to reduce road washouts. ➢ Remove abandoned bridges and culverts to improve channel stability and water quality. ➢ Retrofit newer culverts to improve aquatic organism passage. ➢ Investigate gullies and determine feasibility of remediation for water quality improvement and increased channel stability. ➢ Improve stream bank and bed stability through redesign of stream vehicle and animal fords. ➢ Stabilize active headcuts to arrest channel incision and prevent loss of floodplain access.
Pollution Prevention, Abatement, and Mitigation	➢ River clean up	➢ Clean up garbage in and around streams to improve water quality and promote channel stability.
River - Planting	➢ Riparian buffer planting	➢ Plant native tree and shrub species to restore riparian habitat, provide floodplain roughness and cover along banks, and stabilize eroding banks.
River Corridor Easement – Design	➢ River corridor easement	➢ Adopt river corridor and/or conservation easements on large tracts of land to provide room for the river to reach an equilibrium condition and protect against new encroachments. ➢ Protect floodplains and wetland habitat to preserve floodwater and sediment storage.
Stormwater – Preliminary Design	➢ Investigate stormwater management on town road	➢ Investigate options for stormwater management on roads where overland flow discharges directly to surface waters without treatment.

6.2 Program Descriptions

River Restoration and Conservation Programs

There are a number of federal, state, and local programs available for river restoration and protection. Funding sources provided below could be leveraged for further project development and implementation. These programs are as follows:

- ANR River Corridor Easement Program (RCE)
- Ecosystem Restoration Program (ERP)
- Conservation Reserve Enhance Program (CREP)
- Trees for Streams (TFS)
- Environmental Quality Incentives Program (EQIP)
- Wildlife Habitat Incentives Program (WHIP)
- Wetland Reserve Program

River Corridor Easement
The River Corridor Easement is designed to promote the long-term physical stability of the river by allowing the river to achieve a state of equilibrium (where sediment and water loads are in balance). River corridor easements are vital for a passive geomorphic restoration approach and can also be used for conserving rivers that are in good condition (equilibrium). Rivers that are in equilibrium have access to their floodplains and therefore experience less *erosion* and negative impacts from flooding events. Corridor easements are a high priority for reaches that are not in equilibrium; these channels are experiencing channel adjustments, which are causing conflicts with current/future land-use expectations. Providing an easement on these reaches reduces the conflict and provides a long-term solution to sediment storage and flood water attenuation needs.

- Easements are in perpetuity, meaning the agreement stays with the land forever.
- A onetime payment is received by the landowner for transferal of channel management rights to a second party (a land trust).
- Transferal of channel management rights means that the landowner would no longer be able to rock line river banks or remove gravel for personal use.
- A RCE requires a minimum 50 foot buffer that floats with the river. No active land-use is allowed within the buffer. The buffer can be actively planted or allowed to revegetate passively.
- The easement does not take away the agricultural land-use rights, so the landowner could continue to crop or pasture the farm land mapped outside of the buffer, yet within the corridor, for as long as the river allows.

Ecosystem Restoration Program
The Ecosystem Restoration Program, formerly called the Clean and Clear Program, is a Vermont program designed to improve water quality by addressing one or more of the following areas:

stream stability, protecting against flood hazards, enhancing in-stream and riparian habitat, reducing stormwater runoff, restoring riparian wetlands, enhance the environmental and economic sustainability of agricultural lands. Funding is available for project identification, project development and project implementation. Vermont municipalities, local or regional governmental agencies, non-profit organizations, and citizens groups are eligible to receive funding.

Conservation Reserve Enhancement Program
The USDA Farm Service administers a program called the Conservation Reserve Enhancement Program that helps agricultural producers to take farmland out of production in sensitive areas, such as river corridors. This helps to improve water quality and restore wildlife habitat.

- CREP can be either a 15 or 30 year contract to plant trees.
- 90% of the practice costs are covered with the remaining 10% either resting with the participants or could be paid by the US Partners for Fish and Wildlife. Examples of the practice costs include fencing, watering facilities, and trees. There are some costs that are capped, but generally all the practice costs can be paid through the program.
- To provide additional incentives to enroll in CREP, the program offers upfront and annual rental payments for the land where agricultural production is lost during the contract period.

Trees for Streams
Programs offered by the US Fish and Wildlife Service or through State funding to work with local partners and landowners to restore native streamside vegetation along river banks.

Environmental Quality Incentives Program
EQIP is a voluntary program available through the Natural Resources Conservation Service (NRCS) that provides financial and technical assistance to implement conservation practices to meet local environmental regulations. Owners of land in agricultural or forest production are eligible for the program. Contracts with landowners can be up to ten years in length.

Wildlife Habitat Incentives Program
WHIP is a voluntary program offered to landowners to improve wildlife habitat on their land. Owners of agricultural land, nonindustrial private forest land, and Native American land are eligible. Technical assistance and up to 75 percent cost-share is available to improve fish and wildlife habitat.

Wetland Reserve Program
WRP is a voluntary program offered by NRCS to landowners to protect, restore and enhance wetlands on their property. NRCS provides technical assistance and financial support for projects that establish long-term conservation and wildlife practices and protection.

Flood Resiliency Programs and Initiatives

Additionally, there are numerous programs in place to aid communities in becoming more flood resilient. A collection of several of these programs follows:

- Vermont Emergency Relief Assistance Fund (ERAF)
- Vermont Municipal Planning Grants (MPG)
- Clean Water State Revolving Fund
- National Flood Insurance Program Community Rating System (CRS)
- U.S. Department of Housing and Urban Development Community Development Block Grants (CDBG)
- Federal Emergency Management Agency Buyout Program
- Vermont Agency of Natural Resources River Corridor Protection

Emergency Relief Assistance Fund
In 2014, the state of Vermont established an Emergency Relief Assistance Fund (ERAF) to provide matching funding for federal assistance after federally-declared disasters. This program allows towns in Vermont to increase the amount of state aid money they could receive as a match to federal aid for post-disaster recovery. By taking certain steps to become more prepared and resilient, a town can be eligible for increased state aid money. Certain damage costs from federally-declared disasters are reimbursed 75% by federal money. The state of Vermont contributes a minimum of 7.5% of the total cost, but if a town takes additional steps, the state aid can increase to 12.5% or 17.5% of the cost, leaving less for the town itself to pay (State, 2015). The table below shows the ERAF status for Cambridge, Vermont.

Town ERAF Rating	Cambridge (Town & Village) 12.5%
12.5%	
Participate in the National Flood Insurance Program	X
Adopt 2013 Road & Bridge Standards	X
Adopt a Local Emergency Operations Plan	X
Adopt a Local Hazard Mitigation Plan	X
17.5% (need one to qualify)	
Protect River Corridors from new encroachment	
Protect flood hazard areas from new encroachments and participate in the FEMA Community Rating System	

Vermont Municipal Planning Grants Program
The Vermont Department of Housing and Community Development has established the MPG program to support local planning and revitalization initiatives for municipalities. Funding can go toward such projects as municipal and hazard mitigation plan updates, natural resource

inventories, and flood resiliency planning. Grants over $8,000 in value require small cash matching funds (ACCD, 2015).

Clean Water State Revolving Fund
The Clean Water State Revolving Fund is a program sponsored by the Vermont Department of Environmental Conservation to minimize water pollution that occurs as a result of wastewater treatment operations and stormwater. Municipalities can apply for funding for design and implementation of such projects as wastewater treatment facility upgrades, repairs to municipal wastewater and stormwater infrastructure, development of stormwater infrastructure, and repair of homeowner on-site wastewater treatment systems. Upgrades could improve wastewater utilities by flood-proofing and making infrastructure more flood resilient.

National Flood Insurance Community Rating System
In 1990, the National Flood Insurance Program implemented the Community Rating System, which is a voluntary program aimed at encouraging floodplain management activities that exceed NFIP minimum standards. The program allows communities to reduce their flood insurance payments by engaging in any of nineteen qualified activities that fall into the categories of

- Public Information
- Mapping and Regulations
- Flood Damage Reduction, and
- Warning and Response.

This program not only reduces flood insurance costs, it improves community flood resiliency and can reduce future damage and losses (FEMA, 2017).

U.S. Department of Housing and Urban Development Community Development Block Grants
The CDBG program provides communities with resources to address community development needs. Funding is available for recovery assistance after federally-declared disasters, as well as in the form of state administered grants.

FEMA Buyouts
Property acquisition, also known as buyouts, is a hazard mitigation assistance program offered through FEMA. Buyouts involve the purchase of at-risk properties by municipalities with 75% FEMA Hazard Mitigation Grant Program money and 25% municipality money. These properties are purchased for fair market (pre-disaster if disaster has occurred). The properties are required to be cleared and left in open space indefinitely. A buyout property may never be sold or developed again (FEMA, 2014).

VANR River Corridor Protection
In 2014, the Vermont Agency of Natural Resources developed river corridors on a state-wide scale. The purpose of defining and regulating river corridors is to prevent increases in man-

made conflicts that can result from development in identified river corridor areas; minimize property loss and damage due to fluvial erosion; and prohibit land-uses and development in river corridors that pose a danger to health and safety. Additionally, river corridor delineation and protection facilitates stream stability and dynamic equilibrium. By limiting conflicts between rivers and development, management actions that lead to channel instability are also limited. The basis of a river corridor is a defined area which includes the course of a river and its adjacent lands. The width of the corridor is defined by many model parameters, and may be modified to incorporate field verified data. Certain development is limited within the delineated river corridor, but corridors can be further protected by adopting development regulations at the municipality level. More information on ANR river corridor protection can be found at:
http://www.watershedmanagement.vt.gov/rivers.htm

6.3 Next Steps

There are many opportunities to restore the Seymour River watershed to a more stable condition. Proposed projects are part of a greater strategy to improve flood resiliency, water quality, and habitat in the watershed. Further, the implementation of river corridor protection is recommended to restrict future development within the river corridor, minimize damage to infrastructure during flood events, and save money on flood recovery.

Specific steps recommended following this study are as follows:

- Outreach to private landowners and the public about the plan and potential restoration and protection opportunities.
- Meetings held with project partners and landowners to prioritize projects and discuss implementation.
- Apply to funding sources for implementation grants.
- Phase 3 stream survey work where applicable for restoration projects.
- Implementation of priority projects with project partners and landowners.

For additional information about project development, please contact the Vermont River Management Program or Lamoille County Planning Commission.

In addition to site-specific projects, Cambridge can take steps to become more flood resilient. Modifying existing zoning regulations at the municipality level could protect buildings and infrastructure from future flood damage and losses. For example, new development could be restricted to outside of mapped flood hazard areas only. These communities could also participate at the highest level of the Vermont ERAF program, which can involve joining the NFIP Community Rating System.

7.0 LIST OF ACRONYMS AND GLOSSARY OF TERMS

List of Acronyms

ACCD – Agency of Commerce and Community Development
BCE – Bear Creek Environmental, LLC
CDBG – Community Development Block Grant
CREP – Conservation Reserve Enhancement Program
CRS – Community Rating System
EQIP – Environmental Quality Incentives Program
ERAF – Emergency Relief Assistance Fund
ERP – Ecosystem Restoration Program
GIS – Geographic Information System
FEMA – Federal Emergency Management Agency
LCPC – Lamoille County Planning Commission
MPG – Municipal Planning Grant
NFIP – National Flood Insurance Program
NWI – National Wetlands Inventory
QA/QC – quality assurance/quality control
RCE – ANR River Corridor Easement Program
RHA- Rapid Habitat Assessment
RGA-Rapid Geomorphic Assessment
SGA – Stream Geomorphic Assessment
SGAT – Stream Geomorphic Assessment Tool
TFS – Trees for Streams
TRORC – Two Rivers-Ottauquechee Regional Commission
TSI – Tropical Storm Irene
US ACOE – United States Army Corps of Engineers
USGS – United States Geological Survey
VANR – Vermont Agency of Natural Resources
VTDEC – Vermont Department of Environmental Conservation
VDFW _ Vermont Department of Fish and Wildlife
WHIP – Wildlife Habitat Incentives Program
WRP – Wetland Reserve Program

Glossary of Terms

Adapted from:
Restoration Terms, by Craig Fischenich, February, 2000, USAE Research and Development Center, Environmental Laboratory, 3909 Halls Ferry Rd., Vicksburg, MS 39180
And
Vermont Stream Geomorphic Assessment Handbook, Appendix Q, 2009, VT Agency of Natural Resources, Waterbury, VT.
http://www.vtwaterquality.org/rivers/docs/assessmenthandbooks/rv_apxqglossary.pdf

Adjustment Process – type of change that is underway due to natural causes or human activity that has or will result in a change to the valley, floodplain, and/or channel condition (e.g., vertical, lateral, or channel plan form adjustment processes).

Aggradation - A progressive buildup or rising of the channel bed and floodplain due to sediment deposition. The geologic process by which streambeds are raised in elevation and floodplains are formed. Aggradation indicates that the stream discharge and/or bed load characteristics are changing. Opposite of degradation.

Alluvial Fan – A fan-shaped accumulation of alluvium (alluvial soils) deposited at the mouth of a ravine or at the juncture of a tributary stream with the main stem where there is an abrupt change in slope.

Alluvial Soils – Soil deposits from rivers.

Alluvium – A general term for detrital deposits made by streams on riverbeds, floodplains, and alluvial fans.

Avulsion – A change in channel course that occurs when a stream suddenly breaks through its banks, typically bisecting an overextended meander arc.

Bank Stability – The ability of a stream bank to counteract erosion or gravity forces.

Bankfull Channel Depth - The maximum depth of a channel within a riffle segment when flowing at a bankfull discharge.

Bankfull Channel Width - The top surface width of a stream channel when flowing at a bankfull discharge.

Bankfull Discharge - The stream discharge corresponding to the water stage that overtops the natural banks. This flow occurs, on average, about once every 1 to 2 years and given its frequency and magnitude is responsible for the shaping of most stream or river channels.

Bar – An accumulation of alluvium (usually gravel or sand) caused by a decrease in sediment transport capacity on the inside of meander bends or in the center of an over wide channel.

Berms – Mounds of dirt, earth, gravel or other fill built parallel to the stream banks designed to keep flood flows from entering the adjacent floodplain.

Bifurcated Channel – a river channel that has split into two branches as a result of planform adjustment (i.e. split flow due to island).

Boundary Conditions – Factors that are acting upon a stream and preventing adjustment (e.g. bank armoring prevents channel widening).

Cascade – River bed form where the channel is very steep with narrow confinement. There are often large boulders and bedrock with waterfalls.

Channelization – The process of changing (usually straightening) the natural path of a waterway.

Confluence – The location where two streams flow together.

Culvert – A buried pipe that allows flows to pass under a road.

Degradation – (1) A progressive lowering of the channel bed due to scour. Degradation is an indicator that the stream's discharge and/or sediment load is changing. The opposite of aggradation. (2) A decrease in value for a designated use.

Delta Bar – A deposit of sediment where a tributary enters the main stem of a river.

Depositional Features – Types of sediment deposition and storage areas in a channel (e.g. mid-channel bars, point bars, side bars, diagonal bars, delta bars, and islands).

Diagonal Bar – Type of depositional feature perpendicular to the bank that is formed from excess sedimentation and within the channel and from the development of steep riffles.

Drainage Basin – The total area of land from which water drains into a specific river.

Dredging – Removing material (usually sediments) from wetlands or waterways, usually to make them deeper or wider.

Erosion – The wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.

Flood Resiliency – The ability to withstand and recover from flooding and associated damages.

Floodplain – Land built of sediment that is regularly covered with water as a result of the flooding of a nearby stream.

Floodprone Width – the wetted width of the channel when the water level is twice the maximum bankfull depth. For most channels this is associated with less than a 50 year return period (Rosgen, 1996).

Fluvial Erosion – Erosive forces created by flowing water.

Fluvial Geomorphology – the physics of flowing water, sediments, and other products of watersheds in relation to various land forms.

Gaging Station – A particular site in a stream, lake, reservoir, etc., where hydrologic data are obtained.

Grade Control - A fixed feature on the streambed that controls the bed elevation at that point, effectively fixing the bed elevation from potential incision; typically bedrock, dams or culverts.

Gradient – Vertical drop per unit of horizontal distance.

Habitat – The local environment in which organisms normally grow and live.

Headwater – Referring to the source of a stream or river.

Headcut – Sudden change in elevation or knickpoint on a streambed. Headcutting is the process by which a streambed lowers as headcuts migrate upstream.

Inundation Flooding – Submersion of low-lying areas surrounding a stream by slowly flowing or standing water.

Incised River – A river that erodes its channel by the process of degradation to a lower base level than existed previously or is consistent with the current hydrology.

Islands – Mid-channel bars that are above the average water level and have established woody vegetation.

Lacustrine Soils- Soil deposits from lakes.

Mass Failure – A landslide that has occurred adjacent to a stream and on its valley wall. Involves mass slumping of land down the valley wall.

Meander - The winding of a stream channel, usually in an erodible alluvial valley. A series of sine-generated curves characterized by curved flow and alternating banks and shoals.

Meander Migration – The change of course or movement of a channel. The movement of a channel over time is natural in most alluvial systems. The rate of movement may be increased if the stream is out of balance with its watershed inputs.

Meander Belt Width – The horizontal distance between the opposite outside banks of fully developed meanders determined by extending two lines (one on each side of the channel) parallel to the valley from the lateral extent of each meander bend along both sides of the channel.

Meander Wavelength - The lineal distance downvalley between two corresponding points of successive meanders of the same phase.

Meander Wavelength Ratio – The meander wavelength divided by the bankfull channel width.

Meander Width Ratio – The meander belt width divided by the bankfull channel width.

Mid-Channel Bar – Sediment deposits (bar) located in the channel away from the banks, generally found in areas where the channel runs straight. Mid-channel bars caused by recent channel instability are unvegetated.

Neck Cutoff – This is the occurrence of an avulsion on the inside of a very long and tight meander.

Planform - The channel shape as if observed from the air. Changes in planform often involve shifts in large amount of sediment, bank erosion, or the migration of the channel.

Plane Bed – Channel lacks discrete bed features (such as pools, riffles, and point bars) and may have long stretches of featureless bed.

Point Bar –The convex side of a meander bend that is built up due to sediment deposition.

Pool -- A habitat feature (section of stream) that is characterized by deep, low-velocity water and a smooth surface.

Reach - Section of river with similar characteristics such as slope, confinement (valley width), and tributary influence.

Restoration – The return of an ecosystem to a close approximation of its condition prior to disturbance.

Riffle - A habitat feature (section of stream) that is characterized by shallow, fast-moving water broken by the presence of rocks and boulders.

Riffle-pool - Channel has undulating bed that defines a sequence of riffles, runs, pools, and point bars. Occurs in moderate to low gradient and moderately sinuous channels, generally in unconfined valleys with well-established floodplains.

Riparian Buffer – The width of naturally vegetated land adjacent to the stream between the top of the bank and the edge of other land-uses. A buffer is largely undisturbed and consists of the trees, shrubs, groundcover plants, duff layer, and naturally uneven ground surface.

Riparian Corridor – Lands defined by the lateral extent of a stream's meanders necessary to maintain a stable stream dimension, pattern, profile, and sediment regime.

Segment – A relatively homogeneous section of stream contained within a reach that has the same reference stream characteristics but is distinct from other segments in the reach.

Sensitivity – The valley, floodplain and/or channel condition's likelihood to change due to natural causes and/or anticipated human activity.

Side Bar – Unvegetated sediment deposits located along the margins or the channel in locations other than the inside of channel meander bends.

Step-Pool – Characterized by longitudinal steps formed by large particles (boulder/cobbles) organized into discrete channel-spanning accumulations that separate pools, which contain smaller sized materials. Often associated with steep channels in confined valleys.

Steep Riffle – Associated with aggradation where sediment has dropped out to form a steep face of sediment on the downstream side.

Surficial Sediment/Geology – Sediment that lies on top of bedrock.

Tributary – A stream that flows into another stream, river, or lake.

Tributary Rejuvenation – As the bed of the main stem is lowered, head cuts (incision) begin at the mouth of the tributary and move upstream.

Urban Runoff – Storm water from city streets and gutters that usually carries a great deal of litter and organic and bacterial wastes into the receiving waters.

Valley Wall – The edge of a river valley where the slope of the land increases and a stream is unlikely to ever flow beyond.

8.0 REFERENCES

2015. Cambridge Local Hazard Mitigation Plan. Available at: http://www.lcpcvt.org/vertical/sites/%7B3C01460C-7F49-40F5-B243-0CA7924F23AF%7D/uploads/Cambridget_VT_Hazard_Mitigation_Plan_06-09-15_DEMHS.pdf

Federal Emergency Management Agency. 2014. Hazard Mitigation Assistance – Property Acquisition (Buyouts). Available at: https://www.fema.gov/application-development-process/hazard-mitigation-assistance-property-acquisition-buyouts

Federal Emergency Management Agency. 2017. Community Rating System Fact Sheet. Available at: https://www.fema.gov/media-library-data/1507029324530-082938e6607d4d9eba4004890dbad39c/NFIP_CRS_Fact_Sheet_2017_508OK.pdf

Milone & MacBroom, Inc. 2008. The Vermont Culvert Geomorphic Compatibility Screening Tool. South Burlington, Vermont.

Montgomery, David and Buffington, John. 1997. Channel Reach Morphology in Mountain Basins. GSA Bulletin. Boulder, Colorado.

Rosgen, Dave. 1996. Applied River Morphology. Pagosa Springs, Colorado.

Ryan, J. 2001. Stream Stability Assessment of Lamoille County, Vermont. Washington, Vermont.

State of Vermont, 2015. Emergency Relief and Assistance Fund. Flood Ready Vermont. Available at: http://floodready.vermont.gov/find_funding/emergency_relief_assistance

Thompson, Elizabeth and Sorenson, Eric. 2000. Wetland, Woodland, Wildland: A Guide to the Natural Communities of Vermont. Montpelier, Vermont.

United States Geological Survey. 2018. Lamoille River at Johnson, VT. Accessed in February 2018 and available at http://waterdata.usgs.gov/nh/nwis/current/?type=flow

Vermont Agency of Commerce and Community Development. 2015. Municipal Planning Grants FY 2015. Department of Housing and Community Development. Available at: http://accd.vermont.gov/sites/accd/files/Documents/strongcommunities/cd/mpg/MPG_Overview_FY15.pdf

Vermont Agency of Natural Resources. 2004. Appendix C, Channel Evolution Models. DEC River Management Program. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2007. Vermont Stream Geomorphic Assessment Phase 1 Handbook: Watershed Assessment Using Maps, Existing Data, and Windshield Surveys. DEC River Management Program. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2008. Draft Instructions for the Vermont Rapid Habitat Assessment (RHA). DEC River Management Program. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2009a. Appendix G, Bridge and Culvert Assessment. DEC River Management Program. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2009b. Vermont Agency of Natural Resources Phase 2 Handbook, Rapid Stream Assessment Field Protocols. DEC River Management Program. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2010a. Vermont Agency of Natural Resources River Corridor Planning Guide to Identify and Develop River Corridor Protection and Restoration Projects. DEC River Management Program. Waterbury, Vermont.

Vermont Agency of Natural Resources. 2010b. Municipal Guide to Fluvial Erosion Hazard Mitigation. DEC River Management Program. Waterbury, Vermont

Vermont Agency of Natural Resources. 2016. Lamoille 2016 Tactical Basin Plan. Available at: http://dec.vermont.gov/sites/dec/files/wsm/mapp/docs/2016-12-30_Lamoille_Tactical_Plan_FINAL.pdf

Vermont Department of Environmental Conservation (VDEC). 2016. State of Vermont 2016 Stressed Waters List. Available at: http://dec.vermont.gov/sites/dec/files/wsm/public-notices/mapp/Stressed_2016_draft_complete.pdf

APPENDIX A

Bridge & Culvert Assessment Data

Table 1. Scoring Table
(Vermont Culvert Geomorphic Compatibility Screen Tool, adapted by BCE for bridges)

Score	% Bankfull Width	Sediment Continuity	Approach Angle	Erosion and Armoring
5	%BFW ≥ 120	No upstream deposition or downstream bed scour	Naturally Straight	No erosion **or** armoring
4	100 ≤ %BFW < 120	**Either** upstream deposition **or** downstream bed scour, **without** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	n/a	No erosion **and** intact armoring, **or** low upstream **or** downstream erosion **without** armoring
3	75 ≤ %BFW < 100	**Either** upstream deposition **or** downstream bed scour, **with** either upstream deposits taller than 0.5 bankfull height **or** high downstream banks	Mild bend	Low upstream **or** downstream erosion **with** armoring
2	50 ≤ %BFW < 75	**Both** upstream deposition **and** downstream bed scour, **without** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	Channelized Straight	Low upstream **and** downstream erosion
1	30 ≤ %BFW < 50	**Both** upstream deposition **and** downstream bed scour, **with** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	n/a	Severe upstream **or** downstream erosion
0	%BFW < 30	**Both** upstream deposition **and** downstream bed scour, **with** upstream deposits taller than 0.5 bankfull height **and** high downstream banks	Sharp Bend	Severe upstream **and** downstream erosion, **or** failing armoring upstream **or** downstream

Table 2. Compatibility Rating Results
(Vermont Culvert Geomorphic Compatibility Screen Tool, adapted by BCE for bridges)

Category Name	Screen Score	Threshold Conditions	Description of Structure-channel Geomorphic Compatibility
Fully Compatible	16<GC≤20	n/a	Structure fully compatible with natural channel form and process. There is a low risk of failure. No replacement anticipated over the lifetime of the structure. A similar structure is recommended when replacement is needed.
Mostly Compatible	12<GC≤16	n/a	Structure mostly compatible with current channel form and process. There is a low risk of failure. No replacement anticipated over the lifetime of the structure. Minor design adjustments recommended when replacement is needed to make fully compatible.
Partially Compatible	8<GC≤12	n/a	Structure compatible with either current form or process, but not both. Compatibility likely short term. There is a moderate risk of structure failure and replacement may be needed. Re-design suggested to improve geomorphic compatibility.
Mostly Incompatible	4<GC≤8	% Bankfull Width + Approach Angle scores ≤ 2	Structure mostly incompatible with current form and process, with a moderate to high risk of structure failure. Re-design and replacement planning should be initiated to improve geomorphic compatibility.
Fully Incompatible	0≤GC≤4	% Bankfull Width + Approach Angle scores ≤ 2 **AND** Sediment Continuity + Erosion and Armoring scores ≤ 2	Structure fully incompatible with channel and high risk of failure. Re-design and replacement should be performed as soon as possible to improve geomorphic compatibility.

Table 3. Scoring Table Vermont Culvert Geomorphic Compatibility Screen Tool (Milone & MacBroom, 2008)					
Score	**% Bankfull Width**	**Sediment Continuity**	**Slope**	**Approach Angle**	**Erosion and Armoring**
5	%BFW ≥ 120	No upstream deposition or downstream bed scour	Structure slope equal to channel slope, and no break in valley slope	Naturally Straight	No erosion **or** armoring
4	100 ≤ %BFW < 120	**Either** upstream deposition **or** downstream bed scour, **without** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	n/a	n/a	No erosion **and** intact armoring, **or** low upstream **or** downstream erosion **without** armoring
3	75 ≤ %BFW < 100	**Either** upstream deposition **or** downstream bed scour, **with** either upstream deposits taller than 0.5 bankfull height **or** high downstream banks	Structure slope equal channel slope, with local break in valley slope	Mild bend	Low upstream **or** downstream erosion **with** armoring
2	50 ≤ %BFW < 75	**Both** upstream deposition **and** downstream bed scour, **without** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	Structure slope higher or lower than channel slope, and no break in valley slope	Channelized Straight	Low upstream **and** downstream erosion
1	30 ≤ %BFW < 50	**Both** upstream deposition **and** downstream bed scour, **with** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	n/a	n/a	Severe upstream **or** downstream erosion
0	%BFW < 30	**Both** upstream deposition **and** downstream bed scour, **with** upstream deposits taller than 0.5 bankfull height **and** high downstream banks	Structure slope higher or lower than channel slope, with local break in valley slope	Sharp Bend	Severe upstream **and** downstream erosion, **or** failing armoring upstream **or** downstream

Table 4. Geomorphic Compatibility Rating Results Vermont Culvert Geomorphic Compatibility Screen Tool (Milone & MacBroom, 2008)			
Category Name	**Screen Score**	**Threshold Conditions**	**Description of Structure-channel Geomorphic Compatibility**
Fully Compatible	20<GC≤25	n/a	Structure fully compatible with natural channel form and process. There is a low risk of failure. No replacement anticipated over the lifetime of the structure. A similar structure is recommended when replacement is needed.
Mostly Compatible	15<GC≤20	n/a	Structure mostly compatible with current channel form and process. There is a low risk of failure. No replacement anticipated over the lifetime of the structure. Minor design adjustments recommended when replacement is needed to make fully compatible.
Partially Compatible	10<GC≤15	n/a	Structure compatible with either current form or process, but not both. Compatibility likely short term. There is a moderate risk of structure failure and replacement may be needed. Re-design suggested to improve geomorphic compatibility.
Mostly Incompatible	5<GC≤10	% Bankfull Width + Approach Angle scores ≤ 2	Structure mostly incompatible with current form and process, with a moderate to high risk of structure failure. Re-design and replacement planning should be initiated to improve geomorphic compatibility.
Fully Incompatible	0≤GC≤5	% Bankfull Width + Approach Angle scores ≤ 2 **AND** Sediment Continuity + Erosion and Armoring scores ≤ 2	Structure fully incompatible with channel and high risk of failure. Re-design and replacement should be performed as soon as possible to improve geomorphic compatibility.

Table 5. Aquatic Organism Passage (AOP) Coarse Screen Tool
(Milone & MacBroom, 2009)

VT Aquatic Organism Passage Coarse Screen	Full AOP	Reduced AOP	No AOP			
Updated 2/25/2008	**for all aquatic organisms**	**for all aquatic organisms**	**for all aquatic organisms except adult salmonids**		**for all aquatic organisms including adult salmonids**	
AOP Function Variables / Values	**Green (if all are true)**	**Gray (if any are true)**	**Orange**		**Red**	
Culvert outlet invert type	at grade **OR** backwatered	cascade	free fall **AND**		free fall **AND**	
Outlet drop (ft)	= 0		> 0 $_{1}$ < 1 ft **OR**		≥ 1 ft **OR**	
Downstream pool present			= yes	(= yes **AND**	= no **OR**	(= yes **AND**
Downstream pool entrance depth / outlet drop			n/m	≥ 1)	n/a	< 1) **OR**
Water depth in culvert at outlet (ft)					< 0.3 ft	
Number of culverts at crossing	1	> 1				
Structure opening partially obstructed	= none	≠ none				
Sediment throughout structure	yes	no				

Notes:
Assessment completed during low flows
Outlet drop = invert of structure to water surface
Pool present variable is used alone if pool depths are not measured
n/m = not measured
n/a = not applicable

Table 6. Seymour River Watershed Phase 2 Bridge Assessment
Geomorphic Compatibility

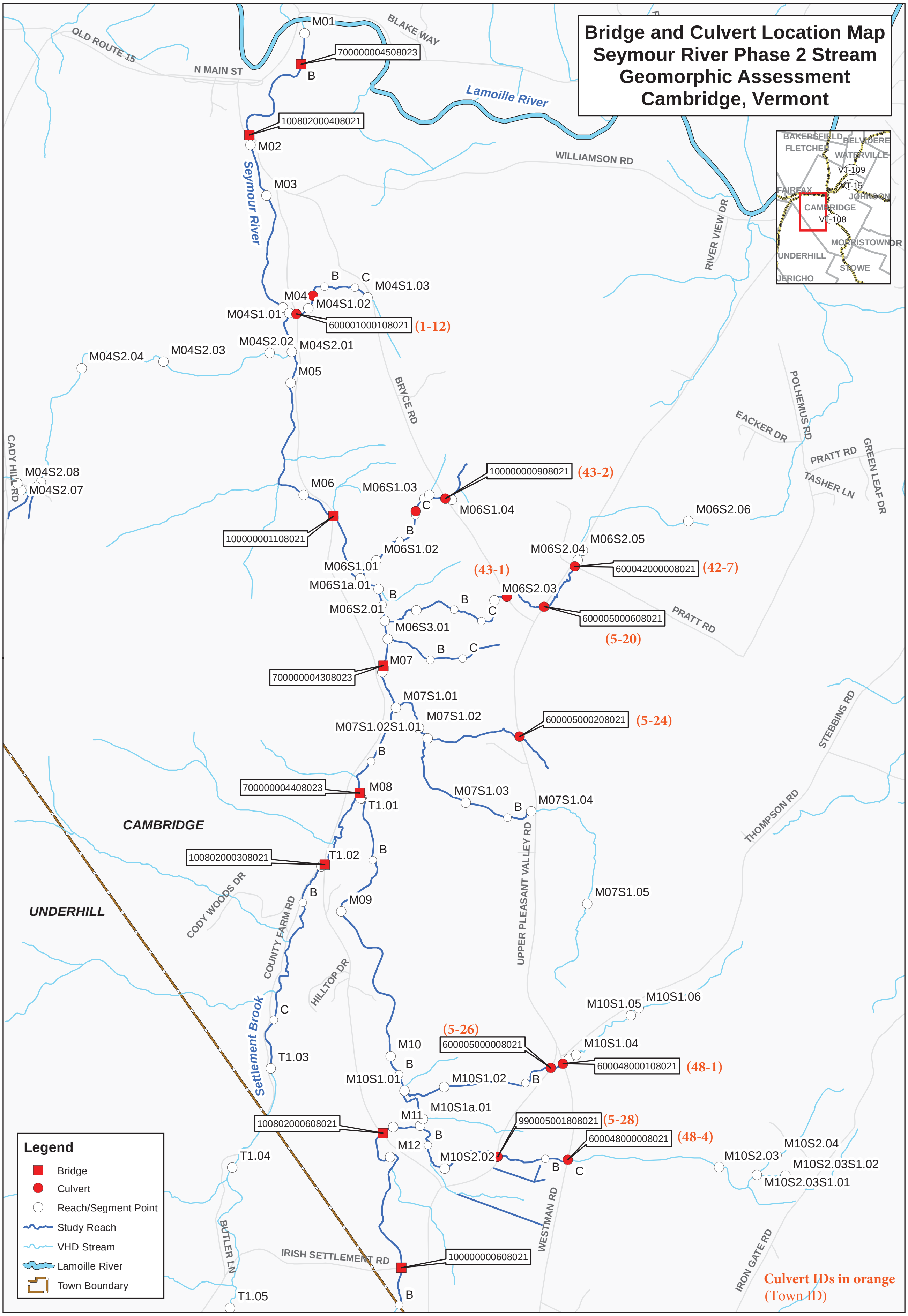
Reach/ Segment Number	Town	Road Name	Structure ID[1]	Percent Bankfull Channel Constriction Width[2]	Phase 2 Notes	Scoring						Priority for Replacement
						% Bankfull Width[3]	Sediment Continuity	Approach Angle	Erosion & Armoring	Total Score	Geomorphic Compatibility	
M01-A	Cambridge	Private Trail	700000004508023	81/51.6 = 157	Gates Covered Bridge. Connects two agricultural fields. Scour along right abutment, otherwise minimal issues.	5	4	3	0	**12**	Partially Compatible	Not recommended for replacement (Well-sized, minimal issues, historic covered bridge)
M01-B	Cambridge	Mansfield Avenue	100802000408021	54/51.6 = 105	Built in 2003; riprap within structure creating constriction of 30 feet.	4	4	2	1	**11**	Partially Compatible	Not recommended for replacement (Well-sized, few issues with structure)
M06-A	Cambridge	Lower Pleasant Valley Road	100000001108021	60/49.2 = 122	Newer looking structure in good condition. Downstream scour may be related to bedrock in the channel and not due to the bridge.	5	4	0	3	**12**	Partially Compatible	Not recommended for replacement (Structure appears to be relatively new and is in good condition)
M06-B	Cambridge	Private Trail	700000004308023	31.5/49.2 = 64	Private bridge for access to agricultural lands. Significant scour/undermining of right abutment, some scour of left abutment near toe.	2	4	5	0	**11**	Partially Compatible	Moderate (Undersized and scour issues with abutments, but causing minimal instream issues)
M07-B	Cambridge	Private Trail	700000004408023	40.5/47.9 = 85	Farm bridge for accessing agricultural lands. Bridge deteriorating, riprap failing, poor condition.	3	2	5	0	**10**	Partially Compatible	**High** (Undersized and in poor condition)
M11	Cambridge	Lower Pleasant Valley Road	100802000608021	66/36.5 = 181	Located at a transition from bedrock gorge to lower slope section of the river. Bridge built on bedrock very high up; some scour along left abutment.	5	4	5	3	**16**	Mostly Compatible	Not recommended for replacement (Appropriately sized and with few issues)
M12-A	Cambridge	Irish Settlement Road	100000000608021	54/36.5 = 148	Bridge built in 2015, well-sized, no issues.	5	4	3	3	**15**	Mostly Compatible	Not recommended for replacement (New structure with no issues noted)
T1.01	Cambridge	Lower Pleasant Valley Road	100802000308021	24/27.8 = 86	Structure built in June 1999; scour above structure; boulder weir above structure on streambed protecting structure.	3	5	2	4	**14**	Mostly Compatible	Low (Evidence of scour issues at inlet of structure, slightly undersized)

[1]The structure ID is the identification number provided by the 2010 "TransStructures_TRANSTRUC" shapefile from the Vermont Center for Geographic Information, unless no number was available. In this case, the SGAID is provided.
[2]Percent Bankfull Channel Width percentages are calculated based on the reference channel width for each reach. The percentage is calculated by dividing the present constriction width by the reference channel width.
[3]The % bankfull width is based on the constriction calculation.

Table 7. Seymour River Watershed Phase 2 Culvert Assessment Geomorphic Compatibility and Aquatic Organism Passage (AOP)														
Reach/ Segment Number	Road Name	Structure Type and ID[1]	Percent Bankfull Channel Width[2]	Phase 2 Notes	Scoring (Geomorphic Compatibility - Milone & MacBroom, 2008; AOP – Milone & MacBroom, 2009)									Priority for Replacement
					% Bankfull Width	Sediment Continuity	Slope	Approach Angle	Erosion & Armoring	Total Score	Geomorphic Compatibility	AOP	
M04S1.01	Lower Pleasant Valley Road	600001000108021[3]	3.1/4.7 = 66	Free fall at outlet; scour below culvert.	2	2	5	0	0	**9**	Mostly Incompatible	No AOP Including Adult Salmonids[4]	**High** (Undersized and free fall at outlet)
M06S1.03	Bryce Road	100000000908021	4.3/5.8 = 74	Free fall at outlet; cobble/boulder material added to streambed below culvert.	2	5	2	0	3	**12**	Partially Compatible	No AOP Including Adult Salmonids[4]	**High** (Undersized and free fall at outlet)
M06S2.03	Bryce Road	990043000708021[3]	5.1/9.2 = 55	Concrete box culvert with free fall at outlet.	2	4	2	5	0	**13**	Partially Compatible	No AOP Including Adult Salmonids	**High** (Undersized and free fall at outlet)
M06S2.03	Upper Pleasant Valley Road	600005000608021[3]	4.1/9.2 = 45	Downstream end of pipe corroding; water exits pipe 3 feet upstream of outlet.	1	2	5	3	2	**13**	Partially Compatible	Reduced AOP	Moderate (Outlet at grade but pipe is rusting out)
M06S2.03	Pratt Road	600042000008021[3]	4/9.2 = 43	Pond just upstream and downstream. Pipe corroded at outlet. At grade.	1	2	5	2	1	**11**	Partially Compatible	Reduced AOP	Moderate (Outlet at grade but pipe is rusting out)
M07S1.02S1.01	Upper Pleasant Valley Road	600005000208021[3]	3.1/4.6 = 67	Plastic corrugated pipe; at grade.	2	4	5	3	1	**15**	Partially Compatible	Reduced AOP[4]	Low (At grade, no note of structural issues)
M10S1.02-B	Upper Pleasant Valley Road	600005000008021[3]	5/10.3 = 49	Steel corrugated pipe with free fall outlet and scour below.	1	2	5	5	0	**13**	Partially Compatible	No AOP Including Adult Salmonids	**High** (Significantly undersized, free fall outlet)
M10S1.02-B	Westman Road	600048000108021[3]	5.1/10.3= 49.5	Steel corrugated pipe with free fall outlet.	1	2	5	0	1	**9**	Mostly Incompatible	No AOP Including Adult Salmonids	**High** (Significantly undersized, free fall outlet)
M10S2.02-A	Upper Pleasant Valley Road	990005001808021[3]	6.5/9.8 = 66	Steel corrugated pipe; at grade. Bottom of culvert is corroded at outlet and water exits pipe 15 feet before end of structure.	2	2	2	0	1	**7**	Mostly Incompatible	Reduced AOP	**High** (Undersized and rusting out)

Table 7. Seymour River Watershed Phase 2 Culvert Assessment Geomorphic Compatibility and Aquatic Organism Passage (AOP)														
Reach/ Segment Number	Road Name	Structure Type and ID[1]	Percent Bankfull Channel Width[2]	Phase 2 Notes	Scoring (Geomorphic Compatibility - Milone & MacBroom, 2008; AOP – Milone & MacBroom, 2009)								Priority for Replacement
					% Bankfull Width	Sediment Continuity	Slope	Approach Angle	Erosion & Armoring	Total Score	Geomorphic Compatibility	AOP	
M10S2.02-B	Westman Road	600048000008021[3]	4.2/9.8 = 43	Steel corrugated pipe with cascade at outlet. Inlet obstructed by wood debris and sediment.	1	3	2	5	0	**11**	Partially Compatible	Reduced AOP	**High** (Significantly undersized, issues with obstruction, cascade at outlet)

[1]The structure ID is the identification number provided by the 2010 "TransStructures_TRANSTRUC" shapefile from the Vermont Center for Geographic Information, unless no number was available. In this case the SGAID is provided.
[2]Percent Bankfull Channel Width percentages are calculated based on the reference channel width for each reach. The percentage is calculated by dividing the culvert width by the reference channel width.
[3]Culvert was assessed in 2012 as part of a larger culvert assessment project. Data for these structures were not collected by Bear Creek Environmental.
[4]Drainage area for this reach is less than 0.25 square miles. It is unlikely fish would be moving through this section of stream.



Data sources include:
Vermont Agency of Natural Resources
Vermont Center for Geographic Information
Lamoille County Planning Commission
Bear Creek Environmental

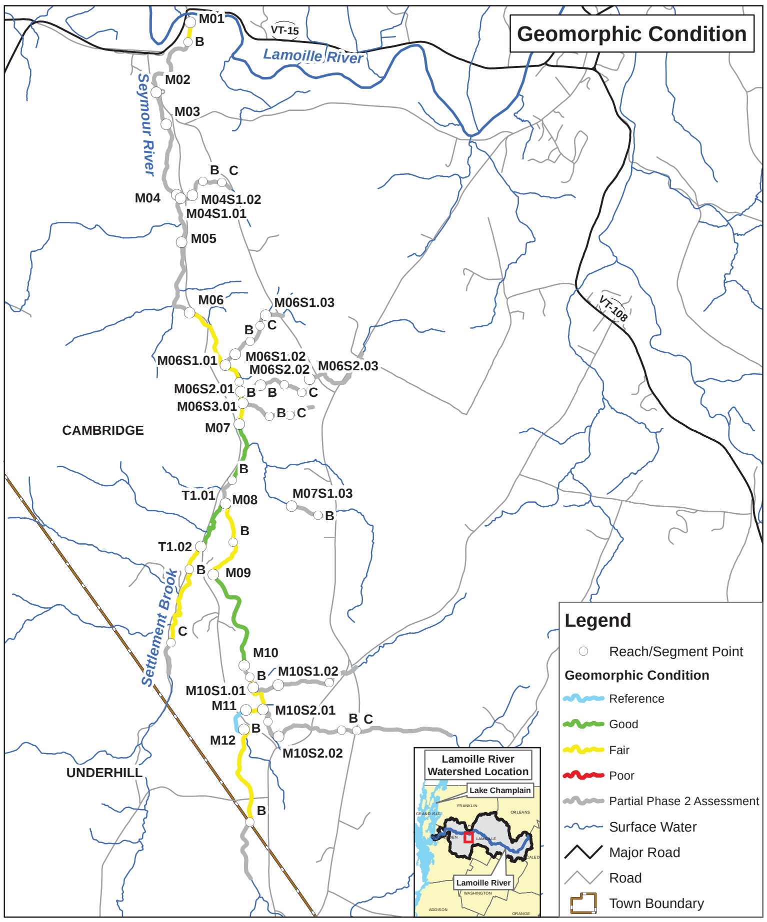
Structure ID Numbers are from the VTrans structure data layer on the ANR Atlas unless no number was available. In this case, the SGA ID is provided. Three structures do not have ID numbers due to not being fully assessed. Map composed on April 19, 2018.

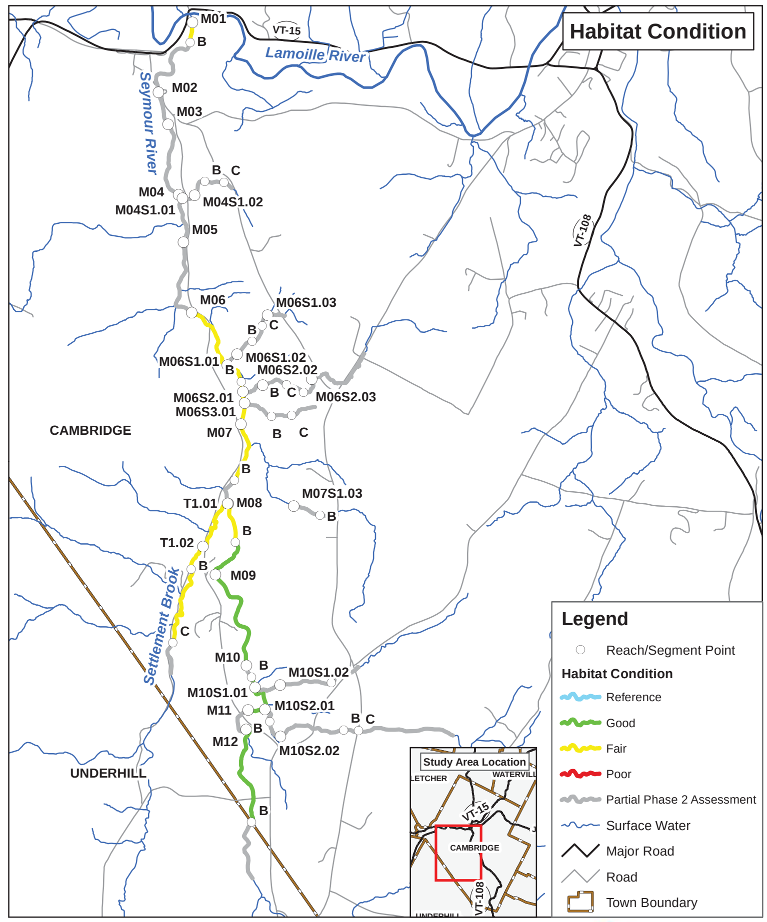
N
1 inch = 1,500 feet
0 1,500 3,000 Feet

Bear Creek Environmental

APPENDIX B

Maps





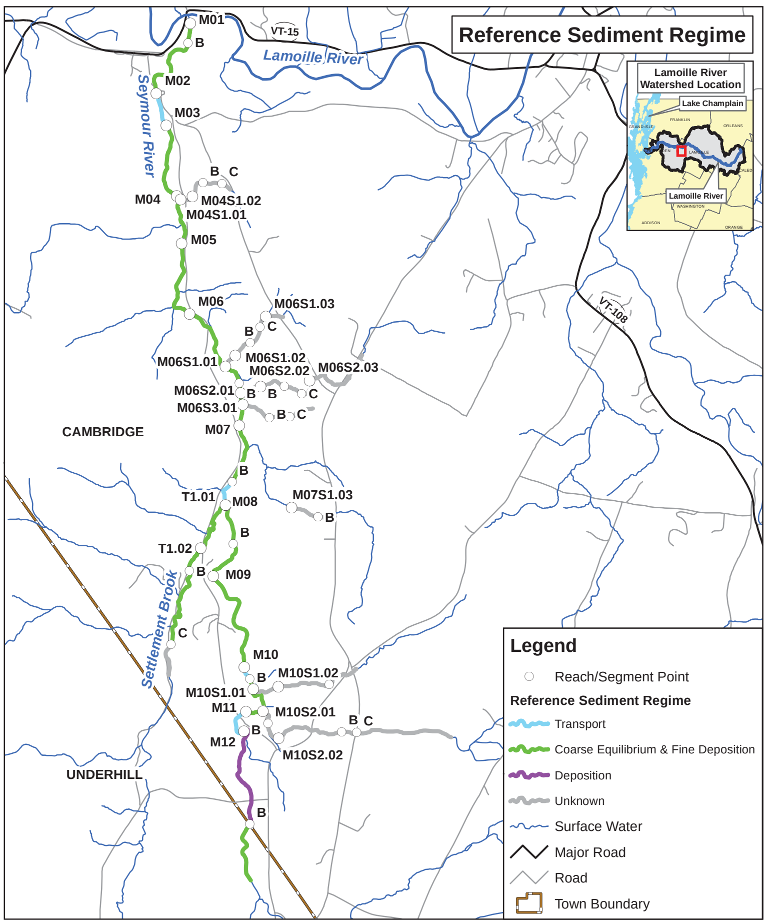
Seymour River Watershed
Stream Condition
Cambridge, Vermont

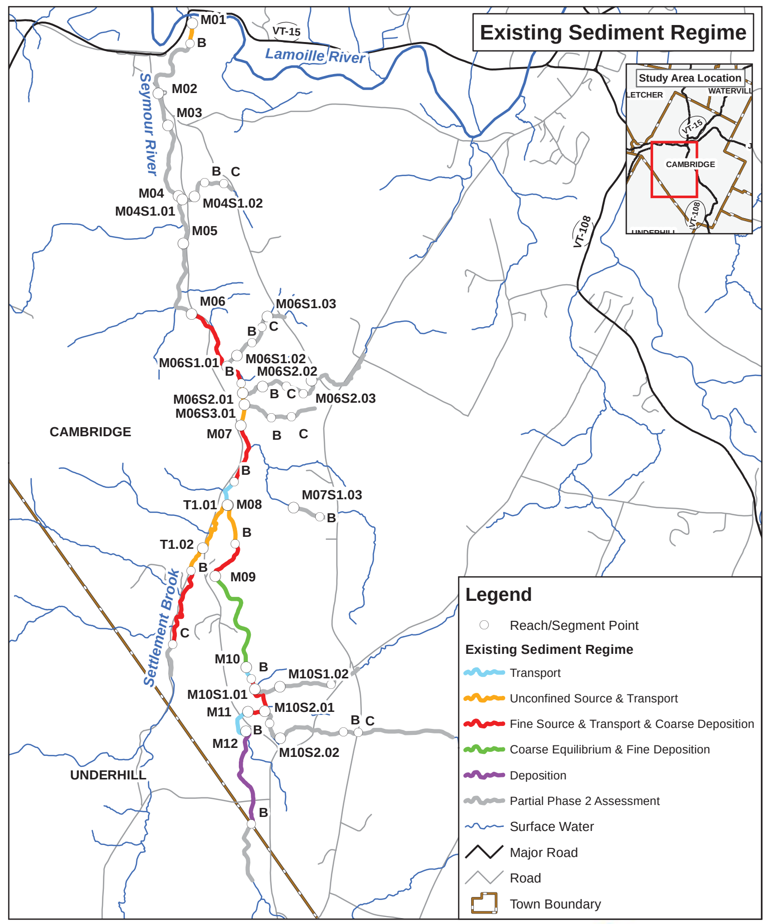
0 0.75 1.5 Miles

N

Bear Creek Environmental

1





Seymour River Watershed Sediment Regime Cambridge, Vermont

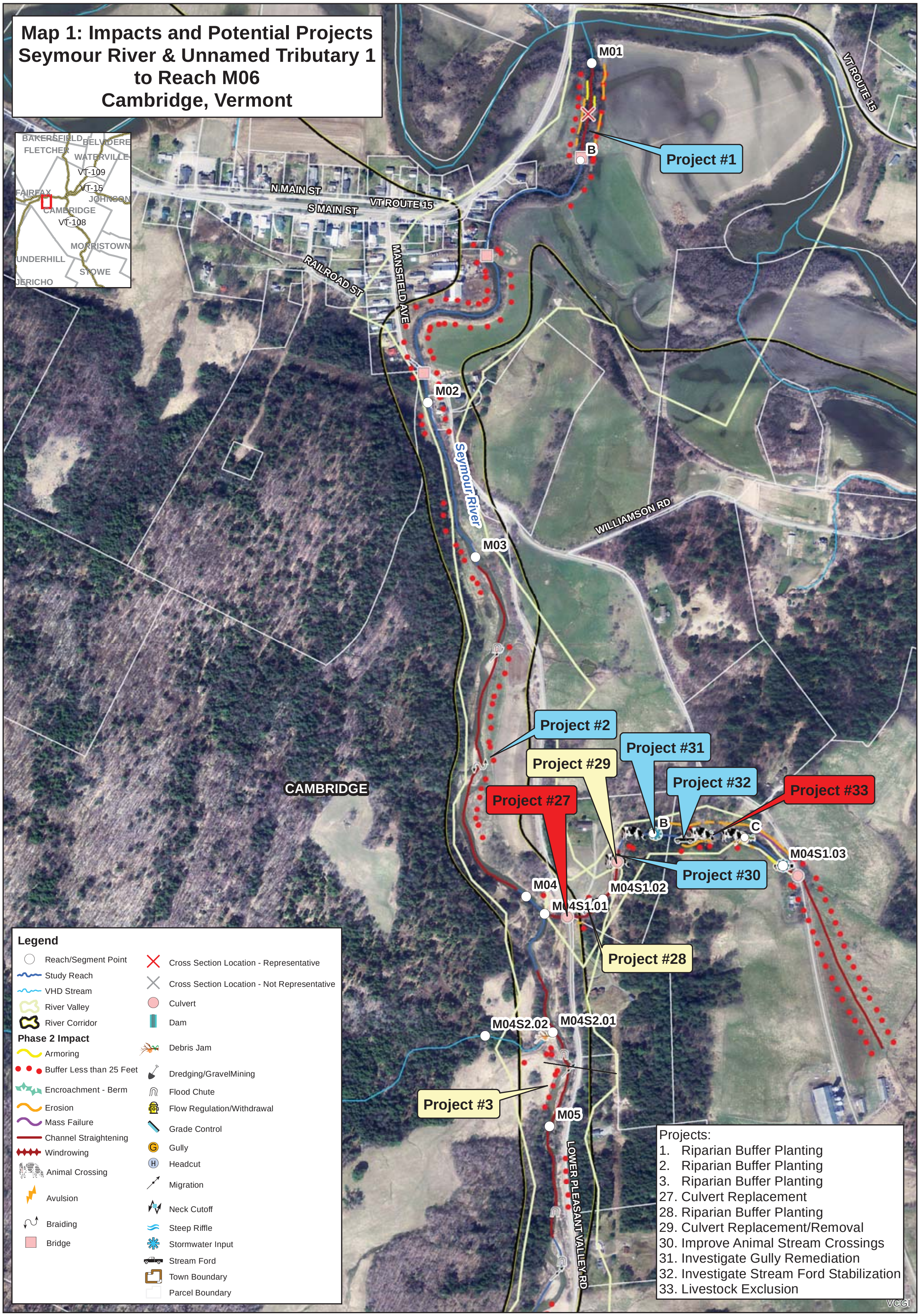
0 0.75 1.5 Miles

N

Bear Creek Environmental

APPENDIX C

Potential Project Locations & Descriptions



Data sources include:
Vermont Agency of Natural Resources
Vermont Center for Geographic Information
Lamoille County Planning Commission
Bear Creek Environmental
Map composed 3/21/18. Revised 5/31/18.

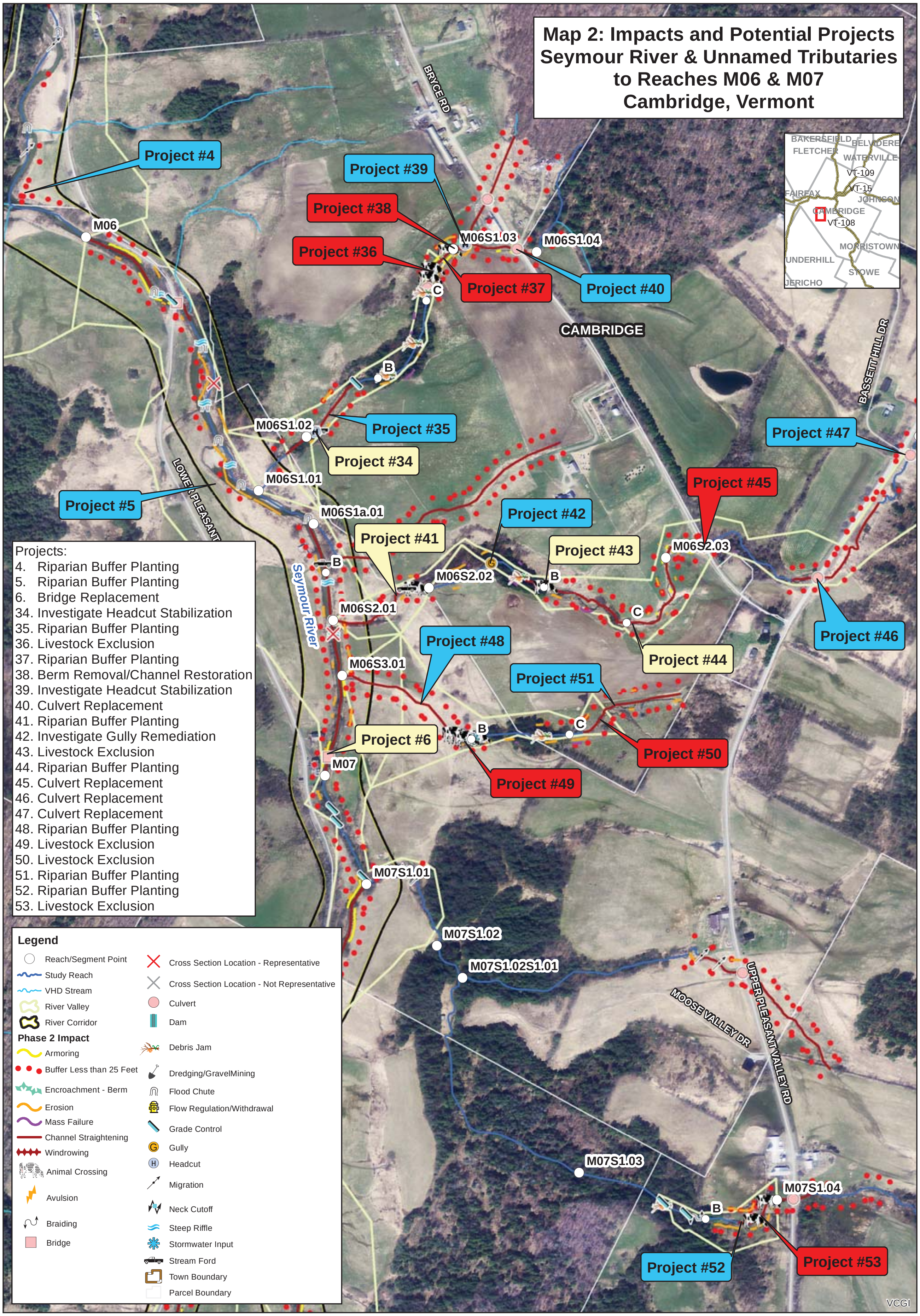
Project Priority:
Low
Moderate
High

N

1 inch = 500 feet

0 500 1,000 Feet

Bear Creek Environmental



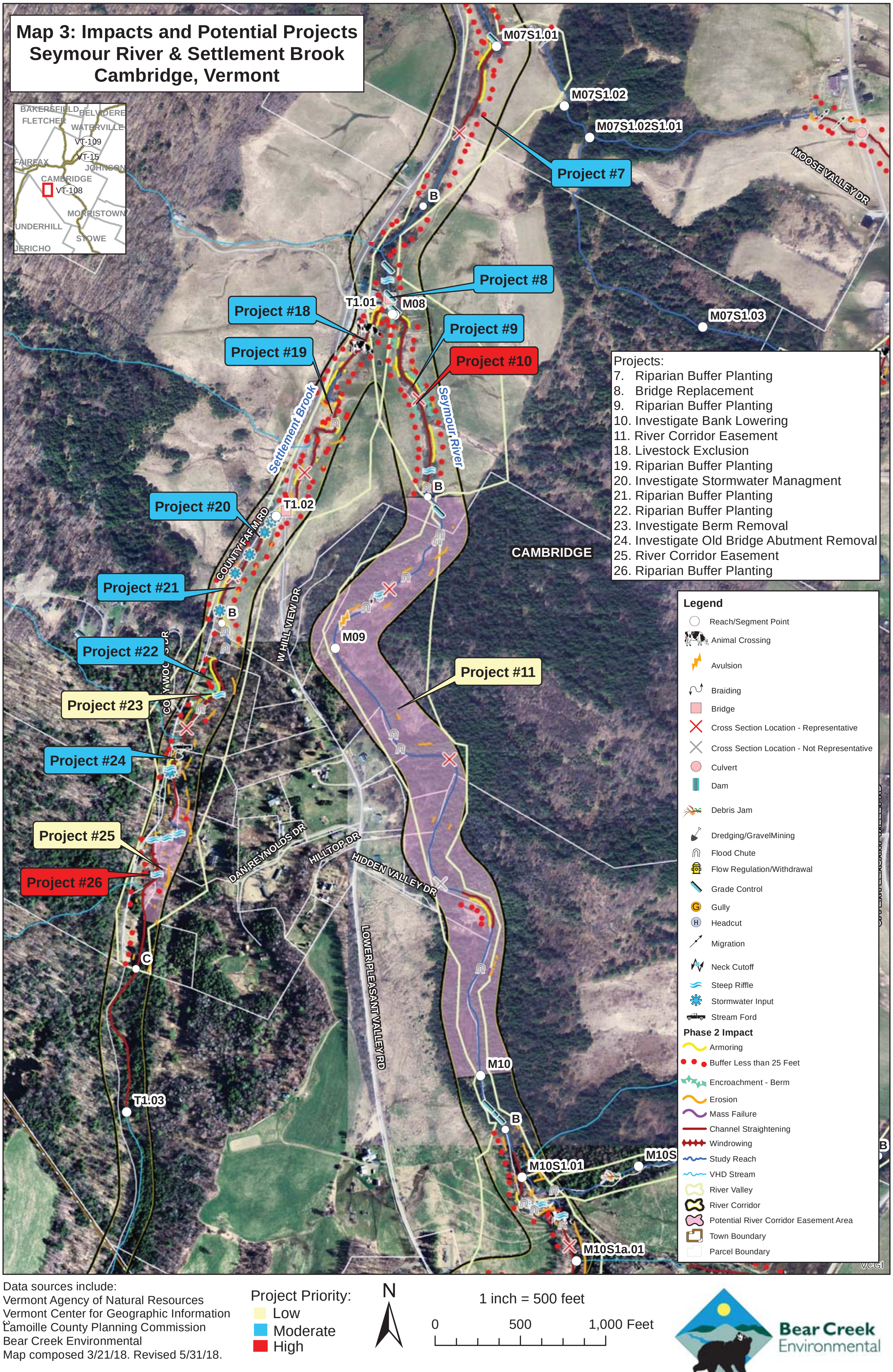
Data sources include:
Vermont Agency of Natural Resources
Vermont Center for Geographic Information
Lamoille County Planning Commission
Bear Creek Environmental
Map composed 3/21/18. Revised 5/31/18.

Project Priority:
Low
Moderate
High

N

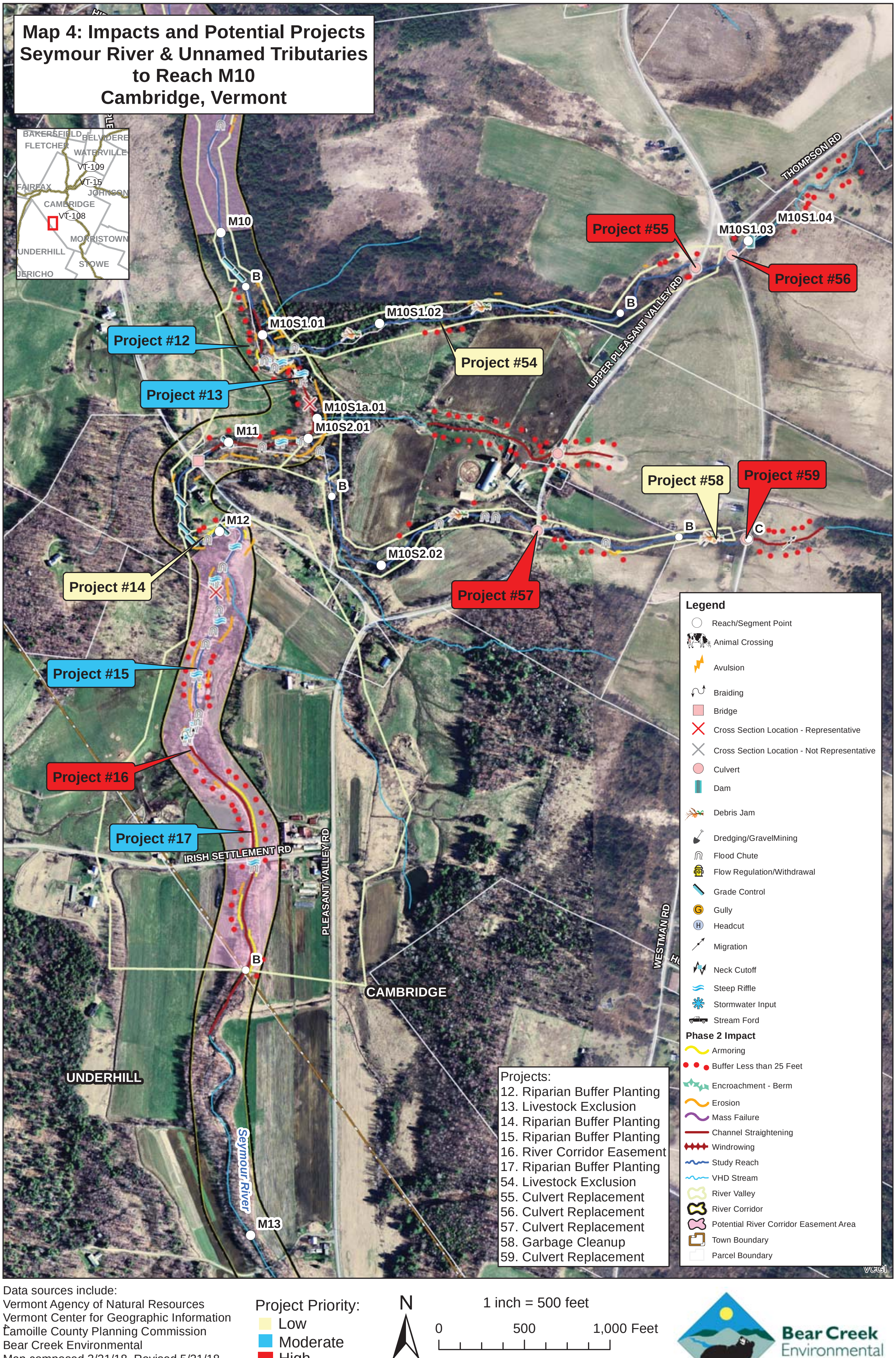
1 inch = 500 feet
0 500 1,000 Feet

Bear Creek Environmental



Data sources include:
Vermont Agency of Natural Resources
Vermont Center for Geographic Information
Lamoille County Planning Commission
Bear Creek Environmental
Map composed 3/21/18. Revised 5/31/18.

Bear Creek Environmental



Data sources include:
Vermont Agency of Natural Resources
Vermont Center for Geographic Information
Lamoille County Planning Commission
Bear Creek Environmental
Map composed 3/21/18. Revised 5/31/18.

Bear Creek Environmental

BCE Project ID	BCE Map Number	ProjectName	ProjectDescription	ProjectType	ProjectTypeID	SGA reach	Latitude	Longitude	Notes	Towns	SubBasin	Priority
1	1	Riparian buffer planting in M01	Riparian buffer vegetation is lacking along both river banks throughout segment M01-A and half of M01-B on the Seymour River due to surrounding agricultural lands. Plant native trees and shrubs to restore buffer.	River - Planting	5	M01	44.646183	-72.872217		Cambridge	Seymour River	Moderate
2	1	Riparian buffer planting in M03	Riparian buffer is lacking for ~1,200 feet on east bank due to agricultural lands. Plant native trees and shrubs to restore buffer.	River - Planting	5	M03	44.636381	-72.874249		Cambridge	Seymour River	Moderate
3	1	Riparian buffer planting in M04	Riparian buffer is lacking for ~500 feet on the west bank of the river. Plant native trees and shrubs to restore buffer.	River - Planting	5	M04	44.631221	-72.872926	Severe bank erosion along west bank.	Cambridge	Seymour River	Low
4	2	Riparian buffer planting in M05	Riparian buffer vegetation is lacking along east river bank for roughly 600' stretch due to surrounding agricultural lands. Plant native trees and shrubs to restore buffer.	River - Planting	5	M05	44.625962	-72.873352		Cambridge	Seymour River	Moderate
5	2	Riparian buffer planting in M06	Riparian buffer vegetation is lacking along the western bank of the river for over 2,000 feet due to agricultural fields. Plant native trees and shrubs to restore buffer.	River - Planting	5	M06	44.621417	-72.869123	Two planting areas with section of wider buffer in between.	Cambridge	Seymour River	Moderate
6	2	Replace farm bridge in M06-B	Undersized private farm bridge with significant abutment scour. Replace with appropriately-sized new structure.	Floodplain/Stream Restoration - Preliminary Design	6	M06-B	44.617195	-72.866649		Cambridge	Seymour River	Low
7	3	Riparian buffer planting in M06-B & M07	Riparian buffer is lacking along nearly 3,500 feet of eastern bank of the river. Plant native trees and shrubs to restore buffer.	River - Planting	5	M06-B & M07	44.614115	-72.866127	Two large parcels	Cambridge	Seymour River	Moderate
8	3	Replace farm bridge in M07-B	Undersized private farm bridge in poor condition (deteriorating). Replace with appropriately-sized new structure.	Floodplain/Stream Restoration - Preliminary Design	6	M07-B	44.611142	-72.868181		Cambridge	Seymour River	Moderate
9	3	Riparian buffer planting in M08-A	Buffer is lacking on both banks for nearly 1,200 feet due to agricultural fields. Plant native trees and shrubs to restore buffer.	River - Planting	5	M08-A	44.609743	-72.867654		Cambridge	Seymour River	Moderate
10	3	Investigate bank lowering in M08-A	Investigate feasibility of lowering the top of bank on one or both banks in this segment.	Floodplain/Stream Restoration - Preliminary Design	6	M08-A	44.609446	-72.867528	At the cross section, the top of bank on both banks is higher than the floodplain behind. Distinctive berms were not observed. Investigate lowering banks to open up floodplain behind higher TOB.	Cambridge	Seymour River	High
11	3	River corridor easement in M08-B & M09	M08-B & M09 are well forested with few human impacts and abundant planform change in some areas. Protect this area from future management activities through river corridor or conservation easement.	River Corridor Easement - Design	57	M08-B & M09	44.604562	-72.867929	One house is located in the corridor in M09. Land ownership is primarily two large parcels.	Cambridge	Seymour River	Low
12	4	Riparian buffer planting in M10-B	Riparian buffer is lacking along roughly 1,500 feet on western bank of river due to cow pasture.	River - Planting	5	M10-B	44.596865	-72.865387	One parcel. Landowner indicated that he has been working with the State on WQ improvements on his farm recently.	Cambridge	Seymour River	Moderate
13	4	Livestock exclusion in M10-B	A stream ford for cows exists within this segment.	Agricultural Pollution Prevention - Preliminary Design	65	M10-B	44.596365	-72.864222	Livestock exclusion could improve water quality. Stream crossing is stable and has electric fencing to keep cows only in the crossing. Landowner indicated that he has been working with the State on WQ improvements on his farm recently.	Cambridge	Seymour River	Moderate
14	4	Riparian buffer planting in M11	Roughly 200' on north side of the river lacks buffer due to lawn. Plant native trees and shrubs to restore buffer or establish a no-mow zone to naturally regenerate buffer.	River - Planting	5	M11	44.593789	-72.866418		Cambridge	Seymour River	Low
15	4	Riparian buffer planting in lower M12-A	Riparian buffer lacking on both banks for nearly 400 feet due to agricultural lands. Plant native trees and shrubs to restore buffer.	River - Planting	5	M12-A	44.591697	-72.866535	Two parcels	Cambridge	Seymour River	Moderate

Project priority based on many factors including feasibility of implementation, geomorphic and habitat benefit, landowner interest, steering committee interest, and more.

BCE Project ID	BCE Map Number	ProjectName	ProjectDescription	ProjectType	ProjectTypeID	SGA reach	Latitude	Longitude	Notes	Towns	SubBasin	Priority
16	4	River corridor easement in M12-A	Protect extremely dynamic section of the river from future management activities through a river corridor or conservation easement.	River Corridor Easement - Design	57	M12-A	44.590375	-72.866647	Highly aggradational braided system with multiple side channels, excellent floodplain connectivity, and abundant planform adjustment. Corridor land use is agricultural and forested. Two large parcels.	Cambridge	Seymour River	High
17	4	Riparian buffer planting in upper M12-A	Riparian buffer lacking for ~700 feet on west bank and ~500 feet on east bank due to adjacent agricultural lands. Plant native trees and shrubs to restore buffer.	River - Planting	5	M12-A	44.589068	-72.865296	Two parcels	Cambridge	Seymour River	Moderate
18	3	Livestock exclusion in T1.01	Two stream fords for horses are present in this reach ~100 feet apart.	Agricultural Pollution Prevention - Preliminary Design	65	T1.01	44.610483	-72.868717	Both fords appear to be stable. Could consolidate to one crossing or do full livestock exclusion.	Cambridge	Seymour River	Moderate
19	3	Riparian buffer planting in T1.01	Riparian buffer lacking on both banks for nearly 1,700 feet due to adjacent agricultural lands. Plant native trees and shrubs to restore buffer.	River - Planting	5	T1.01	44.609288	-72.869419	One large parcel. Part of land is horse pasture.	Cambridge	Seymour River	Moderate
20	3	Investigate stormwater management on County Farm Road	Stormwater runs directly off County Farm Road into Settlement Brook. Investigate options for stormwater management.	Stormwater - Preliminary Design	3	T1.02-A	44.607289	-72.871048	Observed four locations where overland flow from the road appears to be entering Settlement Brook in a 400 foot section of road.	Cambridge	Seymour River	Moderate
21	3	Riparian buffer planting in T1.02-A	Riparian buffer is lacking for roughly 900 feet on eastern bank of Settlement Brook due to agricultural land uses. Plant native trees and shrubs to restore buffer.	River - Planting	5	T1.02-A	44.606472	-72.87162	One landowner	Cambridge	Seymour River	Moderate
22	3	Riparian buffer planting in lower T1.02-B	Riparian buffer is lacking for nearly 500 feet on western bank of the brook due to lawns at two houses. Plant native trees and shrubs to restore buffer.	River - Planting	5	T1.02-B	44.604994	-72.872117	Two landowners, small planting area	Cambridge	Seymour River	Moderate
23	3	Investigate berm removal in T1.02-B	A ~150 foot long and 6 foot tall berm exists on the west bank of the brook. Investigate feasibility of its removal.	Floodplain/Stream Restoration - Preliminary Design	6	T1.02-B	44.604761	-72.872116	Berm looks relatively new and is made of small boulders. Appears to be protecting house and seems likely the brook could avulse and flow closer to the house if the berm were not there.	Cambridge	Seymour River	Low
24	3	Investigate old bridge abutment removal in T1.02-B	Old concrete abutments exists on both banks in this location from a bridge that is no longer in existence. Investigate feasibility of abutment removal to restore natural banks and possibly improve floodplain access in this location.	Floodplain/Stream Restoration - Preliminary Design	6	T1.02-B	44.603749	-72.872903	Distance between abutments is 11.1 feet. Issues noted include: channel constriction, floodprone constriction, deposition above, and scour below.	Cambridge	Seymour River	Moderate
25	3	River corridor easement in T1.02-B	Protect intact wetland floodplain to east of Settlement Brook through river corridor or conservation easement.	River Corridor Easement - Design	57	T1.02-B	44.601938	-72.873204	Nice wetland with some impacts from ATV activity.	Cambridge	Seymour River	Low
26	3	Riparian buffer planting in upper T1.02-B	Riparian buffer vegetation is lacking for nearly 500 feet on the west bank of the brook due to a house and lawn. Plant native trees and shrubs to restore buffer.	River - Planting	5	T1.02-B	44.601873	-72.873509	Spoke with landowner in the field and she indicated a strong interest in participating in a project on her property. She said they would be interested in doing a planting.	Cambridge	Seymour River	High
27	1	Culvert replacement - Lower Pleasant Valley Road in M04S1.01	Culvert is undersized, has scour issues at outlet, and has a free fall outlet. Replace culvert with appropriately-sized, more geomorphically compatible structure.	Floodplain/Stream Restoration - Preliminary Design	6	M04.S1.01	44.633869	-72.872534		Cambridge	Seymour River	High
28	1	Riparian buffer planting in M04S1.01	Riparian buffer is lacking for ~200 feet on north bank and a short distance on the south bank due to adjacent agricultural/residential land uses. Plant native trees and shrubs to restore buffer.	River - Planting	5	M04S1.01	44.634038	-72.872111	Small planting area.	Cambridge	Seymour River	Low
29	1	Culvert replacement or removal in M04S1.02-A	Investigate options for culvert replacement or removal, if not needed.	Floodplain/Stream Restoration - Preliminary Design	6	M04S1.02-A	44.634732	-72.871451	Little is known about this culvert. It appears to be a small plastic corrugated pipe that is beneath a pile of pieces of concrete. Likely not a very stable structure.	Cambridge	Seymour River	Low

Project priority based on many factors including feasibility of implementation, geomorphic and habitat benefit, landowner interest, steering committee interest, and more.

BCE Project ID	BCE Map Number	ProjectName	ProjectDescription	ProjectType	ProjectTypeID	SGA reach	Latitude	Longitude	Notes	Towns	SubBasin	Priority
30	1	Improve stream crossings (animal) in M04S1.01 & M04S1.02-A	Investigate options to improve and/or consolidate up to three animal stream crossings in these segments.	Floodplain/Stream Restoration - Preliminary Design	6	M04S1.01 & M04S1.02-A	44.63483	-72.871439	Three animal crossings. Possibly could be consolidated or redesigned.	Cambridge	Seymour River	Moderate
31	1	Investigate gully remediation in M04S1.02-B	Gully exists on north bank and is a source of sediment. Investigate options to remediate gully.	Floodplain/Stream Restoration - Preliminary Design	6	M04S1.02-B	44.635172	-72.870605	Source of gully is unknown but possibly coming from Bryce Road.	Cambridge	Seymour River	Moderate
32	1	Investigate stream ford stabilization in M04S1.02-B	Stream ford (tractor) contributing to instability, buffer impacts, sediment source, etc. Evaluate options to redesign or remove it.	Floodplain/Stream Restoration - Preliminary Design	6	M04S1.02-B	44.635085	-72.869975		Cambridge	Seymour River	Moderate
33	1	Livestock exclusion in M04S1.02-B	Two animal crossings are contributing to bank instability and reduced buffer cover in M04S1.02-B. Evaluate options for livestock exclusion.	Agricultural Pollution Prevention - Preliminary Design	65	M04S1.02-B	44.635168	-72.869339		Cambridge	Seymour River	High
34	2	Investigate headcut stabilization in M06S1.02-A	A ~4 foot tall headcut exists just below a stream ford. Investigate options to arrest headcut.	Floodplain/Stream Restoration - Preliminary Design	6	M06S1.02-A	44.622272	-72.86697	There is a bedrock grade control ~300 feet upstream of headcut, so any incision from headcut moving upstream would be localized.	Cambridge	Seymour River	Low
35	2	Riparian buffer planting in M06S1.01 & M06S1.02-A	Buffer vegetation is lacking for ~600 feet on the north bank and ~400 feet on the south bank due to adjacent agricultural lands. Plant native trees and shrubs to restore buffers.	River - Planting	5	M06S1.01 & M06S1.02-A	44.62256	-72.866656		Cambridge	Seymour River	Moderate
36	2	Livestock exclusion in M06S1.02-C	Three animal stream crossings exist in this segment and are contributing to bank and streambed instability and impacting buffers. Investigate livestock exclusion.	Agricultural Pollution Prevention - Preliminary Design	65	M06S1.02-C	44.624802	-72.864423		Cambridge	Seymour River	High
37	2	Riparian buffer planting in M06S1.02-C & M06S1.03	Riparian buffer is lacking for ~700 feet on north bank and ~1100 on south bank. Banks are eroding and adjacent land is agricultural. Plant native trees and shrubs to restore buffer.	River - Planting	5	M06S1.02-C & M06S1.03	44.624998	-72.864184		Cambridge	Seymour River	High
38	2	Berm removal/restore windrowed section in M06S1.02-C & M06.S1.03	A 75 foot section of stream was windrowed and streambed material piled on both banks creating berms. Investigate options for berm removal and restoration of windrowed stream channel.	Floodplain/Stream Restoration - Preliminary Design	6	M06S1.02-C & M06S1.03	44.625128	-72.863931		Cambridge	Seymour River	High
39	2	Investigate headcut stabilization in M06S1.03	A headcut exists just above the windrowed section of stream. Investigate options to arrest headcut.	Floodplain/Stream Restoration - Preliminary Design	6	M06S1.03	44.625204	-72.86371		Cambridge	Seymour River	Moderate
40	2	Culvert replacement in M06S1.03	Culvert is undersized and has a free fall outlet. Replace culvert with appropriately-sized structure.	Floodplain/Stream Restoration - Preliminary Design	6	M06S1.03	44.62514	-72.862587		Cambridge	Seymour River	Moderate
41	2	Riparian buffer planting in M06S2.01	Riparian buffers are lacking for ~300 feet on either side of stream channel due to adjacent pastures. Plant native trees and shrubs to restore buffer. Alternately, establish "no mow" zone to allow buffer to naturally regenerate.	River - Planting	5	M06S2.01	44.619734	-72.865181	Some natural buffer regeneration already occurring in areas.	Cambridge	Seymour River	Low
42	2	Investigate gully remediation in M06S2.02-A	A gully exists on the north bank of the brook that is contributing sediment to the channel. Investigate cause of gully and options to remediate it.	Floodplain/Stream Restoration - Preliminary Design	6	M06S2.02-A	44.620232	-72.863119		Cambridge	Seymour River	Moderate
43	2	Livestock exclusion in M06S2.02-B	One animal crossing exists in this segment. Investigate feasibility of livestock exclusion.	Agricultural Pollution Prevention - Preliminary Design	65	M06S2.02-B	44.619857	-72.861931		Cambridge	Seymour River	Low
44	2	Riparian buffer planting in M06S2.02-B, M06S2.02-C, and M06S2.03	Riparian buffers are lacking on both banks for 1400 feet due to adjacent agricultural land use. Plant native trees and shrubs to restore buffer.	River - Planting	5	M06S2.02-B, M06S2.02-C, & M06S2.03	44.619316	-72.859992	Alternately, could establish a "no mow" zone and allow buffer to regenerate naturally.	Cambridge	Seymour River	Low
45	2	Culvert replacement - Bryce Road in M06S2.03	Culvert is significantly undersized and has a free fall outlet that likely impedes AOP. Replace with an appropriately-sized, AOP friendly structure.	Floodplain/Stream Restoration - Preliminary Design	6	M06S2.03	44.620493	-72.858469		Cambridge	Seymour River	High
46	2	Culvert replacement - Upper Pleasant Valley Road in M06S2.03	Culvert is significantly undersized and rusting out. Replace with appropriately-sized, AOP friendly structure.	Floodplain/Stream Restoration - Preliminary Design	6	M06S2.03	44.620028	-72.855984		Cambridge	Seymour River	Moderate

Project priority based on many factors including feasibility of implementation, geomorphic and habitat benefit, landowner interest, steering committee interest, and more.

BCE Project ID	BCE Map Number	ProjectName	ProjectDescription	ProjectType	ProjectTypeID	SGA reach	Latitude	Longitude	Notes	Towns	SubBasin	Priority
47	2	Culvert replacement - Pratt Road in M06S2.03	Culvert is significantly undersized and rusting out. Replace with appropriately-sized, AOP friendly structure.	Floodplain/Stream Restoration - Preliminary Design	6	M06S2.03	44.621946	-72.853975		Cambridge	Seymour River	Moderate
48	2	Riparian buffer planting in M06S3.01-A	Riparian buffer is lacking for ~900 feet on both banks due to adjacent pastureland. Plant native trees and shrubs to restore buffer.	River - Planting	5	M06S3.01-A	44.618033	-72.864615		Cambridge	Seymour River	Moderate
49	2	Livestock exclusion in M06S3.01-A & M06S3.01-B	Five animal crossings within 150 feet are contributing to channel/bank instability. Investigate livestock exclusion options.	Agricultural Pollution Prevention - Preliminary Design	65	M06S3.01-A & M06S3.01-B	44.617473	-72.863681	Consolidate number of crossings at a minimum if full exclusion not feasible.	Cambridge	Seymour River	High
50	2	Livestock exclusion in M06S3.01-C	No animal crossing locations identified but several animal access points on the banks contributing to bank and channel instability. Investigate options for livestock exclusion.	Agricultural Pollution Prevention - Preliminary Design	65	M06S3.01-C	44.617813	-72.860728	ATVs are also an issue in this segment exacerbating bank instability. Consider also limiting their use in/around the stream.	Cambridge	Seymour River	High
51	2	Riparian buffer planting in M06S3.01-C	Riparian buffers are lacking on both banks for ~900 feet due to pastureland. Plant native trees and shrubs to restore buffer.	River - Planting	5	M06S3.01-C	44.618021	-72.860401		Cambridge	Seymour River	Moderate
52	2	Riparian buffer planting in M07S1.03-B	Riparian buffers are lacking on both banks for ~500 feet due to adjacent agricultural lands. Plant native trees and shrubs to restore buffer.	River - Planting	5	M07S1.03-B	44.60995	-72.857539	Restore adjacent wetlands.	Cambridge	Seymour River	Moderate
53	2	Livestock exclusion in M07S1.03-B	Two animal crossings and grazing activities were observed in this segment. Bank erosion is extensive and much of it is related to animal activities. Evaluate options for livestock exclusion.	Agricultural Pollution Prevention - Preliminary Design	65	M07S1.03-B	44.610074	-72.857134		Cambridge	Seymour River	High
54	4	Livestock exclusion in M10S1.02-A	Animal grazing activities on the south bank of the brook have led to reduced buffer vegetation and bank instability. Evaluate options for livestock exclusion.	Agricultural Pollution Prevention - Preliminary Design	65	M10S1.02-A	44.597279	-72.861156		Cambridge	Seymour River	Low
55	4	Culvert replacement at Upper Pleasant Valley Road in M10S1.02-B	Culvert is significantly undersized and has a free fall outlet that likely impedes AOP. Replace with an appropriately-sized, AOP friendly structure.	Floodplain/Stream Restoration - Preliminary Design	6	M10S1.02-B	44.598134	-72.855418		Cambridge	Seymour River	High
56	4	Culvert replacement at Westman Road in M10S1.02-B	Culvert is significantly undersized and has a free fall outlet that likely impedes AOP. Replace with an appropriately-sized, AOP friendly structure.	Floodplain/Stream Restoration - Preliminary Design	6	M10S1.02-B	44.59834	-72.854602		Cambridge	Seymour River	High
57	4	Culvert replacement at Upper Pleasant Valley Road in M10S2.02-A	Culvert is undersized and rusting out. Replace with an appropriately-sized, AOP friendly structure.	Floodplain/Stream Restoration - Preliminary Design	6	M10S2.02-A	44.593909	-72.858931		Cambridge	Seymour River	High
58	4	Clean up garbage in M10S2.02-B	Abundant garbage was observed lining the stream in this section. Clean up garbage.	Pollution Prevention, Abatement, and Mitigation	52	M10S2.02-B	44.593789	-72.854891		Cambridge	Seymour River	Low
59	4	Culvert replacement at Westman Road in M10S2.02-B	Culvert is significantly undersized and has a cascade outlet that may impede AOP. Replace with an appropriately-sized, AOP friendly structure.	Floodplain/Stream Restoration - Preliminary Design	6	M10S2.02-B	44.593791	-72.854253		Cambridge	Seymour River	High

Project priority based on many factors including feasibility of implementation, geomorphic and habitat benefit, landowner interest, steering committee interest, and more.


Project #1


Project #2


Project #3


Project #4

Photo is a screenshot from Bing Maps Streetside (2015)

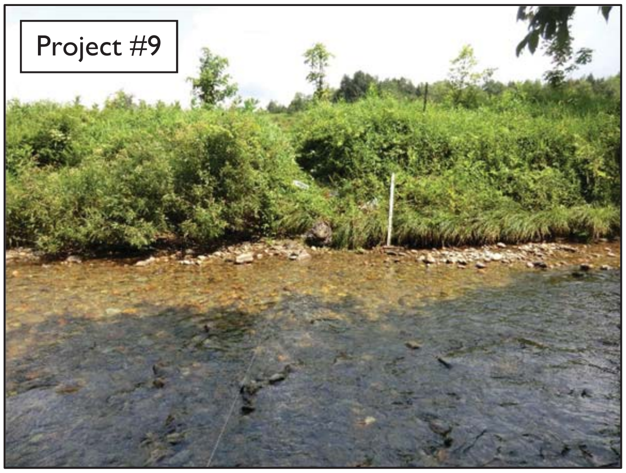

Project #5


Project #6


Project #7

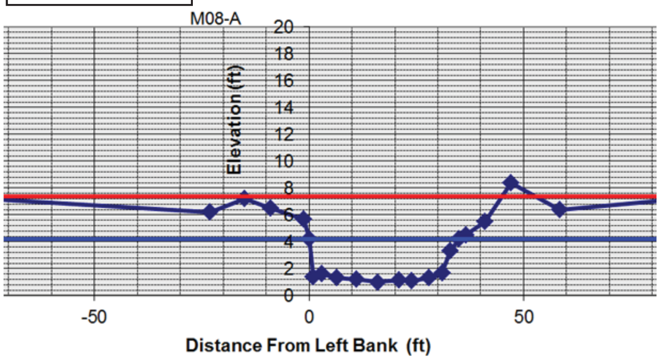

Project #8

Project #9



Project #13

Project #10



Project #14

Project #11

No photo for Project #15

Project #12

Project #16


Project #17


Project #18


Project #19


Project #20


Project #21


Project #22


Project #23


Project #24


Project #25


Project #26


Project #27


Project #28


Project #29


Project #30


Project #31


Project #32


Project #33


Project #34


Projects #35


Project #36


Project #37


Project #38


Project #39


Project #40


Project #41


Project #42


Project #43

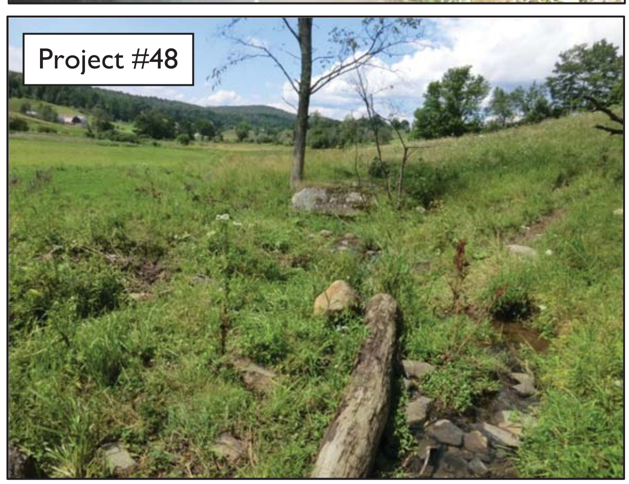

Project #44


Project #45


Project #46

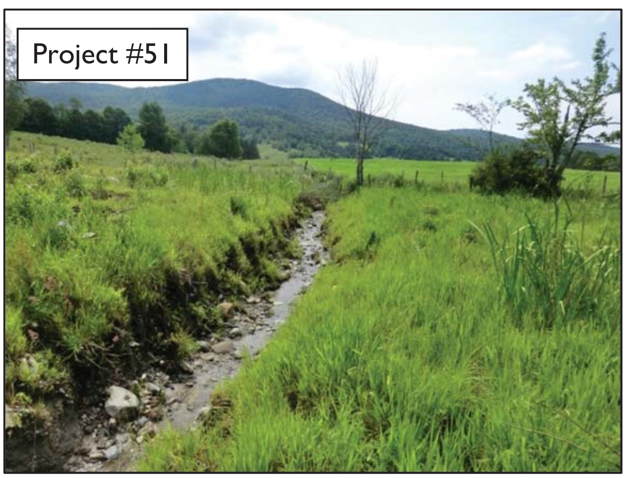

Project #47

Photo taken by Redstart Consulting in 2012


Project #48


Project #49


Project #50

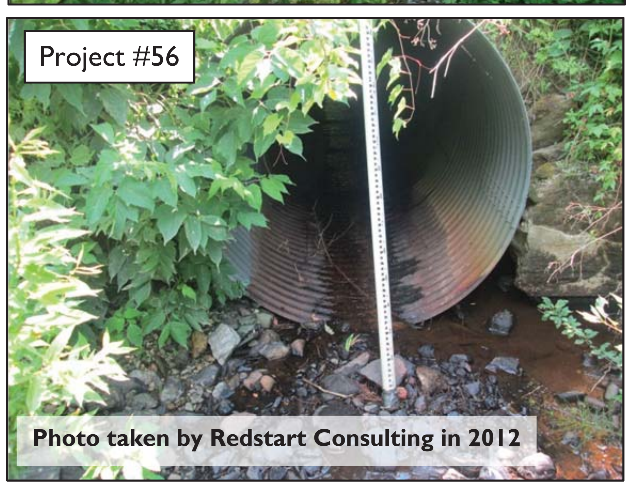

Project #51


Project #52


Project #53


Project #54


Project #55


Project #56
Photo taken by Redstart Consulting in 2012


Project #57


Project #58


Project #59