Upper & Middle White River Watershed Corridor Plan

Barnard, Hancock, Pittsfield, Rochester, and Stockbridge, Vermont

July 15, 2015

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

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1.0 EXECUTIVE SUMMARY

A stream geomorphic assessment of the White River and tributaries was conducted by Bear Creek Environmental, LLC (BCE) under the direction of the White River Partnership (WRP) and the Vermont Agency of Natural Resources (VANR) during the summer of 2014. 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 towns of Barnard, Hancock, Pittsfield, Rochester, and Stockbridge experienced major flooding in August 2011 as a result of Tropical Storm Irene (TSI) and subsequent damage to infrastructure. As part of the long term plan to mitigate the impact of flooding, improve aquatic habitat, and increase river stability, the White River Partnership secured state funding to complete a Phase 2 stream geomorphic assessment of the White River watershed within the Upper and Middle White River and Tweed River sub-watersheds. The stream geomorphic assessment data will be used to help focus stream restoration and protection activities within the watershed and assist the towns with flood resiliency planning.

The study encompassed approximately 38 miles of stream channel within 23 reaches on the White River, Locust Creek, Pond Brook, Little Stony Brook, Stony Brook, Fletcher Brook, Bartlett Brook, Johnson Brook, the West Branch of the White River, and the Hancock Branch of the White River. This stream geomorphic assessment facilitated the identification of major stressors to geomorphic stability and habitat conditions within the study area. The predominant stressor observed within the Middle and Upper White River and Tweed River sub-watersheds is stream channel straightening and corridor encroachment associated with the existence of roads. 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 watershed, including critical travel routes such as VT-12, 73, 100, 107, and 125.

In addition to straightening and corridor encroachment, which create geomorphic instability and degrade aquatic habitat, countless landslides, or mass failures, were observed within the study area. These mass failures are significant sources of fine sediment to the study streams and adversely impact water quality and in-stream habitat.

Following Tropical Storm Irene, immense recovery efforts were undertaken to repair roads, buildings, and other infrastructure that were damaged by the flooding. Many streams within the White River watershed were subjected to gravel mining and windrowing, or excavating sand and gravel from a stream and piling it on the stream banks, to remove material that aggraded in their channels during the storm. This excavation of material has created physical instability and majorly degraded aquatic habitat in these areas. Moving forward, it is important for communities to continually prepare for the next flood by taking steps to become more flood resilient. This report outlines several strategies that can be implemented on both site-specific and community-wide levels to mitigate flood damage and losses in the future.

The river corridor planning effort in the White 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 White River watershed in the past decade. Analysis of these data has facilitated the identification of major impacts and stressors and the development of projects to mitigate impacts, increase geomorphic stability, and improve aquatic habitat.

A list of 94 potential restoration, conservation, and flood resiliency projects was developed using the stream geomorphic assessment data collected within the study area. The projects fall within four primary categories:

Project Category	**Number of Proposed Projects**
Floodplain Improvement and Conservation	44
Public Safety Improvement	10
Stream Channel Improvement and Restoration	24
Structure Replacement/ Removal	16
Total Number of Projects	**94**

These projects provide flood resiliency measures to prepare communities for the next flood, strategies to restore riparian and instream habitat, and recommendations to remove people located in high risk areas from harm's way. Types of projects include river corridor easements, property acquisitions, riparian buffer improvements, berm removals, bridge and culvert replacements, floodplain creation, and many more. Potential projects were prioritized based on several factors, including ease of implementation, cost, landowner interest, effectiveness, and many 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 White River watershed in the towns of Barnard, Hancock, Pittsfield, Rochester, and Stockbridge, Vermont. The main stem of the White River and several of its *tributaries* were assessed during the summer of 2014 using the Vermont Agency of Natural Resources Phase 2 Stream Geomorphic Assessment protocol. The White River tributaries included in this assessment are Locust Creek, Pond Brook, Little Stony Brook, Stony Brook, Fletcher Brook, Bartlett Brook, Johnson Brook, the Hancock Branch, and the West Branch of the White River. A total of 38 river miles were assessed. Phase 2 geomorphic assessments have occurred in numerous areas in the White River watershed within the past decade. Corridor plans for other phase 2 assessment areas in the White 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 Upper and Middle White River watershed is comprised of the White River Partnership (WRP), Bear Creek Environmental (BCE), and the Vermont Agency of Natural Resources (VANR). The 2014 study was funded through The State of Vermont Ecosystem Restoration Program under contract to the White River Partnership. Gretchen Alexander from the Vermont River Management Program of VANR provided a quality control/assurance review of the stream geomorphic assessment data.

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. The White River Partnership 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 Water Quality Management Plan (WQMP) for Basin 9 (White River) specifies the goal of proactively managing streams through identification and prioritization of stream restoration projects that will bring channels back to equilibrium conditions. Specifically, the plan includes recommendations for continued Phase 2 geomorphic assessments in the White River watershed. The plan identifies *floodplain* encroachment, non-point source pollution, and aquatic organism passage, among others, as major stressors within the White River watershed (Vermont Agency of Natural Resources, 2013).

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 White 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" (Vermont Agency of Natural Resources, 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 Geographic Setting

3.1.1 Watershed Description

The White River is a tributary to the Connecticut River and is one of the last free-flowing (undammed) rivers in Vermont (Vermont Agency of Natural Resources, 2013). The 60.1-mile long river drains approximately 712 square miles of land. Generally flowing from northwest to southeast, the White River originates in eastern Ripton, Vermont, and flows through numerous towns before emptying into the Connecticut River in Hartford, Vermont.

The study area for this 2014 phase 2 assessment falls within the boundaries of three sub-watersheds of the White River watershed – the Upper White River sub-watershed, the Middle White River sub-watershed, and the Tweed River sub-watershed (see Figure

3.1). The Upper White River sub-watershed drains approximately 143 square miles and includes such major tributaries as the Hancock Branch and the West Branch of the White River. The middle White River sub-watershed drains approximately 265 square miles and encompasses many tributaries, including Stony Brook, Locust Creek, and Cleveland Brook. The Tweed River sub-watershed drains approximately 51 square miles and includes such streams as the West Branch and South Branch of the Tweed River and Townsend Brook (Vermont Agency of Natural Resources, 2013).

3.1.2 Political Jurisdictions

The Upper and Middle White River and Tweed River sub-watersheds are located in Addison County (towns of Ripton, Granville, Goshen, and Hancock), Windsor County (Rochester, Bethel, Stockbridge, Killington, Barnard, Bridgewater, Royalton, Pomfret, and Sharon), Washington County (Braintree), and Rutland County (Chittenden, Pittsfield, Mendon). The 2014 Phase 2 assessment focused on streams within the towns of Hancock, Rochester, Pittsfield, Stockbridge, and Barnard.

3.1.3 Land-Use

A land cover layer (2002) was obtained from the Vermont Center for Geographic Information (VCGI) to present land-use within the White River watershed for the river corridor plan. The 2002 land cover data indicate that the Upper White River sub-watershed is 93% forested, 4% agriculture, and 2% developed (Figure 3.2). While forest is the dominant land cover in the sub-watershed, agricultural and developed areas are geographically centered on the White River. Similarly, the Tweed River sub-watershed is 93% forested, 2% open water, 2% agriculture, and 2% developed. The land cover data in this sub-watershed also show development and agriculture primarily occurring adjacent to the Tweed River and select tributaries. In the Middle White River sub-watershed, forested land accounts for 82% of land cover, developed 8%, agriculture 7%, and open water 2%. Development abounds along the White River and its tributaries in the towns of Royalton, Sharon, and Barnard.

3.2 Geologic Setting

The Upper and Middle White River sub-watersheds and Tweed River sub-watershed flow through the Southern Green Mountain physiographic region, which is characterized by a large anticline or upfold that extends from southern to northern Vermont. Most of the study area lies within the Moretown Formation, which is Lower Ordovician to Cambrian in age. The dominant bedrock type is in the “Pinstriped” granofels member, which contains light-gray to pale-green granofels and quartzite. Other common types of bedrock include Cambrian schist, phyllite, amphibolite, and greenstone. The most common surficial geologic materials found within the study area are of ice contact, alluvial, glacial lake, and glacial till origins (Bedrock Geologic Map of Vermont, USGS, 2011).

3.3 Geomorphic Setting

A Phase 1 Stream Geomorphic Assessment of the White River watershed was completed in 2002 by Shannon Pytlik of the Vermont River Management Program. The Phase 1 assessment included breaking the watershed into *reaches*. The Upper White River sub-watershed was broken into 104 reaches, the Middle White River sub-watershed into 87 reaches, and the Tweed River sub-watershed into 33 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. A total of 23 reaches were included in the 2014 Phase 2 assessment, which equates to 38 river miles (see Figure 3.3). Each point in Figure 3.3 represents the downstream end of the reach.

The White River flows through a low *gradient* valley overall, with the exception of the two uppermost *reaches* in Granville and Ripton. Most of the main stem has a channel slope of less than 0.5%, though the slope jumps to 5 to 11% in the uppermost reaches. Within the study area, the average channel slope for the reaches on the White River varies from 0.1 to 0.6% and the river flows through a confined and unconfined valley. The average reach slope of tributaries included in this study varies widely. Locust Creek has a 1 to 3.5% reach slope, Pond Brook 3 to 4%, Little Stony Brook 7.7%, Stony Brook 0.3 to 4.5%, Fletcher Brook 5.4%, Bartlett 4.7%, Johnson 4.5%, the West Branch 0.7 to 1.7%, and the Hancock Branch 0.6 to 4%. The smallest tributaries generally flow through the steepest valleys.

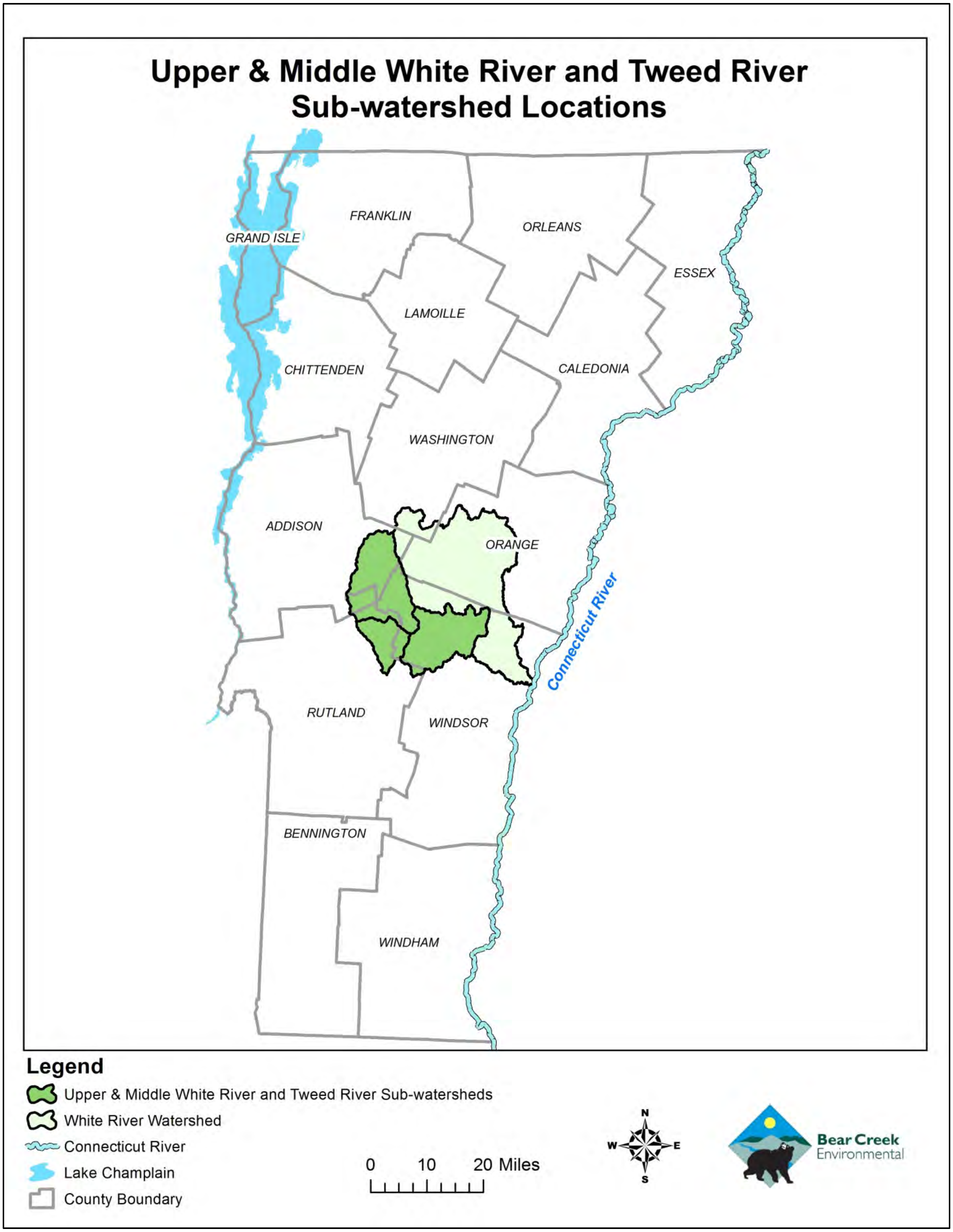

Figure 3.1. Watershed Location Map for White River watershed.

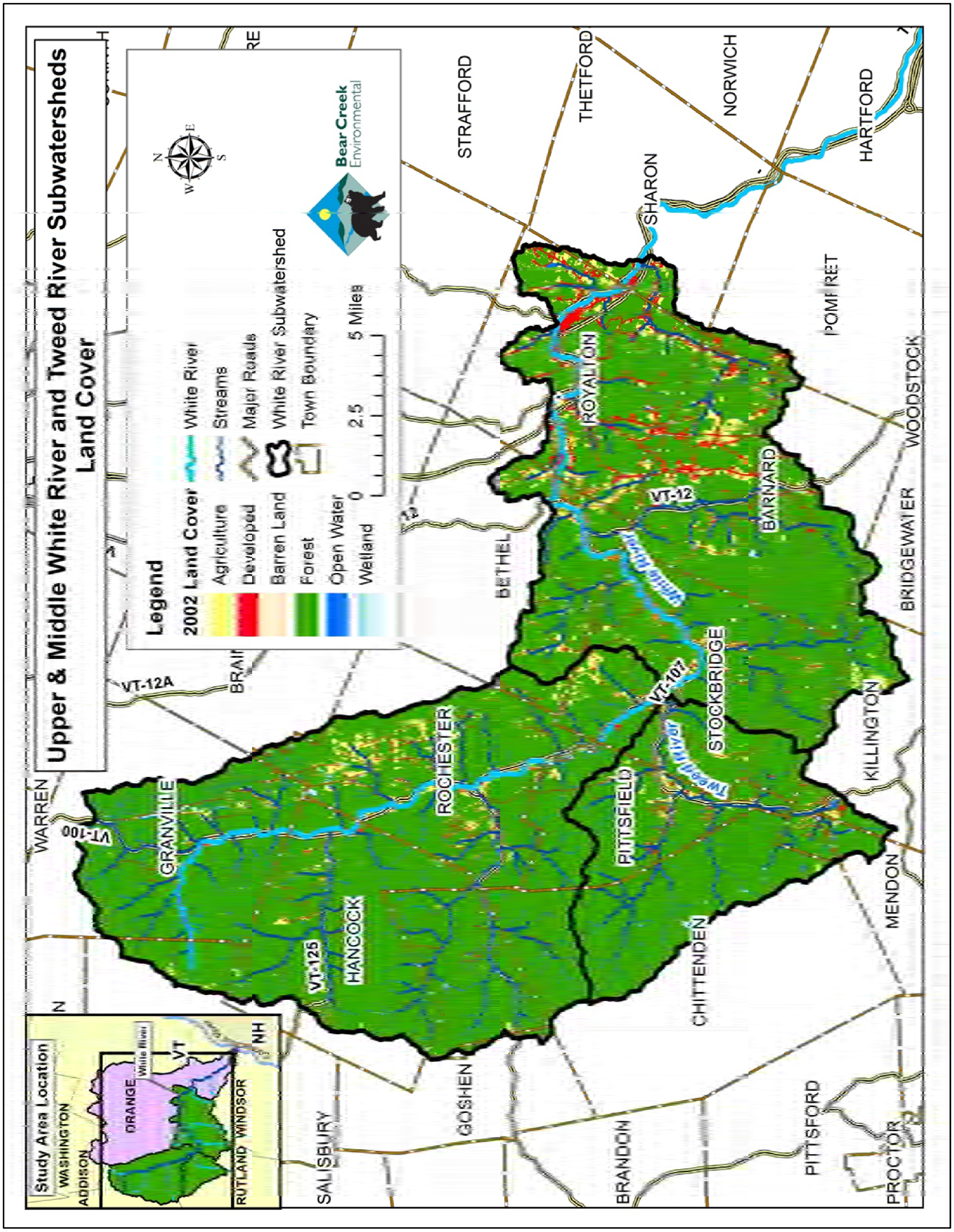

Figure 3.2. Land Cover Map for the Upper and Middle White River and Tweed River sub-watersheds.

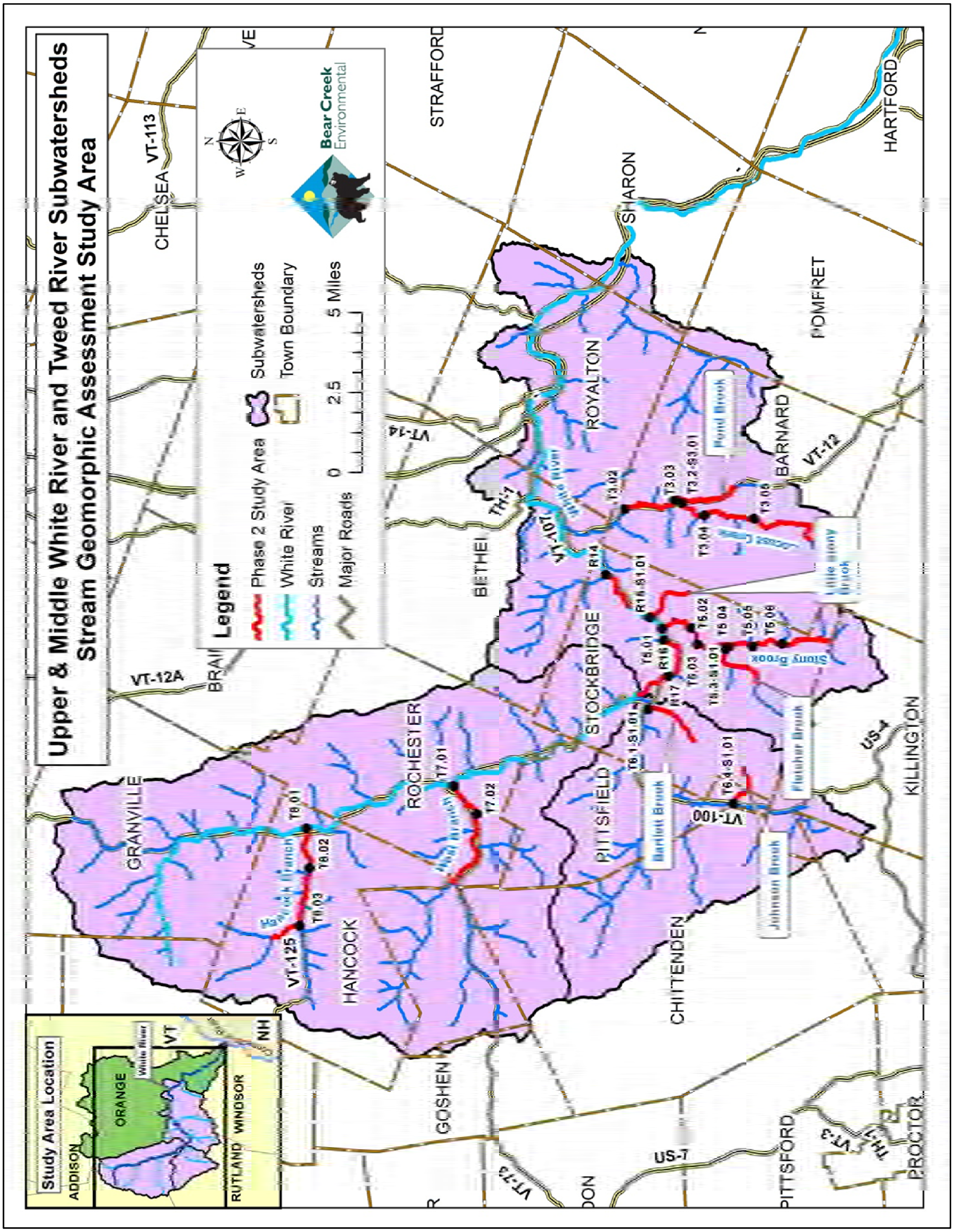

Figure 3.3. White River watershed 2014 stream geomorphic assessment study reaches.

3.4 Hydrology

In late August of 2011, Vermont was hit hard by Tropical Storm Irene (TSI). Heavy rain totaled over seven inches in areas over the course of one day. This immense downpour caused raging floodwaters to tear through Vermont's streams, devastating people and infrastructure throughout central and southern Vermont. In some areas, TSI flooding approached historic flood levels, while in other areas, the storm greatly exceeded them. Over 500 miles of state roads, in addition to over 2000 segments of municipal roads, were damaged as a result of TSI. In total, approximately 500 bridges were damaged or destroyed, as well as almost 1,000 *culverts*. Approximately 1,500 residences were significantly damaged or destroyed as a result of flooding, as well as state, municipal, and commercial buildings (VANR 2012b). The White River and tributaries were impacted by flooding from Tropical Storm Irene as well as instream channel work following the flood.

According to Irene damage data from Two Rivers-Ottauquechee Regional Commission, road and infrastructure damage occurred along the stream reaches included in this study during Tropical Storm Irene. Route 125 was damaged in multiple locations along the Hancock Branch, as were Killooleet Road, Fassett Hill Road, and Texas Falls Road. Floodwaters on the West Branch of the White River caused damage to Route 73 in multiple locations in Rochester. In addition, Johnson Brook damaged Route 100 near its mouth in Pittsfield. Throughout the study area in Stockbridge, the White River washed out Route 107 and damaged Blackmer Boulevard. Multiple bridges were damaged or destroyed on Stony Brook, a camp along the brook was washed away, and Stony Brook Road incurred significant damage due to floodwaters. Fletcher Brook damaged Fletcher Brook Road and destroyed a single family home along its banks during Irene. Little Stony Brook in Stockbridge damaged a bridge on Route 107 as it flowed into the White River. Vermont Route 12 sustained damage along Locust Creek in Barnard, including a bridge over the Creek that was destroyed. The Creek also damaged Chateauguay Road in multiple locations, including several bridges.

In order to better understand the flood history of the White River and its tributaries, long-term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS), were obtained (USGS 2014). There are no USGS *gaging* stations within the study area, but peak flow data from two stations within the White River watershed were reviewed. One station included in this analysis has a drainage area of 690 square miles and is located on the White River at West Hartford, Vermont. A second station, on Ayers Brook, a tributary to the Third Branch of the White River, has a drainage area of 30.5 square miles. A map showing the location of these two gaging stations in relation to the study area is shown in Figure 3.4. Comparing annual peak flow data at these two stations for all years on record allows for an analysis of the recurrence interval of Tropical Storm Irene within the White River watershed.

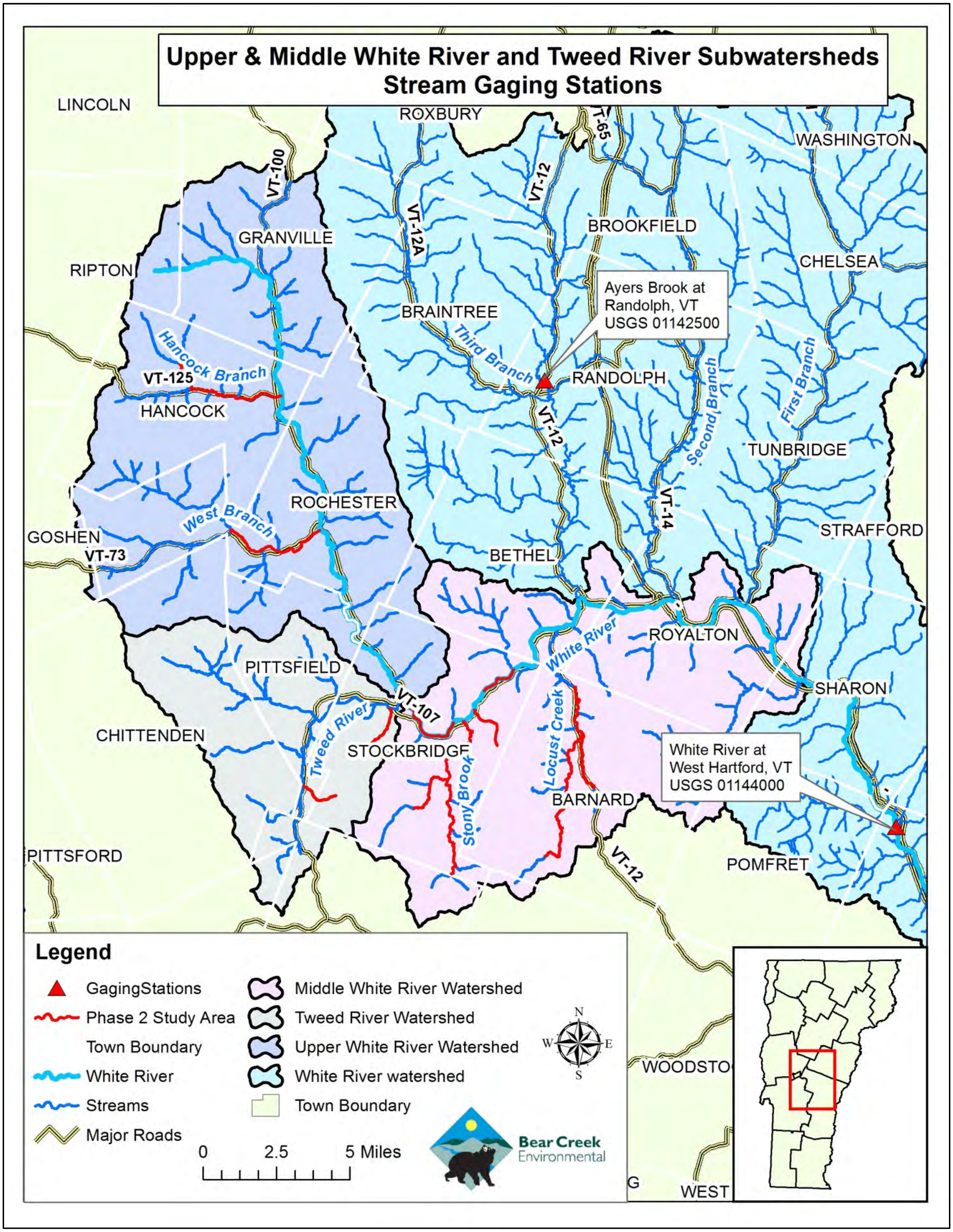

Figure 3.4. Gaging station locations in relation to study area.

Peak discharge records are available for the White River at West Hartford, Vermont from 1916 through 2013 (Figure 3.5) (USGS, 2014). The highest annual peak flow on record is from the Flood of 1927 (November 4, 1927), which exceeded a 500 year recurrence interval. Tropical Storm Irene yielded a peak discharge with a recurrence interval of greater than 100 years but less than 500, the second highest on record.

At the Ayers Brook gaging station, peak discharge records are available from 1940 through 2013. The highest peak discharge available over the period of record for this station is from Tropical Storm Irene in 2011. Flood frequency analyses suggest that flows from TSI on Ayers Brook were slightly above the 100 year return interval.

During Tropical Storm Irene, flood levels throughout many areas in Vermont equaled or approached the historic flood of 1927 (Vermont Agency of Natural Resources, 2012b). In the aftermath of TSI, emergency flood recovery work involved stream channel excavation in areas of infrastructure damage. Throughout central and southern Vermont, depositional materials in stream channels were dug out, in a process known as *dredging*, and often piled on the banks in a process known as *windrowing.* Widespread road damage required immediate repair, which resulted in further stream channel modification. This and other channel work has impacted aquatic habitat in the White River watershed, and has created geomorphic instability that puts stream channels at an elevated risk of causing significant damage to infrastructure during large storms in the future.

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 (Vermont Agency of Natural Resources, 2010). The Vermont Agency of Administration (2012) states that over 733 million dollars has been estimated in funding resources for Tropical Storm Irene recovery. 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 Agency of Natural Resources, 2010). The VANR (2010) 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).

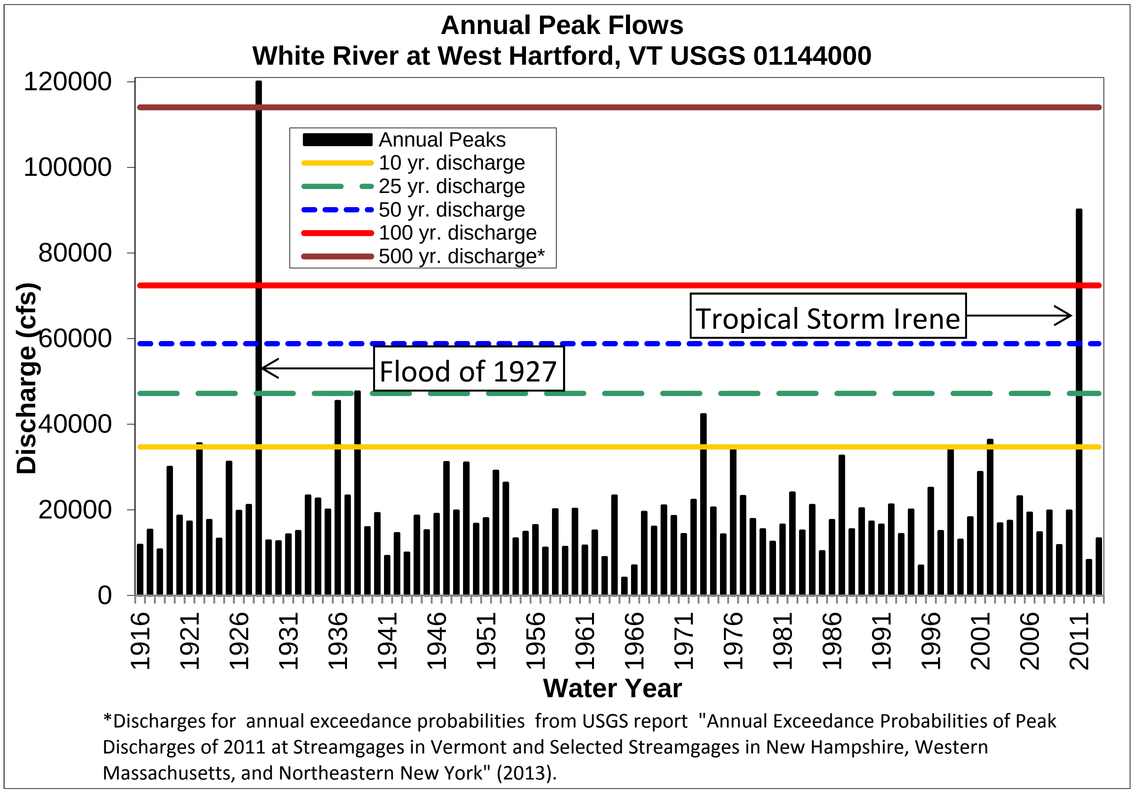

Figure 3.5. Annual Peak Flows for the White River at West Hartford, Vermont.

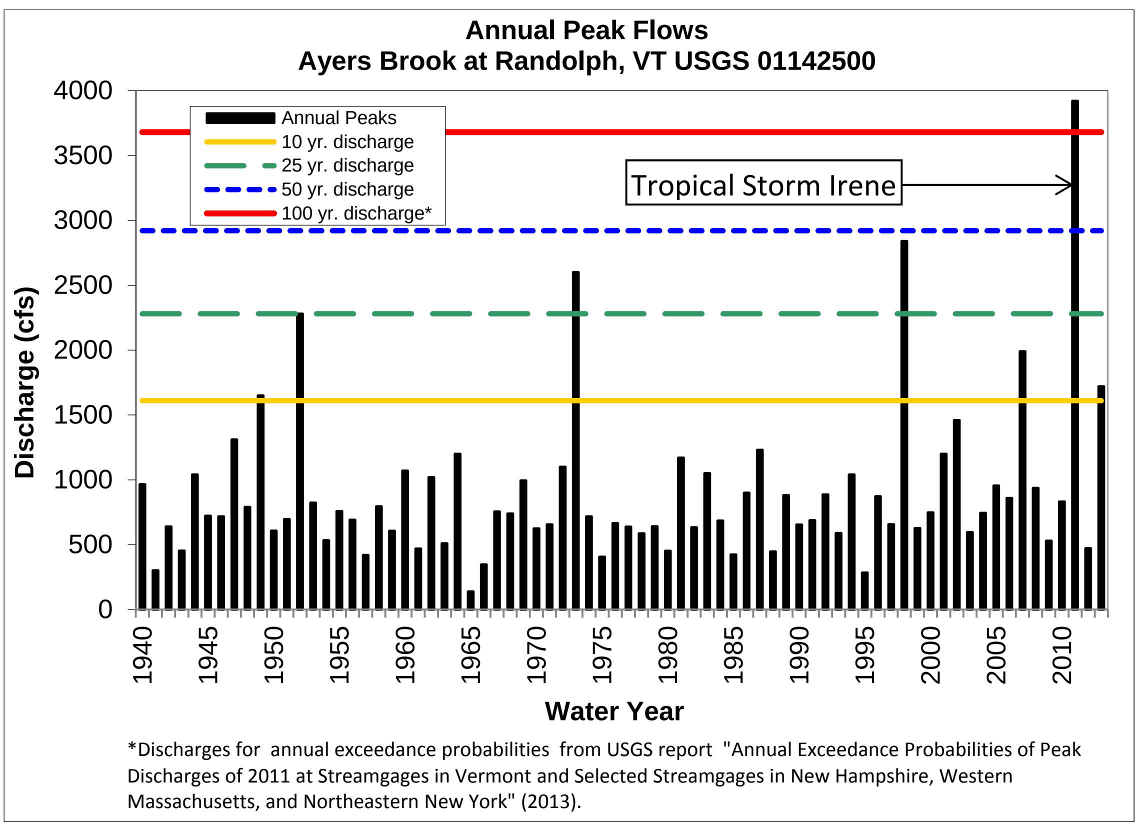

Figure 3.6. Annual Peak Flows for the Ayers Brook at Randolph, Vermont.

3.5 Ecological Setting

The Upper and Middle White River and Tweed River sub-watersheds lie within the Northern Green Mountains 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 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).

Deer wintering areas are present within the study area, especially along upper Hancock Branch, Bartlett Brook, lower Stony Brook, Pond Brook, and Locust Creek. A high proportion of land within the Upper and Middle White River and Tweed River sub-watersheds is incorporated into the Green Mountain National Forest. Core habitat, which represents areas that are at least 100 meters from a zone of human disturbance, is also abundant within these sub-watersheds, as shown on page 1 of Appendix A.

The Vermont Significant Wetland Inventory (VSWI) GIS layer provides important information about the distribution of wetland habitat within the Upper and Middle White River and Tweed River sub-watersheds (Appendix A, page 1). There are numerous wetlands within the sub-watersheds according to the VSWI layer, with the most wetlands located in the northeastern section of the Upper White River sub-watershed, the headwaters of the Tweed River sub-watershed, and the eastern portion of the Middle White River sub-watershed.

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 of the Upper and Middle White River and Tweed River sub-watersheds followed procedures specified in the Vermont Stream Geomorphic Assessment (SGA) Phase 2 Handbook (Vermont Agency of Natural Resources, 2009b), and used version 10.2.1 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 (Vermont Agency of Natural Resources, 2009b). The study used the 2008 Rapid Habitat Assessment (RHA) protocol (Vermont Agency of Natural Resources, 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.

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 December 2014. The Project Team conducted the assessment according to the approved Quality Assurance procedures specified in the Phase 2 handbook. Gretchen Alexander of the State of Vermont Watershed Management Division conducted a QA/QC review of the data collected by (BCE) for the White River watershed during January 2015.

4.3 Bridge and Culvert Methodology

Bridge assessments were conducted by BCE on all public and private crossings within the selected Phase 2 reaches. The Agency of Natural Resources Bridge and Culvert protocols (Vermont Agency of Natural Resources, 2009a) were followed. Latitude and Longitude at each of the structures was determined using a MobileMapper 100 GPS unit. The assessment included photo documentation of the inlet, outlet, upstream, and downstream of each of the structures.

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 B 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 Aquatic Organism Passage (AOP) using the Vermont Culvert Aquatic Organism Passage Screening Tool (Milone and MacBroom, 2009). Tables 3 through 5 in Appendix B explain how each culvert was scored. 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

5.0 RESULTS

5.1 Condition and Departure Analysis

5.1.1 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 (Vermont Agency of Natural Resources, 2009b). Reference reach typing was based on both the Rosgen (1996) and the Montgomery and Buffington (1997) classification systems. Stream and valley characteristics including valley confinement, and slope were determined from digital United States Geological Survey (USGS) topographic maps (Table 2).

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

Table 2 lists the reference stream types for the 2014 assessed reaches in the White River watershed. Most reaches assessed for Phase 2 in the Upper and Middle White River and Tweed River sub-watersheds are "C" channels by reference. Reference "C" channels have unconfined valleys with moderate to gentle valley slopes and moderate to high width to depth ratios and sinuosity. Reference valley confinement varies from semi-confined to very broad throughout the study area. All reaches have a reference bedform of *riffle-pool* except for Little Stony Brook, Fletcher Brook, and two reaches on Stony Brook, which are *step-pool*. The reference reach characteristics were refined during the Phase 2 Assessment.

During the Phase 2 assessment, the 23 study reaches were broken into 66 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. R16-A is the most downstream segment on Reach R16) (Figures 5.1, 5.2, and 5.3). Of the 66 segments, six were not fully assessed; two segments are located in very remote areas and are in stable geomorphic condition (upper Little Stony Brook and upper Bartlett Brook), two are bedrock gorges (on Johnson Brook and Hancock Branch), one could not be accessed due to continuous downed trees in the channel (on Bartlett Brook), and one segment on the West Branch lacked property access.

The existing stream type is based on channel dimensions measured during the Phase 2 assessment. Maps of the reference and existing stream type for each assessed reach/segment are included on pages 2 through 4 of Appendix A. Some of the segments in the 2014 assessment have the same reference and existing stream type. However, the existing stream type differs from the reference stream type in 29 of the 60 fully-assessed segments. This indicates that a stream type departure has taken place in those areas. 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 (Vermont Agency of Natural Resources, 2009b).

Table 2: Geomorphic Setting of 2014 Assessed Reaches

Stream	Reach ID	Reference Stream Type	Reference Confinement	Valley Slope (%)	Bedform
White River	R14	C	Broad	0.14	Riffle-Pool
	R16	B_c	Semi-confined	0.63	Riffle-Pool
	R17	B_c	Semi-confined	0.15	Riffle-Pool
Locust Creek	T3.02	C	Very Broad	1.15	Riffle-Pool
	T3.03	C_b	Broad	4.17	Riffle-Pool
	T3.04	C	Very Broad	2.02	Riffle-Pool
	T3.05	C_b	Narrow	3.84	Riffle-Pool
Pond Brook	T3.2-S3.01	E	Very Broad	4.26	Riffle-Pool
Little Stony Brook	T11.S4.01	C_a	Narrow	8.09	Step-Pool
Stony Brook	T5.01	C	Broad	1.83	Riffle-Pool
	T5.02	B	Narrow	3.67	Riffle-Pool
	T5.03	C	Broad	0.39	Riffle-Pool
	T5.04	C_b	Narrow	4.18	Step-Pool
	T5.05	C	Narrow	0.70	Riffle-Pool
	T5.06	B	Broad	4.68	Step-Pool
Fletcher Brook	T5.3-S1.01	C_b	Narrow	5.67	Step-Pool
Bartlett Brook	T6.1-S1.01	B	Broad	5.06	Riffle-Pool
Johnson Brook	T6.4-S1.01	C_b	Broad	5.02	Riffle-Pool
West Branch of the White River	T7.01	B_c	Very Broad	1.84	Riffle-Pool
	T7.02	C	Very Broad	0.76	Riffle-Pool
Hancock Branch of the White River	T8.01	C	Very Broad	2.02	Riffle-Pool
	T8.02	C	Very Broad	0.72	Riffle-Pool
	T8.03	F_b	Broad	4.12	Riffle-Pool

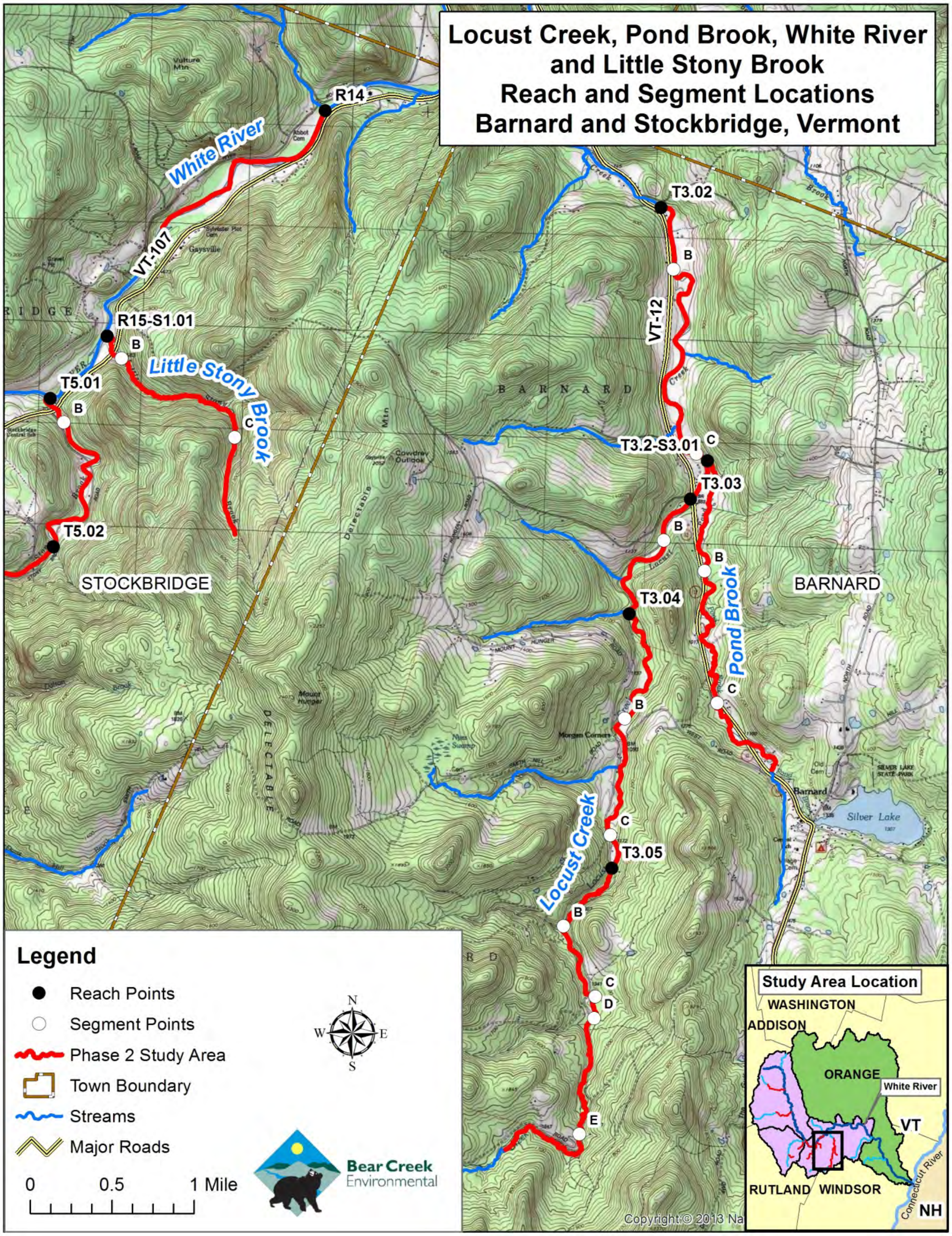

Figure 5.1. Reach and segment locations on Locust Creek, Pond Brook, the White River, and Little Stony Brook.

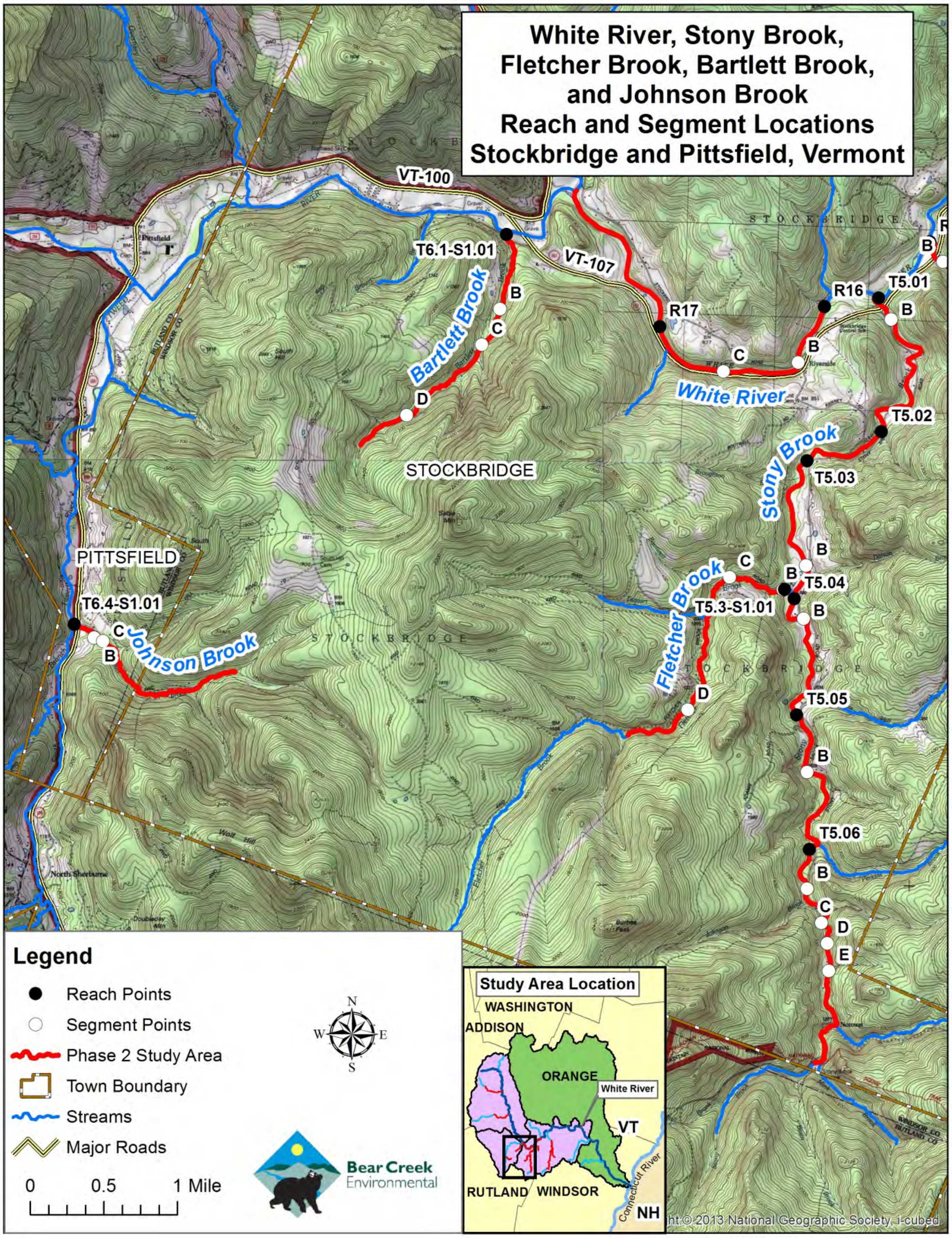

Figure 5.2. Reach and segment locations on Stony Brook, Fletcher Brook, the White River, Bartlett Brook, and Johnson Brook.

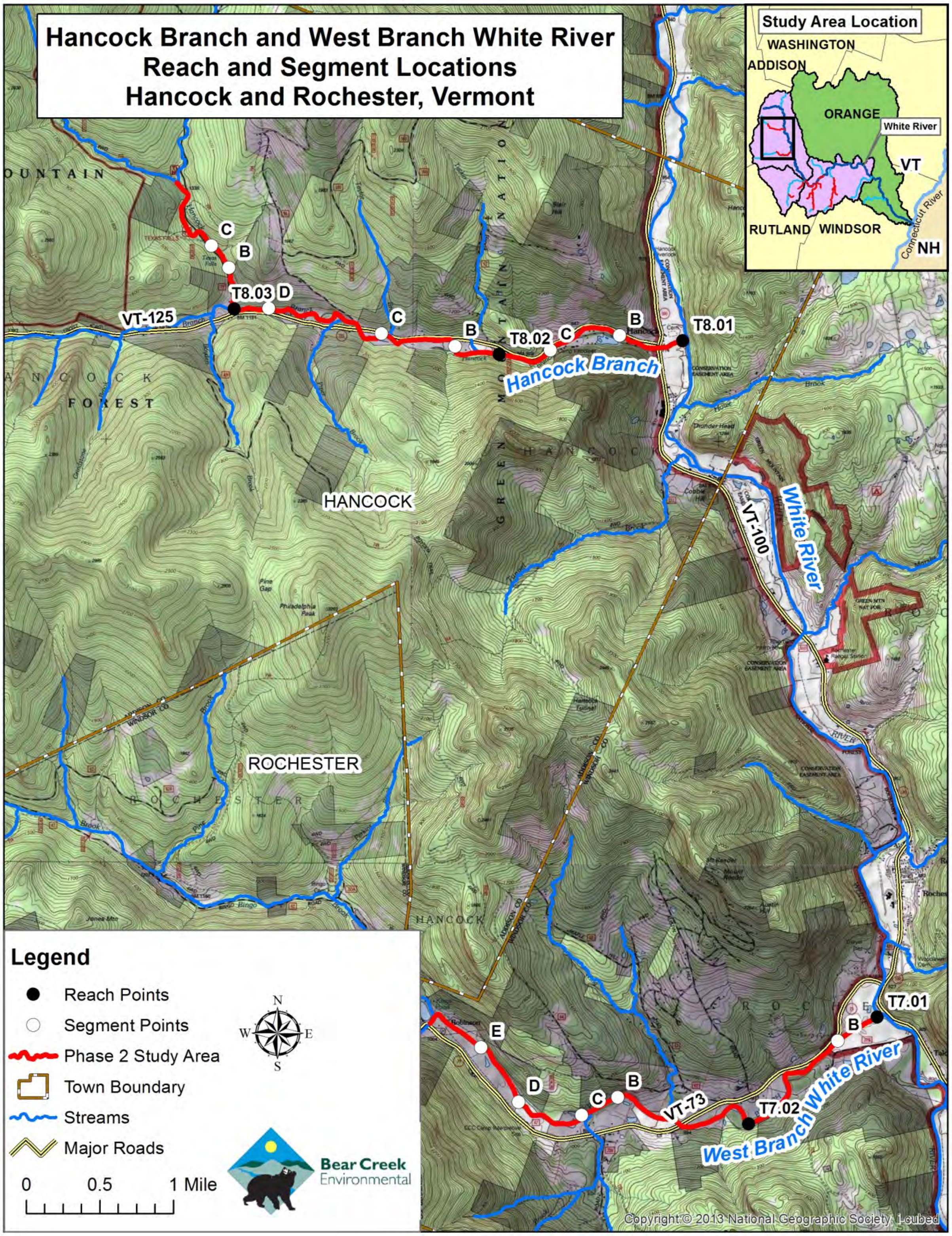

Figure 5.3. Reach and segment locations on the West Branch and Hancock Branch of the White River.

5.1.2 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

Maps of the existing geomorphic condition for each segment are depicted on pages 5 through 7 Appendix A. 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.

Within the 2014 Phase 2 study area in the White River watershed, 17 of 66 segments are in "poor" geomorphic condition, 34 are in "fair" condition, and 9 are in "good" condition. No segment is in "reference" geomorphic condition. Six segments were not assessed due to such constraints as bedrock gorges and property access. The current geomorphic conditions in the assessed segments are a result of several factors. Corridor encroachments are common throughout the study area, as many roads run directly along these streams and houses exist on their banks. Vermont Route 107 significantly encroaches upon the White River for much of the study area, Route 12 encroaches upon Locust Creek, and numerous town roads also cause widespread floodplain encroachment. Development within a river *corridor* can cause a loss of floodplain access, changes in valley confinement, and overall geomorphic instability.

Following Tropical Storm Irene, areas within the White River watershed were dredged and windrowed in order to obtain gravel with which to rebuild damaged roads and in an attempt to protect infrastructure from future flooding and flood damage. This windrowing and dredging, combined with abundant floodplain encroachment have caused many stream segments to lose access to their floodplains. *Mass failures*, erosion, and aggradation were all exacerbated by TSI, and are contributing to the unstable geomorphic condition of many assessment reaches.

5.1.3 Habitat Condition

The habitat condition for each segment within the Upper and Middle White and Tweed River sub-watershed 2014 study area is presented on pages 5 through 7 of Appendix A. Nine segments in the study are in “good” habitat condition and are located in areas where the stream channel flows away from major roads and into forested areas. These segments have minimal to no corridor encroachments, allowing for high quality vegetated banks and buffers. The segments in “good” condition have high amounts of large woody debris in the channel, many *pools*, and good canopy cover; all of which provide habitat for aquatic life. Fifty-one segments are in “fair” habitat condition. Segments are in “fair” habitat condition mainly as a result of corridor encroachments, poor bank and buffer vegetation, erosion and revetments, channel straightening, and windrowing. Many of the segments in “fair” habitat condition exhibit a habitat stream type departure to a *plane bed*, featureless channel.

The maps on pages 5 through 7 of Appendix A include both the geomorphic and habitat condition maps side by side. Overall, the habitat and geomorphic conditions were often similar, suggesting that the ecological health of the White River watershed is related to the geomorphic condition of the stream.

As shown in Table 1 (Appendix A, pages 11 through 16), many of the segments have *incised* and are undergoing widening, as exhibited by high incision and width to depth ratios. Historically, many encroachments, namely roads and development, have led to straightening of the stream channels and their degradation (incision). Widening has occurred in response to this streambed lowering in many segments. Abundant aggradation as a result of increased flows from TSI in 2011 likely exacerbated the widening process in certain locations. A high width to depth ratio indicates that the channel is relatively wide and shallow. Wide, shallow channels tend to have a reduced number of deep pools, canopy cover in the center of the stream, undercut banks, and sometimes a higher water temperature (Foster, Stein, & Jones, 2001). These factors can contribute to a lower habitat score.

5.1.4 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 within the White River watershed include:

- Channelization and bank armoring
- Removal of woody riparian vegetation
- Floodplain encroachments
- Post-Irene channel work

These anthropogenic practices have altered the balance between water and sediment discharges within the White River watershed. 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 (ANR, 2010a). Sediment can be supplied to the river through bank erosion, large flooding events, and stormwater inputs. Sediment regime maps depicting the reference and existing sediment regimes can be found on pages 8 through 10 of Appendix A. 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 development and agriculture within the riparian corridor) and sediment storage within the watershed have altered the reference sediment regime types for many segments within the study area. Tropical Storm Irene, as well as post-flood channel work, further altered the sediment regimes in the study reaches. 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.

5.1.5 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 degradation and recent channel work are present within the Upper and Middle White and Tweed River sub-watersheds. The placement of numerous state highways, including Routes 12, 107, 73, and 125, has significantly changed river valley widths, floodplain access, and ability of streams to meander within the study area. The floods that came through the area during TSI in August, 2011 have resulted in significant aggradation and planform change within many reaches, and post-TSI channel work has exacerbated these impacts in some areas.

The segment condition ratings of the Upper and Middle White and Tweed River sub-watersheds 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 White River watershed are undergoing a channel evolution process in response to human influences on the watershed and impacts from flooding.

The “F” stage channel evolution model (Vermont Agency of Natural Resources, 2009b; Vermont Agency of Natural Resources, 2004) is helpful for explaining the channel adjustment processes underway in the Upper and Middle White and Tweed River sub-watersheds. The “F” stage channel evolution model 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 5.4 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

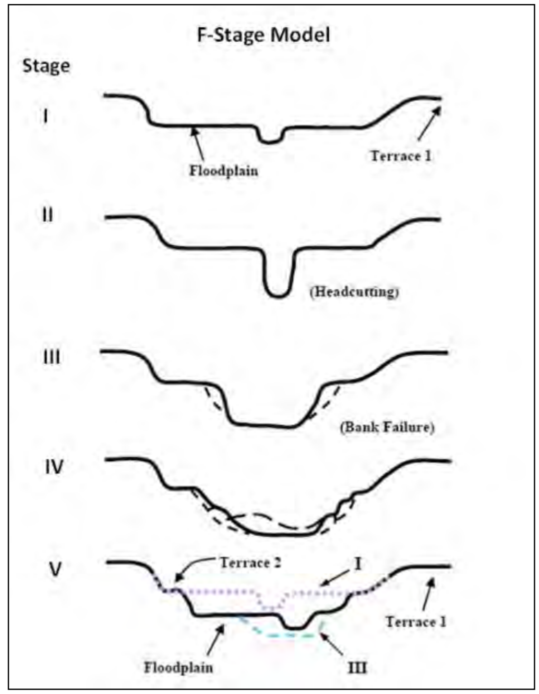

Figure 5.4 Typical channel evolution models for F-Stage (Vermont Agency of Natural Resources, 2009b)

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.

The channel evolution stage for each Phase 2 segment was determined based on field data and observations. A summary of the channel evolution stage by segment is provided on pages 11 through 16 of Appendix A. Five segments – one on Locust Creek, one on Pond Brook, two on Stony Brook, and one on the Hancock Branch – are in stage I of the "F-stage" channel evolution model, indicating that they have not undergone a channel incision process. Eighteen segments within the study area are currently in stage "F-II", indicating that they have incised but not widened, often due to *boundary conditions* limiting lateral channel movement.

Twenty-four segments are in stage III of the "F-stage" channel evolution model. Most of these segments have undergone severe historic incision. The placement of numerous state and town roads has likely led to this incision and the subsequent loss of floodplain access, which has been exacerbated by TSI and post-TSI channel work in some areas. In stage F-III, the entrenched channel begins to widen and migrate laterally through bank erosion caused by the increased stream power.

Thirteen segments have moved into stage IV of the "F-stage" channel evolution model. This means that the channel has stabilized itself by changes in its migration pattern and is building a new floodplain at a lower elevation. Some of these segments are highly depositional and have become braided with many large *bar* features including transverse (*diagonal*) bars. This buildup of sediment has led to channel widening and planform adjustment.

5.2 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=11&rid=227&sid=A&option=view&phid=2.

Site-specific projects have been developed to facilitate restoration, conservation, and increased *flood resiliency* within the Upper and Middle White River and Tweed River sub-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.

Locust Creek

T3.02

The most downstream reach included in this study was split into three segments during assessment due to changes in channel dimensions and human impacts. T3.02 flows through a very broad valley, beginning just upstream of the Route 12 crossing near Rhoades Hill Road, and continuing upstream for almost two miles to just above the *confluence* with Pond Brook.

T3.02-A

This segment begins at the reach point and continues upstream for 2,300 feet to where the Creek becomes extremely aggradational. Locust Creek has been historically straightened along Route 12 and the western *valley wall* for the majority of this segment. Extensive channel straightening in this area caused severe historic incision and led to a stream type departure and loss of floodplain access. Agricultural fields exist to the east of the creek and armoring is abundant on both banks, limiting channel widening and lateral migration. This segment's riffle-pool bedform is not well defined and borders on a featureless, plane bed system. T3.02-A is in **fair** geomorphic condition primarily due to extreme historic incision. The segment is also in **fair** habitat condition due to the lack of diverse bed features and well vegetated riparian buffers.

Figure 5.5. Stream channel has been extensively straightened in T3.02-A and lacks a diversity of bed features.

T3.02-A Data Summary		**Reference**	**Existing**
Length: 2,308 ft	Confinement	Very Broad	Very Broad
Drainage Area: 22 sq. mi.	Stream Type	C	F
Evolution Stage: F-II	Entrenchment Ratio	> 2.2	1.2
Sensitivity: Extreme	Incision Ratio	< 1.2	2.4
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel Straightening, Encroachments, Poor Buffers, Revetments**		

T3.02-B

This segment begins where Locust Creek becomes extremely aggradational and more sinuous than segment A. It continues upstream for 8,000 feet to just below the confluence of Pond Brook. T3.02-B is characterized by abundant deposition and an overly-wide channel. This segment has a lower channel slope and wider valley than the reaches above it. Because of this, large amounts of sediment were deposited here during Tropical Storm Irene. This aggradation has caused major channel widening and planform adjustment. Numerous flood chutes cross very large bars, and one channel *avulsion* is present on the inside of a meander bend. T3.02-B underwent moderate historic incision, but retains good floodplain access for most of the segment. Large bars are forming a juvenile floodplain in some areas. Channel windrowing took place post-Irene in small sections throughout this segment, and associated berms are restricting floodplain access in these areas. This segment is in **poor** geomorphic condition due to the aforementioned adjustments and processes. T3.02-B is in **fair** habitat condition due to its channel morphology, a lack of large woody debris, and impacted riparian buffers.

Figure 5.6. T3.02-B is very aggradational and has majorly widened.

T3.02-B Data Summary		Reference	Existing
Length: 8,015 ft Drainage Area: 22 sq. mi. Evolution Stage: F-IV Sensitivity: Very High	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	>2.2	2.5
	Incision Ratio	< 1.2	1.8
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Poor Bank Vegetation, Erosion, Mass Failures, Poor Buffers, Windrowing**		

T3.02-C

Segment T3.02-C begins just below the confluence of Pond Brook and continues upstream for 1,800 feet to just above the Rt. 12 Bridge between Mount Hunger Road and Chateauguay Road. This segment has a lower slope and wider valley than the segments just upstream of it, creating an *alluvial fan*. It is an area where significant deposition occurs due to a reduction in water velocity that allows sediment to drop out during high flows. Following Irene, this segment was extensively dredged, windrowed, and bermed, lowering the streambed and cutting off floodplain access. The Route 12 Bridge over Locust Creek was destroyed by floodwaters. The channel has widened significantly, which likely occurred due to aggradation during Irene. Planform in this segment has been drastically altered by channelization, and numerous flood chutes have been cut off by windrowing. These channel alterations have caused T3.02-C to be in **poor** geomorphic condition. The segment is in **fair** habitat condition due to a lack of diverse bed features from windrowing, as well as poorly vegetated riparian zones.

Figure 5.7. T3.02-C was extensively windrowed following Tropical Storm Irene.

T3.02-C Data Summary		Reference	Existing
	Confinement	Very Broad	Very Broad
Length: 1,792 ft	Stream Type	C	B_C
Drainage Area: 22 sq. mi.	Entrenchment Ratio	> 2.2	2.0
Evolution Stage: F-III	Incision Ratio	< 1.2	2.0
Sensitivity: Very High	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Windrowing, Dredging, Bar Scalping, Channel Straightening, Poor Buffers**		

T3.03

This reach was split into two segments during assessment to account for changes in channel dimensions, banks/buffers, and geomorphic adjustment processes.

T3.03-A

This segment begins just below the Route 12 Bridge between Mount Hunger Road and Chateauguay Road and continues upstream for approximately 1,700 feet to just above Town of Barnard Highway Department. T3.03-A can be characterized by extreme active incision and major historic and recent channel alteration. Chateauguay Road was built into the river valley years ago and severely encroaches upon Locust Creek. Historic straightening along the road caused channel incision within this segment. Additionally, the downstream end of this segment, which aggraded during Irene, was dredged and windrowed post-flood. This lowering of the streambed sparked further channel downcutting, as evidenced by two active headcuts within the segment. Floodplain access has been lost throughout this segment, and a stream type departure has occurred. Due to significant active adjustment, as well as historic and recent channel alteration, T3.03-A is in **fair** geomorphic condition. This segment is also in **fair** habitat condition due to a lack of diverse bed features, limited woody debris, and altered channel morphology.

Figure 5.8. One of two active headcuts present in T3.03-A.

T3.03-A Data Summary		Reference	Existing
Length: 1,745 ft Drainage Area: 12 sq. mi. Evolution Stage: F-II Sensitivity: Extreme	Confinement	Broad	Broad
	Stream Type	C_b	F_b
	Entrenchment Ratio	> 2.2	1.1
	Incision Ratio	< 1.2	3.4
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel Straightening, Encroachments, Windrowing, Headcuts, Revetments, Mass Failure, Erosion, Poor Buffers**		

T3.03-B

This segment is located along Chateauguay Road, beginning just above the Barnard Highway Department and continuing upstream 3,500 feet to approximately a half mile north of the intersection of Chateauguay Road and Mount Hunger Road. Locust Creek was historically straightened along its eastern valley wall and Chateauguay Road. This led to severe historic channel incision, a stream type departure, and loss of some floodplain access. During Tropical Storm Irene, sections of the creek aggraded and widened significantly, causing major damage to Chateauguay Road. When road repairs occurred, the stream channel was windrowed and bermed in many locations. Due to historic and recent channel alterations, T3.03-B is in **fair** geomorphic condition and **fair** habitat condition.

Figure 5.9. Chateauguay Road washed out during TSI in T3.03-B and post-flood work involved windrowing.

T3.03-B Data Summary		Reference	Existing
Length: 3,508 ft Drainage Area: 12 sq. mi. Evolution Stage: F-III Sensitivity: High	Confinement	Broad	Broad
	Stream Type	C_b	B
	Entrenchment Ratio	> 2.2	1.4
	Incision Ratio	< 1.2	3.0
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Windrowing, Channel Straightening, Revetments, Encroachment, Stormwater Inputs**		

T3.04
This reach of Locust Creek was split into three segments during assessment due to changes in channel dimensions, valley width, and banks and buffers.

T3.04-A
The downstream-most segment on reach four of Locust Creek begins at the downstream reach break and continues upstream for 4,500 feet to just below the West Road Bridge. It flows through a broad river valley mostly through forested land. This segment is undergoing major adjustment both vertically and horizontally. The stream channel historically incised throughout most of this segment, resulting in a stream type departure and loss of floodplain access. Aggradation is a major process as the creek builds large bars, and has caused the channel to widen significantly. These depositional features are forming a juvenile floodplain. Major planform adjustment is also occurring in this segment as water flows around depositional features. Five mass failures are present as well as extensive bank erosion. T3.04-A is in **poor** geomorphic condition due to all of these adjustments. Despite having well vegetated riparian buffers in many areas, habitat condition is **fair** due to changes in channel morphology and unstable river banks.

Figure 5.10. Major aggradation is occurring in T3.04-A.

T3.04-A Data Summary		**Reference**	**Existing**
Length: 4,468 ft Drainage Area: 9 sq. mi. Evolution Stage: F-IV Sensitivity: Very High	Confinement	Broad	Broad
	Stream Type	C	B_C
	Entrenchment Ratio	> 2.2	1.4
	Incision Ratio	< 1.2	2.5
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Erosion, Mass Failures, Windrowing, Encroachments**		

T3.04-B

The middle segment on reach four of Locust Creek is approximately 4,400 feet in length, beginning just downstream of the West Road Bridge and continuing upstream to about 1,000 feet downstream of the next Chateauguay Road bridge. T3.04-B appears to have undergone major aggradation during Tropical Storm Irene. Approximately half of this segment was windrowed to remove this aggradation from the channel during post-Irene recovery work. A large mass failure occurred along Chateauguay Road within this segment during Irene, which was heavily armored during repair. Severe historic channel incision has occurred in this segment, most likely due to extensive straightening along Chateauguay Road. Active incision was also observed during the assessment due to the presence of one headcut moving upstream through the segment. Bank erosion is severe on both banks despite abundant armoring. Planform adjustment is occurring as the Creek carves flood chutes over large bars, which are forming and/or have formed a juvenile floodplain in areas that have not been subjected to windrowing. Major adjustments coupled with extensive channel alteration have caused T3.04-B to be in **poor** geomorphic condition. Due to unstable river banks, poor riparian buffers, and channel alterations, habitat conditions in this segment are **fair**.

Figure 5.11. Bank instability is common in T3.04-B, as is bank armoring.

T3.04-B Data Summary		**Reference**	**Existing**
Length: 4,377 ft	Confinement	Very Broad	Very Broad
Drainage Area: 9 sq. mi.	Stream Type	C	B_C
Evolution Stage: F-IV	Entrenchment Ratio	> 2.2	1.6
Sensitivity: Very High	Incision Ratio	< 1.2	2.8
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel Straightening, Encroachments, Bank Erosion, Revetments, Mass Failure, Windrowing**		

T3.04-C

Segment C on reach four of Locust Creek is characterized by a slightly narrower river valley than segment B. It is a shorter segment, only 1,200 feet long, and begins just downstream of a private driveway bridge to 2353 and 2357 Chateauguay Road and ends just above the next Chateauguay Road bridge. This segment has undergone extreme incision, and continues to downcut through areas of deposition via two headcuts. According to conversations with creek-abutting landowners, the stream channel cut down several feet during Tropical Storm Irene into glacial till. It is currently beginning the widening process, causing bank erosion, one mass failure, and bank slumping. This deeply incised channel has lost access to its floodplain and will continue to widen throughout the near future. Two houses directly on the banks of Locust Creek within T3.04-B are at significant risk due to the widening channel. This segment is in **poor** geomorphic condition and **fair** habitat condition.

Figure 5.12. Extreme channel incision has occurred and continues to occur in T3.04-C.

T3.04-C Data Summary		Reference	Existing
Length: 1,200 ft Drainage Area: 9 sq. mi. Evolution Stage: F-III Sensitivity: Extreme	Confinement	Broad	Broad
	Stream Type	C	F
	Entrenchment Ratio	> 2.2	1.2
	Incision Ratio	< 1.2	3.6
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Encroachments, Headcuts, Bank Erosion, Mass Failure, Revetments, Channel Straightening, Stormwater Inputs**		

T3.05

Reach five on Locust Creek was divided into five segments during assessment. These five segments differ primarily in channel dimensions, but also in valley width, channel alterations, planform, and channel slope.

T3.05-A

The downstream-most segment on T3.05 flows through a well forested area, beginning just above the Chateauguay Road Bridge in T3.04-C, and continues upstream for 2,800 feet to just below the Town Highway 46 Bridge. This section of Locust Creek has undergone major incision, and a large headcut, which is cutting through debris and sediment, is present at the top of the segment. Two ledge grade controls are preventing further incision at the downstream end of the segment. Glacial till and clay are common along the stream banks. Channel widening has also occurred in this area, and bank erosion is abundant. Large depositional features occur throughout T3.05-A and are forming a juvenile floodplain. Planform adjustment is also common via flood chutes on bars and the floodplain. Due to channel incision, some floodplain access has been lost, causing a stream type departure. Overall, T3.05-A is in **fair** geomorphic condition due to various adjustment processes occurring in the segment. It is also in **fair** habitat condition due to unstable stream banks and lacking woody debris cover.

Figure 5.13. Many areas of T3.05-A are very wide and aggradational, building a juvenile floodplain.

T3.05-A Data Summary		**Reference**	**Existing**
Length: 2,797 ft Drainage Area: 6 sq. mi. Evolution Stage: F-IV Sensitivity: High	Confinement	Narrow	Narrow
	Stream Type	C_b	B
	Entrenchment Ratio	> 2.2	1.5
	Incision Ratio	< 1.2	2.7
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Mass Failures, Headcut**		

T3.05-B

Segment B of reach 5 on Locust Creek also flows through a narrow valley. It begins just below the TH 46 Bridge and continues upstream to 3,000 feet just above the next Chateauguay Road Bridge. Similarly to downstream segments, this segment has incised significantly, which has led to loss of floodplain access and stream type departure. A headcut exists directly below the segment, which threatens further incision. T3.05-B is beginning the widening process, and bank erosion is prevalent. Four mass failures are also present in this segment and are sources of sediment for the Creek. Small sections within this segment have a narrower river valley where there is naturally very little floodplain access. The riparian buffers are well forested in T3.05-B. The segment is in **fair** geomorphic condition due to historic incision and **good** habitat condition as a result of diverse bed features.

Figure 5.14. T3.05-B has well forested buffers but abundant bank erosion.

T3.05-B Data Summary		**Reference**	**Existing**
Length: 3,042 ft Drainage Area: 6 sq. mi. Evolution Stage: F-III Sensitivity: Extreme	Confinement	Narrow	Narrow
	Stream Type	B	F_b
	Entrenchment Ratio	1.4-2.2	1.1
	Incision Ratio	< 1.2	2.4
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Mass Failures**		

T3.05-C

T3.05-C is a short segment between two Chateauguay Road bridges in the vicinity of Town Highway 48. This segment was a location of major aggradation during Tropical Storm Irene and was windrowed extensively after the flood. The Creek avulsed during Irene in this location, carving a new channel on the inside of a large meander bend. Post-Irene, the Creek was moved back to its old location and heavily bermed to block off the new channel. Extensive windrowing and berming has led to a narrowing of the stream channel and a stream type departure in this segment. Berms on both sides of the Creek create an incised channel with reduced floodplain access. The reference riffle-pool bedform has been altered due to channel work and now has reduced diversity of bed features, causing habitat conditions in this segment to be **fair**. The extensive channel alteration that occurred in this segment post-Irene has caused it to be in **poor** geomorphic condition.

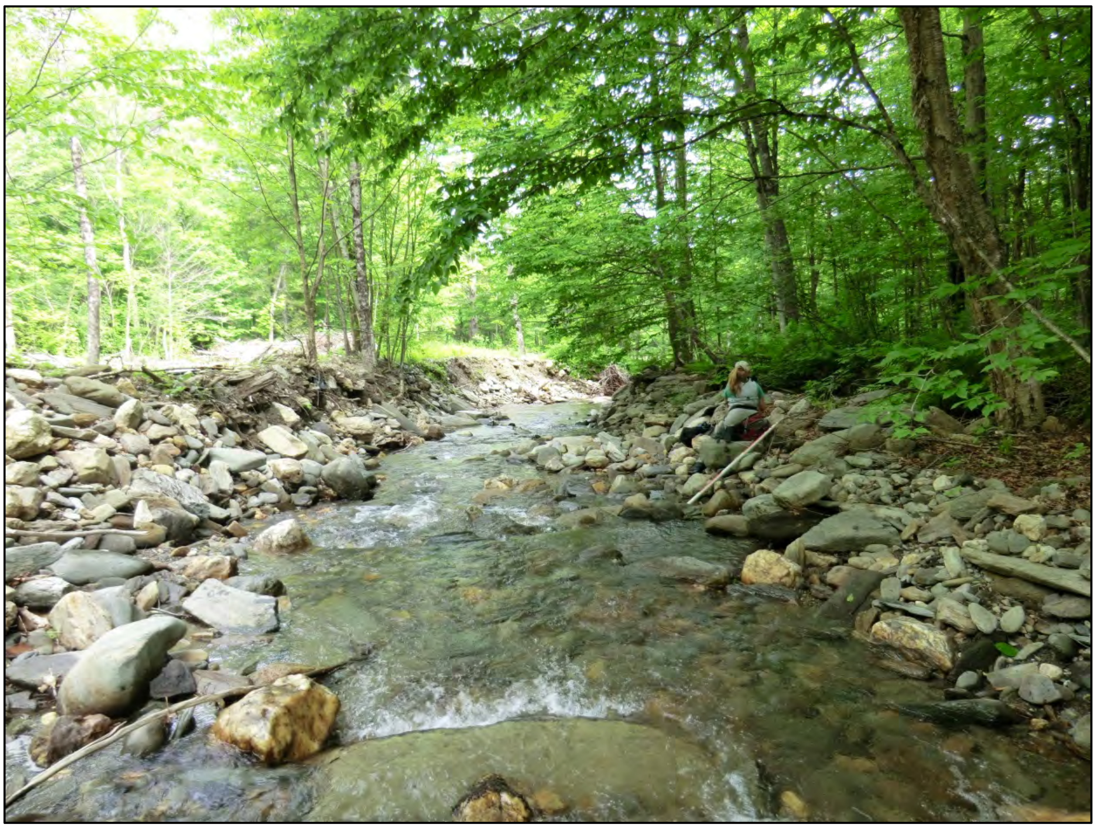

Figure 5.15. Extensive post-flood channel alteration in T3.05-C removed aggradation from the creek and returned the channel to its pre-flood location (new channel in left of picture behind windrowing).

T3.05-C Data Summary		**Reference**	**Existing**
Length: 772 ft Drainage Area: 6 sq. mi. Evolution Stage: F-II Sensitivity: Extreme	Confinement	Broad	Broad
	Stream Type	C_b	E
	Entrenchment Ratio	> 2.2	10.2
	Incision Ratio	< 1.2	1.8
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Windrowing, Bank Erosion**		

T3.05-D

Segment D on reach five of Locust Creek begins at the upstream end of the windrowed section in segment C and continues upstream for 3,300 feet to below the Chateauguay Road Bridge near 4411 Chateauguay Road. Sections toward the bottom of this segment were historically straightened along Chateauguay Road, which likely contributed to the channel incision observed throughout the segment. Channel windrowing occurred in sections of stream that directly abut Chateauguay Road where deposition occurred during the flood. These recent channel alterations have caused further downcutting within T3.05-D, as evidenced by the presence of four active headcuts moving upstream through the segment. Bank erosion is almost continuous along both banks, and four mass failures are further contributing to bank instability and adding fine sediment to the channel. Short sections within this segment are flatter and have more aggradation and planform change than others. Historic and recent incision has led to a loss of some floodplain access and a stream type departure. Overall, T3.05-D is in **fair** geomorphic condition as a result of the downcutting of the stream channel. Habitat conditions in this segment, however, are **good** due to abundant large woody debris in the channel, well vegetated riparian buffers, and a well-defined bedform that provides ample pool and riffle habitat.

Figure 5.16. One of four headcuts in T3.05-D contributing to channel incision and instability.

T3.05-D Data Summary		Reference	Existing
Length: 4,338 ft Drainage Area: 6 sq. mi. Evolution Stage: F-III Sensitivity Very High	Confinement	Narrow	Narrow
	Stream Type	C_b	B
	Entrenchment Ratio	> 2.2	2.1
	Incision Ratio	< 1.2	2.1
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Headcuts, Bank Erosion, Mass Failures, Windrowing, Encroachments, Stormwater Inputs**		

T3.05-E

This segment is the upstream-most section of Locust Creek included in this assessment. It is 4,000 feet in length, beginning just below the upstream-most bridge over Locust Creek on Chateauguay Road. The creek flows through a densely forested area for this whole segment, with no development nearby except for Chateauguay Road. T3.05-E has excellent floodplain access and has not incised or widened. Some areas have more planform adjustment than others via flood chutes formed around downed trees. Several bedrock grade controls throughout this segment are holding the bed in place and deterring channel incision. Small areas of bank erosion are present, but overall the banks are stable and mossy. T3.05-E is in **good** geomorphic condition due to its stability and good floodplain access. It is also in **good** habitat condition due to well forested banks and buffers, abundant woody debris in the channel, and a diversity of pool and riffle habitat.

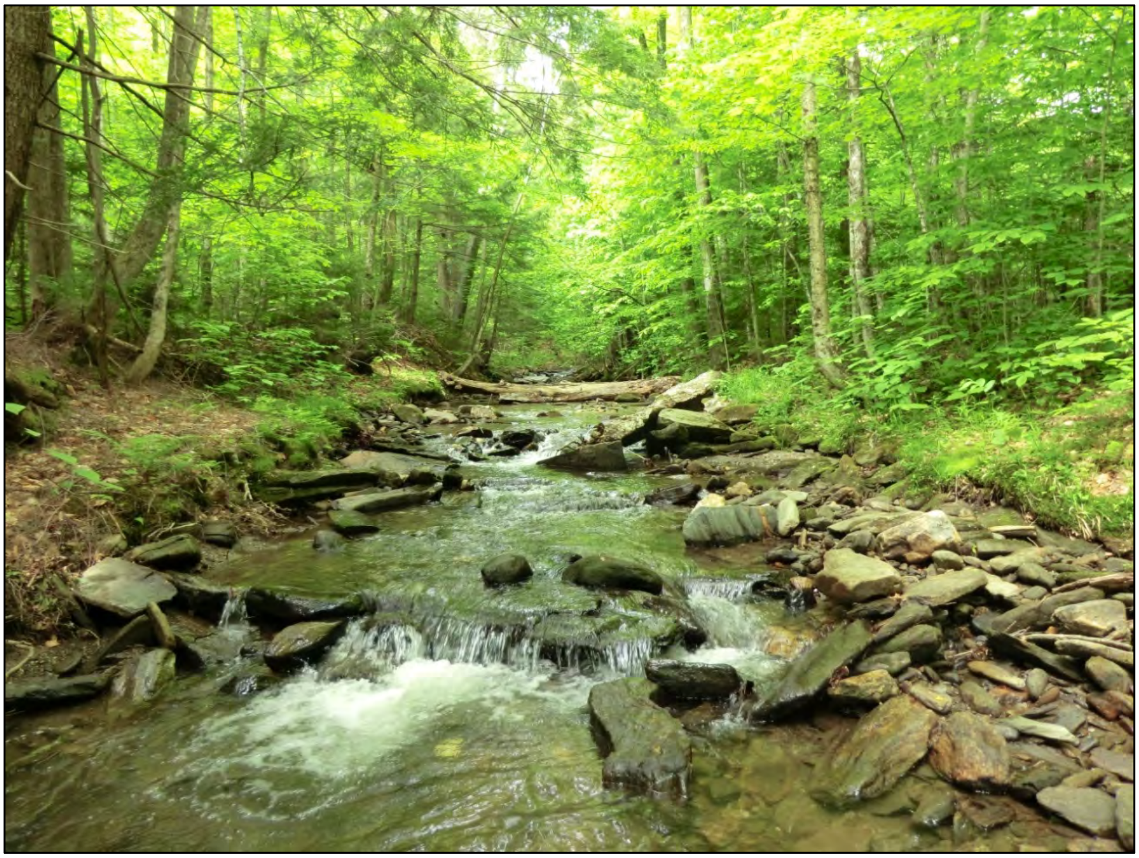

Figure 5.17. T3.05-E has excellent floodplain access and is very stable.

T3.05-E Data Summary		**Reference**	**Existing**
Length: 3,995 ft Drainage Area: 6 sq. mi. Evolution Stage: F-I Sensitivity: High	Confinement	Semi-Confined	Semi-Confined
	Stream Type	C_b	C_b
	Entrenchment Ratio	> 2.2	2.9
	Incision Ratio	< 1.2	1.0
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Mass Failures, Bank Erosion, Stormwater Inputs**		

Pond Brook

T3.2-S3.01

The study area on Pond Brook for this assessment was split into three segments to account primarily for changes in channel dimensions. Reach one on Pond Brook alternates in abutting land cover between wetland, forested, residential, and agricultural. Pond Brook originates partially from Silver Lake in the center of Barnard, flows along Vermont Route 12 and into Locust Creek in segment T3.02-C.

T3.2-S3.01-A

The downstream-most segment on Pond Brook begins at the confluence with Locust Creek and continues upstream for approximately 4,000 feet to where surrounding land use and reference stream type change near 7939 Route 12. Pond Brook is a narrow wetland channel by reference in segment T3.2-S3.01-A, but the majority of adjacent wetlands in this section have been converted over time to agricultural and residential land. Channel incision in this segment is moderate. The majority of the segment was historically straightened, likely to produce crop land, and the brook is now pushed up against its east valley wall in many places. A few short sections within this segment were windrowed or dredged post-Irene. There is little woody vegetation along the banks to provide root structure; subsequently the lack of riparian buffers is contributing to bank erosion. Bank armoring is scattered throughout T3.2-S3.01-A, but most of it is failing and not preventing further erosion. Three mass failures are present along the east valley wall. A constructed log dam exists within the segment and is creating a barrier for aquatic organism passage. This segment is in **fair** geomorphic condition due to historic channel management that has led to incision. It is also in **fair** habitat condition as a result of altered adjacent wetlands, unstable banks, and poor riparian buffers.

Figure 5.18. Riparian buffers are lacking in T3.2-S3.01-A and bank erosion is abundant.

T3.2-S3.01-A Data Summary		Reference	Existing
Length: 4,146 ft Drainage Area: 7 sq. mi. Evolution Stage: F-II Sensitivity: Extreme	Confinement	Very Broad	Very Broad
	Stream Type	E	E
	Entrenchment Ratio	> 2.2	15.3
	Incision Ratio	< 1.2	1.6
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Poor Bank Vegetation, Poor Buffers, Straightening**		

T3.2-S3.01-B

Segment B on reach one of Pond Brook flows through primarily forested land along Route 12 for 5,700 feet, ending at the Route 12 culvert near 7129 Route 12. The brook flows through a very broad valley in this segment, though the valley narrows in three locations where the channel is also slightly steeper. The brook has mostly natural planform in this segment, except for a few areas where it was historically straightened along Route 12. Segment B has incised only very slightly, and has not widened. Four channel constrictions are present and are creating extra deposition and scour features in their proximity. Overall, Pond Brook has excellent floodplain access in this segment and has not undergone much recent geomorphic change. For these reasons, segment B is in **good** geomorphic condition. It is in **fair** habitat condition due to a lack of large pools and altered adjacent wetlands.

Figure 5.19. T3.2-S3.01-B has good floodplain access and well forested buffers.

T3.2-S3.01-B Data Summary		Reference	Existing
	Confinement	Very Broad	Very Broad
Length: 5,669 ft	Stream Type	C	C
Drainage Area: 7 sq. mi.	Entrenchment Ratio	> 2.2	9.0
Evolution Stage: F-II	Incision Ratio	< 1.2	1.3
Sensitivity: Moderate	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Encroachments, Channel Straightening, Stormwater Inputs**		

T3.2-S3.01-C

The upstream-most segment on Pond Brook included in this assessment is 3,600 feet in length and flows through mainly residential land. The reach ends just below the Route 12 culvert near the southeastern intersection of Route 12 with Davis Road. Similar to segment A on Pond Brook, this segment is a narrow wetland channel by reference but most of its adjacent wetlands were altered over time and converted to different land uses. Davis Road and Route 12 encroach upon the brook in several locations in this segment, and the brook was historically straightened along them in certain areas. Bank erosion and armoring are scattered throughout the segment. Despite historic channel alteration, T3.2-S3.01-C has not incised or widened and has continuous floodplain access. These factors cause this segment to be in **good** geomorphic condition. It is in **fair** habitat condition as a result of impacted banks and buffers and lacking woody debris in the channel.

Figure 5.20. Pond Brook is a narrow wetland channel in T3.2-S3.01-C with impacted buffers.

T3.2-S3.01-C Data Summary		**Reference**	**Existing**
Length: 3,617 ft	Confinement	Very Broad	Broad
Drainage Area 7 sq. mi.	Stream Type	E	E
Evolution Stage: F-I	Entrenchment Ratio	> 2.2	9.2
Sensitivity: High	Incision Ratio	< 1.2	1.1
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Bank Erosion, Mass Failures, Encroachment, Poor Buffers**		

White River Main Stem

R14

The downstream-most reach on the White River included in this assessment is reach fourteen in Stockbridge. It begins just above the confluence of Lilliesville Brook and continues upstream for 7,300 feet to just below the Gaysville Bridge. The lower half of R14 was historically straightened due to the construction of River Road and Vermont Route 107 within the White River valley. The upper portion of the reach has a more natural, sinuous planform. Historic channel alteration, such as straightening, has led to moderate historic incision within R14. Despite this, the White River retains good floodplain access throughout this reach. The river has aggraded and widened substantially and will continue to do so as it moves toward a least erosive state. During Tropical Storm Irene, floodwaters caused the formation of a mass failure along the river's northern valley wall. The storm also likely contributed to the aggradation and widening observed during assessment. Bank armoring is continuous where the river flows along River Road and Route 107. Due to historic and active channel adjustment processes within R14, the reach is in **fair** geomorphic condition. The over-widened channel present in R14 lacks diverse bed features, in-stream woody debris, and well forested riparian buffers, which causes is to be in **fair** habitat condition.

Figure 5.21. Reach R14 on the White River is very wide and aggradational.

R14 Data Summary		Reference	Existing
Length: 7,257 ft Drainage Area: 227 sq. mi. Evolution Stage: F-III Sensitivity: High	Confinement	Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	4.0
	Incision Ratio	< 1.2	1.5
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Encroachments, Poor Buffers, Erosion, Revetments**		

R16

Reach sixteen on the White River was divided into three segments during assessment to account for changes in valley width, channel dimensions, and planform. Most of the reach flows directly along Vermont Route 107.

R16-A

The downstream-most segment on R16 begins at Stockbridge Central School and continues upstream approximately 2,300 feet to the Blackmer Boulevard Bridge. The White River valley is wooded and largely undisturbed throughout R16-A. Human impacts are minimal, and localized in the vicinity of the Blackmer Boulevard Bridge. This segment has undergone moderate historic incision, but retains its reference stream type and access to its floodplain. The White River is in the process of widening in this location, which has led to extensive bank erosion and two large mass failures. R16-A is in **fair** geomorphic condition as a result of historic incision and active widening. It is also in **fair** habitat condition due to lacking pool features, refuge areas, and general in-stream cover for fish.

Figure 5.22. Widening has caused mass failures and bank erosion along the White River in R16-A.

R16-A Data Summary		**Reference**	**Existing**
Length: 2,278 ft	Confinement	Semi-Confined	Semi-Confined
Drainage Area: 198 sq. mi.	Stream Type	B_C	B_C
Evolution Stage: F-III	Entrenchment Ratio	1.4 – 2.2	1.5
Sensitivity: High	Incision Ratio	< 1.2	1.8
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Erosion, Mass Failures**		

R16-B

The second segment on reach sixteen of the White River is characterized by continuous corridor encroachment by Route 107 and extensive historic channel straightening. It begins at the Blackmer Boulevard Bridge and extends upstream 2,900 feet to where the river channel becomes narrower. The straightening and encroachment that the White River has been subjected to due to Route 107 have led to extreme historic incision and loss of floodplain access. The majority of the southern bank of the river has been riprapped along Route 107. The river has widened to the north where there is no bank armoring to prevent it, creating extensive bank erosion. This segment is aggrading and building a juvenile floodplain on its large bars. Major infrastructure damage occurred within R16-B during Tropical Storm Irene. The Blackmer Boulevard Bridge was damaged due to a landslide that occurred adjacent to the bridge. The Route 107 embankment was also damaged in at least two locations and had to be rebuilt post-flood. It is likely that gravel mining occurred within R16-B during flood recovery work, though it is difficult to identify exactly where. The severe incision and widening present in R16-B have caused it to be in **fair** geomorphic condition. This segment is also in **fair** habitat condition because its overly-wide channel provides little cover and lacks a diversity of bed features.

Figure 5.23. The White River is overly-wide in R16-B and is building large bars.

R16-B Data Summary		**Reference**	**Existing**
Length: 2,929 ft Drainage Area: 198 sq. mi. Evolution Stage: F-IV Sensitivity: Extreme	Confinement	Semi-Confined	Narrowly Confined
	Stream Type	B_C	F
	Entrenchment Ratio	1.4 – 2.2	1.2
	Incision Ratio	< 1.2	2.8
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Encroachment, Straightening, Revetments, Bank Erosion, Stormwater Inputs**		

R16-C

The upstream-most reach on R16 of the White River begins in the vicinity of Hunt Farm Road and continues upstream about 3,100 feet to where the river no longer flows directly along Route 107. The entirety of R16-C was channelized along Route 107 historically and again recently after Tropical Storm Irene. Floodwaters from TSI caused the White River to wash out the Route 107 embankment and one lane of the road throughout most of R16-C. During post-flood recovery, extensive gravel mining occurred in R16-C to obtain material with which to rebuild the road. Route 107 is a significant encroachment, which has created a very narrow and deep channel in this location. The river aggraded and widened substantially during Irene, but was narrowed and directed toward the north valley wall during post-flood work. Extensive armoring due to Route 107 on the south bank and the valley wall on the north bank are preventing the river from widening once more. It may continue to downcut because it is unable to widen. Irene floodwaters also caused two large mass failures along the northern bank of the river, which are extremely silty and an evident source of fine sediment. Historic and recent channel alterations and associated incision have resulted in R16-C being in **fair** geomorphic condition. The segment is also in **fair** habitat condition due to its loss of bedform and conversion to a featureless plane bed system.

Figure 5.24. Route 107 is a significant encroachment in R16-C, creating a deep, narrow channel.

R16-C Data Summary		**Reference**	**Existing**
Length: 3,076 ft Drainage Area: 198 sq. mi. Evolution Stage: F-II Sensitivity: Extreme	Confinement	Semi-Confined	Narrowly Confined
	Stream Type	B_C	F
	Entrenchment Ratio	1.4 – 2.2	1.4
	Incision Ratio	< 1.2	2.6
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Encroachment, Straightening, Revetments, Mass Failures, Erosion, Stormwater Inputs, Gravel Mining**		

R17

Reach seventeen on the White River was not divided into any segments during assessment. The river flows through a semi-confined valley in this reach, beginning where it flows away from Route 107, continuing upstream for 6,500 feet, and ending at the confluence of the Tweed River. Blackmer Boulevard encroaches upon the river corridor frequently, but historic channel straightening appears to have been minimal. Major historic incision has occurred in R17, which has led to loss of floodplain access and a stream type departure. The White River has widened significantly in this reach, and bank erosion and mass failures are abundant. The downstream end of R17 majorly aggraded during Irene, and was subjected to gravel mining post-flood where the river flows toward Route 107. This reach is currently in **fair** geomorphic condition as a result of its loss of floodplain access and overly-wide channel. Habitat is also in **fair** condition here due to unstable banks, lack of connectivity to its floodplain, and changing morphology.

Figure 5.25. R17 has incised and widened significantly.

R17 Data Summary		**Reference**	**Existing**
Length: 6,500 ft Drainage Area: 196 sq. mi. Evolution Stage: F-III Sensitivity: Extreme	Confinement	Semi-Confined	Semi-Confined
	Stream Type	B_C	F
	Entrenchment Ratio	1.4 – 2.2	1.1
	Incision Ratio	< 1.2	2.4
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Encroachment, Erosion, Mass Failures, Stormwater Inputs**		

Little Stony Brook

R15-S1.01

Little Stony Brook is a tributary to the White River located in the town of Stockbridge. It flows through the woods mostly away from human impacts and enters the White River in R15. Little Stony Brook is the smallest stream included in this assessment, with a watershed size of only 2.3 square miles at its mouth. Reach one of Little Stony Brook is steep, with an average channel slope of 7.7 percent. It was split into three segments during assessment to account for changes in valley width and planform.

R15-S1.01-A

The downstream-most segment on reach one of Little Stony Brook extends from the confluence with the White River upstream about 1,100 feet to above the Route 107 bridge. This segment is an alluvial fan, which forms due to a significant drop in channel slope and widening of the valley as it opens up into the White River valley. Segment A is a natural area of significant deposition and has a braided bedform by reference. Development is abundant along this section of Little Stony Brook, and as a result it has been historically managed to be a single-thread channel. During Irene, major deposition occurred within this segment. To protect the houses on the banks of the brook, the channel was dredged and windrowed. Bank failure occurred on the north bank just above the confluence during Irene, and riprap was installed post-flood to protect a house on the bank. Three headcuts are present within R15-S1.01-A due to recent channel excavation. The water surface of the White River is substantially lower than that of Little Stony Brook at its mouth. The White River was extensively riprapped post-Irene in this location, creating a riprap cascade at the mouth of Little Stony Brook. This segment is in **poor** geomorphic condition due to major historic and recent channel alteration. Habitat is in **fair** condition due to a loss of bedform resulting from extensive channel work.

Figure 5.26. Extensive dredging and windrowing create an incised channel in R15-S1.01-A.

R15-S1.01-A Data Summary		Reference	Existing
Length: 1,059 ft	Confinement	Very Broad	Very Broad
Drainage Area: 2 sq. mi.	Stream Type	D	F_b
Evolution Stage: F-III	Entrenchment Ratio	N/A	1.3
Sensitivity: Extreme	Incision Ratio	< 1.2	2.8
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Braided	Plane Bed
Major Stressors:	**Straightening, Windrowing, Encroachments, Revetments, Erosion**		

R15-S1.01-B

Segment B on reach one of Little Stony Brook flows through a narrow valley above the Route 107 Bridge. Human impacts within this segment are very minimal and include corridor encroachment by a driveway at the downstream end of the segment. An abandoned logging road runs along the brook in areas, and may be contributing increased stormwater. A large rusted tank is present in the stream channel where a culvert under the abandoned trail has blown out. The valley walls are frequently adjacent to the stream channel within this segment and are very steep and comprised of wet sandy soils underlain by glacial till. These conditions have caused the formation of continuous mass failures along both valley walls (nineteen in total). These mass failures are a major source of fine sediment for Little Stony Brook. The brook's substrate particle distribution indicates an excess of fine sediment in the channel, and pools are filled in. The mass failures also contribute large amounts of woody debris to the channel, which is causing aggradation and planform change. Severe historic channel incision has led to a loss of floodplain access and a stream type departure. Little Stony Brook is in the process of widening. All of the aforementioned factors have caused R15-S1.01-B to be in **fair** geomorphic condition. Despite abundant woody debris, a lack of human impacts, and well forested buffers, this segment is in **fair** habitat condition due to unstable banks and an excess of fine sediment in the channel.

Figure 5.27. Continuous mass failures are contributing woody debris and sediment to R15-S1.01-B.

R15-S1.01-B Data Summary			Reference	Existing
Length:	5,534 ft	Confinement	Narrow	Narrow
Drainage Area:	2 sq. mi.	Stream Type	C_a	F_a
Evolution Stage:	F-III	Entrenchment Ratio	> 2.2	1.4
Sensitivity:	Extreme	Incision Ratio	< 1.2	2.8
		Dominant Bed Material	Cobble	Gravel
		Dominant Bedform	Step-Pool	Step-Pool
Major Stressors:		**Mass Failures, Erosion**		

R15-S1.01-C

The upper-most segment on Little Stony Brook included in this study was not fully assessed due to its remote location and lack of human impacts. It flows through a vast expanse of forested land with no nearby development. Qualitative observations taken from the downstream end of this segment suggest that it is very similar to segment B in terms of stream type and geomorphic condition. It appears to have undergone historic incision and a stream type departure.

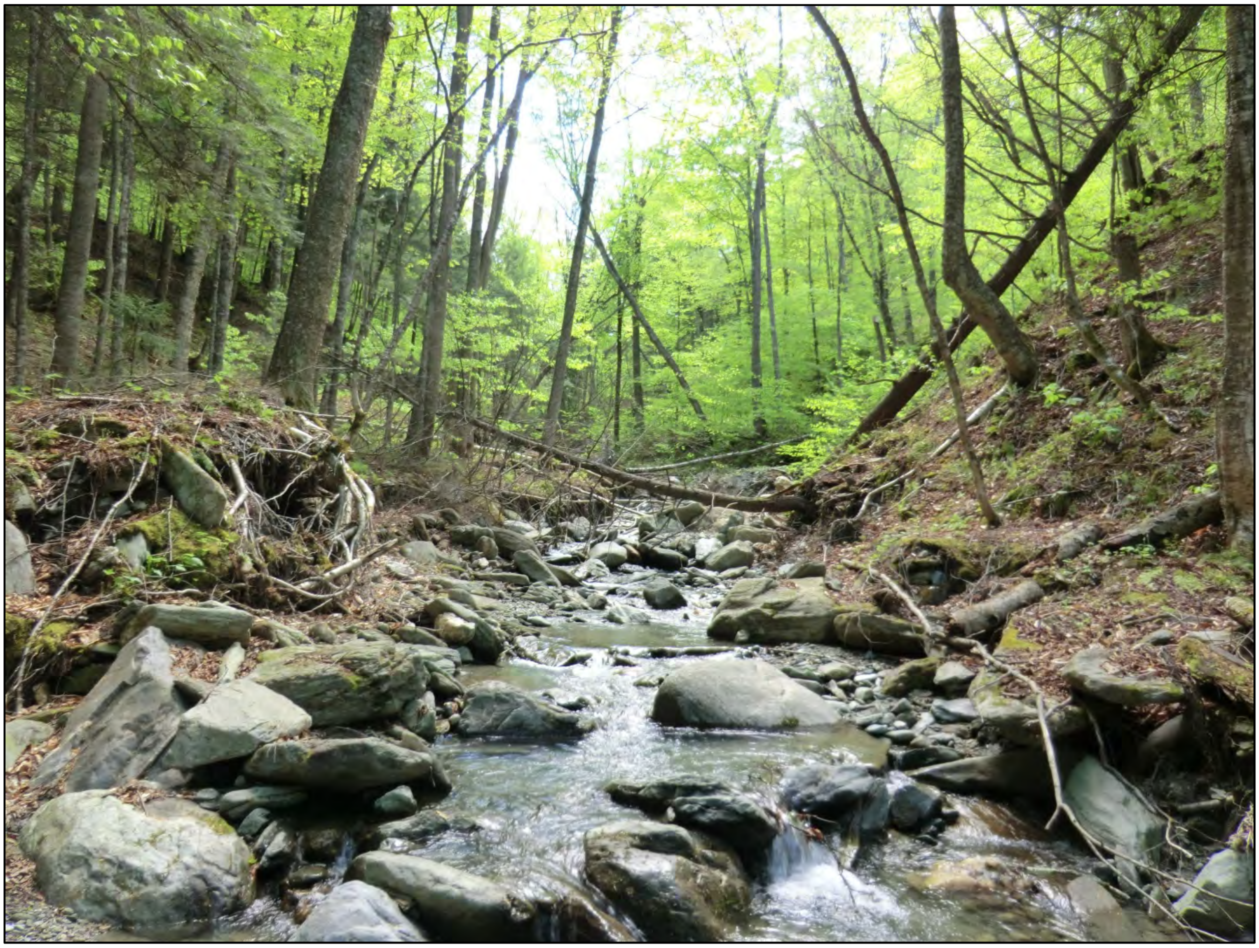

Figure 5.28. The upper segment on reach one of Little Stony Brook was not fully assessed, but appears to be very similar to segment B.

R15-S1.01-C Data Summary	***NOT ASSESSED**	**Reference**	**Existing**
Length: 3,258 ft Drainage Area: 2 sq. mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Semi-Confined	Semi-Confined
	Stream Type	C_a	F_a
	Entrenchment Ratio	> 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Step-Pool	Step-Pool
Major Stressors:	**Mass Failures, Erosion**		

Stony Brook

T5.01

The downstream-most reach on Stony Brook was divided into two segments during assessment to account for changes in valley with and channel planform. Stony Brook flows north from state owned land in Killington and enters the White River in R15 in Stockbridge.

T5.01-A

Segment A on reach one of Stony Brook forms an alluvial fan as the stream flows into the White River. It is highly depositional and has a low slope. Vermont Route 107 crosses Stony Brook in this segment. The Route 107 Bridge was destroyed during Tropical Storm Irene and rebuilt thereafter. The new bridge appears to have been built onto large amounts of fill and is so high up that it is now on the valley walls of Stony Brook. The fill and riprap associated with the bridge create a pinch point and alter channel planform. The abutments from the old bridge remain in place in the channel, and two older stone abutments from different bridges are also present. Two large mass failures are present on the western bank along a pull off on Stony Brook Road. If these mass failures continue to erode, they could put the road at risk of washing out. Severe bank erosion has occurred along the eastern bank directly in front of a house, which has been riprapped. Most of T5.01-A has good floodplain access and has not incised. This segment is in **fair** geomorphic condition due to planform alteration and major aggradation. Habitat is also in **fair** condition as a result of lacking woody debris, few pools, and poor riparian buffers.

Figure 5.29. T5.01-A is highly depositional and has many old abutments throughout it.

T5.01-A Data Summary		**Reference**	**Existing**
Length: 1,178 ft Drainage Area: 23 sq. mi. Evolution Stage: F-I Sensitivity: Extreme	Confinement	Narrow	Narrow
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	6.7
	Incision Ratio	< 1.2	1.0
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Mass Failures, Straightening, Encroachments**		

T5.01-B

The more upstream segment within T5.01 is characterized by extreme active channel adjustment. It begins upstream of the Route 107 Bridge and continues along Stony Brook Road for approximately 6,200 feet. Long sections of the brook in this segment were historically straightened along Stony Brook Road, which has contributed to extreme incision. During Irene, Stony Brook avulsed on the inside of a sharp bend, creating a *neck cutoff*. This new channel is headcutting through sediment and debris. Stony Brook has widened significantly due to historic and recent incision and is changing planform through several flood chutes and the neck cutoff. Aggradation is major, and large bars are building a juvenile floodplain in many areas. Adjustments have led to a loss of some floodplain access and a stream type departure. Geomorphic condition is **poor** as a result of major channel adjustment currently occurring within T5.01-B. Habitat is in **fair** condition due to loss of strong bedform, lacking woody debris, unstable banks, and poor buffers.

Figure 5.30. Much of T5.01-B was historically straightened along Stony Brook Road and is extremely incised.

T5.01-B Data Summary		Reference	Existing
Length: 6,227 ft Drainage Area: 23 sq. mi. Evolution Stage: F-IV Sensitivity: Very High	Confinement	Broad	Broad
	Stream Type	C	B_C
	Entrenchment Ratio	> 2.2	1.7
	Incision Ratio	< 1.2	3.7
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Encroachments, Revetments, Bank Erosion, Mass Failures, Headcut, Stormwater Inputs**		

T5.02

Reach two on Stony Brook begins at 1079 Stony Brook Road and continues upstream for 3,200 feet to near 1607 Stony Brook Road. This segment was almost entirely straightened along Stony Brook Road, which significantly encroaches upon the brook. This extensive straightening has led to major channel incision, loss of floodplain access, and stream type departure. The channel has widened, aggraded, and is actively adjusting planform. Floodwaters from Tropical Storm Irene destroyed a bridge on Ranney Road over Stony Brook in this segment, which was rebuilt during the summer and fall of 2014. Bank erosion is abundant in T5.02 due to major widening. Four mass failures are also present in T5.02. Bank armoring is continuous throughout sections of this segment, especially in areas where the brook flows along Stony Brook Road. The upstream section of the segment appears to have been subjected to gravel mining to remove significant aggradation from TSI. Multiple flood chutes are causing lateral adjustment and deposition is creating a juvenile floodplain in some sections of T5.02. The aforementioned historic and active channel adjustments have caused T5.02 to be in **poor** geomorphic condition and **fair** habitat condition.

Figure 5.31. Bank armoring along Stony Brook Road is extensive in T5.02.

T5.02 Data Summary		Reference	Existing
Length: 3,241 ft Drainage Area: 22 sq. mi. Evolution Stage: F-III Sensitivity: Extreme	Confinement	Narrow	Narrow
	Stream Type	B	F_b
	Entrenchment Ratio	1.4 - 2.2	1.3
	Incision Ratio	< 1.2	3.0
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel Straightening, Encroachments, Revetments, Bank Erosion, Mass Failures, Poor Buffers**		

T5.03

Reach three on Stony Brook was split into three segments during assessment to account for changes in planform, channel dimensions, and valley width. T5.03 flows through wooded, residential, and agricultural areas along Stony Brook Road.

T5.03-A

The downstream segment on reach three experienced significant historic incision, and continues to incise via headcutting. T5.03-A is an area where major deposition of material occurred during Irene, creating very large bars. Significant widening has occurred throughout the segment, causing frequent bank erosion and mass failures. Several sections within T5.03-A were windrowed and/or dredged post-Irene, removing deposited material from the channel and creating berms to restrict floodplain access. An alluvial fan is present toward the downstream end of the segment where the channel slope drops and extreme aggradation is present. Planform has been altered by recent channel work in T5.03-A, and adjustment is actively occurring. Depositional features are building a juvenile floodplain within this segment. Due to the geomorphic processes at work in T5.03-A, as well as recent channel alteration, the segment is in **poor** geomorphic condition. Unstable river banks, poor riparian buffers, and impacted bedform and morphology are causing habitat to be in **fair** condition in T5.03-A.

Figure 5.32. T5.03-A has undergone major deposition and widening.

T5.03-A Data Summary		Reference	Existing
Length: 4,431 ft Drainage Area: 22 sq. mi. Evolution Stage: F-IV Sensitivity: Very High	Confinement	Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	3.4
	Incision Ratio	< 1.2	1.9
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel Straightening, Windrowing, Dredging, Bank Erosion, Mass Failures**		

T5.03-B

The upstream segment on T5.03 is approximately 1,400 feet long, ending just upstream of the Fletcher Brook confluence. Segment B was historically straightened for its entirety along Stony Brook Road. Moderate historic incision occurred here as a result of this straightening. Stony Brook is narrow in this section, in part due to riprap that may be preventing widening. A short section was windrowed post-Irene. T5.03-B is in **fair** geomorphic condition due to past channel alterations and incision. Lacking woody debris, altered planform, and disturbed banks and buffers have caused T5.03-B to be in in **fair** habitat condition.

Figure 5.33. T5.03-B is extensively encroached upon by Stony Brook Road, creating a narrow channel.

T5.03-B Data Summary		Reference	Existing
Length: 1,368 ft Drainage Area: 22 sq. mi. Evolution Stage: F-II Sensitivity: Very High	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	< 1.4	5.1
	Incision Ratio	< 1.2	1.7
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Channel Straightening, Encroachments, Poor Buffers, Revetments**		

T5.04

Reach four on Stony Brook was divided into two segments during assessment to account for changes in channel dimensions and alterations. In this reach, Stony Brook flows along Stony Brook Road from just above Fletcher Brook to just above Davis Hill Brook.

T5.04-A

The downstream segment on reach four of Stony Brook is characterized by a wide channel with abundant deposition. The downstream third of this segment was likely historically straightened along the eastern valley wall to create agricultural land. Historic incision followed, causing a stream type departure and loss of floodplain access. In this segment, the stream channel has widened significantly, and is in the process of building large bars. Bank erosion is common along both banks as the channel continues to widen. Two large mass failures along the western valley wall are contributing fine sediment to the stream channel within T5.04-A. Due to significant channel incision and widening, this segment is in **fair** geomorphic condition. It is also in **fair** habitat condition because woody debris is lacking within the channel, pool habitat is lacking, and stream banks are unstable.

Figure 5.34. T5.04-A has widened and is actively aggrading.

T5.04-A Data Summary		Reference	Existing
Length: 1,281 ft Drainage Area: 13 sq. mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Narrow	Narrow
	Stream Type	C_b	F_b
	Entrenchment Ratio	> 2.2	1.4
	Incision Ratio	< 1.2	2.0
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Mass Failures, Bank Erosion, Encroachments, Poor Buffers**		

T5.04-B

Segment B on reach four of Stony Brook begins just upstream of 2730 Stony Brook Road and continues upstream for 4,200 feet to 3494 Stony Brook Road. This segment is less incised than segment A and has not widened as much. Moderate historic incision occurred within segment B likely as a result of some straightening along Stony Brook Road, and has caused a stream type departure and partial loss of floodplain access. T5.04-B is currently in the process of widening to achieve equilibrium once more. Some sections of the segment widened significantly and underwent major planform change during Tropical Storm Irene. Just downstream of the confluence of Davis Hill Brook, Stony Brook avulsed, cutting a new channel on the eastern bank. In the process of doing so, the brook washed away a camp and flowed down Stony Brook Road. The camp was destroyed, as was a segment of the road. In post-flood recovery work, the brook was rerouted to its old course, and the new channel was filled in. The road was repaired but the camp was not rebuilt. Mass failures are abundant within T5.04-B, primarily occurring along the western valley wall. Bank erosion is also widespread due to channel widening, and armoring is present in areas where the brook flows along the road. This segment is in **fair** geomorphic condition as a result of major recent adjustments and channel work. It is also in **fair** habitat condition, with lacking riparian buffers and impacted channel morphology.

Figure 5.35. Stony Brook avulsed and destroyed a camp and Stony Brook Road in T5.04-B (left side of photo).

T5.04-B Data Summary		**Reference**	**Existing**
Length: 4,150 ft Drainage Area: 13 sq. mi. Evolution Stage: F-III Sensitivity: High	Confinement	Narrow	Narrow
	Stream Type	C_b	B
	Entrenchment Ratio	> 2.2	1.8
	Incision Ratio	< 1.2	1.9
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Encroachments, Poor Buffers, Channel Straightening, Windrowing, Mass Failures, Bank Erosion, Revetments**		

T5.05

This reach was divided into two distinct segments during assessment to account for changes in valley width and channel planform. Segment A flows through a semi-confined valley, while segment B flows through a very broad valley.

T5.05-A

The downstream segment on reach five of Stony Brook is naturally confined between Driscolls Road and Stony Brook Road. It extends from the reach break upstream approximately 2,400 feet to where the river valley widens significantly. A section of the segment was historically straightened along Driscolls Road, which has contributed to the severe historic incision observed during the assessment. Major widening has also occurred in T5.05-A, most of which likely happened during Tropical Storm Irene. The valley walls in this segment are very steep and unstable, which has led to the formation of nine mass failures. Many of these mass failures have occurred along Stony Brook Road and Driscolls Road, putting them at risk of future damage. In two locations, mass failures occurred along Stony Brook Road during Irene, washing out the road and requiring large amounts of embankment armoring post-flood. For most of the segment, aggradation is minor, however, at the bottom of T5.05-A, a bedrock pinch point has created a sediment plug with localized aggradation. The Driscolls Road Bridge over Stony Brook is a significant channel constriction and was damaged by TSI floodwaters. Historic incision has resulted in a loss of floodplain access in T5.05-A and a stream type departure. In combination with widening, this segment is in **fair** geomorphic condition. Habitat condition is also **fair** as a result of unstable banks, impacted buffers, and an over-widened channel.

Figure 5.36. One of many large mass failures contributing sediment to Stony Brook in T5.05-A.

T5.05-A Data Summary		Reference	Existing
Length: 2,356 ft	Confinement	Semi-Confined	Semi-Confined
Drainage Area: 10 sq. mi.	Stream Type	B	F_b
Evolution Stage: F-III	Entrenchment Ratio	1.4 - 2.2	1.2
Sensitivity: Very High	Incision Ratio	< 1.2	3.0
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Mass Failures, Bank Erosion, Revetments, Straightening, Channel Constriction**		

T5.05-B

The upstream segment on T5.05 flows through a wider valley than the downstream segment and is lower gradient. It begins slightly upstream of the Driscolls Road Bridge and continues upstream for 3,900 feet to just above the second Stony Brook Road Bridge in reach five. Stony Brook Road was built into the river valley in T5.05-B and the majority of this segment was straightened along the road when it was built. Major historic downcutting has led to a stream type departure and partial loss of floodplain access. Aggradation is major throughout segment B, and widening is occurring in most places, with it – extensive bank erosion. Sections of T5.05-B that have been straightened along Stony Brook Road have lost their reference bedform and are featureless plane bed rather than riffle pool. The majority of this segment is building a juvenile floodplain on large bars and adjusting laterally via flood chutes. These adjustments have resulted in T5.05-B being in **fair** geomorphic condition. Habitat condition is also **fair**. In-channel woody debris is lacking, bedform has been altered, and banks and buffers are unstable and lacking vegetation.

Figure 5.37. Aggradation is abundant throughout T5.05-B.

T5.05-B Data Summary		**Reference**	**Existing**
Length: 3,898 ft Drainage Area: 10 sq. mi. Evolution Stage: F-IV Sensitivity: Very High	Confinement	Very Broad	Very Broad
	Stream Type	C	B_C
	Entrenchment Ratio	> 2.2	1.9
	Incision Ratio	< 1.2	2.0
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Encroachments, Erosion, Revetments**		

T5.06

The upstream-most reach on Stony Brook included in this assessment was split into five segments during assessment due to changes in channel dimensions, depositional features, and valley width. T5.06 flows through forested land primarily owned by the Vermont Department of Fish and Wildlife.

T5.06-A

Segment A on reach six of Stony Brook begins just upstream of the second upstream-most Stony Brook Road Bridge within the assessment area and continues upstream for 1,700 feet. This segment can be characterized by an extremely wide channel with abundant aggradation. This aggradation is causing braiding of the channel in two locations and is creating a juvenile floodplain. The banks are eroding as the stream channel widens. Corridor development is minimal within T5.06-A, but Stony Brook Road does encroach upon the brook briefly at the upstream end of the segment. Historic channel incision has led to a stream type departure and significant loss of floodplain access. Active planform adjustment is evidenced by flood chutes and a multiple thread channel in some locations. T5.06-A is undergoing major adjustments as it progresses toward equilibrium, which places it in **poor** geomorphic condition. Habitat is in **fair** condition due to lacking habitat features such as pools, refuge areas, and undercut banks.

Figure 5.38. T5.06-A is majorly aggrading and building a juvenile floodplain.

T5.06-A Data Summary		**Reference**	**Existing**
Length: 1,657 ft Drainage Area: 8 sq. mi. Evolution Stage: F-IV Sensitivity: Extreme	Confinement	Broad	Broad
	Stream Type	C	F
	Entrenchment Ratio	> 2.2	1.2
	Incision Ratio	< 1.2	2.2
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Mass Failure, Encroachment**		

T5.06-B

This segment flows through a narrow valley and has a steeper channel slope than segment A. T5.06-B spans approximately 2,000 feet in the vicinity of 5095 Stony Brook Road. It has incised only slightly and has not widened for the majority of the segment. Some sections are more incised and/or wider, but these are not dominant. A short portion of this segment was windrowed post-Irene in the vicinity of the Stony Brook Road Bridge. Three mass failures exist within T5.06-B and erosion is scattered throughout. Bank armoring is minimal and limited to the vicinity of the bridge. T5.06-B is in **fair** geomorphic condition as a result of minor aggradation and planform adjustment. It is in **good** habitat condition because of a well-defined riffle-pool bedform, ample woody debris cover, and good hydrologic characteristics.

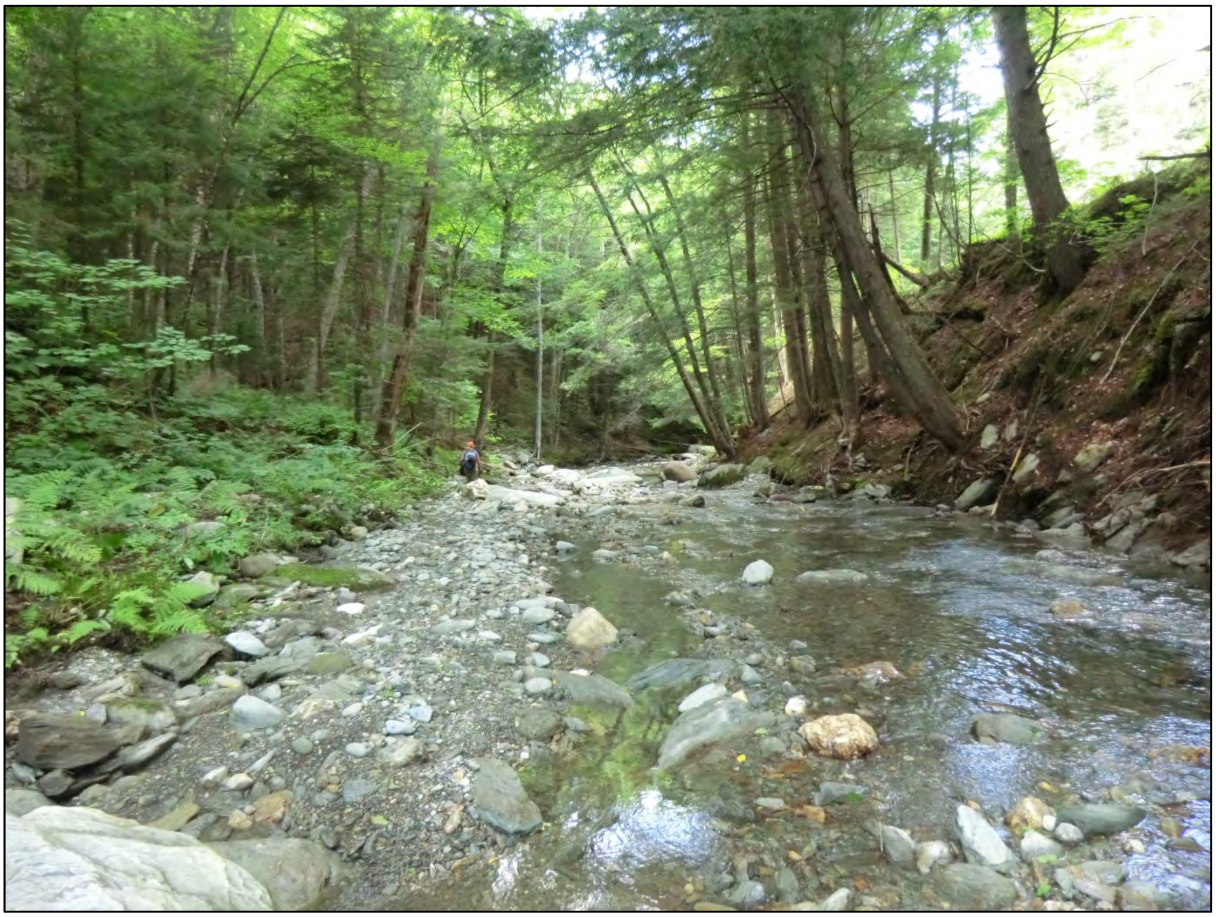

Figure 5.39. T5.06-B flows through a narrow valley is not very incised.

T5.06-B Data Summary		**Reference**	**Existing**
Length: 1,952 ft Drainage Area: 8 sq. mi. Evolution Stage: F-II Sensitivity: Very High	Confinement	Narrow	Narrow
	Stream Type	F	F
	Entrenchment Ratio	< 1.4	1.4
	Incision Ratio	< 1.2	1.2
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Mass Failure, Windrowing**		

T5.06-C

Segment C on reach T5.06 is similar to segment A. It is 900 feet in length and is an extremely wide, aggradational section. This segment has incised slightly, but retains good floodplain access. Floodwaters from Tropical Storm Irene deposited large amounts of material in T5.06-C, which has caused severe channel widening. Deposition is causing braiding of flows in one location. Channel widening has resulted in abundant bank erosion in T5.06-C. Flood chutes cross large bars in this segment, which are in the process of forming a juvenile floodplain. T5.06-C is in **poor** geomorphic condition due to historic and active adjustment processes. Poorly formed bed features, unstable banks, and lacking woody debris contribute to the segment's **fair** habitat condition.

Figure 5.40. Aggradation and widening are two major processes that have occurred in T5.06-C.

T5.06-C Data Summary		Reference	Existing
Length: 899 ft Drainage Area: 8 sq. mi. Evolution Stage: F-IV Sensitivity: Very High	Confinement	Broad	Broad
	Stream Type	C_b	C_b
	Entrenchment Ratio	> 2.2	2.6
	Incision Ratio	< 1.2	1.5
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Bank Erosion, Encroachment, Stormwater Inputs**		

T5.06-D

This segment flows directly along Stony Brook Road for approximately 1,000 feet. T5.06-D has undergone moderate historic incision, likely due to the placement of Stony Brook Road within the river valley. Stony Brook is beginning to widen in this segment, and bank erosion is scattered. Incision has resulted in a stream type departure and loss of floodplain access within T5.06-D. One bedrock grade control is present, which may have a localized effect on deterring future downcutting. Aggradation and planform adjustment are not actively occurring within T5.06-D. Historic channel degradation and current widening have caused this segment to be in **fair** geomorphic condition. T5.06-D is also in **fair** habitat condition due to lacking woody debris cover and impacted channel morphology.

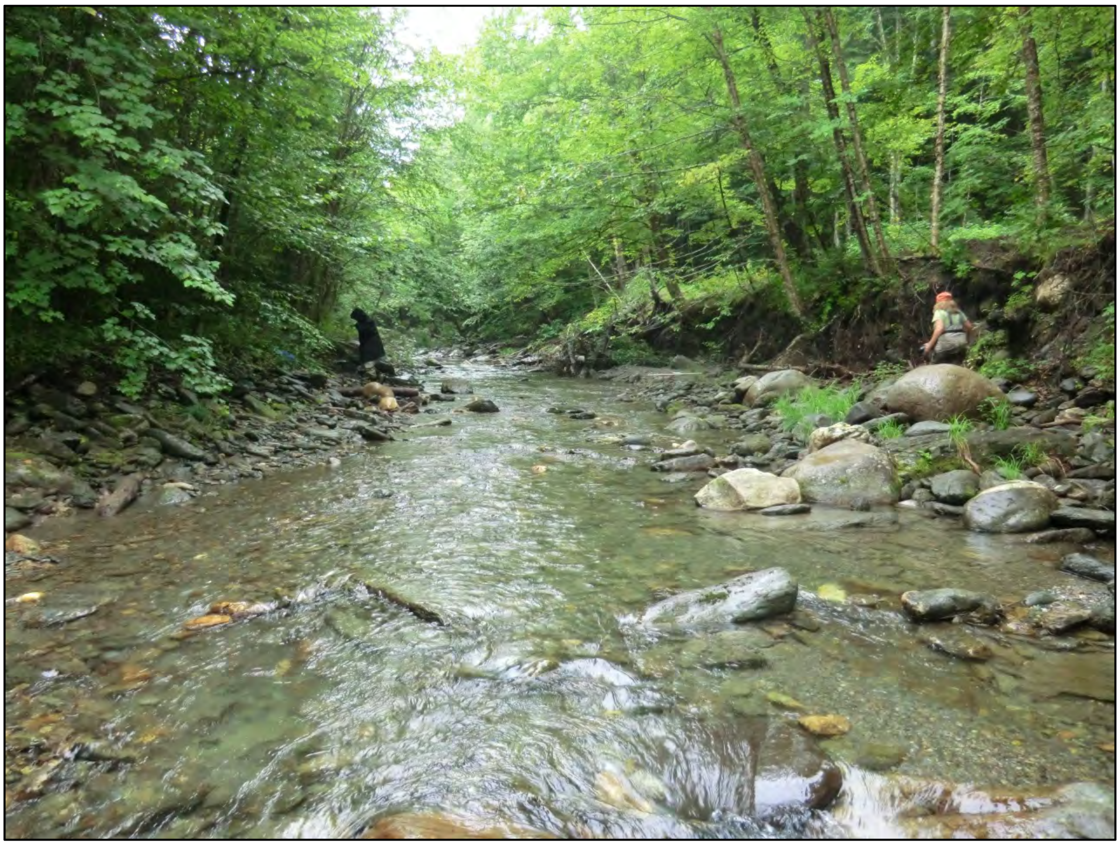

Figure 5.41. T5.06-D has incised historically and is beginning the widening process.

T5.06-D Data Summary		Reference	Existing
Length: 1,021 ft Drainage Area: 8 sq. mi. Evolution Stage: F-III Sensitivity: Extreme	Confinement	Broad	Broad
	Stream Type	B	F_b
	Entrenchment Ratio	1.4 – 2.2	1.4
	Incision Ratio	< 1.2	1.6
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Step-Pool	Riffle-Pool
Major Stressors:	**Straightening, Encroachment, Erosion, Stormwater Inputs**		

T5.06-E

Segment E on reach six is the upstream-most segment on Stony Brook included in this assessment. It is in very stable condition and has not incised. Two bedrock grade controls provide vertical stability to this segment. Stony Brook road encroaches upon the brook for the majority of the segment, but it does not appear to be having significant impacts on the brook. Stormwater inputs from Stony Brook Road are abundant in this segment, and could be delivering sediment to the brook. T5.06-E is in **good** geomorphic condition due to its stability and lack of active adjustment. It is also in **good** habitat condition as a result of diverse bed features and minimal human impacts.

Figure 5.42. T5.06-E is very stable and has good floodplain access.

T5.06-E Data Summary		Reference	Existing
Length: 4,268 ft Drainage Area: 8 sq. mi. Evolution Stage: F-I Sensitivity: Moderate	Confinement	Narrow	Narrow
	Stream Type	B	B_a
	Entrenchment Ratio	1.4 – 2.2	2.2
	Incision Ratio	< 1.2	1.1
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Step-Pool	Step-Pool
Major Stressors:	**Stormwater Inputs, Encroachment**		

Fletcher Brook

T5.3-S1.01

Fletcher Brook is a tributary of Stony Brook that flows primarily through the woods along Fletcher Brook Road and enters Stony Brook in reach T5.03. T5.3-S1.01. The reach has a drainage area of 6.8 miles and average channel slope of 5.4 percent. It was split into four segments during assessment due to changes in valley width, planform, and grade controls.

T5.3-S1.01-A

The downstream-most segment on Fletcher Brook is approximately 500 feet in length, extending from the mouth upstream to where the river valley narrows. This segment is an alluvial fan, occurring as the Fletcher Brook valley widens to meet the Stony Brook valley and the channel slope drops. T5.3-S1.01-A is an area of continual deposition that is very dynamic. During Tropical Storm Irene, major aggradation occurred in this location, causing the brook to rapidly adjust planform. A house on the north bank of the brook was destroyed as floodwaters flowed out from the channel. After the flood, recovery work aimed at returning the brook to a single thread channel. Sediment deposition was windrowed and dredged out of the brook as it was channelized. Major channel alteration post-Irene has caused this segment to be in **poor** geomorphic condition. Channel work also caused a loss of bedform and conversion to a featureless, plane bed system. For this reason, T5.3-S1.01-A is in **fair** habitat condition.

Figure 5.43. Fletcher Brook was extensively dredged and windrowed at the alluvial fan in T5.3-S1.01-A after Irene.

T5.3-S1.01-A Data Summary		Reference	Existing
Length: 465 ft Drainage Area: 7 sq. mi. Evolution Stage: F-II Sensitivity: Extreme	Confinement	Broad	Broad
	Stream Type	D	C
	Entrenchment Ratio	N/A	3.7
	Incision Ratio	< 1.2	1.3
	Dominant Bed Material	Gravel	Cobble
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Windrowing, Straightening**		

T5.3-S1.01-B

Segment B on reach one of Fletcher Brook flows through a narrow valley from above the alluvial fan in segment A upstream 2,200 feet to near 231 Blanchard Road. Bedrock grade controls are present throughout this segment, and a short bedrock gorge exists at the downstream end. Moderate channel incision has occurred in between these grade controls. Short areas of the segment were historically straightened along Fletcher Brook Road, but mostly planform is natural. Six mass failures are present along the southern valley wall. Fletcher Brook Road washed out in at least one location during Irene within this segment. Road rebuilding and armoring led to a narrowing of the channel in areas. Aggradation is present immediately upstream of grade controls but is not a major process. Historic channel incision has caused T5.3-S1.01-B to be in **fair** geomorphic condition. Habitat is also in **fair** condition due to unstable banks and a lack of large pools.

Figure 5.44. Many bedrock grade controls are present within T5.3-S1.01-B.

T5.3-S1.01-B Data Summary		**Reference**	**Existing**
Length: 2,228 ft	Confinement	Narrow	Narrow
Drainage Area: 7 sq. mi.	Stream Type	C_b	C_b
Evolution Stage: F-II	Entrenchment Ratio	> 2.2	2.3
Sensitivity: High	Incision Ratio	< 1.2	1.8
	Dominant Bed Material	Gravel	Cobble
	Dominant Bedform	Step-Pool	Step-Pool
Major Stressors:	**Encroachment, Straightening, Mass Failures, Erosion, Revetments**		

T5.3-S1.01-C

This segment is approximately 5,600 feet in length, flowing through a narrow valley from above Spiegel Road to below Blanchard Road. There are several areas in segment C that were historically straightened along Fletcher Brook Road, which likely led to major historic incision. T5.3-S1.01-C has lost access to its floodplain and undergone a stream type departure. The channel has also experienced major widening and aggradation, and is currently building a juvenile floodplain on large bars. High flows in Fletcher Brook during Irene caused damage to Fletcher Brook Road in numerous locations in T5.3-S1.01-C. During road repair, short sections of the brook were windrowed in the vicinity of damage locations. Bank erosion is nearly continuous along both banks of Fletcher Brook, which can be attributed to the major widening that has occurred. Mass failures are abundant, and are contributing fine sediment and large woody debris to the brook. Debris jams are common in segment C due to these woody debris inputs, and are causing planform change in areas. At the upstream end of the segment, major aggradation occurred during Irene, causing the brook to avulse and cut a new channel over its western bank. T5.3-S1.01-C is in **fair** geomorphic condition due to historic and recent channel adjustment. It is also in **fair** habitat condition due to unstable banks and an overly-wide channel.

Figure 5.45. Mass failures and large depositional features are common in T5.3-S1.01-C.

T5.3-S1.01-C Data Summary		**Reference**	**Existing**
Length: 5,635 ft	Confinement	Narrow	Narrow
Drainage Area: 7 sq. mi.	Stream Type	C_b	F_b
Evolution Stage: F-IV	Entrenchment Ratio	> 2.2	1.4
Sensitivity: Extreme	Incision Ratio	< 1.2	3.9
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Step-Pool	Riffle-Pool
Major Stressors:	**Erosion, Mass Failures, Encroachments, Windrowing, Stormwater Inputs**		

T5.3-S1.01-D

The upstream-most segment included in the assessment of Fletcher Brook begins near 135 Spiegel Road and continues upstream for 2,700 feet to the reach break. This segment has not been subjected to any straightening along Fletcher Brook Road and retains its natural planform. Despite this, the brook has undergone moderate historic incision in this segment and is currently widening. A short bedrock gorge is present in the middle of this segment, which is holding the grade and likely reducing further incision. Bank erosion is nearly continuous throughout the segment and large mass failures are common. The mass failures are sources of sediment and woody debris for the brook, and have led to the formation of numerous debris jams. Minor planform adjustment is occurring in the vicinity of these jams. T5.3-S1.01-D is in **fair** geomorphic condition due to historic incision and active widening. Habitat is in **good** condition, as the brook has an abundance of woody debris that is creating plunge pools and in-stream cover, well vegetated buffers, and diverse bed features.

Figure 5.46. Woody debris from the valley walls lines Fletcher Brook in T5.3-S1.01-D.

T5.3-S1.01-D Data Summary		**Reference**	**Existing**
Length: 2,735 ft Drainage Area: 7 sq. mi. Evolution Stage: F-III Sensitivity: High	Confinement	Semi-Confined	Semi-Confined
	Stream Type	B_a	B_a
	Entrenchment Ratio	1.4 – 2.2	1.7
	Incision Ratio	< 1.2	1.5
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Erosion, Mass Failures**		

Bartlett Brook

T6.1-S1.01
Bartlett Brook is a tributary of the Tweed River in Stockbridge, Vermont. The Tweed River is a major tributary of the White River. Bartlett Brook flows into the Tweed River in reach T6.01 and has a drainage area of 2.6 square miles at its mouth. The brook is remote in location, surrounded only by forest. Reach one, the only reach included in this study, was split into four segments during assessment. The segments differ in planform, banks and buffers, access, and valley width.

T6.1-S1.01-A
The downstream-most segment on Bartlett Brook is approximately 3,000 feet in length, beginning at the mouth of the brook and continuing upstream to where the stream becomes inaccessible due to woody debris in the channel. T6.1-S1.01-A flows through a broad valley and is currently in very stable condition. The brook has incised slightly, which could be due to channel alteration on the Tweed River just below the confluence. Saturated soils on the valley walls have led to the formation of several mass failures, which are contributing sediment and woody debris to the channel. Debris jams are abundant, and are causing minor planform adjustment and some bank erosion. The brook has good floodplain access in this area. T6.1-S1.01 is in **good** geomorphic condition because channel adjustment is minimal. The brook is also in **good** habitat condition in this location as a result of ample woody debris and good bed cover.

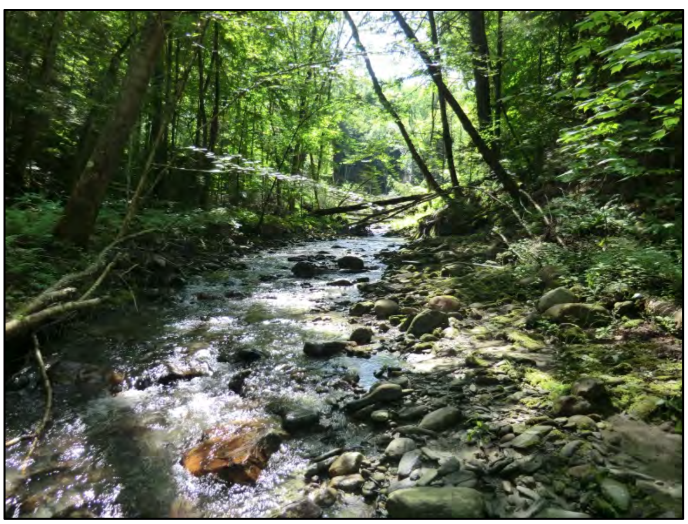

Figure 5.47. T6.1-S1.01-A is geomorphically stable and has good floodplain access.

T6.1-S1.01-A Data Summary		**Reference**	**Existing**
Length: 2,944 ft	Confinement	Broad	Broad
Drainage Area: 2.6 sq. mi.	Stream Type	B	B
Evolution Stage: F-II	Entrenchment Ratio	1.4 – 2.2	1.8
Sensitivity: Moderate	Incision Ratio	< 1.2	1.4
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Erosion, Mass Failures**		

T6.1-S1.01-B

Segment B on reach one of Bartlett Brook is approximately 1,600 feet in length. This segment could not be fully assessed because access to the channel was not possible. Enormous mass failures line the valley walls of the brook. Bank erosion is severe and abundant. The unstable banks in T6.1-S1.01-B have contributed a large amount of woody debris to the stream channel, making it inaccessible. Qualitative observations were taken throughout this segment. It is estimated to be in **fair** geomorphic condition.

Figure 5.48. Woody debris in the channel in T6.1-S1.01-B made it inaccessible for assessment.

T6.1-S1.01-B Data Summary	***NOT ASSESSED**	**Reference**	**Existing**
Length: 1,630 ft Drainage Area: 2.6 sq. mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Very Broad	Very Broad
	Stream Type	B	B
	Entrenchment Ratio	1.4 – 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Mass Failures, Erosion**		

T6.1-S1.01-C

This segment flows through a broad river valley and is approximately 4,000 feet in length. The brook has not incised or widened in this location, but it is undergoing aggradation and planform adjustment. Sections of T6.1-S1.01-C are braided around large depositional features formed by brief decreases in channel slope. Numerous flood chutes cross bars throughout this segment. A logging road runs along Bartlett Brook for some sections of this segment, but its impacts are minor. Overall, the segment retains excellent floodplain access and natural channel planform. Small areas of bank erosion are scattered throughout T6.1-S1.01-C, as are three mass failures. This segment is in **good** geomorphic condition due to a lack of incision and human impacts. It is also in **good** habitat condition, with excellent woody debris cover, ample pool and riffle habitat, and good floodplain connectivity.

Figure 5.49. T6.1-S1.01-C has great habitat features, including abundant plunge pools.

T6.1-S1.01-C Data Summary		**Reference**	**Existing**
Length: 4,009 ft	Confinement	Broad	Broad
Drainage Area: 2.6 sq. mi.	Stream Type	C_b	C_b
Evolution Stage: F-IV	Entrenchment Ratio	> 2.2	4.6
Sensitivity: High	Incision Ratio	< 1.2	1.3
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Erosion, Mass Failures, Revetments**		

T6.1-S1.01-D

The upstream-most portion of Bartlett Brook included in this study was not fully assessed due to its remote location, lack of human impacts, and stable condition. The segment is approximately 2,000 feet in length. Qualitative observations were taken at the downstream end of the segment to characterize it. The brook is very stable in this location and appears to be in **reference** geomorphic condition with a step-pool bedform.

Figure 5.50. T6.1-S1.01-D was not fully assessed, but is in very stable condition.

T6.1-S1.01-D Data Summary	*NOT ASSESSED	Reference	Existing
Length: 2,058 ft Drainage Area: 2.6 sq. mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Narrow	Narrow
	Stream Type	B_a	B_a
	Entrenchment Ratio	1.4 – 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Step-Pool	Step-Pool
Major Stressors:	**None**		

Johnson Brook

T6.4-S1.01

Johnson Brook is a tributary of the Tweed River that is located in Stockbridge and Pittsfield, Vermont. It originates on forested lands in Stockbridge and flows into the Tweed River in reach T6.04 in Pittsfield. Land use along the brook is mostly forest, but also includes residential and industrial. Reach one was divided into three segments during assessment to account for changes in valley width, channel dimensions, planform, and grade controls.

T6.4-S1.01-A

The downstream-most segment on Johnson Brook forms an alluvial fan as it meets the Tweed River. The channel slope is less than the segment above and the river valley is wider. Naturally, this segment would be a highly aggradational area where large amount of sediment from upstream is deposited. Due to the presence of a culvert under Vermont Route 100 and houses on the northern bank, Johnson Brook has been historically and recently managed in a way that has caused it to lose its alluvial fan characteristics. T6.4-S1.01-A has been channelized to flow as a single thread channel, when naturally it would be a braided system. During Tropical Storm Irene, large amounts of sediment deposited within this segment. To protect infrastructure, the brook was dredged and windrowed following the flood. This recent channel alteration, in combination with historic channel management, has caused the brook to incise significantly. Bank erosion indicates that the channel is beginning to widen in some areas in response to this incision. The aforementioned factors have caused T6.4-S1.01-A to be in **fair** geomorphic condition. Recent channel dredging and windrowing have resulted in a loss of reference bedform and conversion to a featureless plane bed system. Habitat is in **fair** condition as a result of this.

Figure 5.51. T6.4-S1.01-A was subjected to windrowing and dredging post-Irene.

T6.4-S1.01-A Data Summary		**Reference**	**Existing**
Length: 951 ft	Confinement	Very Broad	Very Broad
Drainage Area: 4 sq. mi.	Stream Type	D	F
Evolution Stage: F-III	Entrenchment Ratio	N/A	1.3
Sensitivity: Extreme	Incision Ratio	< 1.2	2.0
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Braided	Plane Bed
Major Stressors:	**Straightening, Windrowing, Dredging, Revetments, Erosion**		

T6.4-S1.01-B

Segment B on reach one of Johnson Brook is a short bedrock gorge that exists where the valley walls pinch in before widening to meet the Tweed River valley in segment A. This segment is characterized by continuous bedrock on the bed, which is creating a very stable channel. For this reason, T6.4-S1.01-B was not fully assessed. Qualitative observations suggest that this segment is in **good** geomorphic condition and is not undergoing major adjustment. Small areas of bank erosion exist where bedrock is not present on the banks. The brook flows through a semi-confined valley in this location.

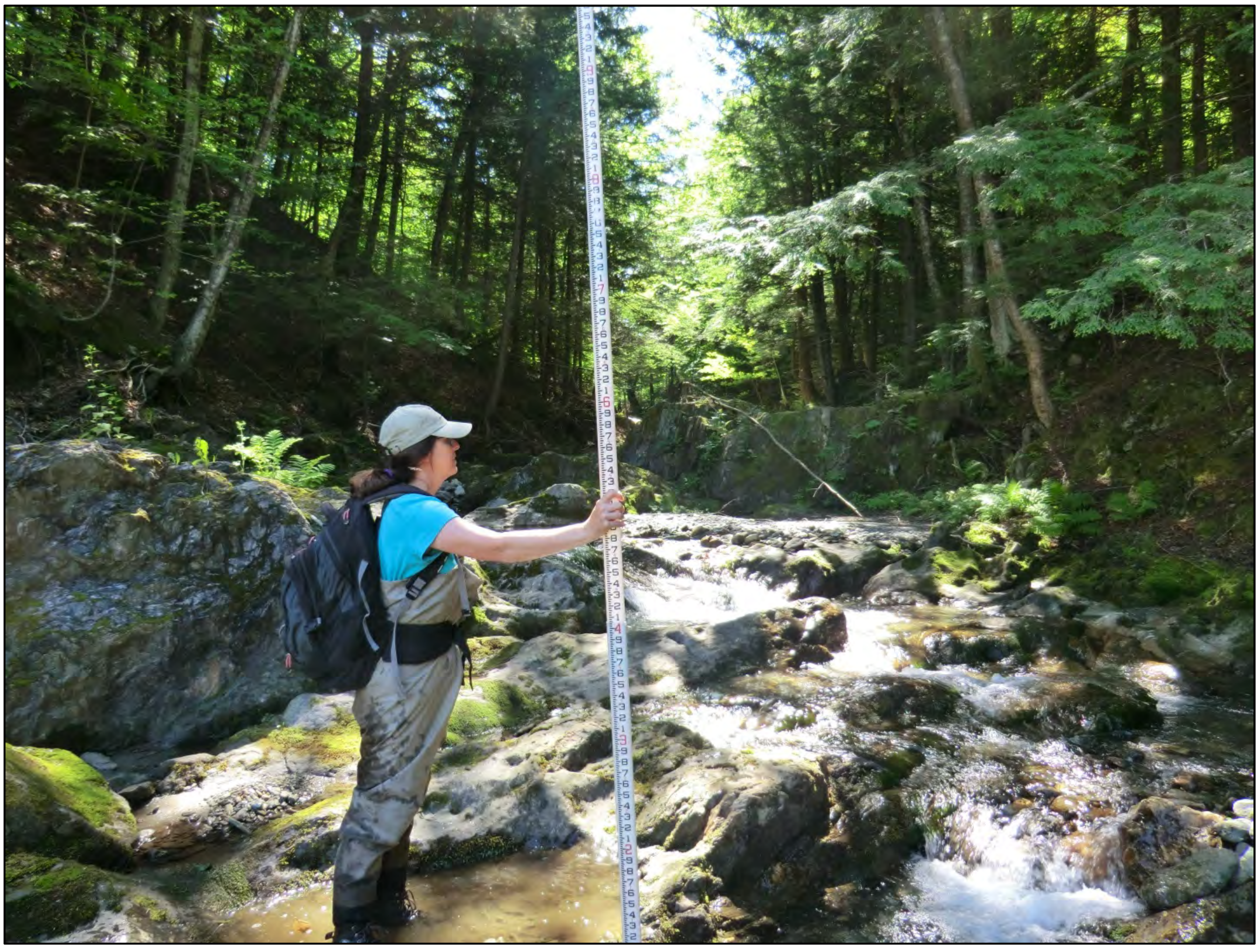

Figure 5.52. T6.4-S1.01-B was not fully assessed due to the presence of a bedrock gorge.

T6.4-S1.01-B Data Summary	*NOT ASSESSED	Reference	Existing
Length: 367 ft Drainage Area: 4 sq. mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Semi-Confined	Semi-Confined
	Stream Type	F_a	F_a
	Entrenchment Ratio	< 1.4	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Bedrock	Bedrock
	Dominant Bedform	Bedrock	Bedrock
Major Stressors:	**Erosion**		

T6.4-S1.01-C

The upstream-most segment on Johnson Brook included in this study begins above the bedrock gorge and continues upstream for 6,400 feet to just above a gravel pit that is located on the south side of the brook. Camp 12 Road encroaches upon the brook in several locations within this segment. Windrowing and berming post-Irene was common within segment C, especially in areas where the brook flows along the road. Sections of the brook were historically straightened along Camp 12 Road. Abundant recent channel alteration caused a narrowing of the channel, which has led to active incision. Berms are restricting floodplain access in many areas, which is exacerbating channel downcutting. In areas that have not been subjected to historic or recent channel alteration, planform is more natural and Johnson Brook is beginning to form a juvenile floodplain. Bank erosion is abundant, and eleven mass failures line the valley walls. These slope failures are contributing large amounts of sediment to the brook. Channel alteration has sparked major adjustment in T6.4-S1.01-C, which has caused it to be in **fair** geomorphic condition. Silty substrate and a lack of diverse bed features have caused this segment to also be in **fair** habitat condition.

Figure 5.53. T6.4-S1.01-C was subjected to extensive windrowing and berming post-Irene.

T6.4-S1.01-C Data Summary		**Reference**	**Existing**
Length: 6,409 ft	Confinement	Narrow	Narrow
Drainage Area: 4 sq. mi.	Stream Type	C_b	E_b
Evolution Stage: F-II	Entrenchment Ratio	> 2.2	3.9
Sensitivity: Extreme	Incision Ratio	< 1.2	1.5
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Windrowing, Straightening, Encroachments, Erosion, Mass Failures, Stormwater Inputs**		

West Branch of the White River

T7.01

The West Branch of the White River is a major tributary of the White River with a drainage area of 43 square miles. The West Branch originates in the Green Mountain National Forest in Rochester, flows east along Vermont Route 73, and enters the White River main stem at Route 100 in Rochester. Reach one on the West Branch was divided into two segments during assessment to account for changes in valley width and channel dimensions.

T7.01-A

The downstream-most segment on the West Branch is an alluvial fan, forming as the channel slope drops and valley walls widen to meet the White River. The river flows through a very broad valley in this segment, but was historically straightened for its entirety due to Route 73 and adjacent farm fields. This historic straightening led to major channel incision, loss of floodplain access, and a stream type departure. Tropical Storm Irene deposited large amounts of sediment in the channel and on adjacent lands within this segment. The stream was subjected to windrowing after the flood at its downstream end to remove some of the deposited material from the stream channel. This material has created large bars in the channel and contributed to extreme widening. Bank erosion is abundant within this segment. Historic and recent channel alteration in T7.01-A have led to a major deviation from reference conditions. Because of this, the segment is in **poor** geomorphic condition. A loss of bedform has also occurred in T7.01-A, and the featureless plane bed channel has caused the segment to be in **fair** habitat condition.

Figure 5.54. The West Branch is overly wide and highly aggradational in T7.01-A.

T7.01-A Data Summary		Reference	Existing
	Confinement	Very Broad	Very Broad
Length: 1,675 ft	Stream Type	C	F
Drainage Area: 43 sq. mi.	Entrenchment Ratio	> 2.2	1.2
Evolution Stage: F-III	Incision Ratio	< 1.2	2.2
Sensitivity: Very High	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Straightening, Windrowing, Erosion, Encroachment**		

T7.01-B

The second segment on reach two of the West Branch begins where the river valley opens up at the alluvial fan and continues upstream approximately 5,000 feet to near Austin Hill Road. Most of this segment was historically straightened along Route 73 and agricultural fields. The West Branch has incised slightly in this segment, and has widened significantly. Major aggradation has occurred in this area, which is exacerbating the widening process. Bank erosion is scattered throughout the segment, and six large mass failures have occurred along the southern valley wall. The river is adjusting planform via one flood chute and two areas of braiding. Route 73 was washed out in one location in segment B during Irene. Windrowing and gravel mining occurred toward the upstream end of the segment post-Irene. Major active aggradation, widening, and planform adjustment have caused T7.01-B to be in **fair** geomorphic condition. It is also in **fair** habitat condition due to a lack of woody debris, unstable banks, and poor riparian buffers.

Figure 5.55. The West Branch has widened and is adjusting planform in T7.01-B.

T7.01-B Data Summary		Reference	Existing
Length: 4,919 ft	Confinement	Broad	Broad
Drainage Area: 43 sq. mi.	Stream Type	B_C	B_C
Evolution Stage: F-III	Entrenchment Ratio	1.4 – 2.2	1.7
Sensitivity: High	Incision Ratio	< 1.2	1.3
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Erosion, Encroachments, Windrowing, Dredging**		

T7.02

Reach two on the West Branch was divided into five segments during assessment to account for changes in channel dimensions, valley width, planform, and property access. The segment flows through residential and agricultural lands, ending upstream at the confluence of Bingo Brook.

T7.02-A

The downstream-most segment on reach two of the West Branch is characterized by major historic straightening undergone to create agricultural fields. The river forms an alluvial fan in this segment, created by abrupt widening of the river valley and a drop in channel slope. The channel has not incised in this location, but due to large amounts of aggradation during Irene, has widened considerably. Two sections of the river in T7.02-B are braiding over large depositional features, and flood chutes are common. Windrowing and gravel mining took place in the vicinity of a Route 73 Bridge in this segment post-Irene. The river avulsed within T7.02-A, cutting a new channel toward the downstream end of the segment likely during TSI. T7.02-A is in **fair** geomorphic condition as a result of aggradation, widening, and channel alteration. Habitat is also in **fair** condition due to lacking bed cover and poor bank and buffer vegetation.

Figure 5.56. A wide, aggradational channel is characteristic of T7.02-A.

T7.02-A Data Summary		Reference	Existing
Length: 5,668 ft Drainage Area: 42 sq. mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	6.4
	Incision Ratio	< 1.2	1.0
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Erosion, Encroachments, Windrowing, Dredging**		

T7.02-B

T7.02-B begins approximately 2,500 feet upstream of the Route 73 Bridge in segment A and continues upstream 1,500 feet to just above the confluence of Corporation Brook. This segment flows through a narrow river valley and has fewer human impacts than the surrounding segments. T7.02-B has not been subjected to recent or historic channel straightening and retains a natural planform. Major deposition occurred in this segment during Irene, followed by extreme channel widening. Bank erosion is common within T7.02-B. One section of this segment has become braided due to major aggradation. Overall, this segment is in **fair** geomorphic condition due to aggradational and widening processes occurring. Lacking woody debris cover and unstable banks have contributed to T7.02-B being in **fair** habitat condition.

Figure 5.57. Typical channel in T7-02B.

T7.02-B Data Summary		**Reference**	**Existing**
Length: 1,464 ft Drainage Area: 42 sq. mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Narrow	Narrow
	Stream Type	B_C	B_C
	Entrenchment Ratio	1.4 – 2.2	1.4
	Incision Ratio	< 1.2	1.1
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Erosion, Mass Failures**		

T7.02-C

Segment C on reach two of the West Branch flows through a very broad valley for 2,700 feet in the vicinity of the Green Mountain National Forest Civilian Conservation Corps camp in Rochester. This area of the West Branch underwent extreme aggradation and widening during Tropical Storm Irene. Following TSI, the entire segment was subjected to windrowing and gravel mining, some of which created berms along the banks of the river. Slight incision has occurred in T7.02-C, but the river retains good floodplain access where berms do not exist. Due to extensive channel excavation, the river's reference riffle-pool bedform has been converted to a featureless, plane bed system. Geomorphic condition is **poor** as a result of extensive recent channel alteration. T7.02-C is in **fair** habitat condition also due to windrowing and dredging, which have destroyed habitat features.

Figure 5.58. T7.02-C was subjected to extensive windrowing and gravel mining post-Irene.

T7.02-C Data Summary		**Reference**	**Existing**
Length: 2,709 ft Drainage Area: 42 sq. mi. Evolution Stage: F-III Sensitivity: High	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	5.3
	Incision Ratio	< 1.2	1.3
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Windrowing, Dredging, Erosion**		

T7.02-D

This segment flows through a very broad valley for approximately 2,500 feet downstream of King Farm Road. T7.02-D was not fully assessed due to restricted property access throughout the segment. Using aerial photographs, it was possible to determine that the majority of the segment was historically straightened along the northern valley wall to create agricultural fields. Qualitative field observations suggest that T7.02-D has good floodplain access and has not undergone a stream type departure. It has, however, lost its reference riffle-pool bedform, which has been converted to featureless plane bed. The upstream end of the segment was windrowed post-Irene.

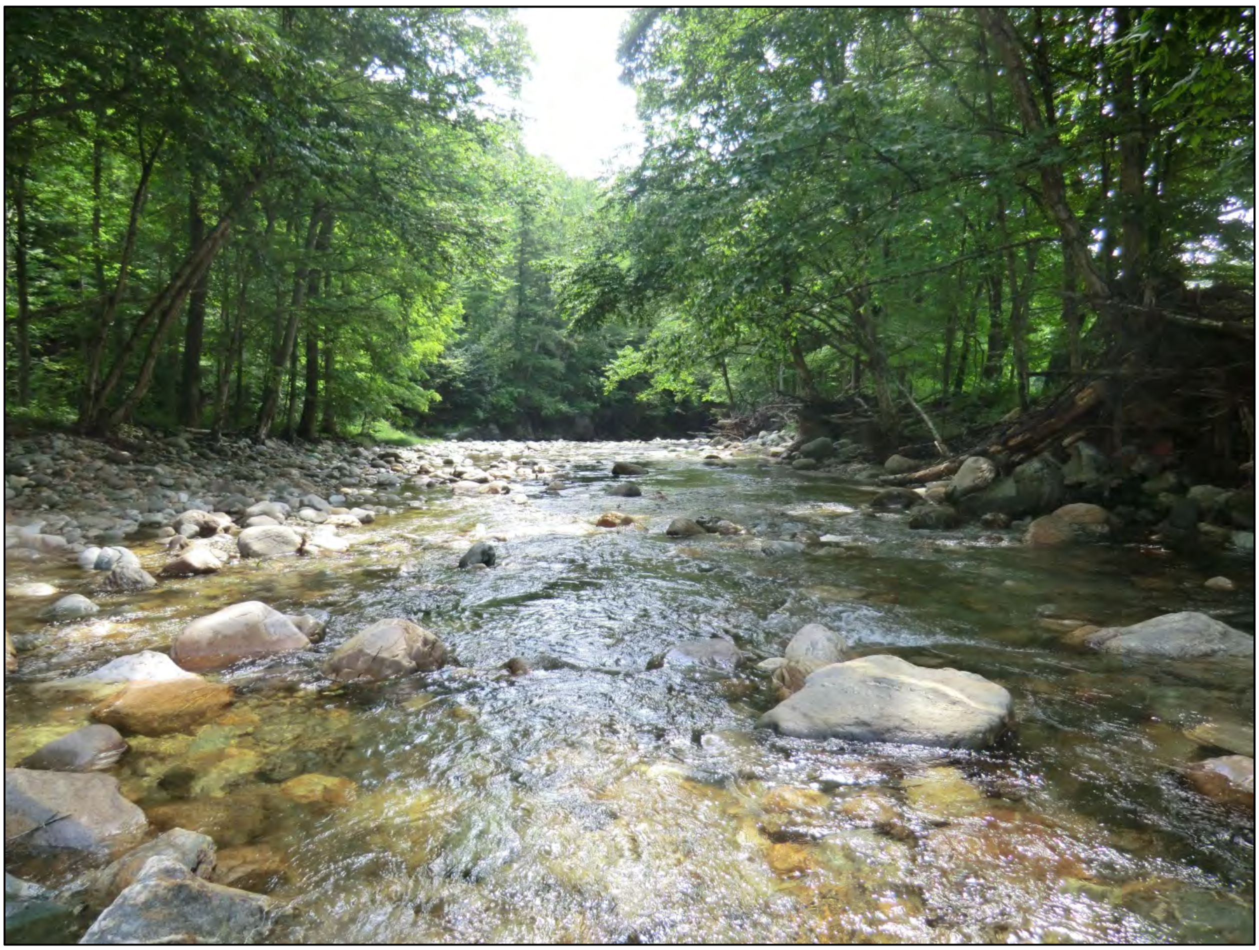

Figure 5.59. T7.02-D could not be fully assessed due to a lack of property access.

T7.02-D Data Summary	*NOT ASSESSED	Reference	Existing
Length: 2,446 ft Drainage Area: 42 sq. mi. Evolution Stage: N/A Sensitivity: N/A	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	N/A
	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Straightening, Poor Buffers, Windrowing**		

T7.02-E

The upstream-most segment on the West Branch included in this assessment begins downstream of the King Farm Road Bridge and continues upstream 2,400 feet to just above the confluence of Bingo Brook. The river flows through a very broad valley in T7.02-E, where it has been straightened extensively due to the presence of Route 73 and King Farm Road. This straightening has led to moderate incision and a loss of bedform. The West Branch has widened slightly in this segment, but riprap is preventing further widening in some areas. T7.02-E was windrowed and dredged post-Irene in multiple locations. One headcut is present within the segment, but a bedrock grade control is providing some channel stability. T7.02-E is in **fair** geomorphic condition as a result of extensive historic channel straightening and recent alteration. It is also in **fair** habitat condition due to the loss of riffle-pool bedform and conversion to featureless plane bed.

Figure 5.60. Extensive historic straightening in T7.02-E has created a featureless, plane bed channel.

T7.02-D Data Summary		Reference	Existing
Length: 2,416 ft Drainage Area: 42 sq. mi. Evolution Stage: F-II Sensitivity: High	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	2.6
	Incision Ratio	< 1.2	1.7
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Straightening, Encroachments, Revetments, Erosion, Stormwater Inputs, Windrowing, Dredging**		

Hancock Branch of the White River

T8.01

The Hancock Branch of the White River originates on Green Mountain National Forest Land in Hancock, Vermont. It flows out of the woods and along Vermont Route 125, entering the White River at Route 100. At its mouth, the stream has a drainage area of 22 square miles. Reach one on the Hancock Branch was divided into three segments at the time of assessment. These segments differ in valley width, channel dimensions, and planform.

T8.01-A

The downstream-most segment on the Hancock Branch is an alluvial fan, occurring where the channel slope drops and valley expands to meet the White River valley. Large amounts of sediment were deposited in T8.01-A during Tropical Storm Irene. Following the storm, almost the entire segment was dredged and windrowed, piling channel materials onto the banks and creating continuous berms. This channel excavation and associated berms have caused some loss of floodplain access on the Hancock Branch. Riprap is common along the banks within this segment, especially where the river flows along Route 125. During Irene, the West Branch caused damage to Killooleet Road, which runs along the southern bank of the river. Channel excavation has created a narrow, deep channel in this segment, which would naturally be wide, shallow, and depositional. T8.01-A is in **poor** geomorphic condition due to extensive recent channel alteration. The segment is in **fair** habitat condition because the Hancock Branch has poor channel morphology, unstable banks, and is lacking woody debris cover.

Figure 5.61. T8.01-A was extensively windrowed post-Irene.

T8.01-A Data Summary		**Reference**	**Existing**
Length: 2,431 ft Drainage Area: 22 sq. mi. Evolution Stage: F-II Sensitivity: Extreme	Confinement	Very Broad	Very Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	3.2
	Incision Ratio	< 1.2	1.7
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Windrowing, Dredging, Straightening, Encroachments, Poor Buffers**		

T8.01-B

Segment B on reach one of the Hancock Branch begins near the pond at Camp Killooleet and continues upstream along Route 125 for 2,800 feet, ending above the old Killooleet Dam. The entire segment was historically straightened along Route 125, which is a significant corridor encroachment. T8.01-B has majorly incised due to this historic straightening. The river has lost all floodplain access here and has undergone a stream type departure. Post-Irene windrowing throughout half of the segment has exacerbated this incision. Riprap lines the northern bank of the river and is scattered along the southern bank. This armoring is preventing widening to the north. Despite the riprap, erosion is extensive, especially on the southern bank. Overall, the channel has not begun major widening due to recent channel excavation and boundary factors. An old dam is present within T8.01-B, which blew out several years ago. Overall, this segment is in **fair** geomorphic condition because of extensive channel straightening and major incision. It is also in **fair** habitat condition due to a lack of diverse bed features.

Figure 5.62. T8.01-B was historically straightened along Route 125.

T8.01-B Data Summary		Reference	Existing
Length: 2,809 ft Drainage Area: 22 sq. mi. Evolution Stage: F-II Sensitivity: Extreme	Confinement	Very Broad	Very Broad
	Stream Type	C	F
	Entrenchment Ratio	> 2.2	1.2
	Incision Ratio	< 1.2	2.6
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Straightening, Encroachments, Windrowing, Revetments, Stormwater Inputs, Poor Buffers**		

T8.01-C

The upstream-most segment on reach one of the Hancock Branch flows through a narrower valley than its surrounding segments. It is approximately 2,000 feet long and flows through a semi-confined valley on the southern side of Route 125. Sections of this segment were historically straightened along Route 125. Bank armoring is abundant along the road, which is built into the northern valley wall for most of the segment. The Hancock Branch is fairly stable in T8.01-C, and a bedrock grade control holds the bed in place toward the upstream end. The river has not incised or widened here, so it is in **good** geomorphic condition. The segment is lacking in-channel woody debris and has impacted buffers, which has caused it to be in **fair** habitat condition.

Figure 5.63. T8.01-C flows through a semi-confined valley along Route 125.

T8.01-C Data Summary		Reference	Existing
Length: 2,018 ft Drainage Area: 22 sq. mi. Evolution Stage: F-II Sensitivity: Very High	Confinement	Semi-Confined	Semi-Confined
	Stream Type	F	F
	Entrenchment Ratio	< 1.4	1.4
	Incision Ratio	< 1.2	1.2
	Dominant Bed Material	Cobble	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Encroachments, Revetments, Poor Buffers**		

T8.02

Reach two on the Hancock Branch was divided into four segments during assessment to account for changes in planform, channel dimensions, and depositional features.

T8.02-A

The first segment on reach two of the Hancock Branch begins near the intersection of Tucker Brook Road and Route 125, continues upstream for about 1,800 feet, and ends where the river is straightened along Route 125. The majority of T8.02-A was historically straightened along its southern valley wall to create residential land on the north bank. Likely due to this historic channelization, the river has incised slightly and widened substantially. Erosion lines the banks for the majority of the segment. Development is abundant within the river corridor in T8.02-A. Toward the upstream end of T8.02-A, major aggradation occurred during Tropical Storm Irene that created a sediment plug in the channel. This filling in of the channel caused the river to avulse and cut a new channel on the inside of a meander bend. Overall, T8.02-A is in **fair** geomorphic condition due to channel widening and alteration of planform. Habitat condition is also **fair**, as woody debris and pool features are lacking.

Figure 5.64. The Hancock Branch was straightened along its southern valley wall in T8.02-A.

T8.02-A Data Summary		Reference	Existing
Length: 1,831 ft Drainage Area: 21 sq. mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Very Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	3.8
	Incision Ratio	< 1.2	1.4
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Straightening, Erosion, Poor Buffers, Encroachments**		

T8.02-B

Segment B on T8.02 flows directly along Route 125, beginning near 1513 Route 125, continuing upstream for 3,000 feet, and ending at the Taylor Brook confluence. The entirety of this segment was historically straightened along Route 125, which caused major historic incision and a loss of bedform. Extensive riprap along the northern bank of the river is preventing widening in that direction. Erosion is abundant on the southern bank, as the river begins to widen along the unarmored bank. Route 125 embankments were damaged in two locations by Irene floodwaters. Sections of T8.02-B were windrowed post-Irene, creating several large gravel berms. These berms are restricting floodwaters, but overall floodplain access within the segment is good. T8.02-B is in **fair** geomorphic condition as a result of historic and recent channel alteration. The segment is also in **fair** habitat condition due to human alterations that have converted the reference riffle-pool channel into a featureless, plane bed stream.

Figure 5.65. The river was straightened along Route 125 for all of T8.02-B.

T8.02-B Data Summary		**Reference**	**Existing**
Length: 2,922 ft Drainage Area: 21 sq. mi. Evolution Stage: F-III Sensitivity: Very High	Confinement	Very Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	2.9
	Incision Ratio	< 1.2	1.9
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Straightening, Encroachments, Windrowing, Stormwater Inputs, Poor Buffers, Revetments, Erosion**		

T8.02-C

This segment is approximately 5,000 feet in length, beginning at the end of channel straightening along Route 125 and ending upstream near 2751 Route 125. It can be characterized by very large depositional features and a wide channel. Some of this aggradation likely occurred during Irene, and was followed by major planform change. Eight large flood chutes have formed across meander bends, some of which have the potential to cause a channel avulsion. Large deposits of sediment are beginning to form a juvenile floodplain in this segment. After Irene, sections of the river in T8.02-C were windrowed to remove aggradation, and gravel berms were created. Bank erosion is prevalent on both banks throughout this segment. Floodwaters from Irene damaged Fassett Hill Road to the north of the river. Overall, T8.02-C is in **poor** geomorphic condition due to major historic and recent adjustments. It is in **fair** habitat condition because these adjustments have decreased in-stream cover and altered the stream's hydrologic characteristics.

Figure 5.66. Major aggradation and a wide channel are characteristic of T8.02-C.

T8.02-C Data Summary		Reference	Existing
Length: 4,962 ft Drainage Area: 21 sq. mi. Evolution Stage: F-IV Sensitivity: Very High	Confinement	Very Broad	Broad
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	3.5
	Incision Ratio	< 1.2	1.7
	Dominant Bed Material	Gravel	Gravel
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Erosion, Windrowing, Encroachments, Poor Buffers, Straightening**		

T8.02-D

The upstream-most segment on reach two of the Hancock Branch is approximately 1,300 feet in length, beginning near 2796 Route 125 and ending upstream just above the Robbins Branch confluence. This entire segment was historically straightened along Route 125 and Texas Falls Road. Moderate historic incision has occurred in T8.02-D due to this channelization. Bank armoring is abundant along the two roads that encroach upon the Hancock Branch in this segment. The stream channel seems to have widened during Irene, but riprapping and windrowing that occurred post-flood have narrowed the channel once more. Berms are present along both sides of the stream. Geomorphic condition in T8.02-D is **fair** due to extensive historic straightening and recent windrowing. These alterations have led to a loss of bedform in this segment and conversion to a featureless, plane bed system. For this reason, habitat is also in **fair** condition.

Figure 5.67. Windrowing is common in T8.02-D.

T8.02-D Data Summary		Reference	Existing
Length: 1,294 ft Drainage Area: 21 sq. mi. Evolution Stage: F-II Sensitivity: High	Confinement	Broad	Narrow
	Stream Type	C	C
	Entrenchment Ratio	> 2.2	2.8
	Incision Ratio	< 1.2	1.5
	Dominant Bed Material	Gravel	Cobble
	Dominant Bedform	Riffle-Pool	Plane Bed
Major Stressors:	**Straightening, Encroachments, Windrowing, Revetments, Stormwater Inputs**		

T8.03

Reach three on the Hancock Branch flows through forested and residential land along Texas Falls Road in Hancock. It was divided into three segments during assessment to account for changes in valley width, channel dimensions, and grade controls.

T8.03-A

The downstream-most segment on reach three of the Hancock Branch begins just above the confluence with the Robbins Branch and continues upstream for approximately 1,600 feet. The lower portion of this segment was historically straightened along Texas Falls Road. The Hancock Branch has incised moderately in this location, but has not yet widened. One headcut is present within the segment, which threatens good floodplain access upstream in the segment. An alluvial fan is present toward the bottom of the segment, but historic channel management has caused the alluvial fan to lose its depositional character. T8.03-A is in **fair** geomorphic condition due to active channel degradation and historic straightening. Habitat is also in **fair** condition because the stream channel is lacking woody debris and pool habitat.

Figure 5.68. Much of T8.03-A was historically straightened along Texas Falls Road.

T8.03-A Data Summary		Reference	Existing
Length: 1,587 ft Drainage Area: 9 sq. mi. Evolution Stage: F-II Sensitivity: High	Confinement	Broad	Narrow
	Stream Type	C	B
	Entrenchment Ratio	> 2.2	2.0
	Incision Ratio	< 1.2	1.6
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Straightening, Encroachments, Headcut**		

T8.03-B

Segment B is approximately 1,000 feet in length and flows through a narrowly confined valley. The Hancock Branch forms Texas Falls as it flows through a bedrock gorge in this segment. For this reason, T8.03-B was not fully assessed for this study. Continuous bedrock on the bed and banks provide stability to the river in this segment. Qualitative observations taken in the field suggest that this segment is in **reference** geomorphic condition.

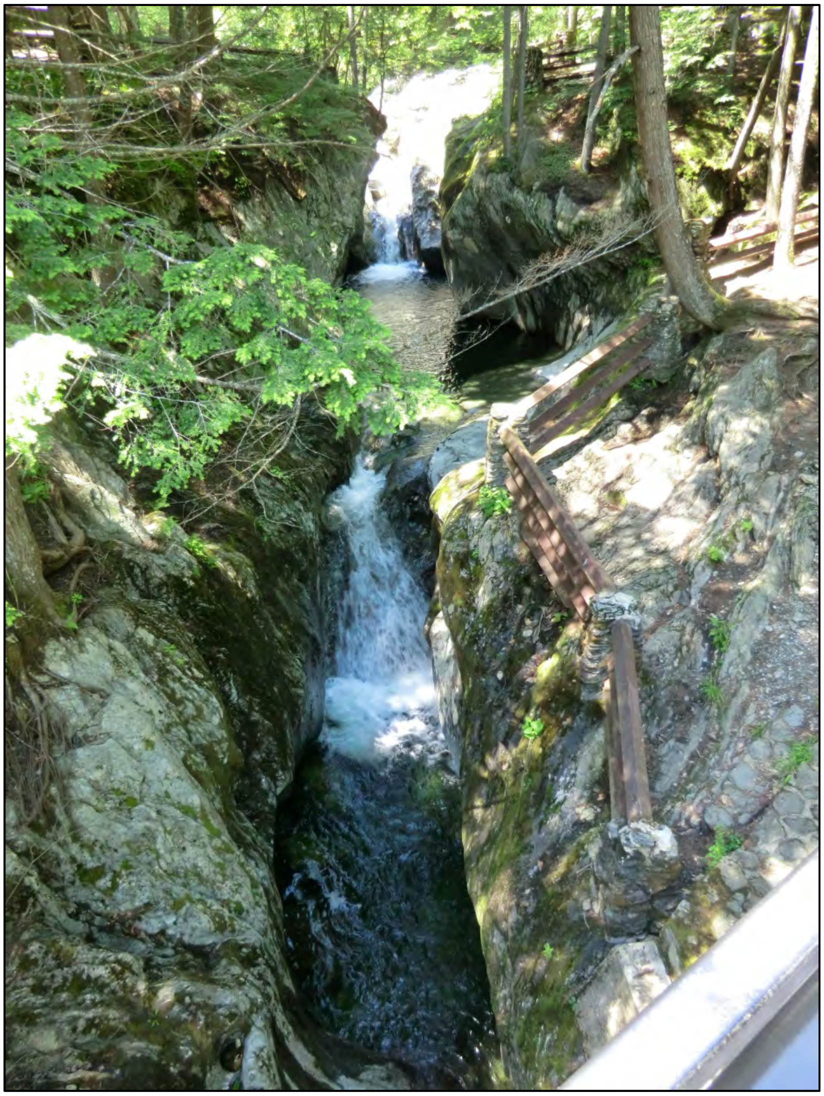

Figure 5.69. T8.03-B contains the renowned Texas Falls.

T8.03-B Data Summary	*NOT ASSESSED	Reference	Existing
Length: 1,053 ft	Confinement	Narrowly Confined	Narrowly Confined
Drainage Area: 9 sq. mi.	Stream Type	A	A
Evolution Stage: N/A	Entrenchment Ratio	< 1.4	N/A
Sensitivity: N/A	Incision Ratio	< 1.2	N/A
	Dominant Bed Material	Bedrock	Bedrock
	Dominant Bedform	Cascade	Cascade
Major Stressors:	**None**		

T8.03-C

The upstream-most segment included in this assessment begins at the top of Texas Falls and continues upstream for 3,200 feet. It flows through Green Mountain National Forest Land, which includes a campground. The river has a mostly natural planform, except for small areas where it has been straightened along Texas Falls Road. Hancock Branch flows through a very broad valley, but is naturally entrenched between a high terrace and the western valley wall. The river has not incised despite areas of historic straightening. During Irene, the river aggraded and avulsed just above the Texas Falls Road Bridge in T8.03-C, flowing across the road and destroying a section of it. After Irene, the river was set back to its original path, riprapped, and bermed to prevent it from taking that course again. Overall, the segment is in **good** geomorphic condition due to its stability and lack of adjustment throughout most of the segment. Habitat is also in **good** condition, as the Hancock Branch has minimal human impacts in this area.

Figure 5.70. T8.03-C flows through the Green Mountain National Forest and has very few human impacts.

T8.03-C Data Summary		**Reference**	**Existing**
Length: 3,243 ft Drainage Area: 9 sq. mi. Evolution Stage: F-I Sensitivity: High	Confinement	Very Broad	Very Broad
	Stream Type	F_b	F_b
	Entrenchment Ratio	< 1.4	1.2
	Incision Ratio	< 1.2	1.0
	Dominant Bed Material	Cobble	Cobble
	Dominant Bedform	Riffle-Pool	Riffle-Pool
Major Stressors:	**Encroachments, Revetments, Erosion, Straightening**		

5.3 Stream Crossings

Tables 6 and 7 in Appendix B summarize the data collected for the assessed structures within the Phase 2 study area. The maps on pages 9 through 11 in Appendix B show the location and geomorphic compatibility rating of each structure. Of the 41 bridges and culverts assessed, two were determined to be "fully incompatible," eight are "mostly incompatible," twenty-five are "partially compatible," five are "mostly compatible," and one is "fully compatible." This information can be used by municipalities and the Vermont Agency of Transportation to prioritize bridge and culvert replacements. Information on recommended structures for replacement can be found in Appendix B.

6.0 PRELIMINARY PROJECT IDENTIFICATION

During early 2015, Phase 2 Stream Geomorphic data were analyzed for the Upper and Middle White River and Tweed River sub-watersheds in order to determine major stressors and impacts to each 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 94 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, woody debris installments, floodplain creation, bridge and culvert replacements, and many more. Detailed information about proposed projects can be found in Appendix C. There are four categories of projects – floodplain improvement and conservation, public safety improvement, stream channel improvement and restoration, and structure replacement/removal. Examples of types of these projects, as well as their flood resiliency and habitat benefits, are shown in the table below.

Project Category	Project Type	Flood Resiliency and Habitat Enhancement Measures
Floodplain Improvement and Conservation	1. Riparian Buffer Planting 2. Road Relocation 3. Floodplain Creation 4. ANR River Corridor Easement 5. Conservation Easement 6. Conservation Reserve Enhancement Program 7. Restore Adjacent Wetlands	➢ Plant native tree and shrub species to restore riparian habitat, provide floodplain roughness and cover along banks, and stabilize eroding banks. ➢ Reduce river-road conflicts by relocating vulnerable infrastructure. Improve floodplain access to provide storage of floodwaters and sediment. ➢ 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

Project Category	Project Type	Flood Resiliency and Habitat Enhancement Measures
		encroachments. ➢ Protect floodplains and wetland habitat to preserve floodwater and sediment storage. ➢ Improve riparian habitat and increase floodwater and sediment storage by mitigating wetlands previously lost to ditch and drain practices.
Public Safety Improvement	1. Consider FEMA Buyouts 2. Adopt River Corridor Protection Areas	➢ Remove homes and businesses located in high risk areas to reduce future flood damages and losses. ➢ Protect the ANR river corridor on the municipality level to prevent future encroachments, flood damage, and losses.
Stream Channel Improvement and Restoration	1. Restore Alluvial Fan 2. Remove/ Return Windrowed Material 3. Berm Removal 4. Build Up Streambed with Weirs 5. Arrest Headcuts 6. Livestock Exclusion 7. Install Large Woody Debris for Channel Roughness	➢ Restore dynamic areas that were damaged due to post-Tropical Storm Irene dredging, gravel mining, and windrowing practices. Remove gravel berms to increase floodplain access and flood storage. ➢ Stabilize and provide streambed features in areas where major channel degradation is occurring or has occurred through the installation of boulder weirs. Weirs also create plunge pools which are important for dissipating energy in the channel. Raising the bed with weirs can improve floodplain access. ➢ Improve physical stability and habitat condition of a river by excluding livestock from accessing it; also allow buffer regeneration at previous access points. ➢ Improve stream habitat diversity and channel roughness through addition of large woody debris.
Structure Replacement/ Removal	1. Bridge Replacement 2. Culvert Replacement 3. Bridge Removal 4. Culvert Removal 5. Dam Removal 6. Culvert Retrofit	➢ 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. ➢ Remove unused and unpermitted dams to improve aquatic organism passage and channel stability. ➢ Retrofit newer culverts to improve aquatic organism passage.

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 of each town within the Upper and Middle White River and Tweed River sub-watershed 2014/2015 study area.

Town ERAF Rating	Barnard 7.5%	Hancock 12.5%	Pittsfield 12.5%	Rochester 12.5%	Stockbridge 12.5%
12.5%					
Participate in the National Flood Insurance Program	X	X	X	X	X
Adopt 2013 Road & Bridge Standards	X	X	X	X	X
Adopt a Local Emergency Operations Plan	X	X	X	X	X
Adopt a Local Hazard Mitigation Plan		X	X	X	X
17.5%					
Protect River Corridors/ Flood Hazard Protection Participate in the Community Rating System	X				

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, 2014a).

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, 2014b).

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 Upper and Middle White River and Tweed River sub-watersheds to a more stable condition. Proposed projects are part of a greater strategy to recover from Tropical Storm Irene and post-flood channel work through improving flood resiliency in the White River 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 the White River Partnership.

In addition to site-specific projects, the towns within the study area 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 involves 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
CRWC – Connecticut River Watershed Council
EQIP – Environmental Quality Incentives Program
ERAF – Emergency Relief Assistance Fund
ERP – Ecosystem Restoration Program
GIS – Geographic Information System
FEMA – Federal Emergency Management Agency
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 – White River Partnership

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.

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.

Windrowing – The process of removing gravel from a streambed and piling it on the bank, creating a gravel berm.

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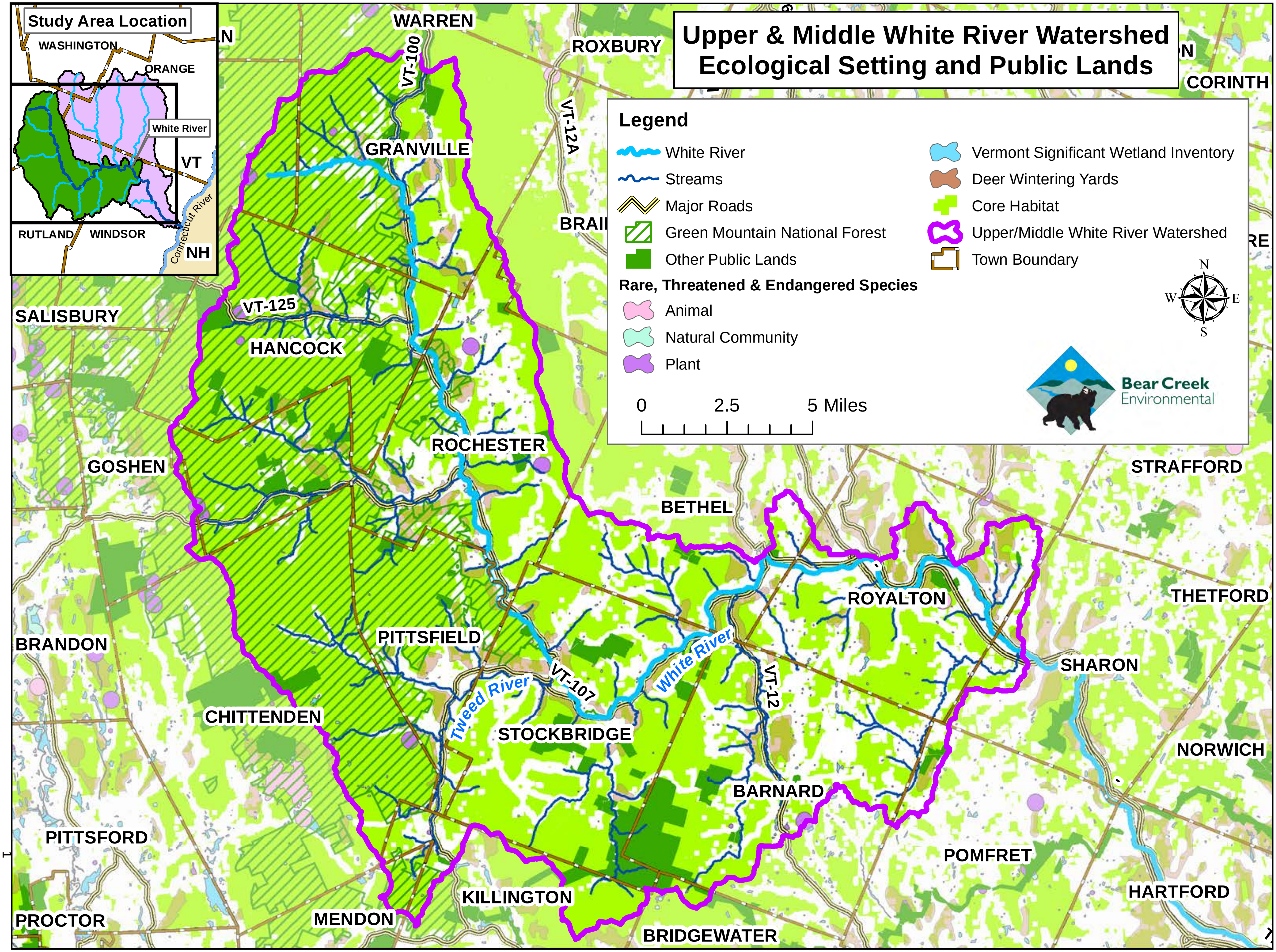
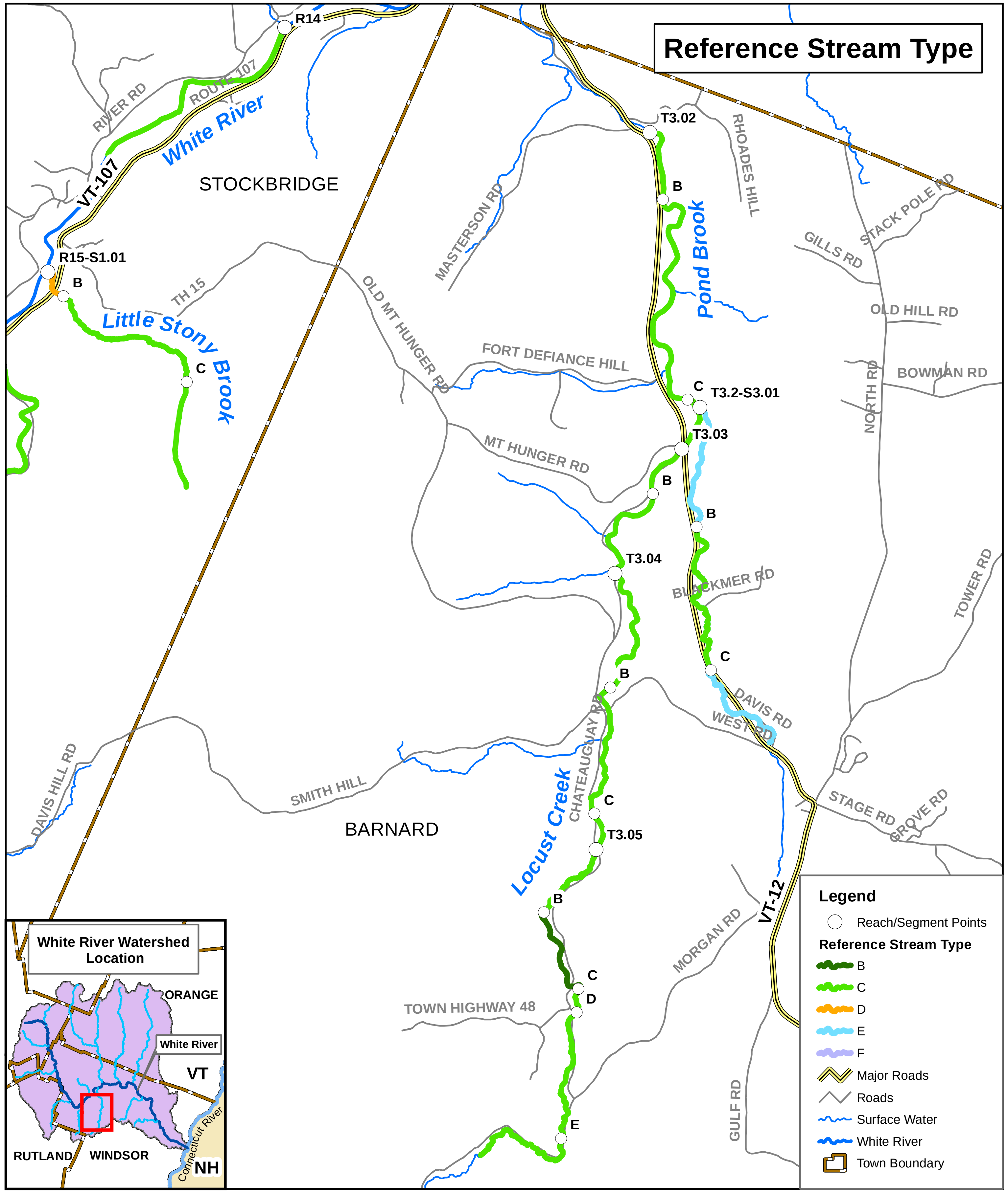
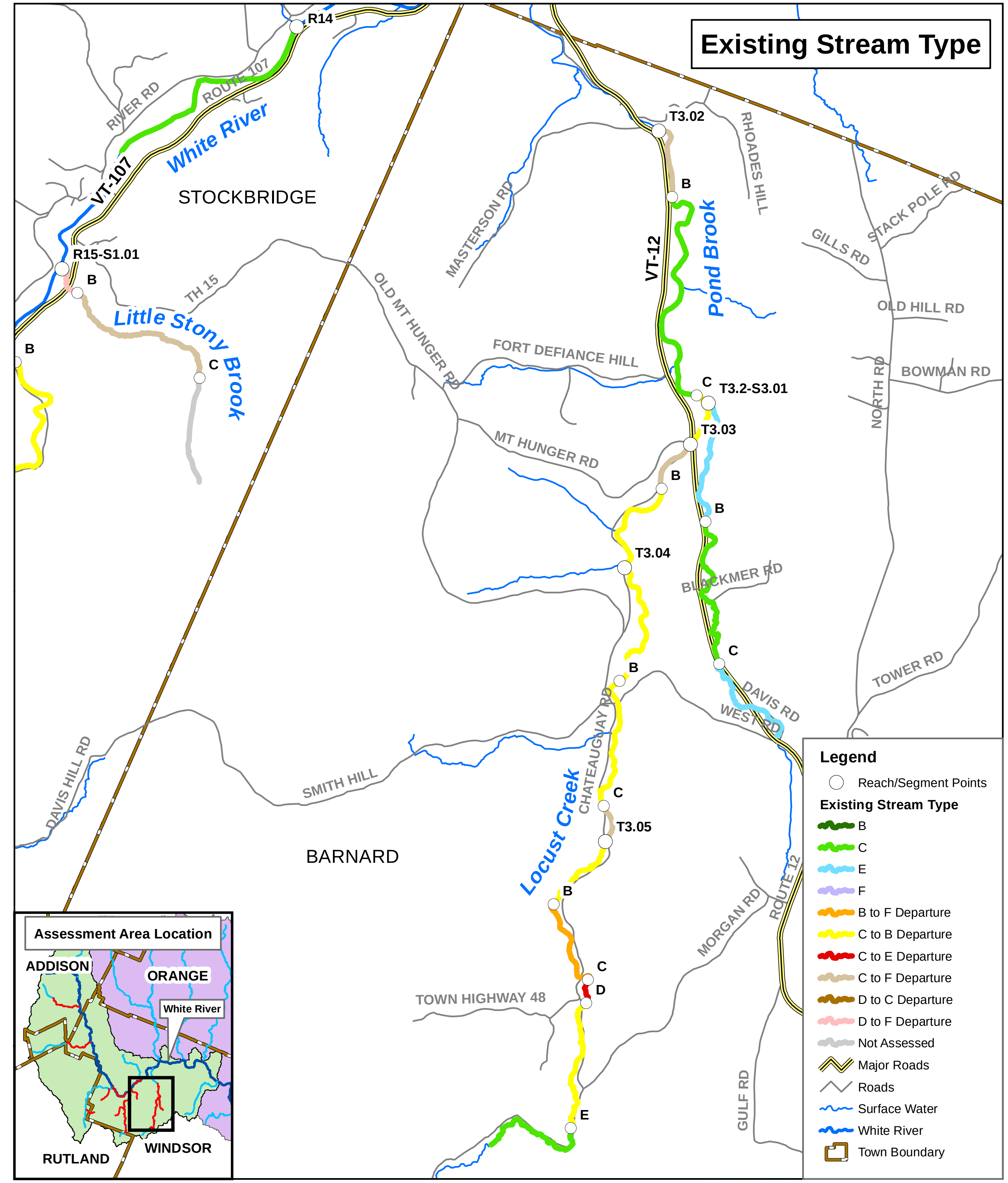
APPENDIX A

Maps



Upper & Middle White River Watershed
Ecological Setting and Public Lands
Study Area Location
WASHINGTON
ORANGE
White River
VT
RUTLAND
WINDSOR
Connecticut River
NH
Legend
White River
Streams
Major Roads
Green Mountain National Forest
Other Public Lands
Rare, Threatened & Endangered Species
Animal
Natural Community
Plant
Vermont Significant Wetland Inventory
Deer Wintering Yards
Core Habitat
Upper/Middle White River Watershed
Town Boundary
0
2.5
5 Miles
N
W
E
S
Bear Creek
Environmental
WARREN
ROXBURY
CORINTH
GRANVILLE
VT-100
VT-12A
VT-125
SALISBURY
HANCOCK
GOSHEN
ROCHESTER
BETHEL
STRAFFORD
ROYALTON
THETFORD
BRANDON
PITTSFIELD
SHARON
VT-107
White River
Tweed River
VT-12
CHITTENDEN
STOCKBRIDGE
NORWICH
BARNARD
PITTSFORD
POMFRET
HARTFORD
KILLINGTON
MENDON
PROCTOR
BRIDGEWATER

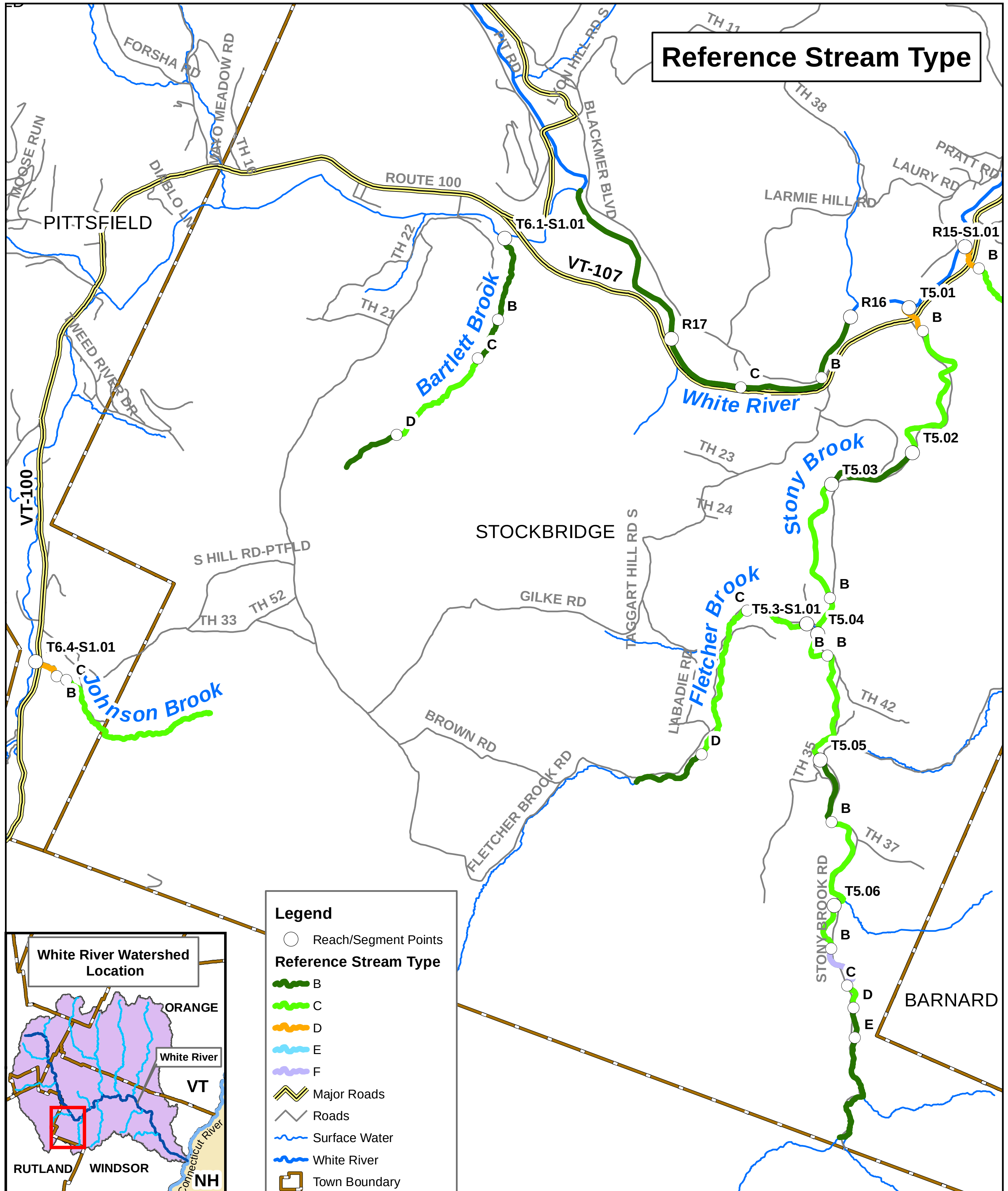


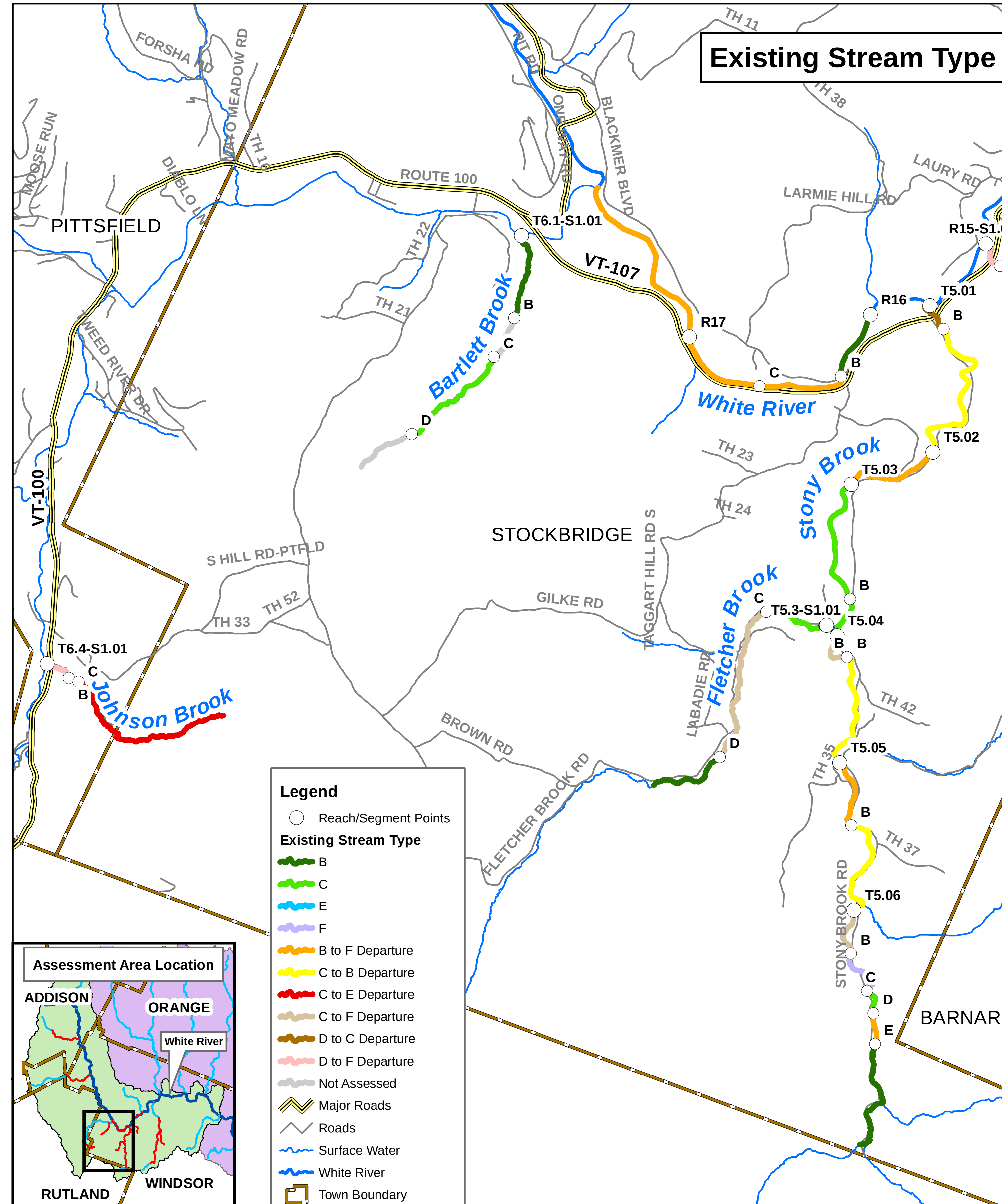


Locust Creek, Pond Brook, White River & Little Stony Brook Stream Type - Barnard and Stockbridge, Vermont

0 1 2 Miles

Bear Creek Environmental

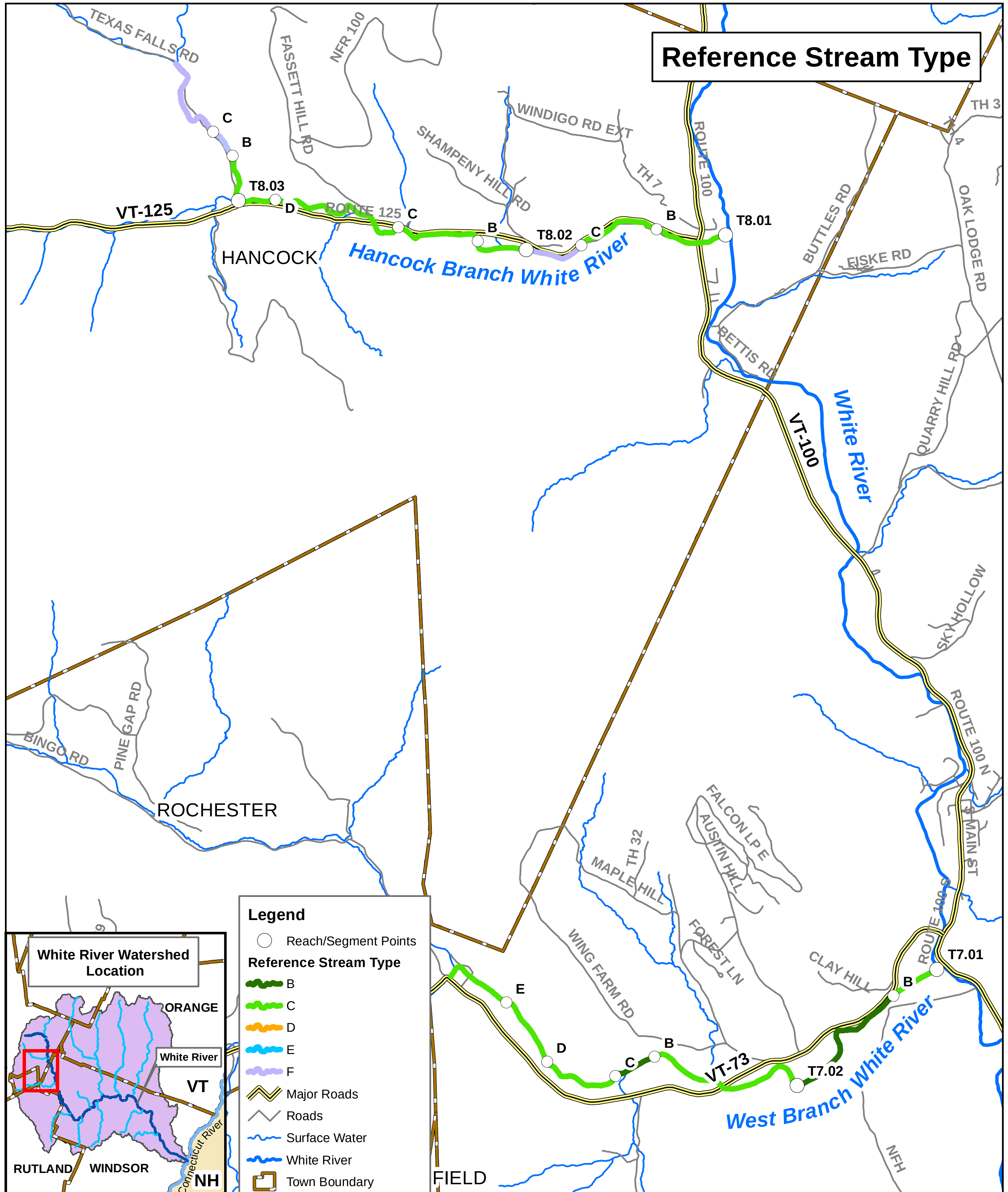


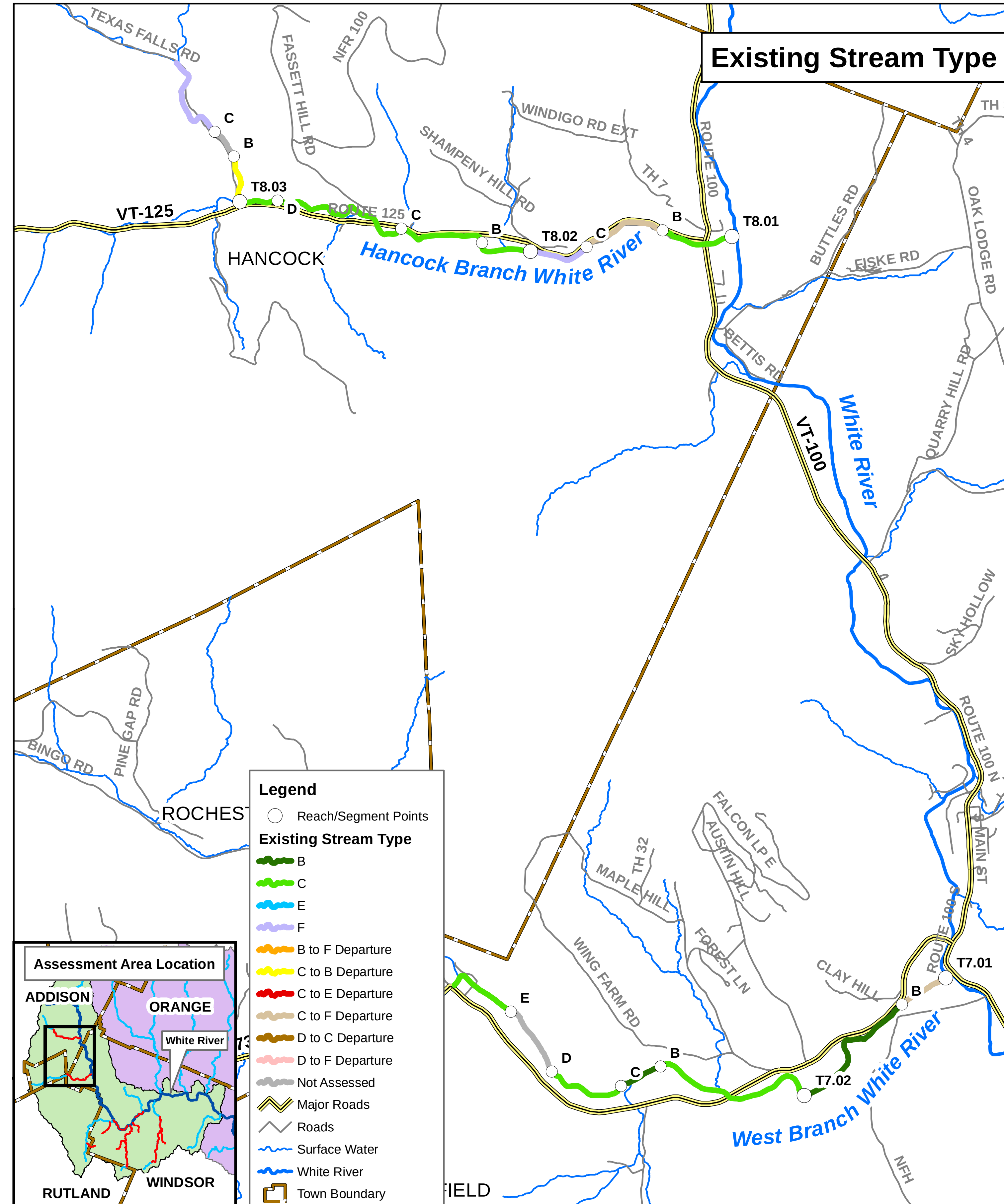


White River, Stony Brook, Fletcher Brook, Bartlett Brook & Johnson Brook Stream Type - Stockbridge and Pittsfield, Vermont

0 1 2 Miles

Bear Creek Environmental

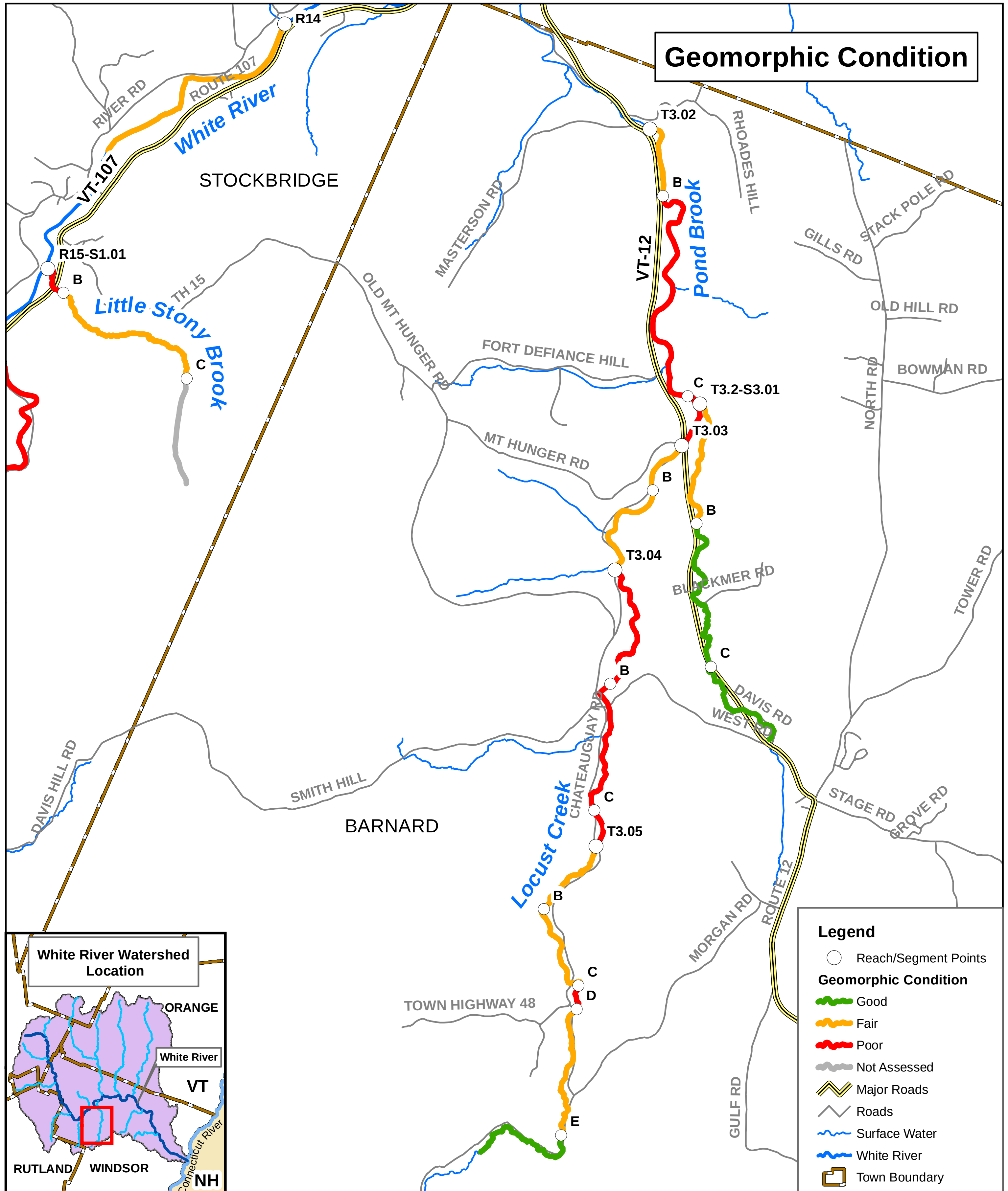


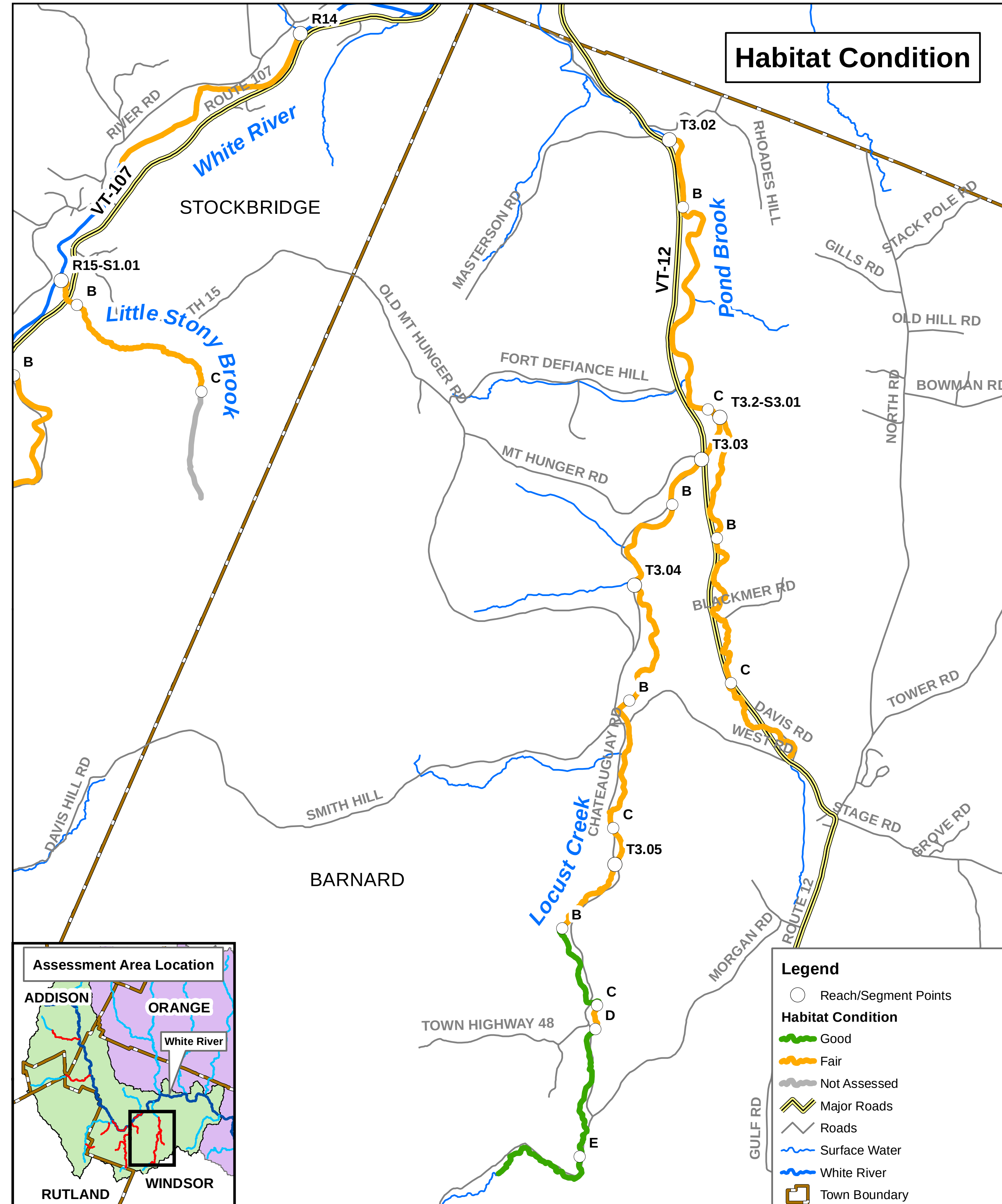


Hancock Branch & West Branch White River Stream Type - Hancock and Rochester, Vermont

0 1 2 Miles

Bear Creek Environmental



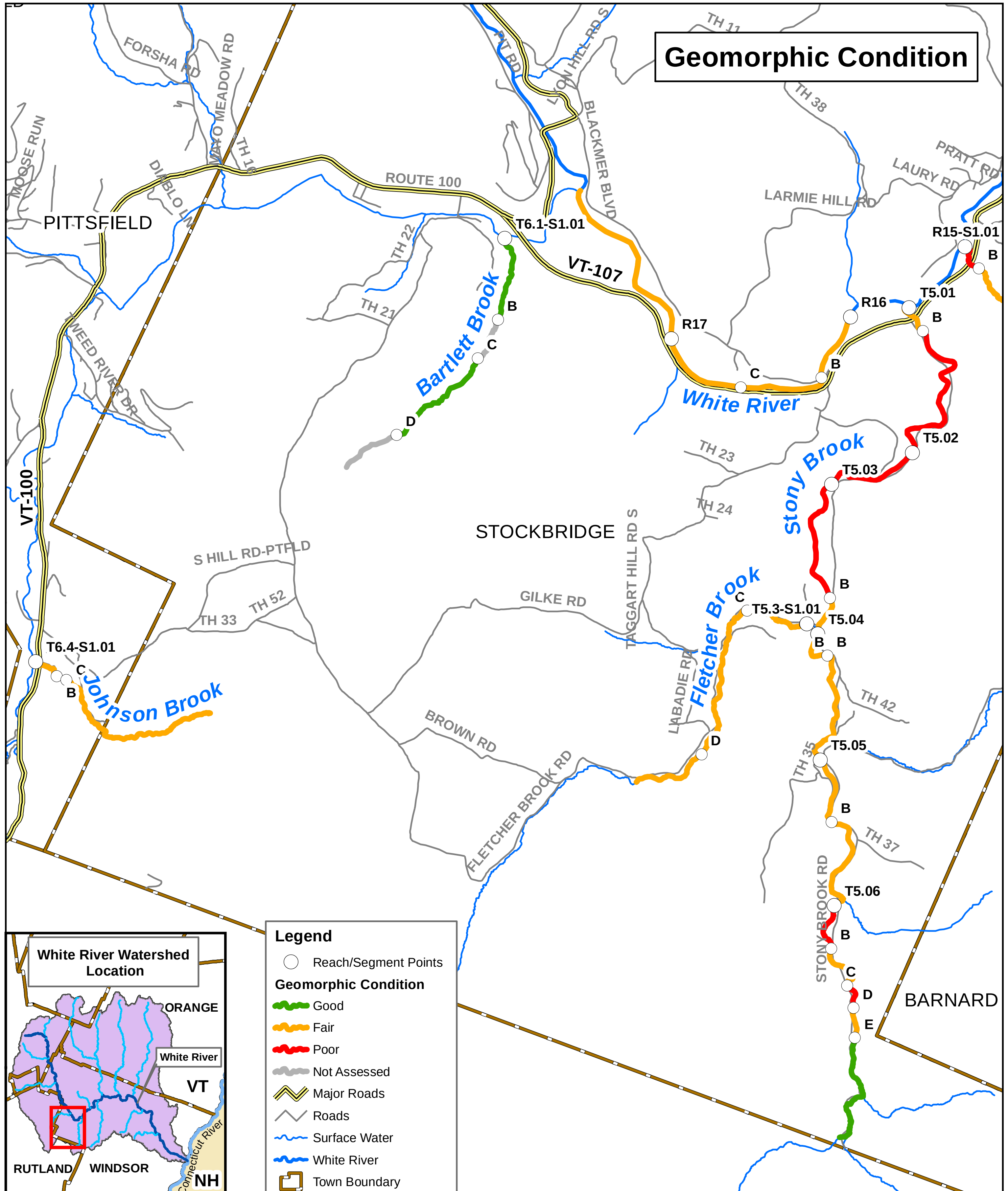


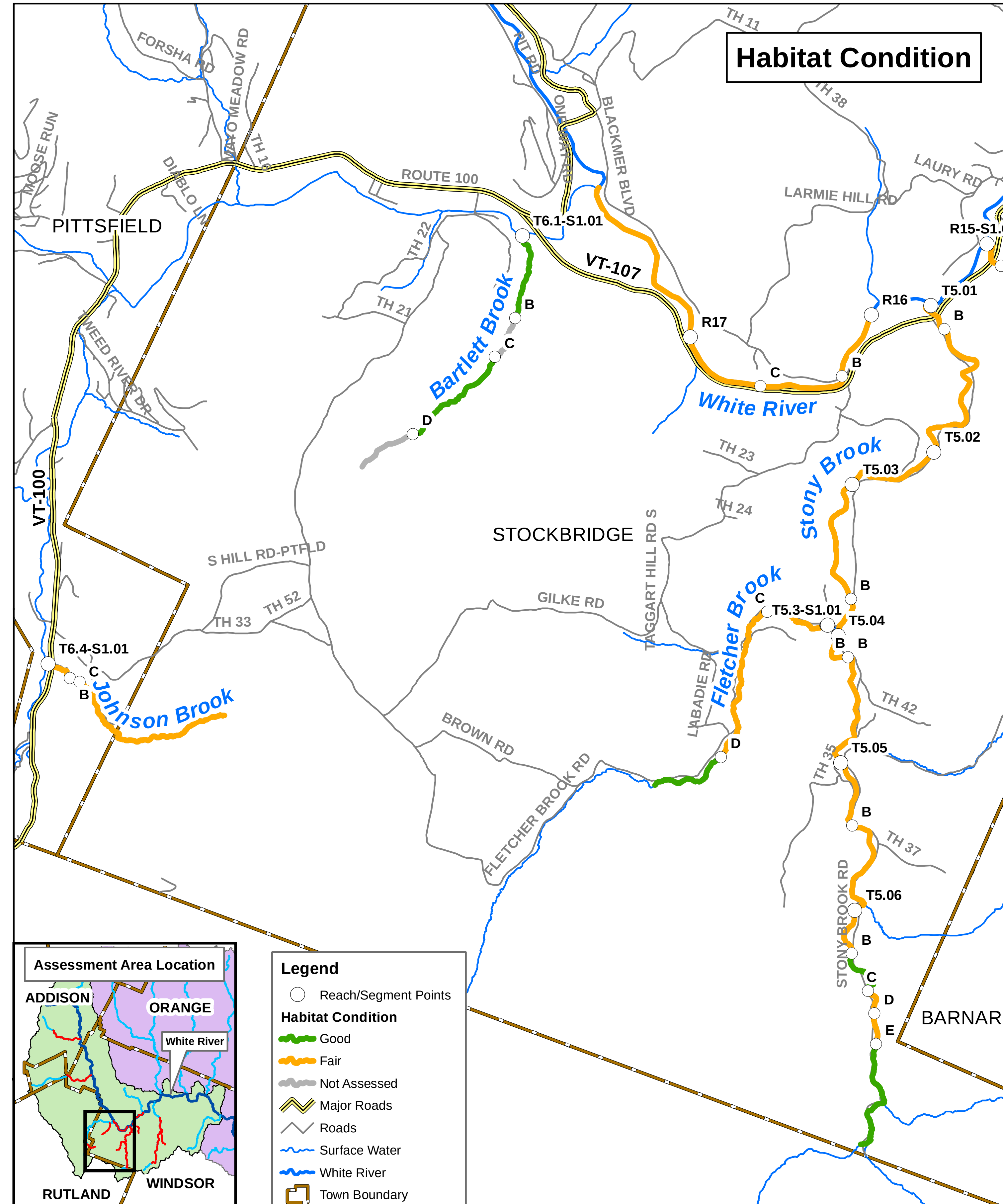
Locust Creek, Pond Brook, White River & Little Stony Brook
Stream Condition - Barnard and Stockbridge, Vermont

N W E S

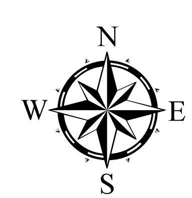
0 1 2 Miles

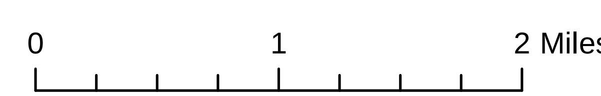
Bear Creek Environmental



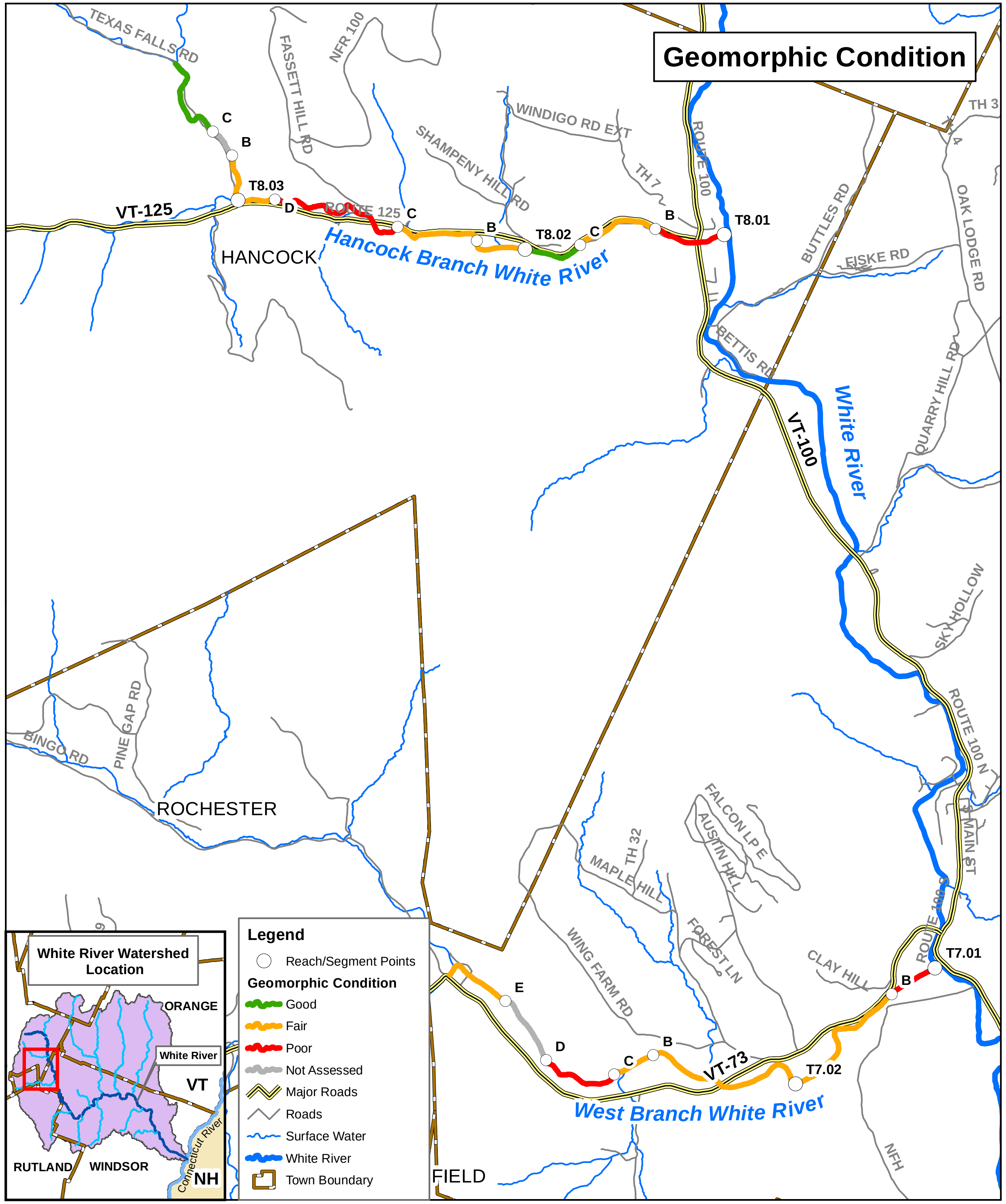


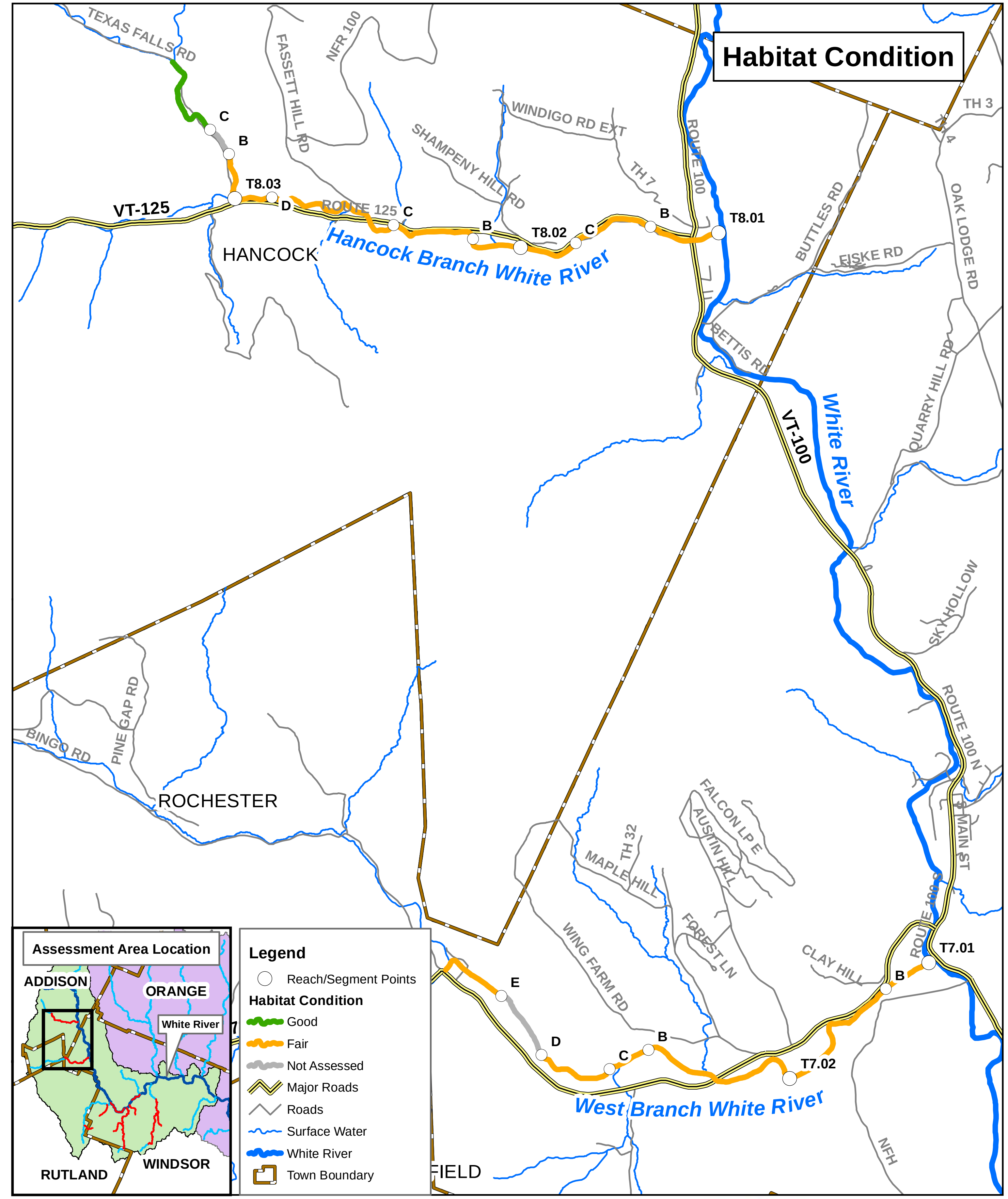
White River, Stony Brook, Fletcher Brook, Bartlett Brook & Johnson Brook Stream Condition - Stockbridge and Pittsfield, Vermont



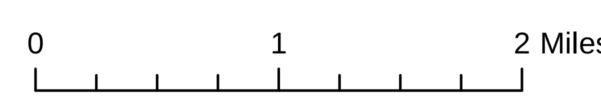


Bear Creek Environmental

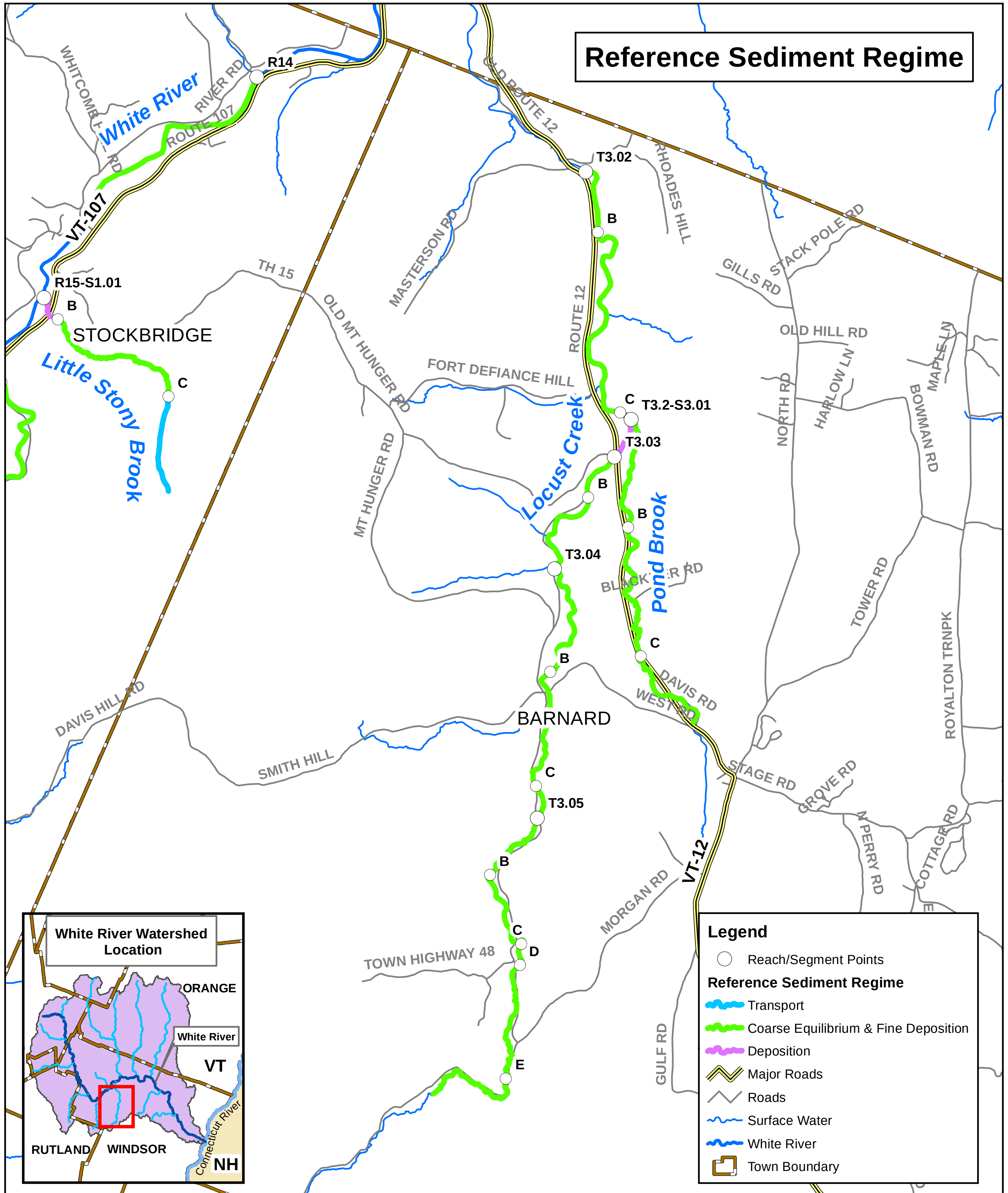


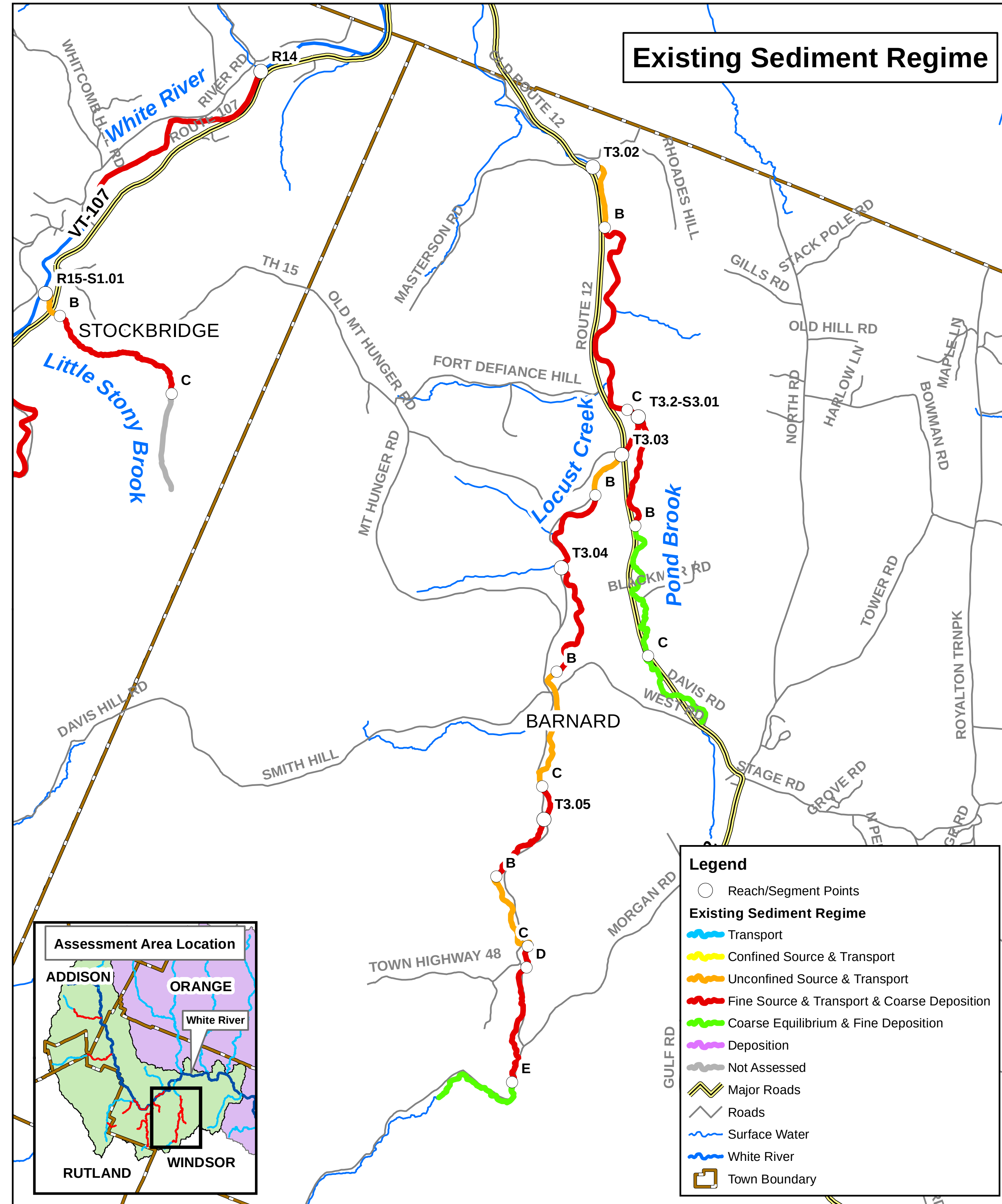


Hancock Branch & West Branch White River
Stream Condition - Hancock and Rochester, Vermont

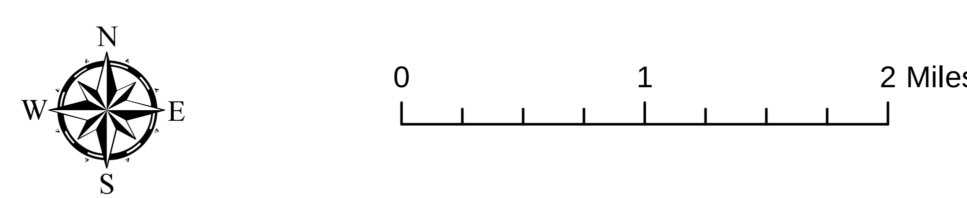


Bear Creek Environmental

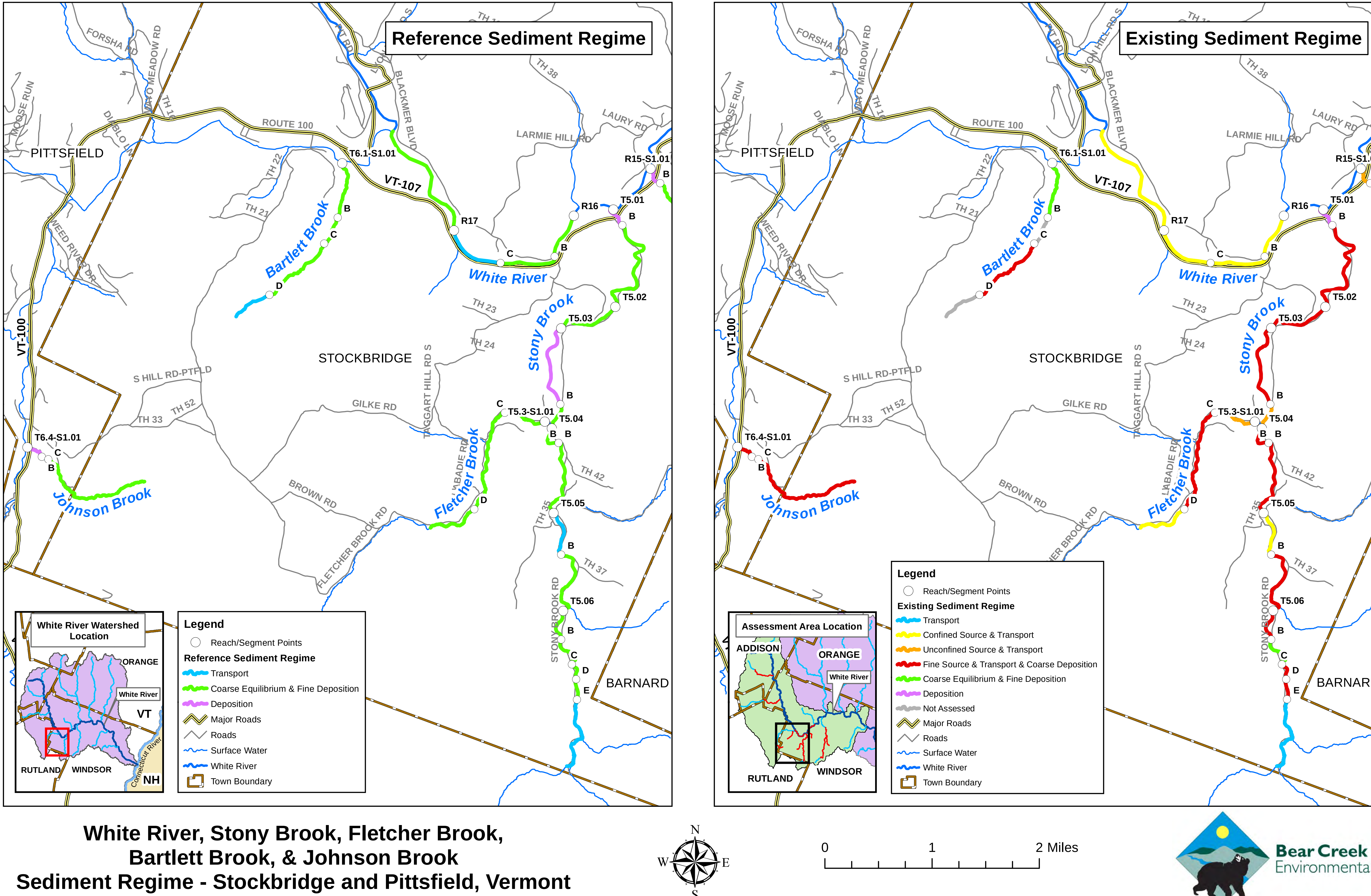




Locust Creek, Pond Brook, White River & Little Stony Brook Sediment Regime - Barnard and Stockbridge, Vermont

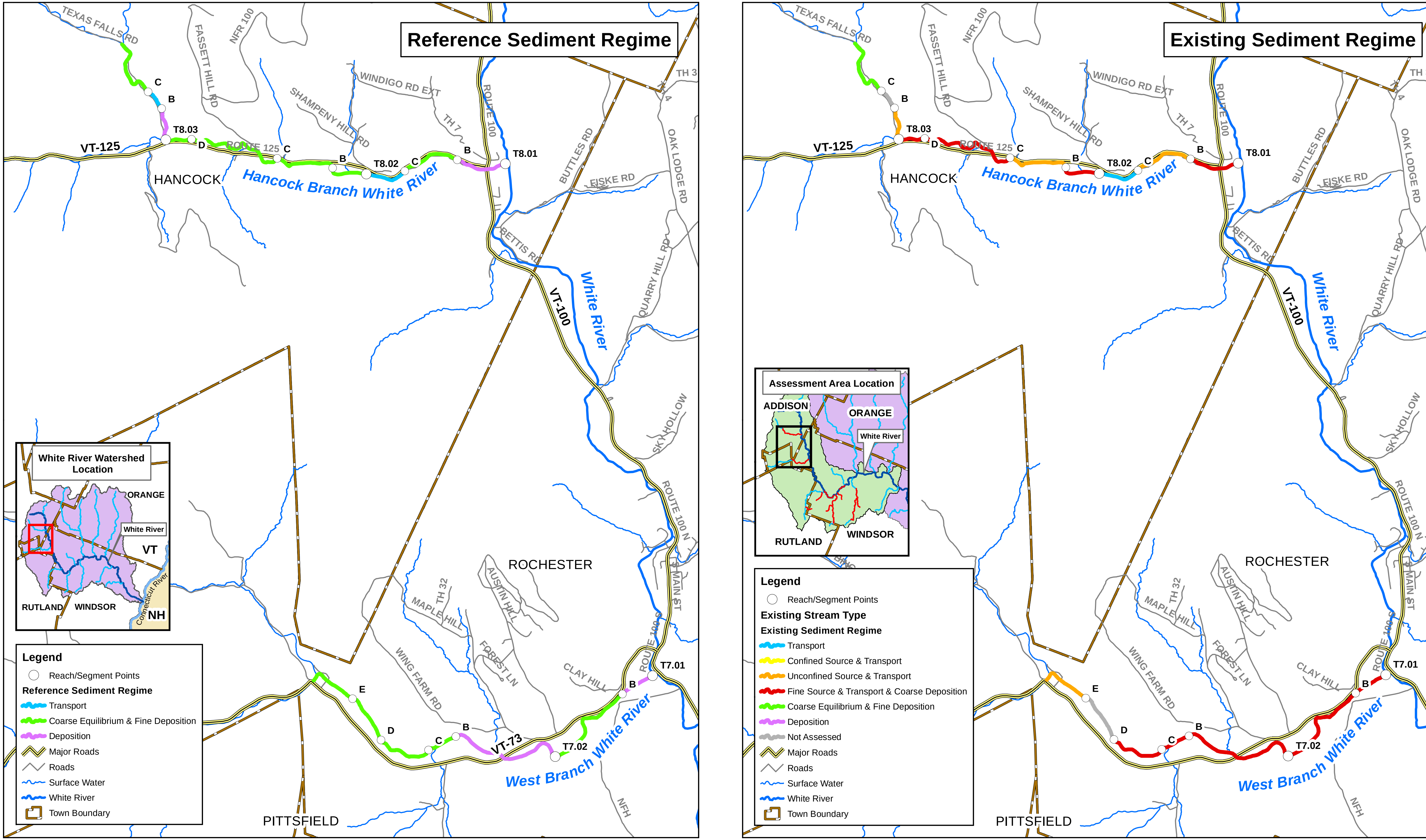


Bear Creek Environmental



White River, Stony Brook, Fletcher Brook, Bartlett Brook, & Johnson Brook Sediment Regime - Stockbridge and Pittsfield, Vermont

Bear Creek Environmental



Hancock Branch & West Branch White River Sediment Regime - Hancock and Rochester, Vermont

Bear Creek Environmental

Table 1. Stream Type and Channel Evolution Stage Summary Upper & Middle White River Watershed							
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Reference Stream Type**	**Incision Ratio**	**Existing Stream Type**	**Channel Evolution Stage**	**Active Adjustment Process**
White River Mainstem							
R14	4.0	65.6	C	1.5	C	F-III	**Incision** **Aggradation** **Widening** Planform
R16-A	1.5	30.7	B_c	1.8	B_c	F-III	**Incision** Aggradation **Widening** Planform
R16-B	1.2	48.5	B_c	2.8	F	F-IV	**Incision** **Aggradation** **Widening** Planform
R16-C	1.4	18.5	B_c	2.6	F	F-II	**Incision** Aggradation Widening Planform
R17	1.1	42.3	B	2.4	F	F-III	**Incision** Aggradation **Widening** Planform
Locust Creek							
T3.02-A	1.2	21.9	C	2.4	F	F-II	**Incision** Aggradation Widening **Planform**
T3.02-B	2.5	40.7	C	1.8	C	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T3.02-C	2.0	32.9	C	2.0	B_c	F-III	**Incision** **Aggradation** **Widening** **Planform**
T3.03-A	1.1	25.0	C_b	3.4	F_b	F-II	**Incision** Aggradation **Widening** **Planform**
T3.03-B	1.4	26.4	C_b	3.0	B	F-III	**Incision** Aggradation Widening Planform

Table 1. Stream Type and Channel Evolution Stage Summary Upper & Middle White River Watershed							
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Reference Stream Type**	**Incision Ratio**	**Existing Stream Type**	**Channel Evolution Stage**	**Active Adjustment Process**
T3.04-A	1.4	50.2	C	2.5	B_c	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T3.04-B	1.6	16.9	C	2.8	B_c	F-IV	**Incision** **Aggradation** Widening **Planform**
T3.04-C	1.2	14.7	C	3.6	F	F-III	**Incision** Aggradation **Widening** Planform
T3.05-A	1.5	24.2	C_b	2.7	B	F-IV	**Incision** Aggradation Widening Planform
T3.05-B	1.1	19.1	B	2.4	F_b	F-III	**Incision** Aggradation Widening Planform
T3.05-C	10.2	9.7	C_b	1.8	E	F-II	**Incision** Aggradation Widening **Planform**
T3.05-D	2.1	14.8	C	2.2	B	F-III	**Incision** **Aggradation** Widening Planform
T3.05-E	2.9	11.1	C_b	1.0	C_b	F-I	Aggradation Widening Planform
Pond Brook							
T3.2-S3.01-A	15.3	7.8	E	1.6	E	F-II	**Incision** Aggradation Widening Planform
T3.2-S3.01-B	9.0	12.3	C	1.3	C	F-II	Incision Aggradation Widening Planform
T3.2-S3.01-C	9.2	8.9	E	1.1	E	F-I	Incision Aggradation Planform

Table 1. Stream Type and Channel Evolution Stage Summary Upper & Middle White River Watershed							
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Reference Stream Type**	**Incision Ratio**	**Existing Stream Type**	**Channel Evolution Stage**	**Active Adjustment Process**
Stony Brook							
T5.01-A	6.7	29.7	D	1.0	C	F-I	**Aggradation** Widening Planform
T5.01-B	1.7	30.6	C	3.7	B_c	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T5.02	1.3	26.8	B	3.0	F_b	F-III	**Incision** **Aggradation** **Widening** **Planform**
T5.03-A	3.4	36.4	C	1.9	C	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T5.03-B	5.1	10.6	C	1.7	C	F-II	**Incision** Aggradation Widening **Planform**
T5.04-A	1.4	32.7	C_b	2.0	F_b	F-III	**Incision** **Aggradation** **Widening** Planform
T5.04-B	1.8	23.9	C_b	1.9	B	F-III	**Incision** Aggradation Widening **Planform**
T5.05-A	1.2	30.6	B	3.0	F_b	F-III	**Incision** Aggradation **Widening** Planform
T5.05-B	1.9	24.7	C	2.0	B_c	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T5.06-A	1.2	50.6	C	2.2	F	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T5.06-B	1.4	16.6	F	1.2	F	F-II	Incision Aggradation Widening Planform

Table 1. Stream Type and Channel Evolution Stage Summary Upper & Middle White River Watershed							
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Reference Stream Type**	**Incision Ratio**	**Existing Stream Type**	**Channel Evolution Stage**	**Active Adjustment Process**
T5.06-C	2.6	54.2	C_b	1.5	C_b	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T5.06-D	1.4	18.7	B	1.6	F_b	F-III	**Incision** Aggradation Widening Planform
T5.06-E	2.2	19.1	B_a	1.1	B_a	F-I	Aggradation Widening
Fletcher Brook							
T5.3-S1.01-A	3.7	10.1	D	1.3	C	F-II	Incision **Aggradation** Widening Planform
T5.3-S1.01-B	2.3	10.8	C_b	1.8	C_b	F-II	**Incision** Aggradation Planform
T5.3-S1.01-C	1.4	34.9	C_b	3.9	F_b	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T5.3-S1.01-D	1.7	29.6	B_a	1.5	B_a	F-III	**Incision** Aggradation Widening Planform
Little Stony Brook							
R15-S1.01-A	1.3	21.7	D	2.8	F_b	F-III	**Incision** **Aggradation** **Widening** **Planform**
R15-S1.01-B	1.4	19.9	C_a	2.8	F_a	F-III	**Incision** **Aggradation** **Widening** **Planform**
Bartlett Brook							
T6.1-S1.01-A	1.8	18.1	B	1.4	B	F-II	Incision Aggradation Widening Planform

Table 1. Stream Type and Channel Evolution Stage Summary Upper & Middle White River Watershed							
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Reference Stream Type**	**Incision Ratio**	**Existing Stream Type**	**Channel Evolution Stage**	**Active Adjustment Process**
T6.1-S1.01-C	4.6	13.6	C_b	1.3	C_b	F-IV	Incision Aggradation Widening Planform
Johnson Brook							
T6.4-S1.01-A	1.3	12.0	D	2.0	F	F-III	**Incision** Aggradation **Widening** **Planform**
T6.4-S1.01-C	3.9	9.3	C_b	1.5	E_b	F-II	**Incision** Aggradation Planform
West Branch White River							
T7.01-A	1.2	38.9	C	2.2	F	F-III	**Incision** **Aggradation** **Widening** **Planform**
T7.01-B	1.7	45.6	B_c	1.3	B_c	F-III	Incision **Aggradation** **Widening** **Planform**
T7.02-A	6.4	31.9	C	1.0	C	F-III	**Aggradation** **Widening** **Planform**
T7.02-B	1.4	52.8	B_c	1.1	B_c	F-III	**Aggradation** **Widening** Planform
T7.02-C	5.3	98.5	C	1.3	C	F-III	Incision **Aggradation** **Widening** **Planform**
T7.02-E	2.6	20.6	C	1.7	C	F-II	**Incision** **Aggradation** Widening **Planform**
Hancock Branch							
T8.01-A	3.2	12.3	C	1.4	C	F-II	**Incision** **Aggradation** Widening **Planform**

Table 1. Stream Type and Channel Evolution Stage Summary Upper & Middle White River Watershed							
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Reference Stream Type**	**Incision Ratio**	**Existing Stream Type**	**Channel Evolution Stage**	**Active Adjustment Process**
T8.01-B	1.2	17.4	C	2.6	F	F-II	**Incision** **Aggradation** Widening **Planform**
T8.01-C	1.4	22.2	F	1.2	F	F-II	Incision Aggradation Widening Planform
T8.02-A	3.8	32.2	C	1.4	C	F-III	Incision Aggradation **Widening** **Planform**
T8.02-B	2.9	22.7	C	1.9	C	F-III	**Incision** Aggradation Widening
T8.02-C	3.5	41.7	C	1.7	C	F-IV	**Incision** **Aggradation** **Widening** **Planform**
T8.02-D	2.8	18.9	C	1.5	C	F-II	**Incision** Aggradation Widening Planform
T8.03-A	2.0	16.1	C	1.6	B	F-II	**Incision** Aggradation Widening Planform
T8.03-C	1.2	27.3	F_b	1.0	F_b	F-I	Aggradation Widening Planform

	F Stream Type	B Stream Type	C Stream Type
Entrenchment Ratio	< 1.4	1.4 – 2.2	> 2.2
Width to Depth Ratio	> 12	> 12	> 12

Bold Red lettering – denotes severe adjustment process
Bold Black lettering – denotes major adjustment process
Black lettering (no bold) – denotes minor adjustment process
Red denotes severe incision ratio (≥2.0)
Blue denotes moderate incision ratio (1.4 – <2.0)
Green denotes no incision to minor incision (<1.4)
Orange denotes a stream type departure

APPENDIX B

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.

Milone & MacBroom, Inc., 2008

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 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. Upper-Mid White River Watershed Bridge Assessment (2014)
Geomorphic Compatibility

Reach/ Segment Number & Map #	Town	Road Name	Structure ID[1]	Percent Bankfull Channel Constriction Width[2]	Phase 2 Notes	Scoring						Priority for Replacement
						% Bankfull Width	Sediment Continuity	Approach Angle	Erosion & Armoring	Total Score	Geomorphic Compatibility	
T3.2-S3.01-A (Map 1)	Barnard	Private Trail	700000000114033	36/29.9 = 120	Stormwater inputs at abutments. Dredging above and below bridge. Deposition above and below bridge. Not a channel constriction. Rusted I-beams.	5	4	2 Channelized Straight	0	**11**	Partially Compatible	Not recommended for replacement
T3.2-S3.01-A (Map 1)	Barnard	Private Drive	700000000214033	18/29.9 = 60	Riprap failing around structure. Windrowed below. Rusted I-beams but in fairly good condition.	2	5	2 Channelized Straight	0	**9**	Partially Compatible	Moderate (Undersized but in good condition, abundant aggradation was windrowed below)
T3.2-S3.01-A (Map 1)	Barnard	Private Drive	700000000314033	23.1/29.9 = 77	Many invasives surrounding bridge in banks and buffers. I-beams rusting, riprap falling around right downstream abutment.	3	5	3 Mild Bend	0	**11**	Partially Compatible	Low (Slightly undersized, rusted I-beams)
T3.2-S3.01-A (Map 1)	Barnard	Private Drive	700000000414033	23/29.9 = 77	Fair condition. Scour under right abutment. Failing riprap and rusting I-beams.	3	5	2 Channelized Straight	0	**10**	Partially Compatible	Moderate (Slightly undersized, fair condition and abutment scour)
T3.2-S3.01-B (Map 1)	Barnard	Private Drive	700000000514033	14.5/29.9 = 48	Poor condition. Scour around both abutments upstream. Channel windrowed/dredged downstream. Material was left piled on bank (no berm). Deposition above.	1	4	2 Channelized Straight	0	**7**	Mostly Incompatible	**High** (Significantly undersized, poor condition, scour around abutments)
T3.2-S3.01-B (Map 1)	Barnard	Blackmer Road	990030047014031	13.9/29.9 = 46	Very undersized. Alignment is not ideal but overall good condition.	1	5	3 Mild Bend	3	**12**	Partially Compatible	**High** (Significantly undersized, poor alignment)
T3.2-S3.01-C (Map 1)	Barnard	Private Trail	700000000614033	23.5/29.9 = 79	Bridge access to hayfield. New decking. Deposition below.	3	5	3 Mild Bend	3	**14**	Mostly Compatible	Low (Slightly undersized)
T3.02-A (Map 1)	Barnard	Hambsch Farm Road	700000000714033	36/50.8 = 71	Good condition. Scour on western bank abutment. Side bar inside and downstream of structure.	2	5	2 Channelized Straight	0	**9**	Partially Compatible	Low (Good condition, slightly undersized, abutment scour, deposition)
T3.03-A (Map 1)	Barnard	Chateauguay Road	101403003414031	29/38.4 = 76	Steep riffle and pool with sand and silt. West bank abutment and wing wall scour. Except for the scour, bridge in good condition. Mass failure on downstream western bank resulting in bare vegetation. Stormwater input from overland flow on all sides of structure. Poor alignment and deposition above and below.	3	1	5 Naturally Straight	0	**9**	Partially Compatible	Moderate (Slightly undersized, scour around abutments and wing wall, mass failure downstream)
T3.04-B (Map 1)	Barnard	West Road	101403003614031	26/34.4 = 76	Boulder weir just downstream of structure. Pool inside structure. Weir creates another pool downstream. Scour around upstream abutment.	3	5	3 Mild Bend	1	**12**	Partially Compatible	Moderate (Slightly undersized, abundant erosion and abutment scour upstream)
T3.04-C (Map 1)	Barnard	Private Drive	700000000814033	29/34.4 = 84	Bridge in adequate condition but cement blocks are being used for abutments. Structure may not hold out for long term. Deposition above.	3	4	2 Channelized Straight	3	**12**	Partially Compatible	Moderate (Good condition but needs stronger abutments, slightly undersized)

Table 6. Upper-Mid White River Watershed Bridge Assessment (2014) Geomorphic Compatibility													
Reach/ Segment Number & Map #	Town	Road Name	Structure ID[1]	Percent Bankfull Channel Constriction Width[2]	Phase 2 Notes	Scoring							Priority for Replacement
						% Bankfull Width	Sediment Continuity	Approach Angle	Erosion & Armoring	Total Score	Geomorphic Compatibility	
T3.04-C (Map 1)	Barnard	Chateauguay Road	101403003214031	19.5/34.4 = 57	Boulder weir just downstream of structure. Bridge in good condition but out of alignment with stream channel. Riprap failing but abutments intact. Deposition above and below. Scour below. Large side bar upstream.	2	3	5 Naturally Straight	0	**10**	Partially Compatible	Moderate (Undersized but in good condition, poor alignment)
T3.05-B (Map 1)	Barnard	Private Drive	700000000914033	26/29.4 = 88	Stormwater from overland flow is entering at downstream abutment. Large mass failure just upstream of structure. Stream fords both upstream and downstream. Scour on downstream eastern abutment. Bridge damaged during TSI. Deposition above and below.	3	2	3 Mild Bend	0	**8**	Mostly Incompatible	Moderate (Slightly undersized, mass failure present, abutment scour, abundant erosion)
T3.05-B (Map 1)	Barnard	Chateauguay Road	101403003114031	17/29.4 = 58	Good condition. Large avulsion from TSI enters above bridge. Floodplain was bermed to put channel back to its original place. Deposition above and below. Scour below.	2	4	2 Channelized Straight	4	**12**	Partially Compatible	Moderate (Undersized but in good condition, geomorphically unstable upstream)
T3.05-D (Map 1)	Barnard	Chateauguay Road	101403003014031	20/29.4 = 68	Good condition overall but scour under western downstream abutment and wing wall. Riprap in bed within the structure. Headcut in structure. Poor alignment.	2	4	0 Sharp Bend	0	**6**	Mostly Incompatible	**High** (Good condition but undersized, poor alignment, head cut present)
T3.05-E (Map 1)	Barnard	Chateauguay Road	400000000414031	13/29.4 = 44	Significantly undersized. Bridge built on bedrock grade control. Scour on western abutment. Log landing adjacent to eastern side. I-beams rusting and in fair condition. Poor alignment and major aggradation above.	1	3	0 Sharp Bend	0	**4**	Fully Incompatible	**High** (Fair condition, significantly undersized, major aggradation)
T8.01-A (Map 3)	Hancock	Route 100	200013014501082	51/51.3 = 99	Very low clearance. Bermed and windrowed heavily upstream and downstream. If channel avulses around structure homes are vulnerable in residential area. Rusty I-beams but intact. Scour around the decking.	3	4	2 Channelized Straight	2	**11**	Partially Compatible	Moderate (Low clearance, homes in area are vulnerable)
T8.01-B (Map 3)	Hancock	Private Trail	700000000001083	70/51.3 = 136	Footbridge for Camp Killooleet. Remnants of old Killoleet Dam is 125 feet upstream of structure. Fairly new structure with extensive windrowing and riprap. Channel filled in with large side bar between center pier and northern abutment.	5	4	2 Channelized Straight	4	**15**	Mostly Compatible	Moderate (Good condition, adequate size, but major aggradation between pier and abutment)
T8.02-B (Map 3)	Hancock	Private Trail	700000000101083	56/50 = 112	Old rusty I-beams. Abutments unstable. New riprap. Stream ford below bridge. No major geomorphic problems noted.	4	5	2 Channelized Straight	0	**11**	Partially Compatible	Low (Rusty I-beams and unstable abutments but adequately sized)
T8.02-C (Map 3)	Hancock	Route 125	200174002301082	43.5/50 = 87	Scour below and poor alignment. Span is 69 feet but riprap causing a constriction width of 43.5 feet. Mid-channel bar upstream of structure. Bermed and windrowed downstream of bridge.	3	4	3 Mild Bend	3	**13**	Mostly Compatible	Low (Slightly undersized but mostly compatible)
T8.03-B (Map 3)	Hancock	Private Trail	700000000201083	72/34.6 = 208	Foot bridge located on top of valley walls over bedrock gorge. Not bankfull or floodprone constriction. Brand new and no problems. Pool downstream not due to bridge.	5	5	5 Naturally Straight	5	**20**	Fully Compatible	Not recommended for replacement

Table 6. Upper-Mid White River Watershed Bridge Assessment (2014)
Geomorphic Compatibility

Reach/ Segment Number & Map #	Town	Road Name	Structure ID[1]	Percent Bankfull Channel Constriction Width[2]	Phase 2 Notes	Scoring						Priority for Replacement
						% Bankfull Width	Sediment Continuity	Approach Angle	Erosion & Armoring	Total Score	Geomorphic Compatibility	
T8.03-C (Map 3)	Hancock	Texas Falls Road	100108000801081	25.5/34.6 = 74	Abutments are very old but in good condition. Channel split/avulsed above bridge during TSI and flowed over road. Major deposition above on bend. Poor alignment.	2	3	2 Channelized Straight	2	**9**	Partially Compatible	Moderate (Slightly undersized, poor alignment, channel overtopped during TSI)
T7.02-A (Map 3)	Rochester	Brandon Mountain Road	200162001714152	90/67.8 = 133	Rusty I-beams and in stable condition. Abundant riprap upstream and above the riprap is severe erosion on northern bank. Manmade pond drainage input with iron seepage just upstream of bridge. Abundant aggradation above bridge.	5	4	3 Mild Bend	0	**12**	Partially Compatible	Low (Adequately sized and in stable condition)
T7.02-E (Map 3)	Rochester	King Farm Road	100000000114151	36/67.8 = 53	Northern bank abutment on bedrock. This concrete abutment is scoured. Steel structure is rusted but still intact. Structure rebuilt after TSI. Span is 57 feet but constriction width is 36 due to bedrock and riprap.	2	2	2 Channelized Straight	0	**6**	Mostly Incompatible	Moderate (Undersized and abutment scour but stable on bedrock)
R15-S1.01-A (Map 1)	Stockbridge	Route 107	200022001014192	27/18.7 = 144	Significant scour on western downstream abutment. Deterioration and cracking of eastern abutment. Fair condition. Bridge was likely plugged with sediment after Irene. Span is 27 feet at riprap and 34.8 feet at abutments. Deposition above and below and poor alignment.	5	2	3 Mild Bend	1	**11**	Partially Compatible	Low (Not undersized, fair condition)
R16-B (Map 2)	Stockbridge	Blackmer Blvd	101419000614191	120/134 = 90	Scour on northern pier. Bedrock on upstream northern bank protects abutment. Fairly new bridge with very deep pool underneath it due to bedrock. Sharp turn just upstream of structure. Road embankment on upstream northern bank eroded severely during TSI and has since been armored. Bridge span is 180 feet but constriction width is 120 feet due to piers.	5	4	0 Sharp Bend	1	**10**	Partially Compatible	Low (Slightly undersized, poor alignment)
T5.01-A (Map 2)	Stockbridge	Route 107	20002200914192	63/52.3 = 120	New structure built high on valley walls. Riprap creating constriction; bridge span is 135 feet, but riprap width is 63 feet causing constriction. Some stormwater inputs around structure.	5	3	2 Channelized Straight	1	**11**	Partially Compatible	Not recommended for replacement
T5.01-B (Map 2)	Stockbridge	Stony Brook Road	101419000514191	43.5/52.3 = 83	New bridge. Was washed out during TSI.	3	4	5 Naturally Straight	4	**16**	Mostly Compatible	Low (Slightly undersized, new construction)
T5.01-B (Map 2)	Stockbridge	Private Drive	700000000014193	37.5/52.3 = 72	New wooden decking. Most likely washed out during TSI. Bedrock on abutment on western bank. Constriction is 37.5 feet from bedrock on one side.	2	2	3 Mild Bend	0	**7**	Mostly Incompatible	Moderate (Decking most likely washed out during TSI, scour on abutment)
T5.03-B (Map 2)	Stockbridge	Fletcher Brook Road	101419003314191	33/50.7 = 65	Fair condition. Scour on eastern bank wing wall/abutment. Located just below confluence with Fletcher Brook. Large depositional features including delta bar from Fletcher Brook, which is not due to bridge. Western bank approach is in good condition but is severely constricting. Stony Brook overtopped the bridge during TSI and washed out Fletcher Brook Road to the west.	2	1	5 Naturally Straight	0	**8**	Mostly Incompatible	**High** (Undersized, fair condition, scour on abutment and wing wall, overtopped during TSI)

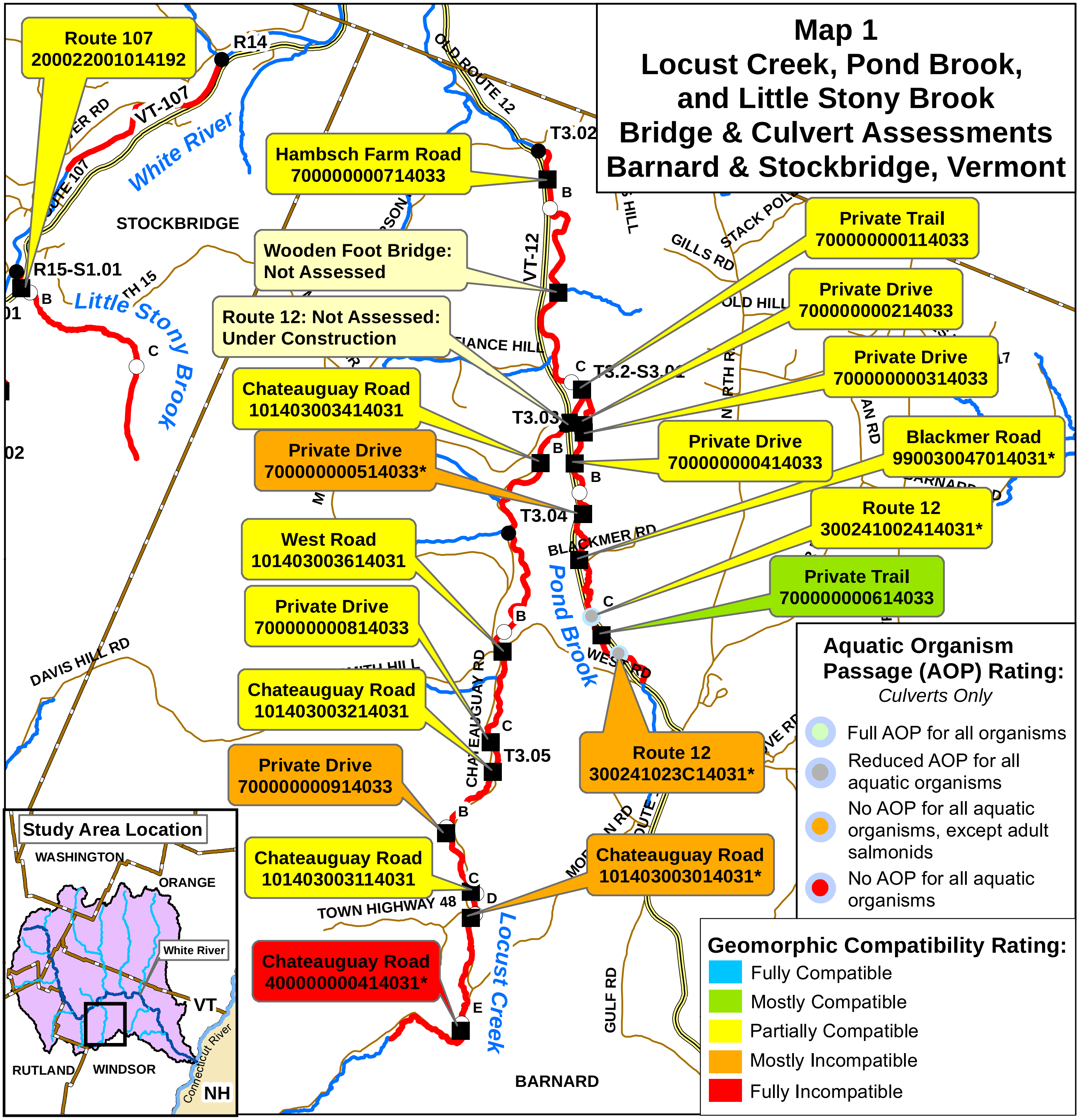
Table 6. Upper-Mid White River Watershed Bridge Assessment (2014) Geomorphic Compatibility												
Reach/ Segment Number & Map #	**Town**	**Road Name**	**Structure ID[1]**	**Percent Bankfull Channel Constriction Width[2]**	**Phase 2 Notes**	**Scoring**						**Priority for Replacement**
						% Bankfull Width	**Sediment Continuity**	**Approach Angle**	**Erosion & Armoring**	**Total Score**	**Geomorphic Compatibility**	
T5.04-B (Map 2)	Stockbridge	Private Drive	700000000114193	18/40 = 45	Riprap failing around structure. Eastern abutment leaning in. Bedrock grade control and large pool present within bridge. Span is 30 feet but constriction width with bedrock on eastern side is 18 feet. Channel avulsed above bridge during TSI and caused landslide across road. Poor condition. Bridge clogged during TSI.	1	3	2 Channelized Straight	0	**6**	Mostly Incompatible	**High** (Poor condition, significantly undersized, clogged during TSI).
T5.05-A (Map 2)	Stockbridge	Driscolls Road	10149003014191	18/36 = 50	Structure built into bedrock at sharp bend in stream. Eastern abutment leaning into stream. Major channel constriction and bend causing aggradation above. Span is 26 feet but constriction width with bedrock on western side is 18 feet. Mass failure along eastern valley wall at outlet. Poor condition and alignment.	2	1	0 Sharp Bend	0	**3**	Fully Incompatible	**High** (Poor condition, undersized, major aggradation upstream)
T5.05-B (Map 2)	Stockbridge	Stony Brook Road	101419002414191	35/36 = 97	Localized severe bank erosion on east side below bridge (riprap has failed). Minor deposition above.	3	4	5 Naturally Straight	0	**12**	Partially Compatible	Low (Slightly undersized, failed riprap)
T5.05-B (Map 2)	Stockbridge	Stony Brook Road	101419002514191	33/36 = 92	Riprap unstable below bridge (not intact). No other problems noted.	4	4	5 Naturally Straight	0	**13**	Mostly Compatible	Not recommended for replacement
T5.06-B (Map 2)	Stockbridge	Stony Brook Road	101419002614191	28/31.8 = 88	Bridge in good condition (fairly new). Very little riprap protecting wing walls. Large mass failure just upstream. Low clearance.	3	4	2 Channelized Straight	1	**10**	Partially Compatible	Low (Good condition, slightly undersized, low clearance)
T6.4-S1.01-C (Map 2)	Stockbridge	Camp 12 Road	400000000014191	12/24.1 = 50	Span is 21 feet but riprap in structure is constricting the channel to 12 feet. Good condition other than riprap failing.	2	5	3 Mild Bend	0	**10**	Partially Compatible	Moderate (Undersized but in good condition)

[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.

Table 7. Upper-Mid White River Watershed Culvert Assessment (2014)
Geomorphic Compatibility and Aquatic Organism Passage (AOP)

Reach/ Segment Number & Map #	Town	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	
T3.2-S3.01-B (Map 1)	Barnard	Route 12	300241002414031	10.3/29.9 = 34	Significantly undersized and poor channel alignment. Heavily riprapped at outlet. Scour below.	1	5	2	3 Mild Bend	0	**11**	Partially Compatible	Reduced AOP	**High** (Significantly undersized, poor alignment)
T3.2-S3.01-C (Map 1)	Barnard	Route 12	300241023C14031	15.8/29.9 = 53	Riprap falling all around. Scour of eastern wing wall upstream. Abundant algae at outlet. No material inside. Culvert at grade. Poor alignment.	2	4	2	2 Channelized Straight	0	**10**	Mostly Incompatible	Reduced AOP	**High** (Undersized, low slope, failing riprap and wing wall scour)
T6.4-S1.01-A (Map 2)	Pittsfield	Route 100	300022012311151	14.5/24.1 = 60	Deposition and scour below. Outlet perched 0.2 feet. Culvert in good condition.	2	2	5	3 Mild Bend	0	**12**	Partially Compatible	No AOP except adult salmonids	Moderate (Good condition but undersized and slightly perched)
T5.3-S1.01-C (Map 2)	Stockbridge	Blanchard Road	990027001214191	16/30.3 = 53	Significant outlet drop (1.8 feet) causing a barrier to aquatic organism passage. Slight alignment problem. Flow undermining wing wall on northern downstream side. Overall good condition. Deposition below.	2	4	2	3 Mild Bend	0	**11**	Partially Compatible	No AOP including adult salmonids	**High** (Good condition but significant outlet drop and undersized)
T6.4-S1.01-C (Map 2)	Stockbridge	Camp 12 Road	100000000914191	5/24.1 = 21	Structure problematic with aquatic organism passage due to 0.8 foot freefall. Significantly undersized. Deposition above and below.	0	3	5	2 Channelized Straight	0	**10**	Partially Compatible	No AOP including adult salmonids	**High** (Significantly undersized and no AOP)

[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.



Legend

- Bridge
- Culvert
- Reach Points
- Segment Points
- Phase 2 Study Area
- Streams
- Roads
- Major Roads
- Town Boundary

The ID numbers are provided by the 2010 "TransStructures_TRANSTRUC"shapefile from the Vermont Center for Geographic Information, unless no number was available. The SgaID (State of Vermont Data Management System) was used if no "TransStructures_TRANSTRUC" information was available.

Geomorphic Compatibility Rating for bridges is adapted from the Vermont Culvert Geomorphic Compatibility Screening Tool (Miloneand MacBroom, Inc. 2008).

Aquatic Organism Passage Rating for culverts is from the Vermont Culvert Aquatic Organism Passage Screening Tool (Milone and MacBroom, 2009).

*Structure is recommended for replacement.

0 0.5 1 Mile

N E S W

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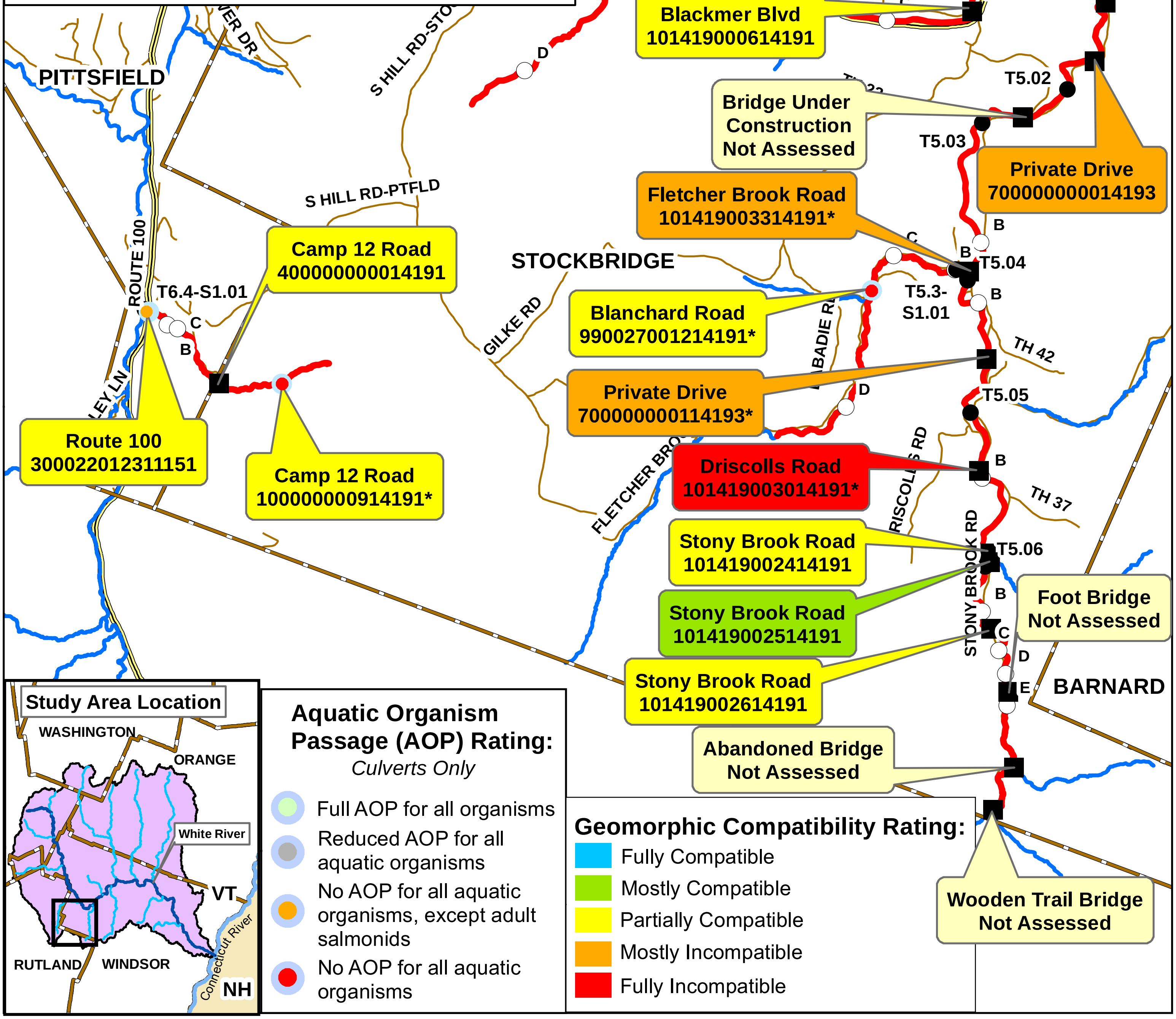
Map 2
White River, Stony Brook, Fletcher Brook, and Johnson Brook Bridge & Culvert Assessments Stockbridge, Vermont



Legend

- Bridge
- Culvert
- Reach Points
- Segment Points
- Phase 2 Study Area
- Town Boundary
- Streams
- Major Roads
- Roads

0 0.5 1 Mile

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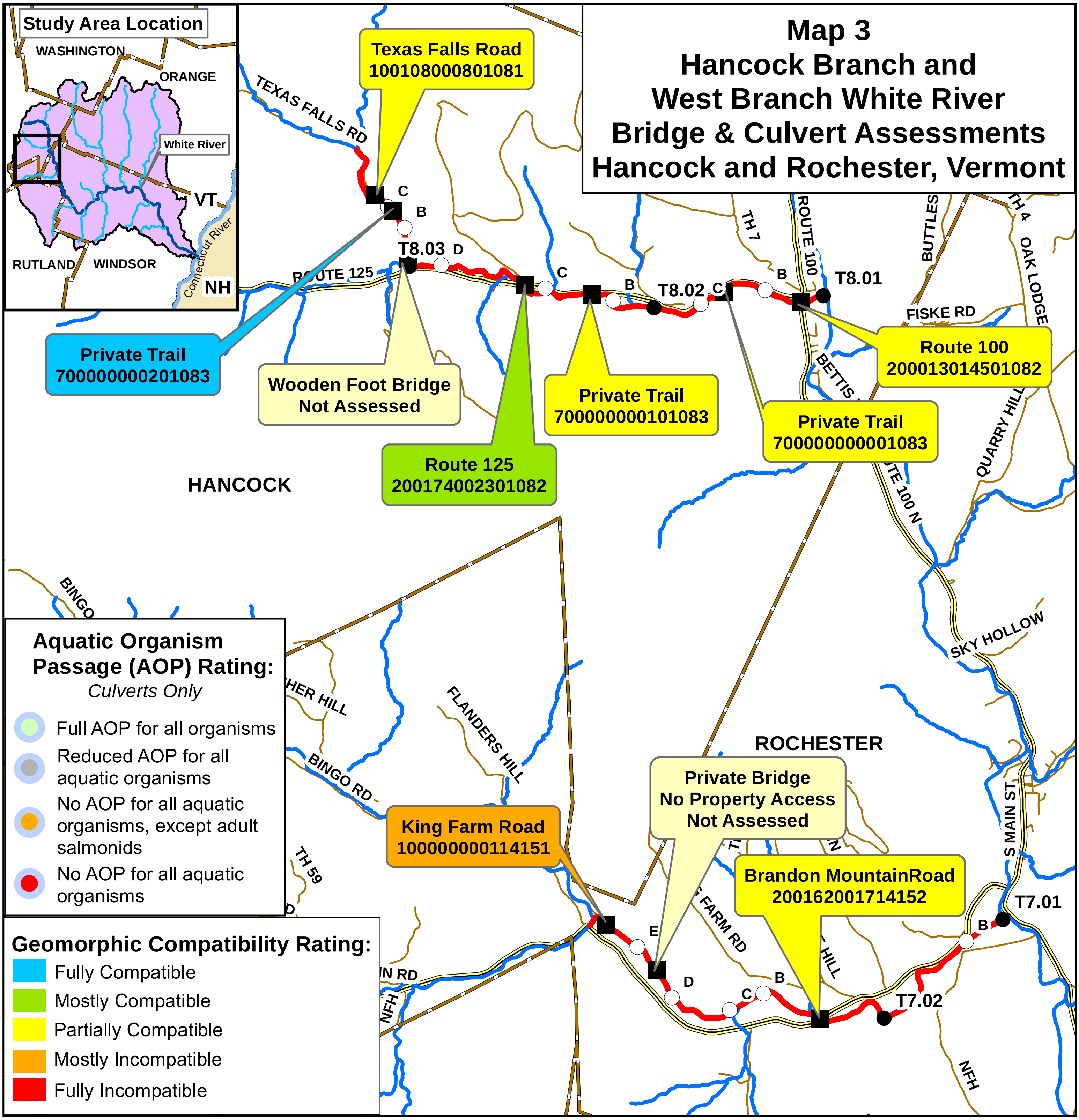

Legend

- Bridge
- Culvert
- Reach Points
- Segment Points
- Phase 2 Study Area
- Town Boundary
- Streams
- Major Roads
- Roads

0 0.5 1 Mile

N W E S

The ID numbers are provided by the 2010 "TransStructures_TRANSTRUC"shapefile from the Vermont Center for Geographic Information, unless no number was available. The SgaID (State of Vermont Data Management System) was used if no "TransStructures_TRANSTRUC" information was available.

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*Structure is recommended for replacement.

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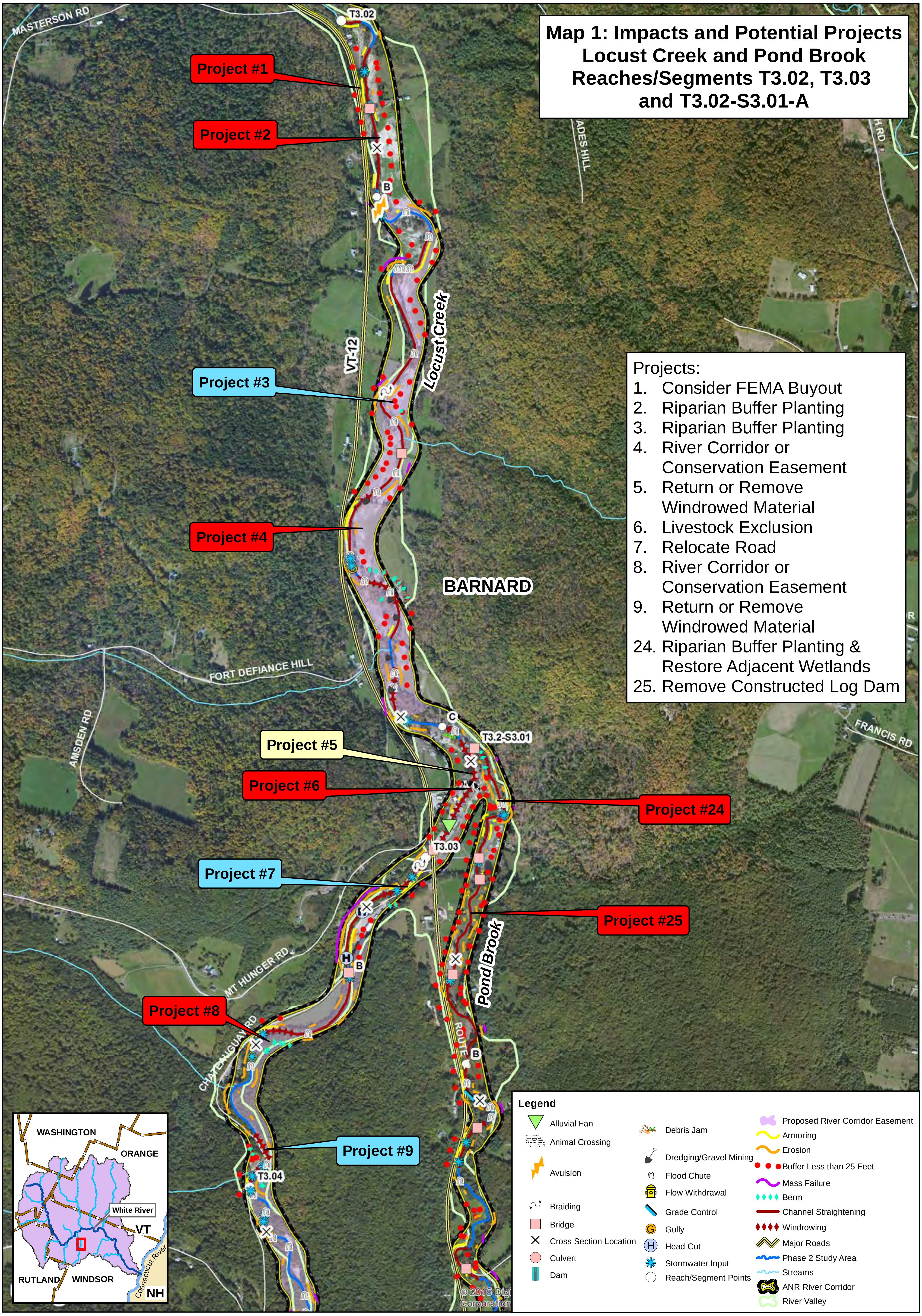
APPENDIX C

Potential Project Locations & Descriptions



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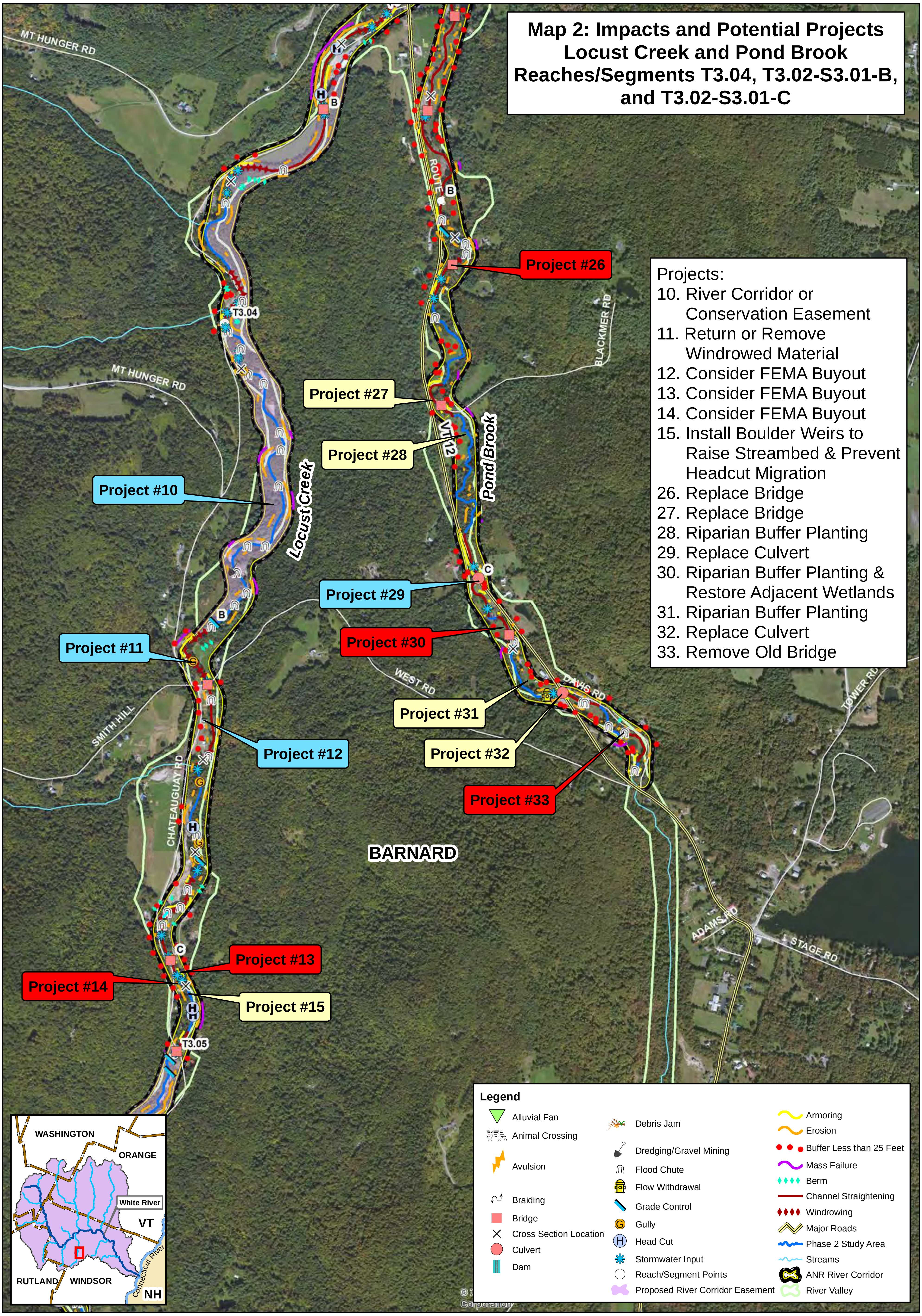
Project Priority:
Low
Moderate
High

0 1,000 2,000 Feet
1 inch = 1,000 feet

Bear Creek Environmental



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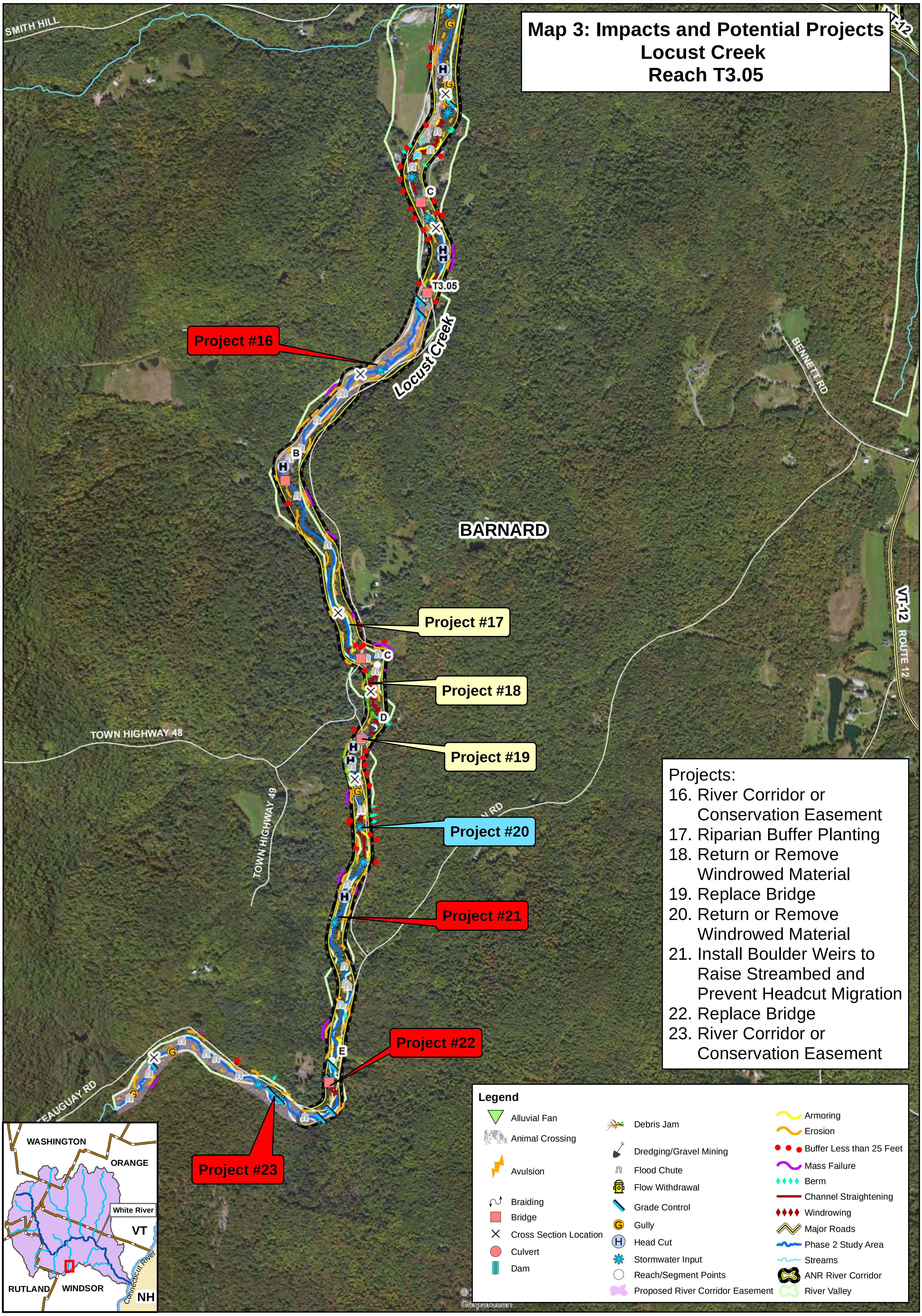
Project Priority:
Low
Moderate
High

N W E S

0 1,000 2,000 Feet

1 inch = 1,000 feet

Bear Creek Environmental



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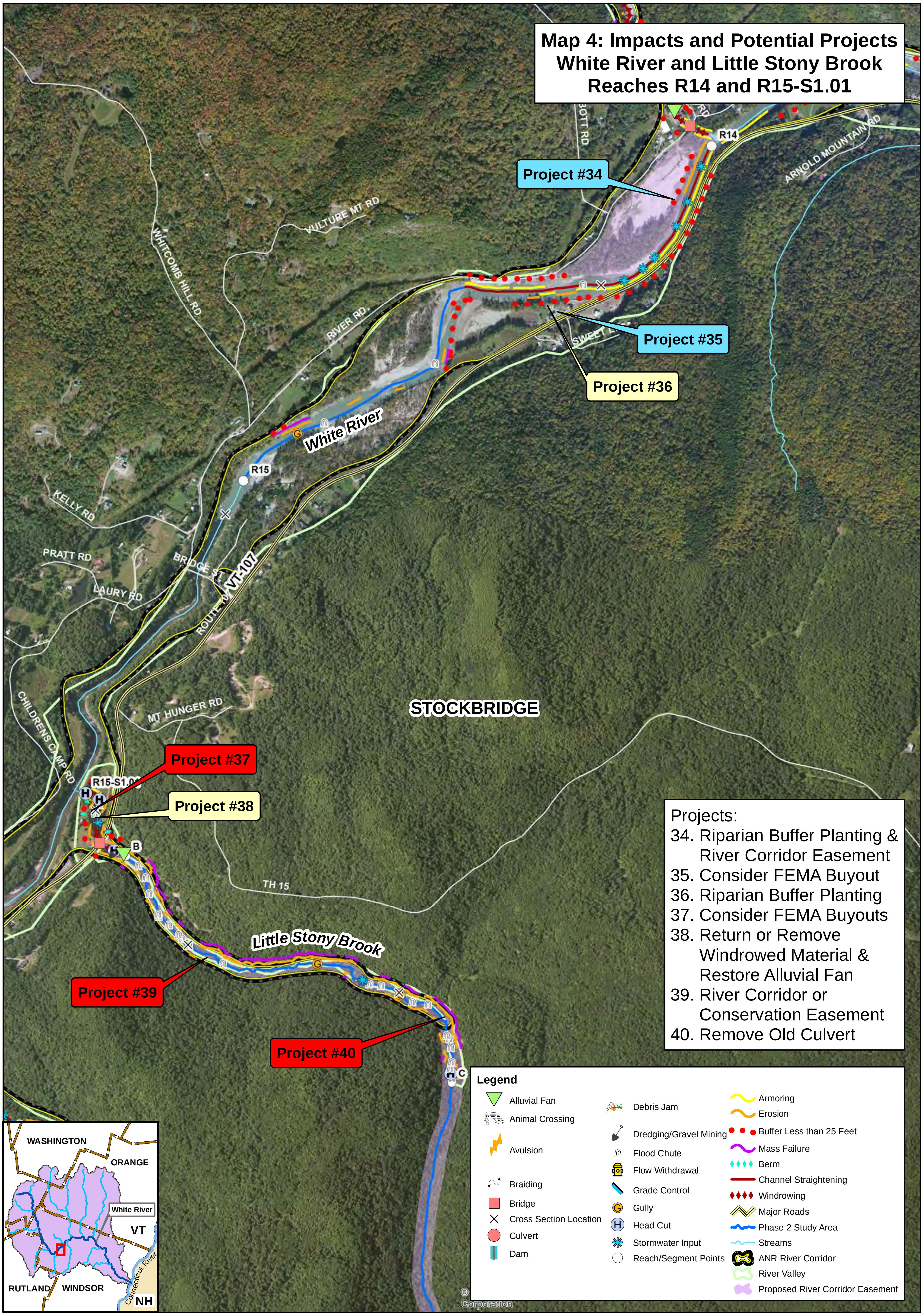
Project Priority:
Low
Moderate
High

0 1,000 2,000 Feet
1 inch = 1,000 feet

Bear Creek Environmental



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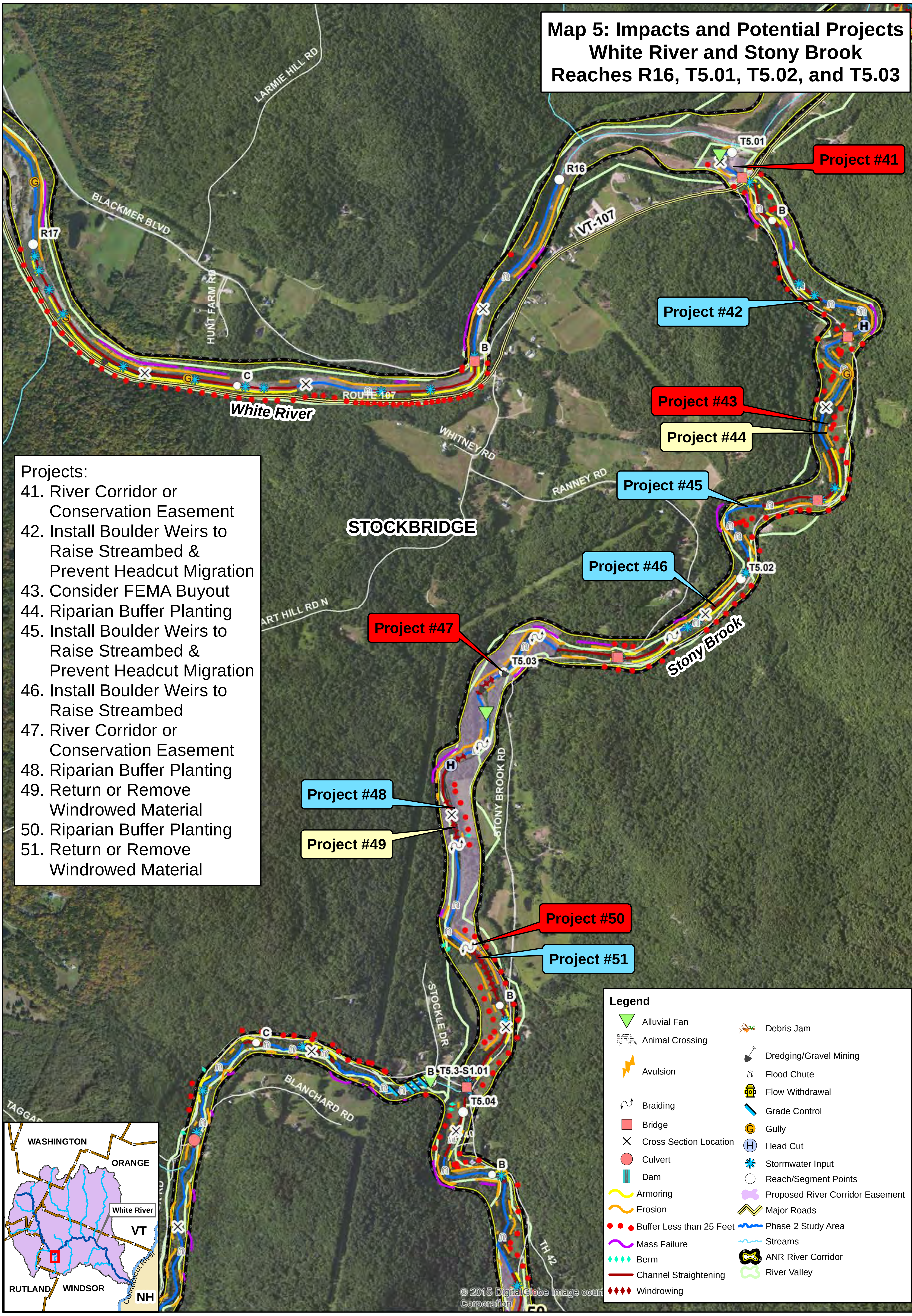
Project Priority:
Low
Moderate
High

0 1,000 2,000 Feet
1 inch = 1,000 feet

Bear Creek Environmental



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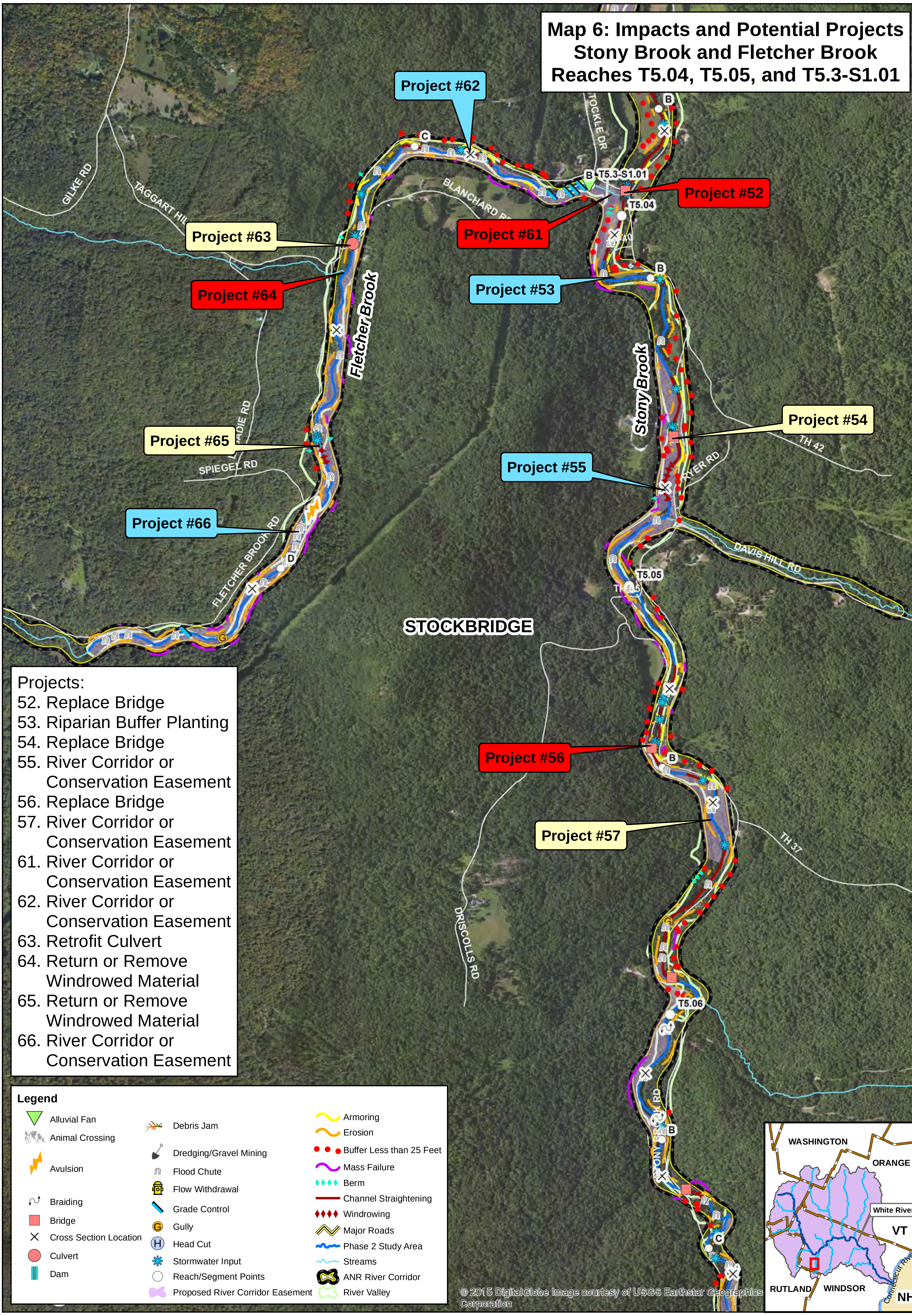
Project Priority:
Low
Moderate
High

N
W E
S

0 1,000 2,000 Feet
1 inch = 1,000 feet

Bear Creek Environmental



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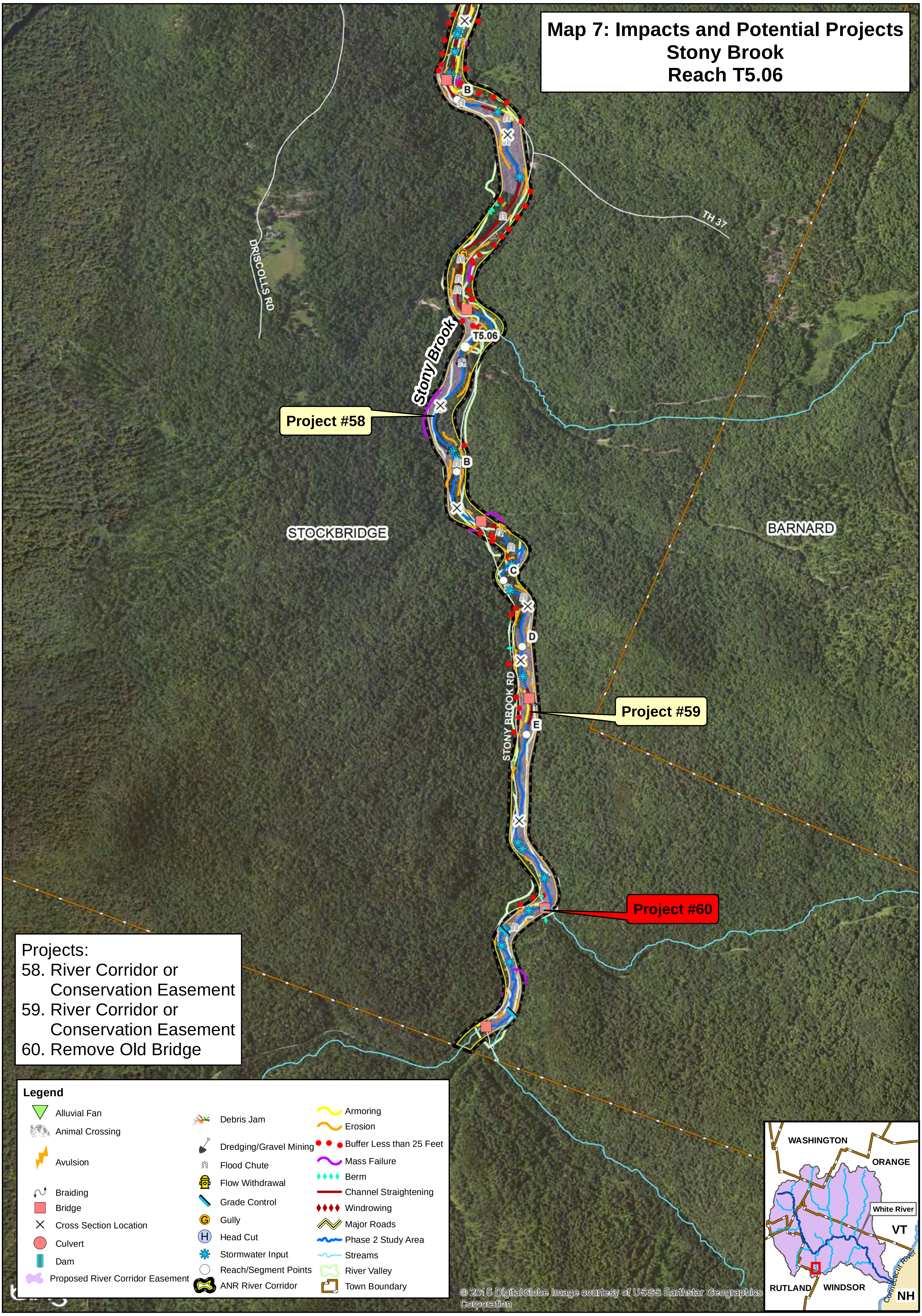
Project Priority:
Low
Moderate
High

1 inch = 1,000 feet

0 1,000 2,000 Feet

Bear Creek Environmental



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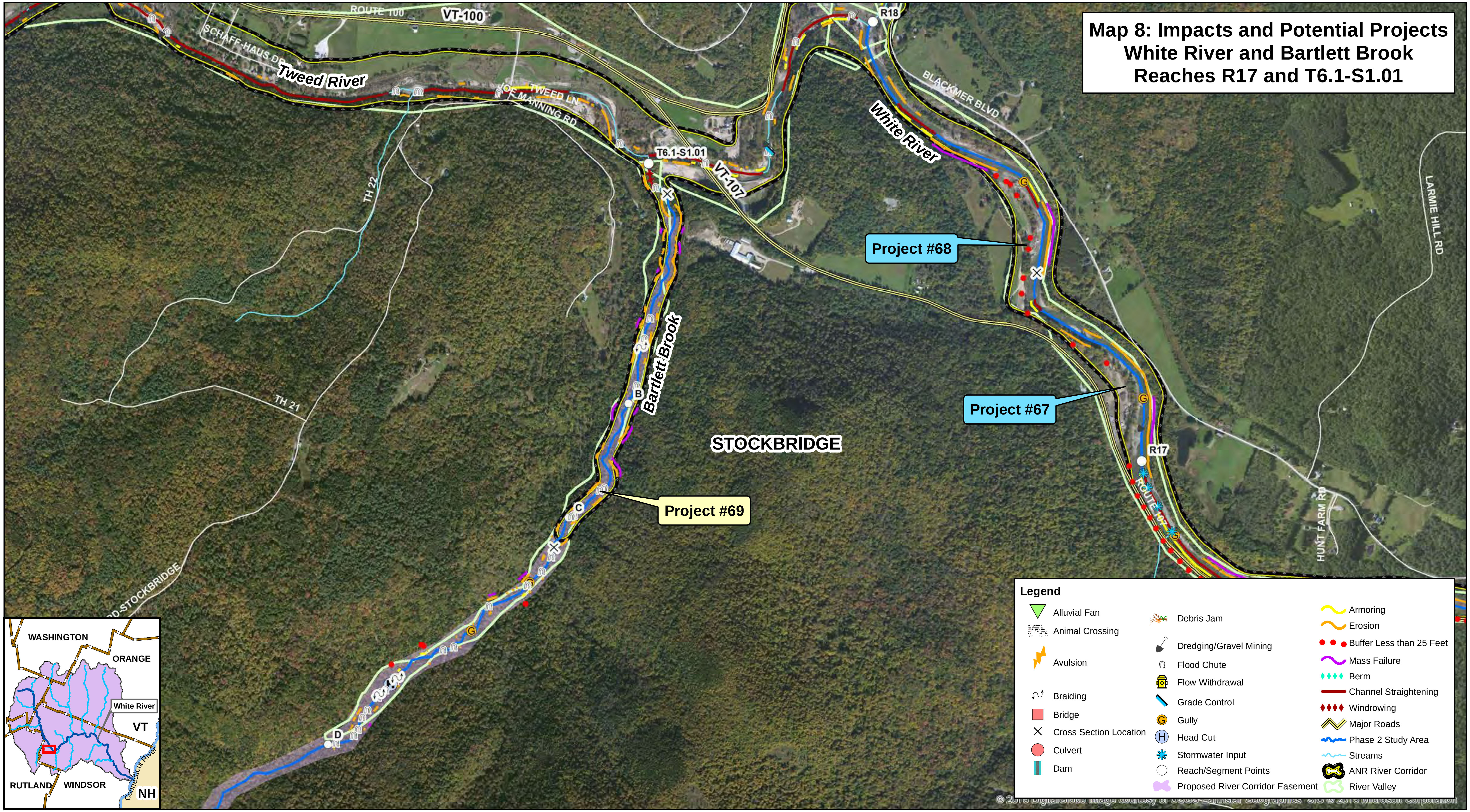
Project Priority:
Low
Moderate
High

N W E S

0 1,000 2,000 Feet

1 inch = 1,000 feet

Bear Creek Environmental



Background is Bing Imagery

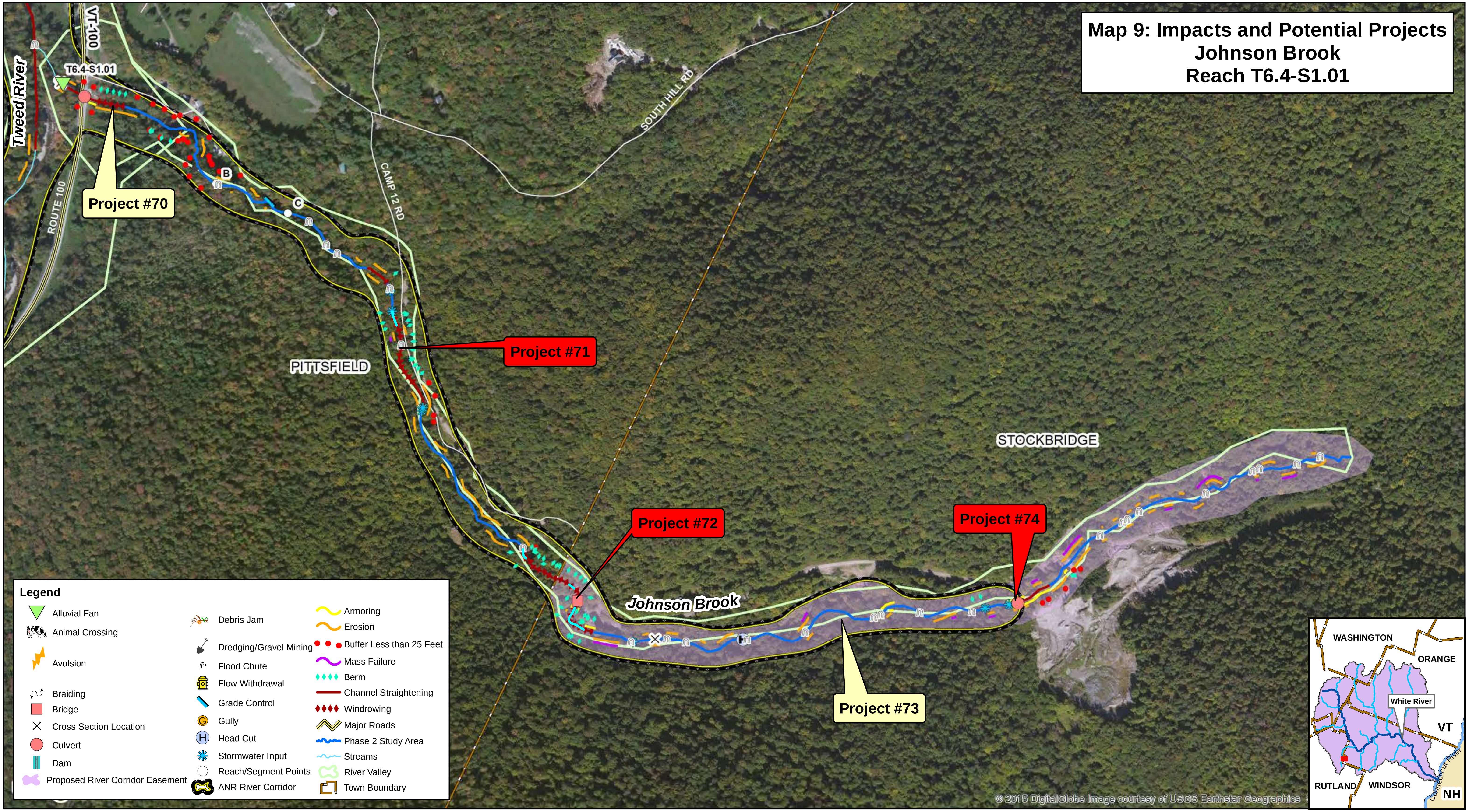
Project Priority:
- Low
- Moderate
- High

Projects:
67. Create Floodplain
68. Create Floodplain
69. River Corridor or Conservation Easement

N W E S

0 1,000 2,000 Feet
1 inch = 1,000 feet

Bear Creek Environmental



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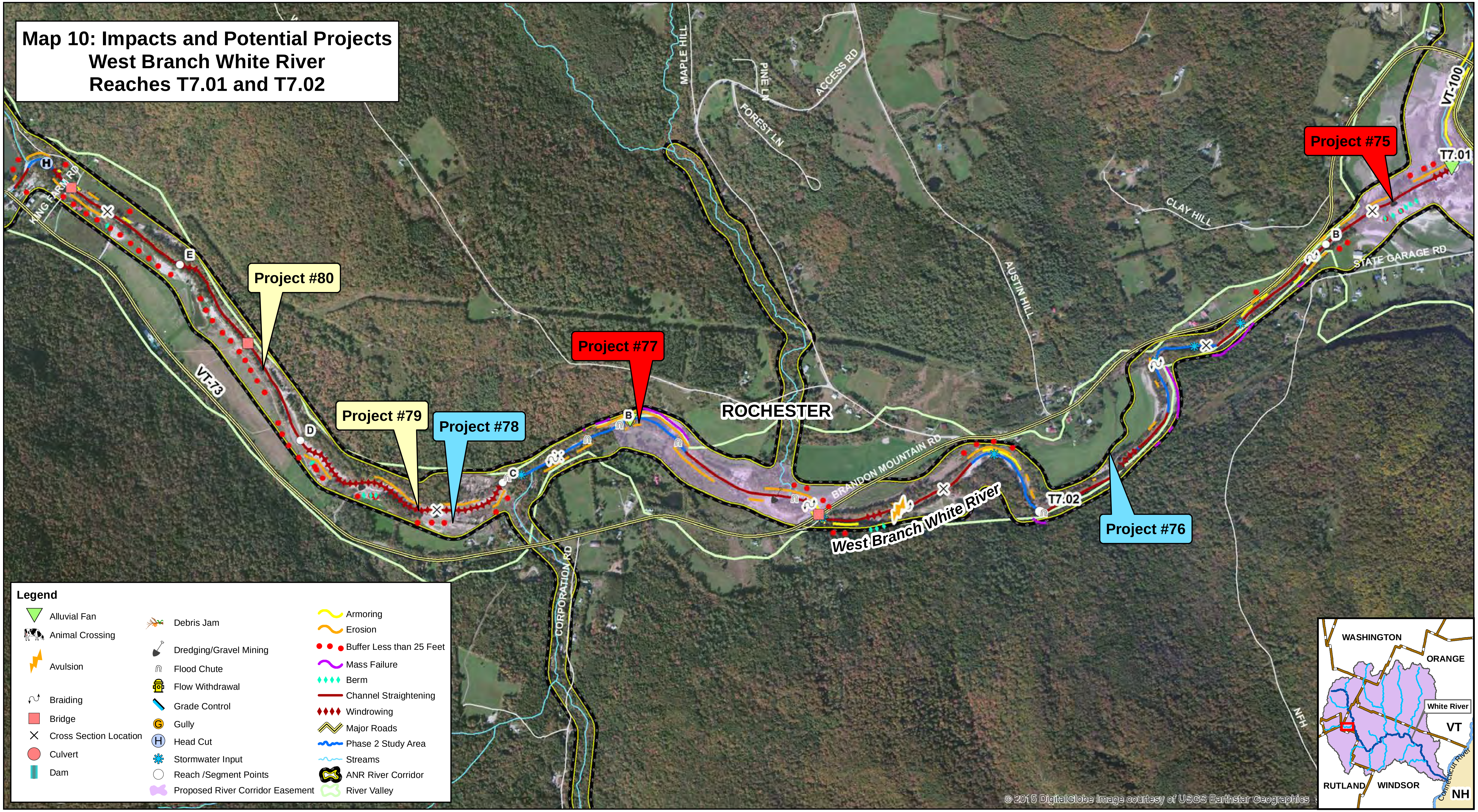
Project Priority:
- Low
- Moderate
- High

Projects:
70. Return or Remove Windrowed Material
71. Return or Remove Windrowed Material
72. Return or Remove Windrowed Material
73. River Corridor or Conservation Easement
74. Replace Culvert

N W E S

0 400 800 Feet
1 inch = 400 feet

Bear Creek Environmental



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Project Priority:

- Low
- Moderate
- High

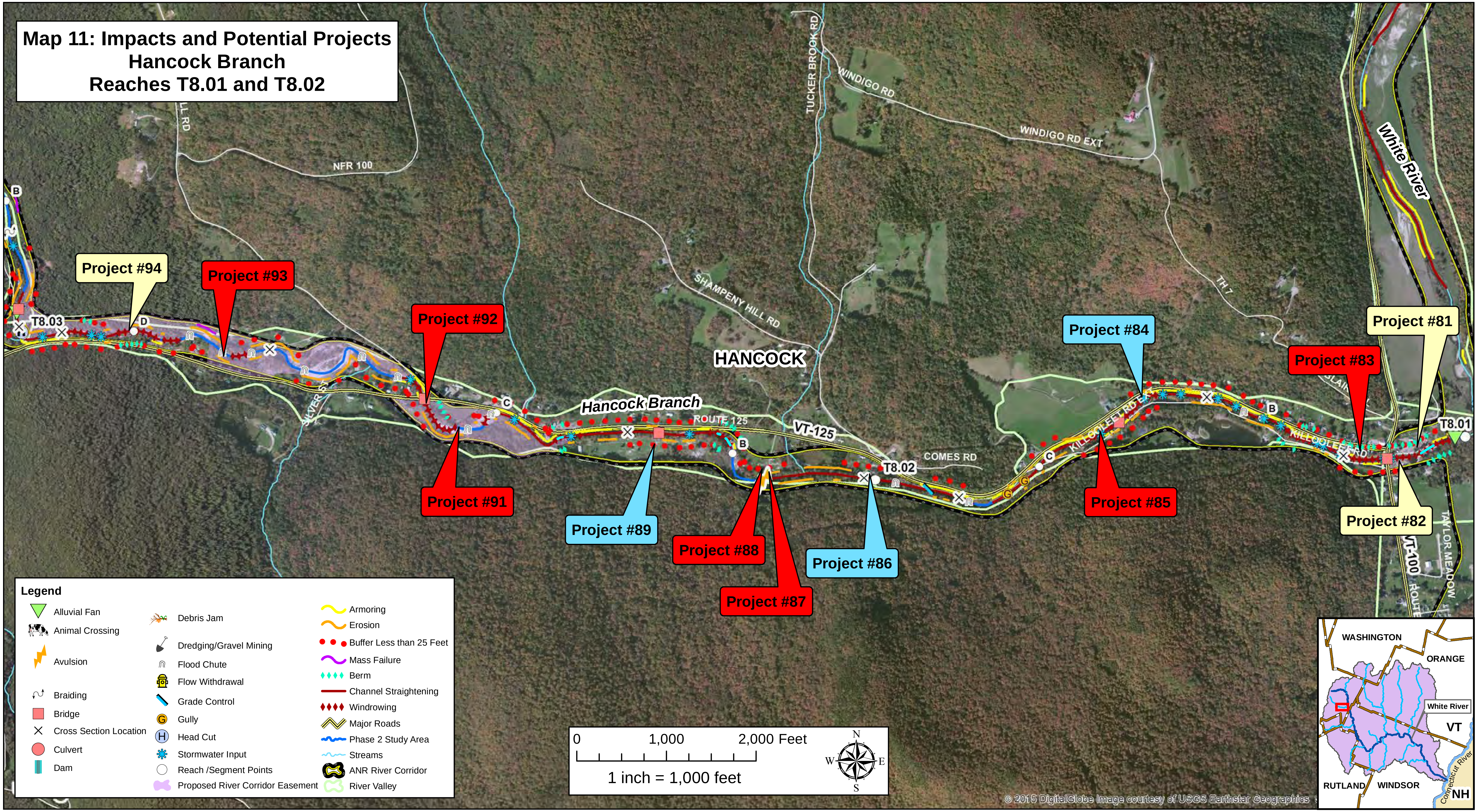
Projects:
75. Riparian Buffer Planting & River Corridor Easement
76. Riparian Buffer Planting
77. River Corridor or Conservation Easement
78. Riparian Buffer Planting
79. Return or Remove Windrowed Material
80. Riparian Buffer Planting

N
W E
S

0 1,000 2,000 Feet

1 inch = 1,000 feet

Bear Creek Environmental



Background is Bing Imagery

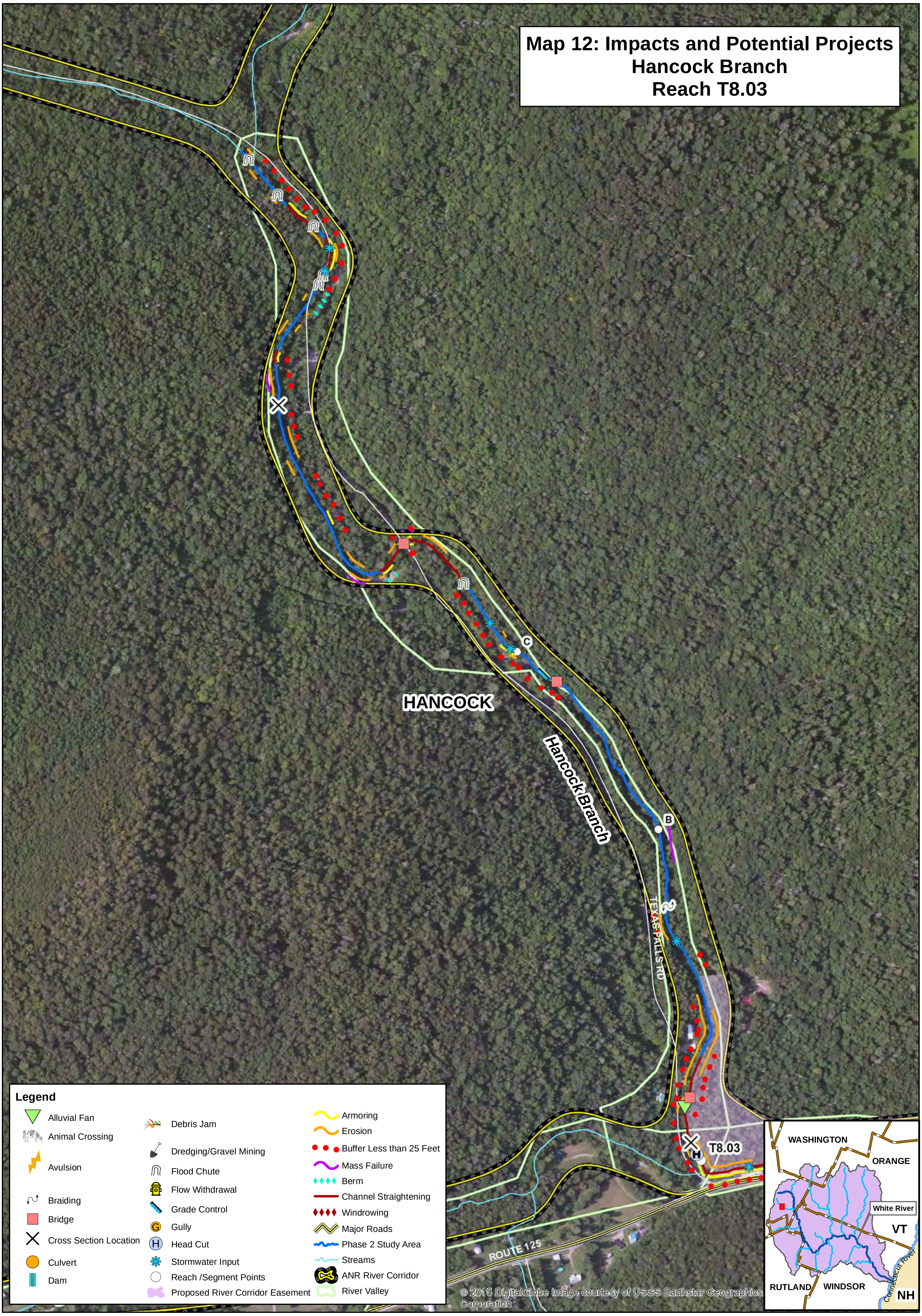
Project Priority:

- Low
- Moderate
- High

Projects:

81. Riparian Buffer Planting
82. Return or Remove Windrowed Material & Restore Alluvial Fan
83. Consider FEMA Buyouts
84. Install Boulder Weirs & Large Woody Debris to Raise Streambed & Provide Channel Roughness
85. Remove Destroyed Dam
86. Riparian Buffer Planting
87. Riparian Buffer Planting
88. Consider FEMA Buyout
89. Riparian Buffer Planting & Restore Adjacent Wetlands
90. Consider FEMA Buyout
91. River Corridor or Conservation Easement
92. Return or Remove Windrowed Material
93. River Corridor or Conservation Easement
94. Return or Remove Windrowed Material

Bear Creek Environmental



Background is Bing Imagery

No additional projects identified in T8.03.

0 400 800 Feet

1 inch = 400 feet

Bear Creek Environmental

Upper & Middle White River Watershed Restoration & Protection Projects
Barnard, Hancock, Pittsfield, Rochester, and Stockbridge, Vermont
White River Partnership
March 26, 2015

Legend

● Effective ◓ Limited ○ Ineffective

Project Number Segment	Project Category	Project Type	Stream Name	Town	Project Location	Priority	OBJECTIVES: Improves or Protects Habitat[1]	OBJECTIVES: Improves Water Quality[2]	OBJECTIVES: Improves Long-term Channel Stability[3]	OBJECTIVES: Protects Infrastructure, and Property[4]	Comments
Project #1 T3.02-A (Refer to Map 1)	Public Safety Improvement	Consider FEMA Buyout	Locust Creek	Barnard	10050 Vermont Route 12	**High**	○	○	●	●	Single family dwelling is located on the western bank of Locust Creek between the stream and Route 12. The creek is widening in this location and the house is at risk of damage/destruction due to fluvial erosion.
Project #2 T3.02-A (Refer to Map 1)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Locust Creek	Barnard	Along eastern bank throughout segment	**High**	●	●	◓	○	Agricultural fields line the eastern bank of the creek. Riparian buffers are lacking for approximately 1,600 feet of the segment. Property belongs to a single landowner. Project may be eligible for CREP.
Project #3 T3.02-B (Refer to Map 1)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Locust Creek	Barnard	Buffer zone on both sides of the creek throughout segment	Moderate	●	●	◓	○	Riparian buffers are lacking on both sides of the creek in this segment. Bank erosion is abundant; buffer plantings could stabilize banks. Land is mostly crop and pasture. Project may be eligible for CREP.
Project #4 T3.02-B & C (Refer to Map 1)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Locust Creek	Barnard	River corridor throughout segment	**High**	●	◓	●	●	Five large parcels suggested for river corridor easements. An alluvial fan exists in this area, which is a particularly dynamic feature. This is a very depositional section of the creek and is important for floodwater and sediment attenuation.
Project #5 T3.02-C (Refer to Map 1)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Locust Creek	Barnard	From Route 12 Bridge downstream 1,600 feet	Low	◓	○	●	◓	All of this section of the creek was windrowed post-Irene, excavating the channel and creating gravel berms. This section is an alluvial fan, which is important for floodwater and sediment attenuation. Restoring floodplain access here would increase flood storage. Several buildings exist on the western bank of the creek in this section, which could be damaged if material is returned to the channel.
Project #6 T3.02-C (Refer to Map 1)	Stream Channel Improvement and Restoration	Livestock Exclusion	Locust Creek	Barnard	Just below Route 12 bridge	**High**	◓	●	◓	○	Livestock has access to the creek within this section. Exclusion would improve water quality and reduce the physical impact of large animals being in the channel (i.e. substrate compaction and streambed disturbance). Project may be eligible for CREP.
Project #7 T3.03-A (Refer to Map 1)	Floodplain Improvement and Conservation	Relocate Road	Locust Creek	Barnard	Chateauguay Road between Route 12 and the Barnard Highway Department	Moderate	◓	○	●	●	Lower Chateauguay Road is a significant channel encroachment to Locust Creek. Its presence has caused a loss of floodplain access and geomorphic instability. Investigate road relocation - could be relocated to run along southern valley wall, which would remove encroachment and open up a large potential floodplain.

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Project #8 T3.03-B (Refer to Map 1)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Locust Creek	Barnard	Upstream of first Chateauguay Road bridge	**High**	Limited	Limited	Effective	Limited	The creek is widening and adjusting in this area. One large tract of land.
Project #9 T3.03-B (Refer to Map 1)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Locust Creek	Barnard	Along Chateauguay Road upstream of first Chateauguay Road bridge	Moderate	Limited	Ineffective	Effective	Limited	Two areas of the Creek were windrowed post-Irene, creating gravel berms.
Project #10 T3.04-A (Refer to Map 2)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Locust Creek	Barnard	Below West Road bridge	Moderate	Limited	Limited	Effective	Limited	This section of the creek is undergoing extreme active adjustment.
Project #11 T3.04-B (Refer to Map 2)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Locust Creek	Barnard	From below West Road bridge to near 2355 Chateauguay Road	Moderate	Limited	Ineffective	Effective	Limited	Sections of the creek were windrowed post-Irene, creating gravel berms that restrict floodplain access. Some of these areas are away from development.
Project #12 T3.04-B (Refer to Map 2)	Public Safety Improvement	Consider FEMA Buyout	Locust Creek	Barnard	1821 Chateauguay Road	Moderate	Ineffective	Ineffective	Limited	Effective	Single family dwelling located between the road and the creek. Very close to creek and little vertical drop from house to water. Creek is majorly adjusting in this segment.
Project #13 T3.04-C (Refer to Map 2)	Public Safety Improvement	Consider FEMA Buyout	Locust Creek	Barnard	2357 Chateauguay Road	**High**	Ineffective	Ineffective	Limited	Effective	A house exists directly on the eastern bank of Locust Creek. The house is fairly high up but the bank blew out during Irene and the house was nearly destroyed. Bank was heavily riprapped post-flood and is now sending increased energy into the neighbor's bank. House is at very high risk of being destroyed.
Project #14 T3.04-C (Refer to Map 2)	Public Safety Improvement	Consider FEMA Buyout	Locust Creek	Barnard	2411 Chateauguay Road	**High**	Ineffective	Ineffective	Limited	Effective	The creek incised severely during Irene in this location and is now rapidly widening. Landowners lose land to slumping continuously. The single family house is only several feet from the edge of the creek, and is at risk of being destroyed by the widening channel.
Project #15 T3.04-C (Refer to Map 2)	Stream Channel Improvement and Restoration	Install Boulder Weirs to Raise Streambed and Prevent Headcut Migration	Locust Creek	Barnard	Between private bridge to 2357 Chateauguay Road to Chateauguay Road bridge upstream	Low	Limited	Limited	Effective	Limited	Extreme incision occurred here during Irene. Two active headcuts are traveling upstream through this segment. Floodplain cannot be accessed. Cutting through glacial till. Bed could be built up and stabilized with weirs to provide better geomorphic stability and habitat. Could put adjacent houses at risk (see projects 13 and 14).
Project #16 T3.05-A (Refer to Map 3)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Locust Creek	Barnard	Between Chateauguay Road bridge downstream & Town Highway 46 bridge upstream	**High**	Limited	Limited	Effective	Limited	This area has undergone major recent adjustment and is building a juvenile floodplain. Three landowners with large tracts of land.
Project #17 T3.05-B (Refer to Map 3)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Locust Creek	Barnard	3450 Chateauguay Road	Low	Limited	Limited	Limited	Ineffective	Buffer is lacking for 300' stretch along eastern bank. Landowners indicated preliminary interest in potential projects, but bank is high.

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Project #18 T3.05-C (Refer to Map 3)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Locust Creek	Barnard	Between two Chateauguay Road bridges in vicinity of Town Highway 48	Low	◓	○	●	◓	This section was heavily windrowed and dredged post-Irene. It has lost its natural planform and habitat has been majorly degraded. Removing windrowing could cause the channel to avulse as it did during Irene, which could cause damage to Chateauguay Road.
Project #19 T3.05-D (Refer to Map 3)	Structure Replacement/ Removal	Replace Bridge	Locust Creek	Barnard	On Chateauguay Road approximately 300' south of TH 48 and Chateauguay Road intersection	Low	◓	○	●	●	This bridge is in good condition, but is undersized and has poor alignment and a headcut on the streambed within it. Replace with adequately sized structure and arrest headcut with boulder weirs.
Project #20 T3.05-D (Refer to Map 3)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Locust Creek	Barnard	Along Chateauguay Road between TH 48 & Morgan Road	Moderate	◓	○	●	◓	The creek was windrowed in the vicinity of Chateauguay Road in multiple locations. Gravel berms are restricting floodplain access and channel excavation is contributing to geomorphic instability/headcuts. Proximity to road may make this project difficult to implement.
Project #21 T3.05-D (Refer to Map 3)	Stream Channel Improvement and Restoration	Install Boulder Weirs to Raise Streambed and Prevent Headcut Migration	Locust Creek	Barnard	Locust Creek Near Morgan Road	**High**	◓	○	●	◓	Four active headcuts are present in this segment and traveling upstream. Consider installing boulder weirs above headcuts to stabilize streambed and prevent headcut migration upstream.
Project #22 T3.05-E (Refer to Map 3)	Structure Replacement/ Removal	Replace Bridge	Locust Creek	Barnard	On Chateauguay Road near 4411 Chateauguay Road	**High**	◓	○	●	●	This bridge is significantly undersized, old, and being scoured around its abutments. It is poorly aligned to Locust Creek, and the stream is majorly aggrading above it.
Project #23 T3.05-E (Refer to Map 3)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Locust Creek	Barnard	Locust Creek upstream of 4411 Chateauguay Road	**High**	◓	◓	●	◓	This section of the creek has few human impacts and good aquatic habitat. Two large tracts of land. Good candidate for conservation easement.
Project #24 T3.2-S3.01-A (Refer to Map 1)	Floodplain Improvement and Conservation	Riparian Buffer Planting and Restore Adjacent Wetlands	Pond Brook	Barnard	From confluence with Locust Creek upstream ~4,000 feet on both banks	**High**	●	●	◓	○	Buffers are lacking on both banks for almost all of segment A due to agricultural activities. Adjacent wetlands were historically ditched & drained. Project may be eligible for CREP.
Project #25 T3.2-S3.01-A (Refer to Map 1)	Structure Replacement/ Removal	Remove Constructed Log Dam	Pond Brook	Barnard	At 8262 VT Route 12	**High**	●	○	●	○	A constructed log dam exists in this location, creating a 7-foot total drop (3.5 feet to water surface) in the streambed. It is a barrier to aquatic organism passage.
Project #26 T3.2-S3.01-B (Refer to Map 2)	Structure Replacement/ Removal	Replace Bridge	Pond Brook	Barnard	Private Drive to 7854 & 7856 VT Route 12	**High**	◓	○	●	●	The bridge is a major channel constriction and is in poor condition. Aggradation was windrowed in vicinity of bridge post-Irene.
Project #27 T3.2-S3.01-B (Refer to Map 2)	Structure Replacement/ Removal	Replace Bridge	Pond Brook	Barnard	On Blackmer Road near intersection with Route 12	Low	◓	○	●	●	Bridge is very undersized and has poor channel alignment. Bridge is in good condition.

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Project #28 T3.2-S3.01-B (Refer to Map 2)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Pond Brook	Barnard	~175' upstream of Blackmer Road bridge	Low	●	●	◓	○	The riparian buffer is lacking along the western bank for approximately 800 feet in this location. A field is mowed right up to the brook. A "no mow" zone could be created in lieu of planting.
Project #29 T3.2-S3.01-B (Refer to Map 2)	Structure Replacement/ Removal	Replace Culvert	Pond Brook	Barnard	Culvert under Route 12 near 7129 Route 12	Moderate	◓	○	●	●	This culvert is significantly undersized and has poor channel alignment. Evidence that the brook has blown out eastern embankment at outlet from large, extensive riprap. Culvert is in good condition structurally.
Project #30 T3.2-S3.01-C (Refer to Map 2)	Floodplain Improvement and Conservation	Riparian Buffer Planting and Restore Adjacent Wetlands	Pond Brook	Barnard	From Route 12 culvert near 7129 Route 12 to upstream ~1,000 feet	**High**	●	●	◓	○	Adjacent wetlands were historically drained to create agricultural fields. Riparian buffers are lacking on both banks for a long stretch.
Project #31 T3.2-S3.01-C (Refer to Map 2)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Pond Brook	Barnard	At 6871 Route 12	Low	●	●	◓	○	Riparian buffer is lacking on eastern bank due to landowner's lawn. Could stop mowing and let it regrow.
Project #32 T3.2-S3.01-C (Refer to Map 2)	Structure Replacement/ Removal	Replace Culvert	Pond Brook	Barnard	On Route 12 near northern intersection of Davis Road	Low	◓	○	●	●	Culvert is undersized, has scour and failing riprap, and is poorly aligned to the stream channel. Culvert is in good condition structurally.
Project #33 T3.2-S3.01-C (Refer to Map 2)	Structure Replacement/ Removal	Remove Old Bridge	Pond Brook	Barnard	Near 6714 Route 12	**High**	◓	○	●	◓	An abandoned bridge across the brook exists and is creating a channel constriction.
Project #34 R14 (Refer to Map 4)	Floodplain Improvement and Conservation	Riparian Buffer Planting and River Corridor Easement	White River	Stockbridge	At 1340 River Road	Moderate	◓	◓	●	◓	Large parcel of land is located on the inside of a meander bend. Good floodplain access; large amounts of sediment deposited in field during Irene. There is an open-air roofed shelter on property within river corridor.
Project #35 R14 (Refer to Map 4)	Public Safety Improvement	Consider FEMA Buyout	White River	Stockbridge	5321-5361 Route 107	Moderate	◓	◓	●	●	A single family dwelling at 5361 Route 107 was destroyed during Irene. The single family dwelling next door at 5321 Route 107 appears to be at high risk of damage/destruction during flooding.
Project #36 R14 (Refer to Map 4)	Floodplain Improvement and Conservation	Riparian Buffer Planting	White River	Stockbridge	5321-5361 Route 107	Low	●	●	◓	○	Riparian buffer is lacking along southern bank due to landowner's lawns. Planting could stabilize eroding bank.
Project #37 R15.S1.01-A (Refer to Map 4)	Public Safety Improvement	Consider FEMA Buyouts	Little Stony Brook	Stockbridge	3693 , 3731, & 3771 Route 107	**High**	◓	◓	●	●	Two houses exist on the western bank of the brook and one on the eastern. This section is an alluvial fan that has been channelized due to development. Dynamic section of stream and houses at risk due to adjustment.
Project #38 R15.S1.01-A (Refer to Map 4)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material and Restore Alluvial Fan	Little Stony Brook	Stockbridge	From confluence with White River upstream to Route 107 bridge	Low	●	◓	●	○	Alluvial fan has been extensively windrowed. Very important floodwater and sediment attenuation area. Return windrowed material, raise bed, and restore alluvial fan. Three houses on banks at risk of flooding.

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Project #39 R15.S1.01-B & C (Refer to Map 4)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Little Stony Brook	Stockbridge	From just upstream of Route 107 bridge to upstream reach break	**High**	◓	◓	●	◓	Three very large tracts of forested land along Little Stony Brook. Brook is undergoing many adjustments. It is unlikely that the river corridor would be developed in this area, but is possible. Good candidate for conservation easement.
Project #40 R15.S1.01-B (Refer to Map 4)	Structure Replacement/ Removal	Remove Old Culvert	Little Stony Brook	Stockbridge	Approximately 4,700 feet upstream of Route 107 bridge	**High**	◓	●	◓	○	An old rusted tank pipe, which was previously used as a culvert under a logging road, was blown out and is located along the eastern bank. Access to site may be difficult.
Project #41 T5.01-A (Refer to Map 5)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Stony Brook	Stockbridge	From confluence with White River upstream to Route 107 bridge	**High**	◓	◓	●	◓	This area is an alluvial fan and is important for sediment storage.
Project #42 T5.01-B (Refer to Map 5)	Stream Channel Improvement and Restoration	Install Boulder Weirs to Raise Streambed and Prevent Headcut Migration	Stony Brook	Stockbridge	From segment break to about 1,200 feet upstream of Stony Brook Road bridge	Moderate	◓	◓	●	◓	This section of Stony Brook is extremely incised and continues to incise. Rock weirs were built after Irene to stop downcutting but the weirs failed due to improper construction.
Project #43 T5.01-B (Refer to Map 5)	Public Safety Improvement	Consider FEMA Buyout	Stony Brook	Stockbridge	New house between 588 and 630 Stony Brook Road	**High**	◓	◓	●	●	A newly-built home between 588 and 630 Stony Brook Road is on the eastern bank of the brook and at high risk of damage from floodwaters.
Project #44 T5.01-B (Refer to Map 5)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Stony Brook	Stockbridge	New house between 588 and 630 Stony Brook Road	Low	●	●	◓	◓	The riparian buffer is lacking at new house between 588 and 630 Stony Brook Road due to the landowner's lawn.
Project #45 T5.01-B (Refer to Map 5)	Stream Channel Improvement and Restoration	Install Boulder Weirs to Raise Streambed and Prevent Headcut Migration	Stony Brook	Stockbridge	From 630 Stony Brook Road to reach break near 1079 Stony Brook Road	Moderate	◓	◓	●	◓	This section of Stony Brook is extremely incised and continues to incise. Rock weirs were built after Irene to stop downcutting but the weirs failed due to improper construction.
Project #46 T5.02 (Refer to Map 5)	Stream Channel Improvement and Restoration	Install Boulder Weirs to Raise Streambed	Stony Brook	Stockbridge	From near 1079 Stony Brook Road upstream to just above Ranney Road bridge	Moderate	◓	◓	●	◓	This section of the brook has been historically straightened along Stony Brook Road and is extremely incised. The brook would benefit from increased bed structure and raising the bed could provide more floodplain access.
Project #47 T5.02 & T5.03-A (Refer to Map 5)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Stony Brook	Stockbridge	At alluvial fan approximately 1,500 feet upstream of Ranney Road bridge	**High**	●	◓	●	◓	This area is an alluvial fan that is very important for floodwater and sediment attenuation. It was subjected to extensive dredging post-Irene.
Project #48 T5.03-A (Refer to Map 5)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Stony Brook	Stockbridge	At 2034 Stony Brook Road	Moderate	●	●	◓	◓	Riparian buffer is lacking on the eastern bank due to landowner's lawn.
Project #49 T5.03-A (Refer to Map 6)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Stony Brook	Stockbridge	In vicinity of 2034 Stony Brook Road	Low	●	○	●	◓	Windrowed sections have gravel berms restricting floodplain access in small areas.

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Project #50 T5.03-A & B (Refer to Map 5)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Stony Brook	Stockbridge	Near 2299 Stony Brook Road	**High**	●	●	◓	◓	Riparian buffer is lacking on both banks due to landowner's lawn. Landowner is interested in potential projects.
Project #51 T5.03-A & B (Refer to Map 6)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Stony Brook	Stockbridge	Near 2299 Stony Brook Road	Moderate	●	○	●	◓	Windrowed sections have gravel berms restricting floodplain access. Landowner is interested in potential projects.
Project #52 T5.03-B (Refer to Map 6)	Structure Replacement/ Removal	Replace Bridge	Stony Brook	Stockbridge	On Fletcher Brook road just west of intersection with Stony Brook Road	**High**	◓	○	●	●	This bridge is undersized and the brook is scouring around it. It was overtopped during Irene due to its small span and Fletcher Brook Road was washed out.
Project #53 T5.04-A (Refer to Map 6)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Stony Brook	Stockbridge	2730 Stony Brook Road	Moderate	●	●	◓	○	Riparian buffer is lacking on eastern bank. Landowner indicated interest in potential projects.
Project #54 T5.04-B (Refer to Map 6)	Structure Replacement/ Removal	Replace Bridge	Stony Brook	Stockbridge	Private drive to 3222 Stony Brook Road	Low	◓	○	●	●	Bridge is very undersized and was clogged by debris and sediment during Irene. Channel avulsed just above and destroyed a house and the road. Landowners are interested in getting help with their bridge.
Project #55 T5.04-B (Refer to Map 6)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Stony Brook	Stockbridge	From private drive at 3222 Stony Brook Road to above the confluence of Davis Hill Brook	Moderate	●	◓	●	◓	Davis Hill Brook enters Stony Brook within this section. It is a very dynamic area, and an avulsion destroyed a house on the eastern bank of Stony Brook during TSI. Protecting it would prevent future development and future losses.
Project #56 T5.05-A (Refer to Map 6)	Structure Replacement/ Removal	Replace Bridge	Stony Brook	Stockbridge	Driscolls Road bridge just west of intersection with Stony Brook Road	**High**	◓	○	●	●	Bridge was determined to be fully incompatible with the brook for geomorphology. It is undersized, has poor channel alignment, and is in poor condition. Bridge is built onto bedrock on one side, but span could be extended farther out on other side.
Project #57 T5.05-B (Refer to Map 6)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Stony Brook	Stockbridge	Near 4189 Stony Brook Road	Low	●	◓	●	◓	This section is highly aggradational and is actively adjusting. Fish & Wildlife owned land, small area.
Project #58 T5.06-A (Refer to Map 7)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Stony Brook	Stockbridge	Above Stony Brook Road bridge in T5.05-B	Low	●	◓	●	◓	This section of the corridor is undeveloped and owned by Vermont Fish and Wildlife. The brook is majorly adjusting here and forming a juvenile floodplain.
Project #59 T5.06-C, D, & E (Refer to Map 7)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Stony Brook	Stockbridge	Above Stony Brook Road bridge in T5.06.A	Low	●	◓	●	◓	Brook is actively adjusting. Land is well-forested and owned by Vermont Fish & Wildlife.
Project #60 T5.06-E (Refer to Map 7)	Structure Replacement/ Removal	Remove Old Bridge	Stony Brook	Stockbridge	Near confluence with unnamed tributary below Mink Brook	**High**	◓	◓	●	◓	An abandoned bridge across the brook exists and is creating a floodprone constriction.

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Project #61 T5.3-S1.01-A (Refer to Map 6)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Fletcher Brook	Stockbridge	At confluence with Stony Brook	**High**	●	◒	●	●	This section is an alluvial fan, where the brook is prone to extreme adjustment indefinitely. The property within this suggested easement was a FEMA buyout due to house destruction during Irene. The buyout may include an easement.
Project #62 T5.3-S1.01-B & C (Refer to Map 6)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Fletcher Brook	Stockbridge	Above alluvial fan upstream to near 231 Blanchard Road	Moderate	●	◒	●	◒	A river corridor easement is suggested to protect Fletcher Brook from potential development in this section.
Project #63 T5.3-S1.01-C (Refer to Map 6)	Structure Replacement/ Removal	Retrofit Culvert	Fletcher Brook	Stockbridge	Culvert under Blanchard Road just east of intersection with Fletcher Brook Road	Low	●	○	●	●	Culvert is undersized and has a significant drop from its outlet to the water surface. It is a barrier to aquatic organism passage. Outlet drop of 1.8 feet may be a challenge to retrofitting structure.
Project #64 T5.3-S1.01-C (Refer to Map 6)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Fletcher Brook	Stockbridge	At confluence of Taggart Brook	**High**	●	○	◒	◒	The confluence of Taggart Brook was heavily windrowed post-Irene. The tributary forms an alluvial fan here, but it was channelized during post-flood work.
Project #65 T5.3-S1.01-C (Refer to Map 6)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Fletcher Brook	Stockbridge	Areas where the brook flows along Fletcher Brook Road in segment C	Low	●	○	◒	○	Sections of Fletcher Brook were windrowed post-Irene where the brook flows along Fletcher Brook Road. There are several gravel berms restricting floodplain access.
Project #66 T5.3-S1.01-C & D (Refer to Map 6)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Fletcher Brook	Stockbridge	Above Blanchard Road crossing	Moderate	●	◒	●	◒	This section of the brook is undeveloped, with the exception of Fletcher Brook Road. Preventing future development here would allow the brook to continue to adjust toward equilibrium.
Project #67 R17 (Refer to Map 8)	Floodplain Improvement and Conservation	Create Floodplain	White River	Stockbridge	Just downstream of 1117 Route 107	Moderate	◒	◒	●	●	Large flat parcel on the western bank of the river on the inside of a meander bend. It is unknown whether the river can access this land currently. Further investigation is needed. Land could be lowered if not easily accessed, or protected via an easement if it is already being accessed by floodwaters.
Project #68 R17 (Refer to Map 8)	Floodplain Improvement and Conservation	Create Floodplain	White River	Stockbridge	Between 1041 and 1117 Route 107	Moderate	◒	◒	●	●	This section of river has incised and lost floodplain access. Land on the inside of a meander bend could be lowered to restore floodplain access.
Project #69 T6.1-S1.01-A, B, C, & D (Refer to Map 8)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Bartlett Brook	Stockbridge	From confluence with Tweed River upstream throughout assessment area	Low	●	◒	●	●	Bartlett Brook is not impacted by development and retains natural planform. Protecting it from future corridor development would eliminate future conflicts.
Project #70 T6.4-S1.01-A (Refer to Map 9)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Johnson Brook	Pittsfield	From Route 100 culvert to upstream about 500 feet	Low	●	◒	●	◒	Johnson Brook was windrowed and bermed above the Route 100 culvert. Returning or removing this windrowed material could restore floodplain access, however there is a house on the north bank that the berm may be protecting.

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Upper & Middle White River Watershed Restoration & Protection Projects
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White River Partnership
March 26, 2015

Legend: ● Effective ◓ Limited ○ Ineffective

Project Number Segment	Project Category	Project Type	Stream Name	Town	Project Location	Priority	OBJECTIVES: Improves or Protects Habitat[1]	Improves Water Quality[2]	Improves Long-term Channel Stability[3]	Protects Infrastructure, and Property[4]	Comments
Project #71 T6.4-S1.01-C (Refer to Map 9)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Johnson Brook	Pittsfield	Along Camp 12 Road near 147 Camp 12 Road	**High**	Limited	Ineffective	Effective	Limited	Johnson Brook was windrowed and bermed along Camp 12 Road after Irene. Berms are restricting floodplain access and sending energy downstream.
Project #72 T6.4-S1.01-C (Refer to Map 9)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Johnson Brook	Pittsfield and Stockbridge	Along Camp 12 Road at Pittsfield/Stockbridge town line	**High**	Limited	Ineffective	Effective	Limited	The brook was heavily windrowed in this area following Irene due to impacts to Camp 12 Road.
Project #73 T6.4-S1.01-C (Refer to Map 9)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Johnson Brook	Stockbridge	From town line upstream to end of study area	Low	Effective	Limited	Effective	Effective	Johnson Brook is actively adjusting here and an easement could prevent future corridor development and river conflicts.
Project #74 T6.4-S1.01-C (Refer to Map 9)	Structure Replacement/ Removal	Replace Culvert	Johnson Brook	Stockbridge	On Camp 12 Road just west of gravel pit	**High**	Effective	Ineffective	Effective	Effective	This culvert is majorly undersized and has an outlet drop of two feet, making it impassible to all aquatic organisms.
Project #75 T7.01-A (Refer to Map 10)	Floodplain Improvement and Conservation	Riparian Buffer Planting and River Corridor Easement	West Branch White River	Rochester	From confluence with White River to upstream approximately 1,500 feet	**High**	Effective	Effective	Effective	Effective	The section of the West Branch at the confluence with the White River is an alluvial fan and naturally depositional area. The river flowed over its banks during Irene and left large amounts of sediment behind. It is important to protect this floodwater and sediment attenuation area. Riparian buffers are lacking on both banks. Project may be eligible for CREP.
Project #76 T7.01-B (Refer to Map 10)	Floodplain Improvement and Conservation	Riparian Buffer Planting	West Branch White River	Rochester	At 1239 Brandon Mountain Road	Moderate	Effective	Effective	Limited	Ineffective	Riparian buffer is lacking due to hay field along north bank of the river. Project may be eligible for CREP.
Project #77 T7.02-A (Refer to Map 10)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	West Branch White River	Rochester	From first bridge on Route 73 upstream approximately 2,800 feet	**High**	Effective	Limited	Effective	Effective	This section of the river is an alluvial fan, which is very dynamic and important for floodwater and sediment attenuation.
Project #78 T7.02-C (Refer to Map 10)	Floodplain Improvement and Conservation	Riparian Buffer Planting	West Branch White River	Rochester	In vicinity of 2548 Route 73	Moderate	Effective	Effective	Limited	Ineffective	Riparian buffer is lacking along the southern bank.
Project #79 T7.02-C (Refer to Map 10)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	West Branch White River	Rochester	From confluence of Corporation Brook to upstream approximately 2,500 feet	Low	Effective	Effective	Effective	Limited	The West Branch was extensively windrowed and dredged in this location. Gravel berms restrict floodplain access. This is the location of a habitat enhancement project being implemented by WRP in 2015.
Project #80 T7.02-D & E (Refer to Map 10)	Floodplain Improvement and Conservation	Riparian Buffer Planting	West Branch White River	Rochester	From Rochester CCC camp upstream approximately 0.8 miles	Low	Effective	Effective	Limited	Ineffective	Riparian buffer is lacking along the southern bank for a long stretch due to agricultural fields. Landowner interest may be an issue here. Project may be eligible for CREP.
Project #81 T8.01-A (Refer to Map 11)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Hancock Branch White River	Hancock	From confluence with White River upstream to Route 100 bridge	Low	Effective	Effective	Limited	Ineffective	Riparian buffer is lacking on the northern bank of the river.

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Project Number Segment	Project Category	Project Type	Stream Name	Town	Project Location	Priority	OBJECTIVES: Improves or Protects Habitat[1]	Improves Water Quality[2]	Improves Long-term Channel Stability[3]	Protects Infrastructure, and Property[4]	Comments
Project #82 T8.01-A (Refer to Map 11)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material and Restore Alluvial Fan	Hancock Branch White River	Hancock	From confluence with White River upstream to near pond at Camp Killooleet	Low	●	○	●	◓	Almost all of this segment was windrowed post-Irene, and tall gravel berms abound. Removing them could restore some floodplain access, but the berms are protecting several buildings from flooding. Two landowners have expressed an interest in projects.
Project #83 T8.01-A (Refer to Map 11)	Public Safety Improvement	Consider FEMA Buyouts	Hancock Branch White River	Hancock	10, 38, 48, 82, 88, & 96 Route 125 and 1217 Route 100	**High**	◓	◓	●	●	Five single family dwellings (one of which appears to be abandoned), Hancock's town office, and the Hancock General Store are directly on the northern bank of the river in this location. The river is going to widen in response to the windrowing that occurred here after Irene, and these buildings are at major risk of being destroyed.
Project #84 T8.01-B (Refer to Map 11)	Stream Channel Improvement and Restoration	Install Boulder Weirs and Large Woody Debris to Raise Streambed and Provide Channel Roughness	Hancock Branch White River	Hancock	From downstream end of pond at Camp Killooleet to near 829 Route 125	Moderate	●	◓	●	◓	This section of the river is extremely incised and lacks strong bedform and habitat features. Building it up and installing woody debris could increase floodplain access and create more diverse channel features.
Project #85 T8.01-B (Refer to Map 11)	Structure Replacement/ Removal	Remove Destroyed Dam	Hancock Branch White River	Hancock	At Camp Killooleet	**High**	●	◓	●	◓	Remnants of an old concrete dam are in the river in this location. The edges of the old dam create a channel constriction.
Project #86 T8.01-C & T8.02-A (Refer to Map 11)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Hancock Branch White River	Hancock	1210 Route 125	Moderate	●	●	◓	○	Riparian buffer is lacking for ~350 feet on the north bank due to landowner's lawn. Landowner indicated interest in potential projects.
Project #87 T8.02-A (Refer to Map 11)	Floodplain Improvement and Conservation	Riparian Buffer Planting	Hancock Branch White River	Hancock	1400 Route 125	**High**	●	●	◓	◓	Riparian buffer is lacking along the northern bank due to lawn. Landowners indicated interest in planting more trees on their property to fill in what they already have.
Project #88 T8.02-A (Refer to Map 11)	Public Safety Improvement	Consider FEMA Buyout	Hancock Branch White River	Hancock	1400 Route 125	**High**	◓	◓	●	●	Single family home is directly on the north bank. A channel avulsion that likely occurred during Irene caused the river to change course and it now flows only a few feet from their house. The house is at major risk of damage/destruction during flooding due to the dynamic nature of this section of river and the location of the house on the inside of a bend.
Project #89 T8.02-B (Refer to Map 11)	Floodplain Improvement and Conservation	Riparian Buffer Planting and Restore Adjacent Wetlands	Hancock Branch White River	Hancock	1628 Route 125	Moderate	●	●	◓	○	Riparian buffer is lacking along approximately 1,000 feet along the southern bank of the river due to hay field. It appears that the field was historically wetlands that have been drained. Project may be eligible for CREP.
Project #90 T8.02-C (Refer to Map 11)	Public Safety Improvement	Consider FEMA Buyout	Hancock Branch White River	Hancock	1882 Route 125	**High**	●	○	●	●	Single family dwelling located on the inside of a meander bend on the northern bank of the river. The house is in a very vulnerable spot between the road and the river. The river was windrowed in this location post-flood and heavily armored and bermed.

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Project #91 T8.02-C (Refer to Map 11)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Hancock Branch White River	Hancock	Between 1882 and 2198 Route 125	**High**	Effective	Limited	Effective	Effective	Very aggradational section of river that is moving laterally. Landowner is interested in potential projects.
Project #92 T8.02-C (Refer to Map 11)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Hancock Branch White River	Hancock	Just below Route 125 bridge near 2198 Route 125	**High**	Limited	Ineffective	Effective	Limited	A 150 foot long gravel berm exists along the northern bank of the river in this location. The channel was windrowed post Irene. Removing the berm could allow floodwaters to access a large undeveloped floodplain on the inside of a meander bend.
Project #93 T8.02-C & D and T8.03-A (Refer to Map 11)	Floodplain Improvement and Conservation	River Corridor or Conservation Easement	Hancock Branch White River	Hancock	Between Route 125 bridge and just above the Robbins Branch confluence	**High**	Effective	Limited	Effective	Effective	One large tract of land with landowner interest. This section of the river is building a juvenile floodplain and is an alluvial fan.
Project #94 T8.02-C & D (Refer to Map 11)	Stream Channel Improvement and Restoration	Return or Remove Windrowed Material	Hancock Branch White River	Hancock	Throughout segments C and D	Low	Effective	Limited	Effective	Limited	Windrowing and berming is scattered throughout segments C and D. Berms restrict floodplain access but protect homes.

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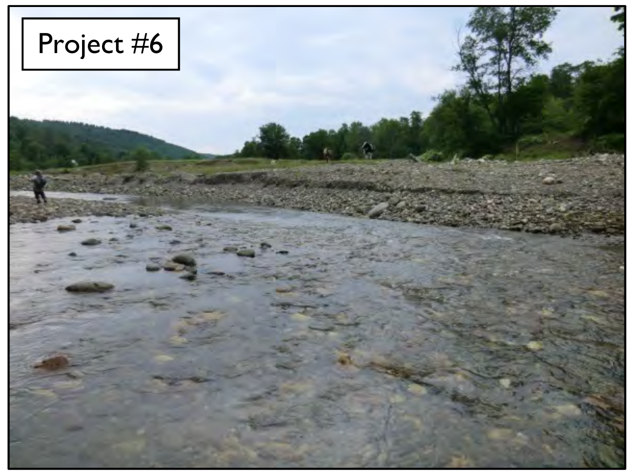
Project #1


Project #5


Project #2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Project #3


Project #7


Project #4


Project #8


Project #9


Project #10


Project #11


Project #12


Project #13


Project #14


Project #15


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

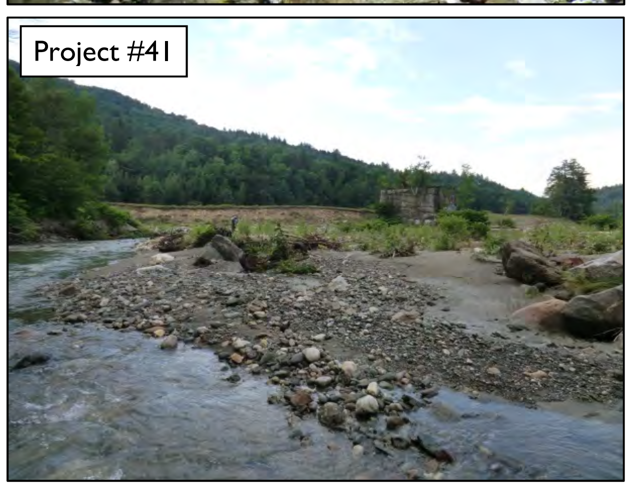

Projects #35 & 36


Project #37


Project #38


Project #39


Project #40


Project #41

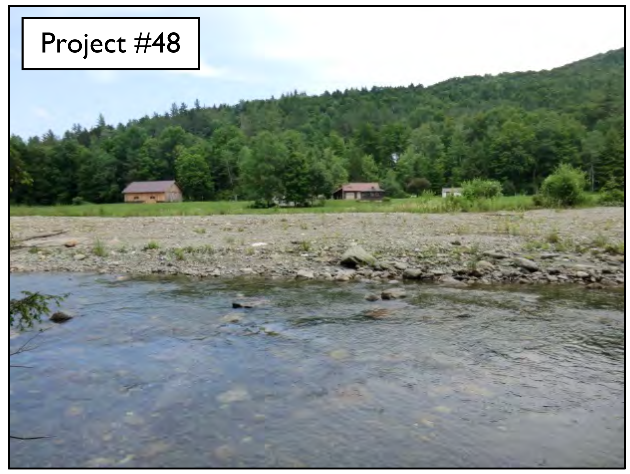

Project #42


Projects #43 & 44


Project #45


Project #46


Project #47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Project #50

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Project #52


Project #53


Project #54


Project #55


Project #56


Project #57


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Project #59


Project #60


Project #61


Project #62

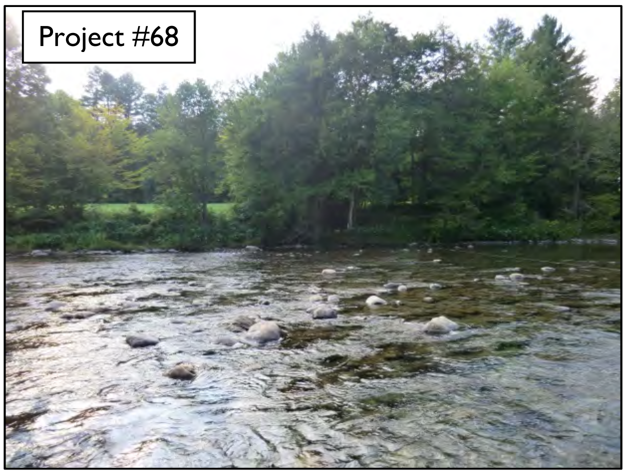

Project #63


Project #64


Project #65


Project #66


Project #67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Project #69

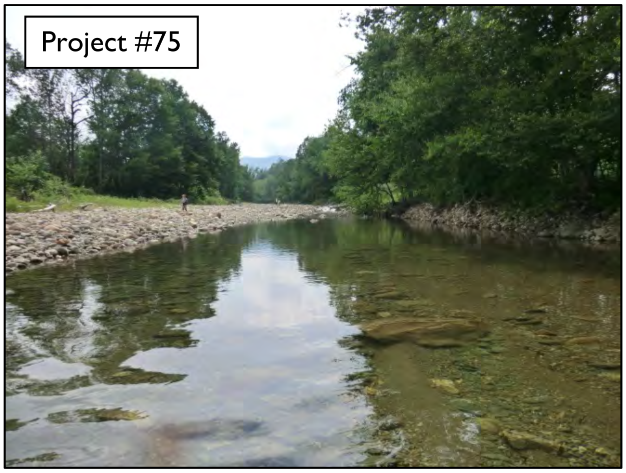

Project #70


Project #71


Project #72


Project #73


Project #74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Project #77


Project #78


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Project #81


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Project #83

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Project #85


Project #89


Project #86

No Photo for Project #90


Project #91


Project #92


Project #93


Project #94