Lamoille River Corridor Plan
Hardwick to Johnson
Lamoille County, Vermont
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Prepared by:

Bear Creek Environmental, LLC
297 East Bear Swamp Road
Middlesex, Vermont 05602

Prepared for:

The Lamoille County Planning Commission
632 LaPorte Road
Morrisville, VT 05661

Lamoille River Corridor Plan

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Bear Creek **Environmental**
297 East Bear Swamp Road, Middlesex, Vermont 05602
Phone: (802) 223-5140 / **Fax:** (802) 229-4410

EXECUTIVE SUMMARY
Lamoille River Corridor Plan
Hardwick to Johnson, Vermont

The Phase 2 stream geomorphic assessment study area focused on 10 stream reaches between the Hardwick Lake Dam and Railroad Street in Johnson. The Lamoille River has a watershed size of 204 square miles at the downstream end of the study area in Johnson, Vermont. The combined length of the river reaches assessed is approximately 25.8 miles. The Lamoille River within the study area flows east to west through the Towns of Hardwick, Wolcott, Morristown, Hyde Park and Johnson. The Lamoille continues to flow westerly downstream of Johnson and eventually joins Lake Champlain in Milton at an elevation of 95 feet above sea level.

All assessed segments and reaches in the Lamoille study area were found to be in fair geomorphic condition. 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 describes the raising of the bed elevation through an accumulation of sediment. The planform is the channel 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. The most common adjustment processes in the Lamoille River study area between Hardwick and Johnson are widening and planform adjustment as a result of historic degradation within the channel.

Lamoille River Hardwick to Johnson	
Watershed Size	204 sq. miles
Length of Assessed Reaches	25.8 miles
Phase 1 by LCPC	2005
Phase 2 by BCE (DEC and volunteers assessed 10 Bends)	2006
Bridge and Culvert Survey by BCE	2006
Phase 2 Focus	Main Stem
Most Common Active Adjustment Process	Widening and Planform migration
Total Number of Potential Projects	15
Number of Potential Municipal Projects	1
Number of Potential Landowner Projects	11

The main stem of the Lamoille River is experiencing high rates of bank erosion. The bank erosion has been accelerated due to land use activities and channel and floodplain modifications. Significant channel straightening, bank armoring, berming, and floodplain encroachment have occurred within this river system both on the main stem and major tributaries. Along much of the main stem, the river channel is currently migrating laterally to recreate a new floodplain at a lower elevation to dissipate energy and become more stable. As the river works toward a more stable equilibrium, the communities of Hardwick, Wolcott, Hyde Park, Morristown, and Johnson have the opportunity to reestablish floodplain vegetation and protect the river from further encroachments through the adoption of fluvial erosion hazard zones.

Site specific projects are identified for the Lamoille River main stem in the river corridor plan. The project strategy, technical feasibility, and priority for each project are listed by project number and reach. High priority projects include river corridor easements and floodplain restoration projects to provide attenuation of sediment and floodwaters, riparian buffer improvement areas, and the replacement of undersized bridges.

A floodplain restoration project was completed on the Lamoille main stem by the Vermont Agency of Natural Resources in 2008. Two of these project sites are located within the section between Hardwick and Johnson.

Lamoille River Corridor Plan
Hardwick to Johnson
Lamoille County, Vermont

1.0 INTRODUCTION

This river corridor plan includes the Lamoille River main stem from Hardwick to Johnson, Vermont. The River Corridor Planning effort is sponsored by the Lamoille County Planning Commission (LCPC) with funding provided through a grant from the Agency of Natural Resources Clean and Clear Program. The Vermont Department of Environmental Conservation River Management Program provided technical expertise and shared quality control/quality assurance responsibilities with Bear Creek Environmental. The River Corridor Plan (RCP) followed the Vermont Agency of Natural Resources River Corridor Planning Guide (Vermont Agency of Natural Resources, 2007a). Information for the RCP came from the DEC, the Vermont Center for Geographic Information (VCGI), and field data collected by Bear Creek Environmental, LLC.

The primary objective of the RCP is to use stream geomorphic assessment data to identify and prioritize river corridor protection and restoration projects within the Lamoille River watershed in the Towns of Hardwick, Wolcott, Hyde Park, Morristown and Johnson. 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 Vermont Stream Geomorphic Assessment Protocol includes three phases:

1. Phase 1- Remote sensing and cursory field assessment;
2. Phase 2 – Rapid habitat and rapid geomorphic assessment 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.

A Phase 1 Stream Geomorphic Assessment following Agency of Natural Resources Protocols was completed for the Lamoille River by LCPC in 2005. The LCPC then retained Bear Creek Environmental to perform Phase 2 Stream Geomorphic Assessments and Bridge and Culvert Assessments of select reaches of the Lamoille River during 2006, including the reaches focused on in this report in the towns of Hardwick, Wolcott, Hyde Park, Morristown and Johnson. Staci Pomeroy was responsible for leading the field team of community volunteers that assessed the area known as "Ten Bends", located in the lower end of the study area in Morristown, Hyde Park and Johnson. These stream geomorphic assessments provide information about the physical condition of the Lamoille River watershed and the factors that influence the stability of these systems.

2.0 LOCAL PLANNING PROGRAM OVERVIEW

2.1 RIVER CORRIDOR PLANNING TEAM

The river corridor planning team for the Lamoille River watershed is comprised of the Lamoille County Planning Commission, the Agency of Natural Resources, Bear Creek Environmental, local municipalities and landowners. This planning effort is sponsored by the Lamoille County Planning Commission. Funding for the project is provided through a grant from the Clean and Clear Program. Staci Pomeroy from the Vermont River Management Section of the Vermont Agency of Natural Resources (VANR) provided technical guidance for this project.

2.2 GOALS AND OBJECTIVES OF THE PROJECT

The LCPC, as part of the grant with the Agency of Natural Resources, hired Bear Creek Environmental, LLC to develop a River Corridor Management Plan for the Lamoille River from Hardwick to Johnson. The primary objective of the River Corridor Management Plan is to use the Phase 1 and 2 Assessment data to identify and prioritize river corridor protection and restoration projects within the study area. Bridge and culvert data collected during the Phase 2 Assessment were used to identify structures that have the potential to fail because of channel adjustments, are having a geomorphic impact on the stream, or are impeding aquatic organism passage.

2.2.1 State River Management Goals and Objectives

The State of Vermont's River Management Program has set out several goals and objectives that are supportive of the local initiative in the Lamoille River watershed from Hardwick to Johnson. 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, 2007a). The objectives of the Program include: fluvial erosion hazard mitigation; sediment and nutrient load reduction; and 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 these 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.

2.2.2 Local Goals and Objectives

A community-based river corridor management plan provides many opportunities for enhancing and restoring the Lamoille River Watershed. Some of the local goals are listed below:

- Identify watershed, floodplain and channel impacts along each priority reach

- Evaluate geomorphic condition and habitat condition
- Identify stream channel adjustment processes
- Conduct bridge and culvert assessments
- Verify valley walls identified in Phase 1 assessment
- Participate in public meetings to inform local stakeholders of study findings
- Identify potential stream restoration projects.

3.0 BACKGROUND WATERSHED INFORMATION

3.1 Geographic Setting

3.1.1 Watershed Description

BCE was contracted to conduct Phase 2 Assessments on selected reaches of the Lamoille River watershed (Figure 1), including those between the dam at Hardwick Lake and the Railroad Street Bridge in Johnson. The Lamoille River watershed is 204 square miles at the Railroad Street Bridge in Johnson, Vermont, the most downstream reach break (Figure 2). The Lamoille River watershed drains from approximately 1350 feet elevation at East Greensboro, Vermont, westerly through the spine of the northern Green Mountains and empties into Lake Champlain at the Sand Bar National Waterfowl Management Area at approximately 95 feet above sea level. The study area included in this report focused on the 10 stream reaches between the Hardwick Lake Dam and the Railroad Street Bridge in Johnson (Figures 2 and 3).

The upper-most reach in the study area (R23), which begins in Hardwick, is approximately 303 feet higher in elevation than the lowest reach (R14) in Johnson. All reaches assessed in the Phase 2 investigation have a channel slope of less than 1 percent.

3.1.2 Political Jurisdictions

Phase 2 and RCP project reaches for the study area are located in Lamoille County Vermont within the Towns of Hardwick, Wolcott, Hyde Park, Morristown and Johnson. The Lamoille River watershed falls under the jurisdiction of the Lamoille County Planning Commission.

3.1.3 Land Use

The study area is dominated by forested land, however agricultural and urban land uses are subdominant within the watershed (Figure 4).

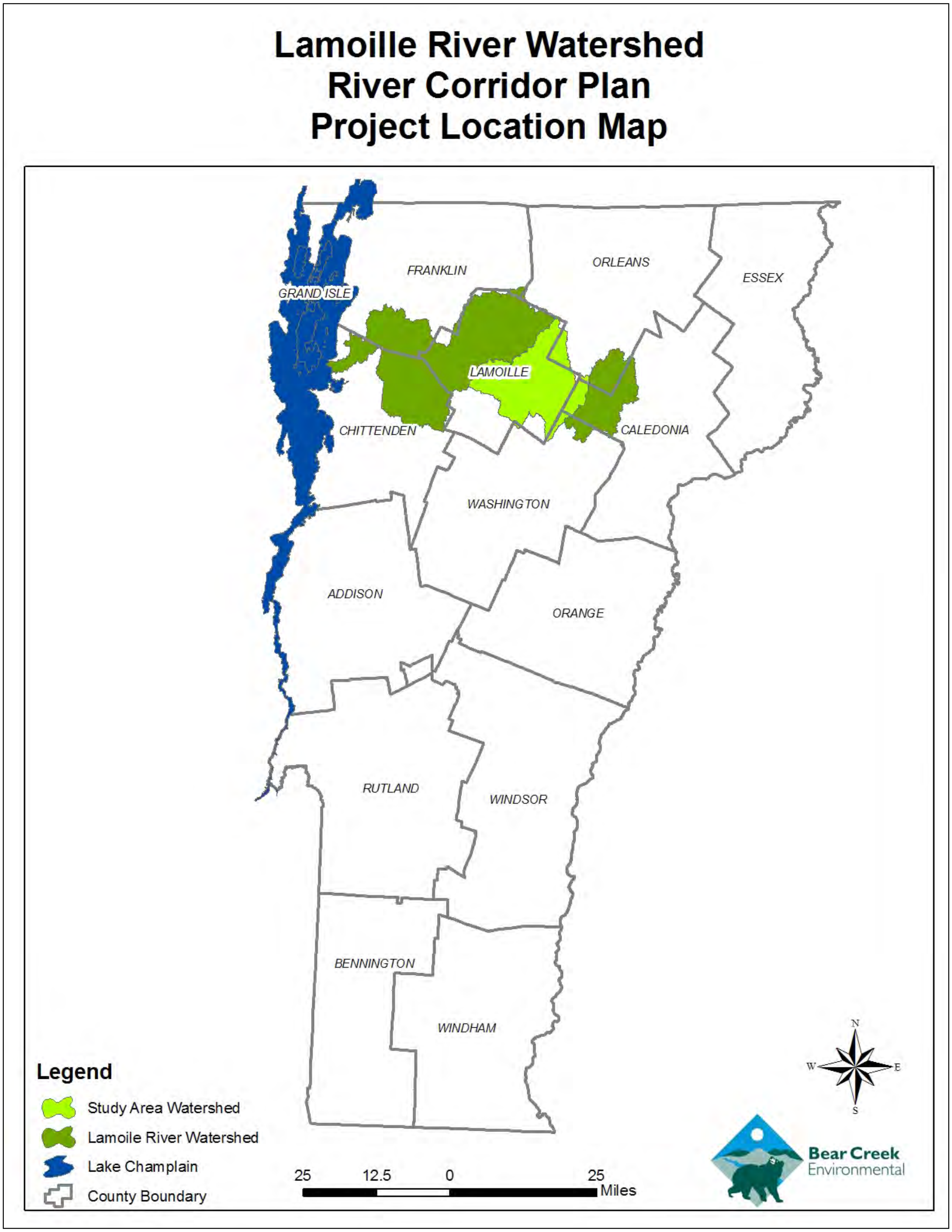

Figure 1: Project location map

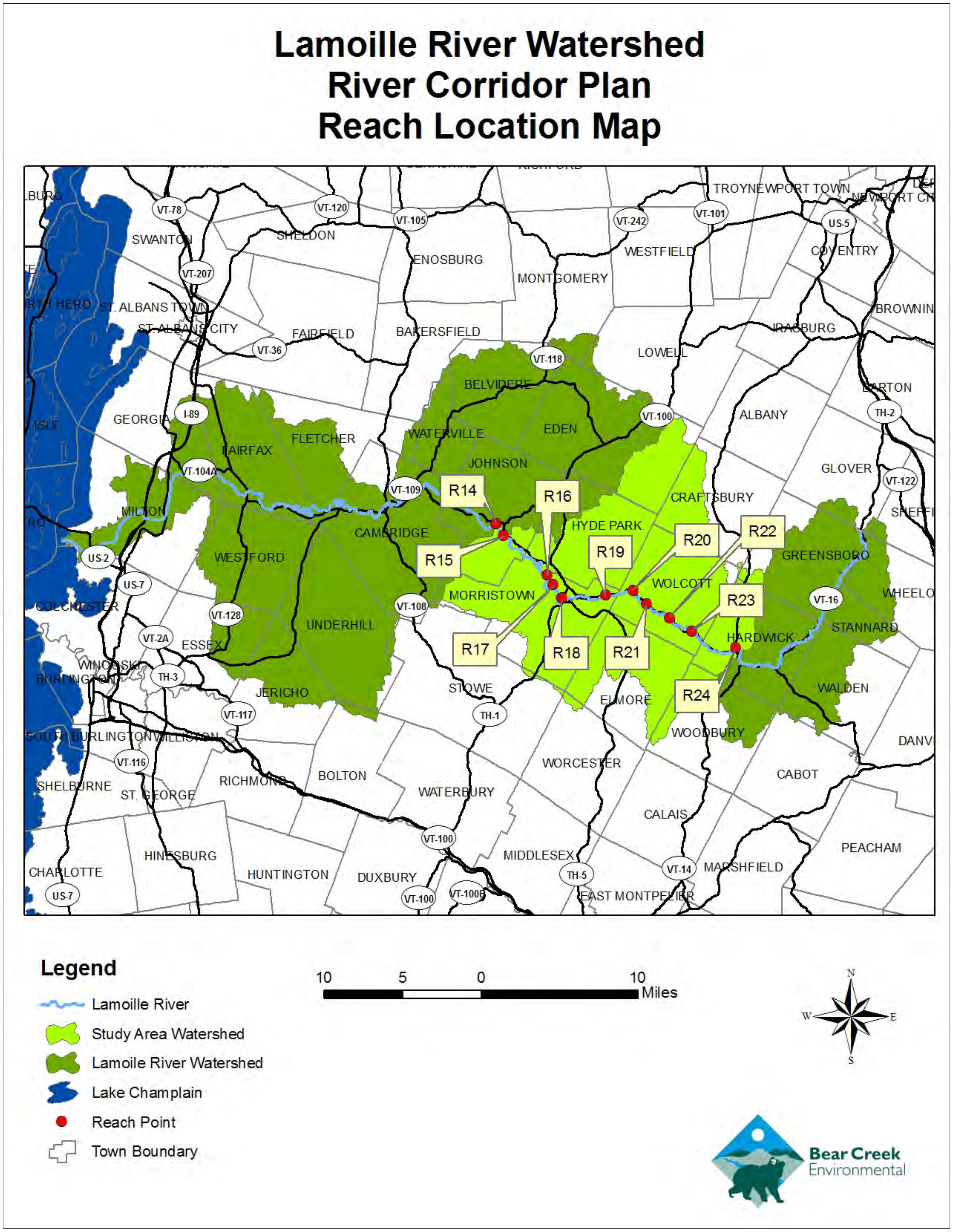

Figure 2: Reach location map for Phase 2 Assessments and River Corridor Plan

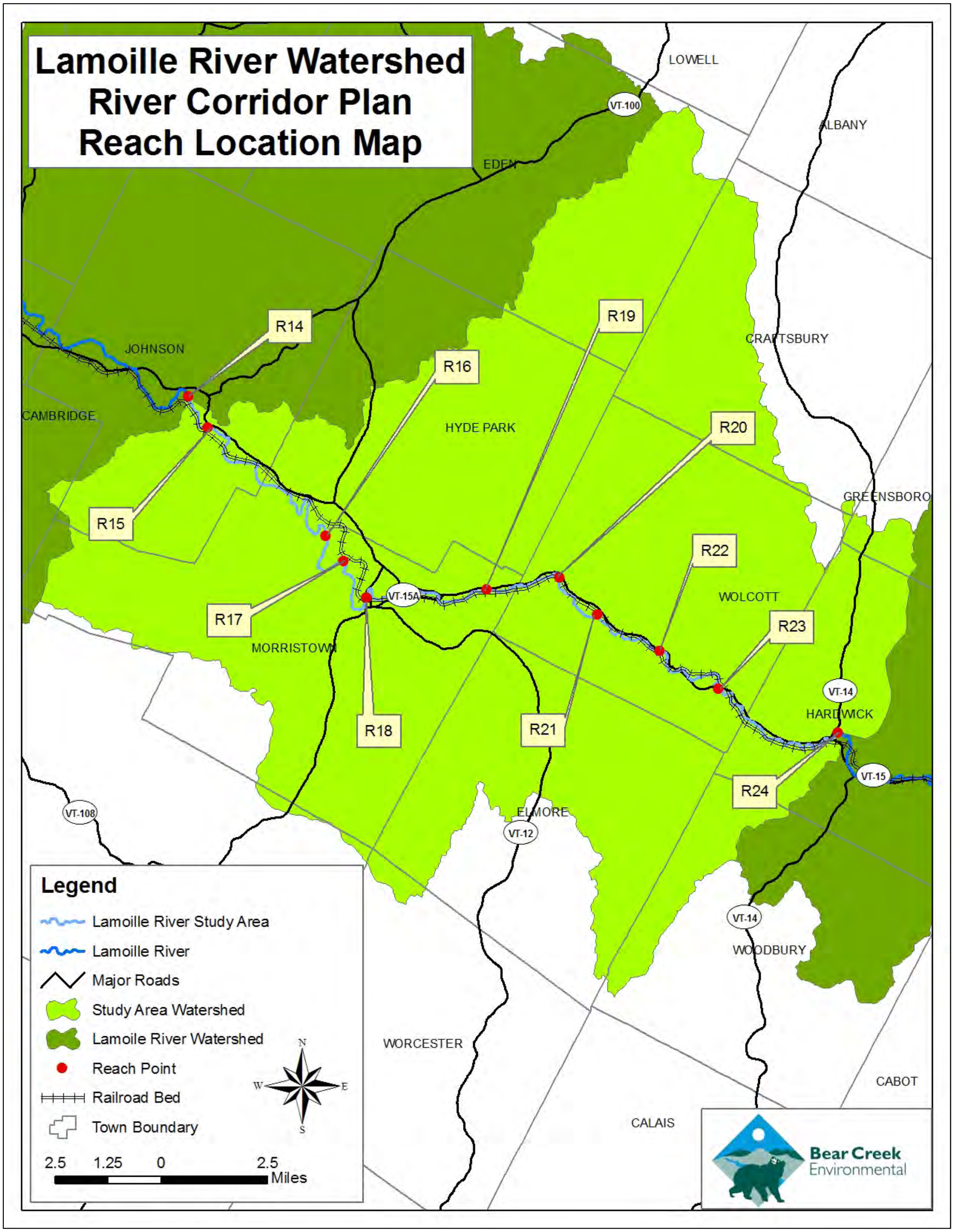

Figure 3: Detailed reach location map for Phase 2 Assessments and RCP

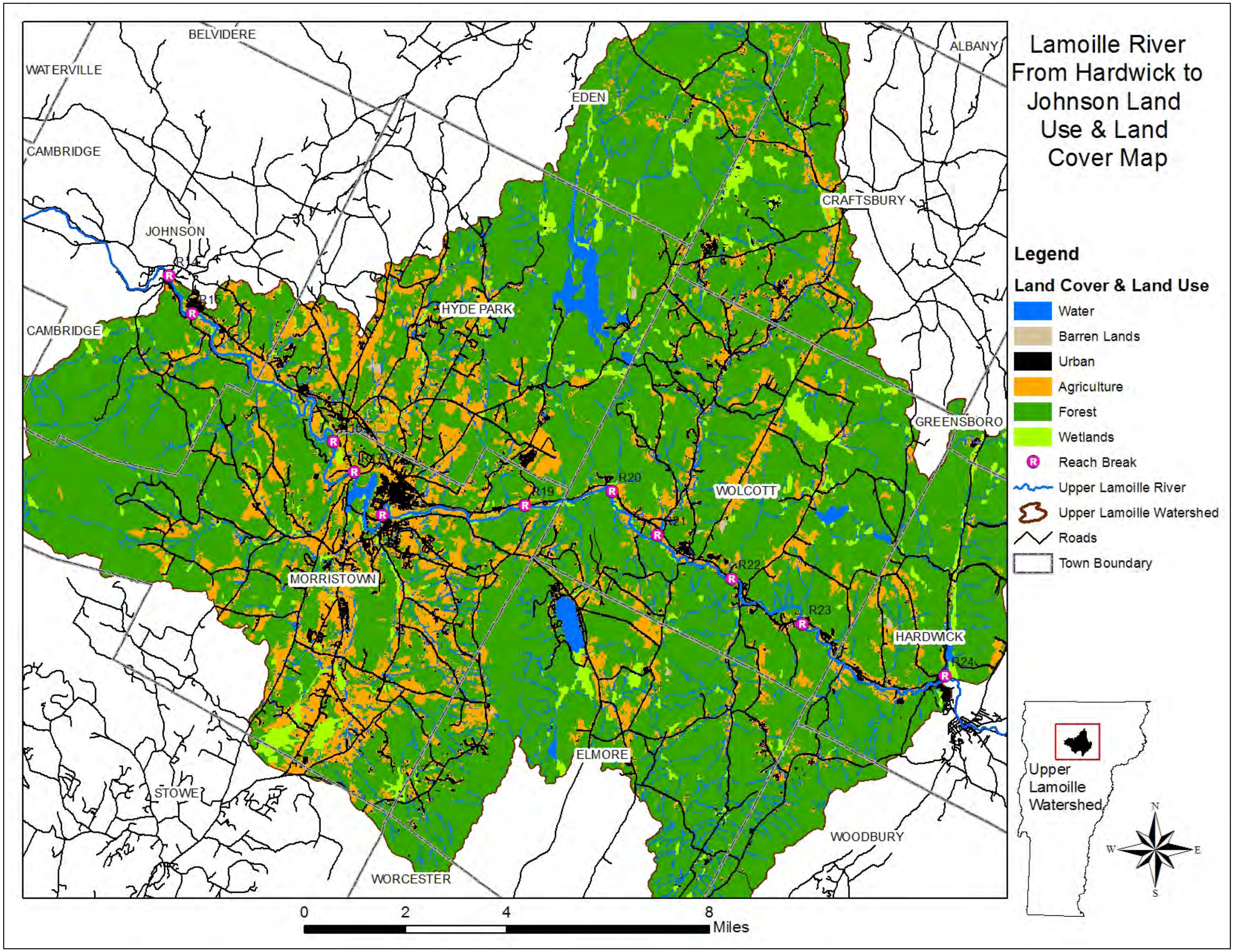

Figure 4. Land cover and land use for Upper Lamoille River Watershed

3.2 Geologic Setting

The Lamoille River watershed is located within the Green Mountain Geo-physiographic Province. The Green Mountains were uplifted during the Taconic orogeny about 455 million years ago (Doolan, 1996). The bedrock underlying the study area of the Lamoille watershed primarily includes the Moretown member of the Missisquoi Formation in the eastern part of the watershed. The Moretown member of the Missisquoi Formation is comprised of quartzite and quartz-plagioclase granulite separated by thin layers of minerals and also phyllite and schist. The Stowe Formation is located in the center of the watershed and is comprised of quartz and chlorite phyllite and schist with abundant segregations of granular white quartz. Located within the Stowe formation in this area is greenstone and amphibolite. On the western side of the study area, the Hazens Notch Formation is dominant. The Hazens Notch Formation is an interbedded carbonaceous and non-carbonaceous schist that grades to quartzite and gneiss (Doll, 1961).

The Green Mountains and adjacent valleys have been covered with ice during historic glacial periods. The last large ice sheet, the Laurentide Ice Sheet, covered all of New England and advanced up the Lamoille River Valley. As the climate warmed, the glacier slowly retreated and glacial lakes were dammed in the Lamoille River valley. Following the retreat of the ice sheet, the Lamoille River and its tributaries began eroding the glacial and lake sediments that were left behind (Wright, 2003).

Based on Natural Resource Conservation Service (NRCS) soils information the dominant surficial geology of the study area within the Lamoille River watershed consists of alluvial deposits. The downstream end of the study area is predominately glacial outwash (ice-contact deposits) and the upstream end of the study area is mostly glacial till. The study area is primarily comprised of moderately erodible soils. The soils on the downstream end of the study area have very severe erodibility and the upstream end contains soils with severe erodibility. Where there are highly erodible soils there is a higher potential for sediment input to the stream channel.

3.3 Geomorphic Setting

3.3.1 Description and Mapped Location of the Assessed Reaches

The Phase 2 study focused on 10 stream reaches on the main stem of the Lamoille River within the Towns of Hardwick, Wolcott, Hyde Park, Morrisville and Johnson from the confluence with the dam at Hardwick Lake downstream to the Railroad Street Bridge. The combined length of the stream reaches assessed is approximately 26 miles (Figure 3).

The Lamoille River watershed was divided into reaches for the Phase 1 and Phase 2 Stream Geomorphic Assessments. 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. Each point represents the downstream end of the reach. The hydrological unit code (HUC) 2 portion of the watershed (from Hardwick to Johnson) is included in this corridor plan.

A separate corridor plan will be prepared for the HUC 1 part of the watershed that includes the Lamoille River from Johnson to the Fairfax town line. A number of corridor plans have been prepared for major tributaries of the Lamoille River within the HUC 2 watershed under the direction of the LCPC. These subwatersheds (see Figure 5 for a map) are listed below with a reference to the river corridor plan or phase 1 report.

- Centerville Brook Corridor Plan– Bear Creek Environmental, LLC (2010a)
- Elmore Pond Brook- Phase 1 Assessment completed by LCPC
- Elmore Branch Corridor Plan – Bear Creek Environmental, LLC (2009)
- Green River Reservoir – Phase 1 Assessment completed by LCPC
- Rodman Brook Phase 1 and 2 Report – LCPC and Bear Creek Environmental, LLC (in preparation)
- Wild Branch Corridor Plan – Bear Creek Environmental, LLC (2010b)

3.3.2 Longitudinal Profile, Alluvial Fans, and Natural Grade Controls

Natural bedrock grade controls were noted in five of the assessed reaches (R14-B, R15, R22-A, R22-B, R22-D). The steepness of the valley side slopes was determined using a combination of a topographic map and the soils layer.

3.3.3 Valley and Reference Stream Types

Reference stream types are defined as stream channel forms and processes that would exist in the absence of human-related changes to the channel, floodplain, and/or watershed. Stream and valley characteristics including valley confinement, and slope determined from digital USGS topographic maps were used to determine the stream type. The reference reach characteristics were later refined during the windshield survey and Phase 2 Assessment. Reference reach typing was based on both the Rosgen (1996) and the Montgomery and Buffington (1997) classification systems.

Table 1 shows the typical characteristics used to determine reference stream types (Vermont Agency of Natural Resources, 2005). Reference stream types for the assessed reaches within the project area are summarized in Table 2. The majority of the stream reaches are "C" stream types which tend to have unconfined valleys and gentles slopes. Reach R14 has a similarly gentle valley slope, but has a semi-confined valley with a reference stream type of "B".

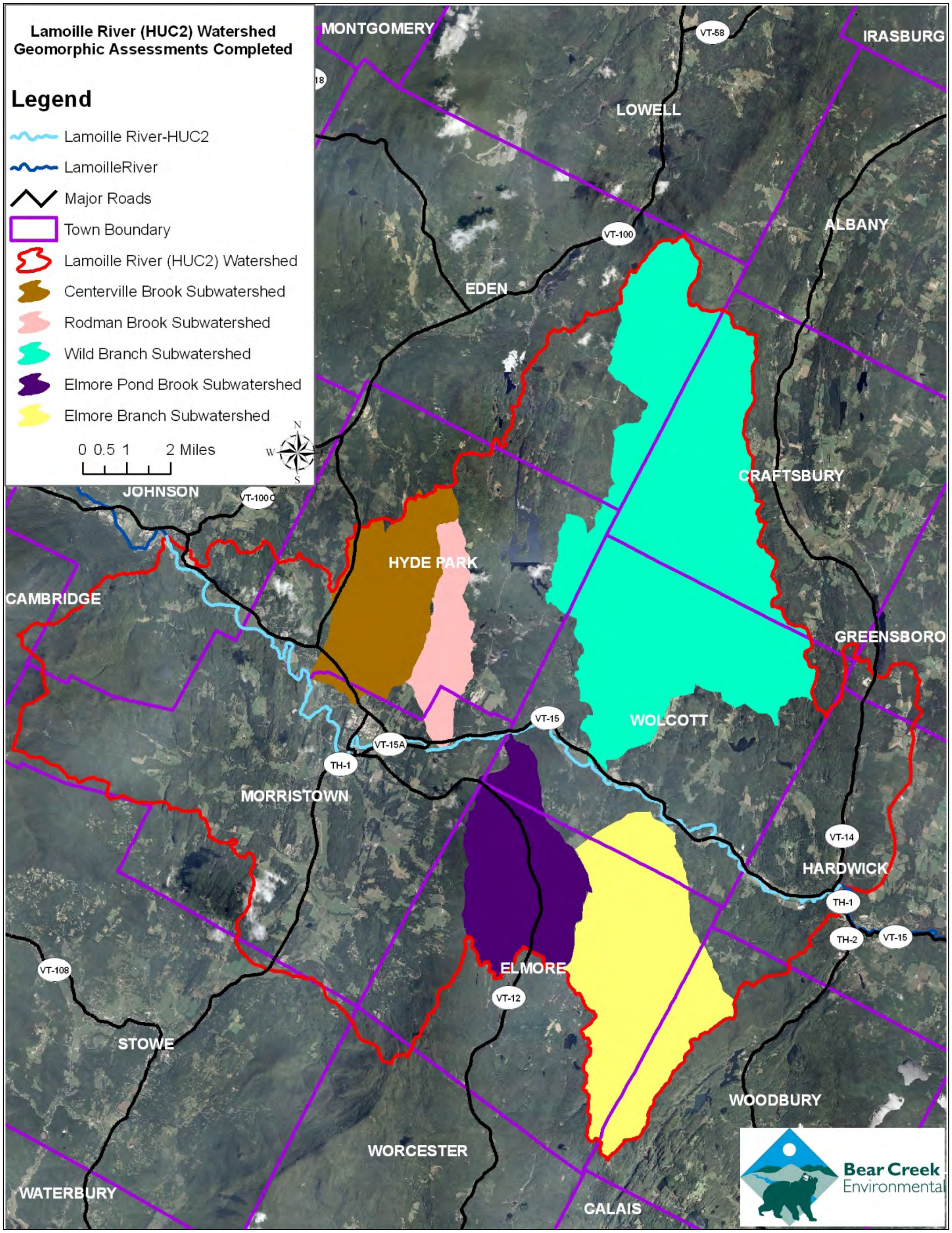

Figure 5. Geomorphic Assessments Completed in the Lamoille River (HUC2) Watershed

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

Table 2: Geomorphic Setting of Assessed Reaches

Reach ID	Reference Stream Type	Confinement	Valley Slope	Bed Form
R23	C	Broad	0.15	Riffle-Pool
R22	C	Broad	0.80	Riffle-Pool
R21	C	Broad	0.15	Riffle-Pool
R20	C	Very Broad	0.01	Riffle-Pool
R19	C	Narrow	0.17	Riffle-Pool
R18	C	Broad	0.08	Riffle-Pool
R16	C	Very Broad	0.34	Riffle-Pool
R15	C	Broad	0.12	Riffle-Pool
R14	B	Semi-Confined	0.35	Riffle-Pool

3.4 Hydrology

3.4.1 USGS Gage and/or Stream Stats Information

In order to better understand the flood history of the Lamoille River, long term data from the U.S. Department of the Interior, U.S. Geological Survey (USGS) gauge on the Lamoille River in Johnson, VT were obtained (USGS, 2007). Ninety-three years of record are available for the Lamoille River gauge at Johnson, VT which provides a continuous record of flow from 1912 through the present.

The near-term record for the Lamoille River shows that a 25 year flood event or greater occurred in 1973. The long term record on the Lamoille gauge shows major flood events also occurred in the years 1912, 1936, 1983, 1995 and 1997. The graph below (Figure 6) provides a flood frequency analysis for the Lamoille River gauge.

3.4.2 Flood History

Between 1995 and 1998 Vermonters suffered nearly $60,000,000 in flood damages; much of these losses were avoidable. Through Vermont's history, flood waters on the Lamoille River have destroyed property on numerous occasions. Precipitation trend analysis suggests that intense, localized storms, which can cause flash flooding, are occurring with greater frequency.

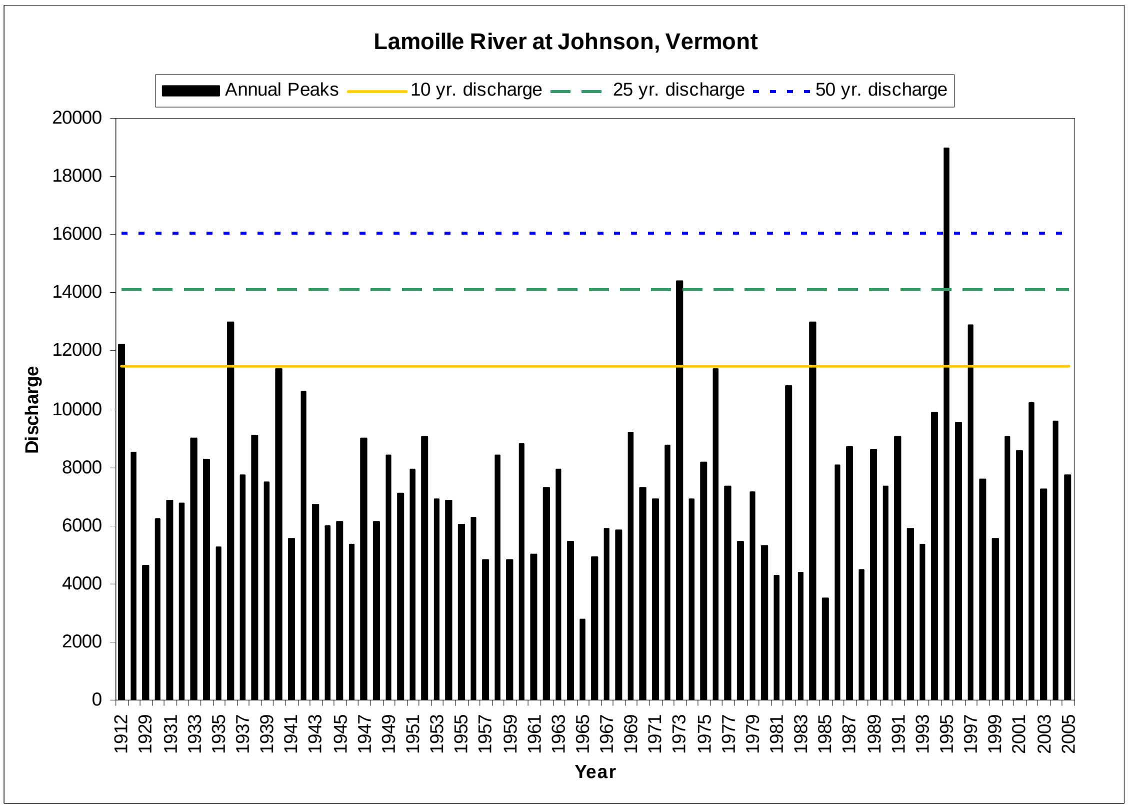

Figure 6. Flood frequency analysis for Lamoille River at Johnson, VT

3.5 Ecological Setting

The Lamoille River watershed between Hardwick and Johnson lies almost exclusively within the Northern Green Mountains biophysical region (Figure 7). This region is characterized by Thompson and Sorenson (2005) as having high elevations and cool summers. The Green Mountains have a strong influence on the weather resulting in an abundance of precipitation in the form of both rain and snow. Northern hardwood forest is the dominant community in this biophysical region. The Northern Green Mountains provide important habitat for both aquatic and terrestrial animals. According to Thompson and Sorenson (2005), the Green Mountains offer extensive habitat for black bear, white-tailed deer, bob cat, fisher, beaver and red squirrel. Birds such as blackpoll warbles, Swainson's thrush and the rare Bicknell's thrush nest in the high elevation forests. Deer wintering areas identified by the Vermont Department of Fish and Wildlife (Figure 3.8) are common adjacent to the Lamoille River in Wolcott. Concentrated areas of wetland (included in the Vermont Significant Wetland Inventory) exist near the Green River Reservoir, the Morristown Bog Natural Area State Park and the Wolcott Research Forest.

Public lands include within the Lamoille watershed between Hardwick and Johnson include:

- The Wild Branch Wildlife Management Area in the Town of Eden;
- Green River Reservoir State Park in the Towns of Hyde Park and Eden;
- Wolcott Research Forest;
- East Hill Wildlife Management Area in the Town of Wolcott;
- Hardwick Village Forest;
- Elmore State Forest;
- Morristown Bog Natural Area State Park;
- Mount Mansfield State Forest in Johnson and Morristown; and
- CC Putnam State Forest in Elmore and Worcester.

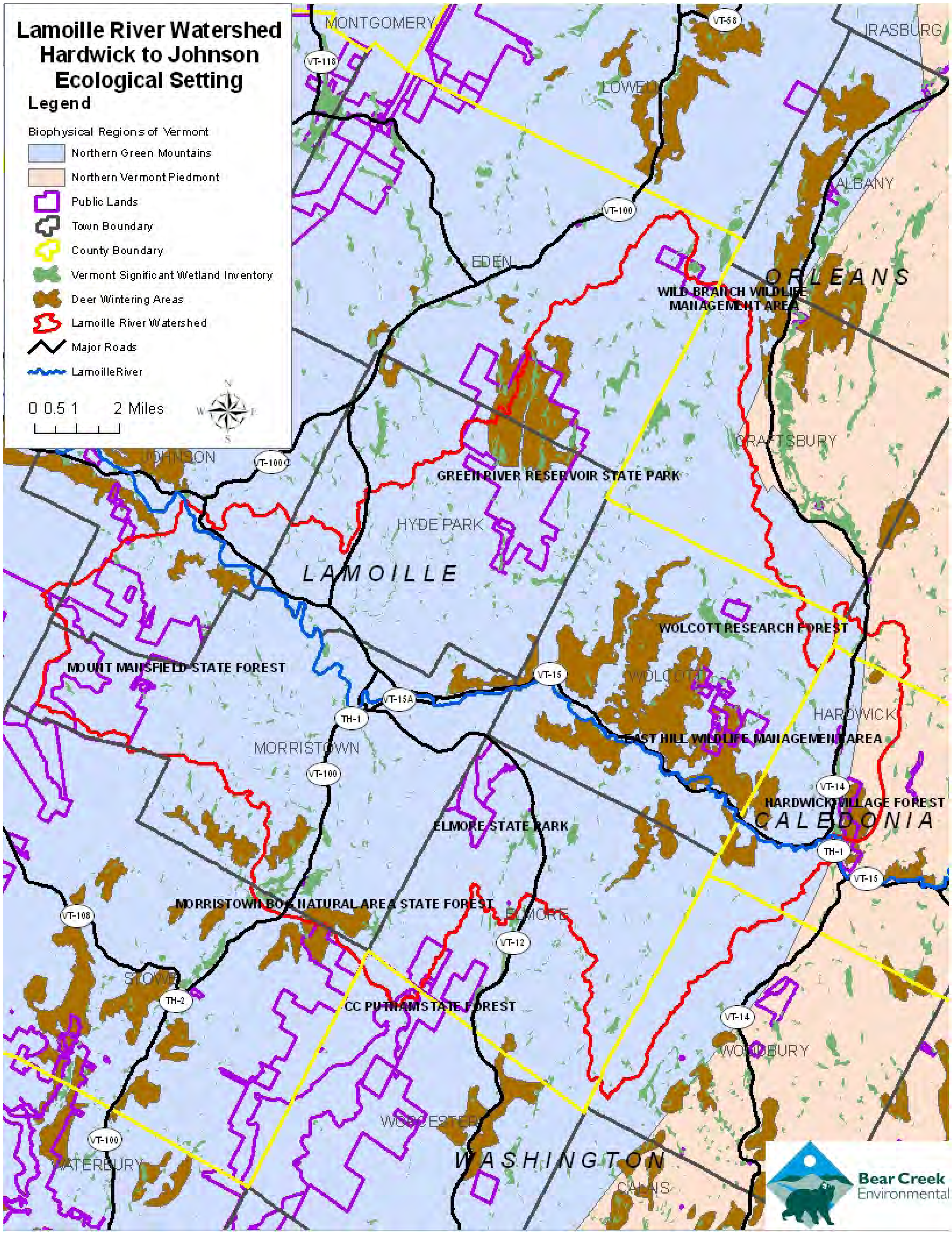

Figure 7. The ecological setting of the Lamoille River Watershed between Hardwick and Johnson

4.0 METHODS

4.1 Fluvial Geomorphic and Habitat Assessment Protocols

4.1.1 Phase 1 Methodology

A Stream Geomorphic Assessment process is divided into three phases, based on VANR protocols. 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" (Vermont Agency of Natural Resources, 2005). The Phase 1 assessment provides an overview of the general physical nature of the watershed.

The Phase I assessment followed procedures specified in the Vermont Stream Geomorphic Assessment Phase 1 Handbook (Vermont Agency of Natural Resources, 2005), and used version 4.53 of the Stream Geomorphic Assessment Tool (SGAT) GIS extension. All assessment data were recorded on the Agency of Natural Resources (VANR) Phase I data sheets and were entered into the VANR Data Management System (DMS).

4.1.2 Phase 2 Methodology

The Phase 2 assessment of the Lamoille River followed procedures specified in the Vermont Stream Geomorphic Assessment Handbook Phase 2 (Vermont Agency of Natural Resources, 2007b). All assessment data were recorded on the Agency of Natural Resources Phase 2 data sheets, and were entered in to the VANR Stream Geomorphic Assessment data management system (DMS). The Phase 1 database was updated using the field data from the Phase 2 assessment in 2006.

The parameters and protocols used for undertaking each of the above steps are outlined in the Phase 2 Handbook (Vermont Agency of Natural Resources, 2007b). The entire length of each Phase 2 reach was walked to determine segment breaks. Bank erosion, grade control structures, bank revetments, debris jams, depositional features, stormwater inputs, flood chutes and other important features were mapped within all segments.

4.1.3 Bridge and Culvert

The Bridge and Culvert Assessment and Survey Protocols specified in the Vermont Stream Geomorphic Assessment Handbook (Vermont Agency of Natural Resources, 2007b) were followed. All assessment data were recorded on the Vermont Agency of Natural Resources (VANR) Bridge and Culvert Assessment – Geomorphic and Habitat Parameters data sheet, and were entered into the VANR Data Management System (DMS).
The bankfull channel width from the regional curve was used to determine the expected bankfull width in the vicinity of a particular structure. Latitude and Longitude at each of the structures was determined using a Garmin Etrex Vista GPS unit. The assessment

included photo documentation of the inlet, outlet, upstream, and downstream of each of the structures.

4.1.4 River Corridor Plan

Bear Creek Environmental used SGAT version 4.53 to index features that were mapped during the Phase 2 assessment. BCE also indexed locations where riparian buffers are less than 25 feet on either side of the channel using SGAT version 4.56 based on orthophotography from 2003.

The Vermont Agency of Natural Resources River Corridor Planning Guide (2007a) was followed to generate a series of stressor maps. These maps were created using indexed data from the Phase 1 and Phase 2 Stream Geomorphic Assessments along with existing data available from VCGI, including roads, buildings and driveways. The stressor maps were then used to identify potential project locations that have few constraints to channel adjustment.

4.2 Quality Control/Quality Assurance Procedures

To assure a high level of confidence in the Phase 1 and 2 SGA data, strict quality assurance/quality control (QA/QC) procedures were followed by BCE. These procedures involved a thorough in-house review of all data as well as automated and manual QC checks with the DEC River Management Program.

In 2006, BCE completed its own in-house QA review after all the Phase 2 data were entered into the DMS and the Phase 1 data were updated. The Phase 1 DMS and ArcView shapefiles were updated by Michael Blazewicz and Pamela DeAndrea based on the Phase 2 field assessment work during the Phase 2 QA/QC process in 2006. The DMS and the ArcView shapefiles for the Lamoille River Phase 2 study were submitted to Staci Pomeroy of the VANR for a Quality Assurance review in March 2007. Some minor revisions were made by Bear Creek Environmental to the DMS following this review.

5.0 RESULTS

5.1 Phase 2 Results

Functioning floodplains play a crucial role to providing long term stability to a river system (see Figure 4). Natural and anthropogenic impacts may alter the delicate equilibrium of sediment and discharge in natural stream systems and set in motion a series of morphological responses (aggradation, degradation, and 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 Lamoille River watershed include:

- Forest clearing

- Channelization and bank armoring
- Removal of woody riparian vegetation
- Floodplain encroachments
- Urbanization
- Poor road maintenance and installation of infrastructure
- Loss of wetlands

These anthropogenic practices have altered the delicate balance between water and sediment discharges within the Lamoille River watershed. Channel morphologic responses to these practices contribute to channel adjustment that may further create unstable channels.

Geomorphic Evaluation

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, 2005). The reference condition for each of the Phase 2 reaches was previously identified in Table 2. All 10 of the assessed segments rated in the fair category for geomorphic condition. Figure 8 illustrates the geomorphic condition of the streams in relation to the watershed. Detailed segment summary data are provided in Appendix 1. Segments R23-B, R22-C, R17, and R14-B were not assessed because they are impounded by dams. Two of the segments, R22-B and R14-B, also did not receive a full geomorphic assessment because the channel is bedrock dominated.

The most common adjustment processes in the Lamoille River are widening and planform migration as a result of historic degradation within the channel. 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 is the channel 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 occurs when stream flows are contained in a channel as a result of degradation or floodplain encroachment or when sediments overwhelm the stream channel and the erosive energy is concentrated into both banks.

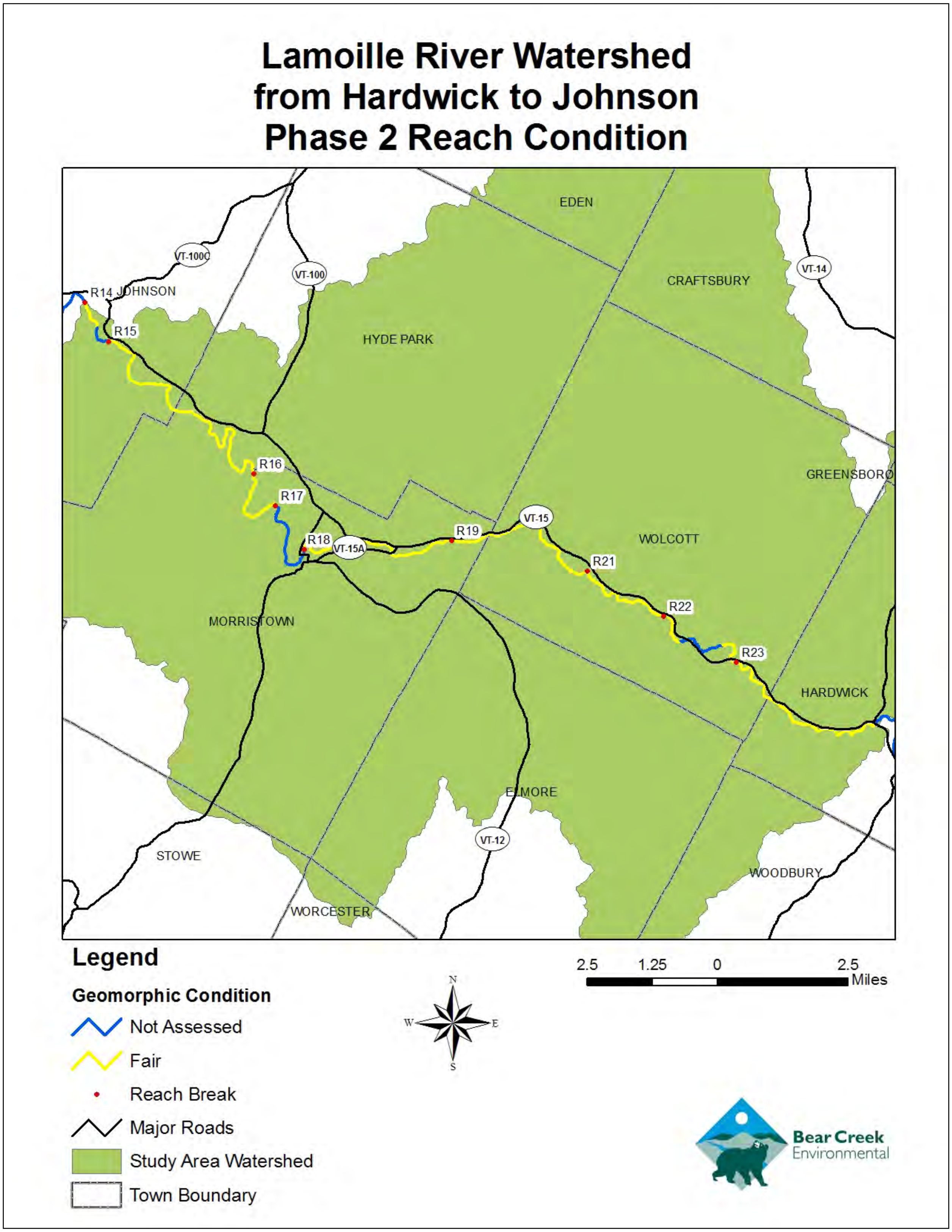

Figure 8: Phase 2 Geomorphic Condition of the Lamoille Watershed from Hardwick to Johnson

Table 3. Stream Type and Channel Evolution Stage						
Segment Number	**Entrenchment Ratio**	**Width to Depth Ratio**	**Reference Stream Type**	**Existing Stream Type**	**Channel Evolution Stage**	**Active Adjustment Process**
R23-B	Reach Not Assessed – Impounded					
R23-A	6.98	16.33	C4	C4	III	**Aggradation** Widening **Planform**
R22-D	1.31	33.24	B4c	B4c	III	Aggradation **Widening** Planform
R22-C	Reach Not Assessed – Impounded					
R22-B	Reach Not Assessed – Bedrock					
R22-A	1.09	29.72	C4	F4	III	Aggradation **Widening** Planform
R21	5.30	28.16	C4	C4	III	**Widening** **Planform**
R20	9.59	20.44	C4	C4	III	Aggradation Widening **Planform**
R19	3.23	40.00	C4	C4	III	**Aggradation** **Widening** **Planform**
R18	6.14	28.94	C4	C4	III	**Aggradation** **Widening** **Planform**
R17	Reach Not Assessed – Impounded					
R16	4.17	36.46	C4	C4	III	**Aggradation** **Widening** Planform
R15	4.24	35.85	C4	C4	III	**Aggradation** Widening **Planform**
R14-B	Reach Not Assessed – Bedrock					
R14-A	1.07	25.54	B3	F3	III	Aggradation Widening Planform
Bold Black lettering – denotes major adjustment process Black lettering (no bold) – denotes minor adjustment process						

Habitat Evaluation

Table 4 below shows a comparison of the habitat condition based on the Rapid Habitat Assessment (RHA) and the geomorphic condition based on the. For all of the ten assessed segments, both the RHA and the RGA resulted a fair rating, implying that the ecological health of the Lamoille River from Hardwick to Johnson is closely related to the geomorphic condition of the stream. In general several of the study reaches lacked a strong riffle-pool bedform and the diversity of habitat features that this brings. Many reaches involved in the study had major intrusion into their river corridor from Route 15 and other major roads and many had inadequate riparian buffers due to historic and /or recent land clearing.

Table 4. Comparison of RHA and RGA for Phase 2 Reaches

Segment Number	Score RHA	Score RGA	Rating RHA	Rating RGA
R23-B	Not Assessed – Impounded			
R23-A	0.41	0.45	Fair	Fair
R22-D	0.47	0.59	Fair	Fair
R22-C	Not Assessed – Impounded			
R22-B	Not Assessed – Bedrock			
R22-A	0.36	0.40	Fair	Fair
R21	0.43	0.51	Fair	Fair
R20	0.53	0.54	Fair	Fair
R19	0.43	0.40	Fair	Fair
R18	0.39	0.40	Fair	Fair
R17	Not Assessed – Impounded			
R16	0.50	0.49	Fair	Fair
R15	0.59	0.51	Fair	Fair
R14-B	Not Assessed – Bedrock			
R14-A	0.58	0.53	Fair	Fair

5.2 Bridge and Culvert Assessment

Seventeen bridges/arches were included in the assessment of stream crossings conducted coincidentally with the Phase 2 field work in 2006. The geomorphic and habitat data for this bridge and culvert assessment were collected following the VANR protocol.

In order to assist local municipalities with priorities for replacement of the structures, priority lists were generated using the information and photographs taken during the assessment. The bridge span as a percentage of the channel width was used as a first cut in prioritizing the structures for replacement. The following categories were used as a second cut to determine project priorities for stream crossings.

High Priority: Bridges and culverts with spans of approximately 50 percent of the bankfull width or less, which are significantly impeding natural sediment transport or are blocking aquatic organism passage (AOP).

Moderate Priority: Bridges and culverts with spans less than 50 percent that are not causing significant geomorphic instability or blocking AOP and structures with spans greater than 50% that are causing instability and/ or impeding aquatic organism migration are also in this category.

Low Priority: Stream crossing structures that are not included in either of the two categories above.

Table 5 below provides a summary of the stream crossings assessed within the study area. There were 17 bridges assessed as part of the Phase 2 assessment and no culverts. One bridge identified as high priority for replacement is located in reach R15 on River Ridge Road that had a percent channel width of less than 50 percent. Two bridges were not recommended for replacement, and the remaining 14 bridges were given either a low or moderate priority rating for replacement. A bridge located in R14-A was being replaced during the Phase 2 assessment (Figure 9); and was, therefore, not recommended for replacement. The other bridge not recommended for replacement had a percent channel width of 158 percent and there were no signs of its impact on the river.

Table 5. Lamoille River from Hardwick to Johnson Stream Crossing Structures

Reach/ Segment No.	Structure No.	Structure Type	Road Name/ Location	% Channel Width	Phase 2 Notes	Priority for Replacement
R23-A	200030006603052	Bridge	Route 15	85	Deposition below, scour above and below, alignment; newer structure, Hardwick Lake Dam directly upstream	Low
R23-A	100305002503051	Bridge	McAllister Farm Road	55	Deposition and scour above; newer bridge in good condition	Moderate
R23-A	700000000403053	Bridge	Russell Farm	56	Deposition above and below, scour below; delta bar from tributary nearby has narrowed channel; farm bridge; designed with road approaches lowered to allow floodwaters to go around bridge	Moderate
R23-A	100305003003051	Bridge	Kate Brook Road	76	None; newer bridge, good condition	Low
R23-A	700000000308103	Bridge	Railroad	78	Deposition above, scour above and below	Low
R22-D	200030006108102	Bridge	Route 15	85	None; good condition	Low
R22-B	200030005808102	Bridge	Route 15	158	None noted, not a constriction; newer	NR[1]

Table 5. Lamoille River from Hardwick to Johnson Stream Crossing Structures						
Reach/ Segment No.	Structure No.	Structure Type	Road Name/ Location	% Channel Width	Phase 2 Notes	Priority for Replacement
					bridge not impacting river	
R22-A	700000000208103	Bridge	Railroad	93	Scour above, alignment	Low
R22-A	100810000608101	Bridge	School Street	85	Deposition above and below, alignment; good condition, truss bridge; new cement footers poured onto bedrock	Low
R21	100810000808101	Bridge	Elmore Pond Road	83	Deposition above, scour above and below; newer bridge	Low
R20	100810002508101	Bridge	Corley Road	67	Deposition above, scour above and below, alignment; newer bridge, could remove old abutments – narrower than new abutments	Moderate
R20	700000000108103	Bridge	Railroad	100	Deposition above, scour above and below	Low
R18	200240000108072	Bridge	Park Street	75	Deposition above and below, scour above, alignment	Moderate
R16	200239000808072	Bridge	Cady's Falls Road	86	Scour above and below	Low
R15	700000000008073	Bridge	River Ridge Road	47	Deposition below, scour above	High
R15	700000000108063	Bridge	Railroad	98	Deposition above and below, scour above and below	Low
R14-A	100806000608061	Bridge	Railroad Street	79	Deposition below, scour above and below; old steel truss bridge	NR[1] – being replaced at time of assessment
NR[1] : Structure not recommended for replacement.						

Figure 9: Railroad Street Bridge in Reach 14-A under construction.

6.0 Stressor, Departure and Sensitivity Analysis

Stressor, departure and sensitivity maps are presented here as a means of displaying the effects of all significant physical processes occurring within the Lamoille River stream network from Hardwick to Johnson that were observed during the Phase 1 and Phase 2 Stream Geomorphic Assessments. These maps also provide an indication of the degree to which the channel adjustment processes within the watershed have been altered, at both the watershed scale and the reach scale. The analysis of existing and historic departures from equilibrium conditions along a stream network allows for the prediction of future alterations within the watershed. This is helpful in developing and prioritizing potential protection and restoration projects.

6.1 Departure Analysis and Stressor Identification

6.1.1 Hydrologic Regime Stressors

The hydrologic regime is the timing, volume, and duration of flow events throughout the year and over time and is characterized by the input and manipulation of water at the watershed scale. When the hydrologic regime has been significantly changed, stream channels will respond by undergoing a series of channel adjustments. The land use within the watershed plays a role in the hydrology of the receiving waters. The percentage of urban and cropland development within the watershed are factors which change a watershed's response to precipitation. The most common effects of urban and cropland development is increasing peak discharges and runoff by reducing infiltration and travel time (United States Department of Agriculture, 1986).

The dominant watershed land cover/land use within the Lamoille watershed is forest. None of the 10 reaches within the study area resulted in a watershed land cover/land use impact rating of high (10% or more is crop and/or urban). Analysis of hydric soils located where current land uses are agricultural or urban indicates some minor loss of wetland attenuation. Historical deforestation in the study area may also have contributed to historic incision.

The study area has a modest network of roads as shown on page 1 of Appendix 2. Stormwater inputs within the Lamoille River watershed are mapped on page 2 of Appendix 2. Extensive road networks can contribute significantly to increased flows within a river resulting both from increased runoff and stormwater ditching. According to Foreman and Alexander (1998), increased peak flows in streams may be evident at road densities of 3.2 miles/ square mile. Six of the 10 subwatersheds in the study area have road densities less than 3.0 miles/square mile, while four have road densities greater than 3.0 miles/square mile.

6.1.2 Sediment Regime Stressors

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 regime, and the specific morphology of the valley, floodplain, and stream. The Sediment Load Indicators Map (Page 3 of Appendix 2) shows the distribution of sediment load indicators in the Lamoille River watershed from Hardwick to Johnson at the watershed scale. Mass wasting sites were identified during the Stream Geomorphic Assessments in segments R14-B, R15, R16 and R20. Localized areas of bank erosion and depositional features (steep riffles, mid channel bars, delta bars, flood chutes, and/or avulsions) are prevalent.

6.1.3 Reach Scale Sediment Regime Stressors

The previously discussed alterations to flow and sediment load at the watershed scale serve as a pretext for understanding the timing and degree to which reach scale modifications are contributing to field observed channel adjustment. When the valley, floodplain, channel and channel boundary conditions are modified, a stream may change the way sediment is transported, sorted, stored and distributed. The stressors that alter these conditions either increase or decrease stream power and or increase or decrease the resistance of its boundary conditions. This is helpful for determining why a reach is under adjustment and what types of management activities will be beneficial in returning the stream to equilibrium conditions. The primary stressors in each segment of the study area are identified in Table 6. Increases in stream power are represented in Table 6 with bold print, while plain text is used for decreases. The stressors were given a rating of moderate, high and extreme (see legend at bottom or table).

Table 6. Lamoille River from Hardwick to Johnson Hydrologic and Sediment Load Stressors

	Watershed Input Stressors		Reach Modification Stressors	
River Segment	Hydrologic	Sediment load	Stream Power **Bold**=increase Plain=decrease	Boundary Resistance **Bold**=increase Plain=decrease
R23 B	Wetland loss		Grade Control **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (H)
R23 A	Wetland loss	Historic Degradation Erosion (H) Depositional Features (M)	Constrictions **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E) **Armoring (M)**
R22 D	Wetland loss	Erosion (H) Depositional Features (M)	Constriction Grade Controls **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E) **Armoring (H)**
R22 C	Wetland loss		Constriction Grade Control **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (M)
R22 B	Wetland loss		Constrictions Grade Controls **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E)
R22 A	Wetland loss	Historic Degradation Erosion (H)	Constrictions Grade Controls **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E) **Armoring (H)**
R21	Wetland loss	Historic Degradation Erosion (H) Depositional Features (M)	Constriction **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E) **Armoring (M)**
R20	Wetland loss	Historic Degradation Erosion (H)	Constrictions **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (H) **Armoring (M)**
R19	Wetland loss	Historic Degradation Erosion (H) Depositional Features (M)	**Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E) **Armoring (H)**
R18	Wetland loss Road Density (M)	Historic Degradation Erosion (H) Depositional Features (M)	Constriction **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (H) **Armoring (M)**
R16	Wetland loss	Historic Degradation Erosion (M) Depositional Features (M)	Constriction **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E)

Table 6. Lamoille River from Hardwick to Johnson Hydrologic and Sediment Load Stressors				
	Watershed Input Stressors		Reach Modification Stressors	
River Segment	Hydrologic	Sediment load	Stream Power **Bold**=increase Plain=decrease	Boundary Resistance **Bold**=increase Plain=decrease
R15	Wetland loss Road Density (M)	Historic Degradation Erosion (M)	Constrictions Grade Control **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E) **Armoring (M)**
R14 B	Road Density (M)		Constriction Grade Controls **Straightening (H)** **Encroachment (H)**	
R14 A	Stormwater Inputs (H) Road Density (M)	Erosion (H) Depositional Features (H)	Constriction **Straightening (H)** **Encroachment (H)**	Reduced riparian vegetation (E) **Armoring (H)**

M = Moderate

- Stormwater Inputs and Depositional Features 2-5 mile; Road Density 3-4 mi/sq. mi.
- Straightening, Bank Armoring, Erosion, and Encroachment 5-20%
- Urban 5-10%; Reduced Riparian Buffer 5-20%

H = High

- Stormwater Inputs and Depositional Features >5 mile; Road Density 5-6 mi/sq. mi.
- Straightening, Bank Armoring, Erosion, and Encroachment >20%
- Urban 10-20%; Reduced Riparian Buffer 20-50%

E = Extreme

- Reduced Riparian Buffer >50%; Urban >20%

* Shading indicates segment was not assessed during Phase 2 assessment

6.1.4 Channel Slope Modifiers

Results from the Lamoille River watershed from Hardwick to Johnson indicate that primary stressors include extensive straightening of the channel along with road crossings and encroachments (see Channel Slope Modifiers map on page 4 of Appendix 2). The majority of the channel straightening within the study area was associated with Route 15, which runs parallel to the river, and farm fields within the river corridor.

Instances of gravel mining and dredging of the channel have occurred in reaches R20 and R23-A, according to interviews with personnel at the Vermont Agency of Natural Resources. It is also likely that some dredging may have occurred during the straightening process in areas where the channel has been modified.

6.1.5 Boundary Conditions and Riparian Modifiers

Riparian buffers provide many benefits. Some of these benefits are protecting and enhancing water quality, providing fish and wildlife habitat, providing streamside shading, and providing root structure to prevent bank erosion. Five stream segments, R23-A, R22-A, R21, R16, and R14-A had over 70 percent of the reach with little or no buffer on at least one bank. Most other segments had intermittent locations with riparian buffers less than 25 feet. Areas with little to no buffer were indexed by Bear Creek Environmental based on NAIP photos and are shown on the Boundary Conditions and Riparian Modifiers map (Page 5 of Appendix 2). These stream reaches which lack a high quality riparian buffer are at a significantly higher risk of experiencing high rates of lateral erosion.

6.1.6 Constraints to Sediment Transport and Attenuation

Successful river corridor restoration and protection projects depend on a thorough understanding of the sources, volumes, and attenuation of flood flows and sediment loads within the stream network. If increased loads are transported through the network to a sensitive reach, where conflicts with human investments are creating a management expectation, little success can be expected unless the restoration design accommodates the increased load or finds a way to attenuate the loads upstream (Vermont Agency of Natural Resources, 2007a).

Within a reach, the principles of stream equilibrium dictate that stream power and sediment will tend to distribute evenly over time (Leopold, 1994). Changes or modifications to watershed inputs and hydraulic geometry create disequilibrium and lead to an uneven distribution of power and sediment. Large channel adjustments observed as dramatic erosion and deposition may be the result of this uneven distribution and may continue.

The sediment regime departure map (Page 6 of Appendix 2) shows the Phase 1 reference stream sediment conditions for each reach within the stream network. These reference type streams use available floodplain access as a means to store sediment within the watershed. The majority of the stream network has a reference sediment regime of a *Coarse Equilibrium (in=out) & Fine Deposition*. The bedrock dominated reaches generally have a *Transport* sediment regime.

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 some reach segments. Four segments (R18, R19, R22-A and R23-A) that were *Coarse Equilibrium (in=out) & Fine Deposition* type segments by reference have been converted to *Fine Source and Transport & Coarse Deposition* sediment regimes based on the Phase 2 Stream Geomorphic Assessment data. Fine sediment entering the stream is being transported through without being deposited as a result of channel incision and reduced floodplain access. Additionally coarse sediment storage is increased due to increased load along with lower transport capacity. One segment (R14-A) that was

Transport by reference has been converted to a *Confined Source and Transport* sediment regime from increased sediment supply due to extreme incision and resultant widening and planform adjustment. All departures were derived from the DMS according to the sediment regime criteria established by the Vermont Agency of Natural Resources (2007a).

The existing sediment regime for the Lamoille River watershed from Hardwick to Johnson includes reduced floodplain access, increased stream power, reduced boundary resistance, and lateral constraints at various locations throughout the stream network. Watersheds which 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, 2007a). Segments and reaches of the study area that can act as attenuation assets are identified below to help in designing stream corridor protection and restoration projects within the stream network.

6.2 Sensitivity Analysis

Stream sensitivity refers to the likelihood that a stream will respond to a watershed or local disturbance or stressor, such as; floodplain encroachment, channel straightening or armoring, changes in sediment or flow inputs, and/or disturbance of riparian vegetation (Vermont Agency of Natural Resources, 2007b).

Assigning a sensitivity rating to a stream is done with the assumption that some streams, due to their setting and location within the watershed, are more likely to be in an episodic, rapid, and/or measurable state of change or adjustment. A stream's inherent sensitivity may be heightened when human activities alter the setting characteristics that influence a stream's natural adjustment rate including: boundary conditions; sediment and flow regimes; and the degree of confinement within the valley. Streams that are currently in adjustment, especially those undergoing degradation or aggradation, may become acutely sensitive (Vermont Agency of Natural Resources, 2007b).

There are many variables that are contributing to the sensitivity of the streams in the Lamoille River watershed from Hardwick to Johnson. The existing geomorphic condition and stream sensitivity of the Phase 2 assessed reaches are presented in Table 7.

Table 7. Stream Sensitivity for Phase 2 Reaches

Segment Number	Reference Stream Type	Existing Stream Type	Stream Type Departure	Geomorphic Condition	Sensitivity
R23-B	Not Evaluated – Impounded				
R23-A	C4	C4	No	Fair	Very High
R22-D	B4c	B4c	No	Fair	High
R22-C	Not Evaluated – Impounded				
R22-B	Not Evaluated – Bedrock				

Table 7. Stream Sensitivity for Phase 2 Reaches

Segment Number	Reference Stream Type	Existing Stream Type	Stream Type Departure	Geomorphic Condition	Sensitivity
R22-A	C4	F4	Yes	Fair	Extreme
R21	C4	C4	No	Fair	Very High
R20	C4	C4	No	Fair	Very High
R19	C4	C4	No	Fair	Very High
R18	C4	C4	No	Fair	Very High
R17	Not Evaluated – Impounded				
R16	C4	C4	No	Fair	Very High
R15	C4	C4	No	Fair	Very High
R14-B	Not Evaluated – Bedrock				
R14-A	B3	F3	Yes	Fair	Extreme

The location and slope of a stream also affects is morphology and sensitivity. Streams that are transporting sediment through the channel are less sensitive than streams that are storing and responding to sediment. Additionally, flow regime and floodplain constrictions may be affecting the sensitivity of the study area. Changes in land use and land cover that increase impervious cover, peak discharges, and/or the frequency of high flows will heighten a stream's sensitivity to change and adjustment. Confinement becomes a significant sensitivity concern when structures such as roads, railroads, and berms significantly change the confinement ratio, reduce or restrict a stream's access to floodplain, and result in higher stream power during flood stage. The map on page 7 of Appendix 2 presents the stream sensitivity, generalized according to stream type and condition as per the VANR protocol, and current adjustments for each reach segment in the Lamoille River watershed from Hardwick to Johnson. Sensitivity ratings have not been assigned for segments that were not fully assessed during the Phase 2 study.

The stream sensitivity map also documents vertical channel adjustments currently going on within a reach segment. Major degradation or aggradation adjustment processes are displayed on the sensitivity corridors were they were found to be actively occurring and they were not evaluated as historic. This information is helpful in prioritizing the implementation of the projects identified in section 7 of this report, as certain management actions may be influenced by these active adjustment processes. Current major aggradation is occurring in the following segments:

Segment ID	Current Major Adjustment Process
R23-A	Aggradation
R19	Aggradation
R18	Aggradation
R16	Aggradation
R15	Aggradation

7.0 PRELIMINARY PROJECT IDENTIFICATION AND PRIORITIZATION

The departure and sensitivity analyses presented in Section 6.0 of this report provide beneficial background for selecting potential projects that will effectively help the channel return to equilibrium conditions by assessing limiting factors and by identifying underlying causes of channel instability. The stream reaches evaluated in this study present a variety of planning and management strategies which can be classified under one of the following categories: Active Geomorphic Restoration, Passive Geomorphic Restoration, and Conservation.

Active Geomorphic Restoration implies the management of rivers to a state of geomorphic equilibrium through active, physical alteration of the channel and/or floodplain. Often this approach involves the removal or reduction of human constructed constraints or the construction of meanders, floodplains or stable banks. Active riparian buffer revegetation and long-term protection of a river corridor is essential to this alternative.

Passive Geomorphic Restoration allows rivers to return to a state of geomorphic equilibrium by removing factors adversely impacting the river and subsequently using the river's own energy and watershed inputs to re-establish its meanders, floodplains and equilibrium conditions. In many cases, passive restoration projects may require varying degrees of active measures to achieve the ideal results. Active riparian buffer revegetation and long-term protection of a river corridor is also essential to this alternative.

Conservation is an option to consider when stream conditions are generally good and nearing a state of dynamic equilibrium. Typically, conservation is applied to minimally disturbed stream reaches where river structure and function and vegetation associations are relatively intact.

There are a number of voluntary programs available for river protection. Two of the primary programs are the Conservation Reserve Enhancement Program (CREP) and the River Corridor Easement (RCE). CREP is a program that helps protect environmentally sensitive land, decrease erosion, and restore wildlife habitat by taking land out of agricultural production. An overview of the Conservation Reserve Enhancement Program is found at http://www.fsa.usda.gov/FSA/webapp?area=home&subject=lown&topic=cep. 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. A description of each of the programs prepared by the Vermont River Management Program is provided below.

Conservation Reserve Enhancement Program

- 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.

River Corridor Easement (RCE)

- 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.

7.1Watershed-Level Opportunities

Fluvial Erosion Hazard Zones

Of all types of natural hazards experienced in Vermont, flash flooding represents the most frequent disaster mode and has resulted in by far the greatest magnitude of damage suffered by private property and public infrastructure. While inundation-related flood loss is a significant component of flood disasters, the predominant mode of damage is associated with the dynamic, and oftentimes catastrophic, physical adjustment of stream channel dimensions and location during storm events due to bed and bank erosion, debris and ice jams, structural failures, flow diversion, or flow modification by man-made structures. These channel adjustments and their devastating consequences have frequently been documented wherein such adjustments are related to historic channel management activities, floodplain encroachments, adjacent land use practices and/or changes to watershed hydrology associated with land use and drainage.

The purpose of defining Fluvial Erosion Hazard Zones is to prevent increases in man-made conflicts that can result from development in identified fluvial erosion hazard areas; minimize property loss and damage due to fluvial erosion; and prohibit land uses and development in fluvial erosion hazard areas that pose a danger to health and safety. The basis of a Fluvial Erosion Hazard Zone is a defined river corridor which includes the course of a river and its adjacent lands. The width of the corridor is defined by the lateral extent of the river meanders, called the meander belt width, which is governed by valley landforms, surficial geology, and the length and slope requirements of the river channel. The width of the corridor is also governed by the stream type and sensitivity of the stream. River corridors, as defined by the Vermont Agency of Natural Resources (2008), are intended to provide landowners, land use planners, and river managers with a meander belt width which would accommodate the meanders and slope of a balanced or equilibrium channel, which when achieved, would serve to maximize channel stability and minimize fluvial erosion hazards. Information collected during the Phase 2 Assessment including reach sensitivity, reach condition, and stream type is used to develop these zones. Towns have the opportunity to work with the Vermont River Management Program to develop fluvial erosion hazard zones to reduce conflicts within the river corridor.

STORMWATER

Stormwater runoff rates are of particular concern in urbanized and agricultural watersheds because stormwater runs off from impervious surfaces rather than naturally infiltrating the soil. The cumulative effect of the increased frequency, volume, and rate of stormwater runoff results in increases in wash-off pollutant loading to streams and destabilization of stream channels. All potential restoration projects within the Lamoille watershed should be evaluated in terms of their effects on stormwater.

7.2 Reach-Level Opportunities

A description of each reach/segment is provided in this section along with general recommendations for restoration and protection strategies. The reaches are listed from downstream to upstream. Further details about project types for each reach will be discussed in Section 7.3.

Lamoille River from Hardwick to Johnson (R23-R14)

Reach R23

Reach R23 was segmented due to the impoundment of water behind the dam at Hardwick Lake which is located in the upstream part of reach R23.

R23-B

The most upstream segment of the Lamoille River Phase 2 geomorphic assessment, segment R23-B, received only a partial assessment due to the influence of the run-of-river dam at Hardwick Lake which impounds the Lamoille River (Figure 13).

Figure 13. R23-B is affected by the impoundment of water behind the Hardwick Lake dam.

R23-A
Improve Riparian Buffer
CREP
Floodplain Mitigation

Lamoille River segment R23-A begins below Hardwick Lake Dam and continues downstream through a broad valley until just above the Route 15 Bridge crossing. This segment received a fair geomorphic rating as a result of historic channel degradation (which may be associated with the disruption of sediment transport from the dam upstream). The presence of numerous mid-channel, point, and side bars are indicative of major channel adjustment.

Hay fields, forest, and some residential development were noted to be the dominant land uses within the riparian corridor. The buffer was highly disturbed on both sides (<5 feet in width) with herbaceous vegetation as the dominant vegetation type (Figure 14). There are a number of programs available, such as CREP (see Section 7.0), which are available for landowners to expand the riparian buffer in an effort to improve water quality.

A site (Hardwick_1), located to the east of the Wolcott/Hardwick town line was selected by Milone and MacBroom as a possible floodplain restoration project on the Lamoille Valley Rail Trail. Floodplain mitigation would benefit the Lamoille River within R23-A by providing locations where flood and sediment attenuation could occur.

Figure 14. R23-A has undergone historic channel degradation. The incision ratio, illustrated in this photograph, was recorded at 1.5. Major disturbance of the riparian buffer is also evident in this photograph.

Reach R22

Lamoille River reach R22 was broken into four segments to account for influences of a dam and bedrock grade control which alter the flow and sediment regime of the reach.

R22-D
Improve Riparian Buffer
River Corridor Easement

Lamoille River segment R22-D begins just above a Route 15 bridge in Wolcott and flows downstream for 3,519 feet before the hydropower dam changes the water surface slope of the river. This segment flows through predominately forested land and is bordered by the old Lamoille Valley railroad line on the east bank. The fill of the rail bed has altered the floodprone width of the river. There is a lack of buffer on both sides due to the encroachment of the road and railroad and agricultural fields (Figure 15). Riverside plantings are recommended for this segment to improve the riparian buffer. A river corridor easement would allow room in the west corridor for the river to adjust.

Figure 15. Lack of buffer on eastern bank due to encroachment in R22-D.

R22-C

Lamoille River segment R22-C was created to capture the influence of a hydropower dam on the stream channel (Figure 16). The segment begins just upstream from the hydropower dam east of Wolcott and continues to the powerhouse location for the dam where the flow of the Lamoille is again moving at its full capacity. Due to the extreme influence of the dam on the flow of water and sediment, this segment was only partially assessed.

Figure 16. The hydropower dam east of Wolcott village alters the flow of sediment and water in segment R22-C.

R22-B

Below the dam powerhouse, the Lamoille once again becomes a free flowing river. Within segment R22-B, the Lamoille River is squeezed through a 3,258 foot long valley over and against bedrock ledges and into deep wide pools.

The extensive presence of bedrock (Figure 17) and absence of floodplain essentially make this segment a bedrock gorge that transports sediment and water. Segment R22-B was only given a partial assessment because of the abundant bedrock in the channel and stable nature of the system.

Figure 17. Abundant bedrock grade controls within R22-B.

R22-A

Improve Riparian Buffer

Lamoille River segment R22-A flows through Wolcott Village. It begins just upstream from the confluence with the Elmore Branch and continues to the confluence of Wolcott Pond Brook, which enters on the north bank behind the Wolcott General Store. Although speckled here and there with bedrock ledge on the bed and banks, the valley walls broaden in R22-A. The Lamoille River has historically had floodplain access in R22-A and the ability to undergo some lateral adjustment through the Village of Wolcott.

Influences of the village on segment R22-A are significant. There is little to no riparian buffer throughout much of the segment. Several stormwater inputs were recorded, as was an abundance of channel straightening, rock armoring, and floodplain encroachment. The reference stream type is "B", however, in response to the extensive manipulation the river has become an "F" type stream channel with almost no floodplain access (Figure 18). Plantings in segment R22-A are recommended to improve the riparian buffer. However, given the extreme historic incision and active major widening, plantings along the near bank are not recommended. Rather, plantings should take place back from the river bank and should be in areas that are not prone to active erosion.

Figure 18. R22-A has been historically straightened and managed causing extensive floodplain loss.

Reach R21
Improve Riparian Buffer
CREP

Lamoille River reach R21 begins below Wolcott Village and continues downstream to where the Wild Branch, a major tributary, enters on the north bank. The reach flows through hay fields, forest, and residential lands in a very broad valley that has been narrowed by Vermont Route 15 and the Lamoille Valley rail bed. Historic degradation within the reach has led to active widening and planform adjustment (Figure 19). Many of the side and point bars observed are being outflanked by the river indicating active planform adjustment. Riparian vegetation is absent or minimal along much of the reach and is dominated by herbaceous plants. CREP or other programs, such as the U.S. Fish and Wildlife Service Partners for Wildlife Program, are recommended to improve the riparian corridor in Reach 21.

Figure 19. Lamoille reach R21 is undergoing major planform adjustment and widening.

Reach R20
Improve Riparian Buffer
CREP

Reach R20 begins below the Wild Branch and flows through a very broad valley for 8,215 feet to the confluence with Jones Brook and a change in reference valley confinement. Similar to the upstream reach, R21, this reach flows through hay fields and forest and past residential properties. The reach appears to have been extensively historically straightened (Figure 20). The low incision ratio of 1.14 makes reach R20 a high priority for streamside plantings. Widening was only a minor process in this reach and trees planted along the bank are at lower risk of being uprooted due to channel adjustment.

Figure 20. Lamoille River reach R20 is straightened and flows through a broad valley.

Reach R19
Improve Riparian Buffer

Lamoille River reach R19 begins at the confluence of Jones Brook in Wolcott and flows through a narrow valley until the valley width broadens again east of Morrisville. The reach has been further confined (to a semi-confined valley) by Route 15 and the old Lamoille railway bed (Figure 21). Despite these confinements, the reach has remained a "C" type gravel bed channel with a riffle-pool bedform.

The south side of the river channel is dominated by forested lands with a wide buffer over 100 feet. On the north side of the channel, the riparian vegetation has been significantly removed to less than 5 feet in width as it flows through industrial land and hay fields. Streamside plantings on the north side of the channel are of lower priority given the major historic incision and major active widening that was noted in this reach.

Figure 21. Lamoille River reach R19 with a narrow floodplain visible in the background.

Reach R18
Improve Riparian Buffer
CREP
River Corridor Easement

Lamoille River reach R18 begins east of Morrisville and continues to just above the dam in Morrisville village. By reference this is a broad valley, however, floodplain encroachment by Route 15 and the Lamoille Valley railroad bed has altered the confinement to "narrow" as the stream flows through hay fields and residential land (Figure 22). Much of the riparian vegetation has been removed along this reach. The channel has experienced historic degradation and is currently aggrading, widening, and undergoing planform adjustment. It appears that the channel had been intentionally moved against the valley wall in several locations of the reach. Numerous mid-channel and side bars indicate that the stream is attempting to develop more meanders in response to this historic channel realignment.

Plantings are recommended in reach 18 to improve the riparian buffer. Due to the moderate incision, the plantings were given a moderate priority in the project identification table (see Table 9). There is active major widening and planform adjustment in R18, and plantings should take place back from the river bank and should be in areas that are not prone to active erosion. River corridor protection through a corridor easement is a lower priority because of the current encroachment within the river corridor by Route 15 and the railroad bed.

Figure 22. Lamoille River reach R18 has been historically straightened and is incised.

Reach R17

R17 was not assessed because a dam is located within the reach and is greatly impounding the river. Just downstream of the dam is Cady's Falls and was therefore not appropriate for a full assessment.

Reach R16
Improve Riparian Buffer
CREP
Reach R16 begins just downstream of Cady's Falls and continues to the confluence with Centerville Brook. Overall this reach exhibited a plane-bed bedform, although occasional riffles were noted to have sedimented characteristics. Many areas were lacking a healthy riparian buffer and would benefit from CREP and/or streamside plantings.

Reach R15
Improve Riparian Buffer
Floodplain Mitigation Reach R15 begins below the confluence with Centerville Brook and continues to just above Dog Head Falls, southeast of Johnson Village near a USGS gaging station. This reach mostly exhibits a plane-bed bedform. There is generally a healthy riparian buffer, but some locations could use improvement. Stream side plantings are recommended in reach R16 to improve the riparian buffer. The low to moderate incision ratio makes R15 a relatively good location for planting. Two sites on the Lamoille Valley Rail Trail within R15 (Johnson_2 and Hyde Park_1) were identified by Milone and MacBroom as potential floodplain mitigation sites (refer to map on page 7 of Appendix 3).

The implementation of this project would help improve flood and sediment attenuation within R15.

Reach R14

Lamoille River reach R14 begins above a series of falls east of Johnson village and continues downstream to the mouth of the Gihon River. The reach was segmented to capture changes in bed and bank stability associated with the bedrock waterfalls that are located in the upstream segment.

R14-B

Lamoille River segment R14-B begins at Dog Head Falls, a bedrock waterfall east of Johnson Village. The segment continues downstream to Slide Falls (Figure 23), another large bedrock drop on the mainstem of the Lamoille River. Due to the influence of bedrock on the stream channel this segment received only a partial geomorphic assessment.

Figure 23. The stream channel of segment R14-B is heavily influenced by bedrock ledges such as this one, known as Slide Falls.

R14-A

Lamoille River segment R14-A begins below Slide Falls, east of Johnson village, and continues to the mouth of the Gihon River. Historic floodplain encroachment, fill, and channel straightening within the Village of Johnson have significantly altered the floodplain within segment 14-A. The alteration has caused major historic incision, which has resulted in a loss of floodplain access (Figure 24). Widening and planform adjustment are expected, but the extensive armoring along the banks has limited these processes. The removal of riparian vegetation has impacted both banks. There has been a stream type departure from a "C" to an "F" channel due to the extensive disturbance.

Figure 24. R14-A flows through Johnson Village. Historic channel straightening and floodplain encroachment have resulted in loss of floodplain access.

7.3 Previous Site Level Restoration Efforts

As described above in the Reach Level Opportunities (Section 7.2), channels with disconnected floodplains are common along the Lamoille River. A large floodplain restoration project was completed in 2008 along Black Creek and Lamoille River in 2008 (please see Appendix 3 for a description of this restoration work). Six miles of former rail embankment was removed to reconnect over 200 areas of historic floodplain (Schiff, et. al, not dated). Two of the ten projects selected for the restoration project (Wolcott 1 and Johnson 1) are located with the Lamoille River study area from Hardwick to Johnson.

7.4 Proposed Site Level Restoration Opportunities

River corridor easements along the Lamoille River would be beneficial for reducing armoring and straightening by transferring channel management rights to a second party (such as a land trust). The inclusion of the entire fluvial erosion hazard zone (river corridor) in a corridor easement is expensive due to the size of the floodplain of the Lamoille River main stem. In areas where landuse is in conflict with the Lamoille River main stem, a narrower corridor than the fluvial erosion hazard zone could be defined as part of a corridor easement. Reaches R15 (in Johnson and Hyde Park), R18 (Morristown), and R20 and R21 (Wolcott) are areas where planform adjustment has been identified as a major process. Areas with major to extreme planform adjustment are more apt to result in landowner concerns and conflicts with the river. As landowners approach the Agency of Natural Resources with their concerns and questions about armoring stream banks, this provides an opportunity to discuss the possibility of a corridor easement as an alternative.

Site specific projects were identified using the criteria outlined by the VANR in Chapter 6 Preliminary Project Identification and Prioritization (Vermont Agency of Natural Resources, 2007a). This planning guide is intended to aid in the development of projects that protect and restore river equilibrium. The site level projects that were developed for the Lamoille River from Hardwick to Johnson are provided below in Tables 8 through 11. The project strategy, technical feasibility, and priority for each project are listed by project number and reach. Maps of the project sites are shown in Figures 25 through 28. Projects include river corridor protection to provide attenuation of sediment and floodwaters through corridor easements, riparian buffer improvement areas and the replacement or retrofitting of undersized stream crossing structures. Information from the Phase 2 stream geomorphic assessment and VANR bridge and culvert assessment could be used to inform the Towns of Hardwick, Wolcott, and Morristown of which stream crossings are contributing to localized instability. The high priority projects include:

- **Active Restoration** of floodplain on the Lamoille Valley Rail Trail in Hardwick (project #2);
- **Passive Restoration** with streamside plantings from just downstream of railroad bridge to rapid section near downtown Wolcott (project #6);
- **Passive Restoration** with streamside plantings from Centerville Brook to Cady's Falls (project #10);
- **Active Restoration** of bridge replacement/retrofit at River Ridge Road crossing (project #11);
- **Active Restoration** of floodplain on the Lamoille Valley Rail Trail in Hyde Park (project #12)
- **Passive Restoration** through streamside plantings from Dog Head Falls to Centerville Brook (project #14); and
- **Active Restoration** of floodplain on the Lamoille Valley Rail Trail in Johnson (project #15).

Table 8. Lamoille River Site Level Opportunities for Restoration and Protection Wolcott and Hardwick, Vermont (see Map #1)

Project # Segment	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners
#1 From upstream of Route 15 Bridge in Wolcott to Route 15 Bridge just downstream of Hardwick Lake Dam (Wolcott and Hardwick) R23-A	Passive Restoration	Fair geomorphic rating due to historic degradation, which may be due to sediment retention in upstream dam. Many depositional features and major planform adjustment. Lack of buffer from hay fields is prevalent.	Improve riparian buffer through streamside plantings.	Moderate priority due to moderate incision ratio	Prevent erosion, improve habitat and reduce water temperature	Low cost of plantings	Hay fields to forested buffer	VANR, LCPC, landowner, CREP, US Fish and Wildlife Service
#2 LVRT just east of Johnson/ Hyde Park town line "Hardwick _1" (Hardwick) R23-A	Active Restoration	Location of potential floodplain mitigation site on the Lamoille Valley Rail Trail (Hardwick_1) identified by Milone and MacBroom (see map on page 7 of Appendix 3)	Floodplain mitigation	High priority	Improve flood and sediment attenuation	Unknown	Unknown	VANR, VTrans, VAST, LVRTC, LCPC, LNRCD

Table 9. Lamoille River Site Level Opportunities for Restoration and Protection Morristown and Wolcott, Vermont (see Map #2)								
Project # Segment	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project or Strategy Description**	**Technical Feasibility and Priority**	**Other Social Benefits**	**Costs**	**Land Use Conversion**	**Potential Partners**
#3 From a few thousand feet downstream of Route 15 Bridge to just upstream of the bridge (Wolcott) R22-D	Passive Restoration	Areas with no buffer and erosion, especially on west bank. Fill from the railroad bed has altered the floodprone width.	Protect River Corridor through corridor easement; Improve riparian buffer. Streamside plantings and/or natural regeneration of buffer.	Moderate priority due to small planting area	Reduce erosion, improve habitat and reduce water temperature	Low cost of plantings.	Hay fields to forested buffer	VANR, LCPC, landowner, US Fish and Wildlife Service, LNRCD
#4 From just behind General Store in Wolcott to just downstream of Route 15 (Wolcott) R22-A	Passive Restoration	Little to no riparian buffer throughout segment R22-A. Extreme historic incision with stream type departure.	Streamside plantings	Low priority for plantings due to extreme historic incision. Natural regeneration may be a better option. Little opportunity for ecological connectivity of wooded corridor because of roads.	Reduce erosion, improve habitat and reduce water temperature	Low cost of plantings.	Herbaceous to forested buffer	VANR, LCPC, landowner; US Fish and Wildlife Service, LNRCD
#5 From just downstream of Railroad Bridge to rapid section near downtown Wolcott. R20 and R21	Passive Restoration	Straightened for agricultural fields and road. Low incision ratios in both reaches. Major widening and planform change.	Protect River Corridor through corridor easement	Low priority - The river corridor is wide and costs may be high. There may be opportunity to narrow the area included in the corridor easement.	Flood and sediment attenuation; Prevent erosion, improve habitat and reduce water temperature	Cost of corridor easements. Low cost of plantings.	Hay fields to forested buffer	VANR, LCPC, landowner, CREP, land trust
#6 From just downstream of Railroad Bridge to rapid section near downtown Wolcott. (Wolcott) R20 and R21	Passive Restoration	Riparian vegetation is dominated by herbaceous plants. Erosion is extensive.	Improve riparian buffer. Streamside plantings.	High priority due to low incision. Some opportunity for ecological connectivity by planting north side of river. The southern corridor is generally forested.	Reduce erosion, improve habitat and reduce water temperature	Low cost of plantings.	Hay fields to forested buffer	VANR, LCPC, landowner, CREP, US Fish and Wildlife Service, LNRCD

Table 10. Lamoille River Site Level Opportunities for Restoration and Protection Morristown and Wolcott, Vermont (see Map #3)								
Project # Segment	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project or Strategy Description**	**Technical Feasibility and Priority**	**Other Social Benefits**	**Costs**	**Land Use Conversion**	**Potential Partners**
#7 From about 1 mile upstream of Park Street bridge to Railroad Bridge (Morristown and Wolcott) R19	Passive Restoration	Many areas with no buffer on north side where riparian vegetation has been removed for industrial land and hay fields. Reach has incised and is widening though extensive erosion.	Improve riparian buffer. Streamside plantings and/or natural regeneration of buffer.	Low priority for planting due to moderate incision ratio	Reduce erosion, improve habitat and reduce water temperature	Low cost of planting and little to no cost for natural regeneration	Hay fields to forested buffer	VANR, LCPC, landowner, US Fish and Wildlife Service, LNRCD
#8 From just upstream of Bridge Street Crossing along Route 15 until just across from Ferland Pit Road (Morristown) R18	Passive Restoration	Much of the riparian vegetation has been removed. Floodplain encroachment of Route 15 and railroad bed. Historic incision and the reach is currently widening though extensive erosion, aggrading, and undergoing planform adjustment.	Protect River Corridor through corridor easement	Low priority - The river corridor is wide and costs may be high. There may be opportunity to narrow area included in the corridor easement.	Flood and sediment attenuation	Cost of corridor easement may be high due to wide corridor	Hay fields to forested buffer	VANR, LCPC, landowner, land trust
#9 From just upstream of Bridge Street Crossing along Route 15 until just across from Ferland Pit Road (Morristown) R18	Passive Restoration	Much of the riparian vegetation has been removed. Floodplain encroachment of Route 15 and railroad bed. Historic incision and the reach is currently widening though extensive erosion, aggrading, and undergoing planform adjustment.	Improve riparian buffer. Streamside plantings.	Moderate priority; the channel has a moderate incision ratio. There is less opportunity to provide ecological connectivity of forested area due to roads.	Reduce erosion, improve habitat and reduce water temperature	Low cost of plantings.	Hay fields to forested buffer	VANR, LCPC, landowner, CREP, US Fish and Wildlife Service, LNRCD

Table 11. Lamoille River Site Level Opportunities for Restoration and Protection Johnson, Hyde Park and Morristown, Vermont (see Map #4)								
Project # Segment	**Type of Project**	**Site Description Including Stressors and Constraints**	**Project or Strategy Description**	**Technical Feasibility and Priority**	**Other Social Benefits**	**Costs**	**Land Use Conversion**	**Potential Partners**
#10 Below Cady's Falls downstream to confluence with Centerville Brook (Morristown and Hyde Park) R16	Passive Restoration	Farm fields within corridor (mostly east side) have no buffer and could benefit from streamside plantings.	Improve riparian buffer. Streamside plantings.	High priority; the channel has a low to moderate incision ratio making this a relatively good location for tree planting efforts. Planting on the north side of the channel would provide an ecological connection to the south side, which is forested	Reduce erosion, improve habitat and reduce water temperature	Low cost of plantings. Higher cost for CREP agreement.	Hay fields to forested buffer	VANR, LCPC, landowner, CREP, US Fish and Wildlife Service, LNRCD
#11 River Ridge Road crossing (Morristown and Hyde Park) R15	Active Restoration	The River Ridge Road Bridge is undersized. Deposition below and scour above are issues with the bridge.	Bridge Replacement	High priority	Improved geomorphic stability	High cost for replacement	Unknown	Town of Morristown and Hyde Park, VANR, LCPC
#12 LVRT just east of Johnson/ Hyde Park town line "Hyde Park _1" (Hyde Park) R15	Active Restoration	Location of potential floodplain mitigation site on the Lamoille Valley Rail Trail (Hyde Park_1) identified by Milone and MacBroom (see map on page 7 of Appendix 3)	Floodplain mitigation	High priority	Improve flood and sediment attenuation	Unknown	Unknown	VANR, VTrans, VAST, LVRTC, LCPC, LNRCD

Table 11. Lamoille River Site Level Opportunities for Restoration and Protection
Johnson, Hyde Park and Morristown, Vermont (see Map #4)

Project # Segment	Type of Project	Site Description Including Stressors and Constraints	Project or Strategy Description	Technical Feasibility and Priority	Other Social Benefits	Costs	Land Use Conversion	Potential Partners
#13 From above Dog Head Falls to confluence with Centerville Brook (Johnson, Hyde Park, and Morristown) R15	Passive Restoration	Major planform adjustment is occurring with Reach M15.	Protect River Corridor through corridor easement to reduce conflicts and channel armoring	Low priority – The river corridor is wide and costs may be high. There may be opportunity to narrow the area included in the corridor easement.	Flood and sediment attenuation; Provide channel management alternatives	Cost of corridor easements may be high due to wide corridor	Field/yard to floodplain	VANR, LCPC, landowner, land trust
#14 From above Dog Head Falls to confluence with Centerville Brook (Johnson, Hyde Park, and Morristown) R15	Passive Restoration	Farm fields within corridor (mostly northeast side) have no buffer and could benefit from streamside plantings.	Improve riparian buffer. Streamside plantings.	High priority; the channel has a low incision ratio making this a good location for tree planting efforts. Planting on the north side of the channel would provide an ecological connection to the south side, which is forested	Reduce erosion, improve habitat and reduce water temperature	Low cost of plantings. Higher cost for CREP agreement.	Hay fields to forested buffer	VANR, LCPC, landowner, CREP, US Fish and Wildlife Service, Lamoille Natural Resources Conservation District (LNRCD)
#15 LVRT near River Road "Johnson_2" (Johnson) R15	Active Restoration	Location of potential floodplain mitigation site on the Lamoille Valley Rail Trail (Johnson_2) identified by Milone and MacBroom (see map on page 7 of Appendix 3)	Floodplain mitigation	High priority	Improve flood and sediment attenuation	Unknown	Unknown	VANR, VTrans, Vermont Association of Snow Travelers (VAST), Lamoille Valley Rail Trail Committee (LVRTC), LCPC, Lamoille Natural Resources Conservation District (LNRCD)

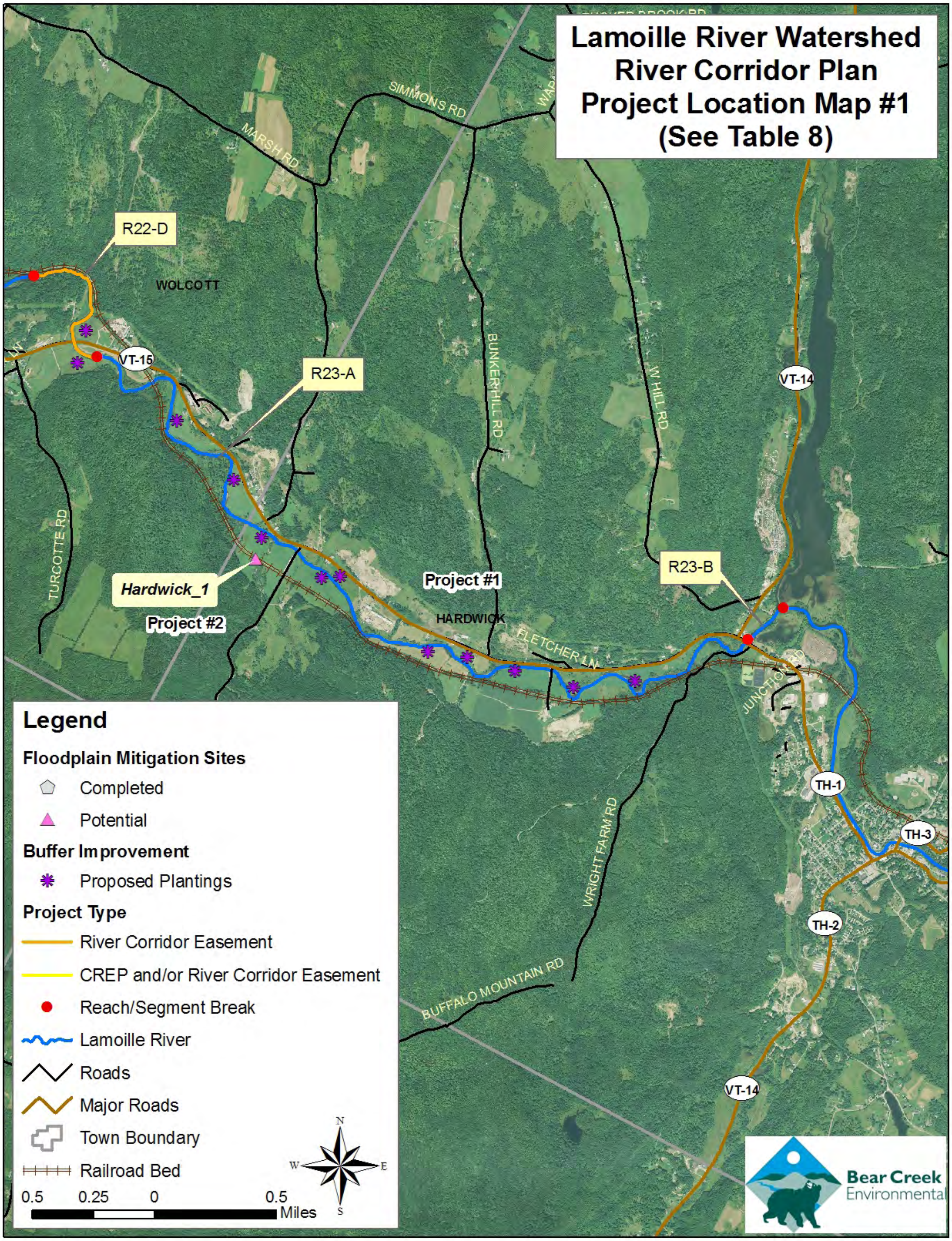

Figure 25. Proposed restoration and protection project for the Lamoille River reaches R23

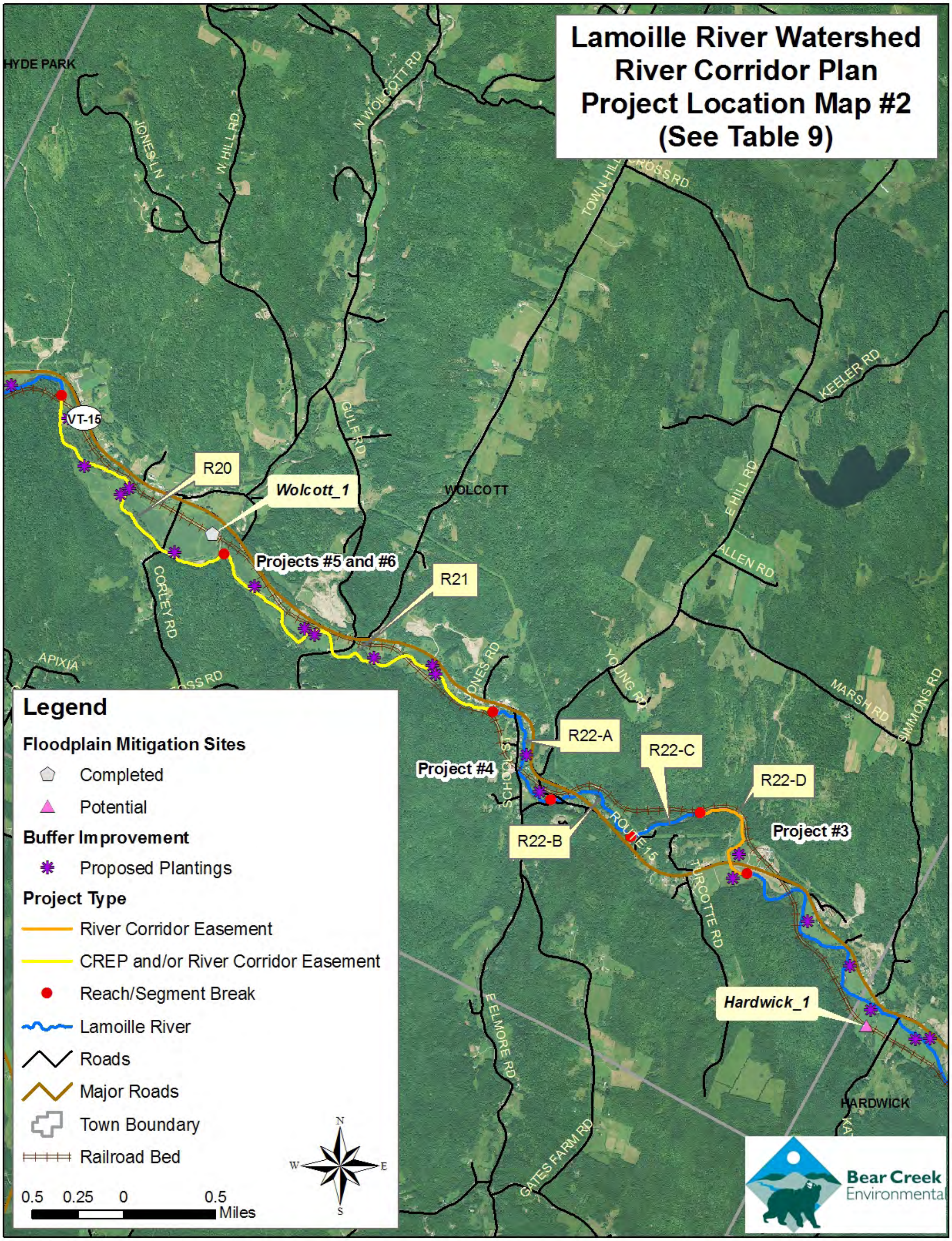

Figure 26. Proposed restoration and protection project for the Lamoille River reaches R20-R22

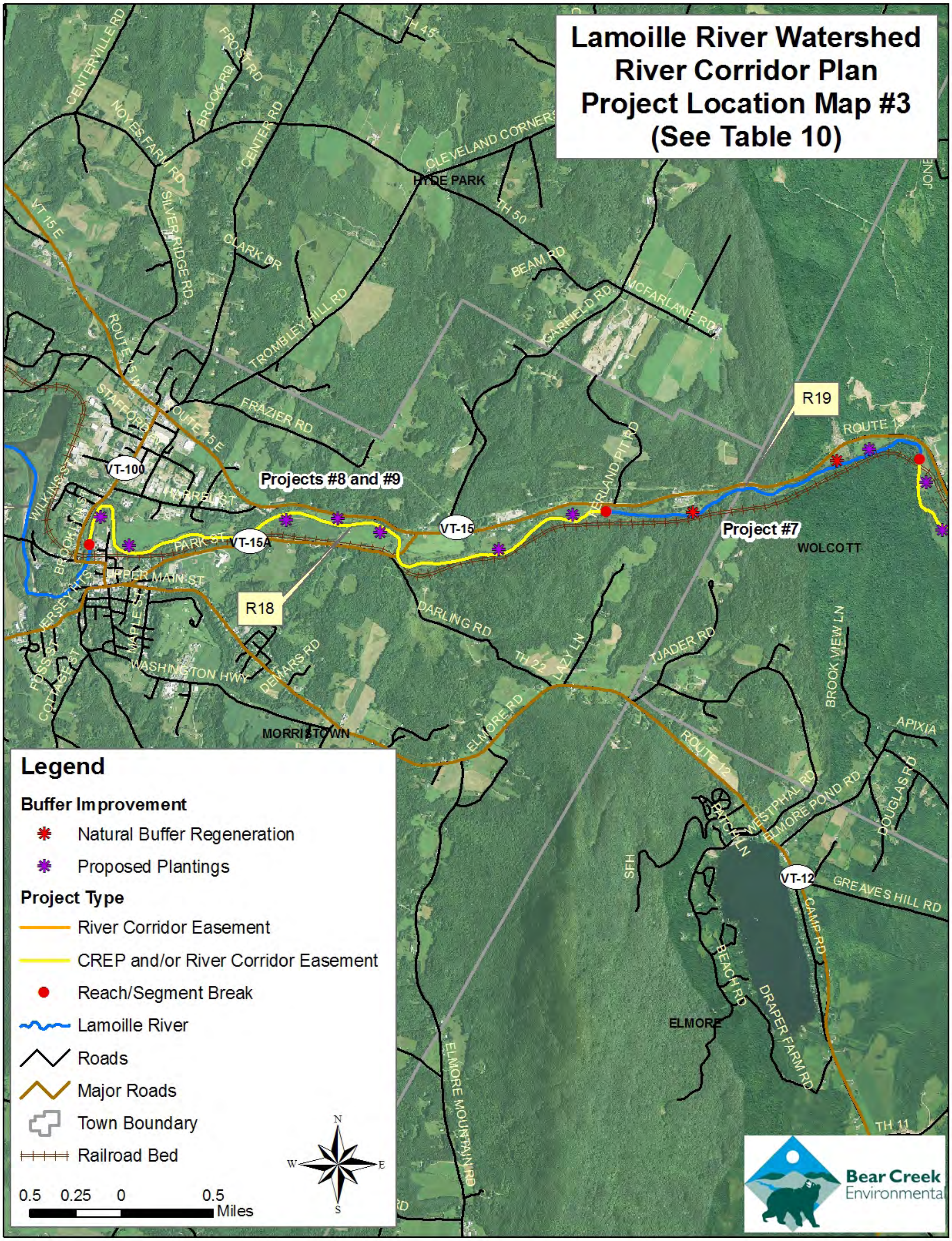

Figure 27. Proposed restoration and protection project for the Lamoille River reaches R18-R19

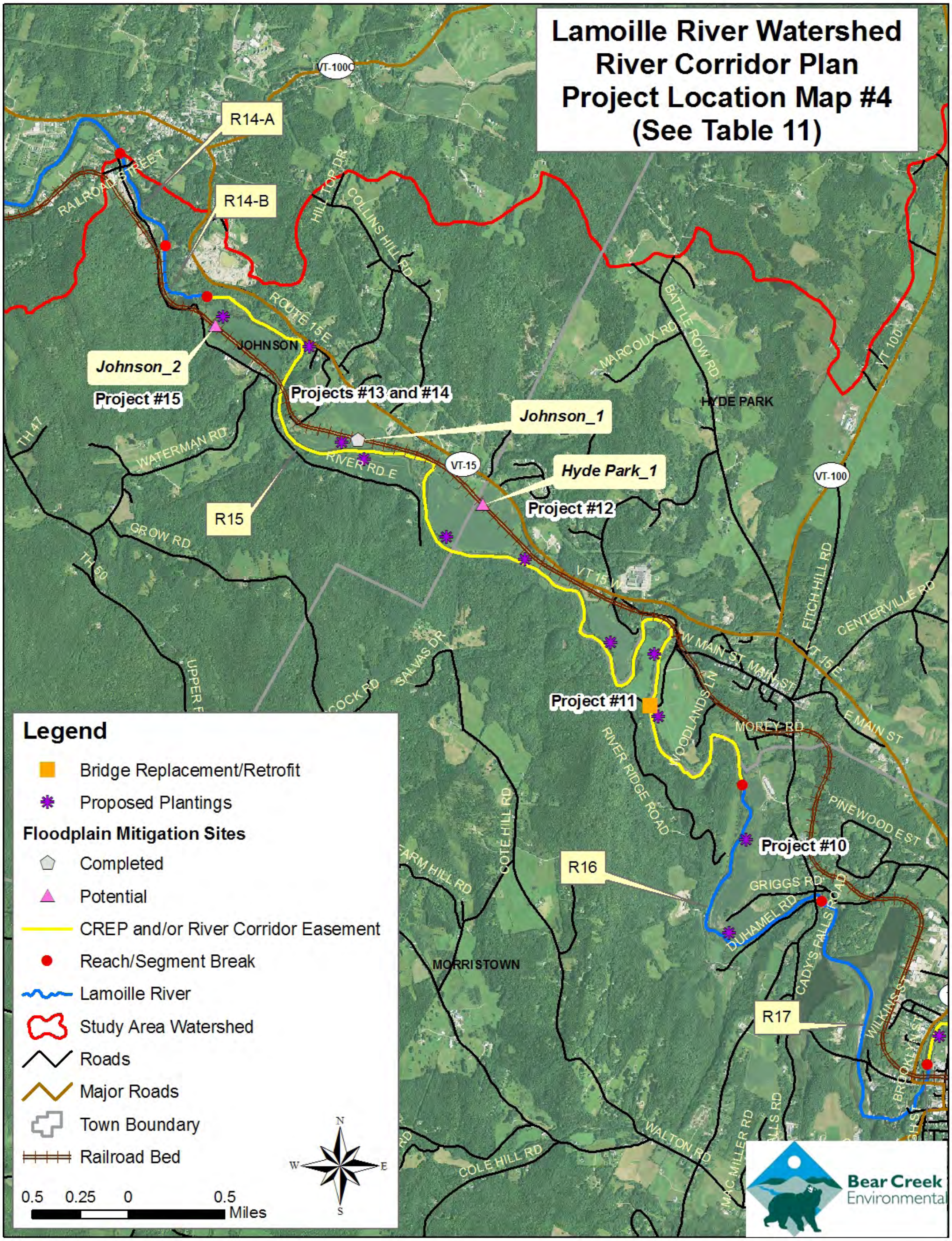

Figure 28. Proposed restoration and protection project for the Lamoille River reach R14-R17

7.5 Next Steps

There are many opportunities to restore the Lamoille River to a stable condition. Types of reach level and site level projects that have been identified in this plan include river corridor protection, streamside plantings, and replacement of stream crossings. On the watershed level, the development and implementation of fluvial erosion hazard zones is recommended to avoid conflicts regarding land use and to save money spent on flood damage and river maintenance. The Towns of Hardwick, Wolcott, Hyde Park, and Morristown could pursue the opportunity to work with the LCPC and the Vermont River Management Program to develop fluvial erosion hazard zones for the land surrounding the Lamoille River. The following are recommendations for next steps:

1. Complete a river corridor plan for the Lamoille River main stem from Railroad Street in Johnson downstream to the confluence of Seymour River in Cambridge (reaches R08 through R13). The phase 2 stream geomorphic assessment data for this section of the main stem was collected in 2006 by BCE and LCPC.
2. Outreach to private landowners and the public about the plan and potential restoration and protection opportunities to be completed by the State and/or LCPC.
3. Town, State, and LCPC representatives meet to discuss the various restoration and protection opportunities and set priorities for action.
4. Meetings to be held with additional partners (Lamoille County Natural Resources Conservation District, Department of Agriculture, Natural Resources Conservation Service, Vermont Agency of Transportation, etc.) to discuss implementation of priority projects.
5. Summary and prioritization of potential projects.
6. Implementation of priority projects with project partners and landowners.

For additional information about fluvial erosion hazard (FEH) zones or project development, please contact the LCPC:

Lamoille County Planning Commission
632 LaPorte Road
Morrisville, VT 05661
(802)888-4548
lcpc@lcpcvt.org

8.0 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, 2004, 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 raising 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 streambank 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.

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.

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 mainstem 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).

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 – 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.

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

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.

Head cut – Sudden change in elevation or knickpoint at the leading edge of a gully

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.

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.

Phase 2 Rapid Stream Assessment – A detailed protocol for gathering scientifically sound information about the stream channel and riparian corridor that can be used for watershed planning and detailed evaluations of aquatic habitat and erosion hazards.

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.

Rapid Geomorphic Assessment – Physical geomorphic parameters are measured along each reach/segment to generate a existing stream type, reach condition, channel adjustment process and reach sensitivity. The assessment is used to understand the degree of departure of the channel from its reference condition.

Rapid Habitat Assessment – Physical habitat parameters are measured along each reach/segment assessed to generate a habitat condition rating. Habitat condition ratings can be used to identify high quality habitat and to "red-flag" areas of degraded habitat for more detailed evaluation.

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.

Surficial sediment/geology – Sediment that lies on top of bedrock.

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

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.

9.0 REFERENCES

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Appendix 1

Phase 2 Stream Geomorphic Assessment Data
Lamoille River
Hardwick to Johnson, Vermont

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream:	Lamoille	SGAT Version:	3
Reach:	R14-A	Organization:	Bear Creek Environmental
Segment Length(ft):	3,009	Observers:	Mike Blazewicz, Pam DeAndrea, & Stacey Ambler
Rain:	Yes	Completion Date:	7/27/2006
		Qualtiy Control Status - Consultant:	Passed
		Qualtiy Control Status - Staff:	Passed

Step 0 - Location: **Segment begins 375 feet downstream of Railroad St. Bridge and continues about 3,000 feet until a rock gorge begins.**

Step 5 - Notes: **Lamoille River segment R14-A begins below Slide Falls, east of Johnson Village, and continues to the mouth of the Gihon River near the center of Johnson Village. Historic floodplain encroachment, fill, and channel straightening within the Village of Johnson have significantly altered the floodplain of the Lamoille River through this reach. The current incision ratio of this reach was measured at 2.8, indicating that the river is not able to access a floodplain. As a result, major widening and planform adjustment are expected, however, significant armoring of the streambanks through this segment have limited these adjustment processes. The segment is additionally impaired from removal of riparian vegetation which has affected both banks. The significant disturbance of the floodplain and alteration of the channel within this segment have caused a stream type departure from a reference "C" type channel to an existing "F" channel. Existing bed material was found to be cobble at the riffle cross section, however, it is likely that this has been influenced by the channel straightening and floodplain fill. It is likely that under reference conditions this reach would be gravel dominated.**

Step 7 - Narrative: **Historic degradation, current minor widening and minor planform adjustment (being limited by extensive rip-rap).**

Step 1. Valley and Floodplain

1.1 Segmentation: **Grade Controls**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft)	One Height	Both Height
Berm:	0		0
Road:	2,586	0	0
Railroad:	2,593	0	0
Imp. Path:	0		0
Dev.:	1,559		1,045

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Sometimes	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	N.E.	N.E.

1.5 Valley Features

Valley Width (ft):	412
Width Determination:	Estimated
Confinement Type:	SC
In Rock Gorge:	No
Human Caused Change in Valley Width?:	yes

1.6 Grade Controls: **None**

Stream: **Lamoille** Reach: **R14-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**143.00**	2.11 Riffle/Step Spacing:	**1000 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**6.80**	2.12 Substrate Composition		Bed:	**22 inches**
2.3 Mean Depth (tf):	**5.60**	Bedrock:	**0.0 %**	Bar:	**14 inches**
2.4 Floodprone Width (ft.):	**153.00**	Boulder:	**8.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**18.80**	Cobble:	**41.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**31.0 %**	Bed Material:	**Cobble**
2.6 Width/Depth Ratio:	**25.54**	Fine Gravel:	**14.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.07**	Sand:	**6.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**2.76**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**11**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Boulder/Cobble**	**Boulder/Cobble**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**559.0**	**634.8**
Erosion Height (ft.):	**3.3**	**3.3**
Revetment Type:	**Multiple**	**Rip-Rap**
Revetment Length:	**1,177.5**	**228.8**

Near Bank Vegetation Type	Left	Right
Dominant:	**Invasives**	**Invasives**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**26-50**	**26-50**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**>100**
Sub-Dominant	**None**	**0-25**
W less than 25		
Buffer Vegitation Type		
Dominant	**None**	**Mixed Trees**
Sub-Dominant	**Herbaceous**	**Herbaceous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Industrial**	**Forest**
Sub-dominant	**None**	**Residential**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R14-A**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments: **None**
Impoundment Loc.:
4.6 Up/Down Strm flow reg.:
(old) Upstrm Flow Reg.: **None**

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **0**
Other: **5** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**120**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Below,Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **2** Point: **0** Side: **1**
Diagonal: **0** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features
Flood chutes: **1**
Neck Cutoff: **0** Avulsion: **0** Head Cuts: **0** Trib Rejuv.: **No**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **1**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **2,413**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **12**
6.2 Pool Substrate: **11**
6.3 Pool Variability: **16**
Total Score: **116**
Habitat Rating: **0.58**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **11**
6.5 Channel Flow Status: **13**
6.6 Channel Alteration: **8**
6.7 Channel Sinuosity: **15**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**7**	**7**
6.9 Bank Vegetation Protection	**4**	**4**
6.10 Riparian Veg. Zone Width:	**1**	**7**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Confined**	Score	STD	Historic
7.1 Channel Degradation	**5**	**B to F**	**Yes**
7.2 Channel Aggradation	**13**	**None**	**No**
7.3 Widening Channel	**11**		**No**
7.4 Change in Planforml	**13**		**No**
Total Score	**42**		

Geomorphic Rating **0.52**
Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R14-B**
Segment Length(ft): **2,421**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **Mike Blazewicz & Pam DeAndrea**
Completion Date: **7/27/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **bedrock gorge**

Step 0 - Location: **Segment begins where reach becomes a bedrock gorge just upstream from major point bar.**

Step 5 - Notes: **Lamoille River segment R14-B begins at Dog Head Falls, a bedrock waterfall east of Johnson Village. It continues downstream to Slide Falls, another large bedrock drop on the mainstem of the Lamoille River. Due to the influence of bedrock on the stream channel this reach received only a partial geomorphic assessment.**

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation: **Grade Controls**
1.2 Alluvial Fan: **None**
1.3 Corridor Encroachments:

	Length (ft)	One	Height	Both	Height
Berm:	0			0	
Road:	2,087	0		307	0
Railroad:	1,499	0		0	
Imp. Path:	0			0	
Dev.:	282			0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Always	Always
Within 1 Bankfull W:	Always	Always
Texture:	Bedrock	Bedrock

1.5 Valley Features
Valley Width (ft): **300**
Width Determination: **Estimated**
Confinement Type: **NC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Waterfall	Downstream	0.0	0.0		
Waterfall	Upstream	0.0	0.0		

Stream: **Lamoille** Reach: **R14-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):		Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):		Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):		Cobble:	**0.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**0.0 %**	Bed Material:	**Bedrock**
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	**0.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**0.00**	Sand:	**0.0 %**	Bed Form:	**Bedrock**
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type	
2.9 Sinuosity:		Detritus:	**%**	Reference Stream Type:	**F**
2.10 Riffles Type:		# Large Woody Debris:		Reference Bed Material:	**Bedrock**
				Reference Subclass Slope:	**None**
				Reference Bedform:	**Bedrock**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**
Lower		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**0.0**	**218.9**
Erosion Height (ft.):	**0.0**	**4.0**
Revetment Type:	**None**	**None**
Revetment Length:	**0.0**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Deciduous**	**Deciduous**
Bank Canopy		
Canopy %:	**51-75**	**51-75**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**None**	**None**
W less than 25		
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**None**	**None**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**Multiple**	**62.5**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures	**0**	**0**
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille**   Reach: **R14-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments: **None**
Impoundment Loc.:
4.6 Up/Down Strm flow reg.:
(old) Upstrm Flow Reg.: **None**

4.7 Stormwater Inputs **None**
Field Ditch:
Road Ditch:
Other:
Tile Drain:
Overland Flow:
Urb Strm Wtr Pipe:
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bedrock Outcrops	**70**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Above,Scour Below**
Bedrock Outcrops	**70**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid:
Point:
Side:

Diagonal:
Delta:
Island:
Braiding: **0**

5.2 Other Features
Flood chutes: **0**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **0**

Neck Cutoff: **0**
Avulsion: **0**
Head Cuts: **0**
Trib Rejuv.:

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score:
Habitat Rating:
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type   Left   Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type   Score   STD   Historic
7.1 Channel Degradation
7.2 Channel Aggradation
7.3 Widening Channel
7.4 Change in Planforml
Total Score

Geomorphic Rating
Channel Evolution Model
Channel Evolution Stage
Geomorphic Condition **Good**
Stream Sensitivity

Phase 2 Segment Summary Report **Lamoille LCRPC HUC2**

Stream:	**Lamoille**	SGAT Version:	**3**
Reach:	**R15-0**	Organization:	**Bear Creek Environmental**
Segment Length(ft):	**30,570**	Observers:	**Staci P., Stacey A., Gerad, Chris**
Rain:	**Yes**	Completion Date:	**8/23/2006**
		Qualtiy Control Status - Consultant:	**Passed**
		Qualtiy Control Status - Staff:	**Provisional**

Step 0 - Location: **Begins just above Dog Head Falls, southeast of Johnson Village near a USGS gaging station and continues upstream to the confluence with Centerville Brook in Hyde Park.**

Step 5 - Notes: **Floodchute at bottom of reach is questionably a historic channel. There are occasional riffles that are complete, these occur at some of the meanders; but overall the reach is exhibiting a "plane-bed" bedform; distance of about 5000 between riffles that were seen. These features were also noted, to help with the habitat discussion that the 10 Bends group is interested in.**

Step 7 - Narrative: **Widening**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft)	One Height	Both	Height
Berm:	**0**		**0**	
Road:	**13,202**	**0**	**0**	
Railroad:	**20,413**	**0**	**0**	
Imp. Path:	**0**		**0**	
Dev.:	**6,625**		**286**	

1.4 Adjacent Side	Left	Right
Hillside Slope:	**Steep**	**Hilly**
Continuous w/ Bank:	**Sometimes**	**Sometimes**
Within 1 Bankfull W:	**Sometimes**	**Sometimes**
Texture:	**N.E.**	**N.E.**

1.5 Valley Features

Valley Width (ft):	**700**
Width Determination:	**Estimated**
Confinement Type:	**NW**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**yes**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	**Upstream**	**0.0**	**0.0**		

Stream: **Lamoille** Reach: **R15-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**164.90**	2.11 Riffle/Step Spacing:	**5000 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**5.50**	2.12 Substrate Composition		Bed:	**150 mm**
2.3 Mean Depth (tf):	**4.60**	Bedrock:	**0.0 %**	Bar:	**95 mm**
2.4 Floodprone Width (ft.):	**700.00**	Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**6.50**	Cobble:	**29.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**47.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**35.85**	Fine Gravel:	**13.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**4.24**	Sand:	**11.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.18**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**15.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Not Applicable**	# Large Woody Debris:	**38**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Gravel**	**Gravel**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**1,973.4**	**2,006.0**
Erosion Height (ft.):	**6.1**	**5.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**981.4**	**4,138.3**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**0-25**	**>100**
W less than 25		
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Herbaceous**
Sub-Dominant	**None**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Hay**
Sub-dominant	**Hay**	**Crop**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**120.0**
Gullies	**Multiple**	**15.0**

	Left	Right
Mass Failures	**0**	**0**
Height	**0.0**	**0.0**
Gullies Number	**3**	
Gullies Length		

Stream: **Lamoille** Reach: **R15-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**

4.2 Adjacent Wetlands: **Minimal**

4.3 Flow Status: **Moderate**

4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**

Flow Reg. Use:

Impoundments: **Large**

Impoundment Loc.: **Upstream**

4.6 Up/Down Strm flow reg.: **Up Stream**

(old) Upstrm Flow Reg.: **Store-release Dam**

4.7 Stormwater Inputs

Field Ditch: **0** Road Ditch: **0**

Other: **1** Tile Drain: **0**

Overland Flow: **0** Urb Strm Wtr Pipe: **0**

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**74**	**Yes**	**Yes**	**Yes**	**No**	**Deposition Below,Scour Above**
Bridge	**160**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid: **9** Point: **2** Side: **8**

Diagonal: **0** Delta: **1** Island: **3** Braiding: **0**

5.2 Other Features

Flood chutes: **2**

Neck Cutoff: **0** Avulsion: **0** Head Cuts: **0** Trib Rejuv.: **No**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **0**

5.4 Stream Ford or Animal Crossing: **No**

5.5 Straightening: **Straightening**

Straightening Length (ft.): **16,258**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **10**

6.2 Pool Substrate: **12**

6.3 Pool Variability: **15**

Total Score: **118**

Habitat Rating: **0.59**

Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **13**

6.5 Channel Flow Status: **14**

6.6 Channel Alteration: **7**

6.7 Channel Sinuosity: **13**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**7**	**8**
6.9 Bank Vegetation Protection	**5**	**3**
6.10 Riparian Veg. Zone Width:	**9**	**2**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**10**	**None**	**Yes**
7.2 Channel Aggradation	**10**	**None**	**No**
7.3 Widening Channel	**11**		**No**
7.4 Change in Planforml	**10**		**No**
Total Score	**41**		

Geomorphic Rating **0.51**

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R16-0**
Segment Length(ft): **8,252**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **Staci P., Stacey A., Gerad, Chris L.**
Completion Date: **8/23/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **Below Cady's Falls to the confluence with Centerville Brook.**

Step 5 - Notes: **Rip rap along paved/Duhamel Rd - potential (unable to determine b/c of vegetation). Occasional riffles were noted and exhibited "sediment" characteristics, the distance noted in step 2.10 reflects that of those features seen. Overall the reach exhibited a plane-bed bedform. These features were also noted, to help with the habitat discussion that the 10 Bends group is interested in.**

Step 7 - Narrative: **Aggrading and some widening still, perhaps on the cusp of stage IV.**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	0		3,404	0
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	2,744		151	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Very Steep	Flat
Continuous w/ Bank:	Sometimes	Never
Within 1 Bankfull W:	Sometimes	Never
Texture:	N.E.	N.E.

1.5 Valley Features

Valley Width (ft): **1,971**
Width Determination: **Estimated**
Confinement Type: **VB**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls: **None**

Stream: **Lamoille** Reach: **R16-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**167.70**	2.11 Riffle/Step Spacing:	**1600 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**6.50**	2.12 Substrate Composition		Bed:	**96 mm**
2.3 Mean Depth (tf):	**4.60**	Bedrock:	**0.0 %**	Bar:	**78 mm**
2.4 Floodprone Width (ft.):	**700.00**	Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**8.20**	Cobble:	**16.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**52.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**36.46**	Fine Gravel:	**11.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**4.17**	Sand:	**21.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.26**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**10.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Sedimented**	# Large Woody Debris:	**10**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Gravel**	**Gravel**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**1,305.3**	**104.8**
Erosion Height (ft.):	**6.2**	**8.0**
Revetment Type:	**None**	**Rip-Rap**
Revetment Length:	**0.0**	**206.2**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**0-25**
Sub-Dominant	**>100**	**0-25**
W less than 25		
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Herbaceous**
Sub-Dominant	**Herbaceous**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Crop**
Sub-dominant	**Residential**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**One**	**30.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures	**0**	**0**
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R16-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Minimal**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs			
4.2 Adjacent Wetlands:	**Minimal**	Flow Reg. Use:		Field Ditch:	**0**	Road Ditch:	**0**
4.3 Flow Status:	**Moderate**	Impoundments:	**Large**	Other:	**1**	Tile Drain:	**0**
4.4 # of Debris Jams:	**0**	Impoundment Loc.:	**Upstream**	Overland Flow:	**0**	Urb Strm Wtr Pipe:	**0**
		4.6 Up/Down Strm flow reg.:	**Up Stream**	4.9 # of Beaver Dams:	**0**		
		(old) Upstrm Flow Reg.:	**Store-release Dam**	Affected Length (ft):	**0**		

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**130**	**Yes**	**No**	**No**	**Yes**	**Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**1**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**5**	Delta:	**0**	Flood chutes:	**1**	Avulsion:	**0**	5.5 Straightening:	**Straightening**
Point:	**1**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**2,469**
Side:	**3**	Braiding:	**0**	Steep Riffles:	**1**	Trib Rejuv.:	**No**	5.5 Dredging:	**None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**10**	6.4 Sediment Deposition:	**12**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**10**	6.5 Channel Flow Status:	**12**	6.8 Bank Stability:	**6**	**8**
6.3 Pool Variability:	**12**	6.6 Channel Alteration:	**7**	6.9 Bank Vegetation Protection	**4**	**2**
Total Score:	**100**	6.7 Channel Sinuosity:	**10**	6.10 Riparian Veg. Zone Width:	**5**	**2**
Habitat Rating:	**0.50**					
Habitat Stream Condition:	**Fair**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic		
7.1 Channel Degradation	**10**	**None**	**Yes**	Geomorphic Rating	**0.49**
7.2 Channel Aggradation	**8**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**10**		**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**11**		**No**	Geomorphic Condition	**Fair**
Total Score	**39**			Stream Sensitivity	**Very High**

Phase 2 Segment Summary Report   Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R18-0**
Segment Length(ft): **18,614**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **Mike Blazewicz, Pam DeAndrea, Stacey Ambler**
Completion Date: **7/26/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Passed**

Step 0 - Location: **Reach begins in downtown Morrisville just about 330 feet upstream of the most upstream bridge in downtown. The reach continues 3.5 miles along Route 15.**

Step 5 - Notes: **Lamoille River reach R18 begins east of Morrisville and continues to just above the dam in Morrisville village. By reference this is a broad valley, however, floodplain encroachment by Route 15 and the Lamoille Valley railroad bed have altered the confinement to “narrow” as the stream flows through hay fields and residential land. Much of the riparian vegetation has been removed along this reach. The channel has sign of historic degradation and is currently actively aggrading, widening, and undergoing planform adjustment. It appears that the channel had been intentionally moved against the valley wall in several locations of the reach. Numerous mid-channel and side bars indicate that the stream is attempting to develop more meanders in response to this historic channel realignment. With the exception of the recreation field behind the school, all erosion is along agricultural fields and is not threatening infrastructure. There seems to be extensive straightening in this rach and it may continue to actively erode its bankds until it develops better meanders.**

Step 7 - Narrative: **Historic degradation. Major aggradation, widening, and planform.**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**
1.2 Alluvial Fan: **None**
1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	0		0	
Road:	14,350	0	2,899	0
Railroad:	13,197	0	0	
Imp. Path:	0		0	
Dev.:	7,017		4,510	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Steep	Hilly
Continuous w/ Bank:	Sometimes	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	N.E.	N.E.

1.5 Valley Features
Valley Width (ft): **835**
Width Determination: **Estimated**
Confinement Type: **NW**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **yes**

1.6 Grade Controls: **None**

Stream: **Lamoille**   Reach: **R18-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**136.00**	2.11 Riffle/Step Spacing:	**1500 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**5.30**	2.12 Substrate Composition		Bed:	**10 inches**
2.3 Mean Depth (tf):	**4.70**	Bedrock:	**0.0 %**	Bar:	**6 inches**
2.4 Floodprone Width (ft.):	**835.00**	Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**7.30**	Cobble:	**12.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**44.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**28.94**	Fine Gravel:	**32.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**6.14**	Sand:	**12.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.38**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**71**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks   Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**9,697.2**	**10,201.5**
Erosion Height (ft.):	**6.7**	**6.2**
Revetment Type:	**Multiple**	**Multiple**
Revetment Length:	**3,871.7**	**2,375.6**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**0-25**
Sub-Dominant	**>100**	**>100**
W less than 25		
Buffer Vegitation Type		
Dominant	**Herbaceous**	**Herbaceous**
Sub-Dominant	**Deciduous**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Hay**	**Hay**
Sub-dominant	**Forest**	**Residential**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R18-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments: **None**
Impoundment Loc.:
4.6 Up/Down Strm flow reg.:
(old) Upstrm Flow Reg.: **None**

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **0**
Other: **4** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**102**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Above,Alignment**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **7** Point: **3** Side: **9**
Diagonal: **1** Delta: **4** Island: **1** Braiding: **0**

5.2 Other Features
Flood chutes: **1**
Neck Cutoff: **0** Avulsion: **0** Head Cuts: **0** Trib Rejuv.: **Yes**

5.3 Steep Riffles and Head Cuts
Steep Riffles: **1**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **13,564**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **7**
6.2 Pool Substrate: **7**
6.3 Pool Variability: **8**
Total Score: **78**
Habitat Rating: **0.39**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **8**
6.5 Channel Flow Status: **9**
6.6 Channel Alteration: **8**
6.7 Channel Sinuosity: **13**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**3**	**3**
6.9 Bank Vegetation Protection	**4**	**4**
6.10 Riparian Veg. Zone Width:	**3**	**1**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**8**	**None**	**Yes**
7.2 Channel Aggradation	**8**	**None**	**No**
7.3 Widening Channel	**9**		**No**
7.4 Change in Planforml	**7**		**No**
Total Score	**32**		

Geomorphic Rating	**0.40**
Channel Evolution Model	**F**
Channel Evolution Stage	**III**
Geomorphic Condition	**Fair**
Stream Sensitivity	**Very High**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream:	**Lamoille**	SGAT Version:	**3**
Reach:	**R19-0**	Organization:	**Bear Creek Environmental**
Segment Length(ft):	**10,106**	Observers:	**Mike Blazawicz, Pam DeAndrea, Stacey Ambler**
Rain:	**Yes**	Completion Date:	**7/26/2006**
		Qualtiy Control Status - Consultant:	**Passed**
		Qualtiy Control Status - Staff:	**Passed**

Step 0 - Location: **Reach begins about 1.25 miles upstream of Route 15A bridge and continues to 200 feet downstream of old railroad bridge.**

Step 5 - Notes: **Lamoille River reach R19 begins at the confluence of the Jones Brook in Wolcott and flows through a narrow valley until the valley width broadens again east of Morrisville. The reach has been further confined (to a semi-confined valley) by Route 15 and the old Lamoille railway bed. Despite these confinements, the reach has remained a "C" type gravel bed channel with a riffle-pool bedform. The left side of the river channel is dominated by forested lands with a wide buffer over 100 feet. On the right side of the channel, the riparian vegetation has been significantly removed to less than 5 feet in width as it flows through industrial land and hay fields.**

Step 7 - Narrative: **Historic degradation associated with floodplain ancroachment from road and railroad and straightening. Current major widening, planform and aggradational adjustment (Step 7.2 row 3 in good catagory because sediments were soft underfoot).**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft)	One	Height	Both	Height
Berm:	**0**			**0**	
Road:	**10,053**	**0**		**0**	
Railroad:	**10,054**	**0**		**0**	
Imp. Path:	**0**			**0**	
Dev.:	**3,857**			**0**	

1.4 Adjacent Side

	Left	Right
Hillside Slope:	**Very Steep**	**Steep**
Continuous w/ Bank:	**Sometimes**	**Sometimes**
Within 1 Bankfull W:	**Sometimes**	**Sometimes**
Texture:	**N.E.**	**N.E.**

1.5 Valley Features

Valley Width (ft):	**530**
Width Determination:	**Estimated**
Confinement Type:	**SC**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**yes**

1.6 Grade Controls: **None**

Stream: **Lamoille**   Reach: **R19-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**164.00**	2.11 Riffle/Step Spacing:	**1200 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**5.20**	2.12 Substrate Composition		Bed:	**16 inches**
2.3 Mean Depth (tf):	**4.10**	Bedrock:	**0.0 %**	Bar:	**5 inches**
2.4 Floodprone Width (ft.):	**530.00**	Boulder:	**2.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**8.00**	Cobble:	**11.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**52.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**40.00**	Fine Gravel:	**24.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**3.23**	Sand:	**11.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.54**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**46**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks   Typical Bank Slope: **Steep**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**5,884.8**	**5,796.9**	Dominant:	**Herbaceous**	**Herbaceous**
Material Type:	**Sand**	**Sand**	Erosion Height (ft.):	**6.9**	**6.9**	Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Consistency:	**Non-cohesive**	**Non-cohesive**	Revetment Type:	**Rip-Rap**	**Rip-Rap**	Bank Canopy		
Lower			Revetment Length:	**922.4**	**2,594.0**	Canopy %:	**1-25**	**1-25**
Material Type:	**Sand**	**Sand**				Mid-Channel Canopy:	**Open**	
Consistency:	**Non-cohesive**	**Non-cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**None**	**>100**
W less than 25		
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Herbaceous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Industrial**
Sub-dominant	**None**	**Hay**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R19-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Minimal**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs			
4.2 Adjacent Wetlands:	**Minimal**	Flow Reg. Use:		Field Ditch:	**0**	Road Ditch:	**0**
4.3 Flow Status:	**Moderate**	Impoundments:	**None**	Other:	**1**	Tile Drain:	**0**
4.4 # of Debris Jams:	**0**	Impoundment Loc.:		Overland Flow:	**0**	Urb Strm Wtr Pipe:	**0**
		4.6 Up/Down Strm flow reg.:		4.9 # of Beaver Dams:			**0**
		(old) Upstrm Flow Reg.:	**None**	Affected Length (ft):			**0**

4.8 Channel Constrictions: **None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**1**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**6**	Delta:	**2**	Flood chutes:	**1**	Avulsion:	**0**	5.5 Straightening:	**Straightening**
Point:	**0**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**9,028**
Side:	**4**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**Yes**	5.5 Dredging:	**None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**7**	6.4 Sediment Deposition:	**8**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**8**	6.5 Channel Flow Status:	**9**	6.8 Bank Stability:	**2**	**3**
6.3 Pool Variability:	**8**	6.6 Channel Alteration:	**8**	6.9 Bank Vegetation Protection	**4**	**4**
Total Score:	**85**	6.7 Channel Sinuosity:	**15**	6.10 Riparian Veg. Zone Width:	**2**	**7**
Habitat Rating:	**0.43**					
Habitat Stream Condition:	**Fair**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Unconfined** Score	STD	Historic		
7.1 Channel Degradation	**7**	**None**	**Yes**	Geomorphic Rating	**0.40**
7.2 Channel Aggradation	**9**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**8**		**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**8**		**No**	Geomorphic Condition	**Fair**
Total Score	**32**			Stream Sensitivity	**Very High**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream:	**Lamoille**	SGAT Version:	**3**
Reach:	**R20-0**	Organization:	**Bear Creek Environmental**
Segment Length(ft):	**8,215**	Observers:	**Mike Blazewicz, Pam DeAndrea, Stacey Ambler**
Rain:	**Yes**	Completion Date:	**6/21/2006**
		Qualtiy Control Status - Consultant:	**Passed**
		Qualtiy Control Status - Staff:	**Passed**

Step 0 - Location: **Segment begins just downstream of railroad bridge and continues another 2000 feet upstream of Corley Road Bridge.**

Step 5 - Notes: **Reach R20 is a short reach that begins below the Wild Branch and flows through a very broad valley to the confluence with the Jones Brook and a change in reference valley confinement. Similar to the upstream reach, R21, this reach flows through hay fields and forest and past residential properties. The reach appears to have been extensively historically straightened.**

Step 7 - Narrative: **Historic degradation, major planform adjustment & some widening and aggradation.**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**3,660**	**0**	**0**	
Railroad:	**3,991**	**0**	**0**	
Imp. Path:	**0**		**0**	
Dev.:	**3,076**		**319**	

1.4 Adjacent Side	Left	Right
Hillside Slope:	**Very Steep**	**Hilly**
Continuous w/ Bank:	**Sometimes**	**Never**
Within 1 Bankfull W:	**Sometimes**	**Never**
Texture:	**N.E.**	**N.E.**

1.5 Valley Features

Valley Width (ft):	**1,200**
Width Determination:	**Estimated**
Confinement Type:	**BD**
In Rock Gorge:	**No**
Human Caused Change in Valley Width?:	**yes**

1.6 Grade Controls: **None**

Stream: **Lamoille** Reach: **R20-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**122.00**	2.11 Riffle/Step Spacing:	**1600 ft.**	2.13 Average Largest Particle on		
2.2 Max Depth (ft.):	**7.00**	2.12 Substrate Composition		Bed:	**8**	**inches**
2.3 Mean Depth (tf):	**5.97**	Bedrock:	**0.0 %**	Bar:	**6**	**inches**
2.4 Floodprone Width (ft.):	**1,170.00**	Boulder:	**0.0 %**	2.14 Stream Type		
2.5 Aband. Floodpn (ft.):	**8.00**	Cobble:	**28.0 %**	Stream Type:	**C**	
Human Elev FloodPln (ft.):		Coarse Gravel:	**50.0 %**	Bed Material:	**Gravel**	
2.6 Width/Depth Ratio:	**20.44**	Fine Gravel:	**17.0 %**	Subclass Slope:	**None**	
2.7 Entrenchment Ratio:	**9.59**	Sand:	**5.0 %**	Bed Form:	**Riffle-Pool**	
2.8 Incision Ratio:	**1.14**	Silt and Smaller:	**0.0 %**	Field Measured Slope:		
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type		
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:		
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**31**	Reference Bed Material:		
				Reference Subclass Slope:		
				Reference Bedform:		

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**1,556.6**	**2,670.1**	Dominant:	**Coniferous**	**Herbaceous**
Material Type:	**Sand**	**Sand**	Erosion Height (ft.):	**4.8**	**6.8**	Sub-dominant:	**Deciduous**	**Deciduous**
Consistency:	**Non-cohesive**	**Non-cohesive**	Revetment Type:	**Rip-Rap**	**Rip-Rap**	Bank Canopy		
Lower			Revetment Length:	**1,013.5**	**1,211.5**	Canopy %:	**26-50**	**1-25**
Material Type:	**Sand**	**Sand**				Mid-Channel Canopy:	**Open**	
Consistency:	**Non-cohesive**	**Non-cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**>100**
Sub-Dominant	**0-25**	**0-25**
W less than 25		
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Herbaceous**
Sub-Dominant	**Herbaceous**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right		Left	Right
Dominant	**Forest**	**Hay**	Mass Failures	**0**	**0**
Sub-dominant	**Hay**	**Residential**	Height	**0.0**	**0.0**
(Legacy)	Amount	Mean Hieght	Gullies Number		
Failures	**One**	**35.0**	Gullies Length		
Gullies	**None**	**0.0**			

Stream: **Lamoille** Reach: **R20-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps:	**Minimal**	4.5 Flow Regulation Type	**None**	4.7 Stormwater Inputs			
4.2 Adjacent Wetlands:	**None**	Flow Reg. Use:		Field Ditch:	**0**	Road Ditch:	**0**
4.3 Flow Status:	**Moderate**	Impoundments:	**Large**	Other:	**2**	Tile Drain:	**0**
4.4 # of Debris Jams:	**0**	Impoundment Loc.:	**Upstream**	Overland Flow:	**0**	Urb Strm Wtr Pipe:	**0**
		4.6 Up/Down Strm flow reg.:	**Up Stream**	4.9 # of Beaver Dams:			**0**
		(old) Upstrm Flow Reg.:	**Store-release Dam**	Affected Length (ft):			**0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**110**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Above,Scour Below,Alignment**
Bridge	**117**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types		Diagonal:	**0**	5.2 Other Features		Neck Cutoff:	**0**	5.4 Stream Ford or Animal Crossing:	**No**
Mid:	**4**	Delta:	**0**	Flood chutes:	**0**	Avulsion:	**0**	5.5 Straightening:	**Straightening**
Point:	**2**	Island:	**0**	5.3 Steep Riffles and Head Cuts		Head Cuts:	**0**	Straightening Length (ft.):	**3,673**
Side:	**3**	Braiding:	**0**	Steep Riffles:	**0**	Trib Rejuv.:	**No**	5.5 Dredging:	**Gravel Mining**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:	**8**	6.4 Sediment Deposition:	**10**	Stream Gradiant Type	Left	Right
6.2 Pool Substrate:	**8**	6.5 Channel Flow Status:	**11**	6.8 Bank Stability:	**7**	**6**
6.3 Pool Variability:	**15**	6.6 Channel Alteration:	**6**	6.9 Bank Vegetation Protection	**8**	**5**
Total Score:	**106**	6.7 Channel Sinuosity:	**12**	6.10 Riparian Veg. Zone Width:	**8**	**2**
Habitat Rating:	**0.53**					
Habitat Stream Condition:	**Fair**					

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	**Unconfined** Score	STD	Historic		
7.1 Channel Degradation	**13**	**None**	**Yes**	Geomorphic Rating	**0.54**
7.2 Channel Aggradation	**11**	**None**	**No**	Channel Evolution Model	**F**
7.3 Widening Channel	**11**		**No**	Channel Evolution Stage	**III**
7.4 Change in Planforml	**8**		**No**	Geomorphic Condition	**Fair**
Total Score	**43**			Stream Sensitivity	**Very High**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R21-0**
Segment Length(ft): **10,773**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **Mike Blazewicz, Pam DeAndrea, Stacey Ambler**
Completion Date: **6/21/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Passed**

Step 0 - Location: **Segment begins about 2000 feet upstream from Corley Road Bridge and continues to rapid section near downtown Wolcott.**

Step 5 - Notes: **Lamoille River reach R21 begins below Wolcott village and continues downstream to where the Wild Branch, a major tributary, enters on the right bank. The reach flows through hay fields, forest, and residential lands in a very broad valley that has been narrowed by Vermont Route 15 and the Lamoille Valley rail bed. Historic degradation within the reach has led to active widening and planform adjustment. Many of the side and point bars observed were being outflanked by the river indicating active planform adjustment. Riparian vegetation, dominated by herbaceous plants, is absent or minimal along much of the reach. Historic straightening for agricultural fields & road. Old railroad on left bank upstream, crosses over at old abutment to right bank.**

Step 7 - Narrative: **Historic degradation, active widening and planform adjustment, many bars being outflanked indicating planform.**

Step 1. Valley and Floodplain

1.1 Segmentation: **None**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft)	One Height		Both	Height
Berm:	0			0	
Road:	9,480	0		0	
Railroad:	10,758	0		0	
Imp. Path:	0			0	
Dev.:	5,857			0	

1.4 Adjacent Side

	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Sometimes	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	N.E.	N.E.

1.5 Valley Features

Valley Width (ft):	779
Width Determination:	Estimated
Confinement Type:	BD
In Rock Gorge:	No
Human Caused Change in Valley Width?:	yes

1.6 Grade Controls: **None**

Stream: **Lamoille** Reach: **R21-0**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**147.00**	2.11 Riffle/Step Spacing:	**1400 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**6.70**	2.12 Substrate Composition		Bed:	**6 inches**
2.3 Mean Depth (tf):	**5.22**	Bedrock:	**0.0 %**	Bar:	**4 inches**
2.4 Floodprone Width (ft.):	**779.00**	Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**8.20**	Cobble:	**16.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**51.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**28.16**	Fine Gravel:	**22.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**5.30**	Sand:	**11.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.22**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**5.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**54**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**4,533.7**	**3,288.3**
Erosion Height (ft.):	**7.1**	**7.3**
Revetment Type:	**Multiple**	**Multiple**
Revetment Length:	**1,040.3**	**1,495.7**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**0-25**	**26-50**
W less than 25		
Buffer Vegitation Type		
Dominant	**Herbaceous**	**Herbaceous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Hay**
Sub-dominant	**Hay**	**Residential**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille**   Reach: **R21-0**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments: **Large**
Impoundment Loc.: **Upstream**
4.6 Up/Down Strm flow reg.: **Up Stream**
(old) Upstrm Flow Reg.: **Store-release Dam**

4.7 Stormwater Inputs
Field Ditch: **0**   Road Ditch: **0**
Other: **2**   Tile Drain: **0**
Overland Flow: **0**   Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Old Abutment	**96**	**Yes**	**No**	**No**	**Yes**	**Deposition Below,Scour Above,Scour Below**
Bridge	**96**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **5**   Point: **2**   Side: **7**
Diagonal: **1**   Delta: **1**   Island: **1**   Braiding: **0**

5.2 Other Features
Flood chutes: **3**
Neck Cutoff: **0**   Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **0**
Head Cuts: **0**   Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **5,136**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **7**
6.2 Pool Substrate: **8**
6.3 Pool Variability: **18**
Total Score: **86**
Habitat Rating: **0.43**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **8**
6.5 Channel Flow Status: **9**
6.6 Channel Alteration: **5**
6.7 Channel Sinuosity: **11**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**3**	**3**
6.9 Bank Vegetation Protection	**2**	**2**
6.10 Riparian Veg. Zone Width:	**8**	**2**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**13**	**None**	**Yes**
7.2 Channel Aggradation	**12**	**None**	**No**
7.3 Widening Channel	**10**		**No**
7.4 Change in Planforml	**6**		**No**
Total Score	**41**		

Geomorphic Rating **0.51**
Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Fair**
Stream Sensitivity **Very High**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R22-A**
Segment Length(ft): **3,901**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **MB, BCE MA, LCPC**
Completion Date: **9/1/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Passed**

Step 0 - Location: **Begins at the a bedrock grade control at the confluence with Wolcott Pond Brook behind the General Store in Wolcott and continues upstream to where the valley walls confine upstream of the confluence iwth the Elmore Branch.**

Step 5 - Notes: **Lamoille River segment R22-A flows through Wolcott Village. It begins just upstream from the confluence with the Elmore Branch and continues to the confluence of Wolcott Pond Brook which enters on the right bank behind the Wolcott General Store. Although speckled here and there with bedrock ledge on the bed and banks, the valley walls of this segment broaden and the Lamoille has historically had floodplain access and the ability to undergo some lateral adjustment through the village of Wolcott.**

Influences of the village on the segment are abundant. This segment has little to no riparian buffer through much of the reach. Several stormwater inputs were recorded, as was an abundance of channel straightening, rock armoring, and floodplain encroachment. The reference stream type through this segment is "B" however due to extensive manipulation the river has become an "F" type stream channel with almost no floodplain access.
Railroad bed below reach may be good area to remove to reduce flooding in village. Bedform was weak riffle-pool.

Step 7 - Narrative: **Historic degradation, current widening attempting to create bankfull bench. Stream transporting sediment so not building bars that would help with planform adjustment (although several sidebars indicate it may want to adjust this way). bedform weak**

Step 1. Valley and Floodplain

1.1 Segmentation: **Channel Dimensions**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	1,211	0	2,649	0
Railroad:	3,901	0	0	
Imp. Path:	0		0	
Dev.:	1,981		1,415	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Never	Never
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	Bedrock	Bedrock

1.5 Valley Features

Valley Width (ft): **400**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **yes**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	Downstream	8.0	4.0		
Ledge	Downstream	5.0	1.0		
Ledge	Downstream	4.0	2.0		
Ledge	Mid-Segment	0.0	0.0		

Stream: **Lamoille** Reach: **R22-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**129.00**	2.11 Riffle/Step Spacing:	**1200 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**5.70**	2.12 Substrate Composition		Bed: **12**	**inches**
2.3 Mean Depth (tf):	**4.34**	Bedrock:	**1.0 %**	Bar: **5**	**inches**
2.4 Floodprone Width (ft.):	**140.00**	Boulder:	**3.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**11.50**	Cobble:	**8.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**36.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**29.72**	Fine Gravel:	**29.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**1.09**	Sand:	**23.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**2.02**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**2.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**30**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Clay**	**Clay**
Consistency:	**Cohesive**	**Cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**553.0**	**1,462.3**
Erosion Height (ft.):	**6.9**	**6.9**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**1,382.3**	**987.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**0-25**
Sub-Dominant	**None**	**0-25**
W less than 25		
Buffer Vegitation Type		
Dominant	**Herbaceous**	**Herbaceous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Residential**	**Residential**
Sub-dominant	**None**	**Pasture**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R22-A**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type
Flow Reg. Use:
Impoundments: **Large**
Impoundment Loc.: **Upstream**
4.6 Up/Down Strm flow reg.: **Up Stream**
(old) Upstrm Flow Reg.: **Store-release Dam**

4.7 Stormwater Inputs
Field Ditch: **0** Road Ditch: **0**
Other: **1** Tile Drain: **0**
Overland Flow: **0** Urb Strm Wtr Pipe: **0**
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	114	Yes	No	Yes	Yes	Scour Above,Alignment
Bridge	94	Yes	No	Yes	Yes	Deposition Above,Deposition Below,Alignment
Bedrock Outcrops	94	Yes	No	Yes	Yes	Deposition Below,Scour Above,Scour Below

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **0** Diagonal: **0**
Point: **0** Delta: **1**
Side: **4** Island: **0**
Braiding: **0**

5.2 Other Features
Flood chutes: **0**
Neck Cutoff: **0**
Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **1**
Head Cuts: **0**
Trib Rejuv.: **Yes**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **1,509**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **6**
6.2 Pool Substrate: **6**
6.3 Pool Variability: **6**
Total Score: **72**
Habitat Rating: **0.36**
Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **6**
6.5 Channel Flow Status: **8**
6.6 Channel Alteration: **6**
6.7 Channel Sinuosity: **13**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	5	6
6.9 Bank Vegetation Protection	4	4
6.10 Riparian Veg. Zone Width:	1	1

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	3	C to F	Yes
7.2 Channel Aggradation	11	None	No
7.3 Widening Channel	7		No
7.4 Change in Planforml	11		No
Total Score	32		

Geomorphic Rating **0.40**
Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Fair**
Stream Sensitivity **Extreme**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R22-B**
Segment Length(ft): **3,258**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **MB, SA**
Completion Date: **8/30/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **bedrock gorge**

Step 0 - Location: **From just above the confluence with the Elmore Branch upstream to the dam east of Wolcott.**

Step 5 - Notes: **Below the dam powerhouse, the Lamoille once again becomes a full flowing river. Through this segment the Lamoille is squeezed through a narrowly confined valley over and against bedrock ledges and into deep wide pools. The extensive presence of bedrock and absence of floodplain in this reach essentially make this a bedrock gorge that transports sediment and water. This reach, also, was only given a partial assessment due to the abundant bedrock in the channel and stable nature of the system.**
No RGA or RHA - partial assessment. Stream type F1.

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation: **Grade Controls**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	2,713	0	483	0
Railroad:	3,258	0	0	
Imp. Path:	0		0	
Dev.:	2,093		78	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Sometimes	Sometimes
Within 1 Bankfull W:	Always	Always
Texture:	Bedrock	Bedrock

1.5 Valley Features

Valley Width (ft): **150**
Width Determination: **Estimated**
Confinement Type: **NC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	Downstream	0.0	0.0		
Ledge	Mid-Segment	8.0	2.0		
Ledge	Upstream	0.0	0.0		

Stream: **Lamoille** Reach: **R22-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):		Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):		Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):		Cobble:	**0.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**0.0 %**	Bed Material:	**Bedrock**
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	**0.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**0.00**	Sand:	**0.0 %**	Bed Form:	**Bedrock**
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type	
2.9 Sinuosity:		Detritus:	**%**	Reference Stream Type:	**F**
2.10 Riffles Type:		# Large Woody Debris:		Reference Bed Material:	**Bedrock**
				Reference Subclass Slope:	**None**
				Reference Bedform:	**Step-Pool**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**
Lower		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**258.7**	**0.0**
Erosion Height (ft.):	**5.0**	**0.0**
Revetment Type:	**Rip-Rap**	**None**
Revetment Length:	**201.7**	**0.0**

Near Bank Vegetation Type	Left	Right
Dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Sub-dominant:	**Herbaceous**	**Herbaceous**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**>100**
Sub-Dominant	**26-50**	**None**
W less than 25		
Buffer Vegitation Type		
Dominant	**Shrubs/Sapling**	**Mixed Trees**
Sub-Dominant	**Herbaceous**	**Herbaceous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Residential**	**Forest**
Sub-dominant	**None**	**None**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R22-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type
Flow Reg. Use:
Impoundments: **Large**
Impoundment Loc.: **Upstream**
4.6 Up/Down Strm flow reg.: **Up Stream**
(old) Upstrm Flow Reg.: **Store-release Dam**

4.7 Stormwater Inputs **None**
Field Ditch: Road Ditch:
Other: Tile Drain:
Overland Flow: Urb Strm Wtr Pipe:
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bedrock Outcrops	**80**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Below**
Bedrock Outcrops	**115**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Below**
Bedrock Outcrops	**93**	**Yes**	**No**	**Yes**	**Yes**	**Scour Above,Scour Below**
Old Abutment	**90**	**Yes**	**No**	**Yes**	**No**	**Deposition Above,Alignment**
Bedrock Outcrops	**90**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid:
Point:
Side:
Diagonal:
Delta:
Island:
Braiding: **0**

5.2 Other Features
Flood chutes: **1**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **0**
Neck Cutoff: **0**
Avulsion: **0**
Head Cuts: **0**
Trib Rejuv.:

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **1,091**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score:
Habitat Rating:
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type Left Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type Score STD Historic
7.1 Channel Degradation
7.2 Channel Aggradation
7.3 Widening Channel
7.4 Change in Planforml
Total Score

Geomorphic Rating
Channel Evolution Model
Channel Evolution Stage
Geomorphic Condition **Good**
Stream Sensitivity

Phase 2 Segment Summary Report   Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R22-C**
Segment Length(ft): **2,179**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **MB, SA**
Completion Date: **8/30/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **impounded**

Step 0 - Location: **The impounded section of water from the dam east of Wolcott upstream for 2179 feet.**

Step 5 - Notes: **Lamoille River segment R22-C was created to capture the influence of a hydropower dam on the stream channel. The segment begins just upstream from the hydropower dam east of Wolcott and continues to the powerhouse location for the dam where the flow of the Lamoille is again moving at its full capacity. Due to the extreme influence of the dam on the flow of water and sediment, this segment was only partially assessed.**

Dam affected reach. Partial assessment. F1 bedrock gorge by refrence.

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation: **Flow Status**
1.2 Alluvial Fan: **None**
1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	136	0	0	
Railroad:	2,179	0	0	
Imp. Path:	0		0	
Dev.:	621		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Very Steep	Very Steep
Continuous w/ Bank:	Sometimes	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	Bedrock	Bedrock

1.5 Valley Features
Valley Width (ft): **100**
Width Determination: **Measured**
Confinement Type: **NC**
In Rock Gorge: **Yes**
Human Caused Change in Valley Width?: **No**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Dam	Mid-Segment	50.0	50.0		

Stream: **Lamoille** Reach: **R22-C**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):		Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):		Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):		Cobble:	**0.0 %**	Stream Type:	**F**
Human Elev FloodPln (ft.):		Coarse Gravel:	**0.0 %**	Bed Material:	**Bedrock**
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	**0.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**0.00**	Sand:	**0.0 %**	Bed Form:	**Bedrock**
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type	
2.9 Sinuosity:		Detritus:	**%**	Reference Stream Type:	**F**
2.10 Riffles Type:		# Large Woody Debris:		Reference Bed Material:	**Bedrock**
				Reference Subclass Slope:	**None**
				Reference Bedform:	**Bedrock**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**
Lower		
Material Type:	**Bedrock**	**Bedrock**
Consistency:	**Cohesive**	**Cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**347.1**	**0.0**
Erosion Height (ft.):	**5.0**	**0.0**
Revetment Type:	**None**	**Multiple**
Revetment Length:	**0.0**	**298.8**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Shrubs/Sapling**
Sub-dominant:	**Shrubs/Sapling**	**Bare**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**>100**	**0-25**
Sub-Dominant	**None**	**51-100**
W less than 25		
Buffer Vegitation Type		
Dominant	**Herbaceous**	**Mixed Trees**
Sub-Dominant	**Shrubs/Sapling**	**None**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Industrial**	**Forest**
Sub-dominant	**Forest**	**Shrubs/Sapling**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R22-C**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **None**
4.2 Adjacent Wetlands: **Minimal**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **Large Store and Release**
Flow Reg. Use: **Other**
Impoundments: **Large**
Impoundment Loc.: **In Reach**
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.: **Store-release Dam**

4.7 Stormwater Inputs **None**
Field Ditch: Road Ditch:
Other: Tile Drain:
Overland Flow: Urb Strm Wtr Pipe:
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bedrock Outcrops	**36**	**Yes**	**No**	**Yes**	**Yes**	**None**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid:
Point:
Side:

Diagonal:
Delta:
Island:
Braiding: **0**

5.2 Other Features
Flood chutes: **0**
5.3 Steep Riffles and Head Cuts
Steep Riffles: **0**

Neck Cutoff: **0**
Avulsion: **0**
Head Cuts: **0**
Trib Rejuv.:

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **None**
Straightening Length (ft.): **0**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score:
Habitat Rating:
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type Left Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type Score STD Historic
7.1 Channel Degradation
7.2 Channel Aggradation
7.3 Widening Channel
7.4 Change in Planforml
Total Score

Geomorphic Rating
Channel Evolution Model
Channel Evolution Stage
Geomorphic Condition **Good**
Stream Sensitivity

Phase 2 Segment Summary Report   Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R22-D**
Segment Length(ft): **3,519**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **MB, SA**
Completion Date: **8/30/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **From a few thousand feet downstream of the second RT 15 bridge in Wolcott (east of the dam) to just upstream from the RT 15 bridge crossing.**

Step 5 - Notes: **Lamoille River segment R22-D begins just above a Route 15 bridge in Wolcott and flows downstream before the hydropower dam changes the water surface slope of the river. This reach flows through predominately forested land and is bordered by the old Lamoille Valley railroad line on the right bank. The fill of the rail bed has altered the floodprone width of the river in this segment.**

Step 7 - Narrative: **Some incision associated with straightening and railroad encroachment (may be limited due to dam grade control at downstream end). Major widening score based on w/d ratio.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Flow Status**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	**0**		**0**	
Road:	**1,697**	**0**	**0**	
Railroad:	**3,499**	**0**	**0**	
Imp. Path:	**0**		**0**	
Dev.:	**208**		**795**	

1.4 Adjacent Side	Left	Right
Hillside Slope:	**Hilly**	**Hilly**
Continuous w/ Bank:	**Sometimes**	**Sometimes**
Within 1 Bankfull W:	**Sometimes**	**Sometimes**
Texture:	**N.E.**	**N.E.**

1.5 Valley Features

Valley Width (ft): **300**
Width Determination: **Estimated**
Confinement Type: **SC**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **yes**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Ledge	**Downstream**	**0.0**	**0.0**		
Ledge	**Downstream**	**0.0**	**0.0**		

Stream: **Lamoille** Reach: **R22-D**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**115.00**	2.11 Riffle/Step Spacing:	**3000 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**5.00**	2.12 Substrate Composition		Bed:	**18 inches**
2.3 Mean Depth (tf):	**3.46**	Bedrock:	**0.0 %**	Bar:	**8 inches**
2.4 Floodprone Width (ft.):	**151.00**	Boulder:	**18.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**6.00**	Cobble:	**31.0 %**	Stream Type:	**B**
Human Elev FloodPln (ft.):		Coarse Gravel:	**12.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**33.24**	Fine Gravel:	**24.0 %**	Subclass Slope:	**c**
2.7 Entrenchment Ratio:	**1.31**	Sand:	**15.0 %**	Bed Form:	**Plane Bed**
2.8 Incision Ratio:	**1.20**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**Yes**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Moderate**	Detritus:	**5.0 %**	Reference Stream Type:	**B**
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**5**	Reference Bed Material:	**Gravel**
				Reference Subclass Slope:	**c**
				Reference Bedform:	**Plane Bed**

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Gravel**	**Gravel**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**1,497.8**	**407.9**
Erosion Height (ft.):	**5.9**	**5.0**
Revetment Type:	**Rip-Rap**	**Rip-Rap**
Revetment Length:	**393.4**	**1,019.4**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Coniferous**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**0-25**
Sub-Dominant	**>100**	**>100**
W less than 25		
Buffer Vegitation Type		
Dominant	**Mixed Trees**	**Mixed Trees**
Sub-Dominant	**Herbaceous**	**Herbaceous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Forest**	**Hay**
Sub-dominant	**Hay**	**Forest**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R22-D**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Minimal**
4.2 Adjacent Wetlands: **None**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **None**
Flow Reg. Use:
Impoundments: **None**
Impoundment Loc.:
4.6 Up/Down Strm flow reg.:
(old) Upstrm Flow Reg.: **None**

4.7 Stormwater Inputs **None**
Field Ditch: Road Ditch:
Other: Tile Drain:
Overland Flow: Urb Strm Wtr Pipe:
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**100**	**Yes**	**No**	**Yes**	**Yes**	**None**
Bedrock Outcrops	**50**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Below**
Bedrock Outcrops	**80**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Mid: **1** Point: **1** Side: **0**
Diagonal: **0** Delta: **0** Island: **0** Braiding: **0**

5.2 Other Features
Flood chutes: **0**
Neck Cutoff: **0** Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Head Cuts: **0**
Steep Riffles: **1** Trib Rejuv.: **No**

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **1,760**
5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **10**
6.2 Pool Substrate: **7**
6.3 Pool Variability: **13**
Total Score: **93**
Habitat Rating: **0.47**
Habitat Stream Condition:

6.4 Sediment Deposition: **8**
6.5 Channel Flow Status: **13**
6.6 Channel Alteration: **10**
6.7 Channel Sinuosity: **5**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**4**	**7**
6.9 Bank Vegetation Protection	**4**	**4**
6.10 Riparian Veg. Zone Width:	**4**	**4**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Plane Bed**	Score	STD	Historic
7.1 Channel Degradation	**13**	**None**	**No**
7.2 Channel Aggradation	**11**	**None**	**No**
7.3 Widening Channel	**10**		**No**
7.4 Change in Planforml	**13**		**No**
Total Score	**47**		

Geomorphic Rating **0.59**
Channel Evolution Model **F**
Channel Evolution Stage **III**
Geomorphic Condition **Fair**
Stream Sensitivity **High**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R23-A**
Segment Length(ft): **20,746**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **Mike Blazewicz, Pam DeAndrea, & Stacey Ambler**
Completion Date: **6/20/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Provisional**

Step 0 - Location: **From Rt 15 bridge in Wolcott to just downstream of Hardwick Lake dam.**

Step 5 - Notes: **Lamoille River segment R23-A begins below Hardwick Lake dam and continues downstream through a broad valley until just above the Route 15 Bridge crossing.**

This segment received a poor geomorphic rating due to historic channel degradation (which may be associated with the disruption of sediment transport from the dam upstream) and a current stream type departure. The presence of numerous mid-channel, point, and side bars in a reference "E" channel is indicative of major channel adjustment.

Hay fields, forest, and some residential development were noted to be the dominant land uses within the riparian corridor. The buffer was highly disturbed on both sides (<5 feet in width). Herbaceous vegetation is the dominant vegetation type.

Evidence of historical straightening. Channel incised.

Step 7 - Narrative: **Historic degradation, evidence of minor widening (although cross section w/d/ ratio is narrow - may be from channelization), aggradation from instream erosion, major planform adjustment.**

Step 1. Valley and Floodplain

1.1 Segmentation: **Grade Controls**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

Length (ft)	One	Height	Both	Height
Berm:	0		0	
Road:	18,984	0	1,708	0
Railroad:	18,355	0	0	
Imp. Path:	0		0	
Dev.:	8,664		783	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Extr.Steep	Extr.Steep
Continuous w/ Bank:	Sometimes	Sometimes
Within 1 Bankfull W:	Sometimes	Sometimes
Texture:	N.E.	N.E.

1.5 Valley Features

Valley Width (ft): **800**
Width Determination: **Estimated**
Confinement Type: **BD**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **yes**

1.6 Grade Controls: **None**

Stream: **Lamoille** Reach: **R23-A**

Step 2. Stream Channel

2.1Bankfull Width (ft.):	**88.00**	2.11 Riffle/Step Spacing:	**1050 ft.**	2.13 Average Largest Particle on	
2.2 Max Depth (ft.):	**6.70**	2.12 Substrate Composition		Bed:	**6 inches**
2.3 Mean Depth (tf):	**5.39**	Bedrock:	**0.0 %**	Bar:	**6 inches**
2.4 Floodprone Width (ft.):	**614.00**	Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):	**9.80**	Cobble:	**5.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**60.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**16.33**	Fine Gravel:	**25.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**6.98**	Sand:	**10.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**1.46**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:	**No**	2.15 Sub-reach Stream Type	
2.9 Sinuosity:	**Low**	Detritus:	**3.0 %**	Reference Stream Type:	
2.10 Riffles Type:	**Complete**	# Large Woody Debris:	**176**	Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Steep**

Bank Texture	Left	Right
Upper		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**
Lower		
Material Type:	**Sand**	**Sand**
Consistency:	**Non-cohesive**	**Non-cohesive**

Bank Erosion	Left	Right
Erosion Length (ft.):	**8,083.9**	**7,908.9**
Erosion Height (ft.):	**7.8**	**8.0**
Revetment Type:	**Multiple**	**Rip-Rap**
Revetment Length:	**1,001.4**	**2,163.7**

Near Bank Vegetation Type	Left	Right
Dominant:	**Herbaceous**	**Herbaceous**
Sub-dominant:	**Shrubs/Sapling**	**Shrubs/Sapling**
Bank Canopy		
Canopy %:	**1-25**	**1-25**
Mid-Channel Canopy:	**Open**	

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**0-25**	**0-25**
Sub-Dominant	**0-25**	**0-25**
W less than 25		
Buffer Vegitation Type		
Dominant	**Herbaceous**	**Herbaceous**
Sub-Dominant	**Shrubs/Sapling**	**Shrubs/Sapling**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Hay**	**Hay**
Sub-dominant	**Forest**	**Residential**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R23-A**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **Abundant**

4.2 Adjacent Wetlands: **Minimal**

4.3 Flow Status: **Moderate**

4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type

Flow Reg. Use:

Impoundments: **Large**

Impoundment Loc.: **Upstream**

4.6 Up/Down Strm flow reg.: **Up Stream**

(old) Upstrm Flow Reg.: **Store-release Dam**

4.7 Stormwater Inputs

Field Ditch: **0** Road Ditch: **0**

Other: **9** Tile Drain: **0**

Overland Flow: **0** Urb Strm Wtr Pipe: **0**

4.9 # of Beaver Dams: **0**

Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Bridge	**100**	**Yes**	**No**	**No**	**Yes**	**Deposition Below,Scour Above,Scour Below,Alignment**
Old Abutment	**45**	**No**	**No**	**Yes**	**Yes**	**Deposition Below,Scour Above,Scour Below**
Bridge	**58**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Above**
Bridge	**60**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Deposition Below,Scour Below**
Bridge	**68**	**Yes**	**No**	**Yes**	**Yes**	**None**
Bridge	**80**	**Yes**	**No**	**Yes**	**Yes**	**Deposition Above,Scour Above,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types

Mid: **9** Diagonal: **0**

Point: **7** Delta: **2**

Side: **6** Island: **0**

Braiding: **0**

5.2 Other Features

Flood chutes: **2** Neck Cutoff: **0**

Avulsion: **0**

5.3 Steep Riffles and Head Cuts

Steep Riffles: **2** Head Cuts: **0**

Trib Rejuv.: **Yes**

5.4 Stream Ford or Animal Crossing: **No**

5.5 Straightening: **Straightening**

Straightening Length (ft.): **19,578**

5.5 Dredging: **None**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.: **8**

6.2 Pool Substrate: **9**

6.3 Pool Variability: **12**

Total Score: **81**

Habitat Rating: **0.41**

Habitat Stream Condition: **Fair**

6.4 Sediment Deposition: **9**

6.5 Channel Flow Status: **10**

6.6 Channel Alteration: **6**

6.7 Channel Sinuosity: **13**

Stream Gradiant Type	Left	Right
6.8 Bank Stability:	**4**	**4**
6.9 Bank Vegetation Protection	**2**	**2**
6.10 Riparian Veg. Zone Width:	**1**	**1**

Step 7. Rapid Geomorphic Assessment Data

Confinement Type **Unconfined**	Score	STD	Historic
7.1 Channel Degradation	**6**	**None**	**Yes**
7.2 Channel Aggradation	**10**	**None**	**No**
7.3 Widening Channel	**11**		**No**
7.4 Change in Planforml	**9**		**No**
Total Score	**36**		

Geomorphic Rating **0.45**

Channel Evolution Model **F**

Channel Evolution Stage **III**

Geomorphic Condition **Fair**

Stream Sensitivity **Very High**

Phase 2 Segment Summary Report Lamoille LCRPC HUC2

Stream: **Lamoille**
Reach: **R23-B**
Segment Length(ft): **1,053**
Rain: **Yes**

SGAT Version: **3**
Organization: **Bear Creek Environmental**
Observers: **Mike Blazewicz, Pam DeAndrea, & Stacey Ambler**
Completion Date: **6/20/2006**
Qualtiy Control Status - Consultant: **Passed**
Qualtiy Control Status - Staff: **Provisional**
Why Not Assessed: **impounded**

Step 0 - Location: **Dam impounds reach and forms Hardwick Lake.**

Step 5 - Notes: **The most upstream segment of this Lamoille River Phase 2 geomorphic assessment, segment R23-B received only a partial assessment due to the influence of the run-of- river dam at Hardwick Lake which impounds the Lamoille River.**

Step 7 - Narrative:

Step 1. Valley and Floodplain

1.1 Segmentation: **Grade Controls**

1.2 Alluvial Fan: **None**

1.3 Corridor Encroachments:

	Length (ft) One	Height	Both	Height
Berm:	0		0	
Road:	935	0	0	
Railroad:	0		0	
Imp. Path:	0		0	
Dev.:	973		0	

1.4 Adjacent Side	Left	Right
Hillside Slope:	Hilly	Hilly
Continuous w/ Bank:	Never	Never
Within 1 Bankfull W:	Never	Never
Texture:	N.E.	N.E.

1.5 Valley Features

Valley Width (ft): **1,200**
Width Determination: **Estimated**
Confinement Type: **VB**
In Rock Gorge: **No**
Human Caused Change in Valley Width?: **yes**

1.6 Grade Controls:

Type	Location	Total Height	Total Height Above Water	Photo Taken?	GPS Taken?
Dam	Downstream	0.0	20.0		

Stream: **Lamoille** Reach: **R23-B**

Step 2. Stream Channel

2.1Bankfull Width (ft.):		2.11 Riffle/Step Spacing:		2.13 Average Largest Particle on	
2.2 Max Depth (ft.):		2.12 Substrate Composition		Bed:	
2.3 Mean Depth (tf):		Bedrock:	**0.0 %**	Bar:	
2.4 Floodprone Width (ft.):		Boulder:	**0.0 %**	2.14 Stream Type	
2.5 Aband. Floodpn (ft.):		Cobble:	**0.0 %**	Stream Type:	**C**
Human Elev FloodPln (ft.):		Coarse Gravel:	**0.0 %**	Bed Material:	**Gravel**
2.6 Width/Depth Ratio:	**0.00**	Fine Gravel:	**0.0 %**	Subclass Slope:	**None**
2.7 Entrenchment Ratio:	**0.00**	Sand:	**0.0 %**	Bed Form:	**Riffle-Pool**
2.8 Incision Ratio:	**0.00**	Silt and Smaller:	**0.0 %**	Field Measured Slope:	
Human Elevated Inc. Rat.:	**0.00**	Silt/Clay Present:		2.15 Sub-reach Stream Type	
2.9 Sinuosity:		Detritus:	**%**	Reference Stream Type:	
2.10 Riffles Type:		# Large Woody Debris:		Reference Bed Material:	
				Reference Subclass Slope:	
				Reference Bedform:	

Step 3. Riparian Features

3.1 Stream Banks

Typical Bank Slope: **Undercut**

Bank Texture	Left	Right	Bank Erosion	Left	Right	Near Bank Vegetation Type	Left	Right
Upper			Erosion Length (ft.):	**0.0**	**43.8**	Dominant:	**Herbaceous**	**Herbaceous**
Material Type:	**Sand**	**Sand**	Erosion Height (ft.):	**0.0**	**8.0**	Sub-dominant:	**Deciduous**	**Deciduous**
Consistency:	**Non-cohesive**	**Non-cohesive**	Revetment Type:	**None**	**None**	Bank Canopy		
Lower			Revetment Length:	**0.0**	**0.0**	Canopy %:	**1-25**	**1-25**
Material Type:	**Sand**	**Sand**				Mid-Channel Canopy:	**Open**	
Consistency:	**Non-cohesive**	**Non-cohesive**						

3.2 Riparian Buffer

Buffer Width	Left	Right
Dominant	**51-100**	**0-25**
Sub-Dominant	**None**	**None**
W less than 25		
Buffer Vegitation Type		
Dominant	**Herbaceous**	**Herbaceous**
Sub-Dominant	**Deciduous**	**Deciduous**

3.3 Riparian Corridor

Corridor Land	Left	Right
Dominant	**Shrubs/Sapling**	**Residential**
Sub-dominant	**Forest**	**Hay**
(Legacy)	Amount	Mean Hieght
Failures	**None**	**0.0**
Gullies	**None**	**0.0**

	Left	Right
Mass Failures		
Height	**0.0**	**0.0**
Gullies Number		
Gullies Length		

Stream: **Lamoille** Reach: **R23-B**

Step 4. Flow & Flow Modifiers

4.1 Springs / Seeps: **None**
4.2 Adjacent Wetlands: **Abundant**
4.3 Flow Status: **Moderate**
4.4 # of Debris Jams: **0**

4.5 Flow Regulation Type **Large Store and Release**
Flow Reg. Use: **Other**
Impoundments: **Large**
Impoundment Loc.: **In Reach**
4.6 Up/Down Strm flow reg.: **None**
(old) Upstrm Flow Reg.: **Store-release Dam**

4.7 Stormwater Inputs **None**
Field Ditch:
Road Ditch:
Other:
Tile Drain:
Overland Flow:
Urb Strm Wtr Pipe:
4.9 # of Beaver Dams: **0**
Affected Length (ft): **0**

4.8 Channel Constrictions:

Type	Width	Photo Taken?	GPS Taken?	Channel Constriction?	Floodprone Constriction?	Problems
Other		**Yes**	**No**	**No**	**Yes**	**Deposition Above,Deposition Below,Scour Below**

Step 5. Channel Bed and Planform Changes

5.1 Bar Types
Diagonal:
Mid:
Delta:
Point:
Island:
Side:
Braiding: **0**

5.2 Other Features
Flood chutes: **0**
Neck Cutoff: **0**
Avulsion: **0**
5.3 Steep Riffles and Head Cuts
Head Cuts: **0**
Steep Riffles: **0**
Trib Rejuv.:

5.4 Stream Ford or Animal Crossing: **No**
5.5 Straightening: **Straightening**
Straightening Length (ft.): **1,038**
5.5 Dredging: **Dredging**

Step 6. Rapid Habitat Assessment Data

6.1 Epifaunal Substrate - Avl.:
6.2 Pool Substrate:
6.3 Pool Variability:
Total Score:
Habitat Rating:
Habitat Stream Condition:

6.4 Sediment Deposition:
6.5 Channel Flow Status:
6.6 Channel Alteration:
6.7 Channel Sinuosity:

Stream Gradiant Type — Left — Right
6.8 Bank Stability:
6.9 Bank Vegetation Protection
6.10 Riparian Veg. Zone Width:

Step 7. Rapid Geomorphic Assessment Data

Confinement Type	Score	STD	Historic
7.1 Channel Degradation			
7.2 Channel Aggradation			
7.3 Widening Channel			
7.4 Change in Planforml			
Total Score			

Geomorphic Rating
Channel Evolution Model
Channel Evolution Stage
Geomorphic Condition **Fair**
Stream Sensitivity

Phase 2 - Stream Geometry Data

Lamoille LCRPC HUC2

		Phase 2 Stream Type					Phase 1 Data			Phase 2 Channel Data												
Reach	Seg-ment	Stream Type	Bed Material	Bedform	Subcl. Slope	Sub Rch?	Channel Slope	Channel Width	Bankfull Width	Max Depth	Mean Depth	Floodpr Width	Recnt Abandn Fldpln	Width Depth Ratio	Entrench-ment Ratio	Incision Ratio	Channel Evolution Stage	Channel Evolution Model	Geo Assess Condition	Hab Assess Condition	QC Staff	QC Auto
R14	A	F	Cobble	Riffle-Pool	None	No	0.33		143	6.8	5.6	153	18.8	25.54	1.07	2.76	III	F	Fair	Fair	P	P
R14	B	F	Bedrock	Bedrock	None	Yes	0.33							0.00	0.00	0.00			Good		P	F
R15	0	C	Gravel	Plane Bed	None	No	0.09		164.9	5.5	4.6	700	6.5	35.85	4.24	1.18	III	F	Fair	Fair	P	F
R16	0	C	Gravel	Plane Bed	None	No	0.21		167.7	6.5	4.6	700	8.2	36.46	4.17	1.26	III	F	Fair	Fair	P	P
R18	0	C	Gravel	Riffle-Pool	None	No	0.06		136	5.3	4.7	835	7.3	28.94	6.14	1.38	III	F	Fair	Fair	P	P
R19	0	C	Gravel	Riffle-Pool	None	No	0.17		164	5.2	4.1	530	8	40.00	3.23	1.54	III	F	Fair	Fair	P	P
R20	0	C	Gravel	Riffle-Pool	None	No	0.01		122	7	5.97	1170	8	20.44	9.59	1.14	III	F	Fair	Fair	P	P
R21	0	C	Gravel	Riffle-Pool	None	No	0.13		147	6.7	5.22	779	8.2	28.16	5.30	1.22	III	F	Fair	Fair	P	P
R22	A	F	Gravel	Riffle-Pool	None	No	0.69		129	5.7	4.34	140	11.5	29.72	1.09	2.02	III	F	Fair	Fair	P	P
R22	B	F	Bedrock	Bedrock	None	Yes	0.69							0.00	0.00	0.00			Good		P	F
R22	C	F	Bedrock	Bedrock	None	Yes	0.69							0.00	0.00	0.00			Good		P	F
R22	D	B	Gravel	Plane Bed	c	Yes	0.69		115	5	3.46	151	6	33.24	1.31	1.20	III	F	Fair		P	P
R23	A	C	Gravel	Riffle-Pool	None	No	0.13		88	6.7	5.39	614	9.8	16.33	6.98	1.46	III	F	Fair	Fair	P	P
R23	B	C	Gravel	Riffle-Pool	None	No	0.13							0.00	0.00	0.00			Fair		P	F

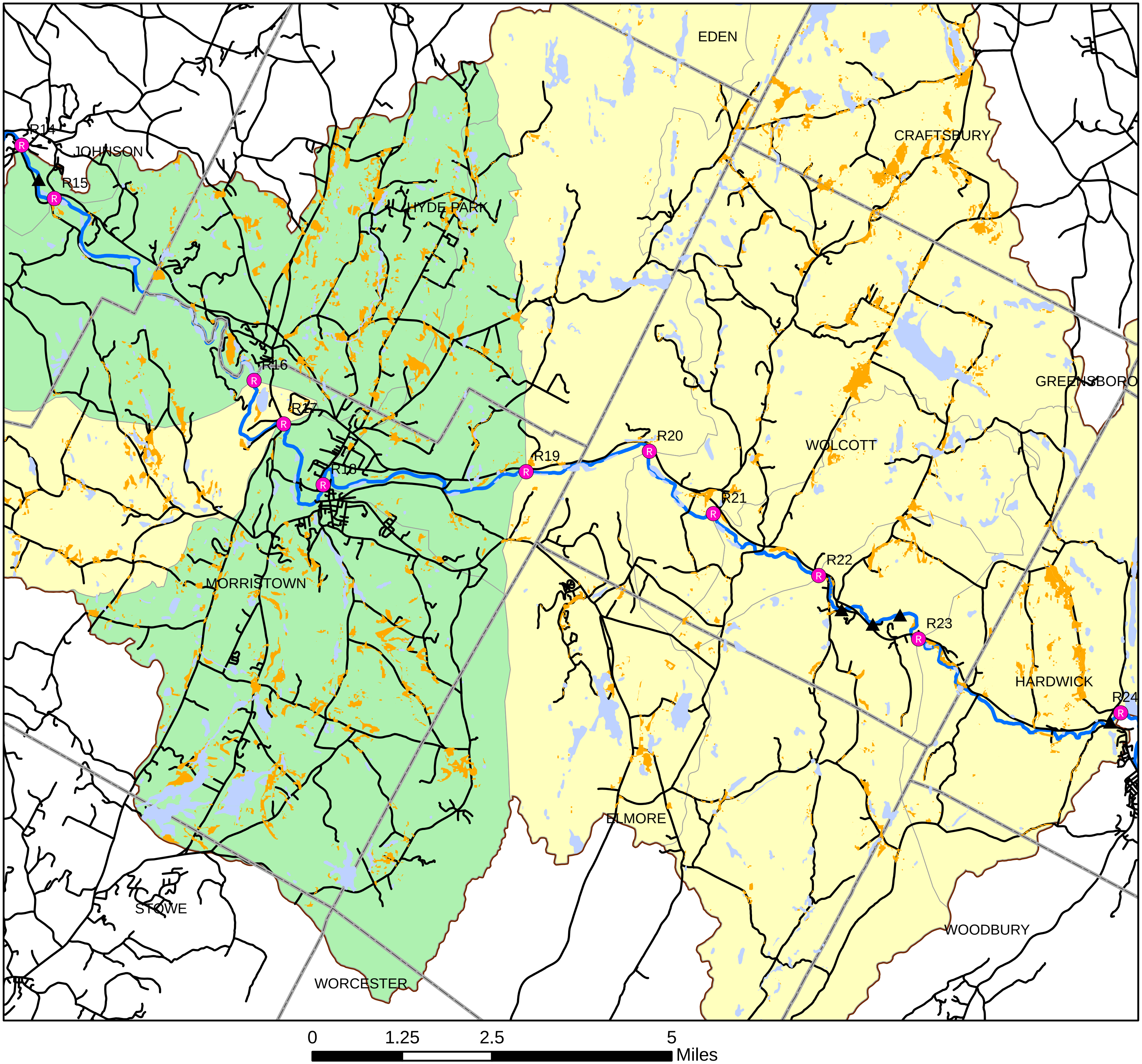
Phase 2 - Rapid Geomorphic Assessment

Lamoille LCRPC HUC2

			Degradation			Aggradation			Widening		Planform								
Reach	Seg-ment	Sub Rch?	Score	STD	Historic	Score	STD	Historic	Score	Historic	Score	Historic	Geo Score	Geo Condition	Evol. Stage	Confin. Type	Sensitivity	QC Staff	QC Auto
R14	A	No	5	B to F	Yes	13	None	No	11	No	13	No	0.53	Fair	III	SC	Extreme	P	P
R14	B	Yes											0.00	Good		NC		P	F
R15	0	No	10	None	Yes	10	None	No	11	No	10	No	0.51	Fair	III	NW	Very High	P	F
R16	0	No	10	None	Yes	8	None	No	10	No	11	No	0.49	Fair	III	VB	Very High	P	P
R18	0	No	8	None	Yes	8	None	No	9	No	7	No	0.40	Fair	III	NW	Very High	P	P
R19	0	No	7	None	Yes	9	None	No	8	No	8	No	0.40	Fair	III	SC	Very High	P	P
R20	0	No	13	None	Yes	11	None	No	11	No	8	No	0.54	Fair	III	BD	Very High	P	P
R21	0	No	13	None	Yes	12	None	No	10	No	6	No	0.51	Fair	III	BD	Very High	P	P
R22	A	No	3	C to F	Yes	11	None	No	7	No	11	No	0.40	Fair	III	SC	Extreme	P	P
R22	B	Yes											0.00	Good		NC		P	F
R22	C	Yes											0.00	Good		NC		P	F
R22	D	Yes	13	None	No	11	None	No	10	No	13	No	0.59	Fair	III	SC	High	P	P
R23	A	No	6	Other	Yes	10	None	No	11	No	9	No	0.45	Fair	III	BD	Very High	P	P
R23	B	No											0.00	Fair		VB		P	F

Appendix 2
Stressor/Departure Maps
Lamoille River
Hardwick to Johnson, Vermont

Lamoille River from Hardwick to Johnson Land Use & Road Density Map



Legend

Lost Wetlands

Existing Wetlands

Road Density

mi/sq mile

0 - 2

3

Roads

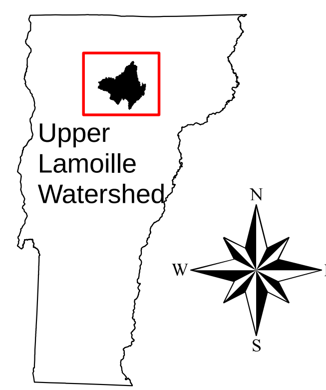
Reach Break

Segment Break

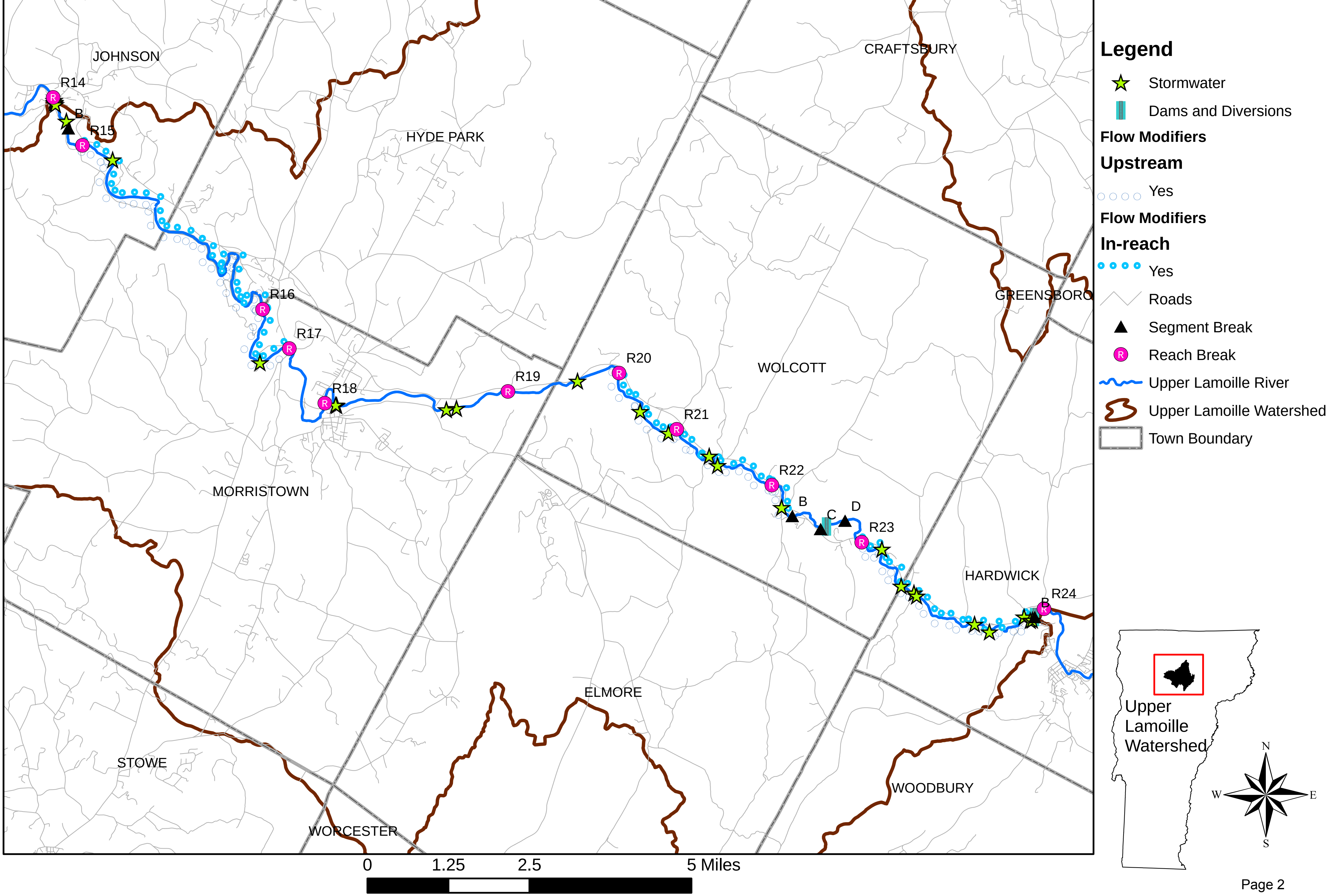
Upper Lamoille River

Upper Lamoille Watershed

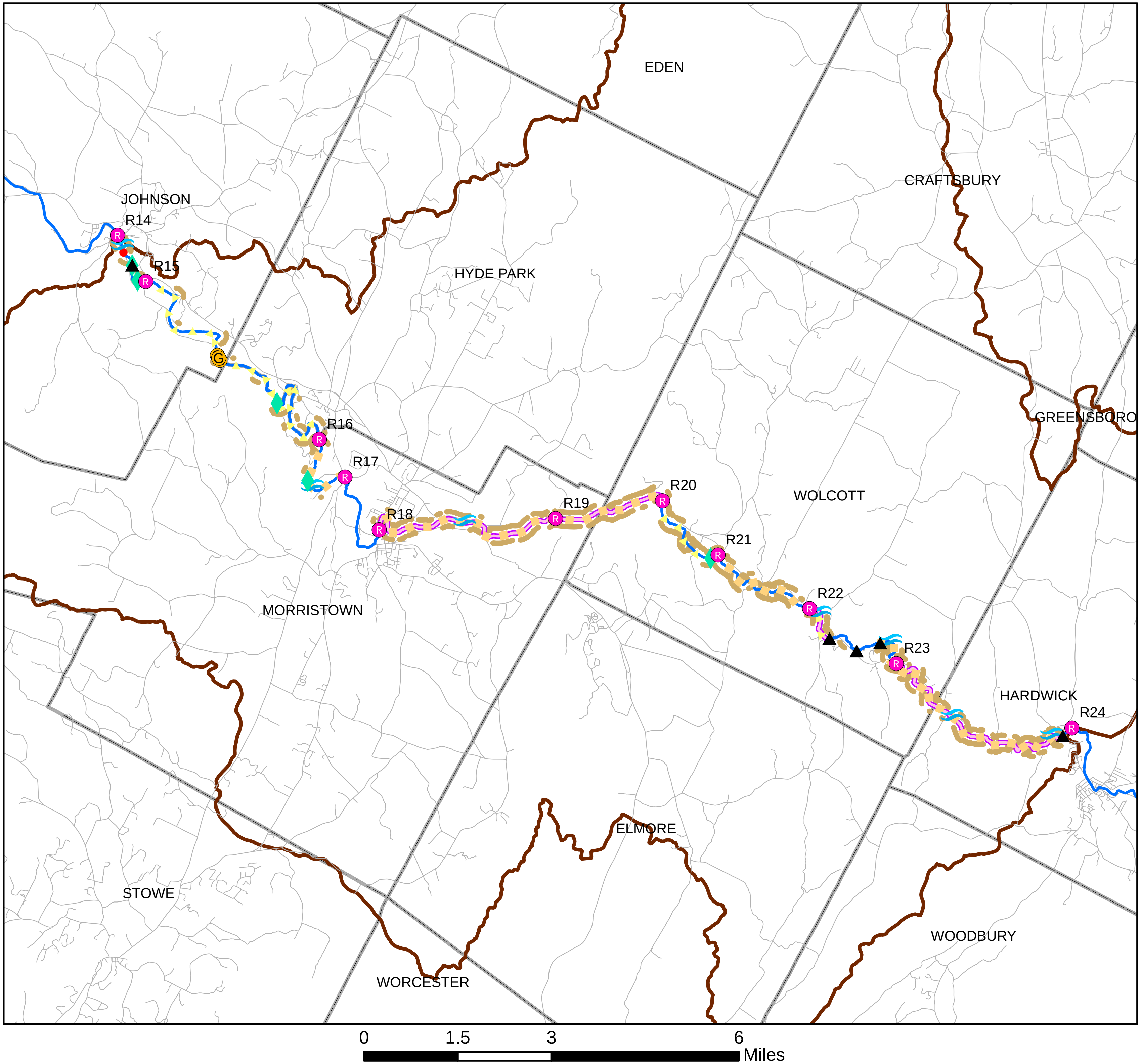
Town Boundary



Upper Lamoille River Hydrologic Alterations Map



Lamoille River From Hardwick to Johnson Sediment Load Indicators Map



Legend

- Mass Failure
- Steep Riffle
- Gully

Depositional features/mile

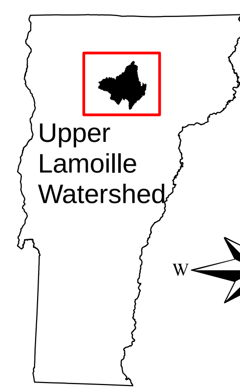
Range

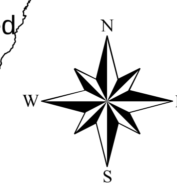
- <=2
- >2 <= 5
- > 5
- Yes
- Upper Lamoille River
- Reach Break

Bank Erosion

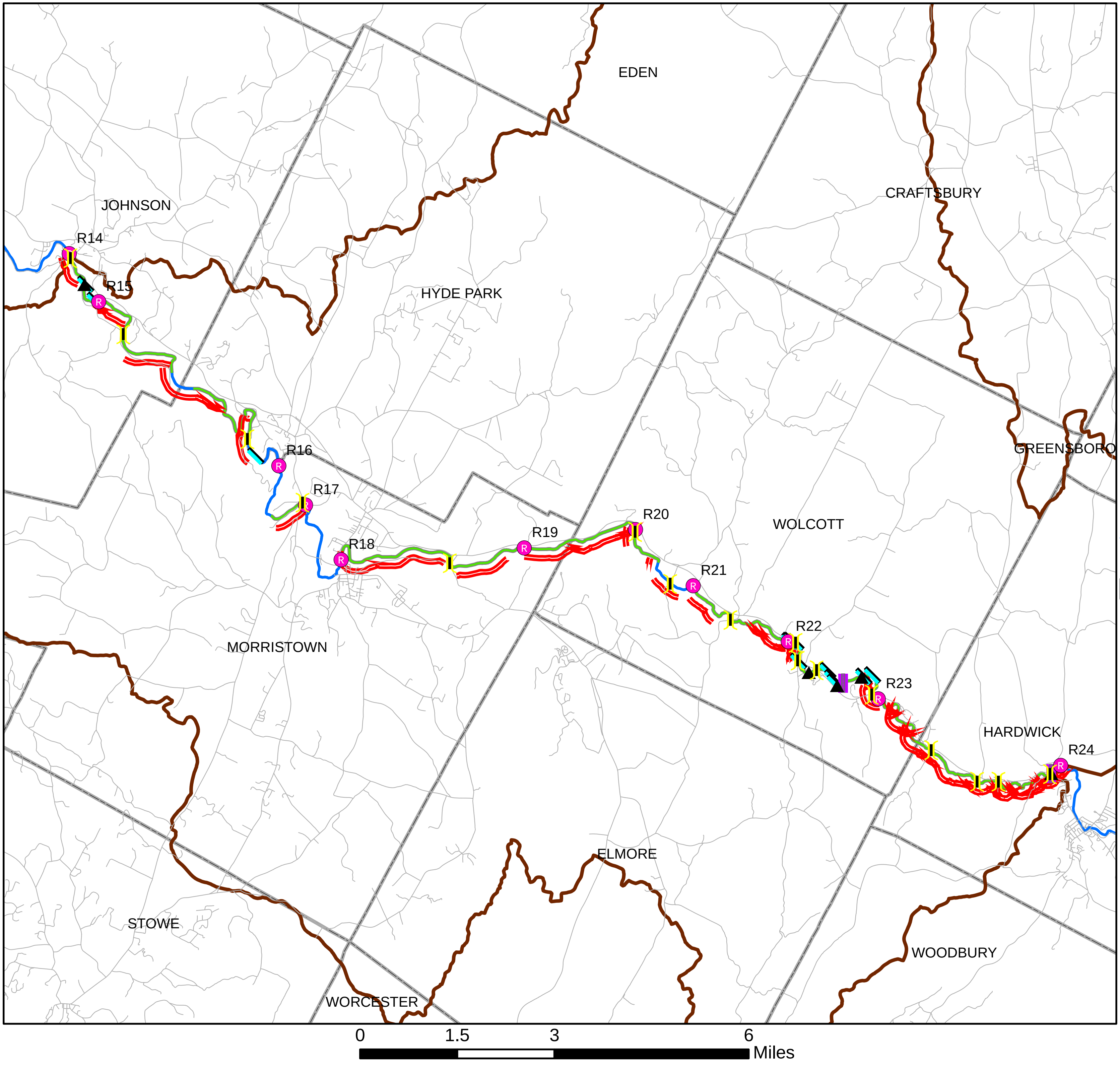
LOCATION

- Left Bank
- Right Bank
- Roads
- Segment Break
- Upper Lamoille Watershed
- Town Boundary



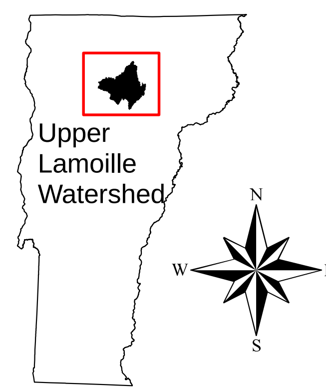


Lamoille River From Hardwick to Johnson Channel Slope Modifiers Map

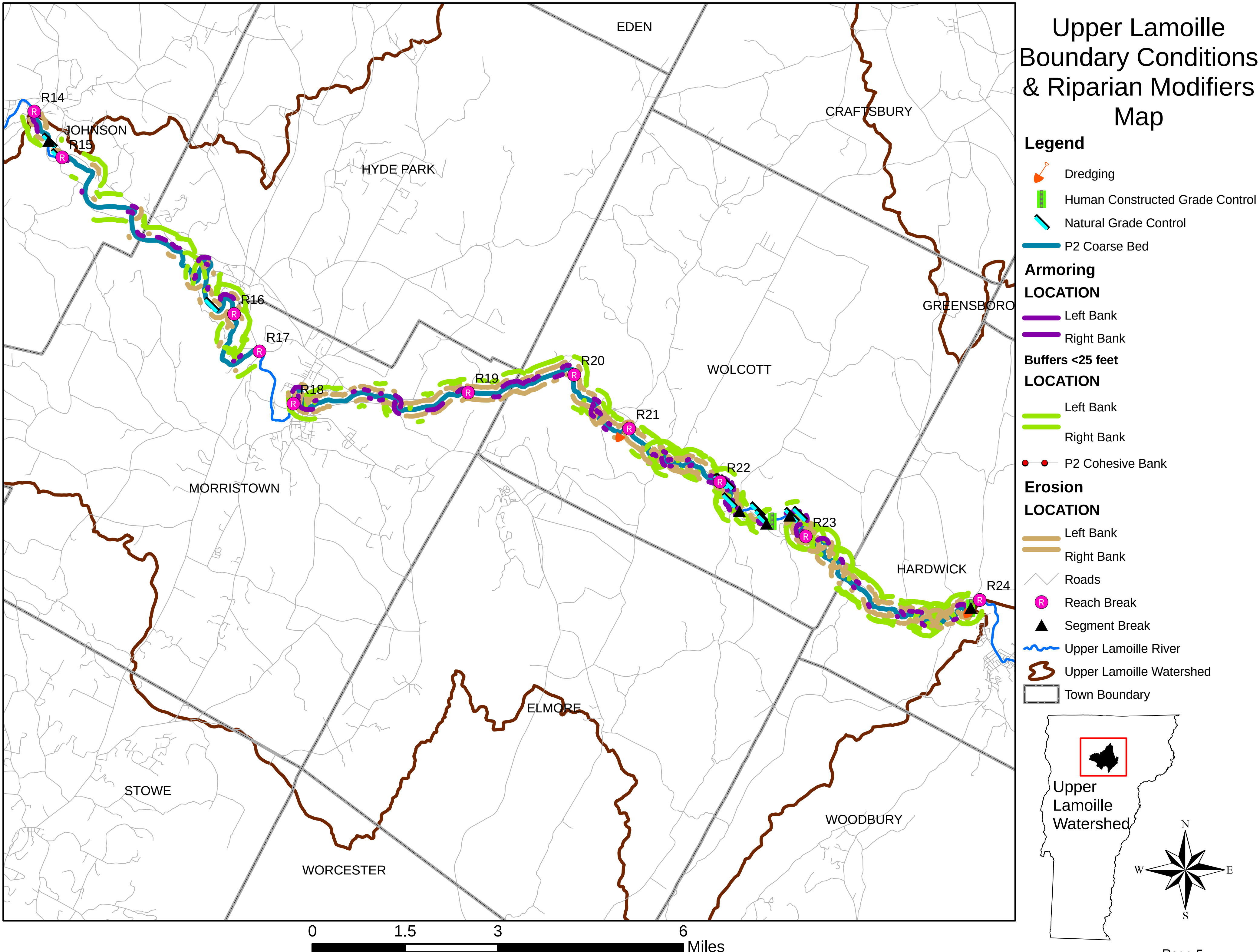


Legend

- Bridge or Culvert
- Human Constructed Grade Control
- Natural Grade Control
- Straightening
- Encroachment/Development
- Roads
- Reach Break
- Segment Break
- Upper Lamoille River
- Upper Lamoille Watershed
- Town Boundary



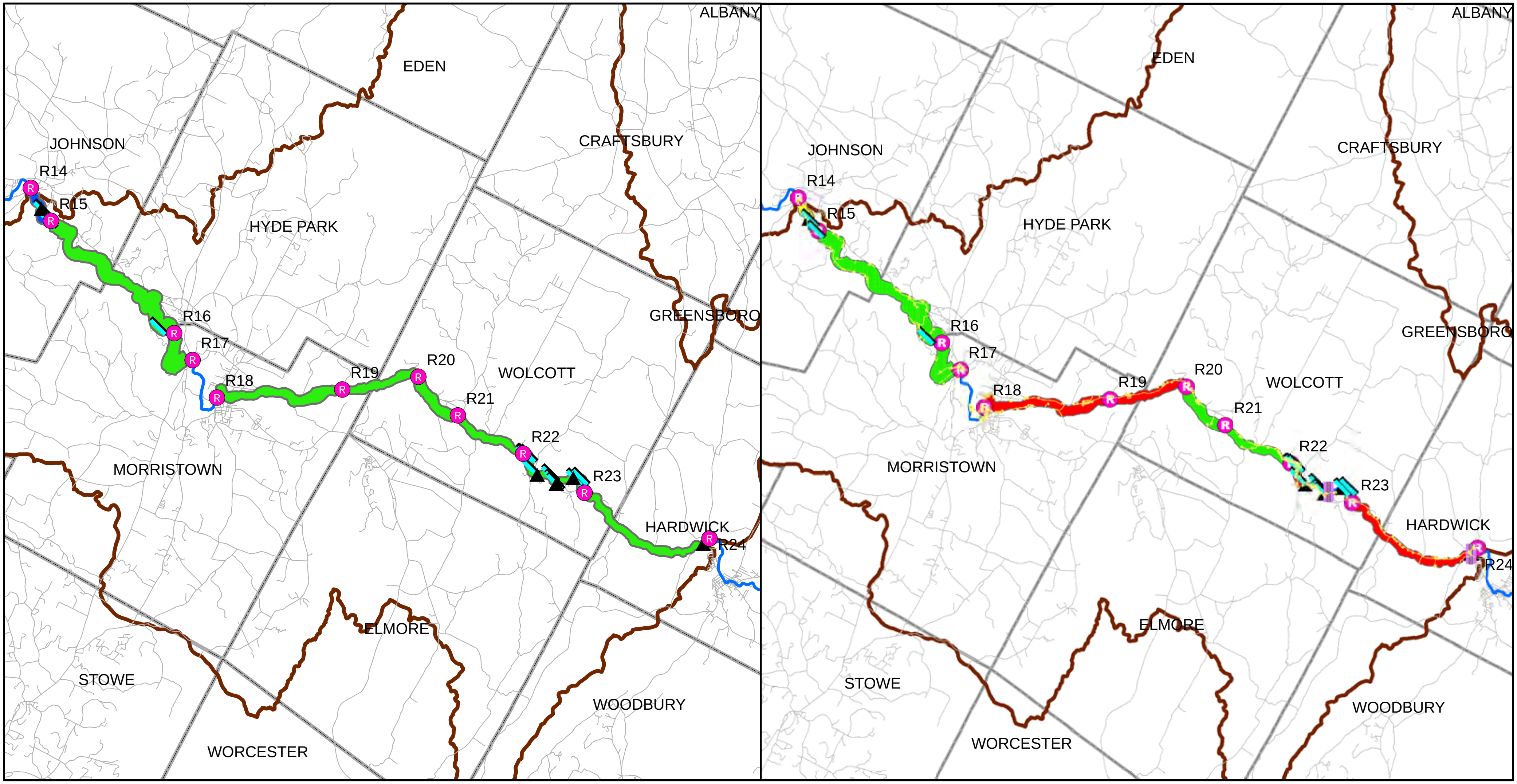
Upper Lamoille Boundary Conditions & Riparian Modifiers Map

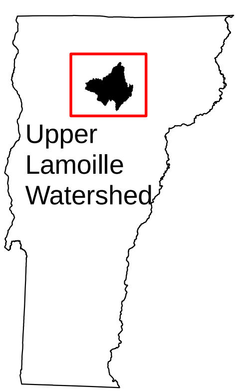


Lamoille River from Hardwick to Johnson Sediment Regime Map

Reference

Existing





P1 Sediment

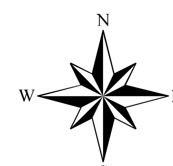
Type

- Coarse Equilibrium ((in=out) & Fine Deposition
- Transport
- Natural Grade Control
- Reach Break
- Segment Break
- Upper Lamoille River

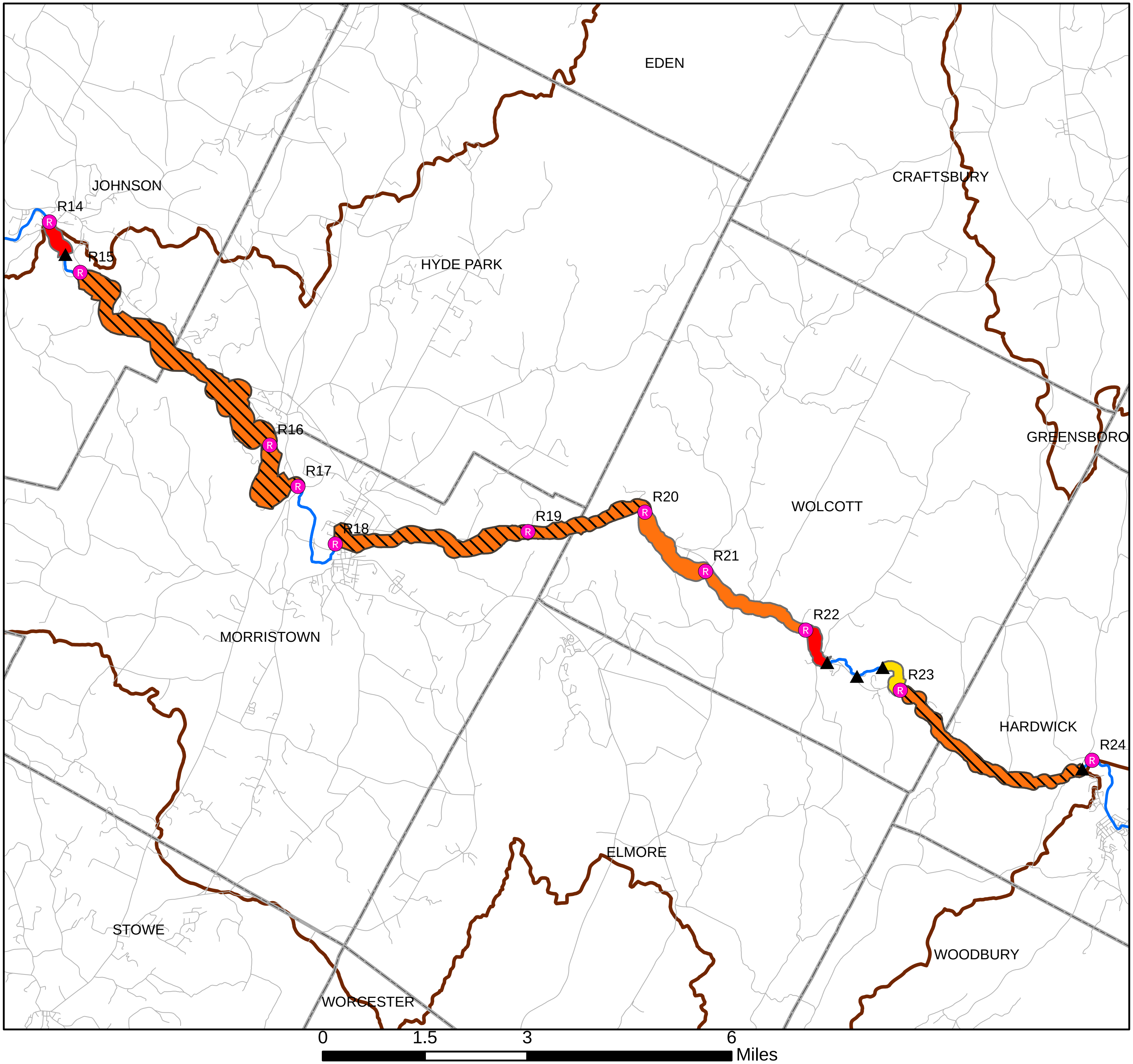
P2 Sediment

Type

- Coarse Equilibrium (in=out) & Fine Deposition
- Confined Source and Transport
- Fine Source and Transport & Coarse Deposition
- Human Constructed Grade Control
- Natural Grade Control
- Reach Break
- Lateral Constraint
- Segment Break
- Upper Lamoille River
- Upper Lamoille Watershed
- Roads
- Town Boundary



Lamoille River from Hardwick to Johnson Stream Sensitivity & Vertical Channel Adjustments Map



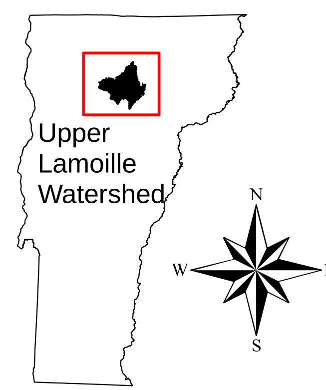
Legend

Sensitivity Level

- High
- Very High
- Extreme

Aggradation vs. Degradation

- Yes, No
- Roads
- Reach Break
- Segment Break
- Upper Lamoille River
- Town Boundary
- Upper Lamoille Watershed



Appendix 3

Black Creek and Lamoille River
Floodplain Restoration Project
2007 and 2008
Milone McBroom and
Agency of Natural Resources

Black Creek and Lamoille River Floodplain Restoration Project

By Roy Schiff, Barry Cahoon, and Mike Kline

Introduction

A large floodplain restoration project was completed in 2008 in northern Vermont where approximately 6 miles of former rail embankment were removed to reconnect more than 200 acres of historic floodplain (Summarized in Schiff et al., 2008). The total project cost was $550,000 and resulted in excavation of 60,000 cubic yards of floodplain fill that led to the return of attenuation of fine sediment and associated nutrients on reconnected floodplains (Figure 1).

Vermont has conducted fluvial geomorphic assessments on nearly 1,500 miles of streams and rivers since 2003. A major finding from the statewide data set is the degree to which river channels are disconnected from their floodplains. Comparing the existing annual flood stage to the stage required for floodplain access, Vermont found that 75% of assessed miles are moderately to severely incised (Kline and Cahoon, 2008). Projects to restore floodplain function have become an important part of Vermont's River Management Program to reduce erosion hazards and restore water quality and river habitat.

FIGURE 1
Black Creek and Lamoille River Floodplain Restoration Project Summary

An agreement between the Vermont Agency of Natural Resources and the Vermont Agency of Transportation established a partnership in pursuing floodplain restoration along the former rail line following track removal and federal rail banking. The end of rail operations was largely the result of regular flood damage and a decrease in regional freight traffic (Pelletier, 2003). The rail line is leased by the Vermont Association of Snow Travelers that also supported the floodplain restoration effort. The Natural Resources Conservation Service funded a portion of the project along with the Vermont Agency of Natural Resources. The project was made possible by the willingness of landowners to naturalize flooding on their lands to achieve the project goals of capturing sediment and nutrients, reducing local flood and erosion hazards, improving water quality, and enhancing habitat. The diverse group of participating project stakeholders indicates floodplains reconnection can be compatible with a diverse set of land uses including agriculture and recreation.

Reconnected floodplains are now periodically inundated (Figure 2) and observable sediment deposition is taking place following flooding (Figure 3).

FIGURE 2
Floodplain Inundation along Black Creek

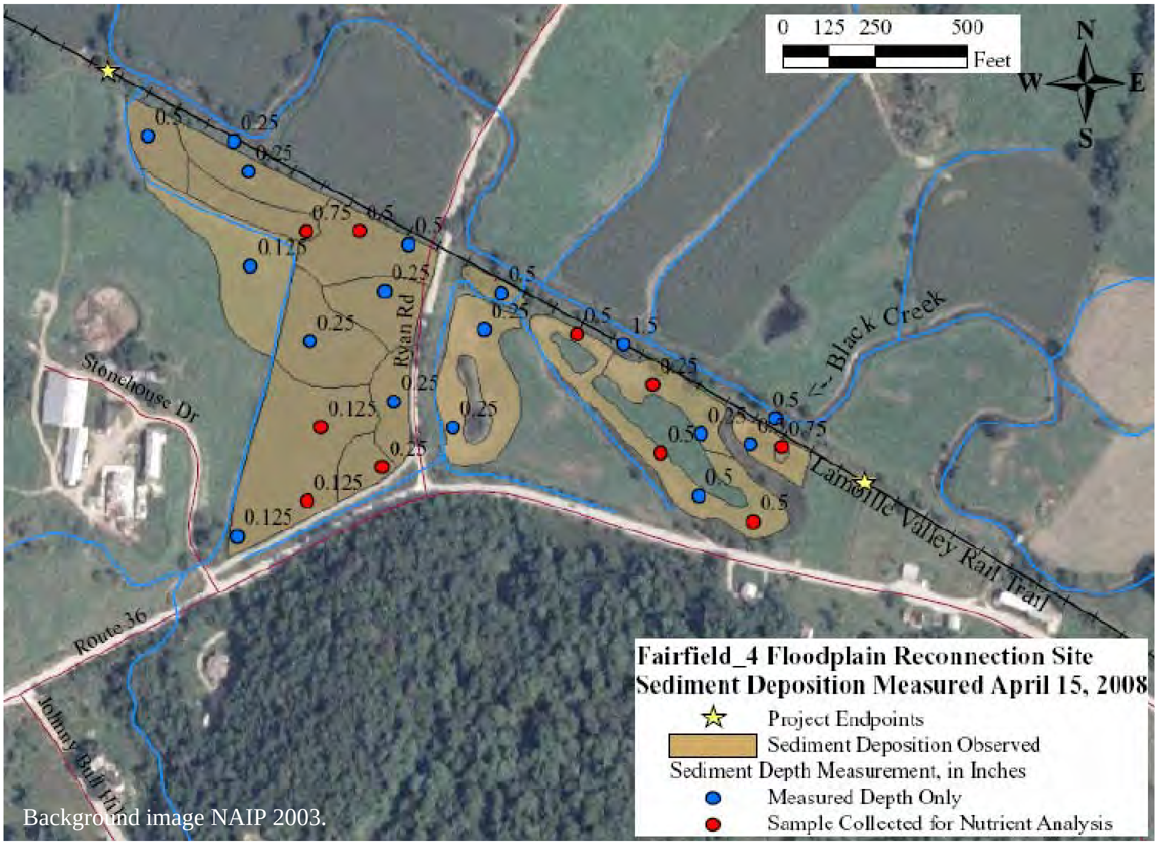
Inundated floodplain at the Fairfield_3 site. February 3, 2009, R. Schiff.

FIGURE 2
Floodplain Sediment Deposition along Black Creek

Evaluation

Evaluation monitoring was conducted at three floodplain restoration sites along Black Creek in Franklin County. The three monitored sites have an area of 21 acres of reconnected floodplain, thus representing approximately 10% of the total reconnected floodplain area for the project. The boundary of fine sediment deposited by the river on the reconnected floodplains was mapped with GPS, and sediment depth was recorded following floodplain access during spring snowmelt and storm floods (Figure 3). Composite sediment samples were collected for analysis of total Phosphorus to provide an indication of potential nutrient capture.

FIGURE 3
Mapped Floodplain Sediment Deposition along Black Creek



Volume (cubic yards) of deposited sediment was calculated for each of the floods. Using a floodplain soil bulk density of 1.3 Mg/m^3 that was estimated during previous floodplain studies in the region, total Phosphorus measurements (ppm) was converted to weight (metric tons).

Approximately 950 cubic yards of fine sediment with nearly 1.0 ton of associated total phosphorus was deposited on the three evaluated floodplains during the first spring flood following floodplain reconnection (Table 1). The level of sediment and nutrient capture on the floodplains was lower in subsequent observations and is thought to be linked to smaller floods as the extent and duration of inundation appeared to be more limited prior to floodplain observations in summer 2008 and spring 2009.

TABLE 1
Deposited Sediment Data

	Bakersfield_1		Fairfield_3		Fairfield_4 (Magnan)		Fairfield_4 (Ryan)		TOTAL	
Date	Vol (cu yd)	P (ton)	Vol (cu yd)	P (ton)	Vol (cu yd)	P (ton)	Vol (cu yd)	P (ton)	Vol (cu yd)	P (ton)
4/15/2008	261	0.2	34	0.0	400	0.5	252	0.2	**946**	**1.0**
7/29/2008	69	0.0	0	0.0	84	0.1	18	0.0	**171**	**0.1**
4/3/2009	85	0.1	14	0.0	8	0.0	93	0.1	**200**	**0.1**
6/2/2009	38	0.0	0	0.0	11	0.0	53	0.0	**102**	**0.1**
TOTALS	**453**	**0.4**	**49**	**0.0**	**502**	**0.6**	**416**	**0.3**	**1,419**	**1.3**

The mean concentration of total phosphorus in the deposited sediment (silt and fine sand) following the April 2008 flood was approximately 1,050 ± 230 mg/kg (Table 2). Mean total Phosphorus is lower in subsequent samples, and also could be linked to smaller floods.

TABLE 2
Total Phosphorus Data

	Bakersfield_1	Fairfield_3	Fairfield_4 (Magnan)	Fairfield_4 (Ryan)	TOTAL	
Date	**TP* (mg/kg)**	**TP (mg/kg)**	**TP (mg/kg)**	**TP (mg/kg)**	**Mean**	**SD**
4/15/2008	863	1260	1240	853	**1054**	**227**
7/29/2008	577	n/m	726	759	**687**	**97**
4/3/2009	909	n/m	670	644	**741**	**146**
6/2/2009	824	n/m	727	664	**738**	**81**
Mean	**793**	**1,260**	**841**	**730**	**805**	
SD	**148**	**n/a**	**267**	**96**	**168**	
*Total P was determined by microwave-assisted digestion in concentrated nitric acid (EPA Method 3051a).						
n/m = not measured						

The Bakersfield floodplain is a cutoff meander bend with native herbaceous vegetation that is hydrologically connected to a hay field across the valley. The Fairfield_3 floodplain is a mixed hay and corn field. The Fairfield_4 (Magnan) floodplain is a corn field and the Fairfield_4 (Ryan) is a hay field. Early spring samples were collected prior to commencement of manure spreading. Residual manure was observed during the June 2009 monitoring at Fairfield_3. The lack of a clear correlation between floodplain land use and total Phosphorus suggests that upstream watershed influences are likely dictating nutrient concentrations, and sediment deposition. Additional study is needed to establish a nutrient and sediment budget for the reconnected floodplains.

The removal of the former railroad embankment and reconnection of natural floodplain has led to observable sediment deposition and associated phosphorus storage. This brief evaluation study is not able to confirm the ultimate fate of the sediment and Phosphorus, yet it is believed that some or all of the sediment will reside on the floodplains over the long term, and some portion of the nutrients will be taken up during growth of wetland plants or crops. Floodplain restoration has achieved the primary project goal of reducing sediment and nutrient inputs to the Missisquoi River and Lake Champlain. Hydraulic modeling indicates that local flood and erosion risks have been reduced by floodplain reconnection.

"To put the 1.3 mt of total phosphorus deposited in those floodplains in perspective, it was more phosphorus than was discharged by 56 (out of 60) individual wastewater treatment plants in the Vermont part of the Lake Champlain Basin during 2008." (Smeltzer, November, 2009, personal communication)

It is likely that the benefits of this project are even greater than portrayed here as this evaluation only considers 3 of the 11 floodplain reconnection sites. Furthermore, larger floods and multiple floods each year are possible that could increase the potential for sediment and nutrient storage on the reconnected floodplains. This project will continue to effectively attenuate sediment and nutrient loads without additional investment for the foreseeable future and thus exemplifies a restoration approach that re-establishes natural processes.

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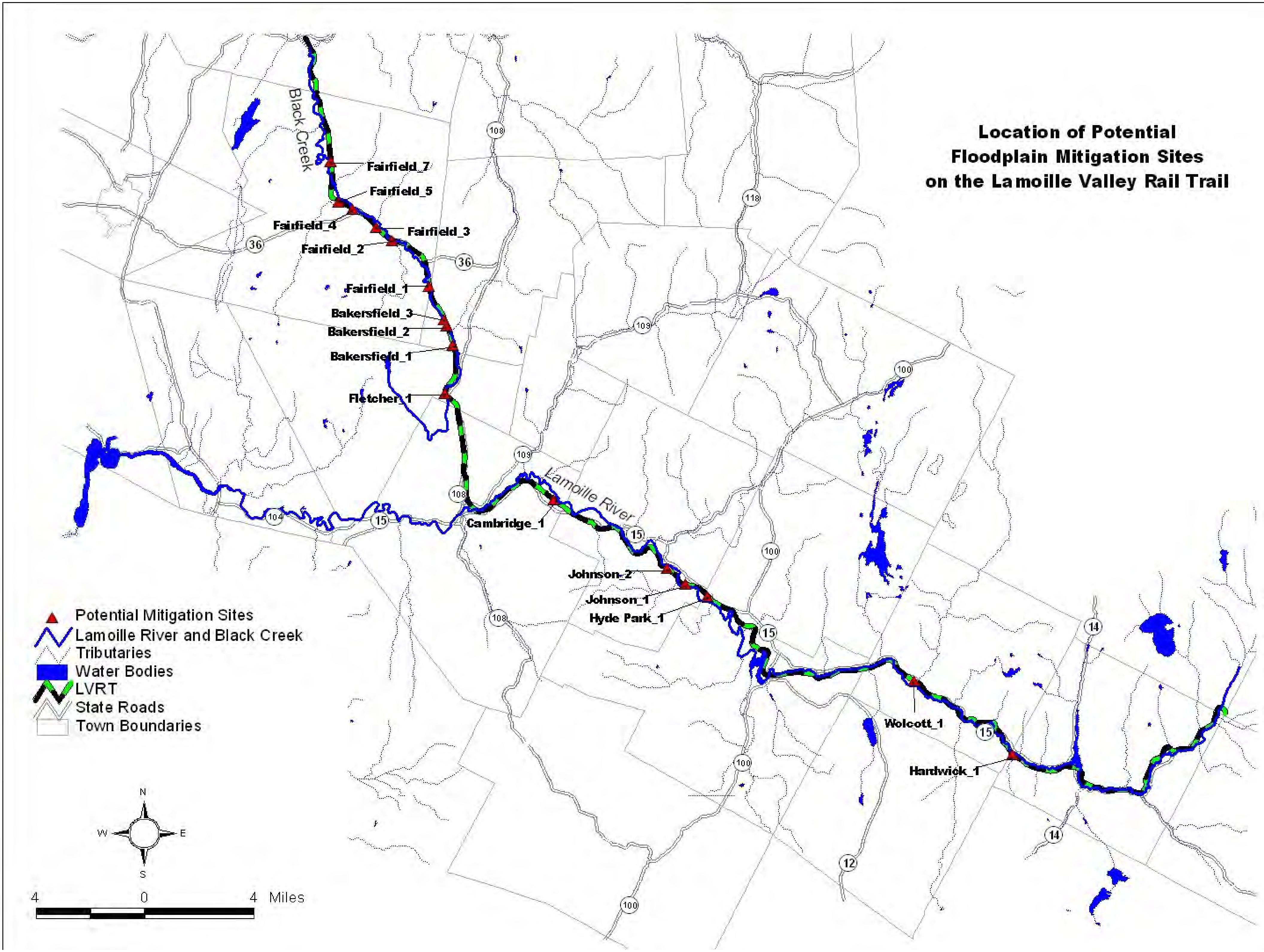

Location of Potential
Floodplain Mitigation Sites
on the Lamoille Valley Rail Trail
Black Creek
Lamoille River
Fairfield_7
Fairfield_5
Fairfield_4
Fairfield_3
Fairfield_2
Fairfield_1
Bakersfield_3
Bakersfield_2
Bakersfield_1
Fletcher_1
Cambridge_1
Johnson_2
Johnson_1
Hyde Park_1
Wolcott_1
Hardwick_1
108
118
36
109
100
104
15
14
12
Potential Mitigation Sites
Lamoille River and Black Creek
Tributaries
Water Bodies
LVRT
State Roads
Town Boundaries
N
W
E
S
4
0
4 Miles

LVRT EMBANKMENT REMOVAL PROJECT LOCATIONS AND DATES							
December 1, 2008							
	Site	**Total Project Length (ft)**	**Valuation Sheet Number**	**East End of Project**	**West End of Project**	**Start Date***	**End Date****
1	Wolcott_1	1,338	v.50/44	2250+50	2263+88	11/12/2007	12/21/2007
2	Johnson_1	2,315	v.50/55	2838+00	2861+15	7/9/2007	7/20/2007
3	Cambridge_1	3,795	v.50/62	3196+70	3234+65	7/24/2007	9/19/2007
3a	Cambridge_1 Fill Site	450	v.50/63	3261+00	3265+50	7/24/2007	8/17/2007
4	Fletcher_1	1,454	v.50/70	3614+80	3629+34	7/2/2007	7/15/2007
5	Bakersfield_1	1,723	v.50/72	3711+80	3729+03	11/12/2007	1/23/2008
6	Bakersfield_2	1,137	v.50/72-73	3756+05	3767+42	1/18/2008	2/22/2008
7	Fairfield_1	1,476	v.50/74	3843+20	3857+96	1/16/2008	2/1/2008
8	Fairfield_2	567	v.50/76	3966+70	3972+37	ASAP	ASAP
9	Fairfield_3	2,260	v.50/77	4003+50	4026+10	7/30/2007	9/4/2007
10	Fairfield_4	2,445	v.50/78	4056+85	4081+30	8/10/2007	9/5/2007
*Start date when clearing of side slopes commenced.							
**End date when site fully stabilized.							
Start and end date taken from construction inspection notes. The dates cover the bulk of the construction work, yet some tasks such as upgrading site stabilization in spring took place outside of this time period.							

Benefits of the Embankment Removal Projects along the LVRT

General Benefits

Embankment removal will re-connect portions of the Lamoille River and Black Creek with its former floodplain, which has been isolated since 1877 when the St. Johnsbury and Lake Champlain Railroad was first constructed. Floodplains serve vital functions such as the storage of flood waters during high flows. As floods recede, fine sediment and nutrients are deposited on the floodplain both protecting water quality in the river and downstream receiving waters and increasing soil fertility on the floodplain. The proposed embankment removals along the Lamoille River and Black Creek will allow water to once again spread over its floodplain in select locations reducing flood and erosion hazards in the river corridors and improving water quality.

Embankment removal also benefits aquatic habitat. Floodplain re-connection leads to a substantial increase in flow area during floods, which translates into a reduction in water velocity. Lower water velocity means less potential for excessive erosion and deposition that can smooth and smother important habitat features. Maintenance of channel roughness leads to more heterogeneous habitats that benefit all aquatic organisms. Embankment removal will generally improve channel stability, which in turn allows for the natural establishment of a range of habitat types. Floodplain access can also increase macroinvertebrate and fish cover by promoting the recruitment of coarse particulate organic matter and woody debris where natural riparian vegetation exists.

Re-connection of truncated meanders that are now essentially oxbow channels mostly disconnected from the mainstem channel is an important habitat benefit of the embankment removal projects. These isolated features once served as holding locations and refuge areas for fish during stressful conditions such as floods or extreme low flows. Refuge areas are important nursery grounds for juvenile fish to grow and avoid predation outside of the main channel. The absence of ample refuge areas can limit fish populations.

Embankment removal also benefits riparian wetlands by improving the direct connection between river channel and wetland. Wetland hydrology, soils and vegetation all depend on frequent flood inundation and flood recession, and isolating these features from rivers initiates changes away from natural conditions. Completely or partially isolating a riparian wetland from its river changes surficial flow patterns, sedimentation, vegetative communities, wildlife habitat, and flood refuge for fish. Removing the embankment will return local inundation cycles to pre-embankment conditions and begin the naturalization of the river-wetland interactions.

In the most recent edition of *Trout*, the quarterly publication of Trout Unlimited, a feature article describes the growing recognition of the benefits of floodplain re-connection projects to reduce risks associated with flood-prone rivers while at the same time protecting habitat and improving important habitat-forming processes.

Site-Specific Habitat Benefits

Below are specific habitat observation and benefits of embankment removal at each site proposed for design and implementation in 2007.

Johnson_1

The floodplain to be re-connected is immediately upstream of a meander bend and river constriction that consists of high quality riffle and run habitat with good overhead cover along the river banks. The constriction is due to a natural rock pinch point that is further reduced in width due to the presence of a bridge. Back-watering is evident at the narrow point based on the water marks on rocks and layered sand deposited on the lower river banks. Removing the embankment immediately upstream would allow flood waters to sit on the floodplain and deposit more sediment up on the land rather than in the back-watered area, thus improving local habitat.

A wetland complex exists along the western edge of the project site, which is bisected by the existing embankment. This wetland feature appears to be mostly disconnected from the nearby Lamoille River, with no direct surface hydrology connection visible. Access to the small channel network that runs up the western edge of the project site would expand fish refuge areas during high flows in the Lamoille.

Cambridge_1

The Lamoille River is located across a broad valley floor from the existing rail embankment that is largely in agricultural production. The river is typically incised along the project site, and contains a range of aquatic habitats. Scour pools on the outside of the meander bends, some distinct grade control locations with downstream scour pools, and limited pockets of woody debris cover create several location that have high quality fish habitat. Reduction of local flood velocities would help maintain these quality habitat spots, and possibly establish more quality habitat by depositing fines on the land rather than in the river. With the limited vegetated buffer along the Lamoille, wood recruitment is not anticipated at the project site unless trees and debris are transported from upstream locations.

There are some aquatic habitat benefits local to the embankment that are associated with small tributaries and large oxbows. Two tributaries flow along the western portion of the project site, which appear to be connected to several oxbow features, especially during higher flows. This aquatic network, which contains locations with dense overhead cover, lots of woody debris, and substantial water depths, is likely a micro-ecosystem supporting assemblages of macroinvertebrates, small fish, amphibians, and other wildlife. Observations in these areas include various adult aquatic insects from the mayfly and caddisfly families, green frogs, wood ducks, black ducks, great blue herons, beaver and coyotes. A small patch of northern white cedar swamp lies along the embankment adjacent to one of the tributaries. There are some weak connections between the channel/oxbow network on the up-gradient side of the embankment and the Lamoille River via small culverts and farm ditches. Embankment removal would only improve connectivity and possibly increase the access to refuge areas during large flood events that fill the valley floor.

Flethcher_1

The meandering Black Creek has fine sediments on its banks and bed adjacent to the project site. Some habitat heterogeneity is apparent, but there reduced cover due to limited trees and sources of coarse particulate matter. Removal of the embankment would re-connect the adjacent shrub wetland back to the river and improve local fish cover. Expansion of nursery grounds and refuge areas for juvenile fish would take place once flood waters can regularly access the existing channel network on the up-gradient side of the embankment. This area is currently accessed via a small collapsed culvert, and thus remains largely isolated.

The land-owner at this site commented on the frequent wildlife use in the riparian wetland to be re-connected to the Black Creek. The new connection will naturalize the timing and frequency of inundation in the wetland and improve wildlife habitat.

Fairfield_3

The benefits of expanding the floodplain at this site primarily revolve around the lowering of local flood velocities during large floods and increasing channel stability. The Black Creek is very sinuous in the area, and shows sign of channel adjustment on the eastern portion of the site. Tight meanders and the absence of shrubs and trees along the river banks have led to localized erosion that introduces sediment into the river channel. The upper portion of the floodplain that is disconnected has some wetland vegetation on the western side and is hydraulically rougher than the lower floodplain that is primarily hay, and thus flood water velocities should be reduced after re-connection. Embankment removal will return the wetland community to a more natural inundation cycle. In places where the Black Creek is disconnected from its floodplain, receding flows deposit sediment in the channel smothering instream habitat features and reducing channel roughness. Expanding the floodplain in this location will promote more local sediment deposition and storage on the land rather than in the channel, and channel roughness.

Fairfield_4

This site contains two truncated meanders that are largely isolated from the Black Creek except for flow exchange via collapsed and undersized culverts. The isolated floodplain at this site is very wet and low, so natural inundation and flood recession frequency is much higher than current conditions. Re-connecting the isolated portions of channel would expand instream habitat refuge and nursery grounds for juvenile fish. A great blue heron was observed fishing in the disconnected meander bend indicating that some fish are currently using this habitat. The Black Creek generally has limited high quality habitat at the project site. The channel has cut down into the floodplain, widened in places, and contains excessive fine sediment smothering habitat features.

The extensive agriculture and absence of any naturally vegetated buffers along Black Creek causes siltation in the channel. This condition is made worse by the embankment when receding flood flows cannot reach the floodplain and remain in the local network of farm ditches and the mainstem channel filling them with fine sediment deposits. The locally straightened channel along the existing rail embankment decreases channel slope and increased flow velocities during floods that leads to additional erosion and deposition. Embankment removal would reduce flow velocities and allow more water to be stored on the floodplain during storms, which would increase the amount of sediment deposited on land and likely improve habitat-forming processes.